International Whaling Commission

TWENTY-SEVENTH REPORT OF THE COMMISSION

(covering the twenty-seventh fiscal year 1975–76)

(Constituted under the International Whaling Convention
signed at Washington on 2 December 1946)

Issued from the Office of the Commission
CAMBRIDGE
1977

Preface

This 27th Annual Report of the International Whaling Commission contains the Chairman's Report of the 27th Meeting held in London in June 1975, the Annual Report for the year ending 31 May 1976, and the Chairman's Report of the 28th Meeting held in London in June 1976. The latter is included in this volume by decision of the meeting in order that the record of the work of the Commission should be available in published form as early as possible.

In addition to the administrative reports, the present publication contains the reports and supporting documents of the Scientific Committee. At its Meeting held in London in June 1976 the Scientific Committee compiled three series of papers:

Documents (SC/28/Doc. . .)

Reports (SC/28/Rep . . .)

Progress Reports (SC/28/Prog. rep. . .)

In addition the Scientific Committee held three special meetings during the preceding year:

La Jolla, March 1976, sperm whales (papers SP/Doc. . .)

Oslo, April 1976, North Atlantic whales (papers NA76/Doc. . .)

London, June 1976, small cetaceans (paper L. . .)

Authors have been given the opportunity to revise the papers they submitted to all these meetings before publication.

Last year the Commission's 26th Annual Report was published as a separate volume from the 'Report and Papers of the Scientific Committee of the Commission 1975'. In order to maintain some degree of continuity for reference purposes, the Scientific publication has been referred to in the present volume as IWC Sci. Rep. 1976 and *Rep. int. Whal. Comm (Sci. Rep.) 26.*

Contents

Papers submitted to the Scientific Committee:

Papers submitted to the Sperm Whale Meeting, La Jolla:

List of Members of the Commission

Contracting Government	*Commissioner*
Argentina	Mr H. R. Basso
Australia	Mr A. G. Bollen *(Chairman)*
Brazil	Dr S. J. De Moura
Canada	Dr W. R. Martin
Denmark	Mr E. Lemche
France	Mr M. Jacquier
Iceland	Mr T. Asgeirsson *(Vice-Chairman)*
Japan	Mr Y. Uchimura
Mexico	Dr A. Rozental
New Zealand	Mr D. B. G. McLean
Norway	Mr I. Rindal
Panama	Dr A. Bissot
South Africa	Mr C. S. Kleu
USSR	Dr I. V. Nikonorov
UK	Dr A. R. Burne
USA	Dr R. M. White

Dr R. Gambell
Secretary to the Commission
June 1976

Office of the Commission
The Red House
Station Road
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Twenty-Seventh Meeting
June 1975 – London
List of Delegates and Observers Attending

Argentina

Mr F. Mirre	Commissioner
Mr D. S. Cullen	Adviser

Australia

Mr A. G. Bollen	Commissioner
Mr J. H. J. Jenkins	Adviser
Dr K. R. Allen	Adviser
Mr J. L. Bannnister	Adviser
Mr J. D. Murray	Adviser
Mr J. H. Chellew	Adviser

Brazil

Dr S. J. De Moura	Commissioner
Mr F. L. Costa Souza	Adviser
Mr H. Iukio	Adviser
Mr I. Ishigami	Adviser

Canada

Dr W. R. Martin	Commissioner
Mr B. Applebaum	Adviser
Dr E. Mitchell	Adviser
Mr V. M. Kozicki	Adviser
Mr B. Mawhinney	Adviser
Dr M. P. Sheppard	Adviser

Denmark

Mr E. Lemche	Commissioner
Mr F. O. Kapel	Adviser

France

Dr C. Roux	Commissioner
Mr M. Jacquier	Alternate Commissioner

Iceland

Mr T. Asgeirsson	Commissioner
Mr J. Jónsson	Alternate Commissioner
Mr K. Loftsson	Adviser
Mr E. B. Ingvarsson	Alternate Commissioner

Japan

Mr I. Fujita	Commissioner
Mr O. Kurino	Adviser
Mr H. Kaya	Adviser
Mr K. Yonezawa	Adviser
Mr Y. Kubota	Adviser
Mr R. Oyama	Adviser
Dr Y. Fukuda	Adviser
Dr S. Ohsumi	Adviser
Mr K. Iino	Adviser
Dr H. Omura	Adviser
Mr S. Ohkuchi	Adviser
Mr K. Hoketsu	Adviser
Mr T. Nakabe	Adviser
Mr S. Kuryu	Adviser
Mr M. Tomita	Adviser
Mr S. Hasui	Adviser
Mr K. Ohtsura	Adviser

Mexico

Dr A. Rozental	Commissioner
Mr D. Gonzales	Deputy Commissioner

Norway

Mr I. Rindal	Commissioner
Dr Å. Jonsgård	Adviser
Mr I. Christensen	Adviser
Mr O. Torgersen	Adviser
Mr E. Aas	Adviser

Panama

Dr A. Bissot Jr	Commissioner

South Africa

Dr B. v D. de Jager	Commissioner
Dr P. B. Best	Adviser
Mr J. M. Sterban	Adviser
Mr L. C. Surmon	Adviser

Union of Soviet Socialist Republics

Dr I. V. Nikonorov	Commissioner
Dr M. V. Ivashin	Adviser
Mr M. G. Stepanov	Adviser
Mr R. J. Borodin	Adviser
Mr Y. B. Riazantsev	Adviser

United Kingdom

Mr J. Graham	Commissioner
Dr A. R. Burne	Adviser
Dr R. Gambell	Adviser
Mr S. G. Brown	Adviser
Mrs C. Lockyer	Adviser

United States of America

Dr R. M. White	Commissioner
Dr E. J. Gould	Deputy Commissioner
Mr E. B. Forsythe	Adviser
Mr J. W. Spensley	Adviser
Mr S. McVay	Adviser
Dr W. Aron	Adviser
Dr L. M. Talbot	Adviser
Dr D. G. Chapman	Adviser
Mr C. A. Bedell	Adviser
Mr R. Eisenbud	Adviser
Mrs P. Fox	Adviser
Mr T. R. Garrett	Adviser
Mr L. Grant	Adviser
Mr K. R. Hampton	Adviser
Dr E. J. Stahr	Adviser
Mr M. F. Tillman	Adviser
Dr R. L. Brownell	Adviser

Korea

Mr Jai-Ryong Jang	Observer

Netherlands

Mr A. van der Struik	Observer

New Zealand

Mr C. R. Keating	Observer

Peru

Mr E. Magan	Observer

Sweden

Mr A. Karlsson	Observer

Food and Agricultural Organisation of the United Nations

Dr S. J. Holt	Observer
Mr L. K. Boerema	Observer

United Nations Environment Programme

Dr K. Curry-Lindahl	Observer

International Council for the Exploration of the Sea

Dr Å. Jonsgård	Observer

International Commission for South East Atlantic Fisheries

Dr B. v D. de Jager	Observer

International Union for the Conservation of Nature and Natural Resources

Dr C. W. Holloway	Observer

Fauna Preservation Society

Mr R. S. R. Fitter	Observer

Friends of the Earth

Miss A. King	Observer
Mrs J. Gordon Clark	Observer (alternate)
Mrs C. Stevens	Observer

International Society for the Protection of Animals

Mr N. Carter	Observer

Project Jonah

Ms M. Saito	Observer
Mr D. O. Hill	Observer (alternate)
Dr P. Spong	Observer (alternate

Sierra Club

Ms P. Rambach	Observer
Mr E. Dawson	Observer

World Federation for the Protection of Animals

Miss P. Forkan	Observer

World Wildlife Fund

Sir Peter Scott	Observer
Miss J. Barber	Observer (alternate)
Mr N. Sitwell	Observer (alternate)

Provisional Agenda for the Twenty-Seventh Annual Meeting

1. Address of Welcome.

2. Arrangements for meeting and adoption of Agenda.

3. Opening statements by member Governments. Statements by Observers from other Countries and International Organisations.

4. Appointment of Committees (Rule XVIII of the Commission's Rules of Procedure applies).

5. Review of previous seasons' catches.

6. Reports of the Scientific Committee
   (a) Report of Meeting at La Jolla, 3–13 December 1974 (circulated)
   (b) Report of Meeting June 1975 (to be circulated as Paper IWC/27/4).

7. Report of the Technical Committee (to be circulated during Meeting as Paper IWC/27/5).

8. Report of the FAO/ACMRR Working Party on Marine Mammals (paragraph 16 of Chairman's Report of 26th Meeting).

9. Classification of Whale Stocks and their Management–
   (a) Report of Special Meeting of Scientific Committee, December 1974. Items 7, 8 and Annexes C1, C2 and D.
   (b) Action arising, including amendments to Schedule as necessary.

10. Whale Stocks and Catch Limits
    (a) Report of Scientific Committee
    (b) Action arising. The determination of catch limits or the establishment of a moratorium in any areas or sub-areas thereof and the determination of size limits will require amendments to the Schedule.
        (i) Southern Hemisphere–Baleen Stocks (paragraph 10(i) of the Chairman's Report of 26th Meeting).
            (a) Catch Limits and divisions of Areas
            (b) Extension of the area for the taking of Bryde's whales to waters south of 25° South Latitude.
            (c) Opening and Closing dates of Antarctic Season.
            (d) Consequential amendments to the Schedule (paragraphs 2(a) 9(b)(c)(d)(e) 11 and 23).
        (ii) Southern Hemisphere–Sperm whales (paragraph 10(ii) of Chairman's Report of 26th Meeting).
            (a) Catch Limits
            (b) Consequential amendments to the Schedule (paragraph 15).
        (iii) North Pacific (paragraph 10(iii) of Chairman's Report of the 26th Meeting).
            (a) Catch Limits
            (b) Consequential amendments to the Schedule (paragraphs 12, 13 and 14).
        (iv) North Atlantic
        (v) Arctic
            (The regulation of catches in these areas would require amendments to the Schedule).
        (vi) Open Seasons for the taking of Sperm whales
            (a) Factory ship type and land station type whaling
            (b) Consequential amendments to the Schedule (paragraphs 2(c) and 3(c)).

11. Stocks of Small Cetaceans
    (a) Report of Scientific Committee
    (b) Action arising. (The regulation of catches would require amendments to the Schedule).

12. International Decade of Cetacean Research. Report of Special Meeting of Scientific Committee, December 1974. Item 10, Annexes E1, E2, E3 and E4.

13. Co-operation with FAO and other Organisations.

14. Adherence of non-member whaling countries. Report by Chairman.

15. Definition of milk-filled whales (paragraph 13(iii) of Chairman's Report of 26th Meeting). Report by Scientific Committee. (Relates to paragraphs 8, 20 and 22 of the Schedule).

16. International Observer Scheme. Report from Observers for 1974 and 1974/75 Seasons (paragraph 13 of Chairman's Report of 26th Meeting).

17. Infractions (paragraph 13 of Chairman's Report of 26th Meeting).

18. Humane Killing of Whales.

19. Finance and Administration
    (a) Progress on Implementation of Strengthened Secretariat and Establishment of Permanent Offices. Report by Chairman (paragraph 19 of the Chairman's Report of 26th Meeting).
    (b) Review of Statement of Account 1974–75
    (c) Consideration of Budget 1975–76
    (d) Consideration of Contributions from Contracting Governments

20. To determine the date when the revised Financial Regulations shall become effective (paragraph (2) of Financial Regulations).

21. Report of Finance and Administration Committee.

22. Twenty-sixth Annual Report (draft to be circulated as Paper IWC/27/8).

23. Proposed Amendments to the International Convention for the Regulation of Whaling and its Schedule. Report of Working Group (paragraph 21 of Chairman's Report of 26th Meeting).

24. Amendment to Rules of Procedure.
    Rule XVII delete "London, England" and add "United Kingdom".

25. Date and Place of next Meeting (Rule II of the Commission's Rules of Procedure applies).

26. Election of Chairman (Rule VIII of the Commission's Rules of Procedure applies).

27. Arrangements for Press Release.

28. Any other business.

Chairman's Report of Twenty-Seventh Meeting

1. DATE AND PLACE

The Twenty-seventh meeting of the Commission was held at Riverwalk House, Millbank, London from 23 to 27 June 1975. The proceedings were conducted by the Chairman of the Commission, Mr I. Rindal (Norway).

2. REPRESENTATION

Commissioners and delegates from all the fifteen member countries attended. The Food and Agriculture Organisation of the United Nations was represented by two observers and there was also an observer from the United Nations Environment Programme. There were also observers present from the Governments of:

Korea
Netherlands
New Zealand
Peru
Sweden

and from the

International Council for the Exploration of the Sea
International Commission for South East Atlantic Fisheries
International Union for the Conservation of Nature and Natural Resources
Fauna Preservation Society
Friends of the Earth
International Society for the Protection of Animals
Project Jonah
Sierra Club
World Federation for the Protection of Animals
World Wildlife Fund

3. ADDRESS OF WELCOME

An address of welcome was given on behalf of the United Kingdom Government by Mr Edward Bishop, MP, Minister of State, Ministry of Agriculture, Fisheries and Food. In welcoming delegates to the meeting, Mr Bishop referred to the further important steps the Commission had taken towards the conservation of the world's whale stocks. He referred particularly to the proposal which was accepted at the last meeting and which had been the subject of a special meeting of the Scientific Committee for the classification of whale stocks. He said that the United Kingdom Government regarded it as a significant step forward in the rational management of the various whale stocks of the oceans because conservation needs varied significantly from stock to stock. He commended the extension of the subdivision of the stocks of the Southern Hemisphere and the setting of individual quotas for the regions involved thus enabling more confident degrees of what he called 'fine tuning' in the control of these stocks.

Now that the Commission had laid the foundation for a new management scheme, he very much hoped that it would be able to move quickly towards agreeing the assessments the Scientific Committee would be presenting. The Commission would be all too aware that, throughout the world, all who share concern for the environment would be anxious that the momentum is kept up.

4. STATEMENTS BY COMMISSIONERS AND OBSERVERS

Statements setting out the views and the position of their Governments on proposals before the Commission were made by the Commissioners for Australia, Canada, Japan, Mexico and USSR and for the USA by the Commissioner and Congressman Edwin Forsythe on behalf of the US Congress. Statements were made by the observers from the international organisations. Press representatives then left the meeting.

5. ADOPTION OF AGENDA

The Commission adopted the provisional agenda which had been circulated sixty days before the meeting in accordance with the Commission's Rules of Procedure.

6. REVIEW OF PREVIOUS SEASONS' CATCHES

Statistics relating to the catch outside the Antarctic in 1974 and the catch in the Antarctic in 1974–75 prepared by the Bureau of International Whaling Statistics had been distributed to the Scientific Committee and were available for delegations. A statement reviewing the seasons' operations prepared by Mr Vangstein, the Director of the Bureau, was circulated.

7. CLASSIFICATION OF WHALE STOCKS

At its last meeting the Commission accepted a proposal that all stocks of whales should be classified into one of the following three categories according to the advice of the Scientific Committee:

(i) *Initial Management Stocks* which may be reduced in a controlled manner to achieve MSY levels or optimum levels as these are determined.
(ii) *Sustained Management Stocks* which should be maintained at or near MSY levels and then at optimum levels as these are determined.
(iii) *Protection Stocks* which are below the level of Sustained Management Stocks and should be fully protected.

It was agreed that:

(a) Commercial whaling should be permitted on Initial Management Stocks subject to the advice of the Scientific Committee as to measures necessary to bring the stocks to the MSY level and then optimum level in an efficient manner and without risk of reducing them below this level.

(b) Commercial whaling should be permitted on Sustained Management Stocks subject to the advice of the Scientific Committee.

(c) There shall be no commercial whaling on species or stocks classified as Protection Stocks, including those species listed for full protection in the current Schedule.

It was decided that the proposal should be implemented by the Scientific Committee providing advice, to be updated annually, on the criteria to be used in defining the above categories of whale stocks to be incorporated in the Schedule as soon as possible, and by the Commission making the necessary amendments not later than its 27th Meeting.

The Scientific Committee at a meeting in La Jolla, California in December 1974 considered the criteria that should be adopted in defining the three categories of stocks and following its meeting in London prior to the meeting of the Commission finalised the following proposals which were considered by the Technical Committee:

> *A Sustained Management Stock* shall be defined as a stock[1] which is not more than Z% of MSY stock level below MSY level, and not more than 20% above that level, MSY being determined on the basis of the number of whales; provided that for stocks between the MSY stock level and Z% below that level the permitted catch shall be not more than is indicated by a straight line from zero at the lower limit to 90% of MSY for stocks above MSY level and that it shall not be more than 90% of MSY for stocks above MSY level.
>
> When a stock has remained at a stable level for a considerable period under a regime of approximately constant catches, it shall be classified as a Sustained Management Stock in the absence of any positive evidence that it should be otherwise classified under the preceding criteria.
>
> *An Initial Management Stock* shall be defined as a stock more than 20% of MSY stock level above MSY level; it is further recommended that the permitted catch for such stocks shall be not more than 90% of MSY as far as this is known, or where it will be more appropriate, fishing effort shall be limited to that which will take 90% of MSY in a stock at MSY level. In the absence of any positive evidence that a continuing higher percentage would not reduce the stock below MSY level, no more than 5% of the estimated initial exploitable stock size should be taken in any one year.
>
> Exploitation should not commence until an estimate of stock size has been obtained which is satisfactory in the view of the Scientific Committee.
>
> *A Protection Stock* shall be defined as a stock which is below Z% of MSY stock level below MSY level.

The Technical Committee agreed with the majority view of the Scientific Committee that the limit below MSY level for Sustained Management Stock and Protection Stock should be 10%.

An alternative formula was proposed by the United Kingdom for determining the annual catch during the transitional period when a sustained management stock is returning to MSY level. The length of the transitional period or the total catch of whales during it would not be affected by the formula which was as follows:

> The annual catch for a Sustained Management Stock for each year during which it remains below MSY level shall not exceed the number of whales obtained by taking 90% of the MSY and reducing that number by 5% for every one per cent by which the stock at the beginning of the sustained management period falls short of the MSY stock level.

The Technical Committee recommended the adoption of the Scientific Committee's proposals as the basis for the classification of the stocks except that for the 1975–76 Antarctic season and the 1976 season in all other areas in the Southern Hemisphere the permitted catch of sei whales should be determined in accordance with the alternative formula set out above.

The Scientific Committee was asked to examine the two formulae with the object of providing the Commission at its next meeting with advice on the advantages and disadvantages of each so that the Committee can decide on the application of one of them to all stocks.

For the purpose of classifying the individual stocks and determining the catch limits the Commission accepted the areas proposed by the Scientific Committee as follows:

Southern Hemisphere for waters between the ice edge and 40°S for fin whales, and the ice edge and the equator for sei and minke whales.

Area I	120°W – 60°W
Area II	60°W – 0°
Area III	0° – 70°E
Area IV	70°E – 130°E
Area V	130°E – 170°W
Area VI	170°W – 120°W

Southern Hemisphere for sperm whales for waters between the ice edge and the equator.

Division 1	60°W – 30°W
Division 2	30°W – 20°E
Division 3	20°E – 60°E
Division 4	60°E – 90°E
Division 5	90°E – 130°E
Division 6	130°E – 160°E
Division 7	160°E – 170°W
Division 8	170°W – 100°W
Division 9	100°W – 60°W

The Commission accepted the Technical Committee's recommendation that the following classification of the whale stocks proposed by the Scientific Committee should be adopted for the 1975–76 Antarctic season and the 1976 season elsewhere:

Sustained Management Stock

Fin whales	Southern Hemisphere
Fin whales	North Atlantic (Iceland Stock)
Fin whales	North Atlantic (Newfoundland Stock)
Sei and Bryde's whales	Southern Hemisphere Areas I, II, IV, V, VI
Minke whales	Southern Hemisphere Area IV, North Atlantic (Stock East of Cape Farewell, Greenland)
Sperm whales–males	Southern Hemisphere Divisions 1, 2, 3, 4, 7 and 9
Sperm whales–females	Southern Hemisphere Divisions 3, 4, 7 and 9

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[1] Stock for this purpose may be defined by the Scientific Committee as total, mature or exploitable as appropriate in each case.

Initial Management Stock

Minke whales	Southern Hemisphere Areas I, II, III, V, VI
Minke whales	North Atlantic (Stock West of Cape Farewell, Greenland)
Bryde's whales	North Pacific
Sperm whales–males	Southern Hemisphere Divisions 5 and 8
Sperm whales–females	Southern Hemisphere Divisions 1, 2, 5, 6 and 8
Sperm whales–males	North Pacific
Sperm whales–females	North Pacific

Protection Stock

Blue whales	All Oceans
Humpback whales	All Oceans
Right whales	All Oceans
Gray whales	All Oceans
Fin whales	Southern Hemisphere Areas II, III, IV, V, VI
Fin whales	North Pacific
Fin whales	North Atlantic (Faroes and West Norway Stock)
Fin whales	North Atlantic (Nova Scotia Stock)
Sei whales	Southern Hemisphere Area III
Sei whales	North Pacific
Sperm whales–males	Southern Hemisphere Division 6

Amendments to the Schedule incorporating the classifications and the formulae on which they were determined were prepared by the Technical Committee and approved by the Commission.

8. CATCH LIMITS

Southern Hemisphere

Fin whales

The Scientific Committee reported that the stock in Southern Hemisphere Area I has been relatively lightly exploited and the Commission accepted the Technical Committee's recommendation that a catch of 220 fin whales in that Area should be approved for the 1975–76 Antarctic season.

Sei whales

The stock in Area III is protected. For the other Areas the Commission accepted the recommendation of the Technical Committee based on the Scientific Committee's assessments of a catch limit for the Southern Hemisphere for the 1975–76 pelagic and 1976 coastal seasons of 2,230 sei and Bryde's whales combined, the catches in the Areas not to exceed the following limits and the total catch not to exceed 2,230:

Area I	198
Area II	567
Area III	0
Area IV	671
Area V	693
Area VI	297

The Scientific Committee drew attention to the lack of information on Bryde's whales and urged that the number taken should be the minimum necessary and coastal catches should not be increased beyond the current level. It suggested that additional data should be obtained wherever possible so that the Commission can consider managing the species separately as the required information becomes available.

Minke whales

The Technical Committee recommended a catch limit of 6,710 Minke whales for the Southern Hemisphere for the 1975–76 pelagic and 1976 coastal seasons based on the assessments made by the Scientific Committee. The Commissioner for the Soviet Union moved an amendment to increase the limit to 7,000, the increase of 290 to be in Area II. This was defeated as were a number of other amendments designed to increase the limit in Area II. Reference was made to the uncertainties expressed in the Scientific Committee's report as to whether the pelagic and land station catches are taken from the same stock and it was suggested that some coastal catches were not included in the assessments. It was suggested that the catch limit in Area II could be safely increased to 1,800 and that the Scientific Committee should re-examine the catches of earlier years and report to the next meeting. The limit recommended by the Technical Committee was increased to 6,810, the catches in the Areas not to exceed the following limits and the total catch not to exceed that figure:

Area I	1,200
Area II	2,160
Area III	2,400
Area IV	891
Area V	840
Area VI	600

Sperm whales

The Scientific Committee's proposals for catch limits in nine Divisions of the Southern Hemisphere within total limits of 5,870 males and 4,870 females for the 1975–76 pelagic and 1976 coastal seasons were recommended to the Commission by the Technical Committee by a majority vote. An amendment to increase the limits for males in Divisions 5 and 8 was defeated but the Commission agreed to divide the catch into six areas instead of the nine Divisions by combining the catches in Divisions 9, 1 and 2 and Divisions 3 and 4 and approved the following catch limits, the total catch not to exceed 5,870 males and 4,870 females:

	Male	*Female*
Divisions 3 and 4	1,562	1,368
Division 5	1,080	756
Division 6	0	324
Division 7	495	396
Division 8	1,512	972
Divisions 9, 1 and 2	2,024	1,992

Length of Antarctic Season

The Commission agreed that there should be no change in the opening and closing dates.

North Pacific

Fin and Sei whales

These species having been classified as Protection Stocks in this area, no catches were approved.

Bryde's whales

The Scientific Committee reported that there is little information on the distribution of the stock of this species and suggested that the pelagic catches should be restricted to not more than the 1974 catches until more information is available. The Commission accepted the Technical Committee's recommendation that the catch limit for the 1976 season should be 1,363.

Minke whales

No catch figures are available for this species in the North Pacific and the Scientific Committee recommended that catches do not increase above the present level. The Commission accepted this, the Japanese Commissioner undertaking to provide the available data for the Scientific Committee so that the position could be reviewed next year.

Sperm whales

The Technical Committee recommended that the Scientific Committee's proposed catch limits of 5,200 males and 3,100 females for 1976 be adopted. These were approved by the Commission after an amendment to increase the limits to 5,600 males and 3,550 females had been defeated.

North Atlantic

Fin whales

The Commission accepted the Technical Committee's recommendation that the catches for 1976 should be 275 in Iceland waters and 90 in Newfoundland waters. It was agreed that the Scientific Committee should examine the possibility of using effort limitation for the purpose of setting the catches in time for the Commission's next meeting.

Minke whales

The Scientific Committee recommended that in the absence of more detailed information the catches should be held no higher than recently and the Technical Committee proposed that the suggested catches of 2,000 in the Eastern North Atlantic and 550 in the Western North Atlantic should be adopted for 1976. This was approved. The Canadian Commissioner pointed out that the minke whale situation in the North Atlantic was not a stable one and recognising that there had been an increase in the catches in the area, Canada, while not taking a catch this time, wished to make a reservation concerning the figure of 550.

9. SPERM WHALES – LENGTH OF SEASON

The Japanese Commissioner proposed that the provision in paragraph 2 (c) of the Schedule for one continuous open season not to exceed eight months out of any period of twelve months for the taking of sperm whales by factory ships and the requirement in paragraph 3 (c) that the eight month period for land stations should include the six month period for baleen whales should be modified with a view to facilitating economic whaling operations. The Scientific Committee reported that the length of the sperm whaling season was no longer important in itself now that the sperm whale stocks were being managed by catch limitation. It referred to the possibility of disturbance of the breeding schools if the extension of the season led to whaling at that time and proposed to consider the question further at its next sperm whale special meeting. The Commission accepted the Technical Committee's recommendation to delete 'one continuous open season' from paragraph 2 (c) of the Schedule and insert 'an open season or seasons' and delete from paragraph 3 (c) 'such period of eight months to include the whole of the period of six months declared for baleen whales, except minke whales, as provided for in sub-paragraph (b) of this paragraph'.

10. DEFINITION OF MILK-FILLED WHALES

In the reports from some of the observers appointed under the International Observer Scheme reference was made to the difficulty of catcher crews in identifying milk-filled or lactating whales the taking of which is penalised under paragraph 20 of the Schedule. This problem was referred to the Scientific Committee whose recommendations for amendments to the Schedule were referred by the Technical Committee to a Working Group. The latter's proposals were accepted by the Committee and adopted by the Commission. They included definitions of lactating whales for inclusion in the Schedule and a number of associated amendments. They are set out in detail in the Appendix to this Report.

11. SMALL CETACEANS

The Commission was informed that the copies of the printed Report of the Sub-Committee of the Scientific Committee on Small Cetaceans which was being published by the Fisheries Research Board of Canada would be available very shortly. The Commissioner for Canada reported that the cost of publication amounted to about 30,000 dollars towards which contributions of 5,000 dollars each had been received from Canada, Norway and the USA and 1,000 Australian dollars from Australia. The Commission agreed to contribute £1,200 towards the cost of publication.

In its report the Scientific Committee made recommendations for future action. It recommended that the Commission considers initially the management of those small cetaceans which are taken in deliberate, direct fisheries. It listed the species taken in fisheries where the cetacean is the desired product and where there is a need for stock assessment. It recommended that all member nations report incidental kills of cetaceans taken in yellow fin purse seine operations as well as any other statistics for direct and indirect fisheries for small cetaceans. The sub-committee is to continue as a standing sub-committee of the Scientific Committee.

12. FAO/ACMRR WORKING PARTY ON MARINE MAMMALS

The Scientific Committee reported that it had adopted the report of its sub-committee which it had set up to consider questions raised in the document on the activities of this Working Party which had been circulated at the last meeting. Dr Holt (FAO) reported on the current position in the work of the four working groups of the Working Party and outlined the plans for a world meeting to be held in Bergen in September 1976 to which will be invited a wide group of marine mammal biologists and others interested in the scientific problems of marine living resources.

13. INTERNATIONAL DECADE OF CETACEAN RESEARCH

The Chairman of the Scientific Committee reported last year that sub-committees had been set up to prepare research proposals. The Scientific Committee considered these at its meeting at La Jolla in December 1974 and they were set out in the annexes of the report of that meeting which had been circulated to Commissioners. The Chairman of the Commission said that he had sent copies of the report to FAO and the United Nations Environment Programme with invitations to attend a meeting to discuss the proposals. UNEP had been unable to send a representative and the observer from UNEP (Dr Curry-Lindahl) said that there had been delay in receiving the report. He did not think that UNEP would wish to say what support it could give to the research programme until it had received the proposals that were to be put forward by the FAO/ACMRR Working Party. The Commission adopted the following resolution proposed by the United States Commissioner:

> *Remembering* that the UN Conference on the Human Environment, Stockholm, 1972, pointed out the necessity of increased whale research;
>
> *Considering* the recommendation of the 24th Meeting of the International Whaling Commission (IWC) in 1972 established the International Decade of Cetacean Research (IDCR);
>
> *Recognising* the decision of the Governing Council of the United Nations Environment Program (UNEP) in May 1975 requesting the Executive Director to support research on whales and small cetaceans; and
>
> After examining the report of the Scientific Committee meeting in La Jolla in December 1974 which sets out priority areas of research for the IDCR;
>
> THE INTERNATIONAL WHALING COMMISSION
>
> *Recommends* that member nations give assistance through vessels, personnel or additional funds as contributions to any part of the IDCR proposals but particularly, in the areas of stock monitoring and stock identification in the Southern Hemisphere; and
>
> *Decides* to indicate to UNEP that its assistance would be most useful in aiding IWC member nations in stock monitoring and stock identification cruises in the Southern Hemisphere.

14. HUMANE KILLING OF WHALES

This subject was introduced by the United States Commissioner and referred for the consideration of the Scientific Committee. The matter had been raised because in the years since the Report of the IWC Working Party 1960 there may have been new developments in anaesthetic or other chemicals, or in explosives which may have an application in killing whales, and also because it was necessary to have continuing information on the efficiency of the explosive harpoon technique. The Committee had available the conclusion of the Survival Service Commission Whale Specialist Group of the International Union for the Conservation of Nature that the explosive harpoon technique when used by expert whaling gunners was still the best available for killing large whales in as short a time as possible. In accepting this conclusion the Committee recommended that the Commission should make enquiries about possible new developments in chemicals and explosives suitable for killing whales and examine ways of improving the efficiency of existing methods, including the killing of small whales where explosive cannot be used, and the training of gunners. This was accepted by the Commission on the recommendation of the Technical Committee.

15. WHALE MARKING PROGRAMME

The Scientific Committee recommended the continuation of the co-ordination of the whale marking programme by the Institute of Oceanographic Sciences and after examining the expenditure incurred by the IOS during the last three years recommended the Commission to increase its contribution in support of the programme to £2,000 with a minimum of £1,500. After consideration by the Finance and Administration Committee the Commission approved a contribution of £2,000 in the current year.

16. SCIENTIFIC DATA COLLECTION

The Scientific Committee recommended that pending the appointment of the permanent Secretary the Commission should appoint, preferably under contract, a suitably qualified person to undertake before the next meeting

(a) provision of a master set of data in a convenient form
(b) routine re-running of computer programmes with updated data or using alternative sets of parameter estimates.

On being informed by the Chairman of the Finance and Administration Committee that funds within an estimate of £7,500 could be made available for the purpose, the Commission adopted the recommendation.

17. PUBLICATION OF THE SCIENTIFIC COMMITTEE'S REPORT

The Scientific Committee recommended that the Committee's report with documents and reports considered at its meeting and the report of the La Jolla meeting should be published in scientific journal format separately from the Annual Report of the Commission possibly on a subscription basis. For the long term the Committee considered it desirable that the Secretary to the Commission should coordinate the editing of the proposed journal, with a review board of competent persons assisting in the preparation of the documents. The Commission on being informed by the Chairman of the Finance and Administration Committee that £3,000 could be made available agreed that the reports should be published separately from the Commission's report.

18. INTERNATIONAL OBSERVER SCHEME SUMMARY OF REPORTS

Infractions

A sub-committee of the Technical Committee was appointed to examine these reports. It reported that the position revealed by the observers was satisfactory and agreed that the Observer Scheme had been implemented smoothly and had been of great assistance to all countries concerned, minimising misunderstandings some of which had been covered by changes in the Schedule.

On infractions, the sub-committee reviewed the individual infractions with the observers' reports. It found the situation satisfactory and did not make any recommendation to the Technical Committee. The Committee noted the position with regard to lactating whale infractions which could be expected to be remedied by the amendments to the Schedule accepted at this meeting to deal with the problem.

19. IMPLEMENTATION OF PROPOSALS FOR STRENGTHENING THE SECRETARIAT

The Chairman informed the Commission that the procedure for the selection of a full-time Secretary as discussed at the last meeting had been followed. Thirty-two applications had been received and screened by the Chairman, the Secretary and representatives of the Ministry of Agriculture, Fisheries and Food – scientific and administrative. A short list of six had been prepared. Copies of their application papers had been circulated at a meeting of the Selection Panel under the Chairman comprising representatives of Argentina, Australia, also representing the Chairman of the Scientific Committee, Japan, USSR, UK and USA. A unanimous choice could not be achieved by correspondence and the candidate selected at a further meeting of the Panel did not accept the appointment.

The Commission reviewed the short list and decided that the post should be re-advertised with a salary range of £10,000 to £12,000. The aim should be to have the full-time Secretary in post by the early spring.

The Chairman reported that the draft agreement between the United Kingdom Foreign and Commonwealth Office to provide immunities and privileges for the Commission and its staff had been completed and would shortly be ready for signature when it would become operative.

It was reported that arrangements had been made with the Natural Environment Research Council for the new Secretariat to be accommodated in the building at Cambridge occupied by the British Antarctic Survey. On the recommendation of the Finance and Administration Committee the Commission approved the amendment of Rule XVII of its Rules of Procedure which provides that the office of the Commission shall be in London by the deletion of 'London' and insertion of 'United Kingdom'.

20. FINANCE

The Report of the Finance and Administration Committee was presented to the Commission.

(a) Statement of Income and Expenditure 1974–75

Expenditure had been estimated to amount to £28,200 based on the expectation that the existing Secretariat might continue until 31 December 1974 and the re-organised full-time Secretariat would become established on 1 January 1975. The appointment of the full-time Secretary was not effected during the year and expenditure amounted to £12,377 compared with £7,356 in the previous year. In addition to the increases approved at the previous meeting and expenditure incurred in special meetings and the selection of candidates for the post of Secretary, there were significant increases due to rising costs under all heads. The statement was accepted on the recommendation of the Finance and Administration Committee.

(b) Budget for 1975–76

In determining the budget the Committee took into account the decision of the Commission to re-advertise the post of full-time Secretary with the object of making the appointment by the early spring. In considering provision for the continuation of the present Secretariat, account had to be taken of the continuing rise in costs and the full effect of recent increases in the charges for staff and services of the Ministry of Agriculture, Fisheries and Food and in the cost of printing, postages etc. The Committee considered that the salary of the present part-time Secretary should be increased to £2,000 having regard to the rise in comparable salaries in the United Kingdom and the additional work he would be required to undertake as proposals related to the strengthening of the Secretariat were implemented during the year. There was an estimated accumulated balance of £19,503 at the end of 1974–75 but the Committee decided that the contributions from Contracting Governments should be assessed to provide the same income in 1975–76 – £28,200 having regard to the proposals for other expenditure during the year now before the Commission. In addition to the proposal made to the Committee that the Commission should make a contribution of £1,200 towards the cost of the Report of the Scientific Committee on Small Cetaceans there were proposals for the increase of the contribution to the Whale Marking Programme, for contracting out work on statistical assessments and for the report of the Scientific Committee and other papers to be published separately from the Commission's Annual Report. The Committee recommended that this additional expenditure should be met from the accumulated balance from which a sum should also be transferred for the establishment of a working capital account as provided in the revised Financial Regulations leaving a balance in hand at the end of the year of about £3,000. The Commission accepted the Committee's budget recommendations.

The Committee considered the possibility of proposing changes in the formula for assessing the contributions of Contracting Governments. One of the suggestions discussed was that the percentage derived from countries with an historical interest in the whaling areas should be increased from 25% to 35% and the percentage based on the catches in the previous season reduced from 25% to 15% and that in addition to their mandatory areas, countries should be given the opportunity of voluntarily adding other areas for the basis of their contributions. The Commission accepted the Committee's suggestion that this was a matter that might be more fully considered at the 28th Meeting and that for the current year contributions should be assessed on the basis approved for 1974–75.

(c) Other Financial Matters

The Commission adopted the Committee's recommendation that when the permanent Secretariat is established those officers authorised to make payments should be bonded against the loss or fraudulent loss of funds.

Rule (2) of the Financial Regulations provides that they shall become effective as from a date decided by the Commission. Approval was given at the last meeting of the Commission to a substantial revision of the Regulations to relate them to the strengthened Secretariat. The Commission approved the Committee's recommendation that the revised Regulations shall become effective as from the date that the permanent Secretary takes up his post.

(d) Place and Date of Next Meeting

The next meeting will be held in London since no invitation had been received for the Commission to hold its meeting elsewhere. The Commission approved the Committee's recommendation that it should be held during the week beginning 21 June 1976.

21. REPORT OF THE WORKING PARTY ON AMENDMENTS TO THE CONVENTION

The report was received. The Commissioner for Canada thought that the conclusion that it would be inadvisable to attempt a revision of Article I before decisions which would be related to whales had been reached at the Law of the Sea Conference was too pessimistic. He suggested that the Working Party's proposals for amending the Convention should be sent to all Contracting Governments for comment and then to other whaling countries. While there was general agreement that they should be sent to other Contracting Governments objections were expressed about their being sent to other Governments until the Commission had reached its own conclusions on them. It was agreed that the proposals should be sent to Contracting Governments and their comments recorded and in the light of these the Chairman would consider what action should next be taken.

22. PARTICIPATION OF NON-MEMBER WHALING NATIONS

The Chairman reported that in accordance with the resolution passed at the previous meeting he had written again to the Secretary General of the United Nations and the Executive Director of the United Nations Environment Programme, to address those nations engaged in whaling activities that are not members of the Commission requesting that they adhere to the Convention. He had had acknowledgements of his letters but had received no further information from either organisation. The Chairman said that he had taken the opportunity of discussing the possibility of Portugal participating with Dr M. Ruivo, Secretary of State for Fisheries when attending the FAO COFI meeting and this had been followed up in correspondence. He had also written to the Ambassador for South Korea in London and his invitation to his being represented by an observer at this meeting had been accepted.

Dr Curry-Lindahl said that there had been some delay in UNEP taking action because of misunderstanding in communication but he was able to report that an approach had been made to those countries but no replies had so far been received.

The Chairman was urged to continue with his efforts to obtain the adherence of other nations and the Commissioner for the United States stressed the importance of persuading non-whaling non-member countries to join the Commission and suggested that the subject should be placed on the agenda for the next meeting.

23. TWENTY-SIXTH ANNUAL REPORT

The Commission approved the draft of the report subject to its completion as certain of the statistical details that were still required became available.

24. MEETING OF THE SCIENTIFIC COMMITTEE

The following proposed meetings were reported by the Chairman of the Committee:

(a) A Working Group on North Atlantic whales
(b) A Sperm whale meeting
(c) A Workshop on odontocete reproduction by the Small Cetaceans Sub-Committee and a meeting of the Sub-Committee just before the next meeting of the Committee
(d) The next meeting of the Scientific Committee ten days before the Commission's next meeting.

25. ELECTION OF CHAIRMAN AND VICE-CHAIRMAN

In accordance with the Commission's Rules of Procedure, the Chairman, Mr I. Rindal, the Commissioner for Norway retired on completion of three years in that office. On the proposition of the Commissioner for Iceland seconded by the Commissioner for Denmark, Mr A. G. Bollen, the Commissioner for Australia was unanimously elected Chairman for the ensuing three years. On the proposition of the Commissioner for Canada seconded by the Commissioner for Australia, Mr Rindal was unanimously elected Vice-Chairman for the coming year.

26. CONSTITUTION OF COMMITTEES

Technical Committee

All member nations. Mr A. G. Bollen (Australia) was elected Chairman.

Scientific Committee

Australia, Brazil, Canada, Denmark, France, Iceland, Japan, Norway, South Africa, USSR, UK and USA. Observers from FAO attended. Dr K. R. Allen (Australia) was elected Chairman.

Finance and Administration Committee

Canada, Iceland, Japan, USA and USSR. Mr Gould (USA) was elected Chairman.

27. AMENDMENTS TO THE SCHEDULE

A list of the amendments to the Schedule made by the Commission at its meeting is contained in the Appendix to this report.

I. RINDAL
Chairman

Appendix

AMENDMENTS TO THE SCHEDULE OF THE INTERNATIONAL WHALING CONVENTION 1946 APPROVED BY THE COMMISSION AT THE 27TH MEETING

Paragraph 1 Add the following at end of paragraph:

'"lactating whale" means (a) with respect to baleen whales – a female which has any milk present in a mammary gland (b) with respect to sperm whales – a female which has milk present in a mammary gland the maximum thickness (depth) of which is 10 cm or more. This measurement shall be at the mid ventral point of the mammary gland perpendicular to the body axis, and shall be logged to the nearest centimetre; that is to say, any gland between 9.5 cm and 10.5 cm shall be logged as 10 cm. The measurement of any gland which falls on an exact 0.5 centimetre shall be logged at the next 0.5 centimetre, e.g. 10.5 cm shall be logged as 11.0 cm.

However, notwithstanding these criteria, a whale shall not be considered a lactating whale if scientific (histological or other biological) evidence is presented to the appropriate national authority establishing that the whale could not at that point in its physical cycle have had a calf dependent on it for milk.'

Paragraph 2 (c)

Line 2. Delete 'one continuous open season'
Insert 'an open season or seasons'

Paragraph 3 (c)

Lines 5 and 6. Delete

'such period of eight months to include the whole of the period of six months declared for baleen whales, except minke whales, as provided for in sub-paragraph (b) of this paragraph.'

Section III Capture

Delete 'Prohibitions and areas'

Delete paragraphs 5, 6 and 7. Amend to read as follows:

'Classification of Areas and Divisions

5. In paragraphs 6 and 11, areas in the Southern Hemisphere are those waters between the ice edge and 40° South Latitude and lying between the following parallels of longitude, except that for sei and Bryde's whales combined and minke whales they shall extend to the equator:

Area I	120°W – 60°W
Area II	60°W – 0
Area III	0 – 70°E
Area IV	70°E – 130°E
Area V	130°E – 170°W
Area VI	170°W – 120°W

In paragraphs 6 and 15, divisions relating to the catch limits for Southern Hemisphere sperm whales are those waters lying between the ice edge and the equator and between the following parallels of longitude:

Division 1	60°W – 30°W
Division 2	30°W – 20°E
Division 3	20°E – 60°E
Division 4	60°E – 90°E
Division 5	90°E – 130°E
Division 6	130°E – 160°E
Division 7	160°E – 170°W
Division 8	170°W – 100°W
Division 9	100°W – 60°W

6. Classification of Stocks

All stocks of whales shall be classified in one of three categories according to the advice of the Scientific Committee as follows:

(a) A Sustained Management Stock is a stock which is not more than 10 per cent of Maximum Sustainable Yield (hereinafter referred to as MSY) stock level below MSY stock level, and not more than 20 per cent above that level; MSY being determined on the basis of the number of whales:

When a stock has remained at a stable level for a considerable period under a regime of approximately constant catches, it shall be classified as Sustained Management Stock in the absence of any positive evidence that it should be otherwise classified.

Commercial whaling shall be permitted on Sustained Management Stocks according to the advice of the Scientific Committee.

For the 1975–76 pelagic season and 1976 coastal season in the Southern Hemisphere and for the 1976 season in all other areas for stocks between the MSY stock level and 10 per cent below that level, the permitted catch, except for sei whales and Bryde's whales combined in the Southern Hemisphere, shall not exceed the number of whales obtained by taking 90 per cent of the MSY and reducing that number by 10 per cent for every one per cent by which the stock falls short of the MSY stock level. For stocks at or above the MSY stock level, the permitted catch shall not exceed 90 per cent of the MSY.

For sei and Bryde's whales combined in the Southern Hemisphere for the 1975–76 pelagic season and the 1976 coastal season the permitted catch of Sustained Management Stocks below the MSY stock level shall not exceed the number of whales obtained by taking 90 per cent of the MSY and reducing that number by five per cent for every one per cent by which the stock at the beginning of the sustained management period falls short of the MSY stock level.

The following stocks are classified as Sustained Management Stocks for the 1975–76 pelagic season and the 1976 coastal season in the Southern Hemisphere and for the 1976 season in all other areas:

Fin whales	Southern Hemisphere Area I
Fin whales	North Atlantic (Iceland Stock)
Fin whales	North Atlantic (Newfoundland Stock)
Sei and Bryde's whales combined	Southern Hemisphere Areas I, II, IV, V, VI
Minke whales	Southern Hemisphere Area IV, North Atlantic (Stock East of Cape Farewell, Greenland)
Sperm whales–males	Southern Hemisphere Divisions 1, 2, 3, 4, 7 and 9
Sperm whales–females	Southern Hemisphere Divisions 3, 4, 7 and 9

(b) An Initial Management Stock is a stock more than 20 per cent of MSY stock level above MSY stock level. Commercial whaling shall be permitted on Initial Management Stocks according to the advice of the Scientific Committee as to measures necessary to bring the stocks to the MSY stock level and than optimum level in an efficient manner and without risk of reducing them below this level. The permitted catch for such stocks will not be more than 90 per cent of MSY as far as this is known, or, where it will be more appropriate, catching effort shall be limited to that which will take 90 per cent of MSY in a stock at MSY stock level.

In the absence of any positive evidence that a continuing higher percentage will not reduce the stock below the MSY stock level no more than five per cent of the estimated initial exploitable stock shall be taken in any one year. Exploitation should not commence until an estimate of stock size has been obtained which is satisfactory in the view of the Scientific Committee.

The following stocks are classified as Initial Management Stocks for the 1975–76 pelagic season and the 1976 coastal season in the Southern Hemisphere and for the 1976 season in all other areas:

Minke whales	Southern Hemisphere Areas I, II, III, V, VI
Minke whales	North Atlantic (Stock West of Cape Farewell, Greenland)
Bryde's whales	North Pacific
Sperm whales–males	Southern Hemisphere Divisions 5 and 8
Sperm whales–females	Southern Hemisphere Divisions 1, 2, 5, 6 and 8
Sperm whales–males	North Pacific
Sperm whales–females	North Pacific

(c) A Protection Stock is a stock which is below 10 per cent of MSY stock level below MSY stock level.

There shall be no commercial whaling on species or stocks whilst they are classified as Protection Stocks. The following stocks are classified as Protection Stocks for the 1975–76 pelagic season and 1976 coastal season in the Southern Hemisphere and for the 1976 season in all other areas:

Blue whales	All Oceans
Humpback whales	All Oceans
Right whales	All Oceans
Gray whales	All Oceans
Fin whales	Southern Hemisphere Areas II, III, IV, V, VI
Fin whales	North Pacific
Fin whales	North Atlantic (Faroes and West Norway Stock)
Fin whales	North Atlantic (Nova Scotia Stock)
Sei whales	Southern Hemisphere Area III
Sei whales	North Pacific
Sperm whales–males	Southern Hemisphere Division 6

7. Notwithstanding the provisions of paragraph 6 the taking of 10 humpback whales not below 35 feet (10.7 metres) in length, per year is permitted in Greenland Waters provided that whale catchers of less than 50 gross register tonnage are used for this purpose and the taking of gray or right whales by aborigines or a Contracting Government on behalf of aborigines is permitted but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines.'

Paragraph 8 Amend to read as follows:

'It is forbidden to take or kill suckling calves or female whales accompanied by calves.'

Paragraph 11 Amend to read as follows:

'The number of fin whales taken during the open season in waters south of 40° South Latitude by factory ships or whale catchers attached thereto under the jurisdiction of the Contracting Governments shall not exceed 220 in 1975–76. The taking of fin whales shall cease not later than 30 June 1976. The number of other species of baleen whales taken during the open season in the Southern Hemisphere by factory ships, land stations or whale catchers attached thereto under the jurisdiction of the Contracting Governments shall not exceed 2,230 sei and Bryde's whales combined and 6,810 minke whales in the 1975–76 pelagic season and the 1976 coastal season. The total catches taken in any of the Areas I to VI shall not exceed the limits shown below. However, in no circumstances shall the sum of the area catches exceed the total quotas for each species:

	Fin	Sei and Bryde's whales combined	Minke
Area I	220	198	1,200
Area II	0	567	2,160
Area III	0	0	2,400
Area IV	0	671	891
Area V	0	693	840
Area VI	0	297	600'

Paragraph 12 Amend to read as follows:

'The number of whales taken in the North Pacific Ocean and dependent waters in 1976 shall not exceed the following limits:

Sperm whales – males	5,200
Sperm whales – females	3,100
Bryde's whales	1,363'

Paragraph 13 Amend to read as follows:

'The number of fin and minke whales taken in the North Atlantic Ocean in 1976 shall not exceed the following limits:

Fin whales – Newfoundland waters	90
Fin whales – Iceland waters	275
Minke whales – East of Cape Farewell	2,000
Minke whales – West of Cape Farewell	550'

Paragraph 14 Delete provisions.

Paragraph 15 Amend as follows:

Line 1	Delete '1974–75'	Insert '1975–76'
Line 2	Delete '1975'	Insert '1976'
	Delete '8,000'	Insert '5,870'
	Delete '5,000'	Insert '4,870'
Line 3	Delete 'Areas I to VI'	Insert 'Divisions 1 to 9'

Lines 6–9 inclusive. Delete and insert the following:

	Male	Female
'Divisions 3 and 4	1,562	1,368
Division 5	1,080	756
Division 6	0	324
Division 7	495	396
Division 8	1,512	972
Divisions 9, 1 and 2	2,024	1,992'

Paragraph 17 Amend to read as follows:

'(a) It is forbidden to use a factory ship or a land station for the purpose of treating any whales (whether or not taken by whale catchers under the jurisdiction of a Contracting Government) which are classified as Protection Stocks in paragraph 6 or are taken by whale catchers under the jurisdiction of a Contracting Government in contravention of paragraphs 2, 3, 9, 11, 12, 13 and 15 of this Schedule.'

Paragraph 20 Amend last sentence to read:

'No bonus or other remuneration shall be paid to the gunners or crews of whale catchers in respect of the taking of lactating whales.'

Paragraph 22 Amend (b) (4) to read:

'If female, whether lactating.'

International Whaling Commission Report 1975–76

1. This report relates to the Twenty-seventh Meeting of the Commission held in London from 23 to 27 June 1975 under the Chairmanship of Mr I. Rindal (Norway) and subsequent developments during the year ended 31 May 1976. The report of the meeting of the Commission will be found in pp. 6–15 and in order to avoid duplication the proceedings are dealt with only briefly in this report or in recording subsequent developments.

The details of the catches of whales contained in the report relate to the 1975–76 season in the Antarctic and to the calendar year 1975 on grounds outside the Antarctic.

CLASSIFICATION OF STOCKS

2. At the Twenty-seventh meeting the Commission made an important change in its measures for the management of the whale stocks. As recorded in the Twenty-sixth Report the Commission decided to classify the whale stocks into three categories and provide for their individual management. The categories were (a) Initial Management Stocks, (b) Sustained Management Stocks and (c) Protection Stocks, and the Scientific Committee was asked to advise on the criteria for defining them and the allocation of stocks to them. The definitions accorded to each of the three categories and the classification of the stocks with them, which were based on the recommendations of the Committee, are given in the Chairman's Report of the 27th Meeting, paragraph 7. All the significant whale stocks exploited by the member countries were classified. As a result all stocks which are estimated to be below 10% of the level estimated to give the maximum sustainable yield are now fully protected and the taking of whales from stocks approaching that level fully controlled. Thus, Protection Stocks include not only those species the taking of which was already prohibited by the Commission's regulations but stocks of other species in individual whaling grounds. Through classifying the stocks by smaller areas it will be possible to identify and manage more readily individual stocks by their standing in relation to their estimated maximum sustainable yield levels.

CATCH LIMITS – SOUTHERN HEMISPHERE BALEEN WHALES

3. Hitherto the catch limits for baleen whales in the Southern Hemisphere have been set for the Antarctic, i.e. south of 40° South, divided into six Areas (see Maps on pp. 521–522). With the classification of stocks, those Areas were, with the exception of Area I, extended to the equator. No change was made to the prohibition of the use of factory ships for the taking of baleen whales north of 40° South. For the 1975–76 season, the Commission limited the catch of fin whales to 220 all to be taken in Area I. For the 1975–76 pelagic season and the 1976 coastal season, the catch limit for sei and Bryde's whales combined was 2,230 and for minke whales 6,810. The following table shows the limits set for each of the six Areas, the sum of the catches not to exceed the total limits:

	Sei and Bryde's	*Minke*
Area I	198	1,200
Area II	567	2,160
Area III	0	2,400
Area IV	671	891
Area V	693	840
Area VI	297	600

These limits represented a reduction over the previous year of 780 fin whales, 1,770 sei and Bryde's whales and 190 minke whales.

THE 1975–76 SOUTHERN HEMISPHERE PELAGIC CATCH

4. The season opened on 12 December 1975 and closed on 7 April 1976. Five expeditions operated in the Antarctic, three from Japan and two from the USSR, compared with seven expeditions in 1974–75. The number of catcher boats operating in the 1975–76 season was 56 compared with 75 in 1974–75. These were distributed as follows:

	1975–76	1974–75
Japan	23	30
USSR	33	45
	56	75

The following table shows the catch by species in 1975–76, the comparative catch in the 1974–75 season being shown in brackets:

	Fin	*Sei and Bryde's*	*Minke*
Japan	118 (598)	1,315 (2,251)	3,017 (3,500)
USSR	88 (381)	505 (1,608)	3,017 (3,500)
Total	206 (979)	1,820 (3,859)	6,034 (7,000)

The distribution of the catch by geographical areas with comparative figures for 1974–75 was:

	Fin	*Sei and Bryde's*	*Minke*
Area I (120°W – 60°W)	206 (228)	198 (1,027)	1,045 (1,870)
Area II (60°W – 0°)	– (53)	515 (4)	1,164 (806)
Area III (0° – 70°E)	– (168)	– (93)	2,154 (1,359)
Area IV (70°E – 130°E)	– (248)	467 (1,071)	881 (2,231)
Area V (130°E – 170°W)	– (166)	393 (507)	631 (734)
Area VI (170°W – 120°W)	– (116)	249 (1,157)	159 (–)
	206 (979)	1,820 (3,859)	6,034 (7,000)

The oil output for the 1975–76 pelagic season, excluding sperm oil, was 63,547 barrels. Oil production in the previous season amounted to 140,312 barrels. The average catch per catcher's day's work by pelagic expeditions was 0.04 for fin whales and 0.33 for sei whales compared with 0.13 and 0.50 respectively in 1974–75.

The average fin whale size was 65.9 feet compared with 66.0 feet in 1974–75 and the average length of sei whales 47.8 feet, the same as in 1974–75. The average sperm whale size was 45.0 feet compared with 42.8 feet in the preceding season and the average size of minke whales was 27.8 feet the same as in the previous season.

SOUTHERN HEMISPHERE – SPERM WHALE CATCH

5. At its Twenty-sixth Meeting the Commission set limits of 8,000 male and 5,000 female sperm whales to be taken in the 1974–75 pelagic season and 1975 coastal season in the Southern Hemisphere. As in the previous year, the catches were related to stock units with limits for each of three major regions bringing together as far as possible the areas in which the stocks were in similar conditions, as follows. It will be seen that some flexibility was allowed in the numbers that could be taken between the areas but in no circumstances could the sum of the area catches exceed the total quotas.

		Male	Female
Areas II and III	60°W – 70°E	2,548	2,563
Areas IV and V	70°E – 170°W	2,730	2,188
Areas VI and I	170°W – 60°W	3,822	1,500

The catch was as follows:

	Male	Female
Areas II and III	2,302	2,319
Areas IV and V	2,403	1,908
Areas VI and I	2,392	510
	7,097	4,737

Of the total catch 5,528 males and 3,402 females were taken in the pelagic season both north and south of 40° South and 1,569 males and 1,335 females were taken by the land stations. The corresponding figures for the previous season are 5,165, 3,149, 1,512 and 1,348 respectively.

Production of sperm oil amounted to 291,057 barrels from the pelagic expeditions north and south of 40°S and 70,311 barrels from the land stations. The comparative figures for the previous year were 268,937 and 72,855 barrels respectively.

At the Twenty-seventh Meeting the total limits set for the 1975–76 pelagic season and the 1976 coastal season were 5,870 males and 4,870 females and were further divided into Divisions as follows, the sum of the catch in Divisions not to exceed the total limits:

		Male	Female
Divisions 3 and 4	20°E – 90°E	1,562	1,368
Division 5	90°E – 130°E	1,080	756
Division 6	130°E – 160°E	0	324
Division 7	160°E – 170°W	495	396
Division 8	170°W – 100°W	1,512	972
Divisions 9, 1 and 2	100°W – 20°E	2,024	1,992

NORTH PACIFIC CATCH

6. The catch limits prescribed in the Schedule for the 1975 season in the North Pacific Ocean were 300 fin whales, 2,000 sei and Bryde's whales and 10,000 sperm whales (6,000 male and 4,000 female). The catches for 1975 were as follows (1974 catches in brackets):

			Sperm	
	Fin	*Sei/Bryde's*	*Males*	*Females*
Japan	129 (238)	1,288 (1,947)	2,493 (2,536)	1,616 (1,628)
USSR	33 (173)	633 (696)	1,768 (1,883)	1,982 (2,080)
Total	162 (411)	1,921 (2,643)	4,261 (4,419)	3,598 (3,708)

The whale stocks in this area were reviewed at the Twenty-seventh Meeting. On the recommendation of the Scientific Committee, fin whales and sei whales were classified as Protection Stocks and the catch limit for 1976 for Bryde's whales was set at 1,363 and for sperm whales the limit was fixed at 8,300 (5,200 male and 3,100 female).

NORTH ATLANTIC CATCH

7. The Commission has not previously set catch limits for the North Atlantic, insufficient data being available to enable firm assessments of the stocks to be made. The Scientific Committee recommended that catches for the 1976 season should be held at the levels of recent seasons and the Commission set the following limits for that area:

Fin whales	–	Newfoundland waters	90
Fin whales	–	Iceland waters	275
Minke whales	–	East of Cape Farewell	2,000
Minke whales	–	West of Cape Farewell	550

INTERNATIONAL OBSERVER SCHEME

8. Observers nominated by member countries who were parties to agreements reached under paragraph 19 (c) of the Schedule were appointed by the Commission for the 1975–76 and 1976 seasons as follows:

Southern Hemisphere	– pelagic	7
Southern Hemisphere	– coastal	3
North Pacific	– pelagic	5
North Pacific	– coastal	2
North Atlantic	– coastal	1

Reports by the Observers for the previous season were considered at the Twenty-seventh Meeting and the situation was found to be satisfactory. Some Observers reported that catcher crews had difficulty in identifying milk-filled or lactating whales and as a result the Schedule was amended to include appropriate definitions.

INFRACTIONS

9. The table on page 21 gives a summary of infractions of the Commission's regulations reported by contracting Governments in respect of the 1975–76 Antarctic season and the 1975 season in waters outside the Antarctic. A sub-committee of the Technical Committee is appointed to examine the infractions.

SCIENTIFIC COMMITTEE ACTIVITY

10. At its June meeting, the Scientific Committee reviewed the principles developed at the special meeting held in La Jolla, December 1974, concerning the classification of whale stocks. These basic principles were amended slightly before being submitted to the Commission for consideration and action. The criteria for defining Initial Management, Sustained Management and Protection Stocks were determined on the basis of the stock levels in relation to the level estimated to provide the maximum sustainable yield. The status of all whale stocks throughout the world were then reviewed and the various stocks classified from the best available evidence for the purposes of management according to the Commission's new procedure.

The Committee also noted the latest research and analyses being carried out not only on the great whales, but also on small cetaceans. Proposals for the collection of statistics from fisheries taking small cetacea either directly or indirectly were made with a view to proper management in the future. The report of the sub-committee on small cetaceans was published in the Journal of the Fisheries Research Board of Canada Volume 32 (7) 1975, the Commission making a contribution towards the costs of publication.

A technical definition of lactating (milk-filled) whales was prepared, and some preliminary consideration given to the problem of the humane killing of whales.

Rules of Procedure were adopted by the Committee, which define its membership and meetings, for endorsement by the Commission.

Two special meetings of the Scientific Committee were held during the year. A sperm whale meeting took place in La Jolla, California, in March 1976, which was charged with the task of carrying out stock assessments world-wide. The meeting explored the sensitivity of the assessment models to various vital rate parameters, derived estimates of the numbers of sperm whales in the Southern Hemisphere since 1946, and considered the changes in catch by weight as well as by number. A working group on North Atlantic whales met in Oslo in April 1976. Data on fin, minke and bottlenose whales were assembled and analysed in preliminary assessments.

INTERNATIONAL DECADE OF CETACEAN RESEARCH

11. The programme of research prepared by the Scientific Committee was accepted by the Commission. Member nations were asked to give assistance in the carrying out of the programme and the help of the United Nations Environment Programme has been sought.

HUMANE KILLING OF WHALES

12. At its Twenty-seventh Meeting the Commission accepted a recommendation of the Scientific Committee that it should make enquiries about possible new developments in chemicals and explosives suitable for killing whales and examine ways of improving the efficiency of existing methods including the killing of small whales where explosives cannot be used. These enquiries have been initiated and from the replies so far received there seems to have been little development since the matter was last considered by the Commission in 1959. Conclusions reached from investigations carried out in South Africa in 1973 however suggest that it is unlikely that death-times could be substantially reduced, at least for sperm whales, by any other method than explosive harpoon. Enquiries concerning the use of certain chemicals including one brought to the attention of the Commission, have been followed up. No experiments have been conducted in the use of these in the killing of whales and from the information available there appear to be considerable difficulties in the way of their being used for this purpose. The information collected is to be considered by the Scientific Committee.

ADHERENCE OF NON-MEMBER WHALING NATIONS

13. Efforts have continued during the year to interest other whaling nations in adhering to the Convention. Several have shown interest and are understood to be examining the position, including New Zealand who, although not now a whaling nation, was previously a member of the Commission.

CO-OPERATION WITH OTHER ORGANISATIONS

14. The Commission has been represented by an observer at meetings of other organisations including the FAO/ACMRR Working Party on Marine Mammals and at working groups which some members of the Scientific Committee attend. The Secretary attended a meeting of staff of regional fishery bodies organised by FAO.

STRENGTHENING THE SECRETARIAT

15. During the year the Commission has proceeded with the implementation of its proposals recorded in previous reports for strengthening the Secretariat. Dr R. Gambell, a whale biologist, was appointed as full-time Secretary to the Commission and took up his appointment on 1 May 1976. An Executive Officer, who will be responsible under the Secretary for all the executive work, including the management of accounts and office administration, has been appointed and will take up his appointment in June 1976. The clerical and typing staff will shortly be appointed.

As previously recorded, arrangements had been made for the Commission's office to be located with the British Antarctic Survey in Cambridge. Unfortunately, owing to the economic situation it has not been possible for the additional accommodation to be provided in the Survey's building and other offices in Cambridge are being sought. It is expected that the office will be set up in Cambridge by September 1976.

FINANCE

16. The Commission reviewed its financial position at the Twenty-seventh Meeting. It approved, subject to audit, the statement of income and expenditure for the financial year ended 31 May 1975. The audited statement was published as Appendix 4 of the Twenty-sixth Report. In considering the estimate of income and expenditure for the year ending 31 May 1976 the Commission expected that the Secretariat would continue in its existing form until the early spring when it was hoped that the full-time Secretary with supporting staff would be in post. The estimate reflected the continuing rise in costs due to inflation and included expenditure of a non-recurring nature on furniture and office equipment that would be incurred in setting-up the Commission's office. Expenditure was estimated to amount to £28,200. The Commission decided that this should be met

from the contributions of Contracting Governments and that, after meeting other items of expenditure approved by the Commission, a sum should be transferred from the Accumulated Balance for the establishment of a working capital account. The amount transferred was £10,000. The contributions of the Contracting Governments were calculated on the same basis as the previous year, i.e. a flat rate contribution to cover 50% of net expenditure the balance being met equally by contributions based on operated areas since 1954 and contributions based on catches in the previous year.

Expenditure for the year amounted to £22,187. As the newly appointed Secretary was in post for only the last month of the year and the Commission's office had not been set up, the capital expenditure budgeted for the period beginning 1 April was not incurred. Other expenditure was higher than estimated due to the continuing increase in costs. Income amounted to £28,200 which included the contributions of the Contracting Governments as estimated and £2,567 interest from the investment of the balance in hand which at the end of the year amounted to £18,326. A copy of the audited accounts for the year appears on pp. 20.

REVIEW OF THE INTERNATIONAL WHALING CONVENTION 1946

17. The Commission received a document setting out suggestions for amending the Convention prepared by a working group of representatives of member nations which had been asked to review the Convention in the light of the changes in whaling and the stocks, and the possible impact of the conclusions of the Law of the Sea Conference on the activities of the Commission. The Commission decided that the document should be sent to Contracting Governments for comments. A meeting of the working group will be held to consider the comments received before the Twenty-eighth Meeting of the Commission.

PERMIT TO TAKE WHALES FOR SCIENTIFIC PURPOSES

18. The Commission was informed by the Government of Japan that it had issued a special permit under Article VIII of the Convention for the taking for scientific research purpose of not more than 80 sperm whales from the North Pacific Ocean in order to prepare a special report to be submitted to a sperm whale meeting of the Scientific Committee.

NATIONAL QUOTAS

19. The Commission was informed of the following arrangements for the allocations of catches made between the countries concerned for the 1975–76 and 1976 pelagic and coastal seasons:

Southern Hemisphere

				Sperm	
	Fin	Sei/Bryde's	Minke	Male	Female
Australia	–	–	–	658	487
Brazil	–	4*	642*	18	49
Japan	132	1,331*	3,017*	878	665
South Africa	–	–	134	658	873
USSR	88	895*	3,017*	3,658	2,796

North Pacific

		Bryde's			
Japan	–	681	–	2,223	1,325
USSR	–	681	–	2,977	1,775

* Brazil, Japan and USSR were unable to agree on the method of allocating the national quotas. The figures given are the majority decision, without prejudice to future negotiations.

R. Gambell
Secretary to the Commission

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 MAY 1976

Previous Year £	*EXPENDITURE*	£	£
	Secretaries' Remunerations:–		
1,200.00	Salary (Mr. R. Stacey)	2,000.00	
88.62	Social Security Contributions	171.19	
	Salary (Dr. R. Gambell)	875.00	
	Social Security contributions	36.02	
			3,082.21
4,923.57	*Administration:* Charges of Ministry of Agriculture, Fisheries and Food and Exchequer and Audit Department	8,434.73	
1,622.26	*Appointment of Secretary* Advertising, Meetings of Selection Panel and Miscellaneous Expenses	532.86	
			8,967.59
908.88	*Stationery, Printing and Postage*		1,698.55
2,323.21	*Cost of Meeting* 27th Annual Meeting June 1975		3,510.49
1,000.00	*Whale Marking* Contribution to National Institute of Oceanography		2,000.00
–	Contribution to Scientific Assistance		1,099.47
55.98	*Cost of Special Meetings* Meeting of Working Group to review Convention	–	
–	Travelling and Subsistence	264.66	
16.68	Small Cetaceans Report, Contribution to Publication	1,200.00	
			1,464.66
–	*Contribution to Working Capital Fund*		10,000.00
–	*Commission's Contribution to Superannuation Fund*		175.00
–	*Miscellaneous Account*		
–	Staff Assessment (Secretary's Salary)		375.00
17,451.58	*Balance:* being excess of income over expenditure, transferred to Balance Sheet		–
£29,590.78			£32,372.97

Previous Year £	*INCOME*	£
28,201.00	*Contribution from 15 Contracting Governments for year 1975/76*	28,200.00
1,389.78	*Other Income* Interest on Investments	2,567.10
–	*Balance:* being excess of expenditure over income, transferred to Balance Sheet	1,605.87
£29,590.78		£32,372.97

BALANCE SHEET 31 MAY 1976

Previous Year £	*LIABILITIES*	£	£
	Creditors:		
2,048.51	Ministry of Agriculture, Fisheries and Food	1,800.49	
586.26	Others	1,705.17	
			3,505.66
	Contributions from Contracting Governments paid in advance		
1,745.00	USSR	–	
–	Mexico 1976/77	46.10	
–	Brazil 1976/77	13.00	
			59.10
	Miscellaneous Account		
–	Staff Assessment (Secretary's salary)		375.00
	Superannuation Account		
–	Secretary's Contribution	87.50	
–	Commission's Contribution	175.00	
			262.50
–	*Contribution to Working Capital Fund*		10,000.00
	Income and Expenditure Account:		
	Balance at 31 May 1975	19,745.94	
	LESS		
19,745.94	Balance transferred from 1975/76	1,605.87	
			18,140.07
£24,125.71			£32.342.33

Previous Year £	*ASSETS*	£	£
3,591.50	*Cash at Paymaster General*		2,325.79
2,496.82	*Outstanding contributions:* Argentina 1975/76		940.00
17,750.00	*Investment in Local Authority Loans*		27,750.00
	Sundry debtors:		
284.88	Accrued interest on Local Authority Loans	400.67	
–	VAT (recoverable)	925.87	
			1,326.54
2.51	Overpayment on Staff costs, recoverable		
£24,125.71			£32,342.33

I have examined the above Account and Balance Sheet. I have obtained all the information and explanations that I have required, and I certify, as the result of my audit, that in my opinion the above Account and Balance Sheet are correct.

RAY GAMBELL
Secretary, International Whaling Commission
22 November 1976

Exchequer and Audit Department,
8 March 1977.

D. O. HENLEY
Comptroller and Auditor General

SUMMARY OF INFRACTIONS

ANTARCTIC SEASON 1975–76

Type of whale	Total catch	Undersized whales		Lactating whales		Lost whales		Protected whales		Whales remaining in sea over 33 hrs		All infractions	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Baleen	2,027	16	0.79	8	0.39	2	0.10	–	–	–	–	26	1.28
Minke	6,034	–	–	–	–	–	–	–	–	–	–	–	–
Sperm	7,046	34	0.48	45	0.64	–	–	–	–	–	–	79	1.12
Total	15,107	50	0.56	53	0.35	2	0.01	–	–	–	–	105	0.69

OUTSIDE ANTARCTIC 1975

Type of whale	Total catch	Undersized whales		Lactating whales		Lost whales		Protected whales		Whales remaining in sea over 33 hrs		All infractions	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Baleen	2,476	38	1.53	12	0.48	–	–	–	–	–	–	50	2.02
Minke	839	–	–	13	1.55	–	–	–	–	–	–	13	1.55
Sperm	10,760	31	0.29	36	0.33	7	0.07	–	–	13	0.12	87	0.81
Total	14,075	69	0.49	61	0.43	7	0.05	–	–	13	0.09	150	1.06

Note: Baleen figures exclude Minke whales. No size restrictions applied to Minke whales.

Chairman's Report of the Twenty-Eighth Meeting

1. DATE AND PLACE

The Twenty-eighth Meeting of the Commission was held at the Waldorf Hotel, Aldwych, London from 21 to 25 June 1976. The proceedings were conducted by the Chairman of the Commission, Mr A. G. Bollen (Australia).

2. REPRESENTATION

Commissioners and delegates from fifteen of the sixteen member countries attended, including New Zealand, which had newly rejoined the Commission. Observers were present from the Governments of:

Chile
Netherlands
Peru
Portugal
Sweden

and the following organisations:

United Nations Food and Agriculture Organisation
United Nations Environment Programme

International Council for the Exploration of the Sea
International Union for the Conservation of Nature and Natural Resources
Fauna Preservation Society
Friends of the Earth
International Society for the Protection of Animals
Project Jonah
Sierra Club
World Confederation of Organisations of the Teaching Profession
World Federation for the Protection of Animals
World Wildlife Fund

3. ADDRESS OF WELCOME

An address of welcome on behalf of the United Kingdom government was given by Mr Edward Bishop MP, Minister of State, Ministry of Agriculture, Fisheries and Food. In welcoming the delegates Mr Bishop expressed the view that the progress represented by the new management policy adopted last year must now be consolidated. The United Kingdom, which had not caught any whales since 1962, had banned the import of the products of baleen whales, whose stocks are significantly reduced, and was being asked to prohibit the import of sperm whale products. There was a great upsurge of interest in and concern for whales by conservation groups and the general public which made it important that the Commission should make the most of its achievements by improving its public relations. The establishment of a new and permanent secretariat at Cambridge offered a new opportunity to this end, and Mr Bishop conveyed his best wishes to the Secretary and his staff. He concluded by wishing the Commission a successful week at the meeting, when it could demonstrate that it wished to conserve, control and manage the world's whale stocks in a wise and responsible manner.

4. STATEMENTS BY THE CHAIRMAN, COMMISSIONERS AND OBSERVERS

The Chairman, Mr Bollen (Australia), referring to the achievements of the Commission under his predecessor, Mr Rindal (Norway), commented that the adoption of the new management regime was the most critical decision in the Commission's history. Mr Bollen recorded his appreciation of the work of Commissioners who had retired in the last year and welcomed the new Commissioners to the meeting. He now saw the Commission's role as being to satisfy all concerned that the Commission had the will and capacity to ensure that the whale populations of the world are not endangered.

Statements indicating the views and positions of their Governments on subjects to be considered during the meeting were made by the Commissioners for Canada, Mexico, USSR, France, Brazil, USA and Japan; the Commissioner for New Zealand spoke on the return of his country to the Commission.

Statements were then made by the observers from the International organisations. Dr K. Curry-Lindahl for the United Nations Environment Programme included a resolution from UNEP's Governing Council which (a) expressed its satisfaction with recent advances in stock management; (b) urged increased efforts for appropriate controls of further exploitation of whales at the twenty-eighth session of the Commission; and (c) re-emphasised concern with the conservation of whales as a global renewable resource.

Mr L. K. Boerema for the Food and Agriculture Organisation of the United Nations mentioned the work of the FAO/ACMRR Working Party on Marine Mammals which had been reported to the Commission's Scientific Committee and which would be submitted to the Scientific Consultation on Mammals in the Sea to be held in Bergen in September.

Statements were also delivered by the conservations groups represented. Press representatives left the meeting at the end of these statements.

5. ADOPTION OF AGENDA

The Commission adopted the provisional agenda which had been circulated sixty days before the meeting in accordance with the Rules of Procedure.

6. CLASSIFICATION OF WHALE STOCKS AND THEIR MANAGEMENT

The three categories adopted by the Commission last year as the basis for the classification of whale stocks were reviewed.

(a) Sustained Management Stock

(i) The Scientific Committee had been asked to compare the alternative proposals for determining quotas put forward last year by the Scientific Committee and the Commissioner from the United Kingdom. They reported that the rate of rebuilding under the UK scheme was slightly faster than with the Scientific Committee's proposal, but noted that the risks resulting from errors of assessment are greater in the UK scheme.

The Technical Committee recommended by a majority vote that the UK scheme which provides an exception in paragraph 6 (a) of the Schedule for sei and Bryde's whales in the Southern Hemisphere should be deleted, and this was accepted by the Commission.

(ii) Iceland submitted a memorandum which set out the reasons for proposing a continuation of the long-standing effort limitation on her shore-based fishery. The Scientific Committee reviewed this document and preferred to set catch quotas as the safest approach to management. They suggested two possible quota systems and the Technical Committee recommended a six year block with the limit in any one year to be the average plus 50 whales. The Commission adopted this proposal.

(b) Initial Management Stock

No changes were adopted by the Commission but Japan pointed out that under the existing formula for calculating the permitted catch the stocks of male sperm whales in most Divisions of the Southern Hemisphere would take many years to be reduced to the Sustained Management category and in some Divisions would never reach that level. The matter was referred to the Scientific Committee for further study during the next year.

(c) Protection Stock

No changes were made.

The Commission accepted the recommendation of the Technical Committee for the following classification of the whale stocks proposed by the Scientific Committee for the 1976–77 Antarctic season and the 1977 season elsewhere:

Sustained Management Stocks

Fin whales	North Atlantic (East Greenland–Iceland stock)
Sei whales	Southern Hemisphere Areas I, II, IV, V, VI
Minke whales	North Pacific (Western stock)
Minke whales	North Atlantic (North American coast, East Greenland, East Atlantic stocks)
Sperm whales–males	Southern Hemisphere Divisions 3, 5
Sperm whales–females	Southern Hemisphere Divisions 2, 3, 6, 7
Sperm whales	North Atlantic

Initial Management Stocks

Fin whales	North Atlantic (Newfoundland–Labrador stock)
Bryde's whales	Southern Hemisphere all Areas
Bryde's whales	North Pacific
Minke whales	Southern Hemisphere all Areas
Minke whales	North Pacific (Except the Western stock)
Sperm whales–males	Southern Hemisphere Divisions 1, 2, 4, 6, 8
Sperm whales–females	Southern Hemisphere Divisions 1, 5, 8
Sperm whales–males	North Pacific
Sperm whales–females	North Pacific

The Scientific Committee will be asked to classify the North Pacific sperm whales by suitable sub-units in future years to prevent excessive catches being taken from small areas.

Protection Stocks

Blue whales	All oceans
Humpback whales	All oceans
Right whales	All oceans
Gray whales	All oceans
Fin whales	Southern Hemisphere all Areas
Fin whales	North Pacific
Fin whales	North Atlantic (West Norway –Faroe, Nova Scotia stocks)
Sei whales	Southern Hemisphere Area III
Sei whales	North Pacific
Sei whales	North Atlantic (Nova Scotia stock)
Sperm whales–male	Southern Hemisphere Divisions 7, 9
Sperm whales–females	Southern Hemisphere Divisions 4, 9

The Scientific Committee had been unable to place some stocks into any of the three management categories shown above because the stocks were too poorly documented for their status to be assessed. The Commission therefore decided that the following stocks should be provisionally listed as Sustained Management Stocks for 1977, pending the accumulation of sufficient information for classification:

Fin whales	North Atlantic (North Norway, Spain-Portugal-British Isles stocks)
Sei whales	North Atlantic (Iceland–Denmark Strait stock)
Minke whales	North Atlantic (West Greenland stock)

The necessary amendments to the Schedule to incorporate all these classifications were approved by the Commission.

7. CATCH LIMITS

Following the classification of the whale stocks into the three management catagories, the Commission approved the appropriate quotas which necessitate amendment of the Schedule as follows:

(a) Southern Hemisphere

(i) Sei whales.

Area I	353
Area II	103
Area III	Protected – zero quota
Area IV	348
Area V	569
Area VI	490

These quotas give a total allowable catch for the Southern Hemisphere of 1,863 sei whales and the Commission agreed with the suggestion from Japan that the quotas in each Area might exceed these figures by not more than 10%, but in no circumstances shall the sum of the Areas exceed the total quota.

The Scientific Committee had not been able to take into account the effect of the substantial early catches and the preponderance of females in part of this fishery, and there is uncertainty about the rate of recruitment to the stocks. The Commission agreed that further study of these problems is needed and Japan invited the Scientific Committee to meet in Tokyo during the next year for this purpose.

(ii) Bryde's whales

The Scientific Committee had advised a zero quota pending a full assessment and this was recommended by the Technical Committee and adopted by the Commission.

(iii) Minke whales

Area I	965
Area II	1,855
Area III	2,730
Area V	1,385
Area VI	365

The Area IV minke whale stock is estimated to be close to the boundary between the Initial and Sustained Management categories. The Scientific Committee therefore put forward two possible quota figures, 1,830 and 1,386, reflecting the differences of classification. By a majority vote, the Technical Committee recommended 1,830. An amendment by Mexico for a quota of 1,386 was defeated, but the figure of 1,830 failed to obtain the necessary three-quarters majority. Norway then proposed a quota of 1,600, which was approved by the Commission.

The Commission approved a Japanese proposal for a 10% allowance in each Area except Area IV provided that the sum of the catches in each Area does not exceed the total quota.

Brazil noted that the quota for Area II would be divided between her coastal season from July to December 1977 and the Antarctic pelagic season from December 1976 to April 1977. This did not appear to be a very appropriate combination and she will raise the matter again next year. In the meantime, the question was referred to the Scientific Committee for consideration.

(iv) Fin whales

Since all stocks are now classified as Protection Stocks the Commission accepted the Technical Committee's recommendation that the sentence in paragraph 11 of the Schedule 'The taking of fin whales shall cease not later than 30 June 1976' should be deleted.

(v) Sperm whales

The Scientific Committee held a special meeting in La Jolla, California in March 1976 to consider sperm whale assessments. A slightly refined version of the population model developed in 1972 was used but with conservative population parameters and particularly the changes in the population parameters to be expected in response to exploitation, leading to significantly lower estimates of sustainable yield.

For the male sperm whales, the Technical Committee recommended the quotas proposed by the Scientific Committee, by majority votes for Divisions 1, 2, 4, 6 and 8 and without vote for Divisions 3 and 5. The quotas for each Division were discussed individually by the Commission, and after the defeat of amendments proposed by Japan and the USSR for Divisions 2, 6 and 8, the Technical Committee's recommended figures were adopted as follows:

Males

Division 1	287
Division 2	764
Division 3	712
Division 4	536
Division 5	508
Division 6	261
Division 7	Protected – zero quota
Division 8	826
Division 9	Protected – zero quota

The quotas for female sperm whales proposed by the Scientific Committee and endorsed by the Technical Committee were approved by the Commission as follows:

Females

Division 1	66
Division 2	176
Division 3	204
Division 4	Protected – zero quota
Division 5	116
Division 6	60
Division 7	85
Division 8	190
Division 9	Protected – zero quota

Japan and the USSR both stated that they reserved their positions over the quotas for male and female sperm whales in the Southern Hemisphere. The Japanese request for a 10% allowance on catches in each Division was agreed by the Commission, but with the proviso that the sum of the catches shall not exceed the total quotas of 3,894 males and 897 females.

(b) North Pacific

(i) Bryde's whales	1,000
(ii) Sperm whales – males	4,320
Sperm whales – females	2,880
(iii) Minke whales (except Western stock)	0 (pending assessment)

For the Western stock of minke whales, the Scientific Committee pointed out that a non-member nation – Korea – was also significantly involved in the fishery. It recommended, therefore, that, for the coming year only, the quota should not exceed the level of the maximum post-war catch by Japan, i.e. 541.

The Technical Committee recommended that the quota be set at 541 and, following the defeat of a Mexican amendment for 400, the Commission agreed.

(c) **North Atlantic**

(i) Fin whales	East Greenland–Iceland	1,524 in the 6 years 1977–82, a maximum of 304 in any one year
	Newfoundland	90
	North Norway	61
(ii) Sei whales	Iceland–Denmark Strait	132
(iii) Minke whales	North American coast	48
	East Greenland	320
	East Atlantic	1,790
(iv) Sperm whales		685

It was pointed out by Iceland that a large part of the North Atlantic sperm whale catch is taken by non-members of the IWC, and this led to the formulation of a resolution dealt with in paragraph 15 below. The Scientific Committee had been unable to decide between two catch levels for the West Greenland stock of minke whales: 227–250 or 406–429, the averages excluding or including the Norwegian pelagic catch. The Technical Committee, by a majority vote, recommended a quota of 400 whales, with the instruction that the Scientific Committee should review the situation next year. Canada proposed an amendment to this figure of 325, which was adopted by the Commission together with the call for further studies to be carried out.

8. SIZE LIMIT FOR SOUTHERN HEMISPHERE SPERM WHALES

The Scientific Committee put forward three possible ways of protecting breeding bulls during the breeding season of sperm whales in the Southern Hemisphere. The Technical Committee, by a majority vote, recommended that a sentence 'It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the Southern Hemisphere north of 40°S Latitude during the months of October to January inclusive' be added to the Schedule paragraph 15 (c). After an amendment to prohibit all sperm whaling in this zone from October to February failed to gain a three-quarters majority, this proposal was approved by the Commission.

9. OPENING AND CLOSING DATES OF THE ANTARCTIC SEASON

The Commission agreed that there should be no change in the opening and closing dates.

10 REVIEW OF REPORTING REQUIREMENTS

The Commission approved a recommendation by the Technical Committee for the following amendments to the Schedule suggested by the Scientific Committee:

VI Information required

21. '(d) A record similar to that described in sub-paragraph (b) of this paragraph shall be maintained by "small-type whaling" operations conducted from the shore or by pelagic fleets, and all of this information mentioned in the said sub-paragraph shall be entered therein as soon as available.'

23. (para. 1) (c). 'Particulars with respect to each whale treated in the factory ship, land station, and "small-type whaling" operations as to the date and approximate latitude and longitude of taking, the species and sex of the whale, its length and, if it contains a foetus, the length and sex, if ascertainable, of the foetus.'

23. (para. 2) (b) '(v). Any modifications of the above measures or data from other suitable indicators of fishing effort for "small-type whaling" operations.'

'"Small-type whaling" means catching operations using powered vessels with mounted harpoon guns hunting extensively for minke, bottlenose, pilot or killer whales.'

11 STOCKS OF SMALL CETACEANS

The Scientific Committee considered the report of the Sub-Committee on Small Cetaceans, and supported recommendations which were endorsed by the Technical Committee. The Commission took the following action:

(a) **Recognised list of smaller cetaceans:**
The Commission agreed to recognise, for administrative and reference purposes, the list of smaller cetaceans of the world given in Appendix 1 of this report.

(b) **Management of small cetaceans:**
The Commission noted the Scientific Committee's view that there is a need for an international body to manage stocks of all cetaceans not covered by the present IWC Schedule. The matter will be considered by the working group concerned with redrafting the Convention (see paragraph 24).

The Commission also agreed that, in the meantime, all cetaceans taken for their own value be subject to consideration by the Scientific Committee and that the following species in the following areas should be considered for immediate action:

Northern Bottlenose Whale *(Hyperoodon ampullatus)* North Atlantic
Striped Dolphin *(Stenella coeruleoalba)* North West Pacific
Dall's Porpoise *(Phocoenoides dalli)* North West Pacific
Harbour Porpoise *(Phocoena phocoena)* North Atlantic

(c) **Definition of new stock category:**
The Commission noted that the Scientific Committee was not in a position to classify stocks of small cetaceans in the same way as the large whales but that some urgent action might be required for 'vulnerable' stocks. It agreed that the matter should be included in next year's agenda.

(d) **Research:**
The Commission accepted the recommendation that the Secretariat and governments of member nations be urged to initiate or augment research on species involved in direct fisheries and in particular the four species listed at item (b) above.

(e) **Age determination:**
The Commission agreed with the Scientific Committee and recommended that to facilitate stock assessment

efforts be made whenever possible to collect information relative to age-determination.

(f) **Need to convene workshops:**
The Commission agreed to consider joining in the sponsership of two proposed workshops suggested by the FAO/ACMRR Small Cetacean Group. One workshop would deal with age determination and the other with female reproduction in toothed whales. The Commission supported the Scientific Committee's suggestion that the latter should be extended to include male reproduction.

(g) **Research on captive cetaceans:**
The Commission agreed that more information from captive cetaceans would be useful and instructed the Secretary to initiate the appropriate action.

12 REPORTING REQUIREMENTS FOR THE TAKE OF SMALL CETACEANS

In addition to the Schedule amendments reported in paragraph 10, the Commission accepted the recommendation of the Scientific Committee through the Technical Committee that the Secretary take the necessary action to ensure collection of the statistics and data identified by the sub-Committee on Small Cetaceans and included as Appendix 2 to this report.

13. INTERNATIONAL DECADE OF CETACEAN RESEARCH

The Chairman of the Scientific Committee pointed out that the Committee had produced 10 year research proposals at an estimated first year cost of $2.4 million (1974 prices). In response to a request from the Finance Administration Committee for advice on priorities should funds be available, the Scientific Committee selected programmes at an estimated cost of $175,000. Details appear in Appendix 3. Canada pointed out that the Commission had approved the establishment of a voluntary Research Fund.

The USA felt that the problem was to get the IDCR started and although the Research Fund would give a small start, large funding from bodies such as UNEP would still be required in this connection. The Commission instructed the Secretary to ask members of the Commission what action they are taking to urge the participation of interested Governments and to co-ordinate further activity.

14. DISTRIBUTION OF QUOTAS AMONG THE MEMBER COUNTRIES

Brazil had placed this item on the agenda, and explained the difficulties which had arisen since the introduction of the Commission's new management scheme. The Commission referred the matter to the Working group on the Revision of the Convention, who incorporated appropriate words and paragraphs in the suggested text for consideration by member governments (see paragraph 24).

15. ADHERENCE OF NON-MEMBER WHALING COUNTRIES

During the discussion of catch quotas in areas where non-member countries of the IWC take significant numbers of whales it was agreed that these whaling nations should be invited to join the Convention because their activities are weakening the Commission's conservation and management systems which are binding on member nations. The UNEP observer commented that his organisation had already approached non-member whaling nations and had now received negative replies. The Latin American States had their own organisation.

A small working group was set up, consisting of Canada (convening), Denmark, Iceland, UK and USA to review the whole matter of the adherence of non-member nations and the effects of their catches. In their report the group recommended the adoption of a resolution noting the situation in regard to a particular stock exploited in whole or in part by non-member nations and requested that the non-member states co-operate to avoid over-exploitation and join the Commission. The Commission adopted the resolution, amended to give the Chairman responsibility for transmission to non-member states and worded appropriately for each stock. The form of the resolution, using the North Atlantic sperm whale problem for illustration purposes, is given in Appendix 4. In addition to the North Pacific minke whale case, it was noted that an equivalent resolution might be adopted in the case of whale stocks or species in the Protected category which are exploited by non-member nations. It was also noted that it might be useful to have a resolution by the Commission requesting member states to prohibit the importation of whale products from non-member states which exploit whales in a manner inconsistent with the regulations of the Commission.

16. PROHIBITION ON THE TRANSFER OF WHALING VESSELS AND EQUIPMENT AND OTHER TYPES OF ASSISTANCE FROM IWC MEMBER COUNTRIES TO NON-MEMBER COUNTRIES

The Technical Committee recommended the adoption of a resolution to prohibit the transfer of vessels, equipment and other types of assistance, to countries which are not members of the IWC. The resolution is given in Appendix 5. The Commission agreed that members should seek legal advice from national governments on the inclusion of the resolution in the Schedule, and that this item should be included on the agenda of the 29th meeting.

17. CO-OPERATION WITH FAO AND OTHER ORGANISATIONS

The Commission has continued to participate in the work of the FAO/ACMRR Working Party on Marine Mammals. The Chairman of the Scientific Committee has attended meetings as the IWC observer and other members of the Committee are members of the working groups.

The outgoing Secretary attended an informal meeting of the staff of regional fishery bodies and the Sub-Committee on the Development of Co-operation with International Organisations concerned with Fisheries, organised by the FAO Committee on Fisheries. His report of these meetings was received by the Commission.

The Commission was also represented by observers at the annual meeting of the International Council for the Exploration of the Sea and at the regular meeting of the International Commission for the Conservation of Atlantic Tunas.

18. INTERNATIONAL OBSERVER SCHEME AND INFRACTIONS

A sub-committee of the Technical Committee was appointed to examine the reports under both these items. It stated that the International Observer Scheme and the infractions reporting system were operating effectively although the sub-committee suggested some minor refinements in the recording and presentation of information. The Commission accepted the recommendation that member nations undertake in future to provide the monetary amounts involved in fines and in the withholding of pay and bonuses, translated into US dollars, together with other relevant information on administrative penalties. The situation revealed by all the reports was satisfactory. On the report of the alleged killing of an undersized sperm whale by the Soviet whaling fleet in the North Pacific on 27 June, 1976, the sub-committee was of the opinion that a comparison of the reports of the Japanese observer and the Greenpeace Foundation, who made the charge, yielded no evidence upon which to base a claim of violation of the Schedule. The Brazilian Commissioner informed the Commission that his government had commenced negotiations with Australia and hoped to join the International Observer Scheme and put it into effect this year. This was noted with approval.

19. HUMANE KILLING OF WHALES

The Scientific Committee considered the responses by member nations to enquiries regarding new developments in the efficiency and technique of killing whales. Their recommendations were endorsed by the Technical Committee and accepted by the Commission as follows:

(a) The Secretary should contact health authorities in the UK, USA, Japan and other member countries to determine their regulations concerning the use of chemicals in the slaughtering process.

(b) The Secretary should contact member nations taking minke and other small whales and ask them what methods were used at present to secure and kill them.

(c) The Secretary should contact the US Government with regard to experiments on the application of CO_2 gas as a method of euthanasia.

(d) The Secretary should contact member whaling nations to enquire whether research into the use of high velocity projectiles for speeding death times is being considered.

The USA and UK both expressed the deep concern felt in those countries about the methods used to kill whales and the UK made a suggestion that members might consider the possibility that countries which lacked substantial expertise in this matter might make facilities available for more exploratory work.

20. PROGRESS ON IMPLEMENTATION OF STRENGTHENED SECRETARIAT AND ESTABLISHMENT OF PERMANENT OFFICES

The Commission had appointed Dr R. Gambell to be its full-time Secretary, and he took up office on 1 May 1976.

The Secretary reported that Mr M. Harvey had been appointed Executive Officer with effect from 14 June 1976.

It was not now possible for the Commission's offices to be located with the British Antarctic Survey as had been proposed originally, but suitable accommodation had been obtained on the outskirts of Cambridge. It was expected that the Secretariat would be able to move there during August, when typing and clerical staff would be appointed.

21. FINANCE

The report of the Finance and Administration Committee was presented to the Commission.

(a) **Statement of income and expenditure 1975–76:**
The expenditure amounted to £32,187, but this sum included £10,000 transferred to the Working Capital Fund. The actual expenditure included a contribution of £1,200 towards the cost of publishing the report on small cetaceans, an increase in the contribution for whale marking and payment for assistance on the work of data processing approved by the Commission at the Twenty-seventh meeting. The cost of administrative and accounting services provided by the Ministry of Agriculture, Fisheries and Food continues to rise, both on account of the increase in the time spent by the Ministry's staff on the Commission's work and because of inflation. Thus the expenditure of £22,187 could not be readily compared with expenditure amounting to £12,140 in the previous year.

On the income side, one contribution for the year, that from the Argentine, was still outstanding.

The statement was approved on the recommendation of the Finance and Administration Committee.

(b) **Consideration of budget 1976–77:**
The estimated expenditure in the year to 31 May 1977 was about £62,000. The greater part of the increase could be attributed to the cost of the changes arising from the strengthening of the Secretariat including the non-recurring costs for office equipment and furniture estimated at £12,000. The Finance and Administration Committee considered the possibility of spreading the non-recurring expenditure over two or three years, but this could only be done by meeting part of the costs from the Working Capital Fund. The Committee concluded that the amount in this fund was barely adequate for its purpose and it would not be prudent to deplete it in the early stages of the development of the full-time Secretariat.

The Committee recommended that the Secretary should represent the Commission at the FAO/ACMRR Mammals in the Sea consultation in Bergen and the ICES annual meeting in Copenhagen. He should also visit the Bureau of International Whaling Statistics in Sandefjord to find out what should be done so that the data and information required by the Scientific Committee can be readily available, and also to ascertain what would be involved should there be a proposal to move the Bureau's work to the Commission.

The high cost of producing the Annual Report, about £900 for 240 copies of the latest volumes, was drawn to the Commission's attention. It was proposed that more copies should be printed in future to disseminate the work of the Commission on a broader front, but that charges should be made for those outside the normal free distribution lists. It was also suggested that the Annual Report could be issued earlier if the Commission's financial year was changed to 1 April–31 March, so that audited accounts were available earlier. The Secretary was asked to examine the position so that member countries could consider the matter at the next meeting.

The Finance and Administrative Committee considered that it would be an advantage if the forecast budget could be available sixty days before the Commission meeting, and proposed an amendment to the Financial Regulations so that this could be initiated next year.

The Commission accepted the budget for 1976–77.

(c) **Contributions from Contracting Governments:**
The Finance and Administration Committee recommended a change in the formula for assessing the contributions of Contracting Governments proposed by Canada, which included a component for 'areas of interest' where member countries had, or could express, an interest or sense of stewardship and responsibility for a particular area or areas. The Commission was unable to accept this new formula because of the principles it involved but several countries expressed the view that a more equitable distribution of contributions is necessary than occurs under the existing arrangements, especially with the greatly increased budget now approved. The Secretary was instructed to contact all member governments and to ask for their views and proposals within four months so that they can be circulated and a comprehensive paper prepared for the 29th Annual Meeting. The Commission agreed that in the meantime the contributions for the current year should be assessed on the basis approved for 1974–75 and 1975–76.

22. RULES OF PROCEDURE AND FINANCIAL REGULATIONS

The Commission adopted the amendments to the Rules of Procedure and Financial Regulations circulated 60 days in advance of the meeting with minor modifications, except that the addition of the words 'and other cetaceans' in Rule 8 was deferred until the responsibilities of the Commission become clear.

The Finance and Administration Committee also proposed some additional amendments designed to improve the efficiency with which the work of the Commission is conducted. These covered the circulation of the agenda and meeting documents, and particularly the completion of the report of the Scientific Committee, in advance of the annual meeting. It also proposed that the Chairman's Report of the most recent annual meeting should be included in the annual report of the year just completed. The Commission agreed to consider these amendments at the next meeting.

23. TWENTY-SEVENTH ANNUAL REPORT

The draft report was approved with minor amendments and, at the request of the Commissioner for Brazil, the addition of a paragraph concerning the allocation of catch quotas in Area II.

24. PROPOSED AMENDMENTS TO THE INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING AND ITS SCHEDULE

The Working Group set up to review the Convention reported that six Governments had replied to the document setting out the changes to the Convention proposed by the Group. Many of the amendments were of a minor nature, and Governments were clearly not in a position to form final views until the outcome of the Law of the Sea Conference was known. The Commission accepted the recommendation that those member Governments that had not replied already should be sent the comments so far received and asked to submit their comments within four months. The Secretariat would then prepare and circulate to Commissioners a new document incorporating all the substantial comments received. The Secretary should also circulate a draft of a covering letter intended for non-member Governments who conduct significant whaling operations or who have stocks of commercial interest off their coasts, suggesting the convening of a meeting of plenipotentiaries to elaborate a new International Whaling Convention. This document would be circulated by the Chairman of the Commission if no objections were received within a further four months, or he would convene another meeting of the Working Group. The timing of the meeting of plenipotentiaries will be decided if possible at the next annual meeting.

25. RESOLUTIONS ON BOWHEAD WHALES AND GRAY WHALES

The Technical Committee drew the Commission's attention to recommendations made by the Scientific Committee that:

(a) steps should be taken to limit the expansion of the fishery of bowhead whales off North America and to reduce the loss rate of struck whales and
(b) that the USA and Mexico should be requested to introduce measures to counter harrassment of gray whales in breeding areas.

Denmark proposed the adoption of resolutions to support the Scientific Committee's recommendations and after minor amendments to wording both were adopted by the Commission. (Appendix 6).

26. RULES OF PROCEDURE FOR THE SCIENTIFIC COMMITTEE

The Commission noted that the Scientific Committee had accepted the rules of procedure developed by a special subcommittee to govern the activities and meetings of the Scientific Committee. The rules are contained in the report of the Scientific Committee.

27. PRESENTATION TO THE RETIRING SECRETARY

The Chairman, on behalf of the Commission, expressed appreciation of the work of the retiring secretary, Mr Reg Stacey, wishing him and Mrs Stacey a happy retirement and presenting him with a cheque from Commissioners. Mr Stacey, replying, thanked Commissioners for the gift and expressed his gratitude to all the Commissioners past and present for the help, friendliness and co-operation he had received from them. In conclusion the Commission endorsed a resolution proposed by the Scientific Committee designating Mr Stacey Secretary Emeritus and recording appreciation of the work carried out for the Commission on a part-time basis by staff loaned by the UK Ministry of Agriculture, Fisheries and Food. (Appendix 7).

28. DATE AND PLACE OF NEXT MEETING

The Government of Australia wished to invite the Commission to hold its Twenty-ninth meeting in Canberra. The Commission was pleased to accept this generous offer on the recommendation of the Finance and Administration Committee and in accordance with Rule II of the Rules of Procedure. The meeting will be held in the week beginning 20 June 1977, and the Scientific Committee will meet beforehand at the headquarters of the CSIRO.

29. ELECTION OF VICE-CHAIRMAN

Mr Rindal (Norway) had accepted the position of Vice-Chairman for one year only when elected last year. On his proposal, seconded by the Commissioner for Denmark, Mr T. Asgeirsson, the Commissioner for Iceland, was unanimously elected Vice-Chairman.

30. CONSTITUTION OF COMMITTEES

Technical Committee

All the member nations except Panama. Chairman: Mr T. Asgeirsson (Iceland).

Scientific Committee

Australia, Brazil, Canada, Denmark, Iceland, Japan, New Zealand, Norway, South Africa, United Kingdom, USSR, USA. Chairman: Dr K. R. Allen (Australia).

Finance and Administration Committee

Canada, Japan, Norway, USA, USSR. Chairman: Dr W. R. Martin (Canada).

31. AMENDMENTS TO THE SCHEDULE

The amendments to the Schedule approved by the Commission are shown in Appendix 8.

A. G. Bollen
Chairman

APPENDIX I

LIST OF SMALLER CETACEANS RECOGNISED

Scientific Name	*Recommended Common Name*
Balaenoptera acutorostrata Lacépède, 1804	Minke whale
Caperea marginata (Gray, 1846)	Pygmy right whale
Tasmacetus shepherdi Oliver, 1937	Shepherd's beaked whale
Berardius arnuxii Duvernoy, 1851	Arnoux's beaked whale
Berardius bairdii Stejneger, 1883	Baird's beaked whale
Mesoplodon pacificus (Longman, 1926)	Longman's beaked whale
Mesoplodon bidens (Sowerby, 1804)	Sowerby's beaked whale
Mesoplodon densirostris (de Blainville, 1817)	Blainville's beaked whale
Mesoplodon europaeus (Gervais, 1855))	Gervais' beaked whale
Mesoplodon layardii (Gray, 1865)	Strap-toothed whale
Mesoplodon hectori (Gray, 1871)	Hector's beaked whale
Mesoplodon grayi von Haast, 1876	Gray's beaked whale
Mesoplodon stejnegeri True, 1885	Stejneger's beaked whale
Mesoplodon bowdoini Andrews, 1908	Andrew's beaked whale
Mesoplodon mirus True, 1913	True's beaked whale
Mesoplodon ginkgodens Nishiwaki & Kamiya, 1958	Ginkgo-toothed beaked whale
Mesoplodon carlhubbsi Moore, 1963	Hubb's beaked whale
Ziphius cavirostris G. Cuvier, 1823	Cuvier's beaked whale
Hyperoodon ampullatus (Forster, 1770)	Northern bottlenose whale
Hyperoodon planifrons Flower, 1882	Southern bottlenose whale
Kogia breviceps (de Blainville, 1838)	Pygmy sperm whale
Kogia simus Owen, 1866	Dwarf sperm whale
Monodon monoceros Linnaeus, 1758	Narwhal
Delphinapterus leucas (Pallas, 1776)	White whale
Steno bredanensis (Lesson, 1828)	Rough-toothed dolphin
Sotalia fluviatilis (Gervais, 1853)	Tucuxi
Sousa chinensis (Osbeck, 1765)	Indo-Pacific hump-backed dolphin
Sousa teuszii (Kükenthal, 1892)	Atlantic hump-backed dolphin
Orcaella brevirostris (Gray, 1866)	Irrawaddy dolphin
Peponocephala electra (Gray, 1846)	Melon-headed whale
Feresa attenuata Gray, 1875	Pygmy killer whale
Pseudorca crassidens (Owen, 1846)	False killer whale
Orcinus orca (Linnaeus, 1758)	Killer whale
Globicephala melaena (Traill, 1809)	Long-finned pilot whale
Globicephala macrorhynchus Gray, 1846	Short-finned pilot whale
Lagenorhynchus albirostris (Gray, 1846)	White-beaked dolphin
Lagenorhynchus acutus (Gray, 1828)	Atlantic white-sided dolphin
Lagenorhynchus obscurus (Gray, 1828)	Dusky dolphin
Lagenorhynchus cruciger (Quoy & Gaimard, 1824)	Hourglass dolphin
Lagenorhynchus australis (Peale, 1848)	Peale's dolphin
Lagenorhynchus obliquidens Gill, 1865	Pacific white-sided dolphin
Lagenodelphis hosei Fraser, 1956	Fraser's dolphin
Tursiops truncatus (Montagu, 1821)	Bottlenose dolphin
Grampus griseus (G. Cuvier, 1812)	Risso's dolphin
Stenella longirostris (Gray, 1828)	Spinner dolphin
Stenella coeruleoalba (Meyen, 1833)	Striped dolphin
Stenella attenuata (Gray, 1846) *Stenella dubia* (G. Cuvier, 1812) *Stenella frontalis* (G. Cuvier, 1829) *Stenella plagiodon* (Cope, 1866)	Spotted dolphin (two species)
Delphinus delphis Linnaeus, 1758	Common dolphin
Lissodelphis peronii (Lacépède, 1804)	Southern right whale dolphin
Lissodelphis borealis (Peale, 1848)	Northern right whale dolphin
Cephalorhynchus heavisidii (Gray, 1828)	Heaviside's dolphin
Cephalorhynchus eutropia (Gray, 1846)	Black dolphin
Cephalorhynchus hectori (van Beneden, 1881)	Hector's dolphin
Cephalorhynchus commersonii (Lacepede, 1804)	Commerson's dolphin
Phocoena phocoena (Linnaeus, 1758)	Harbour porpoise
Phocoena sinus Norris & McFarland, 1958	Cochito
Phocoena spinipinnis Burmeister, 1865	Burmeister's porpoise
Phocoena dioptrica Lahille, 1912	Spectacled porpoise

Appendix I (Cont.)

Scientific Name	*Recommended Common Name*
Phocoenoides dalli (True, 1885)	Dall's porpoise
Neophocaena phocaenoides (G. Cuvier, 1829)	Finless porpoise
Platanista gangetica (Roxburgh, 1801)	Ganges susu
Platanista minor Owen, (1854)	Indus susu
Inia geoffrensis (de Blainville, 1817)	Boutu
Lipotes vexillifer Miller, 1918	White flag dolphin
Pontoporia blainvillei (Gervais and d'Orbigny, 1844)	Franciscana

Appendix 2

COLLECTION OF STATISTICS

(a) Statistics and data should be collected by the IWC on a mandatory or optional basis for the various small cetaceans as indicated below:

(i) Biological data: the already existing form employed by BIWS should be adopted for IWC use and made mandatory for reporting data on small cetaceans taken during pelagic and land-based large whale operations as well as in pelagic and land-based operations relying entirely on small whales. The same form should be used as practical to collect biological data on animals examined or sub-sampled in local small harpoon fisheries for small cetaceans, in direct drive and net fisheries, in purse-seining operations and other situations causing incidental kills.

(ii) Catch effort data:

(a) For small whales taken in the course of large-whale operations the same data should be required as for large whales.

(b) For pelagic and land-based small-whale operations, the following should be collected on a daily basis:

*Time to grounds, *time searching, *time chasing *time towing, *time lost, *time in port.
*Position of sighting
*Numbers sighted by species
Direction of travel of animals
Water temperature
*Numbers killed by species
*Length
*Sex
*Time killed
Average whale sighting distance

Weather observations for morning and afternoon as follows:

*Sea state
Wind speed
*Visibility
Wind direction
Wave height
Atmosphere
*Time landed
* = Essential information

Items included in (b) are included in a form reproduced on pages 173–74 of 'Report and Papers of the Scientific Committee of the Commission 1975'. *Rep. int. Whal. Commn (Sci. Rep.) 26.*

(c) For local, sporadic harpoon fisheries, and
(d) For drive and net direct fisheries, and
(e) For deliberate incidental fisheries (e.g. Tuna seining), and
(f) For inadvertent incidental captures.

The following data should be collected for each operation: (ref. Mitchell, E. 1975 'Porpoise, Dolphin and Small Whale Fisheries of the World', IUCN Monograph No. 3).

The catch and effort statistics should include as a minimum:

(a) The species name and the local vernacular name where available.
(b) The numbers caught, and the gross weight of the accompanying catch where available.
(c) The numbers killed or wounded and not recovered.
(d) The date of capture.
(e) An appropriate indication of the intensity of the catching effort such as:
    (i) Catcher vessel days spent hunting and capturing.
    (ii) The number of cetaceans captured, and killed, in each net set.
    (iii) The number of nets set per month.
    (iv) The number caught in each drive ashore and the number of boats used in the drive.
    (v) The number of hunter days expended in harpooning cetaceans.
    (vi) Any modifications of these measures or data from other suitable indicators of hunting effort.

(b) The small-cetacean sub-committee recommends that the Scientific Committee consider the appropriate way to contact Regional Fishery Management Bodies, requesting them to provide catch and effort data for incidental captures by the fisheries with which they are concerned.

Appendix 3

PROPOSALS FOR RESEARCH PROJECTS 1976–77

Given a budget of £100,000 (US $175,000) during the financial year 1976–77, the Scientific Committee recommends that the following projects should be undertaken:

(a) COMPLETION OF DEVELOPMENT OF DATA BASE (see Scientific Committee Report Section 15.1. first para.)
To complete contract work begun in 1975–76: one man for one year to include travel and computer costs $30,000

(b) SOUTHERN HEMISPHERE, SOUTH EAST INDIAN OCEAN
Marking and sighting cruise, to complement that undertaken in the SW Indian Ocean in 1973–74: 28 days at $2,500 per day, to include costs of marks (approx. $4,000) $70,000

(c) NORTH PACIFIC
Assistance with preparation and analysis of sperm whale age data, at the Far Seas Fisheries Laboratory, Japan: 2 technicians for 6 months each, to include necessary equipment $30,000

(d) NORTH ATLANTIC
Collection and analysis of minke whale age data from the Norwegian fishery: to be undertaken in Norway and UK (see North Atlantic Working Group Report, Annex F). $45,000

It is recommended that overall responsibility for co-ordination of the programme should rest with the Secretary of the Commission, working with local organisers appointed for each project.

Appendix 4

RESOLUTION OF THE INTERNATIONAL WHALING COMMISSION 28TH ANNUAL MEETING
ADHERENCE TO THE CONVENTION

WHEREAS it is the purpose of the International Whaling Commission to provide for the effective conservation and management of whale stocks, and

WHEREAS the Commission has adopted a regulation related to the taking of sperm whales in the North Atlantic ocean establishing a catch limit of 685 animals as the maximum number which can be safely removed from this stock,

AND WHEREAS the Commission has noted that this stock is exploited by vessels under the jurisdiction of a member of the Commission, Iceland, and by vessels under the jurisdiction of Spain and Portugal, which are not members of the Commission.

BE IT HEREBY RESOLVED by the International Whaling Commission that all necessary measures should be taken to ensure that catches of sperm whales in the North Atlantic ocean in 1977 do not exceed the catch limit which has been established by the Commission, to prevent the over-exploitation of this stock.

The Commission requests that the Chairman transmit the text of this resolution to the Governments of Spain and Portugal, requesting their co-operation with regard to the conservation of the sperm whale stocks of the North Atlantic ocean, and urging them to join the Commission.

Appendix 5

RESOLUTION OF THE INTERNATIONAL WHALING COMMISSION 28TH ANNUAL MEETING PROHIBITION OF TRANSFER OF VESSELS, EQUIPMENT AND ASSISTANCE

WHEREAS it is the purpose of the International Whaling Commission to provide for the effective conservation and management of whale stocks, and

WHEREAS, the said Commission had adopted a New Management Procedure to carry out that purpose, and

WHEREAS, the sale, charter, transfer, loan or delivery of vessels, equipment or supplies likely to be used for whaling operations; the dissemination of whaling expertise; and the granting of other assistance necessary to the conduct of whaling operations to any nation or entity under the jurisdiction of such nation which is not a member of the International Whaling Commission would seriously detract from the effectiveness of the management procedures adopted by the International Whaling Commission.

BE IT HEREBY RESOLVED by the International Whaling Commission that all member nations of the International Whaling Commission should:

(1) prohibit the sale, charter, transfer, loan or delivery of vessels, equipment or supplies likely to be used for whaling operations to any nation or entity under the jurisdiction of any nation which is not a member of the International Whaling Commission; and

(2) take all practicable steps to discourage the dissemination by its citizens of expertise and assistance necessary to the conduct of whaling operations in any form, including, but not limited to

  (a) the training of personnel;
  (b) the designing of ships, land stations, or other facilities to be used in the conduct of whaling operations; and
  (c) financial aid for whaling operations;

  to any nation or any entity under the jurisdiction of any nation which is not a member of the International Whaling Commission.

Appendix 6

RESOLUTION OF THE INTERNATIONAL WHALING COMMISSION 28TH ANNUAL MEETING

BOWHEAD WHALES

THE INTERNATIONAL WHALING COMMISSION

having noticed the evidence for an increased effort on bowhead whales in the North American Arctic which species generally is protected in all Oceans;

concerned that the continued relatively high loss rate of struck whales in Alaska should be reduced (without increasing the total take);

noting the recommendations of the Scientific Committee to improve assessments of current population;

recommends

that Contracting governments as early as possible take all feasible steps to limit the expansion of the fishery and to reduce the loss rate of struck whales.

RESOLUTION OF THE INTERNATIONAL WHALING COMMISSION 28TH ANNUAL MEETING

GRAY WHALES

THE INTERNATIONAL WHALING COMMISSION

noting that gray whales are generally protected in the Pacific Ocean;

noting the recommendation of the Scientific Committee concerning the desirability of establishing regulations to reduce harrassment of gray whales in breeding areas by Mexican and United States nationals;

recommends

that Contracting governments establish such regulations as soon as possible.

Appendix 7

RESOLUTION OF THE SCIENTIFIC COMMITTEE IN APPRECIATION OF THE WORK OF THE RETIRING SECRETARY

The Scientific Committee unanimously concurs in recommending to the Commission that Reginald Stacey be designated Secretary Emeritus. This newly created position requires that the Secretary Emeritus attends, at his pleasure, all appropriate meetings, receptions, dinners and other official and non-official functions of the IWC. The Secretary Emeritus will serve without financial remuneration and shall not be provided with any voting authority. The freedom imposed by these latter restrictions will permit the Secretary Emeritus to fulfill all requisite and non-requisite duties free of bias and other onerous burdens.

The Committee would also like to record on this last occasion before the setting up of the new secretariat, its appreciation of the support services provided during this and earlier years by the secretariat loaned on a part-time basis by the Ministry of Agriculture, Fisheries and Food staff of the UK.

Appendix 8

AMENDMENTS TO THE SCHEDULE OF THE INTERNATIONAL WHALING CONVENTION 1946 APPROVED BY THE COMMISSION AT THE 28th MEETING.

Paragraph 1 Add the following at the end of the paragraph:

'"small-type whaling" means catching operations using powered vessels with mounted harpoon guns hunting exclusively for minke, bottlenose, pilot or killer whales.'

Paragraph 6 (a)

sub-paragraph 4. Amend to read:

'For the 1976–77 pelagic season and the 1977 coastal season in the Southern Hemisphere and for the 1977 season in all other areas . . .'

Delete: 'except for sei and Bryde's whales combined in the Southern Hemisphere.'

sub-paragraph 5. Delete whole sentence:

'For sei and Bryde's whales combined in the Southern Hemisphere . . . falls short of the MSY stock level.'

sub-paragraph 6. Amend to read:

'The following stocks are classified as Sustained Management Stocks for the 1976–77 pelagic season and the 1977 coastal season in the Southern Hemisphere and for the 1977 season in all other areas:

Fin whales	North Atlantic (East Greenland-Iceland stock)
Sei whales	Southern Hemisphere Areas I, II, IV, V, VI
Minke whales	North Pacific (Western Stock)
Minke whales	North Atlantic (North American Coast, East Greenland and East Atlantic Stocks)
Sperm whales–males	Southern Hemisphere Divisions 3 and 5
Sperm whales–females	Southern Hemisphere Divisions 2, 3, 6 and 7
Sperm whales	North Atlantic

The following stocks are provisionally listed as Sustained Management Stocks for 1977, pending the accumulation of sufficient information for classification:

Fin whales	North Atlantic (North Norway, Spain-Portugal-British Isles Stocks)
Sei whales	North Atlantic (Iceland-Denmark Strait Stock)
Minke whales	North Atlantic (West Greenland Stock)'

Paragraph 6 (b)

sub-paragraph 3. Amend to read:

'The following stocks are classified as Initial Management Stocks for the 1976–77 pelagic season and the 1977 coastal season in the Southern Hemisphere and for the 1977 season in all other areas:

Fin whales	North Atlantic (Newfoundland-Labrador Stock)
Bryde's whales	Southern Hemisphere all Areas
Bryde's whales	North Pacific
Minke whales	Southern Hemisphere all Areas
Minke whales	North Pacific (except the Western Stock)
Sperm whales–males	Southern Hemisphere Divisions 1, 2, 4, 6 and 8
Sperm whales–females	Southern Hemisphere Divisions 1, 5 and 8
Sperm whales–males	North Pacific
Sperm whales–females	North Pacific'

Paragraph 6(c)

sub-paragraph 2. Amend to read:

'There shall be no commercial whaling on species or stocks whilst they are classified as Protection Stocks. The following stocks are classified as Protection Stocks for the 1976–77 pelagic season and the 1977 coastal season in the Southern Hemisphere and for the 1977 season in all other areas:

Blue whales	All Oceans
Humpback whales	All Oceans
Right whales	All Oceans
Gray whales	All Oceans
Fin whales	Southern Hemisphere all Areas
Fin whales	North Pacific
Fin whales	North Atlantic (West Norway-Faroe and Nova Scotia Stocks)
Sei whales	Southern Hemisphere Area III
Sei whales	North Pacific
Sei whales	North Atlantic (Nova Scotia Stock)
Sperm whales–males	Southern Hemisphere Divisions 7 and 9
Sperm whales–females	Southern Hemisphere Divisions 4 and 9'

Paragraph 11. Delete the first two sentences and the footnote. Amend to read:

'The number of baleen whales taken during the open season in the Southern Hemisphere by factory ships, land stations or whale catchers attached thereto under the jurisdiction of the Contracting Governments shall not exceed 1,863 sei whales and 8,900 minke whales and 0 Bryde's whales (pending a satisfactory estimate of stock size), in the 1976–77 pelagic season and the 1977 coastal season. The total catches taken in any of the Areas I to VI shall not exceed the limits shown below. However, in no circumstances shall the sum of the Area catches exceed the total quotas for each species:

	Sei whales	Minke whales
Area I	388	1,062
Area II	113	2,041
Area III	0	3,003
Area IV	383	1,600
Area V	626	1,524
Area VI	539	402'

Paragraph 12. Amend to read:

'The number of whales taken in the North Pacific Ocean and dependent waters in 1977 shall not exceed the following limits:

Sperm whales – males	4,320
Sperm whales – females	2,880
Bryde's whales	1,000

Minke whales (Western Stock)	541	
Minke whales (remainder of the North Pacific)	0	pending a satisfactory estimate of stock size'

Paragraph 13. Amend to read:

'The number of whales taken in the North Atlantic Ocean in 1977 shall not exceed the following limits:

Fin whales – Newfoundland Stock	90
Fin whales – North Norway Stock	61
Minke whales – North American Stock	48
Minke whales – West Greenland Stock	325
Minke whales – East Greenland Stock	320
Minke whales – East Atlantic Stock	1,790
Sei whales – Iceland–Denmark Strait Stock	132
Sperm whales	685

The total catch of fin whales from the East Greenland-Iceland Stock shall not exceed 1,524 in the six years 1977 to 1982 inclusive, and the total catch in any one year shall not exceed 304.'

Paragraph 14. Amend to read:

'The number of sperm whales taken in the Southern Hemisphere in the 1976–77 pelagic season and the 1977 coastal season shall not exceed 3,894 males and 897 females. The total catch in any of the Divisions 1 to 9 shall not exceed the limits shown below. However, in no circumstances shall the sum of the Division catches exceed total quotas.

	Male	*Female*
Division 1	316	73
Division 2	840	194
Division 3	783	224
Division 4	590	0
Division 5	559	128
Division 6	287	66
Division 7	0	94
Division 8	909	209
Division 9	0	0'

Paragraph 15 (c). Add the following:

'It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the Southern Hemisphere north of 40°S latitude during the months of October to January inclusive.'

Paragraph 21. Add new sub-paragraph as follows:

'(d) A record similar to that described in sub-paragraph (b) of this paragraph shall be maintained by "small-type whaling" operations conducted from shore or by pelagic fleets, and all of this information mentioned in the said sub-paragraph shall be entered therin as soon as available.'

Paragraph 23 (paragraph 1 section (c)). Amend line 7 to read:

'. . . each whale treated in the factory ship, land station or "small-type whaling" operations as to the date and approximate. . . '

(Paragraph 2) sub-paragraph (b). Add new section as follows:

'(v) Any modifications of the above measures or data from other suitable indicators of fishing effort for "small-type whaling" operations.'

Report of the Scientific Committee

1. The Committee met at 9.30 am on 10 June 1976 and following days in the Ministry of Agriculture, Fisheries and Food, London, under the Chairmanship of K. R. Allen.

2. There were present:

K. R. Allen J. L. Bannister	Australia
S. J. C. De Moura S. Monte	Brazil
M. C. Mercer E. D. Mitchell	Canada
F. O. Kapel	Denmark
J. Jónsson	Iceland
Y. Fukuda S. Ohsumi H. Omura	Japan
I. Christensen Å. Jonsgård C. J. Rørvik	Norway
P. B. Best	South Africa
R. G. Borodin G. A. Borovkov M. V. Ivashin Y. B. Riazantsev	USSR
S. G. Brown J. W. Horwood C. Lockyer	UK
W. Aron G. A. Bertrand R. L. Brownell D. G. Chapman M. F. Tillman	USA
L. K. Boerema S. J. Holt	FAO
R. Gambell	Secretary to the IWC

3. The agenda adopted is shown in Annex A.

4. APPOINTMENT OF RAPPORTEURS

Continuing the practice of recent years duties were shared: Aron, Lockyer and Mercer were appointed for the meeting.

5. EXCHANGE AND REVIEW OF DOCUMENTS

Lists of documents, progress and other reports available are appended as Annexes B1, B2 and B3.

6. RULES OF PROCEDURE

With regard to item 21 of the Commission agenda, the Committee agreed that the Secretary should be an *ex officio* non-voting member of the Scientific Committee.

Much deliberation was given to the status of various meetings held under the auspices of the Scientific Committee. The Secretary was requested to prepare a report on the item for consideration at next year's meeting.

A report policy (Annex C1) was approved as the requirement for all meetings, other than the regular annual session of the Scientific Committee.

The Scientific Committee appointed a Sub-Committee to prepare a report on these matters. The Committee considered and adopted their report, see Annex C2. A further statement concerning operations of the Scientific Committee is attached as Annex C3.

7. FAO/ACMRR WORKING PARTY ON MARINE MAMMALS

SC/28/Rep 5 and SC/28/Rep 6 were submitted to the Committee for comment. Members were asked to communicate comments to Holt on an individual basis.

Holt explained that, under the usual procedure, invitations to attend FAO meetings were extended via the governments of FAO member nations and international organisations concerned. The IWC is invited to designate an observer to the Bergen meeting. The Committee therefore recommends that the Secretary be designated to attend the FAO meeting in Bergen in September 1976.

8. INTERNATIONAL DECADE OF CETACEAN RESEARCH – RESEARCH PROPOSALS

The Scientific Committee reminds the Commission that it has developed Consolidated Research Proposals for the IDCR (Annex E, SC/SP 74/Rep 5). These proposals were categorised in three groups according to priority of need. The first year costs of research (estimated in 1974 dollars) in the highest priority group is US $2,393,000, with research in the medium and low priority category costing $708,000 and $155,000 respectively. The Committee urges the Commission to consider means of funding these proposals, either through a Commission research fund or through direct support by national governments. The successful completion of these research studies is essential to the development of rational management advice.
advice.

8.1 Proposals for Research Projects 1976–7

Given a budget of £100,000 (US $175,000) during the financial year 1976–7, the Committee recommends that the following projects should be undertaken.

1. Completion of Development of Data Base
(See Section 15.1. first para). To complete contract work begun in 1975–6: one man for one year to include travel and computer costs $30,000

2. Southern Hemisphere, South East Indian Ocean
Marking and sightings cruise, to complement that undertaken in the SW Indian Ocean in 1973–4: 28 days at $2,500 per day, to include cost of marks (approx $4,000) . . $70,000

3. North Pacific
Assistance with preparation and analysis of sperm whale age data, at the Far Seas Fishery Laboratory, Japan: 2 Technicians for 6 months each, to include necessary equipment . . $30,000

4. North Atlantic
Collection and analysis of minke whale age data from the Norwegian fishery: to be undertaken in Norway and UK (see Annex F of Annex K of this report) $45,000

It is recommended that overall responsibility for co-ordination of the programme should rest with the Secretary of the Commission, working with local organisers appointed for each project.

9. RESEARCH AND INFORMATION

9.1 Progress reports, including reports relative to special permits

The Committee reviewed Progress Reports submitted by National Groups as listed in Annex B3.

Ohsumi reported on the results of a special permit for the taking of 80 sperm whales off the coast of Japan (reference paper SP/Doc 16 submitted to the sperm whale special meeting, Annex J).

One other special permit had been issued during the year, as shown in Annex D.

9.2. Progress of whale marking

Brown presented SC/28/Rep 10 to the Committee, which contained a summary of whale marking activities during 1975 and 1976.

Regarding funding of the International Whale Marking Programme which is co-ordinated by the Institute of Oceanographic Sciences, Brown suggested that a sum of £2,000 would be required for the 1976–77 season. The Committee therefore recommends that the Commission maintains its contribution towards the cost of the whale marking at £2,000, but points out that any research proposals involving marking in the IDCR programme would require extra funding. The Committee agreed that the international marking scheme should not necessarily be limited to the Southern Hemisphere.

9.3. Report of previous season's catches

Statistical data prepared at the Bureau of International Whaling Statistics under the direction of Mr Vangstein, were presented by Jonsgård.

9.4. Data analyses and reports of national groups

Australia indicated the intent to conduct aerial surveys of humpback and right whales.

Data analyses were considered in the appropriate contexts of agenda items 10–14.

9.5 Sighting programme. Data reports from 1975–6 season and analyses of data

The Committee considered a revision of the form proposed for recording sightings data (format described in SC/27/Rep 6), and asked the Secretary to request data on effort from national groups not now providing these data. The Committee suggested that 2 copies of all such data be available in the archives of the Secretariat, and that they also be distributed to members of the Committee on their request.

Ohsumi stated that the decline in sighting effort was linked with the decrease in whaling operations, sightings being made by scouting vessels. It was noted that sightings of protected species by scouting vessels were often the only means of estimating abundance and distribution.

9.6 Reports of special meetings.

The Committee received reports of the meetings held during the previous year, on sperm whales (Annex J), North Atlantic fin, minke and bottlenose whales (Annex K) and small cetaceans (Annex L). Those recommendations endorsed by the Committee are considered under the relevant items of its agenda.

10. CLASSIFICATION OF WHALE STOCKS

10.1 Recommendations on criteria: Definition of new stock categories

In considering the status and possible management of cetacean stocks, the Committee recognised that insufficient information exists to allow classification of some stocks under the New Management Procedure in relation to MSY. In addition, the Committee recognised that information on some stocks is not likely to become available in the immediate future unless a specific effort is made to provide it.

There are stocks for which insufficient information is available and which evidence indicates are, or have been, severely affected by direct fishing, direct fishing and incidental take, or direct fishing and environmental change. There are others that have been fished for which there are no estimates of initial stock size or its relation to current stock size, and where there is no evidence that the stock is being significantly affected by present catches. The Committee believes that for such stocks new management categories might be created.

The Committee is considering categories for addition to the Schedule, and will bring the matter to the Commission's attention next year. Proposals under consideration are given in Annex E.

10.2 Alternative formulae for determining quotas

At its 27th meeting the Commission asked the Scientific Committee to compare proposals originating with the Committee and from the Commissioner for the United Kingdom to establish catch limits for stocks which are Sustained Management Stocks but below the MSY level. It is the aim of the new management procedure to set catch limits so that such stocks would rebuild towards the MSY level.

The alternative procedures are as follows:

(1) The permitted catch shall not exceed 90 per cent of MSY reduced by 10 per cent for every 1 per cent by which the stock falls short of the MSY level (Scientific Committee).

(2) The permitted catch shall not exceed 90 per cent of the MSY reduced by 5 per cent for every 1 per cent by which the stock *at the begining of the sustained management period* falls short of the MSY level (UK).

The essential differences are

(a) The catch limit under the UK proposal initially is greater than in the Scientific Committee proposal, the difference depending on the amount that the stock falls short of the MSY level.

(b) The catch limit under the UK proposal would remain constant during the time period that the stock rebuilds towards the MSY level while under the Scientific Committee proposal it would increase annually.

The Committee considered reviews of the two procedures SC/28/Doc 1, SC/28/Doc 7 and SC/28/Doc 8. SC/28/Doc 8 refers particularly to the operational advantages of the UK proposal but notes that from the viewpoint of safety, the Scientific Committee scheme might be slightly favoured except that safety considerations have already been made. SC/28/Doc 1 and SC/28/Doc 7 show that the rate of rebuilding under the UK scheme is faster than under the Scientific Committee proposal though the difference is very small and the recovery time under the UK scheme tends to be independent of the initial level. They also note that the risks resulting from errors of assessment are greater under the UK proposal than under the Scientific Committee proposal.

The Committee also notes that under the UK proposal whenever a Protection Stock apparently rebuilds to a Sustained Management Stock, a relatively large catch would be immediately permitted. However, when a stock has been in the Protection category there is a great deal of uncertainty as to its status and suitable yield. A relatively large catch would carry the risk of over-exploitation again depleting the stock to the Protection category.

10.3 Use of effort limitation for North Atlantic fin whales

Jónsson pointed out that considerable fluctuations in the annual catches of fin whales made regulations by quota based upon an average very difficult to maintain. This had been Iceland's main objection at the last annual meeting of the Commission. He felt that the effort limitations which had been in use in Iceland for many years provided enough safeguard for the stock; available scientific evidence indicates a stable stock of fin whales in this area and 28 years of whaling by Iceland showed the success of limiting the catch by effort.

Utilisation of effort as a means of regulation implies that such effort can be adequately regulated, whereas the experience of the Committee indicates that accurate prediction of changes in efficiency would be difficult. True effort comprises a complex of many factors such as boat size, engine power, experience of crew, additional equipment, such as asdic, as well as changes in operational techniques, which would be difficult to measure and monitor adequately.

The Committee therefore expressed the view that regulation by catch quota was the safest approach to management. As a means of maintaining the average catch at a desirable level, while meeting the problems which arise for the operators from uncontrollable annual fluctuations in the availability of whales, the Committee considered the possibility of a catch limit for a period of six years. Two alternative possibilities were explored, the so-called block quota and the rolling quota. The block quota is a fixed quota of six times the established annual average, for each successive period of six years. Under the rolling quota system the number of whales which could be taken in any period of six years would be fixed, so that the quota in any one year would be six times the established annual quota, minus the sum of the catches in the preceding five years.

As an example the Committee considered the possible effects of applying these systems to the Icelandic fishery. The total 6-year quota would be set at 1,524 whales (this corresponds to an average of 254 whales per season, which is the mean catch for the 5 year period to 1974). In order to prevent excessive catches in any one year under the block system, it was added that under this system in no year the catch should exceed 304 whales. The results from both systems, if they had been applied since 1952, are shown in Table 1, together with the catches obtained if a fixed annual quota had been set at the average of 254 whales, or at the level of 275 whales adopted by the Commission last year. The years in which the various systems would have reduced the catches are shown by an asterisk. The Table shows that the total losses in catch over the 24 years' period are least under the 6-year quota system. The effect of all quota systems depends on chance and the effect of the 6-year block quota system also depends on the year in which the blocks are started. If one 6-year period had included the period 1962–1967 the loss in that period alone would have been some 100 whales. The Committee concluded that from the aspect of conservation and of long-term loss compared with the annual average of the past period, both types of 6-year quotas would have practically the same effect. The 6-year block quota system might, however, give some problems if it appeared to be desirable to change the quota level during a six year period on the basis of better stock assessments, and it would raise the problem for the exploiting country for which catch level to aim at in the first years in order to compensate for the chance that in the last years of a 6-year period the whale availability would be poor. The rolling quota system essentially allows the country after a year with poor catch to make up for this loss in the following five years.

11. STATUS OF STOCKS RELATIVE TO CRITERIA

11.1 Southern Hemisphere

11.1.1 Baleen whales

FIN WHALES

The Committee considered the stock analysis for Antarctic Area I in SC/28/Doc 6. The best estimate of exploitable population size in Area I for the season 1955–56 is 17,000 and for the season 1976–77 much less than half this figure based on the modified DeLury model. This new estimate of 17,000 for exploitable population size in 1955–56 was accepted as more accurate than that of 12,000 given in IWC Sci. Rep. 1976, p 44, considering that over 12,000 fin whales were taken in pelagic and land station operations in the three year period 1955–56 to 1957–58. SC/28/Doc 38 indicated that, in connection with the above analysis, there remain some questions to be more deliberately considered. It does not seem to suggest any substantial change in above evaluation of the present status of the possible Area I stock, but further study is needed especially in relation to the Area VI stock. Additional evidence of possible depletion of the Area I stock was presented in SC/28/Doc 15 where a significant decline in age at sexual maturity was demonstrated even prior to 1955. The Committee looks forward to receiving analyses of recent and past biological collections made by USSR catching operations in Area I. Updated estimates were prepared using the same model as previously, for the other Southern Hemisphere stocks (SC/28/Doc 37).

Table 1

Fin whales – Iceland. Example of effect of different quota systems

Year	Actual catch	Quota average = 254	Quota as 1976 = 275	6 Year block quota = 1,524	6 Year rolling quota = 1,524
1952	224	224	224	224	224
3	207	207	207	207	207
4	177	177	177	177	177
55	236	236	236	236	236
6	265	254*	265	265	265
7	348	254*	275*	304* 1,413	348
8	289	254*	275*	289	289
9	178	178	178	178	178
60	160	160	160	160	160
1	142	142	142	142	142
2	303	254*	275*	303	303
3	283	254*	275*	283 1,355	283
4	217	217	217	217	217
65	288	254*	275*	288	288
6	310	254*	275*	304*	291*
7	239	239	239	239	142*
8	202	202	202	202	202
9	251	251	251	251 1,501	251
70	272	254*	272	272	272
1	208	208	208	208	208
2	238	238	238	238	238
3	267	254*	267	267	267
4	285	254*	275*	285	285
75	245	245	245	245 1,515	245
Total	5,834	5,464	5,653	5,784	5,718
Total loss in catch under the quota system in 24 years		370	181	50	116

* Indicates years in which the catch would have been limited by the quota system.

Table 2

Basic set of southern hemisphere sei whale population estimates (000's)

Area	1961–62[1] Exploitable stock[2]	1961–62 Mature stock[3]	MSY level 60%	1973–74 Exploitable stock[4]	1973–74 Mature stock[5]
I	–	16.4[6]	9.8	11.2	13.4[7]
II	40.0	47.9	28.7	17.0	24.9
III	25.0	30.0	18.0	6.4	11.4
IV	27.0	32.2	19.4	12.9	18.1
V	22.0	26.4	15.8	12.0	16.4
VI	–	22.6[6]	13.6	14.2	17.0[7]

[1] The 1961–62 stock levels are taken to be initial levels for further calculations
[2] From IWC/27/4 Annex I except Areas I and VI
[3] 119.7% of initial exploitable stock (adding in component 8 to 10 years of age)
[4] From IWC/27/4 Annex I except Areas I and VI
[5] Adding in initial component from 8 to 10 years of age (19.7%)
[6] Back calculated taking into account land station catches where appropriate from mature stock estimate in 1973–74
[7] From SC/28/Doc 42 revised estimates based on sighting data

SEI WHALES

The Committee had available information in SC/28/Docs 4, 5, 17, 36, 42, 43, 44, 45, 47.

The Scientific Committee received and accepted the report of the Sub-Committee on Southern Sei whales. The Sub-Committee began with the basic set of estimates shown in Table 2.

Estimates of r–M averaged over a period of years in the North Pacific during which time the stock levels were reduced from well above to well below MSY levels are given in IWC/27/Doc 25 as 0.04. On this basis the Sub-Committee agreed that at MSY levels r should be taken to be 0.10 (with M = 0.06).

The recruitment rate r was calculated from the formula

$$r = 0.0567\left(1 - \left[\frac{N}{N_{unexp.}}\right]^{2.39}\right) + 0.06$$

which is the modified logistic corresponding to a net recruitment rate of 0.04 at an MSY level of 60% of unexploited level, with constant natural mortality rate of 0.06. Further, the updating made use of the standard formula

$$N_{t+1} = (N_t - C_t)e^{-M} + R_t$$

$$R_t = r_{t-8}\ N_{t-8}$$

Table 3

Updated calculations of southern hemisphere sei whale population sizes (000's)

Season	Parent stock size	r	Stock size beginning of season	Recruitment	Mortality	Catch
Area I						
1973–74	14.3	0.07	13.4	1.0	0.8	1.1
1974–75	14.4	0.07	12.5	1.0	0.8	1.0
1975–76	14.5	0.07	11.7	1.0	0.7	0.2
1976–77			11.3			
Area II						
1973–74	26.0	0.103	24.90	2.69	1.44	0.01
1974–75	15.4	0.113	26.14	1.74	1.52	0.00
1975–76	16.0	0.113	26.36	1.80	1.48	0.53
1976–77			26.15			
Area III						
1973–74	20.9	0.09	11.1	1.9	0.6	0.6
1974–75	17.7	0.10	12.1	1.8	0.7	0.4
1975–76	11.2	0.11	12.1	1.2	0.7	0.1
1976–77			13.2			
	(Catches include those at South Africa and in South Atlantic)					
Area IV						
1973–74	29.3	0.071	18.0	2.09	0.96	1.65
1974–75	29.2	0.072	17.8	2.10	0.96	1.01
1975–76	26.7	0.080	17.1	2.15	1.01	0.47
1976–77			18.8			
Area V						
1973–74	21.0	0.084	16.4	1.76	0.92	0.52
1974–75	20.4	0.085	16.2	1.76	0.95	0.51
1975–76	20.1	0.087	17.2	1.75	0.95	0.39
1976–77			17.1			
Area VI						
1973–74	20.5	0.07	17.0	1.4	1.0	0.8
1974–75	20.1	0.07	16.1	1.4	1.0	1.2
1975–76	19.5	0.07	15.1	1.4	1.0	0.2
1976–77			16.1			

where N_t = mature stock in year t

C_t = catch in year t

R_t = recruitment in year t

r_{t-8} = recruitment rate in year t−8

calculated by the formula above according to the mature stock level in year t−8.

The calculations for this updating are shown in Table 3 by Area.

The final stock sizes, percentages of MSY level and resultant classifications and catch limits are shown in Table 4. Catch limits are calculated on the basis of r–M at MSY level equal to 0.04.

Table 4

Final estimates of southern hemisphere sei whale stock sizes (000's), and resultant classifications and catch limits.

Area	Mature stock size 1976–77	Per cent of MSY level	Classification	Catch limit
I	11.8	116	SM	353
II	26.15	91	SM	103
III	13.2	72	PS	0
IV	18.38	95	SM	348
V	17.41	110	SM	569
VI	16.0	118	SM	490
			Total	1,863

The question of which r–M value to apply at 60% stock level to calculate MSY needs further examination. Reasons have been given (IWC/28/Doc 43) for considering the value of 0.04 used hitherto, and in the present calculations, may be too high.

There were in most areas substantial catches prior to 1960–61 and, further, the great preponderance of females in catches by land stations and until 1964–65 by pelagic operations has not been taken into account. Consideration of either or both of these factors could lead to classification of Area II and Area IV as Protection Stocks. Further, these factors, considered together with a lower value of r at MSY stock level, would lead to a revision downward in the proposed quotas for Sustained Management Stocks. Further study of all these problems is needed.

The Japanese scientists could not agree to the above results of calculation on classifications and catch limits. They were, towards the last day of the Scientific Committee, re-drafted over and over again, successively from 2,135 to 1,622 and then to 1,864 in total of catch limits, based on slightly different hypotheses. Unfortunately the Japanese scientists were unable to have sufficient time to study in what respect and on what basis they had been improved or not, although, indeed, the underlying theoretical model might have been sophisticatedly refined by some members. It was an incredible surprise to the Japanese scientists that each slight modification of the model and/or the parameters involved had changed the overall picture of the recommendations, especially of the catch limits by Area. This feeling is shared by Soviet members of the Committee who are concerned about this method of approach. The Japanese scientists could not find any acceptable reason to hasten to incorporate such a sophistication into formulation of the recommendations at this opportunity.

Under these circumstances, the Japanese scientists insisted on following the the same procedures consistently as the Scientific Committee did last year at the first application of the new management scheme, even if there might be some points of issue involved, because the Scientific Committee can annually review them and monitor their possible effects. Starting with Table 2, the procedures lead to the recommendations on classifications and catch limits, shown in Table 5.

Table 5

Japanese estimates of southern hemisphere sei whale stock sizes (000's), and resultant classification and catch limits.

Area	Mature stock size 1976–77	Per cent of MSY level	Classification	Catch limit
I	11.4	106	SM	353
II	28.2	98	SM	826
III	12.3	68	PS	0
IV	17.7	91	SM	70
V	17.2	109	SM	569
VI	15.0	112	SM	490
			Total	2,308

However, most members of the Scientific Committee do not consider that the Japanese assumption is valid because they no longer believe that it is appropriate to apply the assumption of constant recruitment at a time when the parent stock has been substantially reduced from the original level.

Dr Holt, representative of FAO on behalf of the FAO/UNEP Marine Mammal project, having participated in the calculations and discussion of the sei and minke stocks of the Southern Hemisphere, based in part on documents he had submitted to the Scientific Committee, wished to place on record the following personal view, to which Dr Curry-Lindahl, representative of UNEP, also subscribed:

> "The Scientific Committee, in contrast with its practice in recent years, has not erred, if anything, in the direction of caution when in doubt as to the correct values of vital rates or the appropriateness of models used. In particular, calculations of the sizes of current (1976–77) stocks of sei whales relative to the estimates for 1960–61 imply continuing annual numbers of recruits at levels at least equal to the levels in the unexploited stocks, despite the decline in stocks. No evidence has been presented that such a phenomenon has occurred in sei or minke whales, nor convincing theoretical arguments as to why it should be expected. In addition, it has been demonstrated that in all Areas except I, (especially in Areas II, III, IV and V), substantial catches were taken in the seasons prior to 1960–61, and that catches by land stations and pelagic catches up to and including 1964–65 were predominantly females, have significant effects on the assessments. In Area II before 1960–61 the land station catches alone exceeded or approched the MSY level, as given by the Scientific Committee, every year for a decade. This must mean that the stock was, in 1960–61, already substantially below the initial level. These factors have not been taken into account in the Report of the Scientific Committee.
>
> Assessments in which the above phenomena *are* included indicate that in *all* Areas the ratios of present to initial stock are lower than those adopted by the Committee; several adjustments are necessary and they are cumulative, and would imply reclassification of two sei whale stocks, and possibly a third, from "sustained" to "protection" category. Furthermore, there is no concrete evidence that the net recruitment rate (r–M) of sei whales is, or could be, as high as 4% of the MSY level of 60% of initial stock. Indeed, documents available to the Committee indicated that the true value is lower than 4% though not by how much, and circumstantial evidence for other stocks of sei whales and of related species points in the same direction. Choice of the 4% value implies, for the value of M used by the Committee, that as a stock is reduced from its unexploited level to 60% of that level the annual number of recruits is not only maintained throughout, but actually increases.
>
> This is not supported by the presentation of biological evidence – e.g. for changes in mortality rate, age at maturity or pregnancy rate–of sufficient magnitude and such a phenomenon seems to us highly unlikely. This unreasonable implication can be corrected by using a value of (r–M) no more than half of the 4% level; the quotas for sustained management stocks would be halved accordingly. Similar considerations apply to the calculations made for initial management stocks of minke whales, but do not yet imply different classifications of them than those proposed by the Scientific Committee.
>
> These observations amplify and we hope, clarify the statement made in the cautionary paragraphs [the two paragraphs following Table 4] in the Scientific Committee's Report."

BRYDE'S WHALES

The Scientific Committee noted the lack of satisfactory estimates of stock size for the species in the Southern Hemisphere. It thus repeats its recommendation that sighting and marking of this species be undertaken by pelagic expeditions during transits to and from the Antarctic whaling grounds, and that population studies be carried out.

MINKE WHALES

A sub-committee considered information available in SC/28/Docs 4, 17 and 19 and prepared estimates of initial, MSY, and current stock sizes for each Southern Hemisphere Area (SC/28/Rep 12). These estimates were based upon estimates of abundance for Area IV which were derived in SC/28/Doc 19 by applying the modified DeLury method to CPUE data adjusted for wind strength and period of operation. Estimates in other Southern Hemisphere Areas were determined by applying indices of abundance from CPUE data obtained from each Area in 1975–76, to the 1975–76 Area IV estimate and then extrapolation forward to the start of 1976–77 and backward to the initial year of exploitation. These estimates account for land station catches in Area II by Brazil and in Area III by Natal.

SC/28/Doc 35 raised the issue of utilizing assessment models which incorporated an optimistic assumption about recruitment (constant and proportional to initial stock size) and which ignored the possible selectivity of whaling and the geographic segregation of sexes. The Committee noted that adoption of the assumptions proposed by SC/28/Doc 35 would lead to slightly larger estimates of initial stock size with estimates of current size being unchanged. No change in classification would result.

The Committee took note of the concerns expressed in SC/28/Doc 35 and in particular concurred with the sub-committee's recommendation that future stock assessments should undertake a detailed analysis of the possible effects of the geographic segregation of sexes.

Although new evidence concerning identification of Southern Hemisphere stocks was provided by Brownell, the Committee emphasised that additional information is urgently required and that, in this regard, a marking study involving the breeding grounds eg off Brazil, would be useful.

11.1.2. Sperm whales

The Committee considered the report of the special meeting convened at La Jolla (Annex J) as well as SC/28/Docs 2, 4 and 9. Assessments were made assuming that the 1946 stock was in the unexploited state, although noting that there may have remained residual effects of 19th century whaling.

At the La Jolla meeting the Committee made new estimates of present and initial population sizes and it also reconsidered the population parameters and particularly the changes in the population parameters to be expected in response to exploitation. The new population estimates are slightly lower for 1975 than they were estimated at Parksville for 1972. The population parameters adopted at Parksville and now adopted at La Jolla for the Southern Hemisphere are shown in Table 6.

The parameters adopted are conservative in that they lead to relatively high female population levels to give MSY and to significantly lower estimates of sustainable yield. The calculations to classify stocks and estimate catch limits were made on the alternative basis of yield in total weight of catch and of yield in combined numbers of males and females. At the Parksville meeting the Committee calculated the surpluses estimated to exist in the several stocks and proposed catch limits to reduce these surpluses. Separate calculation for this purpose is no longer required under the new management procedure where a catch limit of 0.9 MSY provides for reduction of the surplus.

The Committee also noted that, on the basis of the standard parameters, in a stable population at MSY level, the ratio of total socially mature males to mature females is 2 to 15 rather than 7 to 15 in an unexploited population. It should be pointed out that the model assumes that all sexes and age groups are equally available to the fishery, whereas the seasonal segregation of larger males and limited distribution of females means that the age and sex groups available to the fishery depend on the type and location of operations. The Committee also recognised that the model, on which these values are based, does not take into account any operational difficulties involved in the transitional period to the MSY level.

The Committee notes that adoption of the new recommended catch limits will result in a greatly reduced catch of females, so that if management is by number, the mean catch will be 128 for those divisions in which exploitation is permitted. This will result in a serious reduction in the availability of potential information on certain biological parameters needed to confirm the validity of the model. This situation would be aggravated if management objectives were taken to be maximum yield by weight rather than by number. One way by which this difficulty might be overcome is through the issuing of special scientific permits.

The Soviet scientists made the following comments:

> "Soviet members agree with the estimates of the initial male stock of sperm whales in the Southern Ocean obtained at the La Jolla meeting (March 1976). However, estimates obtained through models using some insufficiently accurate parameters were presented to the Scientific Committee. Such parameters can result in unobjective assessments. The weight conception of MSY has not been tested by the Scientific Committee either. Its application at the present stage appears to be premature until this problem has been studied more fully. Soviet members believe that the level of MSY for females by weight has not been sufficiently studied and apparently must be lower than 97% of the initial stock.
>
> During the last year the Scientific Committee has not received any significant information on the social structure and behaviour of sperm whales. On the other hand,

Table 6

Population Parameters – Sperm Whales – Southern Hemisphere.

	Parksville (1972)		Present (1976)	
	Unexploited	Exploited (25% of initial mature female stock level)	Unexploited	Exploited (25% of initial mature female stock level)
Natural mortality rate – mature	0.05	0.04	0.05	0.05
Natural mortality rate – immature	0.06	0.05	0.133	0.133
	Average first ten years		Average first 2 years 0.05 thereafter	
Pregnancy rate	0.19	0.30	0.19	0.25
Maturity age – male social	25	22	25	25
female	10	8	10	8.5
Harem reserve	0	0	0.3	0.3
Harem size	10–15	10–15	10	10
Age at recruitment – male	15	15	20 (15 in Division 9)	20 (15 in Division 9)
female			13	13

> the estimates of catch limits have been sharply, or by many times, reduced using abstract pre-requisites. It seems improbable that out of the current stock of mature females of sperm whales assessed by the Committee as being nearly 300,000 only 78 animals can be exempted(!)
>
> The Scientific Committee has to make a more profound study of the new conceptions of determining MSY by weight and by number, as well as of the parameters included in the model and their effect when it has more reliable additional data."

Use of the parameters adopted above gives MSY population levels, relative to unexploited level of:

		Divisions 1–8	Division 9
Objective: Yield by Weight	Males	0.39	0.46
	Females	0.97	0.97
Objective: Yield by Number	Males	0.32	0.38
	Females	0.79	0.75

These calculations lead to the following 1976–77 combined catch limits and maximum sustainable yields for the entire Southern Hemisphere.

	1976–77 Catch Limits		MSY	
	No.	Wt. (1,000 tons)	No.	Wt. (1,000 tons)
Yield by Wt.	3,111	59.1	6,753	163.5
Yield by No.	4,791	86.9	7,138	158.0

The detailed results for each of the Southern Hemisphere Divisions are shown in Annex F.

11.2 North Pacific

11.2.1 Baleen whales

FIN WHALES

No new data were available regarding the status of the stock.

SEI WHALES

The only new data available to the Committee were in Sc/28/Doc 29, which indicated that the index of abundance of sei whales as measured by sightings was at about the same level as in the previous four seasons and considerably lower than in the seasons 1965 to 1970. Catch per unit effort also declined in 1975 to its lowest level since at least 1966, but quota restrictions may have affected effort for this stock.

BRYDE'S WHALES

The Committee considered a report (SC/28/Rep 9) reviewing information on initial stock size. The conclusions given were an initial stock size of 20,000, and a current stock size for the area of exploitation of 16,230 which is 81% of the initial level. The Committee accepted this determination. The Committee noted that this stock may extend south of the equator during the northern winter (SC/28/Prog Rep 6).

MINKE WHALES

No new assessment information was available to the Committee on the central and eastern stocks. The Committee considered SC/28/Doc 20 concerning the stocks exploited by Japanese coastal fisheries. It noted that two stocks may be involved, one on the Pacific coast and in the Okhotsk Sea and the other in the Japan Sea and along the coasts of Korea. The latter is also exploited by Korea.

The Committee requests that information bearing on stock relationships and landings statistics separated by putative stock be made available for evaluation at next year's meeting. It also requests that information on size of whales taken be made available through NP forms.

11.2.2. Sperm whales

The Committee reviewed estimates of exploitable stock sizes given in SC/28/Docs 21, 25 and 34. Due to the different stock subdivisions assumed, the estimates from SC/28/Docs 21 and 25 were not entirely comparable. SC/28/Doc 34 treated the North Pacific as a single stock unit and adjusted estimates (derived from SC/28/Docs 21, 25, IWC/22/Annex K and IWC/24/Annex L) for the recently observed change in median age at recruitment of males. This change, from 19 to 13 years was attributable to the reduction in minimum size limit in 1972, and exploitable males were estimated to be 118,000 in that year. Total females were noted to be 178,000.

The Committee noted that the model developed at La Jolla had not yet been applied to the North Pacific population and also that recommendations by stocks would be preferable to treating the population as a whole. It urged that both of these concerns be taken into account when future assessments are undertaken.

The Committee noted the intent of Japanese scientists to report further data on age structure at the next annual meeting.

11.3 North Atlantic

Fin whales

The Committee considered the reports of the North Atlantic Working Group (Annex K) which recognized the seven stocks as follows:

1. Nova Scotia
2. Newfoundland – Labrador
3. West Greenland
4. East Greenland – Iceland
5. North Norway
6. West Norway – Faroe Islands
7. British Isles – Spain and Portugal

NORTH NORWAY

Available catch/effort data for the period 1948–71 did not produce a significant slope in the DeLury model. This precluded calculation of 1948 stock size and a definitive conclusion on the degree of recovery from the period of earlier extensive over-exploitation. Annual catches 1948–71 ranged from 21 to 138 (mean 61), below the calculated MSY.

EAST GREENLAND – ICELAND

No new data on this stock have become available to the Committee, and there is still little clear evidence on current stock levels. The Committee recognised, however, that the population appears to be relatively stable at the current level of fishing. The mean catch has been 254 whales per season, both for the 5 year period to 1974 and for the 20 year period to 1974.

WEST GREENLAND

No estimates of past or present stock sizes were available.

Landings 1948–58 were 224 (average 20) and a total of only 10–15 was taken 1958–75.

The Committee noted the availability of good whaling log records for the recent fishery and recommends that sightings data from these logs be summarised and analysed.

NEWFOUNDLAND AND NOVA SCOTIA

As no new data were available on either of these stocks the assessments made last year (IWC Sci. Rep. 1976, p. 47) were updated to reflect net recruitment in the absence of exploitation (SC/28/Doc 37).

WEST NORWAY AND FAROE ISLANDS

The Committee considered SC/28/Rep 2 which indicated a 1946 population size of 2700–3007 reduced to 1050–1550 in 1963. Removals were 84 whales in the period 1963–69. The stock may have been reduced to half the initial stock size prior to 1946.

SPAIN, PORTUGAL AND BRITISH ISLES

The Committee considered SC/28/Rep 2 which estimated 1921 population size at 10,567 already reduced by extensive prior removals (3,209 in 1906–14). Lack of trend in catch/effort data in the period 1950 to present precludes assessment of current stock size and lack of accurate data on species composition of the catch precludes detailed determination of the level of recent removals. Removals in 1950–73 appear to have been in the order of 19–152.

Sei and Bryde's whales

SEI WHALES

The Committee considered catch statistics for the Icelandic fishery which is the only significant sei whale fishery in the North Atlantic. It was noted that the catches in the last 5 years were much greater than those of the preceding 15 years, which could indicate an increase in effort in the recent period. Rørvik expressed the view that availability of sei whales was very variable from season to season, and could be affected by environmental conditions. Ohsumi said that more research on the component of the stock outside the range of the coastal operation was needed to supplement estimations of abundance derived only from coastal operations. The only available evidence on population size of North Atlantic stocks was an initial estimate of 870 to 2,248 for the Nova Scotian area where removals were 825 between 1966 and 1972 (IWC Sci. Rep. 1976, p. 79).

BRYDE'S WHALES

No catch data or biological data were reported.

Minke whales

The separation of the minke whale population into four stock units, as described in Annex K, was adopted by the Committee. These are defined by the areas:

1. The Canadian east coast.
2. The West Greenland area.
3. The East Greenland – Iceland – Jan Mayen area.
4. The region from Svalbard, the Barents Sea, along the Norwegian coast, including the Skagerak, the North Sea and other areas around the British Isles.

1. CANADIAN EAST COAST

The only data available to the Committee were biological studies already published (*J. Fish. Res. Bd Can.*, 20: 1489–504 and 32: 985–94) which do not provide conclusive evidence on the situation of the stock formerly fished at Trinity Bay, Newfoundland. The average annual catch over the recent period of exploitation (ending in 1972) was 48 whales.

2. WEST GREENLAND AREA

Recorded landings by the Greenlanders averaged 227 per annum for the 10 years 1966–75 (Annex K Table 3) and Kapel estimated that there were non-recorded landings of about 10 per cent since the beginning of the expanded Greenlandic fishery in 1965. An average catch of 179 per annum was taken in Davis Strait by the Norwegian pelagic fleet in the short period between 1969 and 1975 inclusive.

Kapel pointed out that a drop in the Greenlandic catch in the last few years might reflect the expansion of the exploitation of the West Greenland stock since 1969.

3. EAST GREENLAND – ICELAND – JAN MAYEN AREA

The Committee considered Annex K which provides catch figures and a preliminary analysis of effort data. Recorded landings averaged 298 whales/yr 1961–75 and indications are that unrecorded catches in the early part of the period were in the order of 30/yr at Iceland. While available data do not show any decline in the population the Committee indicated the need to collect sightings data and biological data on the catch.

4. SVALBARD – NORWAY – BRITISH ISLES

There was much discussion on the accuracy of CPUE in the light of papers SC/28/Doc 3 and Annex K. With regard to the Norwegian stock Rørvik expressed the opinion that, despite the various factors complicating the calculation of effort, these factors remained fairly constant over the period of analysis for the months of May and June in which the majority of minke whales are caught (Annex K). However, it was agreed that further study of the monthly distribution of the catch by area would be beneficial.

The current exploitable population size is given as 20,000–40,000 in Annex K; many members have reservations on the accuracy of the estimate because of its dependence on questionable effort analyses; and Mitchell has reservations regarding the assumed stability because of the absence of corrections for effort on the other species (SC/28/Doc 30) in the multi-species fishery.

11.3 Sperm whales

The only population estimate available was that considered previously by the Committee (IWC 23) indicating a present stock size of 22,000 of both sexes and all ages. There remains uncertainty as to the relation of this estimate to initial population levels in view of the intensive 19th century fishery. There is no available evidence to indicate the presence of separate stocks.

The species is presently exploited off Spain, Madeira, Azores and Iceland (and recently by Canada to 1972 and Norway to 1971) the total annual catch averaging 685 (1969–73 inclusive). The Committee was informed that Portugal intends to initiate analyses of data from the Azores fishery. It notes the importance of such analyses and looks forward to receiving reports from Portugal.

11.4 Arctic

The Committee considered information on bowhead whales under agenda item 11.5.1.

11.5. Currently protected species

11.5.1. Bowhead whales

The Committee had available reports on studies of bowhead whales in Alaska in 1975 (SC/28/Doc 16) and 1976 (SC/28/Prog Rep 11). They included new information on the numbers of whales killed, killed but lost, and struck but lost. There was evidence for an increased effort. The initial size of the stock and its present condition are still unknown. The Committee most strongly urges that this situation be rectified and recommends:

(1) a thorough examination of early whaling history including inspection of log books to provide information on past population levels;
(2) marking studies to help assess mortality rates of struck but lost whales;
(3) assessment of current population status;
(4) collection and compilation of better information on sex, length, maturity and age of captured whales.

The Committee strongly recommends that necessary steps be taken to limit the expansion of the fishery and to reduce the loss rate of struck whales (without increasing total take). Effort may also be increasing in the Canadian Arctic with one bowhead recently taken and two other captures attempted (SC/28/Prog Rep 3)

Right whales

NORTH PACIFIC

The Committee reviewed sightings data given in SC/28/Doc 29 in which no trends were evident. Ohsumi mentioned that the research area for sightings was shrinking as a direct result of the shrinking of the area of commercial operations, scouting vessels being used for sightings.

NORTH ATLANTIC

No sightings data were available. The Committee requests that a compilation of data on sightings off Cape Cod be analysed in the hope of developing population estimates.

SOUTHERN HEMISPHERE

Papers SC/28/Doc 4 and SC/28/Doc 17 were available to the Committee. There is evidence that the stock off South Africa is increasing. SC/28/Doc 4 gave a population estimate of 4,765 animals in Antarctic Areas II to VI, based on an extrapolation of sightings data for the South African coast by incorporating Japanese sightings data. Best expressed the view that, for sightings data used in abundance estimates, it was important to seek out areas of high density such as the breeding areas.

SC/28/Doc 17 gave data on sightings, and an estimate based on average sighting abundance of whales south of 30°S in summer was 3,806 animals.

It was indicated that Brazilian legislation prohibits the capture of right whales and that there is therefore no intention to initiate exploitation in the near future. One stranded right whale was killed by coastal fishermen in 1972 and there are some records of captures in the earlier statistics. The Committee requests that the Commission seek further information from Brazil regarding these reports.

11.5.2. Blue whales

NORTH PACIFIC

Some evidence of recovery of the population up to the early 1970s was given in SC/28/Doc 29 which reviewed Japanese sightings from scouting vessels. However, there was no current information available for the main summer areas of distribution because of a shift in the scouting grounds.

NORTH ATLANTIC

Recent strandings on the west coast of Newfoundland were noted (SC/28/Prog Rep 3) and Mitchell indicated that such mortality related to ice-entrapment may be substantial in relation to the local population size. Sightings records are being maintained in Iceland. It is hoped to check the incidence of multiple sightings of individual animals by marking with a visible streamer mark.

SOUTHERN HEMISPHERE

SC/28/Doc 4 and SC/28/Doc 17 provided information on sightings. The apparent density of blue whales off Natal was lower in 1975 than in most previous years, but no trend in abundance was evident; no data on sightings had been received from spotter aircraft, in contrast with previous years.

Ohsumi explained that sightings data for Area V Series D given in Tables 5 and 19 of SC/28/Doc 17 included both blue and pygmy blue whales. The Committee noted that the distribution of the pygmy blue whale would make stock management relatively simple by restriction on location of operation, in the event of a future fishery. However, the Committee felt that it was not in a position to reassess the status of a possible sub-species for the purpose of calculating population sizes, and that pygmy blue whales should continue to be included in blue whale stock assessments.

11.5.3. Humpback whales

NORTH PACIFIC

The Committee considered SC/28/Prog Rep 11. Censuses indicated a minimum of 61 animals summering in the inside waters of Southeastern Alaska and 373 animals wintering around the main Hawaiian Islands; none were seen in the Leeward Hawaiian Islands. Colour phase frequencies were interpreted in the report to indicate that animals in the two areas above belong to different stocks.

SC/28/Doc 29 indicated no trends in abundance based upon sightings by Japanese scouting vessels.

NORTH ATLANTIC

SC/28/Prog Rep 7 reports sightings in the Barents Sea and off East Greenland; no trends in abundance are evident.

Sightings records are being maintained in Iceland. It is hoped to check the incidence of multiple sightings of individual animals marked with a visible streamer mark. The take of humpback whales in Greenland has been higher during the last three years than previously. Kapel indicated that this may be evidence of increasing availability of this species in the coastal waters of Davis Strait.

Mitchell reported that mortality from entanglement in nets around Newfoundland, strandings on the US East Coast, possibly due to damage by ships and other fishing activities, and the continued small take in the Caribbean, taken together with increasing kills in West Greenland, might represent removals in the order of the sustainable yield from the NW Atlantic population.

SOUTHERN HEMISPHERE

SC/28/Doc 17 gives sightings data, and an estimate of average abundance of 4,170 animals in the area south of

30°S. No trend in abundance is shown. There were fewer sightings reported off Natal in 1975 than in previous years (SC/28/Doc 4). The reasons for this were not clear.

11.5.4. Gray whales

The Committee noted that current estimates of the MSY of the Californian stock are about 250 animals. The aboriginal catch taken by the USSR has a domestic quota of 200 animals, and the catch has reached 194 animals in the past. A few animals (up to 5) are also taken annually by St Lawrence Island eskimos. This means that almost 80% of the MSY may be taken by aboriginal fisheries in a given year. The Committee therefore recommends that no commercial whaling should be permitted on this stock and that the species should remain in the protected category.

Because of the problems outlined in SC/28/Doc 33, the Scientific Committee recommends that the Commission request IWC North Pacific countries to continue current research (shore counts from Monterey) and to expand research efforts to investigate the following:

(1) possible changes of the migratory route off Southern California;
(2) the mortality of calves in the lagoons;
(3) changes in distribution of whales related to human activities;
(4) application of whale marking (using the Discovery mark), external tagging, and radio tagging with a view to the possibility of the marked whales being recovered in the Soviet fishery on behalf of the Siberian aborigines.

The Scientific Committee recommends that the Commission request that the US and Mexican Governments establish regulations to reduce harassment of whales in all the breeding areas. The Committee notes with concern the possible effects on the gray whale of petroleum development on the continental shelves of the United States including the Gulf of Alaska and the Bering Sea.

The Scientific Committee recommends that the Commission request the US to analyse the loss rate from the shore whaling stations which operated on the coast of California and Baja California between 1854 and 1886. These data will be invaluable in refining estimates of the initial population size. The Committee recommends that the United States provide a summary of progress in this regard at the next meeting of the Scientific Committee.

12. CATCH LIMITS AND OTHER REGULATORY MEASURES (COMMISSION AGENDA – ITEM 9)

The classification of the stocks and the recommended catch limits are summarized in Annex G.

12.1 Southern Hemisphere baleen whales

12.1.1. Fin whales

All evidence examined by the Committee indicates that the stock in Area I is depleted and requires re-classification as a Protection Stock. Areas II, III, IV, V and VI remain in the classification Protection Stock.

12.1.2 Sei and Bryde's whales

SEI WHALES (see 11.1.1)

BRYDE'S WHALES

The Scientific Committee recommends classification of Bryde's whales in the Southern Ocean as an Initial Management Stock. In view of the absence of new data the Committee repeats the view expressed in its 1975 report (IWC/27/4) that additional exploitation of this species in the whole Southern Hemisphere should not be undertaken until satisfactory estimates of stock sizes have been obtained, and therefore the northern limit for pelagic operations on this species in the Southern Ocean should not be extended for the present. In accordance with this principle, catches from the land stations should not be increased.

12.1.3. Minke whales

The Committee noted the report of the sub-committee on Southern Hemisphere minke whales (SC/28/Rep 12) which recommended that all Areas should continue to be classified as Initial Management Stocks (assuming MSY stock level equal to 60% initial stock level). It concurred with this recommendation for Areas I, II, III, V and VI. For these Southern Hemisphere Areas, the Committee adopted the rule that 5% of initial stock size would provide safe catch limits, giving the following results:

I	965	V	1385
II	1855	VI	365
III	2730		

As a result of the changed estimates of minke whale stocks, the Area IV stock is recommended to be reclassified as an Initial Management Stock. According to the guidelines adopted by the Committee at its 1975 meeting the catch limits of Area IV should not exceed 5% of the initial stock size or 1,830. However, it was pointed out by some Committee members that the Area IV stock is very close to the Sustained Management classification and, in view of the uncertainties, they would prefer the Commission to be conservative and recommend a catch limit according to the guidelines for a Sustained Management Stock. In this case the catch limit would be 90% of 7% of the MSY level (22,000) or 1,386. This is based on the assumption that for minke whales the proportion of the yield available at MSY level is the same as used in 1975 on the same ratio between recruitment rate and natural mortality rate as in fin whales. This assumption will require further consideration in the future.

The Committee agreed that similar steps might have to be taken for each of the Areas as they were estimated to approach MSY level, which in the case of some Areas might occur within five years.

The Committee noted that as the minke whales in Area IV are very close to the Sustained Management level, grouping this catch Area with others by the Technical Committee could result in bringing the stock down very rapidly. Many members of the Committee recommend that the Commission should exercise caution in setting any allowance for catch by Area. Some members felt that no allowance should be allowed for the minke whale in Area IV and some members felt the matter of allowances was strictly a matter to be considered by the Technical Committee.

12.2 Southern Hemisphere sperm whales

The Committee draws the Commission's attention to the fact that the grouping of Divisions resulted in catches above the recommended quotas in several Divisions (Annex H). The Committee recommends that future quotas be set by nine Divisions in accordance with the Scientific Committee's recommendations. The quotas calculated, both on the basis of maximising yield in weight and maximising yield in numbers, are given in the table shown under agenda item 11.1.2.

In response to a request from the Commission the Committee subsequently examined the effects of a method of calculating quotas for Initial Management Stocks of male sperm whales proposed by the Japanese delegation. Under this proposal the catch limit would be the MSY plus 10% of the amount by which the existing stock exceeds the MSY level. On the basis of calculations made by Allen (SC/28/Doc 48) the Committee advises the Commission that the effect would depend on the level of the mature female as well as of the exploitable male stock. If the same model and the same parameter values are used as were employed in calculating the recommendations above, the results are as follows.

If the female stock were kept steady at the unexploited level, the male stock would take about 31 years to decline from unexploited level to the Sustained Management category. During this time the catch limit would decline from 566 to about 290 per 10,000 mature females. For the same female stock under the present schedule, the male stock would ultimately stabilise at about 70% above MSY level, and the catch limit would be constant at 140 per 10,000 mature females.

On the other hand if the female stock were kept steady at the MSY level the time to Sustained Management level for the males under the Japanese proposal would be 16 years with a catch limit again declining from 566 to about 200 per 10,000 mature females in the unexploited stock. In this case, under the present scheme the male population would stabilise very close to the top of the Sustained Management category, and the quota would of course be steady at 140.

On the basis that current estimates of population size in the various Division are assumed to be correct the time to reduce the male stock to the Sustained Management category if the female stock were kept at its present level would be

Division	1	2	4	6	8
Years	8	14	5	7	30

The very short period for Division 4 is the result of the female stock in this Division being already below MSY level.

12.3 North Pacific

12.3.1. Fin whales

The classification of this stock remains Protection Stock.

12.3.2. Sei and Bryde's whales

Sei whales

The classification of this stock remains Protection Stock.

Bryde's whales

The North Pacific Bryde's whale is still an Initial Management Stock. A safe harvest limit would still be 5% of the initial stock estimate, i.e. 1,000 whales.

12.3.3. Minke whales

The Committee noted the need for consideration of data on stock relationships and detailed landings statistics before recommending appropriate management action for the Western Pacific stocks. Western Coastal Areas are:

(1) Sea of Japan, Yellow Sea, and East China Sea,
(2) the Pacific side of the Japanese Coast.

These stocks should be classified as Sustained Management. There should be no increase in the coming year in recent catch levels for these stocks. The Committee points out that a non-member nation (Korea) is also involved in the fishery. All other areas in the North Pacific should be classified as Initial Management with a zero quota.

The highest recorded catch in the post-war years was 541, in 1973, by Japan. However, the catch by the non-member nation, Korea, was 882 in the same season. The Committee recommends that in setting quotas for the North Pacific, the Commission should not exceed the level of maximum recorded catch by Japan, i.e. 541 whales, on the understanding that this is the quota for the coming year only and that the matter will be reviewed at the next meeting.

12.3.4. Sperm whales

The calculations indicated that both sexes should be classified under the category of Initial Management Stock with quotas (90% of MSY) indicated being 4,320 males and 2,880 females.

12.4 North Atlantic

12.4.1. Fin whales

North Norway

It was noted that the stock is not currently exploited. There are not sufficient data available this year on which to classify this stock. The Committee recommends that, should whaling recommence, removals should be held at the level of the catches in the years 1948–71 (61/yr) and that more detailed analyses of past catch/effort and sightings data be conducted.

East Greenland – Iceland

In the absence of new information on the current stock level the stock should be classified as a Sustained Management Stock. The Committee recommends that the average annual catch be limited to the previous annual average of 254 whales. The Committee recognised the difficulty of maintaining average catch levels by a fixed annual quota set at, or somewhat above, the past average catch. It therefore recommends a quota system for 6-year periods with a catch limit of 6 x 254 = 1,524 whales. There are two alternative possibilities with approximately the same effect on the stocks and on the average catches; these are a block quota and a rolling quota. A block quota would mean that a catch limit of 1,524 whales is set for the period 1977 to 1982 inclusive. In order to prevent excessive catches in any one year the Committee recommends that in no year the catch should exceed 254 + 50 = 304 whales. The alternative possibility, a rolling quota, would mean that the quota for each year would be calculated as 1,524 whales minus the catches in the preceding five years. In this case the quota for 1977 would be 1,524 minus the catch in 1972–75 (1,035 whales) minus the 1976 catch. Some aspects of the two alternative methods are described in section 10.3 of this report.

Western Norway and Faroe Islands
The Committee continues to classify the stock in the Protection category.

Spain, Portugal and British Isles
The Committee does not have sufficient data on current stock size to enable classification. It points out that it is exploited by non-member nations only and suggests the need to request details on the catch.

Newfoundland – Labrador
The updated assessment (SC/28/Doc 37), in accordance with the model which was used in assessing the relation to MSY level and yield in 1975, indicated that the stock has reached 122% of MSY level and should thus be re-classified as an Initial Management Stock. The maximum catch which should be permitted is 90% of MSY which is 90.

Nova Scotia
The updated assessment (SC/28/Doc 37), in accordance with the model which was used in assessing the relation to MSY level and yield in 1975, indicated that the stock is presently at 64% of MSY level and should thus remain in the Protection category.

West Greenland
The Committee lacks sufficient data on which to base a classification of this stock.

12.4.2. Sei and Bryde's whales

Sei whales
In the absence of assessment data on sei whales in the Icelandic and Denmark Strait area the Committee recommends that the catch be limited to the average catch of the past five years, i.e. 132 animals. Mitchell, however, cited an estimate of 965 sei whales in the Labrador Sea in spring (May-June) based upon a strip census (IWC Sci. Rep., 1976, p. 79 and map, p. 176). He suggested that this may represent part or all of the stock migrating in late summer to Denmark Strait and fished by Iceland; he argued for a more conservative catch limit.

The Nova Scotian Stock should be classified as a Protection Stock.

Bryde's whales
There are no recorded catches of Bryde's whales presently being taken in the North Atlantic.

12.4.3. Minke whales

1. Canadian East coast
The Committee tentatively assigns the stock to the Sustained Management category and recommends that the annual catch be held at levels of the most recent period of local exploitation, i.e. 48 whales.

2. West Greenland area
A definite conclusion on the status of the stock was not possible. There were two opinions expressed on the level of landings which should be permitted:

1. 227–250/annum which represents the average Greenlandic landings 1966–75;
2. 406–429/annum which includes landings from the Norwegian pelagic fleet.

The Commission may decide to apply a rolling quota.

3. East Greenland – Iceland – Jan Mayen
The Committee tentatively assigns the stock to the Sustained Management category and recommends that the annual catch be held at levels of the average over the past 15 years, i.e. 320 whales/yr. The Commission may wish to consider application of a rolling quota to management of this stock.

4. Svalbard – Norway – British Isles
Although reservations remain on the validity of CPUE statistics, the East Atlantic Stock appears to be in a stable state. The Committee recommends that the stock be classified as a Sustained Management Stock, and the 1977 catch should not exceed the average of the catches during the past 10 years. This would indicate a quota of 1,790 whales.

12.4.4. Sperm whales

The Committee recommends that the North Atlantic sperm whales be classified as a Sustained Management Stock. In the absence of detailed analyses of parameter values the Committee recommends that the catch should be stabilized at current levels, i.e. an average of 685 animals per year, and reminds the Commission that the greater part is taken by non-member nations.

12.5 Sperm whales: need for closed season

The Committee discussed SC/28/Doc 39 which proposed a maximum length limit. Concern was expressed that the current taking of large 'harem master' bulls might significantly reduce pregnancy rates. An alternative proposal considered was a closed season during the breeding season. In the Southern Hemisphere conception is known to occur primarily within the period November to January.

Most members of the Committee recommend that, in the Southern Hemisphere, the Commission should designate a closed season of preferably 5 but not less than 4 months (i.e. October to February, or October to January) in the Southern Hemisphere north of 40°S. If this is unacceptable, an upper size limit of 45 ft should be imposed north of 40°S during these 5 or 4 months. In either case no closed season south of 40°S would be needed. The distribution of females in the North Pacific is not so clear cut as in the Southern Hemisphere and the Committee decided to defer setting a closed season or geographical limits until next year when more data will be available. Japanese members considered that the present quota regulation affords sufficient protection to the stocks. Soviet representatives noted that neither the sperm whale meeting (March 1976) nor the Scientific Committee meeting received results of any definite observations or investigations which would corroborate the unfavourable effect of whaling on the social structure of sperm whales in the temperate zone of the ocean. Taking of lactating females is strictly prohibited and the incidental catch cannot affect the lactation of calves. They further noted, there have been no indications on the changes of the reproductive capacity of males or reduction of the pregnancy rate of sperm whale females caused by whaling operations. Therefore, they feel there is no scientific basis for taking conservation measures with regard to sperm whales in the temperate zone of the ocean.

However, since these aspects of the problem (para 8, Annex J) have arisen it appears necessary to envisage these investigations for the remaining period of the decade of research, so that on the basis of the new materials all the possible aspects could be considered, and scientifically based recommendations made.

12.6 Conversion to metric measurements in the Schedule

The Committee recommends no change in current procedures

12.7 Protected species

Blue, humpback, right and gray whales should continue to be Protection Stocks.

13. OPENING AND CLOSING DATES FOR ANTARCTIC SEASONS 1976–77

The Committee sees no reason for changing the present dates.

14. SMALL CETACEANS

14.1. Status of Stocks

The status of stocks was considered by the standing sub-committee on small cetaceans (See Annex L). The Scientific Committee's attention was drawn to item 5 of recommendations concerning research in Annex L, where the Secretariat and governments of member nations of the Commission are urged to undertake research on the status of stocks affected by direct fisheries, and listed below:

1. Northern bottlenose whale *(Hyperoodon ampullatus)*, N Atlantic.
2. Striped dolphin *(Stenella coeruleoalba)*, NW Pacific.
3. Dall's porpoise *(Phocoenoides dalli)*, NW Pacific
4. Harbour porpoise *(Phocoena phocoena)*, N Atlantic.

This recommendation was accepted by the Scientific Committee (see agenda item 14.2 below).

In addition to Annexes K and L, SC/28/Docs 12, 13, 24, 30, 32 40 and 41 contained information relevant to the bottlenose whale in the N Atlantic. Two views (a and b, below) were discussed by members of the Scientific Committee during the meetings of the working group on North Atlantic whales and the standing sub-committee on small cetaceans regarding the status of the northern bottlenose whale:

(a) The early history of bottlenose whaling clearly shows that catch per vessel is sensitive to changes on the stock size (L. 23, Fig 5). If bottlenose stocks became depleted in the period after the Second World War this would be expected to have been reflected in decreasing catch per vessel. However, such a decline did not occur in 1946–1962 when the grounds off Spitsbergen and to some extent the Norwegian coastal areas were important. In the period 1963–1968 when the grounds between Iceland and Jan Mayen (which are nearer port than Spitsbergen, see SC/28/Doc 40) were important, catch per vessel shows some decrease (L. 23, Tables 1 and 6).

In the years 1969–1971 the Labrador grounds were the important grounds. Average catch per trip was 46.2 in 1969, 37.4 in 1970, 37.8 in 1971 (SC/28/Doc 40). This indicates a decrease in stock size, but no depletion. The expansion westward to Labrador was made by the larger vessels entering the bottlenose fishery in the late 1960s (L.23, Table 5 SC/28/Doc 40). A trip to Labrador would be economically profitable if the availability of bottlenose was 75% higher than on the North East Atlantic ground which may very well have been the fact without a depletion on the old grounds (SC/28/Doc 40).

The minke whale fishery is basically a single species fishery. Bottlenose occur on other grounds than the minke, and the opportunity for the boats to catch and store the meat from minke and bottlenose on the same trip is limited.

Bottlenose whaling stopped after 1972 because of:

1. The loss of the market for petfood in England from 1972.
2. The loss of market for animal food in Norway due to the availability of less expensive food from other sources than whale meat.
3. The increasing relative value of minke whale (L.22).

(b) The Scientific Committee had before it a number of papers giving data (SC/28/Docs 30; 13; 40; 41) and analyses (SC/28/Docs 12; 32) for the N. Atlantic bottlenose whale. One analysis (L. 23) contained errors of calculation which there was no time to correct during the meeting. Another analysis indicated that the bottlenose stock, at least from west Greenland eastwards had been reduced to 30% of its initial value of 130,000 in 1885 by 1913 (SC/28/Doc 32).

From this residual stock an average annual catch of 190 was taken in the period 1914–1927 and the stock seems to have declined further. The average annual catch thereafter was 50 whales until 1966; it is not clear if in that period, under reduced pressure the stock began to recover, and if so to what degree. Further analysis of existing data including resolution of questions raised in the Committee about whether the catch per unit effort data provided give a good index of relative abundance (SC/28/Docs 29; 26) may throw light on this matter, but for the time being the analysis provided suggested that extreme caution should be exercised in considering whether or not to permit further exploitation of this species.

Because of the above some members of the Scientific Committee feel that due to the past heavy exploitation, susceptibility to continued exploitation within the pelagic minke whale fishery, and current poor knowledge of initial and present stock size, the northern bottlenose whale should not be subjected to any further exploitation before a thorough analysis of its present status is carried out. For these reasons they recommend that the northern bottlenose whale *(Hyperoodon ampullatus)* be listed in the Schedule of the IWC and classified as a protected stock.

The Scientific Committee will discuss next year the status of the northern bottlenose whale. The above statements of the two opposing views were asked for by the full Scientific Committee.

14.2. Recommendations for Management and Conservation

The Committee had available the draft report of the Standing Sub-Committee on Small Cetaceans (Annex L) which met on 7 to 9 June. Recommendations by the Scientific Committee following on the ten specific recommendations in the Sub-Committee Report (Section 7) are as follows:

1. Accepted.
2. The Committee brings paragraph 1 to the Commission for attention by its working group on redrafting the Convention and brings paragraph 2 to the immediate attention of the Commission.
3. This recommendation is dealt with under agenda item 10.1 of this report.

4. The Committee supports the recommendation and suggests that the Commission requests the Secretary to take the necessary action to ensure implementation.
5. Accepted.
6. Noted with no further action.
7. Accepted.
8. The Committee accepted the recommendation with inclusion of studies on male reproduction.
9. Accepted.
10. Deferred.

15. DATA COLLECTION

15.1 Review of the arrangements for exchange of data and for collection by a central agency. Continuation of stock assessment work and sources of stock assessment advice.

Chapman reported to the Committee on the work of Breiwick during the past year (SC/28/Rep 18). Partial computer tapes of basic data, forwarded by Vangstein of the Bureau of Whaling Statistics, Sandefjord, to Breiwick, were worked on in Seattle, under the direction of Chapman but completion of the project was delayed pending receipt of additional tapes. The Committee requests the Secretary to recommend that Breiwick continue this work, funded by the Commission on a contract basis, and set up a data store on tape under Chapman. The Secretary explained that this contracting out was presently necessary because of difficulties over access to computer facilities, although he recognised that the central data store should eventually reside in the office of the Commission.

The Committee emphasises the desirability of an early visit by the Secretary, accompanied by an expert in data processing, to the Bureau of International Whaling Statistics in order to examine the nature of data held and to assess the feasibility and methods of setting up a system for rapid access to these data.

The Committee decided that at future meetings. computer facilities for retrieving these data would need to be available. A Sub-Committee was appointed to prepare a report on these matters and to review the data priorities set out in Annex N, IWC Sci. Rep. 1976.

The Scientific Committee recognized the need for a review and analysis of early log books from the sperm whale fishery. The Committee recommended that the Commission request the Secretary to approach the US and other countries to assist in such analysis.

15.2 Collection of additional statistics

Recommendations concerning large whales are made under the appropriate species headings.

Recommendations on the collection of additional statistics for small cetaceans are discussed in the report of the Standing Sub-Committee on Small Cetaceans (Annex L).

16. REVIEW OF REPORTING REQUIREMENTS

The Scientific Committee recognized the need for the systematic collection of data from all whalers, not only the factory ship operations described in the current Schedule. The Scientific Committee recommends that the Commission consider changing the Schedule to include all land stations and ship operations in small type whaling (Annex L), such as the North Atlantic minke whale fishery. The Scientific Committee also urges that the Commission consider including the needs for data as outlined in the reports from the Oslo (Annex K) and the small cetacean meetings (Annex L).

A Sub-Committee consisting of Brownell, Mitchell, Kapel, Ohsumi, Rørvik, Christensen and Jónsson recommended the following amendments to the Schedule, and these are now recommended to the Commission. The Scientific Committee notes that "small-type whaling" is that described by Ohsumi *(J. Fish. Res. Bd. Can.* 32(7): 1111-21).

VI. Information required

21. '(d) A record similar to that described in sub-paragraph (b) of this paragraph shall be maintained by "small-type whaling" operations conducted from shore or by pelagic fleets, and all of this information mentioned in the said sub-paragraph shall be entered therein as soon as available.'

23. (para. 1) (c) 'Particulars with respect to each whale treated in the factory ship, land station, and "small-type whaling" operations as to the date and approximate latitude and longitude of taking, the species and sex of the whale, its length and, if it contains a foetus, the length and sex, if ascertainable, of the foetus.'

23. (para. 2) (b) '(v) Any modifications of the above measures or data from other suitable indicators of fishing effort for "small-type whaling" operations.'

17. EFFECTS OF POLLUTION ON WHALE STOCKS, INCLUDING SMALL CETACEANS

The Committee received no information for large cetacea. Document L. 10, presented to the Sub-Committee on Small Cetacea, June 1976, contained information on toxic substances in tissues of pygmy sperm whales.

18. HUMANE KILLING OF WHALES

The Committee considered a document (Sc/28/Rep 4) prepared by the Secretary in the form of responses by member nations to enquiries regarding new developments in the efficiency and technique of killing whales and another by Ohsumi (SC/28/Doc 31) on death-times of fin, sei and minke whales. A Sub-Committee of two (Best and Brownell) was appointed to study these documents.

1. (a) It appeared (without field testing) that at least one drug, Etorphine Hydrochloride (M 99), exists which is potent enough and has a wide enough therapeutic index to be suitable for anesthetising large cetaceans.
   (b) There are two main questions regarding its use:
      (i) the ability of the animal to float, when anesthetised, can only be determined by field experimentation
      (ii) the acceptability to health authorities of products from an animal to which this drug had been administered, would need to be investigated. It was noted that, in the UK, an animal treated with a non-lethal dose of M 99 may not be slaughtered for 7 days to allow excretion of the drug.

2. The Committee considers that criteria ought to be established for judging the humaneness of the killing. In its opinion, the rapidity with which the whale is rendered unconscious and killed is the most important factor, both from the humane and a commercial point of view. Given the death-times recorded in some areas for sperm whales by

Best (SC/26/24) and for baleen whales by Ohsumi (SC/28/Doc 31), the Committee is uncertain whether administration of a drug would bring about unconsciousness in a significantly shorter time than the use of an explosive harpoon.

3. The need was expressed for some alternative to the use of a "cold grenade" for killing minke whales. It is understood that trials with the use of CO_2 gas as a method of euthanasia in animals are being considered in the USA. However, several members of the Committee commented that such experiments has so far been restricted to sharks, and that the effectiveness of the technique was due to explosion of a CO_2 gas cylinder within the body cavity and not the toxicity of the gas. The method of action of this technique was compared to the current use in some fisheries of a compressed air hose to kill harpooned whales. Some question was raised as to whether CO_2 gas might deleteriously affect the meat quality.

The Committee recommends to the Commission that:

1. The Secretary should contact health authorities in UK, USA, Japan and other member nations to determine their regulations concerning the use of chemical methods of slaughter and subsequent processing.
2. The Secretary should contact member nations taking minke and other small whales and ask them what methods are used at present to secure and kill them.
3. The Secretary should contact the US Government with regard to experiments on the application of CO_2 gas as a method of euthanasia.
4. The Secretary should contact member whaling nations to enquire whether research into the use of high velocity projections for speeding death times is being considered.

Finally, the Committee noted, with concern, the absence of any response from the USSR and Japanese Governments to the Secretary's request for information.

19. EDITORIAL POLICY

A Sub-Committee was set up to develop recommendations for the future policy for the scientific publications of the Commission and to examine the question of which of the documents of the present meeting should be included in the published report. Its recommendations (Annex I) were adopted by the Committee, and those concerned with policy aspects of publication were incorporated in the Rules of Procedure adopted under Item 6, and appear as section 6 of those Rules.

20. FUTURE MEETINGS AND NEED FOR SPECIAL STUDIES

The Committee agreed that there was no need for any special meetings before the next annual meeting.

Regarding special studies, the Committee recommends that member nations taking sperm whales provide data on biological parameters, at least for females in Divisions 4 and 9 where the stocks are currently at low levels. Detailed research is requested on age determination of minke whales off Norway, fin and sei whales off Iceland, and minke and sei whales off Brazil. It was noted that extensive data on age composition of the catch would allow assessment to be made independent of effort data.

It was agreed that the Chairman, Vice-Chairman and Secretary should consult and seek the views of members on the items which should be given priority at the next meeting of the Committee. A subsequent meeting of the convenors of the Standing Sub-Committee proposed a list of names for membership of the Sub-Committees and framed outline plans for their method of working (SC/28/Rep 15)

21. ELECTION OF OFFICERS

K. R. Allen and J. L. Bannister were elected Chairman and Vice-Chairman for the ensuing year. The following convenors of Standing Sub-Committees were elected:

Mathematical	M. F. Tillman
Sperm whales	J. L. Bannister
Northern Hemisphere Baleen whales	S. G. Brown
Southern Hemisphere Ballen whales	S. Ohsumi
Small Cetaceans	R. L. Brownell

22 RESOLUTION IN APPRECIATION OF THE WORK OF THE RETIRING SECRETARY

The Scientific Committee unanimously concurs in recommending to the Commission that Reginald Stacey be designated Secretary Emeritus. This newly created position requires that the Secretary Emeritus attends, at his pleasure, all appropriate meetings, receptions, dinners and other official and non-official functions, of the IWC. The Secretary Emeritus will serve without financial remuneration and shall not be provided with any voting authority. The freedom imposed by these latter restrictions will permit the Secretary Emeritus to fulfill all requisite and non-requisite duties free of bias and other onerous burdens.

The Committee would also like to record on this last occasion before the setting up of the new secretariat, its appreciation of the support services provided during this and earlier years by the secretariat loaned on a part-time basis by the MAFF staff of the UK.

Annex A

Agenda

1. Chairman's remarks
2. Appointment of rapporteurs.
3. Adoption of Agenda.
4. Arrangements for meeting
5. Exchange and review of documents.
6. Rules of Procedure
7. FAO/ACMRR Working Party on Marine Mammals (Commission Agenda–Item 7).
8. International Decade of Cetacean Research–Research Proposals (Commission Agenda–Item 3).
9. Research and information
    - 9.1 Progress reports, including reports relative to special permits.
    - 9.2 Progress of whale marking and whale mark recoveries. Commission's contribution to whale marking.
    - 9.3 Reports of previous season's catches.
    - 9.4 Data analyses and reports of national groups.
    - 9.5 Sighting programme. Data reports from 1975–6 season and analyses of data.
    - 9.6 Reports of special meetings
        - 9.6.1 Sperm whales
        - 9.6.2 North Atlantic whales
        - 9.6.3 Small Cetaceans
10. Classification of whale stocks (Commission Agenda–Item 8)
    - 10.1 Recommendations on Criteria.
    - 10.2 Alternative formulae for determining quotas.
    - 10.3 Use of effort limitation for North Atlantic fin whales.
11. Status of stocks relative to criteria
    - 11.1 Southern Hemisphere.
        - 11.1.1 Baleen whales
        - 11.1.2 Sperm whales
    - 11.2 North Pacific
        - 11.2.1 Baleen whales
        - 11.2.2 Sperm whales
    - 11.3 North Atlantic
    - 11.4 Arctic
    - 11.5 Currently protected species
        - 11.5.1 Right and Bowhead whales
        - 11.5.2 Blue whales
        - 11.5.3 Humpback whales
        - 11.5.4 Gray whales
12. Catch limits and other regulatory measures (Commission Agenda–Item 9)
    - 12.1 Southern Hemisphere baleen whales
        - 12.1.1 Fin whales
        - 12.1.2 Sei and Bryde's whales
            - 12.1.2.1 Catch limits
            - 12.1.2.2 Northern boundary for Bryde's whales
        - 12.1.3 Minke whales
    - 12.2 Southern Hemisphere sperm whales
    - 12.3 North Pacific
        - 12.3.1 Fin whales
        - 12.3.2 Sei and Bryde's whales
        - 12.3.3 Minke whales
        - 12.3.4 Sperm whales
    - 12.4 North Atlantic
        - 12.4.1 Fin whales
        - 12.4.2 Sei and Bryde's whales
        - 12.4.3 Minke whales
        - 12.4.4 Sperm whales
    - 12.5 Sperm whales; need for closed seasons (Commission Agenda–Item 9).
    - 12.6 Conversion to metric measurements in the Schedule (Commission Agenda–Item 9(b)).
13. Opening and closing dates for Antarctic season (Commission Agenda–Item 9(b) i (b)).
14. Small Cetaceans (Commission Agenda–Items 11 and 12)
    - 14.1 Status of stocks
    - 14.2 Recommendations for management and conservation
15. Data collection
    - 15.1 Review of the arrangements for exchange of data and for collection by a central agency. Continuation of stock assessment work and sources of stock assessment advice.
    - 15.2 Collection of additional statistics
        - 15.2.1 On large whales
        - 12.2.2 On small cetaceans
16. Review of reporting requirements–Minke whales in Northern Hemisphere (Commission Agenda–Item 10)
17. Effects of pollution on whale stocks, including small cetaceans.
18. Humane killing of whales
19. Editorial policy relative to publication of the Scientific Committee's reports and associated documents.
20. Future meetings and need for special studies.
21. Election of officers.

Annex B1

LIST OF DOCUMENTS

SC/28/Doc

1 ALLEN, K. R. Changes in catch and population for sustained managed stocks below MSY level.

2 ALLEN, K. R. and KIRKWOOD, G. P. Further development of sperm whale population models.

3 BERTRAND, G. A. Effort statistics in the North Atlantic minke whale fishery.

4 BEST, P. B. Status of whale stocks off South Africa, 1975.

5 BORODIN, R. G. Methods of the assessment of net recruitment and time of possible recovery of whale stocks to the MSY level.

6 BREIWICK, J. M. Analysis of the Antarctic fin whale stock in Area I.

7 CHAPMAN, D. G. Comparison of linear and step partial catch procedures for stock "near" but below the MSY level.

8 FUKUDA, Y. A note on quota determination for sustained management stock below MSY level.

9 FUKUDA, Y. A note on management of sperm whaling–operational constraint and target formulation.

10 HOLT, S. J. Estimation of sperm whale population sizes from changes in the mean size of whales in catches (IWC/SP/Doc 21).

11 HOLT, S. J. Questions about the sex ratio in catches of rorquals.

12 HOLT, S. J. The assessment of bottlenose whales. Critique of document L.23 by I. Christensen.

13 JONSGÅRD, Å. Maps showing the approximate localities where the different species of whales (vagehval = minke; bottlenose; spekkhogger = killer; grindhval = pilot) have been caught by Norwegian whalers in each of the seasons 1949–1975.

14 KAPEL, F. Preliminary data on the catch of whales in Greenland, 1975.

15 LOCKYER, C. A preliminary study of variations in age at sexual maturity of the fin whale with year class, in six Areas of the Southern Hemisphere.

16 MARQUETTE, W. M. National Marine fisheries service field studies relating to the bowhead whale harvest in Alaska, 1975. (National Marine Fisheries Service, Northwest Fisheries Center Processed Report, March 1976.)

17 MASAKI, Y. Japanese pelagic whaling and whale sighting in the Antarctic 1975–76.

18 OHSUMI, S. Further assessment of population of Bryde's whale in the North Pacific.

19 OHSUMI, S. Estimation of population sizes of the Southern Hemisphere minke whale at the initial and 1976–77 levels.

20 OHSUMI, S. Catch of minke whales in the coastal waters of Japan.

21 OHSUMI, S. and MASAKI, Y. Stocks and trends of abundance of the sperm whale in the North Pacific.

22 RØRVIK, C. J. Simulation of an exploited stock of fin whales.

23 TILLMAN, M. F. Estimates of stock size for the North Pacific Bryde's whale.

24 TILLMAN, M. F. and BERTRAND, G. Analysis of effort statistics from the early North Atlantic bottlenose whale fishery.

25 TILLMAN, M. F. and BREIWICK, J. M. Estimates of stock size for exploitable North Pacific male sperm whales.

26. UGLAND, K. I. On the bias caused by CPUE in the estimates of whale abundance.

27 VOLKOV, A. F. and MOROZ, I. F. Oceanological conditions of the distribution of cetacea in the eastern tropical part of the Pacific Ocean.

28 WADA, S. Progress report on the biochemical study for whale stock identification in Japan.

29 WADA, S. Indices of abundance of large-sized whales in the North Pacific in 1975 whaling season.

30 MITCHELL, E. Evidence that the northern bottlenose whale is depleted.

31 OHSUMI, S. A preliminary note on Japanese records on death-times for whales killed by whaling harpoon.

32 HOLT, S. J. Does the bottlenose whale have a sustainable yield, and if so, is it worth taking?

33 BROWNELL, R. Current status of the gray whale.

34 CHAPMAN, D. G. Summary of North Pacific sperm whale assessments.

35 HOLT, S. J. Assessment of Southern Hemisphere minke whales.

36 HOLT, S. J. Simulation of Southern Hemisphere sei whale stocks.

37 ALLEN, K. R. Updated estimates of fin whale stocks.

38 FUKUDA, Y. A comment on analysis of Area I fin whale stock.

39 MITCHELL, E. D. Sperm whale maximum length limit: proposed protection of "harem masters".

40 CHRISTENSEN, I., JONSGÅRD, Å. and RØRVIK, C. J. Some notes concerning the bottlenose fishery in the North Atlantic after the Second World War, with particular reference to the westward expansion.

41 CHRISTENSEN, I., JONSGÅRD, Å. and RØRVIK, C. J. Comments to SC/28/Doc 24, "Analysis of effort statistics from the early North Atlantic bottlenose whale fishery".

42 CHAPMAN, D. G. Additional consideration on Antarctic sei whale stocks.

43 HOLT, S. J. A theoretical basis for determining limits to the allowable catch when density dependence has not been estimated.

44 ALLEN, K. R. Comments on a stock recruitment relationship proposed in SC/28/Doc 43.

45 BORODIN, R. G. A further study of the stock condition of Antarctic sei whales.

46 VIALE, D. Big whales populations on the Atlantic coasts of Spain and Western Mediterranean.

47 OHSUMI, S and FUKUDA, Y. A note on the revised estimates of southern sei whale stocks

48 ALLEN, K. R. Comparison of existing and proposed quota systems for male sperm whales.

Annex B2

LIST OF REPORTS

SC/28/Rep

1 Report of the sperm whale meeting, La Jolla, California, 16–25 March 1976 (Annex J).
2 Report of the working group on North Atlantic whales, Oslo, 5–13 April 1976 (Annex K)
3 Report of the standing sub-committee on small cetaceans, London 7–9 June 1976 (Annex L).
4 Humane killing of whales.
5 Mammals in the Seas, *ad hoc* Group 1 on large cetaceans. Report Supplement 1. April 1976. (ACMRR/MM/SC/2 Suppl. 1).
6 Mammals in the Seas, *ad hoc* Group 1 on large cetaceans. Report Supplement 2. May 1976. (ACMRR/MM/SC/2 Suppl. 2).
7 Report policy IWC Scientific Committee–special meetings. (Annex C1).
8 Sperm whale statistics, Southern Hemisphere. (Annex H).
9 Report of Sub-committee to estimate stock size of North Pacific Bryde's whales.
10 Whale marking–progress report 1976.
11 Report of sub-committee on the status of the gray whale.
12 Report of sub-committee to estimate stock size of Southern Hemisphere minke whales.
13 Definition of new stock categories. (Annex E).
14 Report of the sub-committee on publication policy. (Annex I).
15 Report of meeting convenors of standing sub-committees.
16 Report of the sub-committee on rules of procedure for the Scientific Committee. (Annex C2).
17 Operations of the Scientific Committee. (Annex C3).
18 Report on Commission Contract for development of data base and routine computer analyses.

Annex B3

LIST OF PROGRESS REPORTS

SC/28/Prog Rep

1 Australia
2 Brazil
3 Canada
4 Denmark
5 Iceland
6 Japan
7 Norway
8 South Africa
9 United Kingdom
10 Union of Soviet Socialist Republics
11 United States of America

Annex C1

SC/28/Rep 7

REPORT POLICY IWC SCIENTIFIC COMMITTEE–SPECIAL MEETINGS

The Scientific Committee has held special meetings to consider specific problem areas and to provide reviews, or advice to the full Scientific Committee.

The following report policy is suggested for consideration as the regular requirements for all meetings, other than the regular annual session of the Scientific Committee such as special scientific meetings, working groups, sub-committees, etc.

1. The Chairman or convenor of the meeting will have the responsibility for issuing the meeting report.

2. A draft report will be prepared while the meeting is still in progress, or immediatley thereafter and circulated for review to the participants of the sessions.

3. If the draft report is prepared prior to the close of the meeting, changes by consensus will be made, with minority views included, as necessary.

4. If changes are made by correspondence, the Chairman of the session will be empowered to use his discretion to make requested changes. He is encouraged to include minority views which may surface for the first time in the editorial process–and to indicate that they were not subject to full discussion before the working group.

5. The Chairman will submit the edited report as the final report of the meeting to the Chairman of the full Scientific Committee for review and consideration by the Committee. Any new changes or comments regarding the report will be included as part of the report of the full Scientific Committee, with no changes in the sub-committee report to be allowed, except corrections that are acceptable to the participants in the original meeting.

6. Technical documentation used to reach conclusions expressed in sub-committee reports must be either attached (as in the case of working papers) or appropriately cited for further reference.

7. Two full sets of the working papers considered at special meetings must be deposited with the IWC Secretariat, one for the archives and one as a working set available to Scientific Committee members and others as may be decided.

Annex C2
SC/28/Rep 16

REPORT OF THE SUB-COMMITTEE ON RULES OF PROCEDURE FOR THE SCIENTIFIC COMMITTEE

A. Membership and Observers

1. The Scientific Committee shall be composed of scientists nominated by the Commissioner of each nation which elects, at the annual meeting of the Commission, to be represented on that Committee. The Secretary of the Commission shall be an ex-officio non-voting member of the Scientific Committee.

2. The Scientific Committee recognises that while FAO and UNEP are represented at the Commission's meeting by Observers their representatives attend the Scientific Committee as scientists with the status of advisers to the Committee. The representatives of other international organisations of similar scientific standing may also be given the same status in the Scientific Committee, subject to the agreement of the Chairman of the Committee, acting according to such policy as the Commission or the Scientific Committee may decide.

3. Observers may attend the meetings of the Scientific Committee, subject to the agreement of the Chairman of the Committee, acting according to such policy as the Commission or the Scientific Committee may decide.

B. Agenda

1. The initial agenda for the Committee meeting of the following year shall be developed by the Committee prior to adjournment each year. The agenda should identify as far as possible, key issues to be discussed at the next meeting and specific papers on issues be requested by the Committee as appropriate.

2. The provisional agenda for the Committee meeting shall be circulated for approval sixty days prior to the annual meeting and comments will be considered only if received by the Chairman 21 days prior to the begining of the annual meeting.

C. Organisation

1. The Scientific Committee shall include standing sub-committees by area or species, or other subject, and a standing sub-committee on small cetaceans. The Committee shall decide at each meeting on sub-committees for the coming year.

2. The sub-committees shall prepare the basic documents on the identification and classification of stocks, including biological parameters, initial and present stock size and catch limits using catch records supplied by the Secretariat, and related matters as necessary, for the early consideration of the full Committee.

3. The sub-committees, except for the sub-committee on small cetaceans, shall concentrate their efforts on stocks of large cetaceans particularly those which are currently exploited or for which exploitation is under consideration, but they may examine fishery matters in which both large and small cetaceans are taken or refer those matters as appropriate to the sub-committee on small cetaceans.

4. The Chairman may appoint other sub-committees as appropriate.

5. The Committee shall annually elect from amongst its members a chairman and vice-chairman at the conclusion of the annual meeting of the Commission. The vice-chairman shall act for the chairman in his absence.

D. Meetings

1. The Scientific Committee shall meet during the 10 days begining on Monday of the two weeks prior to the Annual Commission Meetings. The Thursday and Friday of the second week shall be available to the Secretariat for final preparation of the report of the Committee.

2. The sub-committees should meet during the first few days of the full Committee meeting; their progress should be reviewed at regular intervals, at plenary sessions of the full Committee. During those days there should be opportunity for generating ideas, production of papers by individuals and other reviews of data. It should be the aim of the sub-committee to complete its work and prepare reports for the full Committee by the end of the first week. Sub-committees, including sub-committees consisting of the full Committee, may meet on other occasions as necessary.

E. Scientific Papers and Reports

The following documents and papers will be considered by the Scientific Committee for discussion and inclusion in its report to the Commission:

1. Progress Reports. Each nation having information on the biology of cetaceans, cetacean research, the taking of cetaceans, or other matters it deems appropriate should prepare a brief progress report in the format already used by the Committee summarising these matters for consideration by the Committee.
2. Special Reports. The Committee may request special reports, including special national reports, as necessary on matters to be considered by the Committee for the following year.
3. Sub-committee Reports. Reports of the standing sub-committees or of special sub-committees appointed by the Chairman shall be considered by the Committee for inclusion in the Report to the Commission. These reports shall be considered as working documents and the recommendations contained therein be subject to modification by the full Committee before inclusion in the Annual Report.
4. The above reports should be distributed to Committee and Sub-committee members as early as possible.
5. Scientific Papers.
   (a) Any scientist may submit a scientific paper for consideration by the Committee. The Secretary may, with the concurrence of the Committee, set technical guidelines for the preparation and presentation of such papers. Scientific papers shall be of two types, primary papers presenting new data or analysis, and secondary papers expanding or analysing data and concepts in the primary papers or reports to the Committee.
   (b) Primary scientific papers will be considered for discussion and inclusion in the papers of the Committee only if the paper is received by the Secretariat on or by the first day of the annual

Committee meeting. Exceptions to this rule can be granted by the Committee only in the case of exceptional extenuating circumstances.

(c) Secondary papers will be considered for discussion and inclusion in the papers of the Committee only if:

1. The paper is received by the Secretariat before the end of the first week of the Committee meeting, or:
2. Preparation of the paper is specifically requested by the Scientific Committee through its Chairman.

6. Publication of Scientific Papers and Reports.

Scientific papers and reports shall be included in the Commission's archives in the form in which they were considered by the Committee or its sub-committees.

Documents on which management recommendations are based should be available on demand immediately after the meeting of the Committee at which the recommendations were made. Scientific papers and reports (revised as necessary) will be selectively included in the Committee Report published by the Commission. The Secretariat, with the concurrence of the Scientific Committee shall issue guidelines for the technical revision of the papers or reports. Scientific papers which are original contributions and deserve a broad dissemination in the primary literature may be considered for publication at the request of the author in a new scientific journal, published by the Commission, with the possible title "Journal of Cetacean Management". Papers will be subject to outside review before acceptance; the Secretary shall be the Editor.

Annex C3.
SC/28/Rep 17

OPERATIONS OF THE SCIENTIFIC COMMITTEE

K. Radway Allen

Despite the increasing length of time allocated to its pre-Commission meeting, and despite the holding of frequent special mid-year meetings on particular topics, the Scientific Committee is having growing difficulty in completing its tasks and presenting its report to the Commission by the commencement of the Plenary Session.

There are several causes underlying this development. One is the increasing amount of both statistical and biological data available, together with improved understanding of the principles involved in population assessment and management, which is causing the discussions of the Committee to extend to greater depth and therefore to take more time than in earlier years. A second cause is that the Committee, having expressed the view that it would be appropriate for the Commission to accept responsibility for the management of the lesser whales, and at least the directly exploited small cetaceans, is devoting some time to the discussion of the problems of assessment and management of these species.

The principal cause is however the adoption by the Commission of the new management procedure. This requires the Committee both to examine annually every identifiable stock of whales and to make every effort to provide the Commission with a definite statement regarding the categorisation and appropriate catch limits for each stock. Owing to the difficulties of interpreting inadequate data it may take almost as long for the Committee to reach a conclusion on some small stocks which are not currently exploited as on some of large stocks for which much more data exist and which have been well studied. This aspect of the problem is likely to diminish only slowly since small stocks will also require continuing review as more data become available and stock units are elucidated. As well as discussing the individual stocks the Committee also needs to discuss either at the Commission's request or on its own volition general questions regarding the new management procedure including the definition of present or possible future new catagories and the methods of calculating catch limits. This need is likely to continue.

Annex D

SPECIAL PERMITS ISSUED UNDER ARTICLE VIII OF THE CONVENTION

Date	*Country of issue*	*Area*	*Details of permit*
January 1976	Japan	North Pacific	80 sperm whales
May 1976	Japan	North Pacific	100 minke whales

Annex E
SC/28/Rep 13

DEFINITION OF NEW STOCK CATEGORIES

The Committee is considering 2 categories for addition to the Schedule:

(a) Vulnerable stocks.
(b) Indeterminate stocks.

Comments on these two possible categories are as follows:

(a) *Vulnerable Stock*–stocks which evidence suggests have been severely affected by direct fishing, direct fishing and incidental take, or environmental change, and for which adequate stock assessment information does not exist to allow classification in another management category.

Management actions which should be taken in applying this new category are:

1. The catch limit for direct fishing on a vulnerable stock will be set by the Commission but in any event should not exceed the catch (1) at the time of classification or (2) within the recent past history of the catch.
2. National bodies whose activities are affecting a vulnerable stock should provide the Commission with an annual progress report on the status of the stock and efforts made to prevent further reduction of the stock.
3. The Commission will annually review the classification of vulnerable stocks based on the evidence contained in the annual progress report and elsewhere. If the evidence is inadequate the Commission can annually continue classification of the stock as vulnerable for (1) up to five years or (2) the number of years recommended by the Commission. If the annual progress report is not forthcoming or if the information remains inadequate after five years the stock is automatically reclassified as a protection stock unless the Commission has reason to specifically continue the annual classification of the stock as vulnerable.

(b) *Indeterminate stock.* There are many whale stocks that have been fished, where no estimates of initial stock are available and where there is no evidence that the stock is being significantly affected by present catches. It is proposed that all such stocks should be classified as indeterminate, and should be managed as follows:

1. If an estimate of present exploitable stock size is available, catches should not exceed 5% of that value.
2. If no such estimate is available, catches should be held constant until further information becomes available.

Annex F

Southern hemisphere sperm whales – estimated stock sizes and MSYs, and recommended catch limits by Divisions

	DIVISION									
	1	2	3	4	5	6	7	8	9	Total
1946 Stock (males)	12.4	33.0	38.4	23.1	21.9	11.3	15.9	37.7	36.2	229.9
1946 Stock (females)	20.3	54.1	63.0	37.9	35.9	18.5	26.1	58.5	46.4	360.7
%1945/1946 (males)	42.7	47.9	31.5	55.0	33.8	41.1	26.4	91.9	31.8	46.2
%1945/1946 (females	91.6	94.5	82.1	56.5	95.5	93.0	79.9	99.7	53.7	82.7
MAXIMUM WEIGHT										
MSY Males (No)	361	963	1,121	675	639	329	465	1,041	970	6,564
MSY Females (No)	12	32	38	23	22	11	16	35	0	189
MSY Males (Wt)	8,904	23,728	27,632	16,623	15,746	8,114	11,447	25,658	23,038	160,890
MSY Females (Wt)	171	454	529	318	302	155	219	491	40	2,639
1975% of MSYL (males)	109	123	81	141	87	105	68	236	69	–
1975% of MSYL (females)	94	97	85	58	98	96	82	103	56	–
Catch limit (males) (No)	325(S)	867(I)	0(P)	608(I)	0(P)	296(S)	0(P)	937(I)	0(P)	3,033
Catch limit (females) (No)	4(S)	20(S)	0(P)	0(P)	16(S)	6(S)	0(P)	32(S)	0(P)	78
Catch limit (males (Wt)	6,216	16,581	0	11,628	0	5,661	0	17,920	0	55,006
Catch limit (females) (Wt)	56	278	0	0	223	84	0	445	0	1,056
MAXIMUM NUMBER										
MSY Males (No)	319	849	909	595	564	290	410	918	835	5,769
MSY Females (No)	73	195	227	136	129	67	94	211	237	1,369
MSY Males (Wt)	7,797	20,780	24,198	14,557	13,789	7,106	10,025	22,470	19,604	140,326
MSY Females (Wt)	952	2,557	2,955	1,778	1,684	868	1,224	2,744	2,946	17,688
1975% of MSYL (Males)	133	150	98	172	106	128	83	287	84	–
1975% of MSYL (Females)	116	120	104	72	121	118	101	126	72	–
Catch limit (Males) (No)	287(I)	764(I)	712(S)	536(I)	508(S)	261(I)	0(P)	826(I)	0(P)	3,894
Catch limit (Females) (No)	66(I)	176(S)	204(S)	0(P)	116(I)	60(S)	85(S)	190(I)	0(P)	897
Catch limit (Males) (Wt)	5,489	14,612	13,618	10,252	9,716	4,992	0	15,798	0	74,477
Catch limit (Females) (Wt)	919	2,450	2,840	0	1,615	835	1,183	2,645	0	12,487

Annex G

SUMMARY OF STOCK CLASSIFICATION AND CATCH LIMIT RECOMMENDATIONS

Species	Stock or area	Per cent of initial	Per cent above or below MSY		Class		Catch limit	
Fin	S. Hemisphere I	15	−76[1]		P		0	
	II	16	−74		P		0	
	III	25	−58		P		0	
	IV	14	−77		P		0	
	V	11	−82		P		0	
	VI	50	−17		P		0	
Sei	S. Hemisphere I	70	+16[1]		S		353	
	II	55	− 9		S		826	
	III	43	−28		P		0	
	IV	55	− 5		S		70	
	V	66	+10		S		569	
	VI	71	+18		S		490	
							1,863	
Minke	S. Hemisphere I	83	+39[1]		I		965	
	II	85	+41		I		1,855	
	III	90	+49		I		2,730	
	IV	73	+22		I		1,830 (1,386)[2]	
	V	96	+60		I		1,385	
	VI	97	+61		I		365	
							9,130 (8,686)[2]	
Fin	North Pacific total	43	−31		P		0	
Sei	North Pacific total	26	−52		P		0	
Bryde's	North Pacific total	81	+353		I		1,000	
Minke	North Pacific Western	?	?		S		No increase on current catches	
	Central	?	?		I		0[3]	
	Eastern	?	?		I		0[3]	
Sperm male	N Pacific total				I		4,320	
Sperm female	N Pacific total	85			I		2,880	
Fin	North Atlantic Faroes–W Norway	33	50		P		0	
	Iceland	?	?		S		1524–6 yr total	
	Nova Scotia	37	−36		P		0	
	Newfoundland	71	+22		I		90	
	(Spain–Portugal–British Isles)	?	?		?		?	
Sei	North Atlantic							
	Iceland, Denmark Strait	?	?		?		132	
	Nova Scotia	?	?		P		0	
Minke	North Atlantic							
	Canada E. Coast	?	?		S		48	
	W Greenland	?	?		?		238/415[2]	
	E Greenland, Iceland	?	?		S		320	
	Eastern	?	?		S		1,790	
Sperm	North Atlantic total	?	?		S		685	
Sperm Male	S. Hemisphere		Wt[4]	No[4]	Wt[4]	No[4]	Wt[4]	No[4]
	1	43	+ 9	+33	S	I	325	287
	2	48	+23	+50	I	I	867	764
	3	31	−19	− 2	P	S	0	712
	4	55	+41	+72	I	I	608	536
	5	34	−13	+ 6	P	S	0	508
	6	41	+ 5	+28	S	I	296	261
	7	26	−32	−17	P	P	0	0
	8	92	+136	+187	I	I	937	826
	9	32	−31	−16	P	P	0	0
							3,033	3,894
Sperm Female	S. Hemisphere							
	1	92	− 6	+16	S	I	4	66
	2	94	− 3	+20	S	S	20	176
	3	82	−15	+ 4	P	S	0	204
	4	56	−42	−28	P	P	0	0
	5	95	− 2	+21	S	I	16	116
	6	93	− 4	+18	S	S	6	60
	7	80	−18	+ 1	P	S	0	85
	8	100	+ 3	+26	S	I	32	190
	9	54	−44	−28	P	P	0	0
							78	897

1. Assuming MSY at 60% of initial level. 2. Alternative views
3. Currently unexploited stocks, which should not be exploited until population estimates are available.
4. Wt = For maximum yield by total weight, No = For maximum yield by total number of both sexes

SUMMARY OF AVAILABLE CATCHES

		S Hemisphere	N Pacific	N Atlantic
Fin		0	0	394
Sei		1,863	0	132
Bryde's		0	1,000	–
Minke		9,130/8,686	Current level in western area	2,396/2,573
Sperm Male	Wt	3,033	4,320	685
	No	3,894		
Female	Wt	78	2,880	
	No	897		

Annex H

SC/28/Rep 8

SPERM WHALE STATISTICS SOUTHERN HEMISPHERE

Last year the Commission combined Divisions 3 and 4, (1,562 males – 1,368 females) and Divisions 1, 2 and 9 (2,024 males – 1,992 females) into single Division quotas. This caused some of the recommended Division quotas to be exceeded.

This is outlined below:

		Quota	Catch 1975–76	Land stations catch 1975 (quota 1976)	Difference
Divisions (Males)					
1	W Atlantic	450	1,245	9[1] (18)	–804 (–813)
2	E Atlantic	990	388	–	+602
3	W Indian	1,770	406	862[2] (658)	–104 (+106)
4	C Indian	250	417		–167
5	E Indian	900	284	692[3] (658)	– 76 (– 42)
6	E Australian	P	–	–	–
7	N Zealand	450	455	–	– 5
8	C Pacific	1,260	731	–	+529
9	E Pacific	400	96	554[4]	–250
Divisions (Females)					
1	W Atlantic	360	989	45[1] (49)	–674 (–678)
2	E Atlantic	810	424	–	+386
3	W Indian	900	–	810[2] (873)	+ 90 (+ 27)
4	C Indian	240	371	–	–131
5	E Indian	630	73	480[3] (487)	+ 77 (+ 70)
6	E Australian	270	–	–	+270
7	N Zealand	360	328	–	+ 32
8	C Pacific	810	839	–	– 29
9	E Pacific	490	–	239[4]	+251

FOOTNOTES:
[1] Brazil
[2] South Africa
[3] Australia
[4] Peru

Annex I
SC/28/Rep 14

REPORT OF THE SUB-COMMITTEE ON PUBLICATION POLICY

The sub-committee reconsidered Scientific Committee policy and specifically the handling of documentation for the 28th meeting in light of a greatly increased volume of documentation considered. It makes the following recommendations:

1. Documents upon which management recommendations are based should be made available for public distribution immediately following the meeting of the Scientific Committee making management recommendations.
2. The following procedure is proposed for implementation of this policy:
   (a) All documents submitted to meetings of the Scientific Committee and its subsidary elements (sub-committees, working groups etc) should be labelled 'not to be cited without author's permission'.
   (b) Those documents in (a) which form the basis of management recommendations should be cited in the relevant committee, sub-committee or working group Report. At the time of submission of the Report by the Scientific Committee these documents should be released by
      (i) re-labelling with the note *'released for citation in relation to management recommendations and decisions of IWC'.*
      (ii) making publically available, at production cost, a reasonable number (say 50), either of individual documents, or compiled sets in loose-leaf binders.
3. Various options are available for further production and distribution of documents considered in 2(b):
   (a) Single copies and sets can be made available on a request basis at cost from the Secretariat or
   (b) The documents can be edited with respect to such items as format and clarity of expression (but not altered in any fashion which relates to the basis of management recommendations made) and produced either in a separate published volume or in a volume combined with other reports as is current practice.
4. The Report of the Scientific Committee and Reports of its subsidiary elements, together with annexes, and a list of documents and national progress reports should be published annually. The format may be a single volume including reports of all meetings or a volume on each meeting which would include the "decision documents".
5. The sub-committee makes the following recommendations regarding the structure and content of documents submitted for consideration by the Committee:—
   (a) The title should be specific and encompass the content of the report. Literature citations should be made by name and year. An abstract containing relevant (especially quantitative) conclusions should preface the article. Illustrations should be of a size less than standard page (14 by 8½ inches), drafted to stand further reduction in final printing. Figures and tables should be clearly labelled, captioned, and cited in the text: Details of materials and methods should be clearly laid out. Mathematical expressions, equations and formulae should be defined and clearly explained, showing all symbols clearly in correct position. Greek letters should be spelled out the first time they occur. References should be complete, with difficult journal names spelled out, place of publication given, and full pagination indicated. Excessive tabular material should be relegated to Appendices. The entire paper should be organized under the following (or suitable alternate) headings: Title, Abstract, Introduction, Material and Methods, Results, Discussion, Conclusions, Figures, Tables, References Cited.
   (b) The documents should be typed and duplicated in a consistent format. It is suggested that the Secretary consult with ICNAF for consideration of potential application of its production procedure.
6. The sub-committee has identified the following "decision documents" considered at the 28th meeting and recommends public release of these. A list, with appropriate reference to agenda item, follows:

10.2 Alternative formulae for determining quotas Docs 1,7,8

11. Status of Stocks

Southern Hemisphere	
FIN	Docs 6,15,37,38
SEI	Docs 4,5,17,36,42,43,44,45,47
MINKE	Docs 4,17,19, Doc 35 Rep 12
SPERM	Docs 2,4,9 Reps 1,8
North Pacific	
SEI	Doc 29
BRYDE'S	Rep 9
MINKE	Doc 20
SPERM	Doc 21,25,34
North Atlantic	
FIN	Doc 37 Rep 2
MINKE	Docs 3,30 Rep 2
Currently Protected Species	
BOWHEAD	Doc 16 Prog Rep 3,11
RIGHT	Docs 4,17,29
BLUE	Docs 4,17,29 Prog Rep 3
HUMPBACK	Docs 4,17,29 Prog Rep 7,11
GRAY	Doc 33

12.5 Sperm—Closed Season Doc 39
14 Small Cetaceans Rep 3
15 Data Collection Rep 3
16 Review of Reporting Requirements Reps 2,3
18 Humane Killing Doc 31 Rep 4

Humane Killing of Whales

At the Twenty-seventh meeting the Commission accepted a recommendation of the Scientific Committee that it should make enquiries about possible new developments in chemicals and explosives suitable for killing whales and examine ways of improving the efficiency of existing methods, including the killing of small whales where explosives cannot be used, and the training of gunners.

The Commissioners for whaling countries and countries engaged in whaling until recent years were asked to provide details of any developments under these heads since the Commission's Working Party reported in 1959 and of any research or investigational work at present in progress. The following is a summary of the replies received.

AUSTRALIA

No work is being undertaken or is envisaged in the near future. Work undertaken in South Africa is considered adequate for southern sperm whale populations.

CANADA

No research or development has been undertaken in Canada. Most of the Canadian experience is derivative from Norwegian efforts in the North Atlantic. The drive fishery for pilot whales in Newfoundland was one in which small whales were killed without explosives—they were driven ashore and stabbed and their throats cut. Belugas were killed with harpoons or lances. Reference is made to two publications which summarise most of the methods used currently and in the past to kill small cetaceans (*IUCN monograph No 3* and *J. Fish. Res. Bd. Can.* 32(7), 1975).

ICELAND

The only method of killing whales has always been the use of explosives. No research or investigational work has been carried out. The gunners on the four Icelandic catcher boats are very well trained with up to 25 years' experience as gunners and captains of the boats. The first mate takes the place of the captain as gunner in his absence by whom he has been trained in the use of the gun.

NORWAY

Since Norway ceased whaling in the Antarctic in 1968–69 neither the industry nor research institutes have undertaken experiments or scientific study in the humane and expeditious killing of whales.

SOUTH AFRICA

There have been no new developments in the killing of whales other than work recorded in the paper presented to the Scientific Committee at the twenty-sixth meeting. Around 1963 the whaling company experimented with some drugs but found that the doses required were so large that they had to be delivered by a normal whaling harpoon, rather defeating the humane aspects of the exercise.

USA

Mrs Christine Stevens of the Animal Welfare Institute drew attention to the possibility of the drug etorphine hydrochloride being used for killing whales. It is marketed under the trade name Immobilon by Reckitt and Colman in the United Kingdom and had been used for the immobilisation of game animals. They were asked about the possibility of its being used in the killing of whales and replied as follows:

> 'It is possible to form an opinion of the utility of the drug for whale hunting. The drug is probably potent enough for the purpose, by analogy with land mammals a dose between 0.1 to 1 gram would be expected to be sufficient for analgesia, but not death, of a 100 ton whale. This quantity could be contained in a suitably designed bullet rather than a harpoon. Etorphine is an analgesic which also causes pronounced respiratory depression and acts in large land animals (elephants and horses for example) in half to two minutes. There appears to be a strong likelihood that relaxation of the blow-hole of an etorphine-drugged whale would allow escape of air from the lungs and they would not be reinflated if the whale surfaced again after being hit. The expectation therefore is that the whale would sink through inability to retain the buoyancy conferred by the air in its lungs.
>
> The parallel case cited by Dr Munton of Whipsnade Zoo, whom I consulted, is that of the hippopotamus which when drugged by an etorphine dart on land still has time to rush into water before the drug takes effect and then the on-set of muscular relaxation causes the animal to sink and drown.
>
> Unless your whaling experts disagree with my lay understanding of the whales reaction to being hit, i.e. that it immediately dives and unless air is retained in the lungs will also sink, it appears unfortunately that etorphine is unsuitable.
>
> The question of drug residues in the flesh is being considered in general terms by your committee and I need not dwell upon it further except to say that under UK law animals treated with Immobilon may not be slaughtered for food for a period of seven days in order to allow time for the drug to be excreted.'

Dr de Jager was asked for his views on the possibility of the use of this drug and he replied as follows:

> Etorphine hydrochloride (M99) certainly seems one of the best drugs to try as an alternative method for

killing whales. It has a wide therepeutic index, so that once the correct dose is found there should be no need to alter it for animals of different sizes of the same species. It is also extremely powerful, so that only 0.05 ml of the 0.4% game immobilisation solution could be fatal to man. Delivery of an adequate dose via a dart gun should therefore be feasible.

There are three possible objections to its use:

(1) The very potency of the drug makes it extremely hazardous to use, especially under field conditions in the whaling industry.
(2) There is no guarantee that the affected animal will float except possibly in the case of sperm whales. A line attached to the whale is therefore almost a necessity.
(3) It is unlikely that most health authorities would be prepared to allow the import of or sale of whale productions from animals killed by M99 if these were to be used for human consumption.

Mrs Stevens has also forwarded to Dr Aron the report "Ballistic Delivery of Biological Reagents" prepared for the US Department of Agriculture, a copy of which has been lodged in the IWC files.

JAPAN AND USSR

No replies received.

The chemical firm Sandoz Ltd of Switzerland drew the Commission's attention to the possibility of the use of the fish-anaesthetic and tranquilizer MS 222 Sandoz for anaesthetizing whales. No work has been done with whales but they thought that it could be used by gun harpoon which would immediately tranquilize the animal offering a faster and cleaner kill afterwards. In reply to recent enquiries Messrs Thomson and Joseph of Norwich, the international marketing organisation for the product, stated that they had not been able to trace any work done on whales. They would be glad to assist in any experimentation.

The problems of safe delivery of drugs and the subsequent marketing of contaminated carcases suggests that it might be more useful to study the ballistic side of the question in the future.

Report of Sub-Committee to Estimate Stock Sizes of North Pacific Bryde's Whales

Members: Ohsumi, Tillman (Convenor)

The sub-committee reviewed estimates of initial stock size provided by Ohsumi (1977) and Tillman (1977). The estimate of minimum stock size provided by Tillman (1977) for the Japanese coastal area was thought to be low because of the rate of exploitation assumed ($F = 0.04$). Ohsumi (1977) provided evidence that the early rate of exploitation for this area probably was $F = 0.02$. This value was used to re-calculate the estimate for the coastal area, and the new results for Tillman (1977) as well as the original estimate from Ohsumi (1977) are given below:

	Ohsumi (1977)	Tillman (1977)
Initial	20,900 (Total area)	13,100 (Pelagic area)
		6,000 (Coastal area)
		19,100 (Total area)

The similarity of these two independent estimates for the current total area of exploitation gave credibility to adopting 20,000 as an estimate of initial stock size for Bryde's whales.

Ohsumi (1977) provided evidence from mark recoveries which suggested that the total area of exploitation should be treated as a single stock, and this has been done in this report. Nevertheless, further investigation concerning the discreteness of stocks of North Pacific Bryde's whales is required.

The current (1976) stock size for the area of exploitation was determined by forward calculating with the model:

$$N_i = (N_{i-1} - C_{i-1})\, e^{-M} + (1 - e^{-M})\, N_0$$

where the initial year of heavy exploitation was 1971 and $M = 0.085$ (Ohsumi, 1977). This gave a stock size of 16,230 which is 81% of the initial level.

The North Pacific Bryde's whale thus is still an Initial Management Stock. Since a portion of this stock lies outside the permitted area of exploitation (Tillman, 1977), a safe harvest limit probably would still be 5% of the initial stock estimate, 1000.

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Ohsumi, S. 1977. Further Assessment of Population of Bryde's Whale in the North Pacific. Paper SC/28/Doc 18 (published in this volume).

Tillman, M. F. 1977. Estimates of Stock Size for the North Pacific Bryde's Whale. Paper SC/28/Doc 23 (published in this volume).

SC/28/Rep 10
(Revised)

Whale Marking – Progress Report 1976

S. G. Brown

Whale Research Unit, Institute of Oceanographic Sciences

The following information is available on whale marking carried out during 1975 and 1976, and in the Antarctic season 1975–76 (see Table 1).

A total of 331 whales was marked in the southern hemisphere including 4 blue, 2 fin, 30 sei, 16 Bryde's, 4 humpback, 65 minke and 208 sperm whales. 358 whales were marked in the northern hemisphere, comprising 10 blue, 18 fin, 23 sei, 33 Bryde's, 6 humpback, 156 minke and 112 sperm whales.

Marks were recovered from 1 fin, 2 sei, 3 Bryde's and 7 sperm whales in the North Pacific, and from 2 sperm whales in the South Pacific in 1975. In the North Atlantic 1 mark was returned from a minke whale in 1975. Details of marks recovered in the Antarctic seasons 1974–75 and 1975–76, and at Durban, South Africa, in 1975 are given below.

WHALE MARKS RECOVERED IN THE ANTARCTIC WHALING SEASON 1974–75

Nine whale marks found during the Antarctic whaling season 1974–75 have been reported to the Institute of Oceanographic Sciences, including one mark in the USSR series (see Table 2). There are marks from six sei whales and two sperm whales.

Among the marks from the sei whales, No. 25852 was recovered after eleven years fairly close to the marking position in Area V. The whale bearing No. 30937 was captured after thirteen months very close to the position where it was originally marked in Area V. No. 29208 illustrates movement from Area IV eastwards into Area V after three years. Nos. 30968 and 30974 were fired on 6 December 1973 into two male whales which were swimming in company with a single fin whale in position 41°22′/23′S, 111°28′E (Area IV). One whale (Mark No. 30968) was shot almost exactly a year later on 19 December 1974 approximately 500 miles east of the marking position. The other whale (No. 30974) was killed one month later on 23 January 1975 some 800 miles west of the marking position. As in the case of some fin whales, it is possible that these two animals kept company until one was killed, when the survivor moved slowly westwards.

There are three marks returned from sperm whales including one in the USSR series. Nos. 30990, 30993 were fired into the same whale on 4 November 1974 in position 32°58′S, 81°11′E north of Area IV. They were recovered two days later when the whale was killed approximately eighty miles to the north of this position.

WHALE MARKS RECOVERED IN THE ANTARCTIC WHALING SEASON 1975–76

Eight marks found during the whaling season 1975–76 have been reported to the IOS, including one mark in the USSR series (see Table 3). There are marks from five sei whales and two sperm whales.

Of the four sei whales marked in the international scheme series the whale bearing Mark No. 29980 was killed very close to the position of marking three years later. No. 30538 was fired in January 1974 into a whale north of Antarctic Area III, and recovered two years later when the animal was killed in Area IV. Nos. 22734/41 were fired into a female whale in position 46°32′S, 75°55′W during a marking expedition off the coast of Chile. The whale was shot in the western half of Antarctic Area II just over 9 years later. This southward and eastward movement from off the west coast of South America into the western Atlantic sector of the Antarctic is directly comparable to that demonstrated in fin whales marked in the same region.

Two marks have been returned from sperm whales. No. 25889 was fired into a male in February 1963 off the west coast of South Africa, and the whale was killed nearly thirteen years later approximately 550 miles further north off the same coast. No. 28768 was fired off Durban in February 1973 and recovered from a female whale shot in December 1975 to the south west in position 37°02′S, 19°10′E.

WHALE MARKS RECOVERED AT DURBAN IN THE 1975 SEASON

Whale marking in South African waters has continued and five marks from this programme have been recovered from sperm whales at the whaling station at Durban in the 1975 season. In addition, two marks in the USSR series were also recovered from sperm whales. Details of the seven returns are given in Table 4.

The five marks from the South African marking programme were all fired into whales in waters off the south-east coast in the Durban–Port Elizabeth region. They were all returned from the Durban area, two after just over four years, and two after two years. The fifth mark (No. 30617) is from a whale killed within three days of marking at the end of January 1975.

I am indebted to Dr Best, Dr Ivashin and Dr Masaki for their help in checking data on the recovery of the marks included in this report.

Table 1

Whales Marked During 1975 and 1976, and in the Antarctic Season 1975–76.

	Blue	Fin	Sei	Bryde's	Hump-back	Minke	Sperm	Bottle-nose	Total
Southern Hemisphere									
Antarctic 1975–76 (International Scheme–Japan)	3	2	11	–	–	23	22	–	61
Antarctic 1975–76 (USSR)	1	–	5	–	4	42	49	2	103
North of 40°S (International Scheme and North Pacific Marking 1976–Japan)	–	–	2	16	–	–	68	–	86
USSR 1975	–	–	12	–	–	–	68	–	80
Canada 1975	–	–	–	–	–	–	1	–	1
Total	4	2	30	16	4	65	208	2	331
Northern Hemisphere									
North Atlantic									
Norway 1975	–	–	–	–	2	136	–	–	138
Norway 1976	–	–	–	–	4	15	–	–	19
Canada 1976	2	–	–	–	–	–	–	–	2
North Pacific									
Japan 1975	–	10	8	29	–	5	31	–	83
USSR 1975	8	8	15	4	–	–	81	–	116
Total	10	18	23	33	6	156	112	–	358

Table 2

Marks Recovered in the Antarctic Season 1974–75

Mark No.	Date marked	Date recovered	Time elapsed (years, months)	Position marked	Position recovered	Sex	Length in feet
			Sei Whales				
25852	17.xi.63	22.xii.74 (from meat deck)	11.1	41°58′S, 168°33′E	41°57′S, 160°12′E (approx.)	–	–
29208	21.xi.71	15.xii.74	3.1	41°03′S, 123°23′E	40°55′S, 152°13′E	Male	48
30937	15.xi.73	13.xii.74	1.1	39°46′S, 152°38′E	41°09′S, 152°19′E	Female	53
30960	2.xii.73	19.i.75	1.2	42°16′S, 110°45′E	41°51′S, 101°17′E	Female	52
30968	6.xii.73	19.xii.74	1.0	41°23′S, 111°28′E	41°15′S, 122°13′E	Male	45
30974	6.xii.73	23.i.75	1.2	41°22′S, 111°28′E	42°24′S, 92°54′E	Male	47
			Sperm Whales				
30990/93	4.xi.74	6.xi.74	0.0	32°58′S, 81°11′E	31°34′S, 81°25′E	Male	43
			USSR Series				
650834 (Sperm)		9.xii.74			33°18′S, 70°47′E	Male	37

Table 3

Marks Recovered in the Antarctic Season 1975–76

Mark No.	Date marked	Date recovered	Time elapsed (years, months)	Position marked	Position recovered	Sex	Length in feet
			Sei Whales				
22734/41	17.xii.66	26.i.76	9.1	46°32′S, 75°55′W	61°20′S, 56°22′W	Female	52
26942	18.iii.68	9.xii.75	7.9	44°17′S, 177°56′E	42°03′S, 156°09′E	Male	47
29980	9.ii.73	15.ii.76	3.0	64°13′S, 170°41′W	65°29′S, 173°35′W	Female	53
30538	22.i.74	26.i.76	2.0	32°41′S, 67°11′E	43°16′S, 97°48′E	Female	48
			Sperm Whales				
25889	24.ii.63	20.xi.75	12.9	33°54′S, 16°56′E	25°00′S, 13°16′E	Male	36
28768	2.ii.73	6.xii.75	2.10	29°52′S, 32°14′E	37°02′S, 19°10′E	Female	34
			USSR Series				
A 324 (Sei)		27.i.76 (from meat deck)			51°06′S, 44°17′W (approx.)	–	–

Table 4

Marks Recovered at,Durban, South Africa, in the 1975 Season

Mark No.	Date marked	Date recovered	Time elapsed (years, months)	Position marked	Position recovered	Sex	Length in feet
Sperm Whales							
25880	1.ii.71	15.vi.75	4.4	28°51′S, 33°42′E	29°35′S, 33°15′E	Male	34
28864	13.ii.71	12.iv.75	4.2	31°29′S, 31°44′E	30°37′S, 32°22′E	Female	35
29743	10.ii.73	23.iii.75	2.1	34°31′S, 27°31′E	29°43′S, 32°29′E	Female	37
30091	15.ii.73	2.ii.75	2.0	34°18′S, 28°31′E	30°35′S, 32°36′E	Female	36
30617	31.i.75	2.ii.75	0.0	31°01′S, 32°32′E	30°35′S, 32°36′E	Female	33
USSR Series							
650028 (Sperm)		17.vi.75			29°43′S, 32°12′E	Male	39
650675 (Sperm)		27.v.75 (from cooker)			Durban	–	–

Report of Sub-Committee to Estimate Stock Sizes of Southern Hemisphere Minke Whales

Members: Best, Boerema, Borodin, Brownell, De Moura, Ivashin, Ohsumi, Tillman, (Convenor).

The sub-committee reviewed pertinent data and estimates from Best (1977), Masaki (1977), Ohsumi (1977) and Chapman (1976). The sub-committee agreed that the CPUE data based upon catcher hours work (corrected for wind strength and period of operation) and presented in Ohsumi (1977) were the best available indices of minke whale stock abundance, particularly in Area IV.

The rising trend observed in 1975–76 for Area IV was judged to be due to random sampling error. Overall, a minor decline in abundance has occurred in this area since the onset of exploitation in 1971–72. CPUE and sightings data from Best (1977) further indicated that no major decline in availability of this species has occurred off Durban since 1969. The reduced catches in Area IV for 1975–76 were due to the establishment of catch limits by stock and country for the first time in that season.

Ohsumi (1977) utilized the modified DeLury method to estimate the initial abundance of minke whales for Area IV. This estimate was 36,600 and applied to the start of the 1971–72 season. This was thought to be a more reliable estimate than that for Area II since it was based upon two more years of data. Moreover the modified DeLury model may not be applicable to a stock, such as Area II, which has been subject to a long history of exploitation (Table 1).

To estimate stock size in other areas, it was noted that each had been exploited by the Japanese fleet in 1975–76 and, hence, that indices of abundance based upon CPUEs were available for all areas in that year (Table 4, Ohsumi, 1977). The Area IV estimate for 1971–72 thus was forward calculated to 1975–76 using the formula:

$$N_i = (N_{i-1} - C_{i-1})\, e^{-M} + R \qquad (1)$$

where it is assumed

$$R = (1 - e^{-M})\, N_0$$

This formula rather than the one given in Doc 19 was used since, for $M = 0.127$, the approximation of $(1 - M)$ for e^{-M} is not very good.

Since CPUEs are proportional to average stock size during a year, the average for Area IV in 1975–76 was approximated as:

$$\bar{N}_{iv,\,75-76} = N_{iv,\,75-76} - \tfrac{1}{2} C_{iv,\,75-76} = 25{,}936$$

The estimates of stock size for the start of 1975–76 for other Areas were then derived from this estimate and the 1975–76 indices of abundance as follows:

$$N_{A,\,75-76} = \frac{(IA_{A,\,75-76})}{(IA_{iv,\,75-76})}\, \bar{N}_{iv,\,75-76} + \tfrac{1}{2} C_{A,\,75-76}$$

where A denotes the appropriate Area.

To obtain initial stock sizes, the 1975–76 estimates were then back calculated to their initial year of exploitation (Table 1) utilizing the following formula for each area:

$$N_{i-1} = (N_i - R)/e^{-M} + C_{i-1}$$

It was first assumed that R was equal to

$(1 - e^{-M})\, N_{75-76}$ + cumulative catch to 1975–76.

Table 1

Catches by Season and Stock Area for Southern Hemisphere Minke Whales

Season	I	II[1]	III[2]	IV	V	VI
1965–6		67	2			
1966–7		352	5			
1967–8		488	6			
1968–9		456	97			
1969–70		617	112			
1970–1		701	171			
1971–2	3	902	553	2,660		
1972–3	–	702	1,322	4,558		
1973–4	1,257	826	1,871	4,569		13
1974–5	1,870	1,571	1,474	2,231	734	–
1975–6	1,045	2,202	2,265	881	631	159
Cumulative Catch	4,175	8,884	7,878	14,899	1,374	172

[1] Including catches from Brazil

[2] Including catches from South Africa

Then, succeeding back calculations were undertaken using each improved estimate of N_0, i.e., assuming $(1 - e^{-M})\, N_0$. This alternative process was stopped when successive estimates of N_0 differed by 1% or less. Current stock sizes were then obtained using equation (1) and forward calculating from 1975–76.

The results obtained are given in Table 2, along with estimates of MSY level and catch limits for each stock. It was assumed the MSY level was equal to 60% of initial stock size (Chapman, 1976) and that 5% of initial stock size was a safe catch limit. Comparison of current stock size with MSY level indicated that all Areas should be classified as Initial Management Stocks.

The sub-committee examined the sex ratios of catches by statistical series within areas for several years and determined that the sexes segregate geographically. Consequently some bias may be introduced into the above estimates by treating the sexes together rather than separately. The sub-committee recommended that future stock assessments undertake a detailed analysis of the possible effects of this segregation.

The sub-committee also discussed the question of whether land station catches in the Southern Hemisphere are taken from the same stocks as the pelagic catches. Brownell

Table 2

Stock Sizes of Southern Hemisphere Minke Whales

Stock Sizes (000s)

Area	Index of Abundance	1975–6	Current (1976–7)	Initial (year)	MSY[3] level	Ratio of Current to MSY level	Yield[4]
I	4.848	16.7	16.1	19.3 (73–4)	11.6	1.39	965
II	9.528	32.9	31.5	37.1 (65–6)	22.3	1.41	1,855
III	14.770	50.4	48.9	54.6 (68–9)	32.8	1.49	2,730
IV	7.770	26.4	26.8	36.6 (71–2)	22.0	1.22	1,830
V	7.998	27.0	26.5	27.7 (74–5)	16.6	1.60	1,385
VI	2.150	7.3	7.1	7.3 (75–6)	4.4	1.61	365
Total		160.7	156.9	182.6	109.7		9,130

[3] Assumed as 60% of initial

[4] 5% of initial stock size

presented a series of photographs from the Brazilian land station and Antarctic Areas V, VI, I and II. Similar color patterns noted between these two sets of photographs provided additional information suggesting that both pelagic and coastal catches are taken from the same stocks.

The sub-committee again emphasised that additional information is needed as soon as possible on stock identification in the Southern Hemisphere. In this regard, the best location for a marking study might be on the Brazilian winter grounds.

REFERENCES

Best, P. B., 1977. Status of whale stocks off South Africa 1975. Paper SC/28/Doc 4 (published in this volume).

Chapman, D. G., 1976. Estimates of stocks (original, current, MSY level and MSY) as revised at Scientific Committee Meeting June 1975. *Rep. Int. Whal. Comm. (Sci. Rep.)*, 26: 44–7.

Masaki, Y., 1977. Japanese pelagic whaling and whale sighting in the Antarctic 1975–76. Paper SC/28/Doc 17 (published in this volume).

Ohsumi, S., 1977. Estimation of population sizes of the Southern Hemisphere minke whale at the initial and 1976–77 level. Paper SC/28/Doc 19 (published in this volume).

Report of Meeting Convenors of Standing Subgroups

Convenors met briefly at 2.15 pm on 25/6/76 and agreed as follows:

1. **Mathematical** (convenor, Tillman)
   Proposed members: Tillman, Chapman, Allen, Borodin, Horwood, Rørvik, Boerema, Holt, Fukuda.

   Business shall be carried out by correspondence during the year; priority should be given to a generalised model for baleen whales.

2. **Sperm Whales** (convenor, Bannister)
   Proposed members: Bannister, Best, Ohsumi, Ivashin, Allen.

   The convenor will correspond with members to arrange specific data collection and analyses during the year.

3. **Northern Hemisphere Baleen Whales** (convenor, Brown)
   Proposed members: Brown, Mitchell, Jonsgård, Christensen, Jónsson, Masaki, Rørvik.

   The convenor will correspond with members to review problems to study during the year and at next year's Scientific Committee meeting.

4. **Southern Hemisphere Baleen Whales** (convenor, Ohsumi)
   Proposed members: Ohsumi, Breiwick, Best, Holt, Lockyer, Ivashin.

   It was agreed that sei whales should receive priority attention. The convenor should arrange a sub-group meeting during the year.

5. **Small Cetaceans** (convenor, Brownell)
   It was agreed that the Convenor should act by correspondence during the year, with North Atlantic bottlenose problems to receive priority.

It was agreed copies of all correspondence should be sent to the Secretary of the Commission and the Chairman of the Scientific Committee.

SC/28/Rep 18

Report on Commission Contract for Development of Data Base and Routine Computor Analyses

D. G. Chapman

In its 1975 report the Scientific Committee recommended a contract be entered into to provide

(a) a master set of data
(b) routine resuming of computer programmes.

A detailed proposal was given in the 1975 Report, Annex N. A sub-committee of Chapman (Convenor), Allen, Ohsumi and Gambell was appointed to co-ordinate the work. The recommendation of the Committee was adopted by the Commission.

In October Chapman notified other members of the sub-committee that Mr J. Breiwick was available to carry out this work. Other Committee members agreed that he should do so under the supervision of the Committee co-ordinator. The Secretary of the Commission indicated that Chapman should proceed on a reimbursement basis. Chapman then proceeded to communicate with Mr E. Vangstein, of the Bureau of International Whaling Statistics, who promised to provide tapes of basic data drom the Bureau's files. A computer tape of data from 1959 to 1971 for all species from the southern oceans was received shortly and Breiwick began work. Considerable difficulty was experienced in translating these tapes to the computer system available in Seattle. When this was accomplished Breiwick prepared programs to extract data from these tapes. It became apparent that running these programs would be moderately expensive and that it would be much more cost effective to wait until further computer data tapes covering other time periods were received from the Bureau. Since these were not forthcoming the work was put in abeyance and no further charges were made to the Commission. It is our understanding that Mr Vangstein is actively pursuing the problem of preparing the computer tapes required for this study but has encountered unforeseen difficulties. Costs to date for Breiwick's salary and computer activities amount to slightly more than $2,000. If the Commission and Secretary believe it would be useful this work could be resumed under contract as soon as the remaining tapes are received from the Bureau.

SC/28/Prog Rep 1

Australia — Progress Report on Whale Research 1975–76

This Report refers to work carried out at the Western Australian Museum by arrangement with the Department of Primary Industry, CSIRO Division of Fisheries and Oceanography and the Western Australian Department of Fisheries and Wildlife.

1. SPECIES AND STOCKS STUDIED

Data continue to be obtained from the single company operating, on sperm whales off Albany, Western Australia. Sightings and other information on other species are obtained as opportunities occur.

2. FIELD OBSERVATIONS AND COLLECTIONS

No collections were made at Albany during the 1975 season. They have been re-instituted for the 1976 season, collections beginning on 1 May. Teeth, ovary pairs and testis weights are being obtained.

3. MARKING

No marking was carried out. No recoveries were recorded at Albany during 1975. A marking cruise off south-western Australia, scheduled for February–March 1976, was cancelled because sufficient funds could not be made available in time.

4. LABORATORY WORK

Processing of specimens obtained in the 1973 and 1974 seasons has continued. In particular, a collection of 1,004 front mandibular teeth was sectioned and lamination counts obtained, by courtesy of the Institute of Oceanographic Sciences, United Kingdom, and the collection of 407 ovary pairs was sectioned and examined.

5. RESEARCH RESULTS

Catch rates off Albany show little change from recent seasons. The sighting rate of bulls from the spotter aircraft remained lower than in 1973, but is still partly explained by a shift in area of search seawards. The length composition of the catch of males $\geqslant$35 ft in 1975 demonstrated a trend towards the capture of smaller bulls than before. An Asdic correction factor (of 1.19) has been derived. These results, and others, were reported more fully to the La Jolla Meeting, March, 1976.

SC/28/Prog Rep 2

Brazil — Progress Report on Whale Research – June 1975 to June 1976

1 SPECIES AND STOCK STUDIED

Studies on the southern minke, sperm and sei whales caught off Costinha, Paraiba, Brazil have been amplified.

2 FIELD OBSERVATIONS AND COLLECTIONS

Ovaries and ear plugs were collected by technicians of the Brazilian Fisheries Research and Development Project from all whales landed at Costinha during the 1975 season. This material was sent to the Federal University of Rio Grande do Norte for histological examination. Collection of testis weights was discontinued during this year.

The collection of detailed information on capture, fishing effort and factory processing was intensified by the Brazilian Fisheries Research and Development Project during the year.

3 WHALE MARKING

A Brazilian technician participated in the US South Western Atlantic whale cruise during November and December 1975. Only three definite marks were made during this cruise.

4 LABORATORY WORK

Histological examination of ovaries collected during 1974 has been completed by the Federal University of Rio Grande do Norte. A publication is being prepared on this work. Examination of the 1975 material is in progress.

Detailed studies on capture, fishing effort and size composition, commenced by Williamson (1975), are being continued by the Brazilian Fisheries Research and Development Project.

5 RESEARCH (see above)

6 PUBLICATIONS

MONTE, S., MS. Contribution to the study of reproduction of the minke whale *Balaenoptera acuterostrata* (Lacépéde) from northeastern Brazil.

Table 2

Total catch, total day fished and catch per day fished for Antarctic minke whales caught by the Costinha Whaling Station, Brazil.

(Source: International Whale Statistics).

Years	Total number caught	Total No. of days fished	Catch/day fished
1966	361	*168	2.1
1967	490	*168	2.9
1968	447	*168	2.7
1969	617	*168	3.7
1970	701	*168	4.2
1971	900	161	5.6
1972	702	179	3.9
1973	650	153	4.2
1974	761	178	4.3
1975	1,038	175	5.9
Total	6,667	1,686	4.0

(*) estimated values

Table 1

Monthly summary of whaling operations at Costinha, Brazil

Month/ year	Minke	No. caught Sperm	Sei	No. sighted	Days/ month	Hours at sea	Capt./Hs (Minke)	Sightings/ Hs	Hours/day/ month
09/1974	188	–	–	283	29	531.92	0.35	0.53	18.34
10/1974	182	–	–	246	31	566.55	0.32	0.43	18.28
11/1974	128	–	–	181	29	526.75	0.24	0.34	18.16
12/1974	55	–	–	81	18	326.17	0.16	0.24	18.12
06/1975	14	10	2	49	11	178.66	0.08	0.27	16.24
07/1975	78	10	–	161	28	529.58	0.11	0.22	18.91
08/1975*	122	–	–	192	20	337.41	0.36	0.56	16.87
09/1975*	66	–	–	95	10	175.92	0.37	0.54	17.59
10/1975	268	3	–	387	31	593.67	0.45	0.65	19.15
11/1975	188	5	–	295	30	550.58	0.34	0.53	18.35
12/1975	72	26	–	172	22	380.83	0.18	0.45	17.31

*Incomplete information

Year	Minke	No. caught Sperm	Sei	No. Sighted	Average Days/Month	Hours at Sea	Capt./Hs (Minke)	Sightings/ Hs	Average/Hs Day/Month
1974*	553	–	–	791	26.8	1,951.39	0.28	0.40	18.24
1975*	808	54	2	1,351	24.6	2,746.65	0.29	0.49	18.07

*Incomplete information

Scource: Log Books collected by the Brazilian Research and Development Project.

SC/28/Prog Rep 3

Canadian Progress Report on Whale Research – June 1975 to May 1976

Edward Mitchell

Arctic Biological Station Fisheries and Marine Service, Department of the Environment P.O. Box 400, Ste. Anne de Bellevue Province of Quebec, Canada

1 SPECIES AND STOCKS STUDIED

Studies were centered on northwest Atlantic cetaceans, with field work carried out mainly in the Gulf of St. Lawrence on blue, fin and minke whales. Limited work on previous biological collections from fin and sei whales was accomplished. Related studies were continued on the zoogeography, morphology and life history of smaller cetaceans with emphasis on catch statistics and the status of world small cetacean fisheries.

Research on Arctic cetaceans was concerned mainly with field surveys of beluga, narwhal and bowhead whales, and compilation of statistics (by D. E. Sergeant, Keith Hay and others).

North Pacific cetacean research related mainly to studies of movements, discreteness and structure of killer whale pods off British Columbia (M. A. Bigg).

Limited work was carried out on minke and sperm stocks in the South Atlantic on the r/v *Hero* cruise of September 1975, in collaboration with scientists from other nations.

2 FIELD OBSERVATIONS AND COLLECTIONS

Work continued at the land-based observation station on the north shore of the Gulf of St. Lawrence to late November, 1975. Continuous observation for whales was maintained through all daylight hours from 23 May 1973 until late November, 1975, when the project ended due to lack of funds. Staff during 1975 included Mr Andrew MacFarlane, Miss Georgina Blaylock, Mr Michael Manolson, Ms Peggy Edds Bupp, and Mr Ron Magar. MacFarlane carried out most of the 1974–75 baseline observations. Analysis of the data is underway by some of the volunteer staff.

An invitation to participate in a cruise of the r/v *Hero* was tendered by the National Science Foundation through the principal investigator, Dr Robert L. Brownell, Jr., E. Mitchell and V. M. Kozicki took part in the cruise. The *Hero* departed 11 September 1975 and returned to Ushuaia on 6 October 1975. Operations were in the South Atlantic from Tierra del Fuego, north along the continental slope to off Uruguay and Rio Grande do Sul, offshore to Bromley Plateau, then a return south and southwest along the subtropical convergence to outside the Falkland Islands and up the Beagle Channel. Few large whales were sighted, they included in descending order of abundance: sperm whales, sei whales, minke whales, southern bottlenose whales, and various delphinids. One sperm whale was tagged at 37°20′S, 33°52′W.

No special permits were required. Some limited work continued on collections of biological materials from whales killed at Nova Scotia and Newfoundland during the last episode of Canadian whaling. Small new collections were taken from a few stranded animals. A summary of these follows:

In June, 1975 a humpback was entangled in a fishing net in Bonavista Bay, Newfoundland. Peter Beamish tagged this whale with an 18 inch tag of polypropylene line bolted through the dorsal fin. The tagged whale was released alive in early July.

A mass stranding of more than 300 pilot whales occurred in Southern Bay, on the south shore of Bonavista Bay, Newfoundland on 28 September 1975. Local fisheries officers towed approximately 200 animals out to sea, but smaller whales returned to the shallows again. Dr J. R. Geraci and Mr D. St. Aubin examined 39 of the approximately 125 carcasses (28 females, 11 males), ranging in length between 193–605 cm. Eleven of the females were dissected; 4 were pregnant and one was lactating. Of eleven stomachs examined, only one contained evidence of food (squid beaks). Geraci and St. Aubin collected samples of parasites, pathological lesions, teeth and tissues for pesticide and heavy metal analyses.

Another occurrence of the northern bottlenose whale, *Hyperoodon ampullatus* was documented from the Gulf of St. Lawrence. Mr Jean Laurin visited the site of burial of the carcass and excavated the skull, jaws and teeth from a presumed female which apparently stranded a few years ago. Laurin also obtained additional information on the Cap Martin occurrence of 1940. This record is to be added to the 9 records published by Mitchell and Kozicki, 1975. (Note that the Wells Beach, Maine record No. 6 in Table 5, Mitchell and Kozicki 1975, is in error as it is not a bottlenose whale but instead a *Mesoplodon* as determined in subsequent literature by others.)

Three blue whales stranded as they were cut off by ice and forced inshore on the southwest coast of Newfoundland on 21 March 1976. On 22 March, two of them were alive off McDougall's Brook (47°42′N, 59°18′W), north of Port-aux-Basques. On 24 March during the evening both were tagged by hand with visual tags containing the drug Quinacrine. On 25 March during the evening the larger of the two freed itself as wind changes cleared the ice. Observations on respiration rates and behaviour were taken throughout the night of the 24th, and continued on the 25th and 26th. On the 26th the smaller whale (called "Reckless Fred" in the field) was tagged by hand with a second tag containing a streamer and Quinacrine. On the 27th, arrangements were completed and the smaller whale ("Reckless Fred") was pulled off, tail first, by a landing barge from the icebreaker *Sir Humphrey Gilbert* of the Canadian Department of Transport. For the rest of the 27th, Kozicki and Horonowitsch made observations of the freed whale, which was recovering throughout the day and finally swam off to the south. We presume that this double-tagged whale recovered after a total of 6 days on the beach.

The third blue whale at Highlands (48°14′N, 59°00′W) presumably died upon stranding. This whale was subsequently measured and flensed in order to retrieve biological materials and the complete skeleton, which is scheduled for final deposition in the Smithsonian Institution, Washington, DC.

A report was received on 14 April of a fourth blue whale which washed up on a beach in the town of Stephenville (48°32′N, 58°29′W) on the 13th of April. The whale was determined by a local fisheries officer, Mr Wilson Kettle, to be a 62 ft. male blue whale. The assumption was that it could have been "Reckless Fred," also a 62 ft. (sex unknown), very slim, blue whale. Kettle determined (in consultation with Kozicki by telephone) that this whale was not "Reckless Fred." By dissecting parts of the whale, Kettle could not locate either of the two tags known to have been put into "Reckless Fred" (Kettle having been present when "Reckless Fred" was tagged by hand) and Kettle found that a pit from which a 4 X 4 cm chunk of blubber removed from "Reckless Fred" prior to our examination of the whale, was not present on this other blue whale carcass. Thus, we presume that this 62 ft. male was a fourth blue whale. No samples were taken, and it was buried on the beach by local authorities.

In summary, the time of initial stranding, size and sex of each of the four blue whales are:

Whale	Length	Sex	Date Stranding	Remarks
Large whale, live	ca. 75ft.	–	21 March	"Large," escaped alive
Small whale, live	62ft.	–	21 March	"Reckless Fred," released alive
Dead whale	75ft.	Pg. female	21 March	Foetus lost; sampled.
Washed up, carcass	62ft.	male	13 April	Buried, not sampled.

A long dead and decomposed carcass of a beluga was found in March 1976 by Kozicki and Horonowitsch on McDougall's Beach, southwest Newfoundland, (47°42′N, 59°18′W). The skull and flipper were collected.

Mr W. Hoek continued surveys of white whales in the estuary of the Mackenzie River, Northwest Territories, with incidental observations of bowhead whales, by helicopter during July 1975.

Mr K. Hay assisted by three students sampled the Eskimo catch of narwhals at two catching areas in the region of Lancaster Sound near Arctic Bay and Pond Inlet settlements. Sixty-five animals were sampled, 35 females and 30 males. Material collected included unerupted teeth and bone for age determination, and ovaries and testes for reproductive studies. Emphasis is being placed on determining life history parameters and population dynamics of narwhals. Early-summer aerial surveys of both narwhal and white whale populations were made.

Canadian involvement continued in the eastern tropical Pacific tuna/porpoise fishery, with the same five boats fishing since 1968. These are: *Atlantic Gairdner, Atlantic Paton, Atlantic Ocean Main, Atlantic JAG,* and *Atlantic Hawke.* All boats apparently have used the Medina panel in their nets since 1974.

3 TAGGING

One 40 ft. sperm whale was tagged from the r/v *Hero* in the South Atlantic at 37°20′S, 33°52′W by Kozicki at 10.45 h. on 25 September 1975 with a shot on the left side, under the hump, traversing 1 foot of water before entering whale (Canadian sperm tag No. FRBC 15584). A second, concurrent shot at this whale by A. Kawamura was called a miss, low left side, taking 3–4 ft. of water (FRBC 15582).

Two blue whales were hand tagged on the southwest Newfoundland coast while opportunity permitted during their entrapment by ice. A small incision was made with a knife and a modified Discovery tag was inserted by hand to just under the blubber, and with a streamer projecting out of the small slit. The whale showed no observable reaction to this procedure, with four observers watching. One blue whale was tagged with two tags, the other with one tag, as detailed above.

No recoveries of tags were reported in any stranded or other animals observed during the period of this report.

A feasibility experiment was conducted in November 1975 to determine if a 20 ft. outboard launch could be used in the Gulf of St. Lawrence to closely approach fin, blue and minke whales for the purpose of tagging. Preliminary results indicate that close approaches can be made in this particular area, and we have hopes of tagging whales in the future using this launch.

Tables of all Canadian tagging operations to date are appended, giving the number of tagged whales by species and by 1 degree squares in North Atlantic and adjacent waters. (These tables do not show one bowhead tagged in Mackenzie Bay, and one sperm tagged in the South Atlantic.) The 10° square 35N is between 40°N–50°N and 70°W–80°W.

4 LABORATORY WORK

Limited dissections of *Stenella* materials were carried out at the Arctic Biological Station in company with William Perrin in November 1975. Some limited studies were also carried out by Mitchell in company with Perrin in La Jolla in January of 1976.

Curation of specimens continues, preparatory to sending biological materials from whales and porpoises collected in the Atlantic to specialists for joint studies.

Mr August Pivorunas continues dissection of a foetal head for a Ph.D. thesis on feeding mechanisms of baleen whales at Yale University.

Several side trips were made before, during and after meetings or expeditions to study in museums and laboratories. Mitchell and Kozicki visited museums in June and July 1975 in London, Stockholm, Göteburg, Sandefjord, and Copenhagen. In September–October 1975, Mitchell and Kozicki studied in museums and laboratories in Buenos Aires, La Plata, Montevideo, São Paulo, and Rio de Janeiro. In December 1975–January 1976, Mitchell visited museums and laboratories in Los Angeles and La Jolla.

Biological materials from a few stranded killer whales are being analysed, and results of the British Columbia sightings programme are being written up (M. Bigg).

Studies of narwhals will be completed and analysed after one more year's study in the Lancaster Sound region (K. Hay).

Interim studies of white whales in the Beaufort Sea have been completed and are being summarised as a final report to the Beaufort Sea Project of Environment Canada (D. E. Sergeant).

5 DEVELOPMENT OF TECHNIQUES

A blubber sampler, originally devised by H. E. Winn, W. L. Bischoff and A. G. Taruski (1973, *Marine Biology* 23:343–346), was fabricated in our lab with some slight modifications designed to control penetration of the coring device. This sampling dart was tested on a blue whale carcass stranded in Newfoundland in March of 1976 by George Horonowitsch, and results are as follows:

Our dart is fixed on a Kongsberg harpoon, which has a thick stainless steel loop to which one end of a light cable is attached. The bore has inner barbs to retain the blubber sample on retrieval.

The biopsy harpoon was fired from a distance of 50 feet at the lateral surface of the dead whale, at a level 2 feet behind the dorsal fin. The harpoon hit the whale at a slight angle, and bounced back about 10 feet. The area where the harpoon entered showed a clean hole the diameter of the dart-bore, and the outer barbs left a slight impression around the hole.

The harpoon had barbs bent more on one side, indicating that the harpoon did enter slightly off 90° to the surface. A clean plug of blubber and connective tissue was retained in the dart-bore. (The thickness of the blubber was approximately the same as the length of the bore.) The blubber-retaining barbs inside the bore were bent back and the plug of blubber would not come out the anterior end. The sample was removed from the posterior end, after the bore was screwed out of the body of the dart. The stainless steel loop was also bent from the initial impact occurring when the harpoon leaves the barrel.

We intend to carry out the following modifications: reduce the charge in the Kongsberg shell by about 25% and test for the ideal charge for a 25 ft. range; modify the dart to a simpler form to accommodate the Kongsberg harpoon, *e.g.* by screwing the bore or coring section directly into the body of the harpoon and using replaceable external barbs in the body, also new, sturdier blubber-retaining barbs inside the bore; and testing the loop to find ways of making it more reliable.

6 RESEARCH RESULTS

No substantial research results were available during this period although some data from earlier studies were published.

Large cetaceans sighted on the r/v *Hero* cruise in the South Atlantic comprised:

Date	Time	Position	Number	Species
16.ix.75	1000	38°56′S, 52°58′W	3	Sei
17.ix.75	1416	36°20′S, 50°15′W	1	Minke
25.ix.75	0920	37°20′S, 33°52′W	2	Sperm
5. x.75	1707	55°05′S, 66°03′W	3	Sperm

Tentative research results by M. Bigg indicate that off southern British Columbia and northern Washington state, there are four 'resident' pods of killer whales totalling 65–70 individuals, and eight 'transient' pods totalling 55 individuals.

Sightings of fifteen bowheads were obtained in the Lancaster Sound area of the Canadian Arctic, especially in Admiralty Inlet, a former whaling ground. Some of these sightings may have been re-sightings of the same animals.

7 1975 CATCHING OPERATIONS

Commercial whaling for large cetaceans was terminated in Canada in December 1972. Catches of small cetaceans by Eskimos in the Canadian Arctic have continued. This is the first year for some time in which capture attempts have been officially reported and a catch landed and reported of bowhead whales in Arctic Canada. Available catch statistics are continued from the previous Progress Report (and references cited therein) by species and by settlements for the Canadian Arctic for 1975 as follows (where 0 indicates none were taken, – indicates no knowledge of any taken):

Settlement	Beluga	Narwhal	Bowhead
Mackenzie Delta	139	0	0
Sachs Harbour	0	0	0
Paulutuk	0	0	0
Coppermine	5	–	–
Holman Island	5	0	0
Pelly Bay	–	7	–
Spence Bay	–	–	–
Gjoa Haven	0	0	0
Cape Dorset	12	–	–
Frobisher Bay	10	0	0
Lake Harbour	–	–	–
Pond Inlet	–	77	0
Arctic Bay	–	167	0
Resolute Bay	4	0	0
Grise Fiord	10	0	0
Pangnirtung	50	0	0
Igloolik Lake	25	0	0
Hall Beach	–	–	–
Coral Harbour	7	0	0
Repulse Bay	–	–	1
Belcher Island	2	0	0
Broughton Island	0	–	0
Clyde River	0	–	0
Eskimo Point	32	0	0
Whale Cove	20	0	0
Chesterfield Inlet	–	0	0
Rankin Inlet	–	0	0
Churchill	–	–	–
Totals	321	251	1

Note that these statistics, compiled by the fisheries management division of the Freshwater Institute of Environment Canada, Winnipeg, are provisional and must be regarded as minimum kills. For 1975 and earlier years the figures represent confirmed landings. The totals do not include lost or abandoned carcasses or moribund losses. There are no firm data on loss rates. Attempts to kill bowhead were made at Coral Harbour and the Igloolik Hall Beach area. None were taken but probably there were losses by sinking or escape of moribund whales.

These statistics are more conveniently grouped by area, and compared with earlier catches, as follows:

	Year	Western Arctic	Eastern Arctic	Hudson and James Bay	Total
Narwhal	1973	–	330	11	341
	1974	–	291	–	291
	1975	–	251	–	251
White whale	1973	297	63	178	538
	1974	118	136	255	509
	1975	149	111	61	321
Bowhead	1974	–	–	–	(?)
	1975	–	1	–	1

On the British Columbia coast, off Victoria on 16 August, 1975, six or seven killer whales were netted of which two were captured alive for display, and four released. The two taken were: a 13 ft. 5 in. female for Sealand in Victoria; and a 15 ft. 6 in. male for the Niagara Falls aquarium.

8 MANAGEMENT

Federal permits for live capture of killer whales off British Columbia have been suspended, pending review of the status of the local killer whale population and a policy decision on their management.

Discussions continue to be held internally within the Canadian Government regarding the present catch rates of beluga and narwhal, the escape rate of wounded animals in these fisheries, and the loss rate of animals mortally wounded or killed but sunk or otherwise lost, and the effect that the catch and loss rates are having on different populations. Under the existing Canadian Fisheries Act, the hunting of narwhals is controlled with a quota per hunter in the Northwest Territories which gives an open-ended figure. A fixed quota is desirable, subdivided per settlement. Narwhal tusks are in considerable international demand with high prices paid.

Since 1975, Canadian "aboriginals" have been allowed to take bowhead whales without a special permit. Under the recommendations of the IWC, and the Canadian Fisheries Act, native peoples are permitted to kill bowhead whales but must use the products locally. Presumably, this might restrict native peoples from engaging in trade in whale products especially if these are to be exported, *i.e.* are clearly not to be used locally.

9 PUBLICATIONS

Listed here are publications for the period 1975–1976 that were not cited in final form in the last Progress Report, resulting from research on cetaceans carried out by the staff of the Arctic Biological Station, or supported directly or indirectly by that institute.

Omitted are the Canadian articles in the IWC volume (Mitchell, Editor, 1975), listed in the previous Progress Report as in press.

Ackman, R. G., Hingley, J. H., Eaton, C. A., Sipos, J. C. and Mitchell, E. 1975. Blubber fat deposition in Mysticeti whales. *Can. Jour. Zool.* 53(9): 1332–9.

Gaskin, D. E., Smith, G. J. D. and Watson, A. P. 1975. Preliminary study of movements of harbor porpoises (*Phocoena phocoena*) in the Bay of Fundy using radiotelemetry. *Can. Jour. Zool.* 53(10): 1466–76.

Hay, K. and McClung, R. 1976. Observation on Beluga and Narwhal in the Canadian High Arctic, Summer 1974. *Fish Res. Bd. Can.* Manuscript Rept. Ser. No. 1385: i–iii, 1–55.

Lipps, J. H. and Mitchell., E. 1976. Trophic model for the adaptive radiations and extinctions of pelagic marine mammals. *Paleobiology*, 2: 147–55.

Mansfield, A. W., Sergeant, D. E. and Smith, T. G. 1975. Marine Mammal Research in the Canadian Arctic. *Environ. Canada, Fish. Mar. Ser., Tech. Rept.* No. 507; i–iii, 1–23.

Mercer, M. C. 1976. Mammals. *In* A. J. Pinhorn, Living Marine Resources of Newfoundland–Labrador: Status and Potential. *Environ. Canada, Fish. Res. Bd. Canada, Bull.* 194: 46–51.

Mitchell, E. 1975. Progress Report on Whale Research, May 1973–May 1974. *Rep. Int. Whal. Commn*, 25: 270–82.

Mitchell, E. 1975. Preliminary Report on Nova Scotia Fishery for Sperm Whales *(Physeter catodon)*. *Rep. Int. Whal. Commn*, 25: 226–35.

Mitchell, E. 1975. Preliminary Report on Nova Scotia Fishery for Sei Whales *(Balaenoptera borealis)*. *Rep. Int. Whal. Commn*, 25: 218–25.

Mitchell, E. 1975. (Ed.). Review of Biology and Fisheries for Smaller Cetaceans. *J. Fish. Res. Bd. Can.* 32(7): 875–1240.

Mitchell, E. 1975. Phylogeny of Cetacea. *Amer. Zoologist.* 15(3): 824.

Mitchell, E. 1975. Present shortcomings of the data collection programs of the International Whaling Commission. National Whale Symposium, 9–12 November 1975. Indiana Univ., Bloomington, Program, abstract, p. 13.

Mitchell, E. 1975. (Review of:) Mind in the Waters. A book to celebrate the consciousness of whales and dolphins. *Can. Field-Nat.* 89(4): 474–5.

Mitchell, E. 1975. (Review of:) The Whale Problem, A Status Report. *Can. Field-Nat.* 89(4): 475–6.

Mitchell, E. 1976. (Review of:) Dolphins and porpoises: A comprehensive, annotated bibliography of the smaller Cetacea. *Can. Field-Nat.* 90(1): 89–90.

Mitchell, E. 1976. Report by the Chairman, Sub-committee on Small Cetaceans. *Rep. Int. Whal. Commn (Sci. Rep.)*, 26: 55–8.

Mitchell, E. and Kozicki, V. M. 1975 Prototype visual mark for large whales modified from "Discovery" tag. *Rep. Int. Whal. Commin*, 25: 236–9.

Sergeant, D. E. 1976. Cetology in the western North Atlantic Ocean. *Mammal Rev.* 6(1): 37–9.

Sergeant, D. E., 1977. Stocks of Fin Whales *Balaenoptera physalus* L. in the Northern Atlantic Ocean. Paper NA 76/19 (published in this volume).

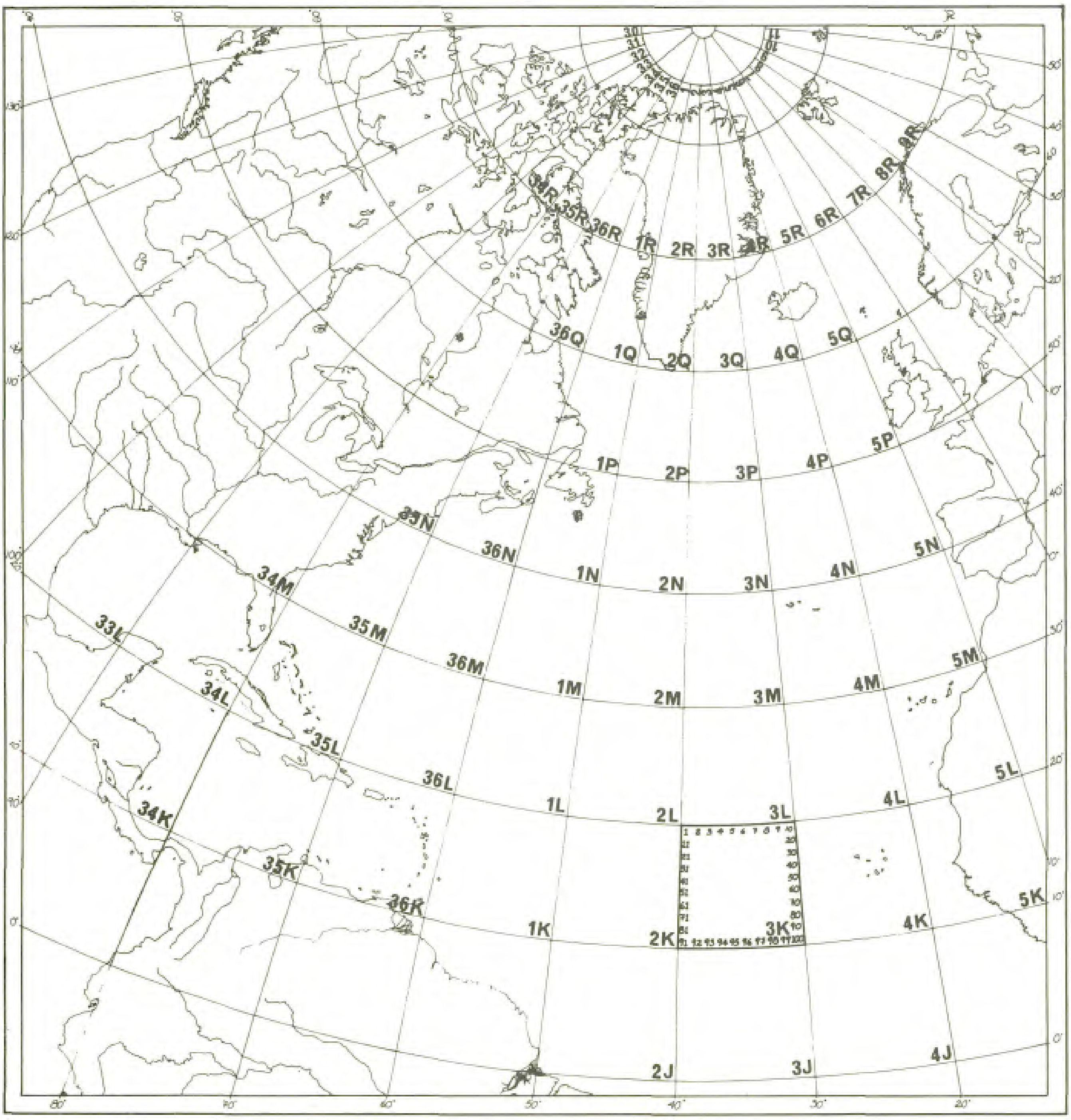
10 WORKING DOCUMENTS

Not all documents listed will be formally published, and those that are may be substantially modified in the final form:

Mitchell, E. 1975 (Ed.). Proposals for a global research programme on small cetaceans. FAO–ACMRR: Working Party on Marine Mammals, Group II, Report, Annex I, p. 1–33 (With others).

Mitchell, E. 1976 Ms. (Ed.). Draft Report of *ad hoc* Group II (Small Cetaceans and Sirenians). FAO/ACMRR: Working Party on marine mammals (With many others).

Mitchell, E. 1975 Ms. Northern Bottlenose Whale, *Hyperoodon ampullatus* (Forster, 1770). Int. Whaling Commn, Sci. Comm., Doc SC/27/Rep. 22, 6 pp.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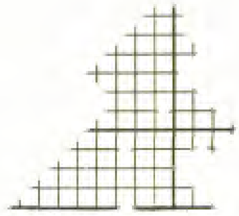

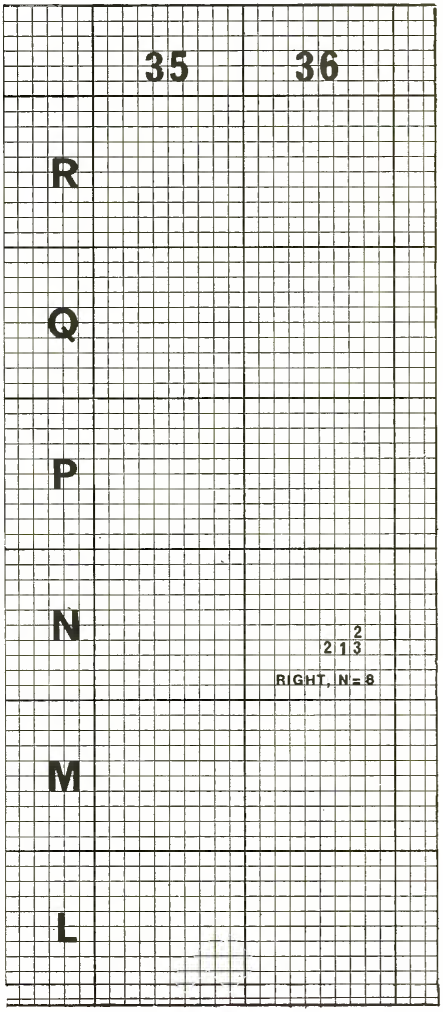
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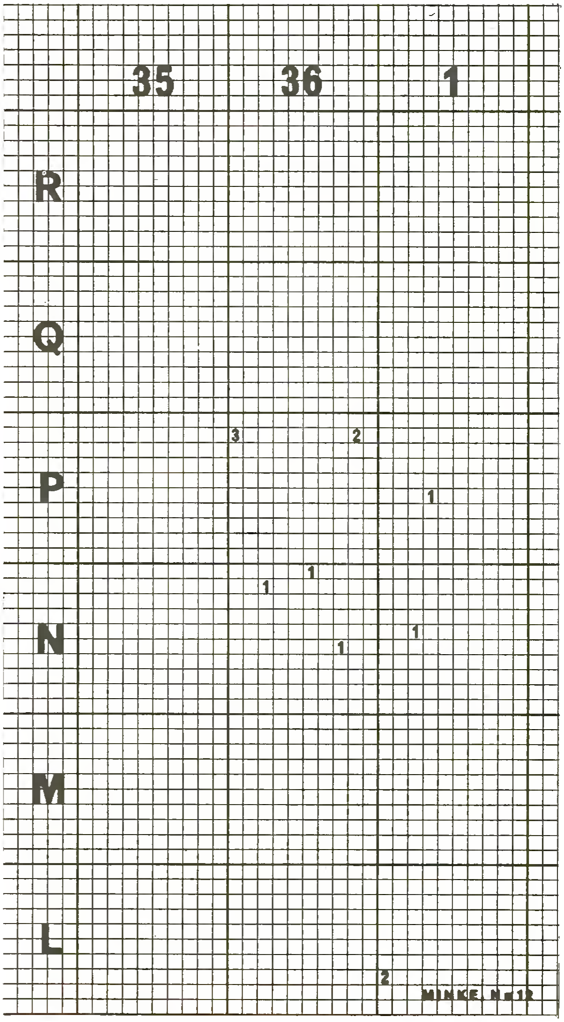
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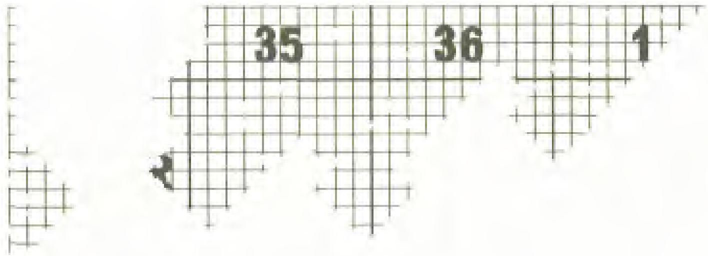
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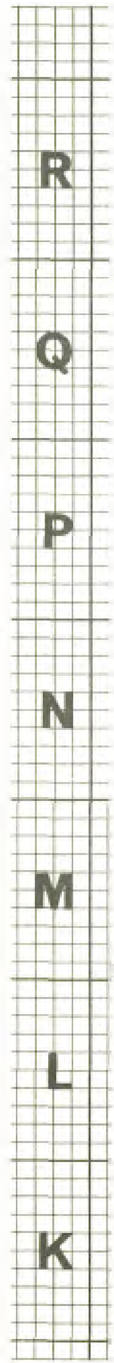
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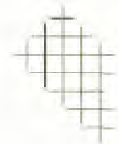

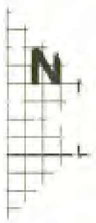
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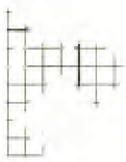

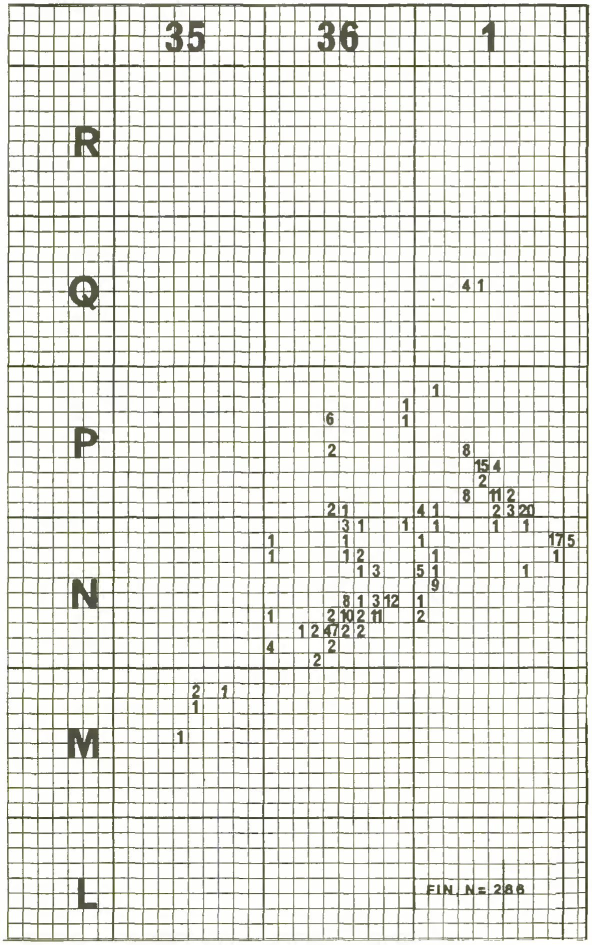
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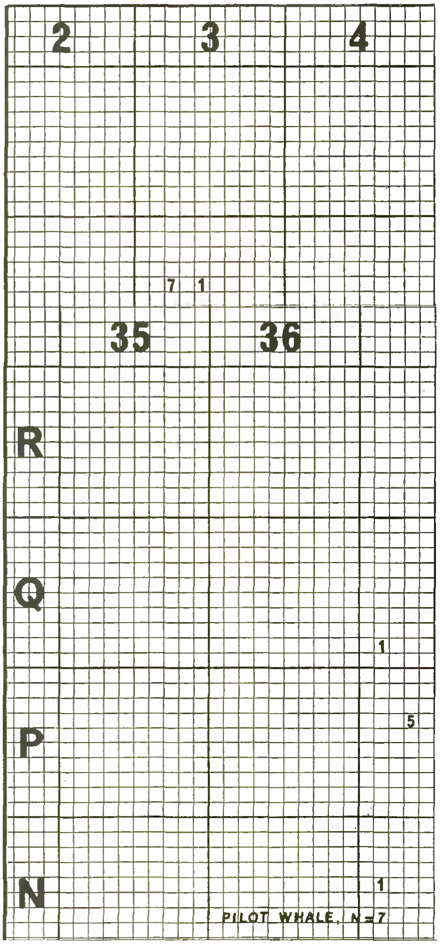
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Tag returns for all species are here corrected and updated from the version in an earlier Progress Report:

TIME OF CRUISE			TAGGING					RECOVERIES										
			TOTAL	AREAS								DATES			POSITION			
MONTH YEAR	CRUISE	SPECIES	NUMBER TAGGED	NOVA-SCOTIA	LABRADOR	GULF of St. LAWRENCE	OTHER	RECOVERED TAG NUMBER	WHALE NUMBER	SEX	LENGTH IN FEET	TAGGING	RECOVERY	ELAPSED TIME IN MONTHS	TAGGING	RECOVERY	DISTANCE IN STRAIGHT LINE (IN MILES)	OTHER TAGS RECOVERED IN SAME WHALE
X-XI 1960	SACKVILLE	FIN	1	1	-	-												
		HUMP	1	-	-	-	1- GULF STREAM											
VII-VIII 1965	CALANUS	FIN	3	-	-	1	2- LABRADOR SEA											
		MINKE	3	-	-	3												
VII-X 1966	WILLIAM S.	FIN	78	64	14			34	B 70 - 66	♀	59	24 - VII - 66	28 - VIII - 66	1	42°50′ N - 65°34′ W	43°40′N - 62°45′ W	130	
								67	D106 - 66	♂	55	24 - VII - 66	23 - IX - 66	2	42°30′ N - 65°36′ W	48°29′ N - 52°36′ W	652	
								16/410	B148 - 66	♂	54	24 - VII - 66	28 - IX - 66	2	42°24′ N - 65°35′ W	43°35′ N - 62°10′ W	155	
								5/410	B250 - 66	♂	59	21 - VII - 66	9 - XI - 66	3½	43°01′ N - 64°16′ W	43°30′ N - 65°01′ W	30	
								C 177	D 45 - 67	♀	57	12 - VIII - 66	2 - VII - 67	10¾	50°30′ N - 53°36′ W	48°20′ N - 52°53′ W	136	
								C 319	D 60 - 67	♂	58	31 - VIII - 66	17 - VII - 67	10½	54°38′ N - 56°06′ W	48°55′ N - 52°33′ W	350	
								94	B123 - 67	♂	44	28 - VII - 66	6 - VIII - 67	12¼	43°52′ N - 62°42′ W	43°45′ N - 62°35′ W	8	
								3/410	B152 - 67	♂	53	23 - VII - 66	16 - VIII - 67	12¾	41°53′ N - 65°31′ W	42°54′ N - 64°07′ W	86	
								63	B176 - 67	♂	59	24 - VII - 66	24 - VIII - 67	13	42°25′ N - 65°32′ W	43°30′ N - 63°08′ W	120	
								72	B 87 - 68	♀	62	24 - VII - 66	30 - VI - 68	24	42°30′ N - 65°36′ W	43°20′ N - 63°10′ W	118	
								15456	B116 - 68	♀	64	15 - X - 66	8 - VIII - 68	21¾	44°13′ N - 61°22′ W	43°27′ N - 63°00′ W	86	
								89	B122 - 68	♂	54	27 - VII - 66	11 - VIII - 68	24½	43°14′ N - 64°35′ W	42°21′ N - 63°03′ W	86	
								C 164	W177 - 68	♂	59	4 - VIII - 66	4 - IX - 68	25	44°23′ N - 59°06′ W	50°22′ N - 53°25′ W	452	
								15466	B208 - 68	♂	49	15 - X - 66	5 - IX - 68	22⅔	44°22′ N - 61°20′ W	43°50′ N - 62°35′ W	65	
								70	B334 - 68	♀	58	24 - VII - 66	28 - X - 68	27	42°30′ N - 65°36′ W	43°20′ N - 65°00′ W	57	
								86	B - - 68	-	-	27 - VII - 66	BEFORE - VI - 68	≈11	43°14′ N - 65°35′ W	NOVA-SCOTIA	-	
								56	B - - 68	-	-	24 - VII - 66	BEFORE 10 - VIII - 68	24 TO 26	42°25′ N - 65°32′ W	NOVA-SCOTIA	-	
								C 154	B - - 68	-	-	3 - VIII - 66	BEFORE 10 - VIII - 68	22 TO 24	43°30′ N - 62° 25′ W	NOVA-SCOTIA	-	
								73	B - - 68	-	-	24 - VII - 66	BEFORE 11 - IX - 68	23 TO 26	42°30′ N - 65°36′ W	NOVA-SCOTIA	-	
								97	B105 - 68	♂	57	3 - VIII - 66	10 - VII - 69	35¼	43°15′ N - 62°10′ W	42°54′ N - 63°12′ W	46;56	*912-POLAR STAR 1967
								85	B104 - 69	♀	56	27 - VII - 66	10 - VII - 69	35½	43°12′ N - 64°30′ W	42°54′ N - 63°12′ W	60	
								3	B128 - 69	♂	51	21 - VII - 66	16 - VII - 69	35¾	43°10′ N - 63°56′ W	43°07′ N - 63°17′ W	28	
								55	B215 - 69	♂	53	24 - VII - 66	21 - IX - 69	38	42°25′ N - 65°32′ W	43°07′ N - 64°54′ W	50	11/410 SAME CRUISE
								10/410	B - - 69	-	-	24 - VII - 66	BEFORE 3 - VII - 69	≈23	42°22′ N - 65°33′ W	NOVA-SCOTIA	-	
								48	B 15 - 70	♀	56	24 - VII - 66	14 - VI - 70	46⅔	42°23′ N - 65°33′ W	43°18′ N - 63°16′ W	115	
								58	B 46 - 70	♀	56	24 - VII - 66	30 - VI - 70	47¼	42°25′ N - 65°32′ W	43°25′ N - 63°14′ W	120	
								C 318	D 90 - 70	♂	56	31 - VIII - 66	27 - VII - 70	47	54°38′ N - 56°06′ W	50°35′ N - 53°45′ W	255	
								C 183	D 24 - 71	♂	57	14 - VIII - 66	1 - VI - 71	57½	53°28′ N - 55°06′ W	48°50′ N - 52°40′ W	275	
		SEI	14	8	-	-	6-CARIBBEAN SEA	C 168	B263 - 71	♀	48	5 - VIII - 66	26 - IX - 71	61⅔	44°16′ N - 55°17′ W	42°56′ N - 65°17′ W	430	C169 SAME CRUISE
		HUMP	8	3	4	-	1-WEST. GREENLAND											
		BLUE	2	2	-	-												
		MINKE	2	-	-	-	2-BAFFIN											
		RIGHT	2	2	-	-												
		SPERM	61	40	-	-	10-AMERICAN AREA	83 (NFLD)	SPAIN	♂	41	26 - VII - 66	7 - VIII - 73	84⅓ (7 YEARS)	42°12′ N - 65°07′ W	44°10′ N - 11°20′ W	3240	
							9-WEST. GREENLAND											
							1-BAFFIN											
							1-NORTH SARGASSO SEA											
		POTHEAD	1	-	-	-	1-WEST. GREENLAND											
		KILLER	2	-	-	-	2-WEST. GREENLAND											

* SAME WHALE TAGGED FOR THE SECOND TIME ON 9-X-67 - 43° 28′ N - 62°12′ W
DISTANCE BETWEEN TAGGING - 44 MILES
TIME BETWEEN TAGGING - 14 MONTHS

TIME OF CRUISE		CRUISE	SPECIES	TAGGING					RECOVERIES										
MONTH	YEAR			TOTAL NUMBER TAGGED	AREAS				RECOVERED TAG NUMBER	WHALE NUMBER	SEX	LENGTH IN FEET	DATES		ELAPSED TIME IN MONTHS	POSITION		DISTANCE IN STRAIGHT LINE (IN MILES)	OTHER TAGS RECOVERED IN SAME WHALE
					NOVA-SCOTIA	LABRADOR	GULF of St. LAWRENCE	OTHER					TAGGING	RECOVERY		TAGGING	RECOVERY		
VII - X	1967	POLAR STAR	FIN	66	19	28	-	2 GULF STREAM	809	W107 - 67	♀	64	3-VIII - 67	19-VIII - 67	½	53°34′N - 55°30′W	50°27′N - 55°20′W	180	
								3 LABRADOR SEA	816	W-9 - 68	♀	56	6-VIII - 67	30-VI - 68	10¾	57°37′N - 60°36′W	50°37′N - 55°32′W	450	
								5 WEST. GREENLAND	753	B-2 - 71	♂	63	29-VII - 67	9-V - 71	9⅓	51°39′N - 54°15′W	44°06.5′N - 59°12.5′W	495	
								8 EAST. GREENLAND	807	W-87 - 72	♀	63	3-VIII - 67	30-VIII - 72	61	53°20′N - 55°26′W	51°24′N - 53°47′W	130	
								1 AMERICAN											
			SEI	3	2	-	-	1 EASTERN GYRE	721	B225 - 71	♀	47	8-VIII - 67	17-IX - 71	50⅓	42°06′N - 65°19′W	42°59′N - 65°06′W	55	
									716	B22 - 72	♂	44	8-VIII - 67	11-VI - 72	59	42°05′N - 65°18′W	42°16′N - 66°20′W	48	
			HUMP	36	-	20	-	2 WEST. GREENLAND	836	GREENLAND NO INFO.			15-VIII - 67	≈25-VIII-68	≈12⅓	63°02′N - 52°06′W	65°00′N - 52°30′W	175	
								14 EAST. GYRE											
			BLUE	1	1	-	-												
			MINKE	1	1	-	-												
			SPERM	26	4	-	-	7 BAFFIN											
								1 EAST. GYRE											
								12 NORTHWEST. AFRICA											
								2 GUINEAN REGION											
VI - XI	1967	CHESTER	HUMP	2	2	-	-												
			BLUE	2	2	-	-												
XI - 68 - I	1969	POLAR STAR	FIN	1	-	-	-	1 AMERICAN AREA											
VII - XI	1968	CHESTER	FIN	1	1	-	-		15481	B83 - 68	♀	50	28-VII - 68	29-VII - 68	1/30	43°30′N - 63°10′W	43°23′N 63°07′W	8	
			BLUE	4	4	-	-												
			RIGHT	4	4	-	-												
VIII	1968	RUTRIDENT	SPERM	1	1	-	-												
II	1969	POLAR STAR	SEI	6	-	-	-	4 CARIBBEAN SEA											
								2 AMERICAN AREA											
			HUMP	33	-	-	-	33 CARIBBEAN SEA											
			MINKE	2	-	-	-	2 SOUTH. SARGASSO SEA											
			SPERM	9	-	-	-	9 CARIBBEAN SEA											
V - VI	1969	POLAR STAR	FIN	39	15	1	22	1 LABRADOR SEA	1083	B110 - 70	♀	62	24-V - 69	12-VII - 71	25⅔	44°42′N - 59°44′W	44°11′N - 63°50′W	177	
			SEI	5	-	-	-	1 LABRADOR SEA											
								4 WEST. GREENLAND											
			HUMP	4	2	2	-												
			BLUE	3	3	-	-												
			MINKE	3	1	-	2												
			SPERM	1	1	-	-												
			POTHEAD	6	1	5	-												
			BOTTLENOSE	2	-	-	-	2 BAFFIN AREA	1446	EDM831	♀	721cm	17-VI - 69	17-VI - 69	1 HOUR	60°27′N - 60°42′W	SAME	0	
VI - XI	1969	CHESTER	FIN	5	5	-	-												
			SPERM	1	1	-	-												
VI - X	1969	FUMI	FIN	1	-	1	-												
			HUMP	42	-	42	-												
IV	1969	ARGUS TOWER	HUMP	8	-	-	-	8 NORTH. SARGASSO SEA											
VI - XI	1970	CHESTER	FIN	1	1	-	-												
VI - XI	1970	FUMI	FIN	1	-	1	-		926	W2 - 70	♀	60	18-VI - 70	22-VI - 70	⅛	49°47′N - 52°36′W	51°28′N - 54°15′W	130	
			HUMP	12	-	12	-												

TIME OF CRUISE		CRUISE	SPECIES	TAGGING					RECOVERIES										
				TOTAL NUMBER TAGGED	AREAS				RECOVERED TAG NUMBER	WHALE NUMBER	SEX	LENGTH IN FEET	DATES		ELAPSED TIME IN MONTHS	POSITION		DISTANCE IN STRAIGHT LINE (IN MILES)	OTHER TAGS RECOVERED IN SAME WHALE
MONTH	YEAR				NOVA SCOTIA	LABRADOR	GULF of St. LAWRENCE	OTHER					TAGGING	RECOVERY		TAGGING	RECOVERY		
IV	1970	ERLINE	HUMP	17	-	-	-	17-NORTH.SARGASSO SEA											
VII	1970	METRIDA	FIN	1	-	-	1												
III	1971	WESTWHALE 8-FRBC	FIN	7	4	-	-	3-AMERICAN AREA											
			SEI	2	-	-	-	1-GULF STREAM											
					-	-	-	1-AMERICAN AREA											
			SPERM	7	-	-	-	1-AMERICAN AREA											
								6-GULF STREAM											
V-XI	1971	THORARINN	FIN	12	12	-	-		1756	B133-72	♀	53	4-X -71	30-VII-72	10	43°13′N-65°56′W	43°04′N-63°32′W	60	
			RIGHT	2	2	-	-												
VII	1971	METRIDA	HUMP	1	-	-	1												
VI-VII	1972	FUMI-FRBC	FIN	47	-	37	10		1296	W53-72	♂	61	10-VII-72	14-VIII-72	1	48°37′N-50°52′W	51°28′N-53°57′W	215	
									1291	W54-72	♂	56	10-VII-72	14-VIII-72	1	48°37′N-50°52′W	51°28′N-53°57′W	215	1293 SAME CRUISE
			HUMP	18	-	18	-												
			BLUE	5	-	-	5												
			MINKE	1	-	1	-												
IX	1972	CARINO-FRBC	FIN	5	-	5	-												
			HUMP	7	-	7	-												
			SPERM	3	-	-	-	3-WEST. GREENLAND											
V-XI	1972	THORARINN	FIN	5	5	-	-												
VII-XI	1972	FUMI	FIN	2	-	2	-												
			KILLER	4	-	4	-												
VI	1972	J.G.MEAD	HUMP	1	-	1	-												
X-XI	1973	ARCTIC ENDEAVOUR	FIN	10	2	-	8												
			BLUE	3	-	-	3												
VII	1974	W. HOEK	BOWHEAD	1	-	-	-	1-MACKENZIE BAY											
IX	1975	HERO	SPERM	1	-	-	-	1-SOUTH ATLANTIC											
III	1976	V.M.KOZICKI	BLUE	2	-	-	2												

TOTAL NUMBER TAGGED, BY SPECIES, 1960-1974	TOTAL NUMBER TAGGED	NOVA SCOTIA	LABRADOR	GULF of St. LAWRENCE	OTHER
FIN	286	129	89	42	26
SEI	30	10	-	-	20
HUMP	190	7	106	1	76
BLUE	22	12	-	10	-
SPERM	110	47	-	-	63
MINKE	12	2	1	5	4
RIGHT	8	8	-	-	-
BOWHEAD	1	-	-	-	1
POTHEAD	7	1	5	-	1
KILLER	6	-	4	-	2
BOTTLENOSE	2	-	-	-	2
TOTAL NUMBER OF WHALES TAGGED, BY AREA		216	205	58	194

TOTAL NUMBER RECOVERIES, BY SPECIES, 1967-1973

FIN	38
SEI	3
HUMP	1
SPERM	1
BOTTLENOSE	1

SC/28/Prog Rep 4

Denmark – Progress Report on Whale Research 1975–76

SPECIES AND STOCKS STUDIED

At the meeting of the Working Group on North Atlantic whales in April 1976 a break-down of the statistics for the Greenland catch of minke whales was presented.

A similar material covering the catch of belugas, narwhal and harbour porpoises in Greenland was presented during the meeting of the sub-committee of Small Cetaceans just prior to the annual meeting of the Scientific Committee, June 1976.

No field work, marking or laboratory work has been carried out.

SC/28/Prog Rep 5

Iceland – Progress Report on Whale Research in 1975

One whaling station was in operation during the year. The catch consisted of following species:

245 fin whales
138, sei whales
37 sperm whales

Information on place of capture, length, and sex of foetus was collected as in previous years.

A collection of ear plugs from fin and sei whales and teeth from sperm whales was collected for the Whale Research Unit of the Institute of Oceanographic Sciences, England.

SC/28/Prog Rep 6

Japan – Progress Report on Whale Research – June 1975 to May 1976

This refers to work at the Far Seas Fisheries Research Laboratory

1 SPECIES AND STOCKS STUDIED

Investigation and studies are continuing mainly of large whales including prohibited whales in the North Pacific and the Antarctic. Sixteen Bryde's whales were caught in the Antarctic Area V (40°–44°S, 171°E–178°W) in 1975–76 season for the first time.

A special permit to take not more than 80 sperm whales from the adjacent waters to Japan was issued by the Government, and investigation was made with co-operation of a whaling company and the Whales Research Institute. A provisional report was presented at the special meeting on the sperm whale in La Jolla, March, 1976.

2 WHALE SIGHTING

Whale sighting by scouting boats which belong to the whaling expedition has been continuing in the same way as in the previous seasons in the North Pacific and the Antarctic, but the research distances have become shorter and shorter in recent years in both whaling grounds, caused by the decrease of activity of expeditions.

In the North Pacific, research area shrank into the middle latitudinal waters as shown in Fig. 1, and research distance was 37,251 miles in 1975. It was 67% of the previous season.

In the Antarctic, research area developed in Areas I and II, but research was not carried out in Area III except in higher latitudinal waters. The research distance was 147,402 miles in 1975–76 season, and it was 77% of the previous season.

A whale sighting and whale marking cruise was carried out with a chartered catcher boat *Miwa maru* in the tropical waters of the west Pacific for 60 days from 20 January to 19 March, 1976, and Mr S. Wada of our laboratory engaged in research with Dr N. Miyazaki of the Ocean Research Institute on board of the vessel. Research distance, number of larger whales, and whales marked are shown in Table 1 by 10° squares. It may be noted that Bryde's whales are distributed in the waters south of Equator in winter. The smaller cetacean species which were found during the cruise are as follows;

Stenella caeruleoalba
Stenella attenuata
Stenella longirostris
Tursiops aduncus
Lagenodelphis hosei
Peponocephala electra
Pseudorca crassidens
Orcinus orca
Grampus griseus
Globicephala macrorhynchus
Feresa attenuata
Ziphidae

Table 1

Research results in *Miwa maru* cruise in the North Pacific from 20 January to 19 March, 1976.

10° x 10° square	Research distance (miles)	Whales sighted		Whales marked	
		Bryde's	Sperm	Bryde's	Sperm
M20	141	–	–	–	–
M21	105	–	–	–	–
L20	225	–	–	–	–
L21	373	–	–	–	–
K20	298	–	–	–	–
K21	349	–	–	–	–
J20	342	–	–	–	–
J21	757	4	–	4	–
J22	434	–	18	–	10
J23	594	15	–	9	–
H20	40	–	–	–	–
H21	452	17	61	9	33
H22	1,030	12	27	7	9
H23	676	–	43	–	19
G23	254	–	–	–	–
Total	6,090	48	149	29	71

The number of whales found by operating catcher boats have also been reported. The number of blue (including pygmy blue), humpback and right whales found are shown for the North Pacific in 1975 and the Antarctic in 1975–76 in Tables 2 and 3, respectively.

Table 2

Sighting records of prohibited whales by operating catcher boats in the North Pacific, 1975.

Sector	Blue	Humpback	Right	Effort (CDW)
II N	5	–	–	63
II P	70	5	–	34
III M	–	–	–	59
III N	–	2	–	145
III P	–	55	–	43
IV L	–	–	–	120.5
IV M	1	–	–	311.5
IV N	6	–	–	75
V L	–	–	–	49
V M	9	3	1	361
V N	8	5	3	255
Total	99	70	4	1,516

3 WHALE MARKING

Whale marking by scouting boats consumed 219 Japanese marks (including two marks which were test-fired), and 60 whales were effectively marked in the North Pacific in 1975 season as shown in Table 4. The *Miwa maru* cruise consumed 194 Japanese marks (including two marks which were test-fired), and 100 whales were effectively marked in 1976 (Table 1).

Table 3

Sighting records of prohibited whales by operating catcher boats in the Antarctic, 1975–76.

Sector	Blue	Humpback	Right	Effort (CDW)
I B	3	7	1	222
I A	–	7	4	92
I D	–	–	4	50
II C	–	–	–	30
II B	1	6	10	118
II A	–	6	2	91
II D	1	5	47	188
III B	–	16	–	93
III E	–	–	–	48
IV B	–	–	–	40
IV A	1	–	–	6
IV D	38	2	124	145
IV E	7	–	–	42
V B	–	–	–	55
V A	–	2	–	65
V D	7	2	4	306
V E	1	–	–	32
VI B	1	19	–	58
VI A	2	5	–	182
VI D	–	–	–	25
VI E	–	–	–	25
Total	62	77	196	1,913

Table 4

Number of whales marked effectively by the scouting boats in the North Pacific, 1975.

10° square	Fin	Sei	Bryde's	Sperm	Minke	Total
N 20 JS	1	–	–	–	–	1
L 23	–	3	–	4	–	7
M 24	–	3	–	3	–	6
L 25	–	–	2	–	–	2
M 25	–	–	9	3	–	12
L 26	–	–	2	–	–	2
N 26	–	2	–	2	5	9
N 28	2	–	–	–	–	2
P 28	3	–	–	3	–	6
N 29	2	–	–	–	–	2
P 29	2	–	–	–	–	2
L 24	–	–	3	6	–	9
Total	10	8	16	21	5	60

In the Antarctic, 99 ordinary Discovery marks and 85 Discovery .410 marks were consumed. In addition 9 marks were used for an experiment for estimating recovery report rate of whales marks in 1975–76 season. Seventy whales (including 23 minke whales) were effectively marked. It was the first time whale marking for the minke whales was carried out in the Antarctic in this season (Table 5).

Japanese whalers recovered 7 Japanese marked whales and two USSR marked whales, and USSR kindly reported for us that whalers recovered 3 Japanese marked whales in the North Pacific in 1975 (Table 6). In the Antarctic season 1975–76, two Discovery marked whales and one USSR marked whale were recovered by Japanese whalers as shown in Table 7. All the marks which were experimentally placed into 7 sei whale carcasses were recovered.

Table 5

Number of whales marked effectively by scouting boats in the Antarctic, 1975–76 season.

10° × 10° square	Blue	Fin	Sei	Minke	Sperm	Total
G 23	–	–	–	–	2	2
F 23	–	–	–	–	5	5
E 18	–	–	2	–	–	2
D 2	–	–	–	–	2	2
D 14	–	–	2	–	–	2
D 15	3	–	2	–	5	10
D 16	–	2	6	–	–	8
D 20	–	–	–	–	2	2
D 22	–	–	–	–	5	5
D 23	–	–	–	–	7	7
D 24	–	–	–	2	–	2
A 1	–	–	–	3	–	3
A 24	–	–	–	1	–	1
B 0	–	–	–	1	–	1
B 9	–	–	–	3	–	3
B 10	–	–	–	8	–	8
B 12	–	–	–	5	–	5
B 34	–	–	1	–	–	1
B 35	–	–	–	–	1	1
Total	3	2	13	23	29	70

Minke whale were marked by .410 Discovery mark

4 FIELD WORK

Dr Y. Masaki engaged in biological research on board a factory ship in 1975–76 season. Dr S. Ohsumi engaged in whale research on a land station in Hokkaido in summer 1975. He also investigated sperm whales with Miss Y. Satake of the Whales Research Institute under a special permit for scientific purposes in winter, 1976.

All the whales caught by Japanese coastal and pelagic whaling were investigated on many biological items, and earplugs, ovaries, teeth, frozen meat and liver tissues and baleen plates were collected from them by whalers or researchers.

The data of minke whales which were caught by *Miwa maru* which engaged in an experimental operation around the coast of Japan were also collected.

Fifteen small cetacean specimens were collected during whale sighting cruise of *Miwa maru* in tropical waters of the west Pacific.

5 LABORATORY WORK

Collected earplugs and ovaries were treated in the laboratory. Biochemical analysis has been continuing.

6 STUDIES

Mr S. Wada has studied biochemical analysis for whale stock identification in the Ocean Research Institute under the leadership of Associate Professor K. Numachi. He developed up-to-date electrophoretic techniques of detection and separation of 26 enzymes in liver and muscle tissue of southern minke whales, and found 4 polymorphic enzymes which had a possibility to be used as genetic markers of stock units.

Stock identification of the southern minke whales by means of these developed techniques is now being undertaken. The frozen materials from sei, sperm and Bryde's whales have been collected from the North Pacific and the Antarctic. Similar procedures as for the southern minke will be also applied with these materials.

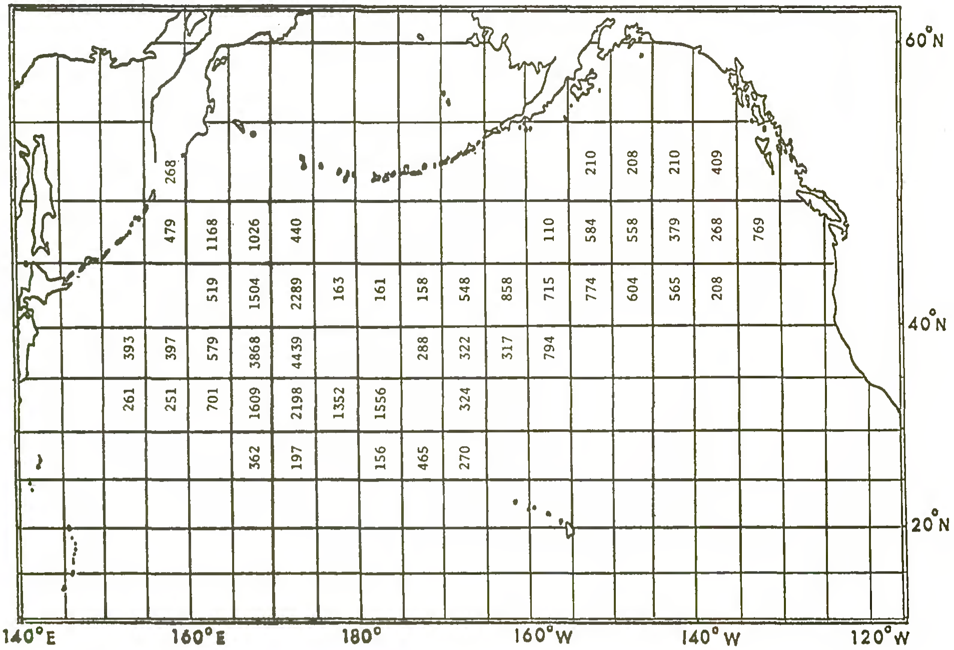

Fig. 1. Scouting distance (miles) by scouting boats by 5° squares in the North Pacific in 1975.

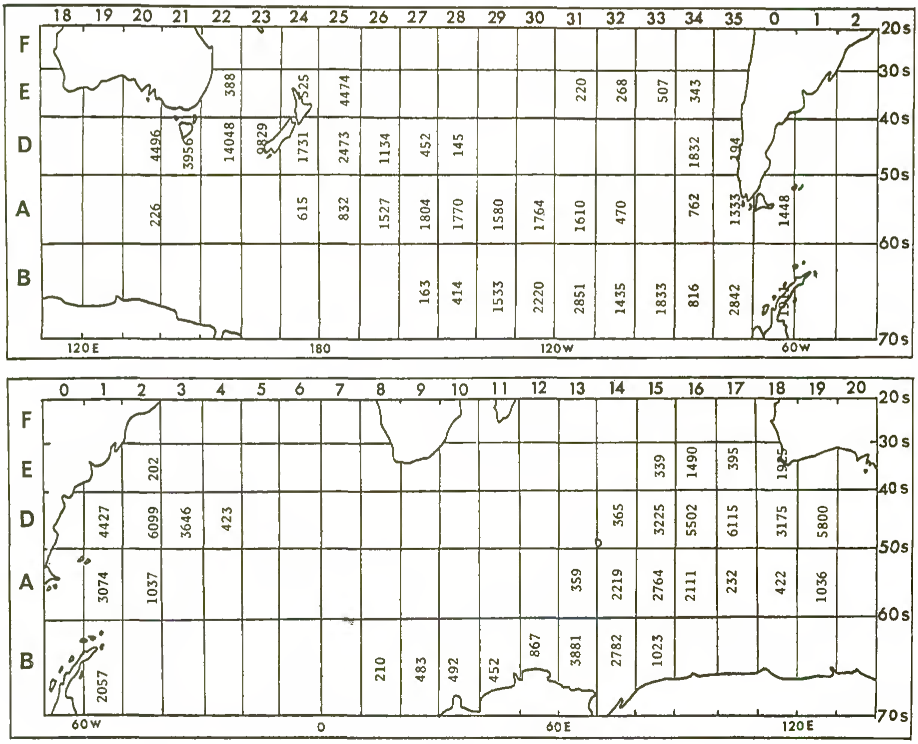

Fig. 2. Scouting distance (miles) by 10° squares in the Antarctic in 1975–76.

The accumulated data of whale sighting by scouting boats which were attached to whaling expeditions in the North Pacific and the Antarctic from 1965 to 1975 were computed, and they are now being analyzed for many items on distribution, migration, density and relation with weather and oceanic conditions.

7 PUBLICATIONS

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8 WORKING DOCUMENTS

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Ohsumi, S. 1976c. Sperm whale catch efficiency by Japanese pelagic whaling catcher boats in the Antarctic IWC/SC/SM76/14.

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Ohsumi, S. and Satake, Y. 1976. Provisional report on investigation of sperm whales off the coast of Japan under a special permit. IWC/SC/SM76/16.

Wada, S. 1975. Indices of abundance of large-sized whales in the North Pacific in 1975 whaling season. IWC/SC/27/Doc. 28.

Whales Research Section, FSRSL. 1975. Progress report on whale research, Japan. IWC/SC/27/Prog. 2.

Table 6

Whale marks recovered by Japanese and USSR whalers in the North Pacific season 1975.

Mark No.	Species	Sex	Body length (m) at recovery	Date marked	Date recovered	Position marked	Position recovered
Japanese marks							
0789	Bryde's	F	14.2	8.v.50	27.vii.75	26°08'N, 143°00'E	36°00'N, 146°12'E
10516	Sei	M	14.2	9.viii.69	14.vii.75	40°42'N, 159°04'E	40°33'N, 169°10'E
11122	Sperm	–	–	28.v.69	11–12.ix.75	48°58'N, 163°02'E	28°10'N – 30°08'N[1,2] 149°40'E–151°24'E
11155	Sperm	M	10.7	28.v.69	7.vii.75	48°53'N, 172°58'E	34°33'N, 156°59'W
11336	Sperm	M	15.6	4.x.70	3.vi.75	39°49'N, 151°09'E	33°36'N, 173°53'E
11510	Sperm	M	15.1	5.x.70	8.vii.75	40°54'N, 153°01'E	33°54'N, 173°51'E
11523	Sperm	M	15.0	5.x.70	1.viii.75	40°52'N, 152°58'E	35°18'N, 158°12'E[2]
12029 12048	Sei	M	12.4	6.ii.72	17.v.75	21°42'N, 151°36'E	34°42'N, 143°20'E
13069	Bryde's	F	12.3	29.i.75	19.vi.75	01°58'N, 138°30'E	28°53'N, 154°45'E[2]
13102 13103	Bryde's	F	13.4	4.ii.75	19.vi.75	02°20'N, 135°26'E	29°20'N, 175°20'E
USSR marks							
882	Sperm	–	–	13.xi.54	(13.i.76)	45°36'N, 153°48'E	(Sanriku coastal)[1]
690727	Fin	F	17.9	26.ii.75	20.vii.75	02°15'N, 108°00'W	51°50'N, 136°53'W

Remarks: [1] Recovered from cooker
[2] Recovered by USSR

Table 7

Whale marks recovered by Japanese whalers in the Antarctic season, 1975–76.

Mark No.	Species	Sex	Body length (m) at recovery	Date marked	Date recovered	Position marked	Position recovered
Discovery marks							
26942	Sei	M	14.4	18.iii.68	19.xii,75	44°17'S, 177°56'E	42°03'S, 156°09'E
30538	Sei	F	14.7	22.i.74	26.i.76	32°41'S, 67°11'E	43°16'S, 97°48'E
USSR mark							
A 324*	Sei	–	–	26.xi.72	27.i.76	40°54'S, 50°07'W	51°06'S, 44°17'W

Remark: *Recovered at meat cutting on a factory ship.

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Norway — Progress Report on Whale Research — April 1975 to April 1976

As in 1974, the only Norwegian whaling carried out in 1975 was whaling for small whales in the northern Atlantic Ocean. A total of 80 Norwegian vessels reported 1,788 minke whales and 2 killer whales caught. Completed questionnaires containing information on date, locality, species, sex, body length, and if present length and sex of foetuses, were received for almost every individual whale caught.

Since 1938 the Norwegian whaling for small whales has been regulated by fishing effort restrictions. The following restrictions were carried out in the 1975 season:

1. Regulation by licences
2. All whaling forbidden in a period of three weeks lasting from July 1 to July 21.
3. In the waters north of 70°N and east of 20°W, whaling is limited to the period May 1 to June 30. For other waters east of 44°W (Cape Farewell) whaling is permitted from April 15 to August 31, and for waters west of Cape Farewell from May 15 to August 31.
4. A maximum quota per season for minke whale meat set at 70 tons per vessel.

Further work on stock assessment of minke and bottlenose whales has been made at the Department of Marine Zoology and Marine Chemistry, University of Oslo, and at the Institute of Marine Research, Bergen. Papers were presented at the meeting of the International Working Group held in Oslo 5–13 April 1976.

A report from the Group will be submitted to the Scientific Committee of the International Whaling Commission at its annual meeting in June 1976.

Biological work covering marking of whales, collection of biological material, and sightings was performed by the Institute of Marine Research in the northern North Atlantic in the 1975 season.

MARKING

In 1974 a marking cruise to northeastern North Atlantic waters with the primary aim of marking minke whales was carried out with two vessels. Altogether 51 minke whales and 12 humpbacks were marked. In addition two minke whales were marked in the North Sea. One mark has been recovered in a minke whale marked at Bear Island. This whale was caught on 4 June 1975 12 nautical miles north of North Cape.

A similar marking cruise was carried out in about the same waters and at about the same period of time with two vessels in 1975. Altogether 136 minke whales and 2 humpbacks were marked.

BIOLOGICAL MATERIAL COLLECTED

An extensive collection of biological data from minke whales was made in 1975 by special research personnel on board five whaling vessels.

Forty-three minke whales were examined in the Barents Sea area. Larger females are known to predominate in the Barents Sea catches, and in agreement with this fact, 76.6% of the animals examined were females. The stomachs contained krill and fish.

Five minke whales were examined in the North Sea area. Four of them had fed upon mackerel, and one had eaten ammodytes.

Forty-six minke whales were examined off East Greenland, 30 of which were females. Almost all of them had fed upon capelan, a few only had krill or a mixture of krill and capelan in their stomachs.

SIGHTINGS

Sightings of whales were made from the whaling vessels in operation on which biological research was carried out, and from the two vessels used during the marking cruise. The following number of species of cetaceans sighted was reported (data from I. Christensen):

Barents Sea: 1339 minke; 10(+) humpbacks; 1 sperm (off Andenes, North Norway); 40(+) killer whales; 10 white whales; 2 large baleen whales (one of which was a fin whale); 4 pilot whales; and many white beaked dolphins and porpoises.

North Sea: 74 minke; 1 killer; 1,000(+) dolphins.

East Greenland: 274 minke; 135 fin; 3 humpbacks; 64 sperm; 1 bottlenose; 23 killer; and about 155 dolphins.

The above data on sightings made in the three areas cannot be directly compared because the period of time and the sighting possibilities in each area were different.

Whale sightings were also made by Institute personnel on cruises in the Arabian Sea with R/V *Dr Fritjof Nansen* during pelagic fish assessment surveys under the FAO Indian Ocean Fishery and Development Programme. These records are on file at the Institute of Marine Research, Bergen.

At the Department of Marine Zoology and Marine Chemistry, University of Oslo, biological material from large whales collected in postwar seasons at the stations in Norway, is now being analyzed. A paper on the sei whale is in press, and studies on fin whales are in progress. In cooperation with the Department of Microbiology, University of Oslo, biochemical studies (especially haemoglobin analyses and electrophoresis of red blood cell isozymes) are being carried out to try and identify stock units in whales.

United Kingdom – Progress Report on Whale Research – June 1975 to May 1976

This refers to work at the Whale Research Unit of the Institute of Oceanographic Sciences

1 SPECIES AND STOCKS STUDIED

Studies are continuing of fin, sei and sperm whales in the southern hemisphere and in Icelandic waters, where the occurrence of blue and humpback whales is also being examined. Some work is being carried out on cetaceans in British waters.

2 FIELD OBSERVATIONS AND COLLECTIONS

With the co-operation of the Icelandic whaling company, Hvalur H.F., and the Marine Research Institute, Reykjavik, a collection of ear plugs from fin and sei whales, and teeth from sperm whales was made at the Icelandic whaling station during the 1975 whaling season. The collection represents 197 fin (80% of catch), 42 sei (30% of catch) and 28 sperm (76% of catch).

The Seals Research Division of the Institute for Marine Environmental Research carried out a survey of the common seal population along part of the west coast of Scotland in July 1975. Facilities were again made available for an observer from the Unit and sightings of dolphins and porpoises were recorded. A specimen of *Lagenorhynchus albirostris* stranded on the Welsh coast in January was examined and a series of measurements and collections made.

Four visits have been made in August, September, and May to observe and film a wild but sociable adult male *Tursiops truncatus*. The dolphin, which actively associates with boats and with skin divers, has been identified as one known previously from the Isle of Man. It moved to Pembrokeshire (Wales) in March 1975 and later to Cornwall. With the co-operation of local observers, records are being kept of its daily movements, and its behaviour towards boats, skin divers, etc, has been studied.

3 WHALE MARKING

In 1973 preliminary experiments were made with a design for a whale mark incorporating an externally visible plastic streamer. A grant from the IUCN/World Wildlife Fund has now enabled the experiments to be continued under a development programme submitted jointly with Dr Best (Sea Fisheries Branch, South Africa), and the mark is now ready for field trials in South African waters.

4 LABORATORY WORK

In connection with the re-examination of pre-1960 collections of fin whale ear plugs from the Antarctic undertaken in 1974–75, a large sample of ear plugs generously loaned by the Far Seas Fisheries Research Laboratory, Japan, have been examined for further work on the decline of age at sexual maturity correlated with changes in population size.

Age readings for sperm whale teeth collected in Australia in 1973 and 1974 have been completed, and examination of the 1975 Icelandic ear plug and teeth collections has begun. Testes samples collected in Iceland in 1973 have been prepared and examined.

5 DEVELOPMENT OF TECHNIQUES

Nil.

6 RESEARCH

A review of the data and methods used in world-wide stock assessments has been completed. Detailed examination of catch and effort statistics for sperm whales in the southern hemisphere has led to a re-analysis of density trends for this species in response to whaling.

A further investigation of the timing of the annual layer formation in the dentine of sperm whale teeth is being undertaken using material from Australia, South Africa, the Antarctic and the North Atlantic.

Studies of the decline in age at sexual maturity of fin whales correlated with changes in population size are continuing. Growth in the sperm whale has been examined and new estimates of energy budgets made for this species.

Records of sightings of cetaceans from ocean weather ships in the northeast North Atlantic ocean over a long series of years are being analysed for information on the seasonal distribution of large whales (including rorquals), pilot whales, and dolphins generally.

A brief review of whale marking, covering its development, present extent, and some of the major results relating to movements and migrations, has been prepared for publication.

7 PUBLICATIONS

Brown, S. G. 1975. Twenty-Sixth meeting of the International Whaling Commission, 1974. *Polar Record,* 17 (No. 109): 402–3.

Brown, S. G. 1975. Relation Between Stranding Mortality and Population Abundance of Smaller Cetacea in the Northeast Atlantic Ocean. *J. Fish. Res. Board Can.* 32 (7): 1095–9.

Brown, S. G. 1975. Marking of Small Cetaceans Using "Discovery" Type Whale Marks. *J. Fish. Res. Board Can.* 32 (7): 1237–40.

Brown, S. G. 1976. Whaling in the 1970's and the 27th meeting of the International Whaling Commission, 1975. *Polar Record,* 18 (No. 112): 85–8.

Brown, S. G. 1976. Modern whaling in Britain and the northeast Atlantic Ocean. *Mammal Review,* 6 (1): 25–36.

Brown, S. G. 1976. Notes on Whale Observing, 1976. *The Marine Observer,* 46 (No. 252): 81–2.

Gambell, R. 1976. World Whale Stocks. *Mammal Review,* 6 (1): 41–53.

Lockyer, C. 1976. Body weights of some species of large whales. *J. Cons. int. Explor. Mer.* 36 (3): 259–73.

In press

Gambell, R. Population biology and the management of whales. *Applied Biology,* 1.

SC/28/Prog Rep 10

Soviet Investigations of Cetacea – Seasons 1975 and 1975–76

M. V. Ivashin

Unlike the last years, when three fleets conducted their whaling in the Southern Hemisphere, only two, i.e. *Sovietskaya Ukraina* and *Sovietskaya Rossiya* operated there throughout the season 1975–76. Throughout the 1975 season, the fleets *Vladivostok* and *Dalny Vostok* continued their actions in the North Pacific.

Scientific investigations were conducted in both areas of whaling. Materials being of some value for the studies of the whales' biology were collected in the field conditions. For this purpose, there were taken the ovaries, samples of the testes, the ear plugs and teeth of baleen and sperm whales. Besides, collections of different materials were made to find out the stock localities by use of population genetics methods. A certain number of adult animals and their embryos were determined by a series of standard measurements, and they were weighed as well.

Observations were also conducted for whales prohibited for killing both in the Northern and Southern Pacific pursuant to the Scientific Committee recommendations. Thus, during the 1975 season, 147 blue whales, 297 humpback whales and 56 right whales were registered in the Southern Hemisphere (Appendix 1). This information was forwarded to the IWC Secretary in July 1975. Data on whales collected as a result of observations through the 1975–76 season will be sent to the IWC Secretary somewhat later.

During the 1974–75 season, investigations on whales distribution in the Pacific sector of the Southern Hemisphere were conducted from on board two catcher boats. Preliminary data show the whole number of whales observed in the above mentioned area; they were 2 blue whales, 16 fin whales, 167 sei whales, 1,249 minke whales, 945 sperm whales; besides, they observed also different species of small cetacea (bottlenose, killer and pilot whales, dolphins).

Throughout the season 1975–76, whale tagging was performed from the modern Antarctic whale fleets *Soviet Ukraina* and *Soviet Rossiya* in the Southern Hemisphere. Preliminary data show that the total number of whales tagged was 103 – 1 blue whale, 4 humpback whales, 5 sei whales, 42 minke whales, 49 sperm whales, 2 bottlenosed whales; 16 sperm whales were tagged north of 40°S.

Data show that 178 whales were tagged from on board the catcher boat *Vnushytelny* in warm waters of the Pacific Ocean through February to June 1975 – 8 blue whales, 8 fin whales, 27 sei whales, 4 Bryde's whales and 133 sperm whales. 12 sei whales and 52 sperm whales of those mentioned above (178) were tagged south of the equator.

Throughout the 1975 season, 3 Japanese and 2 American tags were found on board Soviet fleets operating in the Northern Pacific (Appendix 2). Two Soviet tags were registered at the Peru inshore station.

Four Discovery type tags were found on board Antarctic whale fleets in the 1975–76 season (Appendix 2).

In October 1975, the VIth All-Union Meeting on Marine Mammals took place in Kiev, where some problems connected to large and small Cetacea were discussed.

Publications on whale investigations are given in Appendix 3.

Appendix 1

Form to report sightings of prohibited species
Soviet Fleets: Sovietskaya Ukraina, Sovietskaya Rossiya,
Ju. Dolgorukyi
Antarctic Season 1974–75 (South to 40°S only)

		Number seen				
Month	Area	Blue	Humpback	Right	Others	Effort
December	I	2	7	17	–	426
January	I	26	35	11	–	777
February	I	38	138	6	–	724
March	I	–	–	–	–	26
November	II	–	–	–	–	13
December	II	5	4	7	–	142
March	II	–	–	13	–	195
November	IV	–	2	–	–	221
December	IV	1	2	2	–	527
December	V	–	–	–	–	102
January	V	29	59	–	–	289
March	V	–	–	–	–	102
April	V	1	–	–	–	285
January	VI	1	31	–	–	238
February	VI	36	19	–	–	476
March	VI	9	–	–	–	425
April	VI	–	–	–	–	289
May	VI	–	–	–	–	22
Total		147	297	56	–	5,478

Appendix 2

Recovery of foreign tags on the Soviet fleets throughout the season 1975 and 1975–1976

Nos. of tags	Date of tagging	Position of tagging		Date of recovery	Position of recovery		Species	Sex	Size (m)
		Latitude	Longitude		Latitude	Longitude			
				Northern Pacific					
US 204	16.1.65	34°48′N	121°40′W	2.7.75	38°00′N	127°26′W	Sperm	M	11.9
US 515	27.5.65	32°48′N	119°56′W	23–25.7.75	39°30′–36°42′N	125°25′–130°44′N	Sperm	from boiler	
J13069	29.1.75	01°58′N	138°30′E	19.6.75	28°53′N	154°45′E	Bryde	F	12.0
J11523	5.10.70	40°52′N	152°58′E	1.8.75	35°18′N	158°12′E	Sperm	M	15.0
J11122	28.5.69	48°58′N	163°02′E	11–12.9.75	28°10′–30°08′W	149°40′–151°24′E		from boiler	
				Southern Hemisphere					
25889	24.2.63	33°54′S	16°56′E	21.11.75	25°15′S	13°16′E	Sperm	M	10.8
28768	2.2.73	29°52′S	32°14′E	6.12.75	37°02′S	19°10′E	Sperm	F	10.3
22741	17.12.66	45°32′S	75°55′W	26.1.76	61°10′S	56°19′W	Sei	F	15.7
22734	17.12.66	46°32′S	75°55′W	26.1.76	61°20′S	56°22′W	Sei	F	15.0

Appendix 3

LIST OF PUBLICATIONS ON CETACEA

(Published in Rusian. Names of authors and titles of publications are given in English)

MARINE MAMMALS

Material of the VIth All-Union Meeting (Kiev, October, 1975). Izdatelstvo Naukova Dumka, Kiev.

(Theses of reports concern exclusively large and commercial Cetacea species).

PART I

Berzin, A. A., Lagerev S. I., Isakov, G. I. Material on the population morphology of Cetacea inhabiting the Pacific Ocean, pp. 28–30.

Berzin, A. A., Kuzmin, A. A. Gray and right whales of the Sea of Okhotsk, pp. 30–2.

Borodin, R. G. Analysis of mathematical methods related to the assessment of the whales stock condition as well as to the whaling. pp. 53–4.

Budylenko, G. A., Pervushin, A. S. To the problem of fin whales, sei whales and minke whales migrations in the Southern Hemisphere, pp. 57–9.

Budylenko. G. A. Distribution of sei whales in the Southern Hemisphere, pp. 59–62.

Budylenko, G. A. Some peculiarities of sei whales feeding in the Southern Hemisphere, pp. 64–6.

Bychkov, V. A. Nearly extinct and rare species of marine mammals and the main ways of their conservation in the USSR areas, pp. 66–8.

Vladimirov, V. A. Ocean pollution and accumulation of toxic agents by marine mammals, pp. 80–3.

Doroshenko, N. V. Body proportions of minke whales inhabiting the Antarctic, pp. 108–10.

Zemsky. V. A., Budylenko, G. A. Taxonomic position of some whale species possessing bipolar distribution, pp. 116–19.

Zemsky, V. A., Budylenko, G. A. To the problem of emergence of dwarf species in marine mammals, pp. 119–21.

Ivashin, M. V. On the composition of groupings of minke whales in the Indian sector of the Antarctic, pp. 121–3.

Ivashin, M. V. On the reproduction of minke whale in the Indian sector of the Antarctic, pp. 123–5.

Ivashin, M. V. External parasites of minke whales inhabiting the waters of the Antarctic, pp. 125–7.

Khozac, V. A., Tomilin, A. G. To the problem of explanation of the mechanism of Cetacea submergence, pp. 143–5.

Korzhuev, P. A. On peculiarities of large Cetacea adoption to marine environmental conditions, pp. 147–9.

PART II

Michalev, Ju. A. The way of quantitative characteristic of layers in teeth of marine mammals and of the other registrating structures of vertebrates, pp. 7–9.

Michalev, Ju. A. On some factors accompanying the distribution of whales, pp. 9–10.

Michalev, Ju. A. The test analysis of profilograms of decalcinated sections of sperm whales teeth, pp. 10–12.

Michalev, Ju. A. Growth of whales in the prenatal period pp. 12–14.

Michalev, Ju. A., Shevchenko, V. P., Neizhko, V. I. Distribution of the Jacobson's organ as a population sign to some baleen whales, pp. 14–15.

Ognyetov, G. I. Observations on the beluga approach at the western shore of the Kanin Peninsula, pp. 31–3.

Orlov, V. A. On hydrological conditions in time of baleen whales approach into high latitudes of the IIIrd and the IVth sectors of the Antarctic, pp. 33–4.

Pervushin, A. S. A model of the relationship between the baleen whales migration and some abiotic factors (Southern Hemisphere), pp. 45–7.

Pokrovsky, B. I., Emelyanov, S. V., Bondarenko, K. V., Doroshenko, N. V. Stock assessment of minke whales in the Antarctic, pp. 58–60.

Skryabin, A. S. To the problem of minke whales helminthology in the Southern Hemisphere water, pp. 79–81.

Skryabin, A. S. On some peculiarities of helminth fauna of minke whale, pp. 81–3.

Tomilin, A. G. On progressive morphology physiology developments (aromorphosis and idioadaptations) in the organization of Cetacea, pp. 118–21.

Tormosov, D. D. Ecologic-morphology bases of structure differences in sperm whales stocks (Southern Hemisphere), pp. 127–9.

Tormosov, D. D. To the problem of the ovulation character to sperm whale females, pp. 129–31.

Fedoseev, G. A., Goltsev, V. N. New data on the distribution and the abundance of marine mammals in the Bering and the Chukchi Seas, pp. 144–6 (of Cetacea–only Greenland whale–M.I.).

Shevchenko, V. I. Character of the relationship between the killer whale and other Cetacea, pp. 173–5.

Shevchenko, V. I. Sequences of small sharks attacks on whales, pp. 175–8.

Juchov, V. A., Vinogradov, E. K., Medvedev, L. P. Objects of killer whale *(Orcinus orca* L.) feeding in the Antarctic and in the adjacent waters, pp. 183–5.

Juchov, V. A., Vinogradova, E. K., Savusin, V. P. Objects of sperm whales feeding in the Antarctic and their importance in the ecosystem of the Southern Ocean pelagial, pp. 186–8.

Jablokov, A. V. Transition from the whaling to the whale industry as one of the main long-term perspectives allowing to study marine mammals, pp. 188–9.

In addition, the collections of articles include information on physiology, anatomy, behaviour of large and small Cetacea and the practical use of their raw materials.

III. BIOLOGICAL RESOURCES OF THE FAR EAST SEAS

Theses of the reports of the All-Union Meeting, 1975. Vladivostok, 1975.

Doroshenko, N. V. On the whaling of minke whales in the Southern Pacific, pp. 118–19.

Kuzmin, A. A., Berzin, A. A. Distribution and the modern condition of the abundance of right and gray whales in the Far East Seas, pp. 121–2.

Privalichin, V. I. Whales distribution and whaling of Bryde's whale in the North-Western Pacific, pp. 119–20.

Studenetskaya, I. S. Modern population condition of the California gray whale, pp. 122–3.

Veinger, G. M., Lagerev, S. I., Melikov, V. V. Data on morphologic-population variability of sperm whales inhabiting the Northern Pacific, pp. 117–18.

Osipuk, O. E. 1975. Material to the problem of the embryonic development of sperm whale. "Actual problems of the theoretical and clinical medicine", pp. 44–5. Minsk.

Pershin, S. V., Sokolov, A. S., Tomilin, A. G. 1974. Biomechanical base of regulated hydroelasticity in the finwing supporting surface of whales (dolphins and whales). *Zoologichesky Institute, Trudy,* 54, pp. 266–305.

Khozac, V. A., 1975. Sight-acoustic system of the sperm whale (*Physeter catodon* L., 1758). Collection of articles "Submarine medical-physiology investigations", Kiev, *Naukova Dumka,* pp. 248–54.

Zemsky, V. A., 1975. What is the number of dolphins in the Black Sea waters? *Priroda* No. 6, pp. 97–8.

Jablokov, A. V., 1975. The success and experiences related to gray whales, *"Nauka i Lhizgn" ("Science and Life"),* No. 9, 118–20.

Tinjakov, G. G., Chumakov, V. P., Sevostyanov, B. A., 1975. Microstructure of the sperm whale milk *Physeter catodon. Zoological journal,* 54, pp. 1413–15.

Panfilov, B. G., 1975. Fin whale *(Balaenoptera physalus)* with full cataract on both eyes. *Zoological journal,* 54 (2), pp. 1739–40.

Studenetskaya, I. S., 1975. Conditions of investigations and whaling of Cetacea. *Pybochozhyaistvennoe issledovanie resursov Mirovogo Okeana.* Observational information series I, (7), pp. 1–31.

Baryshev, N. S., 1975. Attention-dolphins! *Hydrometeoizdat,* 128 pp.

With autoregulation of the elasticity (brief information on the self-regulation of the elasticity of the Cetacean fins), 1976. *Nauka i Zhizgn,* No. 5, p. 32.

IV. IZVESTIYA TINRO, 1975, vol. 96.

Kuzin, A. E., Perlov, A. S. The range and some morphological features of Dall's porpoise (*Phocoenoides dalli,* True, 1885), pp. 259–68.

Kuzmin, A. P. Certain points of the development of head skeleton in sperm whale (*Physeter macrocephalus* L., 1758) and some Balaenopteridae in terms of the problem of their origin, pp. 233–52.

Lagerev, S. I. Some data on the morphology of the spleen of the toothed and baleen whales, pp. 253–8.

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United States – Progress Report on Whale Research – June 1975 to June 1976

This report summarizes cetacean research conducted by the Marine Mammal Division of the Northwest Fisheries Center, Seattle. Studies on dolphins in relation to the tuna fishery conducted by the Southwest Fisheries Center, La Jolla, are described in a separate report.

1 SPECIES AND STOCKS STUDIED

During the past year observations were made on the following species and stocks:

- Gray whale *(Eschrichtius robustus)* – California
- Bowhead whale *(Balaena mysticetus)* – Chukchi Sea
- Bryde's whale *(Balaenoptera edeni)* – North Pacific
- Humpback whale *(Megaptera novaeangliae)* – North Pacific
- Killer whale *(Orcinus orca)* – Inside waters of Washington State and British Columbia

2 FIELD OBSERVATIONS AND COLLECTIONS

Shore censuses of the southward migrating gray whales were made at Granite Canyon near Yankee Point, Monterey County (10 December 1975 to 4 February 1976) and at Point Loma, San Diego County, California (15 December 1975 to 11 February 1976). Trials were also made with a Starlight Scope (a light-amplification instrument) to observe whales at night.

Two biologists have been stationed at Barrow, Alaska, and two at Point Hope, Alaska, since late April 1976 to gather catch statistics and biological data on bowhead whales. Three other observers camped at the edge of the fast ice at Barrow to count migrating bowhead whales. Extensive aerial surveys are also under way in the southern Chukchi and northern and eastern Bering Seas to census whales and other marine mammals.

From 13–23 August 1975, a census was made by surface vessel and float plane of the humpback whale population in the inside waters of southeastern Alaska from Glacier Bay and Lynn Canal south to Cape Ommaney and Petersburg.

From 24 February to 6 March a vessel circumnavigated each of the Main Hawaiian Islands, from Hawaii to Kauai and Niihau, to census humpback whales. A watch for whales was also maintained during a cruise along the Leeward Hawaiian Islands northwest to Kure Atoll, from 17 March to 16 April 1976.

At the end of June 1975, a one-year series of fortnightly aerial censuses of killer whales in Puget Sound, the Strait of Juan de Fuca, and the southern end of the Strait of Georgia, was concluded.

On 1 April 1976, an intensive six-month study of killer whales in this area was initiated. Two biologists with an 11 metre cabin cruiser are working full time on the project. The objective is to obtain detailed information on the distribution, size, movements, and sex and age composition of the killer whale population. Individual animals are being identified by natural markings and scars.

3 WHALE MARKING

No whales were marked.

Two sperm whales marked by the United States were recovered by the USSR.:

No.	*Marked*	*Recovered*
204	16 January 1965 34°48'N, 121°40'W	2 July 1975 38°00'N, 127°26'W
515	27 May 1965 32°48'N, 119°56'W	24 July 1975* 38°06'N, 128°05'W

*Mark recovered from cooker; date and position approximate.

4 LABORATORY WORK

A few specimens (ovaries, etc.) were collected from bowhead whales taken by Eskimoes, but have not yet been examined.

5 RESULTS

Gray whale counts, both in Monterey County and San Diego County, were the highest on record. Counts for the past nine years have been as follows:

Season	*Monterey*[1]	*San Diego*[1]
1967–68	3120	1324
1968–69	3081	1154
1969–70	3064	
1970–71	3034	
1971–72	2588	
1972–73	3304	
1973–74	3492	
1974–75	3348	
1975–76	3797	2822

[1] "Comparison period" only – 18 Dec. to 4 Feb., except for 25 Dec. and 1 Jan.; total count for 1975–76 was 4305.

[2] Total counts

The high counts this past season are believed to be due to exceptionally good weather conditions rather than to any marked increase in the whale population which is still estimated at 10,000 to 12,000.

Limited night observations with the Starlight Scope revealed that gray whales move at night as rapidly as they do during the day.

Preliminary figures (through 18 May) indicate that Eskimo whalers at Barrow, Point Hope, and St. Lawrence

Island, Alaska, have landed 30 bowhead whales, and have struck and lost 19 whales. Results of Eskimo whaling last year are summarized in a separate report (Marquette, W. M. 1976. National Marine Fisheries Service field studies relating to the bowhead whale harvest in Alaska, 1975).

Two Bryde's whales were observed at 20°10′N, 170°14′W (near Maro Reef in the Leeward Hawaiian Islands) on 23 March 1976.

The humpback whale censuses revealed a minimum of 61 animals summering in the inside waters of southeastern Alaska, and at least 373 animals wintering around all the Main Hawaiian Islands; none were seen in the Leeward Hawaiian Islands. Color-phase frequencies suggest that the Hawaiian and southeastern Alaskan animals belong to different stocks.

The aerial censuses of killer whales revealed that pods of whales frequently range into the inside waters of Washington State, but that none are permanent residents within the area. Some pods were recognized as those that range in adjacent British Columbia waters. The highest number of whales counted on a single flight was 57, but from 11 to 13 October 1975 an aggregation of six groups totalling about 130 animals was followed by vessel in Puget Sound. Greatest numbers were seen during late summer and autumn, the fewest during winter.

6 PUBLICATIONS

Published:

Bigg, M. A. and Wolman, A. A. 1975. Live-capture killer whale *(Orcinus orca)* fishery, British Columbia and Washington, 1962–73. *J. Fish. Res. Bd. Can.* 32 (7): 1213–21.

Tillman, M. F. 1975. Assessment of North Pacific stocks of whales. *Mar. Fish. Rev.* 37 (10): 1–4.

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Rice, D. W. A list of the marine mammals of the world (third edition). *NOAA Tech. Rep. NMFS SSRF.*

Appendix

SUMMARY OF CURRENT CETACEAN RESEARCH AND STUDY PROJECTS SUPPORTED BY THE MARINE MAMMAL COMMISSION

June 1975–June 1976

Cetacea (General)

Estimate of Recent Major Takings of Marine Mammals (R. L. Brownell and C. M. Schonewald, Smithsonian Institution)

Marine Mammal Strandings Along the New England Coast: A Study into Pathobiology and Life History (J. R. Geraci, New England Aquarium)

Marine Mammal Biological Data from Stranded Cetacean Salvage Program (J. G Mead, Smithsonian Institution)

The Gulf of Maine Whale Sighting Network (S. J. Katona, College of the Atlantic)

A Biological Assessment of the Cetacean Fauna of the Texas Coast (D. J. Schmidly, Texas A&M University)

Whales

Workshop on the Killer Whale *(Orcinus orca)* (D. G. Chapman and A. W. Erickson, University of Washington)

Population Studies of the Killer Whale in the Eastern North Pacific (A. W. Erickson, University of Washington)

Assessment of Two Right Whale Populations by Means of Aerial Censusing and Photogrammetry (R. S. Payne, New York Zoological Society)

Aerial Census, Behaviour and Population Dynamics Study of Gray Whales in Mexico During the 1974–75 Calving and Mating Season (R. Gard, Colorado State University/University of Alaska)

Field Testing of Whale Tracking and Data Recovery Systems (K. S. Norris, University of California, Santa Cruz)

Porpoises

Workshop on Breeding Bottlenose Porpoise in Captivity (K. Benirschke, Zoological Society of San Diego)

Bottlenose Dolphin *(Tursiops truncatus)* Assessment Workshop (D. K. Odell, University of Miami)

Distribution and Abundance of the Bottlenose Dolphin in Florida Waters (D. K. Odell, University of Florida)

Movement and Activities of Atlantic Bottlenose Porpoise *(Tursiops truncatus)* (J. H. Kaufmann and A. B. Irvine, University of Florida)

Mass Strandings of *Lagenorhynchus acutus:* A study into Life History and Pathobiology (J. R. Geraci, New England Aquarium)

The Comparative Utility of Some Aerial Census Methods in Cetacean Stock Assessment (J. S. Leatherwood, Naval Undersea Center)

Tuna-Porpoise

Study and Analysis of the Number of Porpoise Killed or Seriously Injured Incidental to the Commercial Yellowfin Tuna Fishery (W. G. Clark)

Analysis of Tuna-Porpoise Data (D. G. Chapman, University of Washington)

Analysis of Efforts to Reduce Incidental Porpoise Mortality (A. Pivorunas)

A New Device to Reduce Porpoise Mortality (J. T. Gonsalves, Progressive Fishing Enterprises)

Acoustic Characteristics of Nets and Floats in the Water During Purse Seine Fishing for Yellowfin Tuna (W. E Evans and J. S. Leatherwood, Naval Undersea Center)

Estimate of Recent Major Takings of Marine Mammals

(R. L. Brownell and C. M. Schonewald, Smithsonian Institution)

From a review and assessment of reports of marine mammals taken during the past ten years, the investigators are summarizing the best available information on: location of taking; country involved in the take; management programs; type and identity of fishery involved; current research; estimate of population size; distribution of the marine mammal stock involved; years for which data apply; and reliability estimate of data. Recommendations will be developed for species of special concern and those in need of further investigation.

Marine Mammal Strandings Along the New England Coast: A Study into Pathobiology and Life History

(J. R. Geraci, New England Aquarium)

To derive maximum scientific benefit from marine mammal strandings, a communications network for reporting strandings is being established along the New England coast. The investigators will conduct comprehensive postmortem examinations with a multi-disciplinary research team to identify intrinsic and extrinsic factors which may contribute to stranding. Base-line biological parameters for monitoring environmental conditions will be established through such studies as the analysis of pesticides and heavy metals found in marine mammal tissues. This project will provide important life history and distributional data necessary to assess the impact that human activity might be having on marine mammal populations in New England.

Marine Mammal Biological Data from Stranded Cetacean Salvage Program

(J. G. Mead, Smithsonian Institution)

A continuing program of recovery and examination of stranded animals was conducted along the Atlantic coast of the United States. The data collected were documented by photographs and museum species. Supplemental information on cetaceans was obtained from an extensive survey of the literature containing records of cetaceans along the coast. As a result of this project, data were gathered on the distribution, biology, and taxonomy of thirty-four species of cetaceans.

The Gulf of Maine Whale Sighting Network

(S. K. Katona, College of the Atlantic)

Volunteer observers are being recruited and coordinated to form a comprehensive whale sighting network. This network will provide data on species composition, relative abundance, and temporal and spatial variation in the distribution patterns of cetaceans in the Gulf of Maine The investigator will attempt to correlate distribution patterns with independent variables such as fish, sea bird, and euphausiid density. When possible, natural marks on individual animals will be identified to provide a basis for possible future movement studies using mark-recapture techniques.

A Biological Assessment of the Cetacean Fauna of the Texas Coast

(D. J. Schmidly, Texas A&M University)

To gather biological and ecological data on cetaceans along the Texas coast, the investigator established a comprehensive specimen and data recovery network to investigate stranded cetaceans. From these studies, as well as literature surveys, indications of the types, abundance, and seasonal occurrence of cetaceans were gained.

In his efforts to determine factors responsible for the strandings, the investigator found parasitic infections of the brain and lungs were particularly common in animals necropsied. Some individuals seemed to have stranded because of injury. Strandings along the Texas coast showed a pronounced tendency to be more common in colder than in warmer months although this phenomenon could be a result of sampling error.

Workshop on the Killer Whale (*Orcinus orca*) In Puget Sound and Adjacent Waters

(D. G. Chapman and A. W. Erickson,
University of Washington)

A workshop on the killer whale was held to assess the status of this species in the Pacific Northwest, and to recommend studies needed to insure its proper management and conservation. The participants found current knowledge to be sparse, particularly as concerns abundance and distribution.

They noted that although there is little evidence that commercial collecting activities are presently threatening Puget Sound killer whales, the effect of take on the social structure, behaviour, and composition of individual killer whale "pods" (groups) is unknown. The participants recommended the early initiation of a major study of killer whales in the Pacific Northwest. The recommended research would address both the development of technology required to perform the necessary research as well as basic population and life history studies. Technological research would concentrate on the development of suitable marking and aerial census procedures to assess population abundance and movements. Life history studies would concentrate on pod structure, i.e., integrity, age–sex composition, social structure, behaviour, and interaction with other pods.

Population Studies of the Killer Whale in the Eastern North Pacific

(A. W. Erickson, University of Washington)

The investigator has successfully developed and field tested a radio tracking system for use on killer whales. Two killer whales were captured near Olympia, Washington, fitted with 164 MHz radio tags and released after sixty days of detailed observations. They were subsequently tracked for eight consecutive days and have been re-contacted several times since the initial track was terminated. The radios have a life expectancy of about one year and it is hoped that additional movement and behavioural data will be forthcoming.

Assessment of Two Right Whale Populations by Means of Aerial Censusing and Photogrammetry

(R. S. Payne, The New York Zoological Society)

In this study, the investigator will evaluate the usefulness of using photographic techniques to reliably recognize and measure individual right whales *(Eubalaena australis).* He also will complete the analysis of data from a five year assessment of Western South Atlantic right whale populations to provide numerical estimates that are necessary to assess the status and trends of the populations.

Aerial Census, Behaviour, and Population Dynamics Study of Gray Whales in Mexico During the 1974–75 Calving and Mating Season

(R. Gard, Colorado State University,
University of Alaska)

Studies of the behaviour, population and ecology of the gray whale *(Eschrichtius robustus)* were conducted in Baja California and along the west coast of the Mexican mainland between mid-December of 1974 and early March of 1975. No consistent daily activity patterns of whales in Scammon Lagoon were found although activity levels and directional movements were correlated with tides. Observations of a mating triad, consisting of one male, one female and one calf, is supportive of the theory that at least some females breed during consecutive years. A "shore count" method of estimating population abundance in Scammon Lagoon was developed.

Aerial censuses of the coast of the Mexican mainland indicated that the total number of whales counted in 1975 (1,760) was similar to the count in 1974 (1,811). However, in 1975, the number in San Ignacio Lagoon was 25% lower than in 1974. The observed decrease in whales may well be related to the increase in large tourist vessels and small boats. A similar cause may explain the late arrival of fewer whales in Canal Ballenitias where the popularity of whale watching has resulted in increased outboard motor traffic.

The Commission is supporting a continuation of this study for the 1976 calving and mating season to provide further information on changes in distribution, abundance, recruitment, and mortality of whales associated with changes in human activity.

Field Testing of Whale Tracking and Data Recovery Systems

(K. S. Norris, University of California,
Santa Cruz)

The investigators have developed a non-injurious radio tracking technique using an expandable harness to hold recoverable tracking and data gathering equipment. The system was tested on a suckling gray whale. Before the radio package automatically released itself, the calf was tracked for 63 hours and more than 213 kilometers. In addition to providing information on movements, the instruments also recorded behavioural data such as the duration of dives.

Workshop on Breeding Bottlenose Porpoise in Captivity

(K. Benirschke, Zoological Society of San Diego)

The bottlenose porpoise is the cetacean most commonly kept in captivity for display and research. Because most captures are concentrated in small geographic areas, removal from the wild may be having detrimental effects on some stocks. This workshop was convened to explore methods of propagating captive stocks to reduce the need for collection and its impact on wild populations. The final report of the workshop includes a recommended research program designed to improve propagation in captivity.

Bottlenose Dolphin *(Tursiops truncatus)* Assessment Workshop

(D. K. Odell, University of Miami)

This workshop was convened (23 June 1975) to review knowledge of bottlenose porpoise populations; status of research underway and contemplated; management needs; and further studies necessary to provide the base for sound management decisions. Because of the recognized lack of scientific information, participants concentrated on developing a research plan. It included studies of census methodology and means of collecting vital statistics on local populations. Participants also felt that a multi-agency, interdisciplinary bottlenose porpoise research program should be developed, and so recommended. They stressed Commission involvement to ensure uniformity and comparability of data collection procedures, and also suggested that the Commission assume responsibility for the establishment of a central data storage system. They further recommended that guidelines for collecting activities should be established to minimize disturbance to the animals.

Distribution and Abundance of the Bottlenose Dolphin in Florida Waters

(D. K. Odell, University of Miami)

Monthly aerial surveys are providing information on abundance, seasonal distribution, and habitat preference of bottlenose porpoises in the coastal and estuarine waters of Florida. For each herd sighted, data on herd size, composition, and behaviour are recorded. The investigator has recorded population densities in and around Biscayne Bay and in the Everglades National Park. On an opportunistic basis, the investigator has also performed autopsies on ten stranded cetaceans. As a result, significant data are being collected on the dwarf and pygmy sperm whales, species about which little is known.

Movement and Activities of Atlantic Bottlenose Porpoise *(Tursiops truncatus)*

(J. H. Kaufmann and A. B. Irvine,
University of Florida)

The investigators are using radio and visual tags to study movements, activities and habitat preference of bottlenose porpoise along the west coast of Florida. The primary food resource of the observed porpoise appears to be the striped mullet, *Mugil cephalus*, but several other species are thought to be consumed opportunistically. Six porpoise have been radio tagged and monitored for periods up to a week; seven additional animals have been freeze branded and/or marked with plastic tags. In general, the data suggest that movements are limited to local areas.

Mass Strandings of *Lagenorhynchus acutus:* A Study into Life History and Pathobiology

(J. R. Geraci, New England Aquarium)

A September 1974 stranding of approximately 200 Atlantic white-sided porpoises at Lingley Cove, Maine, provided a rare opportunity to investigate causes of mass stranding. Representative carcasses were obtained for detailed studies, and gross pathology examinations, as well as histological studies of selected tissues, were completed. *Stenurus globicephalae*, a parasitic worm of the head sinuses and middle and inner ears, was found in abundance in all of the subadult and adult porpoises. These parasites may cause echo-confusion and contribute to strandings. Concurrent with the biological analyses, characteristics of the cove itself are being studied to determine if acoustic or other characteristics may have contributed to the stranding.

The Comparative Utility of Some Aerial Census Methods in Cetacean Stock Assessment

(J. S. Leatherwood, Naval Undersea Center)

Using aerial surveys, line transects, and square unit sampling techniques, the investigator is assessing the population levels of Atlantic bottlenose porpoises along the coast of Louisiana and Mississippi. By using different census techniques, the accuracy and utility of the various methods are being compared. Field testing is also designed to measure the effects of variables such as weather, type of aircraft, and observer bias.

Study and Analysis of the Number of Porpoise Killed or Seriously Injured Incidental to the Commercial Yellowfin Tuna Fishery

(W. G. Clark)

This study is a review of the total kill of porpoises in the yellowfin tuna purse-seine fishery, the causes of that mortality, and its effect on porpoise populations. The investigator points out the difficulties in trying to estimate the total kill from the observed kill. He recommends a study to assess injury and indirect mortality, because these affect the relationship between observed and total kill. He also recommends investigating the age structure of the incidental kill to determine whether the kill is random with respect to age. He concluded that further reduction of mortality will be most dependent on the effectiveness of improved gear modifications.

Analysis of Tuna–Porpoise Data

(D. G. Chapman, University of Washington)

This study will contribute to an objective basis for evaluating efforts to reduce porpoise mortality caused by the practice of setting on porpoise. The investigator will review and evaluate the estimates of the number of porpoises killed or seriously injured during yellowfin tuna fishing operations. He will also estimate the probable incidental kill, under the 1976 fishing regulations, and determine the best method for establishing and administering a quota.

Analysis of Efforts to Reduce Incidental Porpoise Mortality

(A. Pivorunas)

The investigator collected information on research efforts to reduce incidental mortality and serious injury of porpoises, including those data relating to the behaviour of the porpoise and tuna, fishing gear dynamics and development, and porpoise biology and population estimates. He identified specific information needs and recommended further studies to reduce incidental take. Research on tuna–porpoise behaviour, the nature of the tuna–porpoise bond, the causes of mortality during a set, the total number and the age-sex structure of animals taken, and the size and trends of impacted populations, as well as other aspects of the problem, were identified as unresolved issues which warrant new or increased research efforts.

A New Device to Reduce Porpoise Mortality

(J. T. Gonsalves, Progressive
Fishing Enterprises)

The purpose of this study is to test the use of solid, polyvinyl-coated nylon panels in tuna purse seine nets. If the solid panels prove to be effective in helping porpoises escape from the pursed net, a relatively simple gear modification could greatly contribute to reducing mortality and injury.

Acoustic Characteristics of Nets and Floats in the Water during Purse Seine Fishing for Yellowfin Tuna

(W. E. Evans and J. S. Leatherwood,
Naval Undersea Center)

Measurements will be made of the acoustic reflectivity of various combinations and types of webbing, net floats, lines, and cables used to construct purse seines for the yellowfin tuna purse seine fishery. The assessment of the echo-characteristics (target strengths) of the net may provide a basis for suggesting modifications in material or net design that might reduce the incidental mortality and serious injury of porpoise captured during sets on porpoise.

SC/28/Doc 1

Changes in Catch and Population for Sustained Managed Stocks Below MSY Level

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The procedure adopted by the IWC in 1975 provides that for stocks between MSY level and 90% of that level the permitted catch increases linearly from zero at 90% of MSY level to 0.9 MSY at MSY level. An alternative procedure proposed by the United Kingdom in 1976 would set a fixed catch for such a stock at a level halfway between the initial permitted catch and 0.9 MSY. The intention of this procedure is to bring the stock to MSY level in the same period as under the linear system.

For a simple population model in which only net recruitment is density-dependent the relation between successive population levels may be written:

$$P_2 = P_1 - C_1 + P_{1-L}\left(1 - \left[\frac{P_{1-L}}{P_x}\right]^{n+1}\right)R_0$$

where P_x is the unexploited population level and L is the recruitment lag period, R_0 is the net recruitment rate at zero population level, and n is the density dependence exponent.*

Under the existing IWC procedure:

$$C_1 = 9\ \mathrm{MSY}\left(\frac{P_1}{P_m} - .9\right)$$

where P_m is the MSY population level.

These relationships can be expressed in terms of P_1, P_m, n, L and the nett recruitment rate at MSY level.

Table 1 shows the annual sequence of permitted catches and population levels for a population of 10,000 at MSY level, n = 0, L = 5, MSY level recruitment rates of 0.02, 0.03, 0.04 and 0.06, and initial starting levels of 90% MSY level. For a recruitment rate at MSY level of 0.02, series for starting levels of 92% and 94% MSY level are also given.

The table also shows in Section A, for each series, the time taken to reach MSY level under the existing procedure and the mean catch for these years; Section B shows the fixed annual catch which would be taken under the United

Table 1

Time series of population levels and permitted catches under the existing management procedure compared with times required to reach MSY level under the United Kingdom proposal.

Recruitment rate	.02		.02		.02		.03		.04		.06	
A. *Existing procedure*												
Year 1	9,000	0	9,200	36	9,400	72	9,000	0	9,000	0	9,000	0
2	9,198	36	9,363	65	9,527	95	9,297	0	9,396	143	9,594	321
3	9,360	65	9,496	89	9,632	112	9,514	139	9,649	234	9,867	468
4	9,493	89	9,606	109	9,717	129	9,672	181	9,812	292	9,993	536
5	9,603	108	9,695	125	9,787	142	9,788	213	9,915	330	10,051	
6	9,692	125	9,769	138	9,845	152	9,872	235	9,982	353		
7	9,766	138	9,830	149	9,892	161	9,935	252	10,027			
8	9,828	149	9,880	158	9,932	168	9,982	265				
9	9,878	158	9,921	166	9,964	173	10,016					
10	9,920	166	9,955	172	9,990	178						
11	9,854	172	9,983	177	10,012							
12	9,982	177	10,000									
13	10,005											
Years to MSY level		13		12		11		9		7		5
Mean Catch		106		126		138		171		225		331
B. *United Kingdom proposal*												
Constant catch		90		108		126		135		180		270
Years to MSY level		11		10		10		8		6		5

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* This very simple expression assumes that the number of natural deaths in year 1 does not differ from what it would have been if the initial population in that year was the same as in year (1 − L). A rather better model is

$$P_2 = (P_1 - C_1)e^{-M} + P_{1-L}\left\{\left[1 - \left(\frac{P_1 - L}{P_x}\right)^{n+1}\right]R_0 + M\right\}$$

This leads to slightly different times to MSY level but the relationship between the results of the existing procedure and of the United Kingdom proposal is not affected.

Kingdom proposal, i.e. the mean of the initial and MSY level catches; and the time required to reach MSY level under such a regime.

The results show that the fixed annual catch under the United Kingdom formula is slightly less than the mean of the catches under the existing system. Consequently the population reaches MSY level slightly more rapidly than under the existing system. The difference is, however, only sufficient to change the number of whole seasons involved in cases where the recruitment rate is low, about 0.04 or less. Similar calculations with a density dependence exponent (n) = 1.4 give only very slightly different results. Thus, provided the information on which the catches are determined is correct, the United Kingdom proposal is slightly more conservative than the present system.

However, the United Kingdom proposal will allow higher initial catches. Therefore, if there are errors in the assessment of the current population level, and it has been overestimated relative to the MSY level, this system will give a greater risk of reducing the population than will the present system. However, a reduction in the size of the population will only occur if its true size is such that its sustainable yield is less than the initial catch allowed under the United Kingdom proposal, i.e. 0.45 MSY. If n = 0 this level is about 26% of MSY level, and for n = 1.4 it is 36% of MSY level.

SC/28/Doc 2

Further Development of Sperm Whale Population Models

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This paper reports the results of further work which has been done on sperm whale population models since the Special Meeting in La Jolla in March 1976 (IWC, 1977).

This work concerns two models. The first is the model which has been gradually developed from the original population equations put forward at the Special Meeting in Rome in 1968 (IWC, 19) and first used in computerized form at the Parksville Special Meeting in 1972 (IWC, 23). The second is a cohort model described at the La Jolla meeting (Allen and Kirkwood 1977a).

THE ORIGINAL MODEL

In this model the populations are broken up into a series of blocks by sex, age at maturity and age at recruitment. It has been described in some detail in Allen (1973) and Allen and Kirkwood (1977b). As a result of discussions at La Jolla, two further features have been included in the model. Provision has been made for any desired proportion of the calves accompanying mature females to die as a result of the capture of the females. Secondly, the pregnancy rate is now assumed to decrease proportionally with the number of socially mature males when this is less than sufficient to provide fully for harem masters and reserves. The first change operates on any population in which females are being taken, and the proportion of calves dying is variable between zero and 1. The second change will only operate in populations in which the mature male stock is seriously depleted and does not involve any controllable variable.

The currently used computer programmes based on this model are:

(a) SPVAP (Allen and Kirkwood 1977c) which provides estimates of male population sizes, exploitation rates and sustainable yields, in equilibrium populations in which the mature females have been reduced to various levels relative to the unexploited state. It also identifies the population levels at which the maximum yields by weight of males, of females and of both sexes combined are obtainable. The programme now also produces a summary table listing the maximum yields and corresponding population levels for each combination of parameters.

(b) SPDYN – This programme, which was also used at La Jolla (Allen and Kirkwood 1977a), simulates any desired population by applying a time series of catches to a population of selected initial size and having a given combination of parameters.

(c) POPDYN – This is a new programme developed as a result of discussions at La Jolla which obtains estimates of an initial exploitable male population size and of q by fitting actual catch and effort data to the SPDYN model. The criterion used in fitting is the same as that in the least squares method (Allen 1966) used in the CHPOP computer programme, i.e. the sum of squares of differences between actual and expected catches is minimized. The programme also combines the population estimates with the SPVAP output for the same parameters to classify the stock and calculate the quota under the existing rules of the Commission.

The values for the population parameters used in the simulations and population estimates are listed in Table 1. The full range of 144 possible parameter combinations was used to produce the SPVAP output.

The results of the SPVAP analysis are summarised in Table 2. This shows population levels of males and females separately which give maximum sustained yield by weight of males, of females and of both sexes combined. It also shows the corresponding parameter values. If the weight of the male catch is to be maximized, the required population levels for both males and females are highest when density dependence is at a minimum for all parameters, and the exponent is zero. For maximization of the weight of the female catch, the conditions for the population levels of both sexes are almost exactly reversed. Maximization of the weights of the catch of combined sexes occurs under conditions more similar to those for maximization of male weight, but there seems to be less consistent effect due to the value of the exponent. The proportion of calves dying when their mothers are killed has a relatively minor effect, although there is a consistent tendency for increase in this mortality to increase the MSY population levels. The proportion of reserve males required seems, not unexpectedly, to have an important effect on MSY male population levels, but relatively little on females.

The influence of population parameters on MSY levels is probably of greatest interest when yield is considered in terms of the total weight of catch of both sexes. This relationship is analysed in more detail in Tables 3 and 4. Considering first the female population (Table 3), the proportion of reserve males has a relatively slight effect, although optimum population levels are rather lower with a reserve ratio of 1.0 than with no reserve males. The density dependence exponent has rather more effect and population levels between 85% and 100% of unexploited level only occur if the exponent is zero, although both values tested produced populations as low as 61% to 65% when combined with appropriate values of other parameters. The juvenile mortality ratio, which expresses the extent to which this mortality rate is density dependent, is seen to have only a very slight effect, although high population levels occur slightly more frequently when there is no density dependence. The density dependence of the mortality rate for animals older than juveniles has considerably more effect and population levels greater than 85% are only produced when there is no density dependence. On the other hand, levels of 70% or less are much more frequent in the presence of density dependence. For the pregnancy rate three ranges were tested, two with about equal degrees of

Table 1

Parameters used in running SPVAP, SPDYN and POPDYN models. Asterisks indicate the standard values adopted at the La Jolla Special Meeting for Southern Hemisphere Divisions 1–8.

	Multiple values	Single value
Density dependent parameters		
Juvenile mortality ratio	0.8, 1.0*	–
Adult mortality rate	0.05–0.05*, 0.05–0.04	–
Female age at maturity	–	10–7.7
Pregnancy rate	.19–.25*, .19–.33, .25–.33	–
Fixed parameters		
Male age at recruitment	–	20
Female age at recruitment	–	13
Male age at maturity	–	25
Max. age at juvenile mortality rate	–	2
Reserve male ratio	0*, 1.0	–
Density dependence exponent	0*, 1.4	–
Harem size	–	10
Proportion of calves killed†	0, 0.5, 1.0	–
Bertalanffy parameters W_∞ M	–	38.0
F	–	16.0
K M	–	0.065
F	–	0.095
t_0 M	–	–4.5
F	–	–4.4

† Parameter not used at La Jolla, 'standard' value of 0.5 used in this study.

Table 2

Relative maximum and minimum population levels giving maximum sustainable yields by weight, together with the parameter values at which they occur.

Weight maximized	Population	Relative size	Reserve males	Exponent	Juvenile mortality ratio	Mortality rate	Pregnancy rate	Proportion calves killed
MALE	FEMALE							
	Max.	1.00	1.0	0.0	1.0	.05–.05	.19–.25	1.0
	Min.	.61	1.0	1.4	.8	.05–.04	.19–.33	0–1.0
	MALE							
	Max.	.53	1.0	0.0	1.0	.05–.05	.19–.25, .25–.33	0–1.0
	Min.	.31	0.0	1.4	.8	.05–.04	.25–.33	0
FEMALE	FEMALE							
	Max.	.62	0–1.0	1.4	.8–1.0	.05–.04	.19–.33	1.0
	Min.	.49	0–1.0	0.0	.8	.05–.05	.19–.25, .25–.33	0–1.0
	MALE							
	Max.	.43	1.0	1.4	.8	.05–.04	.19–.33	1.0
	Min.	.19	0.0	0.0	.8	.05–.05	.19–.25	0.0
COMBINED	FEMALE							
	Max.	1.00	0.0	0.0	1.0	.05–.05	.19–.25, .25–.33	0–1.0
	Min.	.62	1.0	0.0	.8	.05–.04	.19–.33	0–.5
	MALE							
	Max.	.49	1.0	0.0	1.0	.05–.05	.25–.33	1.0
	Min.	.27	0.0	0.0	.8	.05–.04	.19–.33	0.0

density dependence but representing high and low pregnancy rates and the third with about twice as much density dependence. It is clear that the degree of density dependence is much more significant than the actual level of the pregnancy rate. With high density dependence no populations over 80% were found and there were some instances below 65%. The proportion of calves killed has very little effect on the MSY population levels for females.

Table 4 shows that for the males much the most important factor is the proportion of reserve males required and there was a complete separation between results for the values tested. With a reserve male ratio of 1, male MSY population levels are between 35% and 50% of unexploited population size, but with a ratio of zero the levels are between 25% and 35%. This implies of course that the model will be equally sensitive to the harem size, although this has not been tested directly in this case. None of the other parameters appear to have much effect individually on male population levels, except that the highest levels, between 45% and 50%, seem only to occur under conditions of high reserve male ratio, zero density dependence exponent and minimal density dependence in pregnancy

Table 3

Distribution of female population levels relative to unexploited level which give MSY in terms of weight of yield of both sexes combined in relation to the values of the parameters tested.

Proportion of unexploited female population	Reserve males		Exponent		Juvenile mortality ratio		Mature mortality		Pregnancy rate			Proportion calves killed		
	1.0	0	1.4	0	1.0	.8	0.05 –0.05	0.05 –0.04	.19 –.25	.25 –.33	.19 –.33	0	.5	1.0
1.00–.96	0	8	0	8	6	2	8	0	5	3	0	2	3	3
.95–.91	2	2	0	4	2	2	4	0	2	2	0	1	0	3
.90–.86	4	2	0	6	4	2	6	0	2	4	0	3	3	0
.85–.81	4	6	4	6	6	4	8	2	6	4	0	1	3	6
.80–.76	8	15	13	10	13	10	16	7	12	7	4	9	8	6
.75–.71	12	22	20	14	17	17	16	18	12	13	9	12	11	11
.70–.66	34	17	33	18	21	30	14	37	9	15	27	17	17	17
.65–.61	8	0	2	6	3	5	0	8	0	0	8	3	3	2

Table 4

Distribution of male population levels relative to unexploited level which give MSY in terms of weight of yield of both sexes combined in relation to the values of the parameters tested.

Proportion of unexploited male population	Reserve males		Exponent		Juvenile mortality ratio		Mature mortality		Pregnancy rate			Proportion calves killed		
	1.0	0	1.4	0	1.0	.8	0.05 –0.05	0.05 –0.04	.19 –.25	.25 –.33	.19 –.33	0	.5	0
.500–.451	9	0	0	9	6	3	9	0	6	3	0	3	3	3
.450–.401	45	0	36	9	24	21	23	22	14	17	14	13	16	16
.400–.351	18	0	0	18	6	12	4	14	4	4	10	8	5	5
.350–.301	0	22	10	12	12	10	17	5	7	8	7	5	7	10
.300–.251	0	50	26	24	24	26	19	31	17	16	17	19	17	14

and mortality rates. The proportion of calves killed again has very little effect on population levels.

THE COHORT MODEL

This model, which is incorporated in the computer programme SPCOH, differs from the original model in dividing the populations into year-class cohorts instead of into age and maturity blocks. It is also designed to simulate the size distribution of the animals in each cohort in each year. It is therefore possible, when simulating an actual population, to remove from it the annual catches in terms not only of the total numbers caught of each sex but also of the numbers caught at each size. Comparison of the size distribution of the actual catch with that in the exploitable part of the simulated population provides a test of the validity of the relation. A further test can be made by comparing the age length matrix of the population with age-length keys constructed from samples of the catch. In particular, these comparisons test the suitability of the growth curves for each sex and the assumptions as to the nature of the length distribution at any age in an unexploited population.

A minor difference in this model from that in the preceding section is that the density dependence operates on the total stock biomass rather than the number of mature females.

Various possible models for the distribution of length at age were considered. Examination of available age-length keys suggested that the standard deviation of length at any given age did not vary greatly with age, and was generally about 3.5 ft. The procedure used in the present simulation was therefore to set up the youngest age group with a normal distribution about the mean length at that age and having a standard deviation of 3.5 ft, and to assume that all animals grow thereafter by annual increments equal to those of the animal of the same age following the mean curve. This has the effect in an unexploited population of keeping the standard deviation constant in all age groups. The distribution becomes significantly changed in exploited populations, due to the abstraction of known numbers of animals at each size. The model assumes that the age distribution of the animals of a given size in the catch is similar to that in the population for animals of the same size. To meet cases where data on the size distribution of the catch are not available, the model may also be run with the assumption that the size distribution of the catch is the same as that of the component of the population above the size limit.

Tables 5 and 6 compare the results of simulating the population of Antarctic Division 4 using the SPDYN and SPCOH models and with the assumption that the population was in an unexploited condition in 1946. Since the length distribution of Southern Hemisphere catches is not available by Divisions, it has been assumed for this study that the distribution in Division 4 was proportionately the same as that given in the statistics for Area IV, combining,

Table 5

Time series of population components for Southern Hemisphere Division 4 using the SPDYN model.

```
TIME SERIES OF POPULATION COMPONENTS FOR GIVEN CATCHES WITH
INITIAL MATURE FEMALE POPULATION OF    37900
NATURAL MORTALITY RATE    =    .0500 UNEXPLOITED,  =  .0500 25 PERCENT POPULATION,    =    .0500 ZERO POPULATION
JUVENILE MORTALITY RATE   =    .1334 UNEXPLOITED,  =  .1334 25 PERCENT POPULATION,    =    .1334 ZERO POPULATION
PREGNANCY RATE            =    .1900 UNEXPLOITED,  =  .2350 25 PERCENT POPULATION,    =    .2500 ZERO POPULATION
AGE AT MATURITY  -  FEMALE  = 10.0 UNEXPLOITED,    =    8.3 25 PERCENT POPULATION,    =      7.7 ZERO POPULATION
AGE AT SOCIAL MATURITY  -  MALE  =  25
AGE AT RECRUITMENT  -  FEMALE    =  13
AGE AT RECRUITMENT  -  MALE      =  20
AGE FOR JUVENILE MORTALITY       =   2
HAREM SIZE  =  10
RESERVE PER HAREM MALE  =  0.000
DENSITY DEPENDENCE EXPONENT  =  0.000
PROPORTION OF CALVES KILLED  =   .500
```

YR	FEMALE POPULATION				MALE POPULATION					CATCH		F	
	IMM-UNEX	MAT-UNEX	MAT-EX	MAT-TOT	IMM-UNEX	IMM-EX	MAT-EX	H+RES	SUR-MAT	M	F	M	F
46	25392	5279	32621	37900	40304	5085	17903	3790	14113	457	0	.021	0.000
47	25392	5279	32621	37900	40304	5004	17538	3790	13748	1174	0	.055	0.000
48	25392	5279	32621	37900	40304	4817	16602	3790	12812	539	0	.026	0.000
49	25392	5279	32621	37900	40304	4797	16173	3790	12383	637	0	.032	0.000
50	25392	5279	32621	37900	40304	4777	15670	3790	11880	1322	0	.069	0.000
51	25392	5279	32621	37900	40304	4651	14631	3790	10841	1084	0	.059	0.000
52	25392	5279	32621	37900	40304	4618	13788	3790	9998	260	0	.015	0.000
53	25392	5279	32621	37900	40304	4774	13602	3790	9812	364	0	.021	0.000
54	25392	5279	32621	37900	40304	4869	13376	3790	9586	1130	0	.066	0.000
55	25392	5279	32621	37900	40304	4786	12589	3790	8799	1747	0	.109	0.000
56	25392	5279	32621	37900	40304	4582	11365	3790	7575	427	0	.028	0.000
57	25392	5279	32621	37900	40304	4711	11163	3790	7373	1115	0	.075	0.000
58	25392	5279	32621	37900	40304	4640	10493	3790	6703	1314	0	.093	0.000
59	25392	5279	32621	37900	40304	4551	9684	3790	5894	1151	0	.086	0.000
60	25392	5279	32621	37900	40304	4539	9001	3790	5211	861	0	.067	0.000
61	25392	5279	32621	37900	40304	4605	8557	3790	4767	688	190	.055	.006
62	25383	5279	32436	37715	40296	4684	8286	3771	4514	1294	988	.108	.032
63	25328	5279	31481	36760	40241	4584	7613	3676	3937	2396	464	.225	.015
64	25240	5279	31084	36363	40152	4141	6248	3636	2612	2181	112	.242	.004
65	25148	5279	31050	36329	40060	3814	5064	3633	1431	1764	229	.228	.008
66	25054	5279	30903	36182	39966	3665	4183	3618	565	1244	73	.177	.002
67	24963	5279	30916	36195	39875	3731	3643	3620	24	494	20	.071	.001
68	24880	5279	30980	36259	39793	4121	3533	3533	0	1002	66	.144	.002
69	24716	5279	30995	36274	39628	4221	3205	3205	0	1640	406	.256	.014
70	24234	5279	30679	35958	39147	3942	2644	2644	0	413	3	.066	.000
71	23293	5274	30770	36044	38200	4290	2694	2694	0	760	245	.118	.008
72	22507	5240	30622	35862	37381	4368	2656	2656	0	597	38	.091	.001
73	21756	5191	30682	35873	36580	4500	2720	2720	0	537	43	.079	.001
74	21115	5144	30730	35875	35888	4665	2800	2800	0	391	145	.053	.005

where appropriate, catches north and south of 40°S. Division 4 was selected both because it contains no land stations and because a number of population estimates for this Division which were considered at the La Jolla meeting gave rather similar results. The population parameters used in the simulations are the same as the standard values adopted at La Jolla and given in Table 1, except for the von Bertalanffy parameters. To account reasonably for the number of very large males which were taken in the early catches, it was necessary to use a higher value of L_∞ than those used at La Jolla, and parameter values of $L_\infty = 54.0$, $K = 0.05$, $t_0 = -5.0$ were adopted for males.

The initial population size was taken to be 37,900 mature females. This was the value adopted at La Jolla for Division 4 and was the female population corresponding to the mean of the various estimates of the exploitable male population.

Assuming the same initial size, it will be seen that the differences between the two time series for the various population components are not very great. The most noticeable difference between the two series is due to the fact that density dependence operates on total biomass in the SPCOH model rather than the mature female population as in the SPDYN model. Table 6 shows that the total biomass drops much more rapidly than does the mature female population size. Consequently, in the later years the pregnancy rates are higher and the age of female maturity lower in the SPCOH model than in the SPDYN model. This leads to the markedly higher immature unexploited populations in the SPCOH model, and ultimately to the higher exploited population levels. The other principal difference is that proportionately the immature exploited male population is lower and the mature exploited male population higher in the SPCOH model than in the SPDYN model. This probably arises from the fact that the SPCOH model allows, as in nature, for recruitment to be spread over any number of age groups, so that some catch is taken from immature age groups below the mean age at recruitment, while the SPDYN model assumes that recruitment is a knife edge process at this age.

The population age-length matrices for the first and last years of the series have been computed. No strictly comparable sets of real data in the form of large age-length keys for the Southern Hemisphere, including catches in both the Antarctic and temperate waters, are available. It is not therefore possible to make a detailed test as to whether the

Table 6

Time series of population components for Southern Hemisphere Division 4 using the SPCOH model.

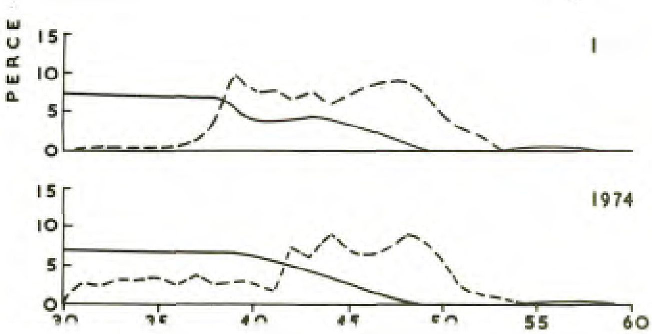
```
TIME SERIES OF POPULATION COMPONENTS
INITIAL MATURE FEMALE POPULATION  =  37900
NATURAL MORTALITY RATE    =    .0500 UNEXPLOITED,  =  .0500 ZERO POPULATION
JUVENILE MORTALITY RATE  =    .1334 UNEXPLOITED,  =  .1334 ZERO POPULATION
PREGNANCY RATE            =    .1900 UNEXPLOITED,  =  .2500 ZERO POPULATION
AGE AT MATURITY  - FEMALE =   10.0 UNEXPLOITED,  = 7.7000 ZERO POPULATION
AGE AT SOCIAL MATURITY - MALE    = 25.0
AGE AT RECRUITMENT - FEMALE      = 13.0
AGE AT RECRUITMENT - MALE        = 20.0
DURATION OF JUVENILE MORTALITY   =  2.0
HAREM SIZE =     10
RESERVE PER HAREM MALE  =  0.0000
DENSITY DEPENDENCE EXPONENT =     0.0000
PROPORTION OF CALVES KILLED =     .500
GROWTH PARAMETERS - MALE   , L∞   = 54.0, K = .050, t0 = -5.0, SDL = 3.5
GROWTH PARAMETERS - FEMALE, L∞   = 38.0, K = .095, t0 = -4.4, SDL = 3.5
PARAMETERS FOR W=ALB - MALE   , A =  .000152, B = 3.180
PARAMETERS FOR W=ALB - FEMALE, A =  .000152, B = 3.180

YR  -------- FEMALE POPULATION --------       --------- MALE POPULATION ---------       -- CATCH --   - BIOMASS (000 T) -
    IMM-UNEX  MAT-UNEX  MAT-EX  MAT-TOT      IMM-UNEX  IMM-EX MAT-EX REQD SUR-MAT       M        F        M     F   TOT

46   25392     5279    32621   37900        40304    5085   17903 3790  14113      457       0       922   546  1468
47   25392     5279    32621   37900        40303    5080   17463 3790  13673     1174       0       903   546  1449
48   25406     5279    32621   37900        40316    5062   16359 3790  12569      539       0       857   546  1403
49   25455     5279    32621   37900        40365    5059   15913 3790  12123      637       0       838   546  1385
50   25512     5279    32621   37900        40421    5053   15397 3790  11607     1322       0       818   546  1364
51   25579     5279    32621   37900        40481    5022   14270 3790  10480     1084       0       773   546  1319
52   25675     5279    32621   37900        40575    5001   13416 3790   9626      260       0       739   547  1286
53   25788     5279    32621   37900        40693    5020   13363 3790   9573      364       0       737   547  1284
54   25893     5279    32621   37900        40799    5024   13227 3790   9437     1130       0       732   547  1279
55   25996     5279    32621   37900        40899    5002   12381 3790   8591     1747       0       700   547  1247
56   26117     5279    32621   37900        41006    4927   11040 3790   7250      427       0       650   548  1198
57   26268     5279    32621   37900        41160    4939   10952 3790   7162     1115       0       647   548  1195
58   26402     5287    32621   37908        41292    4893   10267 3791   6477     1314       0       623   548  1171
59   26527     5312    32621   37933        41432    4843    9430 3793   5637     1151       0       592   549  1141
60   26664     5344    32621   37965        41593    4810    8774 3796   4977      861       0       569   550  1118
61   26803     5376    32627   38003        41771    4801    8404 3800   4603      688     190       556   550  1106
62   26927     5407    32465   37872        41920    4773    8270 3787   4483     1294     998       551   548  1099
63   27022     5439    31535   36974        41879    4577    7893 3697   4196     2396     464       531   533  1064
64   27045     5469    31171   36640        41865    4243    6518 3664   2854     2181     112       481   527  1008
65   27076     5479    31191   36670        41826    3922    5489 3667   1822     1764     229       443   527   970
66   27129     5490    31106   36596        41869    3695    4809 3660   1149     1244      73       418   526   944
67   27170     5520    31177   36697        42064    3669    4347 3670    677      494      20       405   527   932
68   27227     5555    31288   36843        42356    3842    4349 3684    665     1002      66       411   529   940
69   27276     5584    31364   36948        42531    3938    4118 3695    424     1640     406       407   530   937
70   27321     5607    31123   36730        42608    3927    3745 3673     71      413       3       396   526   922
71   27342     5645    31280   36926        42805    4140    3907 3693    215      760     245       406   528   934
72   27364     5674    31209   36884        42924    4275    3994 3688    306      597      38       411   527   938
73   27382     5688    31355   37042        43071    4479    4198 3704    493      537      43       422   529   951
74   27439     5656    31498   37154        43182    4622    4411 3715    695      391     145       431   531   962
```

model matrices accurately simulate the actual populations. Comparisons however with the more localized keys available for the Southern Hemisphere and the large North Pacific key given by Ohsumi (1977), suggest that the model key using the present parameter values resembles the real situation in its general form. In particular the breadth of the length distribution with age diminishes at later ages in the model, as in the real data, as a result of the greater liability to capture of the larger animals, particularly about the age of recruitment. The model also shows clearly that the age-length matrix is very different in 1946 and in 1974, as a result both of the increased mortality rate reducing the outer end of age distributions at length, and of the selection of larger animals reducing the numbers of the larger animals in the length distributions at age. The key therefore changes substantially without any density dependent change taking place in the growth rate of the animals. The model however produces by 1974 an unrealistic absence of animals between 49 and 53 feet, while those above this length range are still present in significant numbers. This indicates a need for further study.

Fig. 1 compares, for representative years, the percentage length distribution of the actual catches with that of the computed population. The general behaviour of the model resembles that of the catch distribution, in that the sizes predominating in the catch have become smaller over the years in a manner corresponding to the reduction in the maximum sizes present in the population. The predominant size range in the catch usually corresponds fairly closely to the ranges over which abundance increases in the population (e.g. 48–56 ft. in 1946 and 41–49 ft. in 1974). The fit is not as good in 1966 and 1974 as in earlier years. In particular the number of large males of about 47 to 52 ft. in the catch is larger than could be taken from the population model. It appears that with the present model structure and parameter values not enough males are reaching this size to maintain the population, while, on the other hand, too many survivors are remaining in the 54–58 ft. range.

POPULATION ESTIMATES

Population estimates have been developed for the exploit-


PERCE
1974
55
60

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Effort Statistics in the North Atlantic Minke Whale Fishery

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Catch per unit effort is the standard method for determining variations in stock size in the absence of confirming biological data. This CPUE has been used in determining minke stocks and quotas in the Antarctic and would be expected to be used in a similar fashion for minke whales in the North Atlantic. This paper summarizes factors which may affect catch per unit effort in the North Atlantic minke whale fishery. This paper is the result of intensive discussions on the subject at the North Atlantic Sub-Committee meetings held in Oslo in April 1976.

HISTORY OF MINKE WHALE CATCH

Minke whaling in the North Atlantic has been recently carried on by Canada, Denmark, and Norway. The Canadian catch has been recently summarized by Mitchell (1973) and Mitchell and Kozicki (1975) and the Greenland catch by Kapel (1975). Greenland and Canada have taken only a small percentage of the total minke take, and the data do not lend themselves to meaningful analysis of catch per unit effort. The Norwegian boat fishery for minke whales began in 1882 (Mitchell, 1975). Jonsgård (1951, 1955, and 1974) summarised the historical development of minke whaling particularly the modern period of the fishery beginning in the late 1920's. It could be expected that this long standing fishery, which has taken over 95% of the minke whales captured in the North Atlantic, would provide suitable data for meaningful catch per unit effort analysis. However, as the following discussion indicates, these data are influenced by a wide variety of relevant factors.

1. DISTRIBUTION OF THE CATCH – WESTERN MOVEMENT

The minke whale fishery has expanded greatly from central coastal Norway to cover the entire northern portion of the North Atlantic (Jonsgård, 1974; Christensen, 1975; and Solvik, 1976). The dates which follow indicate the beginning of significant catch (greater than 15 whales per year) (Christensen, 1975):

Late 1920's	– Central Norway
1933	– North Norway
1938	– Spitsbergen and Barents Sea
1946	– Shetland – Faeroe Islands
1960	– North and West Iceland and East Greenland
1961	– Jan Mayen and East Iceland
1968	– West Greenland and Davis Strait

The existing minke whale fishery is spread throughout the northern North Atlantic (Jonsgård, 1977b).

2. CHANGES IN GEAR

Holm (1962) analyzed the economics of the Norwegian small whale fishery from 1938 to 1960. He found that for the six years 1954 to 1960 the mean vessel length increased in all areas examined and overall from 52.8 to 57.3 ft, about one foot per year. At the same time however horsepower increased by about 35% from 58.1 to 93.4.

Foote (1975) examined the Norwegian small whale fishery in detail during the years 1963–64. Of the 176 vessels in the whaling fleet in 1963, only 12 were greater than 80 ft. in length. Small boats tend to be wooden hulled and 40 to 50 ft. long. Larger newer craft were steel hull construction. The average length of whaling vessels has increased consistently since the war and currently over a dozen vessels are greater than 90 ft. in length. (Christensen, per. comm.)

In 1964, Foote (1975) found horsepower requirements varied greatly within the fleet. Newer vessels had higher horsepower engines than older vessels of the same length. Engine type has gradually changed from semi-diesel to diesel. Foote indicates widespread assent among whaling captains and boat builders that the semi-diesel is a more efficient engine for whale hunting. In 1960, the sum of the average size and average engine power of the whaling vessels was 150, 300 in 1970, and 333 in 1973.

Solvik (1976) found no large correlation between vessel length and horsepower and catch. He indicates that although there has been a major change in mean length and horsepower in the fleet as a whole the larger, newer vessels are going to the western grounds for minke whales. Length of vessel was weakly correlated with catch. The vessels are used in other fisheries besides whaling and the larger size vessel may be in part desired to meet the needs of these fisheries (Rorvik, per. comm.)

Other changes in equipment may have led to greater increased hunting efficiency within the whaling fleet. Gear innovations include sophisticated navigational devices, improved radio contact, improved harpoons and cannons, and introduction in the 1950s of nylon line facilitating a greater killing distance and lower loss rate. Newer larger vessels have increased storage capacity and some vessels have freezer storage.

Solvik (1976) states 'I personally believe the gradual improvement of the radio-equipment has made possible better cooperation within the fleet which along with modern radio navigation has made possible systematic search.'

3. MULTISPECIES CATCHES

One major difficulty in evaluating CPUE for the minke whale fishery is that three other species have, at times, played a significant role in the overall fishery effort. Christensen (1975) shows that the Norwegian small whale fishery is a multispecies fishery in which minke, bottlenose, killer, and pilot whales are taken. Bottlenose whaling was extremely important in the early years but has since been an erratic fishery (Christensen, 1976). In 1949, there were 50 combined catcher vessels for minke and bottlenose whales and 4 exclusively bottlenose catchers. By 1969, there were only 4 combined catchers and 12 exclusively bottlenose catchers. The bottlenose catch has also been highly variable. In 1970, 17 vessels caught 528 bottlenose whales. At present, there is no active bottlenose fishery, and no whales have been reported as caught since 1974. Rorvik (per. comm.) indicates that minke and bottlenose whales are usually found in different areas so a minke boat can only take a bottlenose whale while in transit.

There was an active pilot whale fishery from 1957 to 1970. Three-hundred and sixty-nine whales were taken in 1966, eleven per cent of the total small whale catch for that year. Killer whales in that same year comprised 5.4% of the fishery with 162 whales taken. The killer whale fishery has been more consistent before dropping back to zero last year. The highest percentage of the total small whale fishery was 7.8% for killer whales in 1970 with 246 whales taken. The killer whale catch largely takes place prior to the minke whale season and in recent years its influence on CPUE is distinguishable.

From 1938 to 1950, the minke whale catch was always greater than 90% of the total small whale catch. However, from 1959 to 1971, the take of bottlenose, killer, and pilot whales varied between 11 and 28% of the total fishery. If the fishery, as has been suggested by Mitchell (1975), is indeed relying on targets of opportunity, taking bottlenose whales wherever possible and killer whales when the market is favorable, it would be very difficult to evaluate critically the degree of effort actually expended on the minke whale. Some data do exist, particularly for the Norwegian coastal fishery which can be used to isolate the minke whale effort.

4. WEATHER DEPENDENCE

Solvik (1976) has made the first attempt to analyse the effect of weather on effort data in the minke whale fishery. It was recognised at the 1976 Oslo meeting that weather plays a key factor in evaluating effort in the minke whale fishery. Winds greater than Beaufort 4 prevent effective fishing for minke whales. Solvik's analysis covers the period 1962 to 1972. Some weather data are available for the Norwegian coast as far back as 1952. The weather problem itself varies greatly over the catch area. There is also some evidence for large scale changes in environmental conditions affecting the distribution of whale species over the period of analysis which may affect effort.

Increased daylight time available for fishing in the northwest areas in the high latitudes into which the fishery has expanded also complicates analysis of effort.

5. BIOLOGICAL FACTORS

Mitchell (1974) and Rϕrvik and Jonsgård (1976) discuss the 'ship-loving' tendency or what is called seeking behaviour of minke whales. the tendency of minke whales to approach stationary vessels may produce an important bias into effort data. The bias may be related to size, type, and acoustical characteristics of the vessels, as well as other features. Christensen, in discussions during the 1976 Oslo meeting, indicated that up to 20% of the minke whales captured may be termed seekers. Definition of a seeker is not clear, however. If what is meant by a seeker is a whale that approaches close enough to a stationary vessel to be captured then the percentage is approximately as indicated. The primary difficulty in minke whaling is finding the whale. Once located and approached within some critical distance, seeking behaviour becomes extremely important in allowing the opportunity for a shot. Bias in the biological data from whaling statistics would be introduced if there is differential seeking by sex, size, sexual activity, geographic area, or time of year. There are no data presently in existence on this phenomenon.

There is no statistical information or provision in the whaling forms to allow for analysis on the number of whales captured from a given herd. Solvik (1976) indicates that herd behaviour, number of herds and the ability of a captain to catch many animals from a herd may bias the validity of CPUE statistics.

6. WHALING REGULATIONS

Jonsgård (1977a) presents a summary of Norwegian and international regulations regarding whaling for minke whales. Norwegian regulations began in earnest in 1938 with the requirements that a whaling license be obtained for each vessel and that certain statistics on the whale catch be collected. During the past 30 years in which these regulations were in operation, the total number of vessels and licenses has changed dramatically. In 1938, 381 small whale vessel licenses were issued and approximately 330 were used (Solvik, 1976). In the beginning of the 1950s, these numbers continued to be high, up to 378 licenses issued (Jonsgård, 1977a). By 1975, only 91 licenses were issued and approximately 80 actually used for small whale fishing (Jonsgård, 1977a).

In 1950, a 3-week closed season from 1 July to 21 July was introduced for minke whaling. In addition, whaling was permitted only for a period of six months from 15 March to 14 September. From 1955 to the present, whaling areas have been defined and seasons regulated. An additional requirement in 1973 placed a maximum tonnage of 70 tons per vessel, per season, for waters north of 70°N from 1 April to 30 June.

IWC regulations have been limited to the 1952 imposition of a maximum of six month season and the 1975 quota on catch of 2,000 minke whales and 550 minke whales east and west of Cape Farewell, respectively. Regulations have obviously had a major effect on the nature of the fishing fleet and the fishery itself The major impact of these regulations is more control over the northern grounds and newly exploited minke whaling areas after June 30. Solvik's analysis of the Norwegian coastal area is for May and June and thus less affected by regulation.

It is not possible at present to evaluate the effect of regulations on effort. For regulatory purposes stocks have been treated as a unit when, in fact, four separate minke whale stocks are affected by regulatory measures.

7. HANDLING EFFORT STATISTICS

Present data collection of the Norwegian minke whale fishery does not allow rigorous analysis of CPUE because of the absence of information on time spent in transit, in bad weather, and in searching, hunting, and capture of minke whales. Solvik's analysis, based on 10 day statistical periods, presents some problems because of the inadequacy of weather data, the movement of vessels between statistical areas and handling periods in which no whales were caught. The Sub-Committee in Oslo reworked the data to provide boat-days defined as the number of boats with a catch in a statistical area and month in question, multiplied by the number of days when at least one whale was caught by any boat in the area. The information on the Norwegian coastal stock is better than that for the other stocks in the North Atlantic. However, the Sub-Committee felt that boat-days as a general measure may not adequately reflect true whaling effort.

SUMMARY

This paper has attempted to summarize factors potentially affecting effort statistics in the North Atlantic minke whale fishery. Factors that have been operating continuously, such as seeking behaviour and weather, have not been analyzed for the complete period that minke whaling has been occurring, if at all. Many gaps in our knowledge erode confidence we may have in using catch per unit effort to analyze the state of North Atlantic minke whale stocks. Solvik (1976) has made attempts to bring various factors together. However, CPUE can depend on factors which, in the presented material, are not possible to measure.

It may be that in the long run the compilation of catch per unit effort for this fishery is not a valid method for analyzing minke whale stocks and that independent biological information on the stocks is necessary. If, however, a more reliable catch per unit effort is desired, in the future it will be necessary to gather increased information from whalers. This information would include a detailed breakdown of the travel time to and from the whaling area, time spent in searching, hunting, and capture, occurrence of seeking and increased weather data.

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SC/28/Doc 4

Status of Whale Stocks off South Africa, 1975

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NATAL COAST

During the 1975 season, which ran from 1 February to 26 September, the whaling fleet consisted of five catchers with an average tonnage of 593 tons. All were equipped with asdic. The following catch of whales was made (with the relevant quota levels in brackets).

Fin		21 (45)
Sei		1
Bryde's		3
Minke		110
Sperm	♂	869 (897)
	♀	809 (896)
Killer		4
Total		1,817

The spotter aircraft flew a total of 1,103 hours 35 minutes during the season and saw the following numbers of whales of commercial species.

Fin	22 (14 sightings)
Sei/Bryde's	0 (0 sightings)
Minke	65 (43 sightings)
Sperm	2,249 (193 sightings)
Killer	16 (2 sightings)
Total	2,352 (252 sightings)

Sperm whales

1. Estimates of population size from mark/recapture data.

In January 1975, 18 sperm whales (of which 15 were estimated to be 30 feet or more in length) were marked with Discovery tags off the southeastern coast of South Africa before the whaling season opened. In Table 1 the number of sperm whales marked under the British-South Africa Scheme since 1963 and estimated to have survived till the start of the 1975 season are listed together with recoveries at Durban during 1975.

The number of marked whales available is derived as previously (Best 1976), namely all animals less than 30 ft. in length (or outside assumed stock boundaries) at marking are excluded, and an initial tagging mortality rate of 5% and subsequent natural mortality rate of 6% are assumed. The 1963 data have also been manipulated in order to correct for presumed errors.

Table 1

Recoveries of marked sperm whales at Durban under British-South Africa Scheme, 1975 season

Season of marking	Year group	Number of marked animals available	Number recovered
1975	0	14	1[1]
1973–74	1	103	0
1973	2	104	2
1972	3	39	0
1971	4	47	2
1969	6	14	0
1968	7	6	0
1963	12	5	0
Total		332	5

[1] Protruding mark

Before attempting to incorporate the new data into a population estimate, an assumption basic to these calculations should be investigated, namely, that the number of whales judged to be successfully marked at the time of marking is not biassed. Because of the method of remote application of the mark (fired from a shotgun), the fate of each one fired has to be judged. A successful mark is one that is buried completely in the whale, while an unsuccessful mark could be a miss, a ricochet, a protruding mark, a possible hit (where judgement is impaired, usually through the mark striking the whale below the water line), or a shot where no verdict is possible. Normally, it is assumed that the number of whales incorrectly recorded as being marked successfully is balanced by the number incorrectly recorded as being unsuccessfully marked, so that no correction factor is necessary. This assumption has never been tested.

Records have been kept on marking cruises off Durban since 1968 of the number of whales judged to have been double-marked at the time of marking.

Table 2

Number of double-marked whales recorded on marking cruises off Durban since 1968 and number of recoveries of these whales

Species	Recorded as double-marked at marking	Recovered as single-marked (N_2)	Recovered as double-marked (N_1)
Sperm	39	4	1
Sei	1	0	1
Fin	1	0	1
Total	41	4	3

The number of these that were within stock boundaries at the time of marking and (in the case of sperm whales) estimated to be 30 ft or more in length are shown in Table 2. Data for fin and sei whales are included as it is not considered likely that efficiency of judgement of mark success would be species-specific. Some of these marked sperm whales have subsequently been killed and one or both of the marks recovered at Durban. Both baleen whale recoveries were actually made by pelagic fleets but have been included in this analysis to increase the amount of data available. If it is assumed that the efficiency of mark recovery is 100% (as shown by trials at Durban – see below), and that the chances of mis-reporting are identical for the two marks fired at the whale and recorded as hits, then the degree of mis-reporting can be calculated using the proportions of animals recovered with only one and with both marks present.

If N_1 = number of double-marked whales killed with both marks present,
N_2 = number of double-marked whales killed with one mark present,
and N_3 = number of double-marked whales killed with no marks present.

Then $N_3 = \dfrac{N_2^{\,2}}{4N_1}$

The proportion of marks recorded as hits on double-marked animals but subsequently found to have been mis-reported (P_s) can then be calculated.

$$P_s = \frac{N_2 + 2N_3}{2(N_1 + N_2 + N_3)}$$

which simplifies to $P_s = \dfrac{N_2}{2N_1 + N_2} = 0.40$

(see Fairley, 1969, for derivation of these equations).

This seems to be a surprisingly high degree of mis-reporting of hits. It is based on few data and does make the assumption of a 100% recovery rate during processing of the carcase, an assumption which, although supported by the available data from experiments (see below), may not be truly representative of the recovery rate of marks actually fired at sea. Nevertheless, the degree of error suggested is large enough to warrant its inclusion in calculations of mark recovery rates.

There are of course undoubted errors in the other direction, i.e. whales recorded as not being successfully marked but which in reality were marked. There are three recoveries of such marks at Durban from the 1968 and subsequent cruises, one of which was recorded as a 'possible hit', one as a 'protruding' mark and one as a 'ricochet'. There are several difficulties in estimating what proportion of whales reported as not being successfully marked these recoveries might represent. Firstly, the size of such animals is not usually recorded at marking, so that no stratification of the data is possible. Secondly, because it is impossible to recognise such animals on the flensing platform, indirect estimates of the number that might have been killed have to be made. Thirdly, there are almost certainly different accuracies in reporting different categories – the proportion of mis-reported 'possible hits' is probably higher than the proportion of misreported 'misses', for example. It seems more satisfactory, therefore, to abandon any correction to account for mis-reported unsuccessful marks, and in calculations of mark recovery rates to ignore any recoveries of marks that were actually reported as being unsuccessful at the time of marking. Such calculations would, therefore, be based only on the number of successful marks reported that were recovered as such (i.e. not as protruding marks) expressed as a proportion of the total number of successful marks reported, but adjusted to account for misreporting.

When mark recovery data are being used to estimate population size a further correction may have to be made to account for the greater likelihood of recoveries from double-marked than from single-marked animals.

The proportion of single-marked animals that are in fact not marked will be identical to the misreporting rate of 0.4. The proportion of double-marked animals that are not marked at all will be less,

$$\frac{N_3}{N_1 + N_2 + N_3} \text{ or } 0.16.$$

Consequently, the proportion of double-marked to single-marked animals reported at marking has to be combined with these rates to obtain an estimate of the total number of animals actually marked.

In the case of marking off Durban since 1968, and taking into account the size and geographical limits mentioned above, there have been 39 sperm whales recorded as double-marked and 375 as single-marked. An overall mis-reporting factor for these data will therefore be 0.3774.

The mark recovery data used previously to reach estimates of population size (Best 1976) must therefore be adjusted to account for this mis-reporting factor.

This has been done in the following way:

(a) All 1963 marking and recovery data have been excluded, as a different observer was present on this cruise to subsequent ones, and it is impossible to calculate a meaningful mis-reporting rate.

(b) The number of marked animals available has been calculated for 1968 and subsequent seasons including 1975 as previously, but with a correction factor of (1–0.3774) or 0.6226 to account for mis-reporting.

(c) The three successful marks recovered but which were not recorded as successful hits at marking are excluded (two of which were O-group recoveries, i.e. returns in the season of marking).

Then

Sum of marked animals available, 1968–75 (ΣM) = 1,185
Sum corrected for misreporting (ΣM_1) = 738
Sum of mark recoveries, 1968–75 (Σm) = 21–3 = 18
Mean Durban catch, 1968–75 ($\bar{C}$) = 1,723
Population size $= \dfrac{\Sigma M_1}{\Sigma m + 1} \times \bar{C}$ = 66,925

This estimate is for all mark returns. With O-group returns only over the same period, the calculations will be:

$$\text{Population size} = \frac{371 \times 0.6226}{8 + 1} \times 1{,}664 = 42{,}706$$

These two estimates agree better than those produced from the previous analysis (76,304 and 42,889 respectively – Best, 1976). As before, they may usefully be considered as upper and lower estimates of exploitable population size from marking data. As the 1963 data were excluded, the time span over which the new estimates are valid is 1968–75, with a mean date of 1970 for the estimate based on all returns.

It is interesting to note that the correction made to the number of marked animals available made relatively little difference to the population estimates. It is equally clear, however, that these estimates are very sensitive to the number of reported mark recoveries, and this makes the efficiency of mark recovery a most important factor to be determined.

During the 1974 and 1975 seasons at Durban, 25 Discovery marks (of which ten were 12 bore and 15 were 410 marks) were secreted into whale carcases as they lay at the slipway, 2 km from the factory. Most of these were pushed into the muscle but some were left in the blubber. The details of placement and recovery are given in Table 3. All 25 marks were recovered at the factory, of which 17 could be allocated to specific whales by their finders. A further 16 marks were secreted into whales in 1969 and 1971, and all 41 marks have been recovered, giving a 100% recovery rate for the Durban factory.

On eight occasions the finder of the mark allocated it to the wrong whale, or the wrong group of whales. Six of these were in minke whales, and this may arise from the practice at Durban of flensing two or three minke whales simultaneously, whereas usually only small sperm whales are flensed in pairs. The language difficulties associated with the Zulu platform labourers employed at Durban could also have contributed to some misunderstandings. This confusion of identity may explain some of the inconsistencies that have arisen in past mark recoveries (as for instance when the whale was much smaller at capture than it was estimated to be at marking), and is strong motivation for the development of a streamer tag as an aid to identifying marked whales before they are processed.

2. *Indices of availability*

Catching effort in 1975 expressed as productive-boat-days was its lowest since 1954, due to the use of one less catcher than in any previous year, while aerial spotting coverage was at the same level as 1973 and 1974 (Table 4).

After examination of annual trends in the average distance of sperm whale catches from Durban, it was concluded that an effort-correction factor was needed to account for the time spent steaming to and from the grounds each day (Best 1976). In 1975 the mean distance of the sperm whales caught was 73.2 miles from Durban, considerably less than in any of the years investigated since 1958. Distance-corrected catch per unit effort (CPUE) values, and density indices from sightings, are shown in Table 5 for the two sexes and for three size groups of males.

No significant trends can be discerned in total sperm whale availability (as measured by aircraft sightings and CPUE of both sexes) since 1954. There are also no signs of a decrease in female or small male availability but, as pointed out previously, the availability of males over 40 ft. in length has declined significantly since 1954 (Best 1976). The availability of this size group over the last three seasons has been lower on average than in any previous three-year period since 1954, and although quota restrictions first became effective in 1973, their effect on the composition of the catch (if any) would almost certainly have been to increase the proportion of larger animals. The relative decrease in stock abundance between 1946 and 1974 of medium-sized and large males has been calculated from the regression of asdic- and distance-corrected CPUE on time as 62.8%, i.e. the 1974 stock stood at 37.2% of the 1946 level (Best 1976).

3. *Status of the stock*

Estimates of the size of the Division 3 (or Durban) stock made previously have been reviewed (Best 1976). Besides those estimates based on CPUE, the only ones considered valid were the mark/recovery estimate (revised above) and one based on sightings (54,000 – Gambell *et al.,* 1975) which referred to the total rather than exploitable stock.

Those estimates based on CPUE of the pelagic fleets were criticised because of deficiencies in measuring effort,

Table 3

Marks secreted into whale carcases at Durban, 1974 and 1975

Whale in which mark inserted				Whale from which mark recovered		
Species	Platform No.	Site of placement of mark	Type of mark	Species	Platform No.	Where mark recovered
1974				1974		
Minke	1250	Blubber	.410	Minke	1248	Flensing platform
Minke	1549	Blubber	.410	Minke	1549	Flensing platform
Minke	1550	Blubber, projecting	.410	Minke	1550	Flensing platform
Minke	1681	Epiaxial muscle	.410	Minke	1680–81	Freezing plant
Minke	1877	Hypoaxial muscle	.410	Minke	1877	Flensing platform
Minke	1879	Hypoaxial muscle	.410	Minke	1879–81	Freezing plant
1975				1975		
Minke	1347	Epiaxial muscle (deep)	.410	Minke	1346	Flensing platform
Minke	1346	Hypoaxial muscle	.410	Minke	1346–47	Freezing plant
Minke	1599	Epiaxial muscle	.410	Minke	1599	Flensing platform
Minke	1601	Hypoaxial muscle	.410	Minke	1602	Freezing plant
Minke	1602	Hypoaxial muscle	.410	Minke	1603	Flensing platform
Minke	1605	Epiaxial muscle	.410	Minke	1603	Flensing platform
Minke	1620	Epiaxial muscle	.410	Minke?	1599–1603	Freezing plant
Minke	1769	Hypoaxial muscle	.410	Minke	1767–71	Freezing plant
Minke	1771	Epiaxial muscle	.410	Minke	1771	Flensing platform
Sperm	209	Epiaxial muscle	12	Sperm	207 or 208	Meat extract platform
Sperm	348	Epiaxial muscle	12	Sperm	348	Flensing platform
Sperm	627	Epiaxial muscle	12	Sperm	627	Flensing platform
Sperm	628	Hypoaxial muscle	12	Sperm	624–57	Meat extract platform
Sperm	847	Epiaxial muscle (deep)	12	Sperm	847	Flensing platform
Sperm	849	Hypoaxial muscle	12	Sperm?	?	Filter in factory
Sperm	1491	Hypoaxial muscle	12	Sperm	1491	Flensing platform
Sperm	1489	Epiaxial muscle	12	Sperm	1489	Flensing platform
Sperm	1556	Epiaxial muscle	12	Sperm	1553	Flensing platform
Sperm	1558	Hypoaxial muscle	12	Sperm	1558	Flensing platform

Table 4

Catching and spotting effort off Durban

Year	Miles* flown by spotter aircraft	No. of catchers	Mean gross tonnage	Catcher days†	% Catchers with asdic	10^5 asdic – corrected catcher-ton-days
1966	12.4203	12	525	1,222	50.0	10.6424
1967	14.1901	10	536	981	77.8	10.6681
1968	8.2484	7	539	736	71.4	7.7074
1969	8.7109	7	548	740	71.4	7.8696
1970	8.8809	7	546	741	71.4	7.8529
1971	8.5202	6	557	665	100	8.6002
1972	8.8210	6	569	687	100	9.0642
1973	7.9269	6	568	670	100	8.8290
1974	7.5197	6	568	615	100	8.1042
1975	7.6929	5	593	504	100	6.9338

* (12×10^3) miles, weather-corrected, April to September.
† Productive-boat-days.

i.e. there was no allowance for increasing catcher efficiency through the introduction of asdic or increasing tonnage of the catchers. Revised estimates taking several of these factors into account have now been made (Anon, 1977). Estimates of the 1946 population of exploitable males in Division 3 ranged from 16,100 to 68,700 depending on the origin of the effort data used. It was difficult to decide which estimates were 'more reasonable' than others, and finally an overall mean of the different estimates was taken. This is obviously not completely satisfactory, given the high variability of the estimates. Present stock sizes of exploitable males were then obtained from the 1946 estimates using known catches and a population model incorporating changes in certain biological parameters in response to exploitation. Unfortunately these estimates of present stock size (and their sizes relative to initial) were extremely sensitive to the size of the initial population chosen. As these were in themselves highly divergent for Division 3, little reliance can be placed upon them until further analyses have been made.

An independent estimate for the exploitable stock size off Durban in 1970 is available from mark recoveries (42,700 to 66,900). Its composition can be estimated from the proportions of males of different sizes and of females in the catch, using mean CPUE values for the period 1968–75 (i.e. the same period as covered by the marking data). These give proportions of:

Small males (0.33) = 14,091–22,077
Medium-sized males (0.19) = 8,113–12,711
Large males (0.09) = 3,843– 6,021
Females (0.39) = 16,653–26,091

The number of exploitable males greater than 40 ft. in length in 1970 is therefore estimated to have been between about 12,000 and 18,700. From the regression describing the decline in CPUE of large and medium-sized whales (Best 1976) the 1955 population of the same size class would have been $\frac{1}{0.578}$ of 1970 level. On this assumption the 1955 population would have numbered 20,761–32,353, and if the

Table 5

Availability of sperm whales off Durban

		Catch-per-unit-effort[2]				
			Males			
Season	Aircraft sightings[1]	Small (<40 ft.)	medium (40–45 ft.)	Large (>45 ft.)	Females	Total
1954	217	26.2	54.2	66.4	16.9	164
1955	171	36.7	32.3	29.3	64.7	163
1956	133	25.3	28.3	27.6	33.3	114
1957	204	30.0	41.4	31.3	57.7	161
1958	72	25.1	45.4	20.7	52.7	144
1959	109	37.1	31.5	11.1	38.6	119
1960	138	32.8	32.8	13.4	46.3	125
1961	135	33.8	30.3	7.7	50.8	123
1962	201	42.5	35.5	14.9	64.3	158
1963	151	29.0	40.0	11.1	86.5	167
1964	140	37.9	27.3	12.9	72.2	150
1965	169	50.1	23.5	8.8	99.8	182
1966	202	43.9	29.3	16.9	39.0	129
1967	164	33.1	18.8	9.6	43.9	106
1968	159	46.6	35.6	15.3	20.9	119
1969	243	36.8	24.4	11.4	50.7	123
1970	156	33.4	31.5	12.6	48.9	126
1971	196	47.5	16.3	9.1	62.5	135
1972	275	31.5	31.0	11.9	34.3	109
1973	187	37.8	19.3	8.6	43.0	109
1974	373	41.3	18.4	7.2	55.8	123
1975	223	51.1	13.6	8.3	70.0	143

[1] Number of whales seen per 12×10^3 miles flown, April to September.
[2] Catch per 10^5 catcher-ton-days, asdic- and distance-corrected, April to September.

extrapolation is continued backward till 1946, that population would have been $\frac{1}{0.462}$ of the 1970 level, or 25,974–40,476. However this extrapolation beyond the range of available data is not really valid.

Although these estimates are open to criticism, particularly the assumptions regarding the proper mixing of marked animals, the random sampling of the population by Durban catchers, and the accuracy of CPUE in following actual population trends, they have the following advantages over the analyses made in La Jolla (Anon 1977).

(i) The population estimate for 1970 is independent of trends in CPUE analysis or extrapolation from 1946 estimates.

(ii) The CPUE data employed in extrapolation back to the 1955 estimates are more homogeneous than most of those used at La Jolla, concerning only one operation and covering a much longer time series with correction factors for asdic, tonnage and a shift in whaling grounds included.

(iii) The same component of the stock is concerned throughout the time series of CPUE data, while in certain of the La Jolla meeting calculations it is not clear whether there have been changes in the age at recruitment over the time series of data concerned, so that estimates of 1946 and current stock sizes may not refer to the same components of the population.

The exploitable population of sperm whales off Durban in 1974 can be estimated from the 1970 mark/recovery estimate, assuming:

(i) There has been no change in the stock size of mature females or small males between 1970 and 1974.

(ii) The change in the stock size of males over 40 ft. in length from 1970 to 1974 is accurately reflected by the regression of CPUE on time off Durban (Best 1976).

Then the exploitable population in 1974 will be composed of:

14,100–22,100	Small males
9,700–15,100	Medium-sized and large males
16,700–26,100	Females
40,500–63,300	Total

Baleen whales

The availability of fin, sei and minke whales off Durban since 1966 has been measured by catch-per-unit effort and sightings-per-distance-flown data (Table 6).

Fin and sei whales remained at the same low levels as in 1974, and as such were at their lowest availability off Durban since 1954. The stocks of both species supplying the Durban area are now given complete protection under the Schedule of the International Whaling Commission.

The small catch of Bryde's whales (3) seems to reflect the natural scarcity of this species off Durban, where it has never featured significantly in the catches. The consistency of the small catches would suggest that the industry was exploiting the fringe of a much larger stock outside its operational area.

Minke whale availability from both CPUE and sightings data was higher than in 1974, and comparable to that recorded for 1972 when Antarctic exploitation of the species was beginning. There are no signs of a significant reduction in availability since monitoring of the species started off Durban in 1968.

Sightings of protected species

As usual, crews on the catchers and spotter aircraft were asked to complete special forms for each sighting of a protected species. The results are analysed in Table 7.

The density of humpback whales as reported from the catchers was lower in 1975 than in all but one of the seasons since 1969. This may have been due to a loss of interest in recording data in the second half of the season when rumours about the impending closure of the station circulated. The density of this (and the other protected) species as recorded from the spotter aircraft and shown in Table 7 actually includes data for only the first four days of September. If comparisons are made with the density from April to August between seasons, there seems to have been essentially no change for the last three seasons in the density of humpback whales as recorded from the spotter aircraft:

1969–1.25, 1970–0.54, 1971–0.27, 1972–0.65, 1973–0.57, 1974–0.59, 1975–0.58.

There is no discernible trend in the abundance of blue whales off Natal.

Table 6

Availability of baleen whales off Durban

	Fin			Sei			Minke		
Year	C[1]	CPUE[2]	S[3]	C[1]	CPUE[2]	S[3]	C[1]	CPUE[4]	S[5]
1966	1,239	36	12	3,029	43	10	–	–	–
1967	1,705	28	7	6,931	13	3	2	–	–
1968	842	20	7	2,376	6	1	97	26	5
1969	702	47	14	1,811	11	2	112	26	11
1970	1,593	16	5	2,005	2	1	171	43	9
1971	1,774	21	5	1,075	3	1	199	54	16
1972	1,585	15	5	1,176	1	0	489	35	10
1973	916	13	2	604	1	0	1,360	45	10
1974	445	8	2	395	1	0	1,422	33	4
1975	189	8	3	94	<1	0	1,469	37	8

[1] Catch in Area III, 1965–66, plus catch at Durban, 1966, etc.
[2] Catch per 10^5 catcher-ton-days, May to September.
[3] Whales seen per 12×10^3 miles flown, May to September.
[4] Catch per 10^5 catcher-ton-days, April to September.
[5] Whales seen per 12×10^3 miles flown, April to September.

Table 7

Sightings of protected whale species off Natal

Year	Blue		Humpback		Right	
	No.	Density*	No.	Density*	No.	Density*
			CATCHERS			
1969	12	2.38	19	3.77	0	0
1970	7	1.52	14	3.04	0	0
1971	14	3.13	19	4.25	0	0
1972	4	0.89	19	4.23	2	0.45
1973	12	2.71	25	5.65	4	0.90
1974	5	1.23	20	4.95	1	0.25
1975	4	1.15	11	3.15	0	0
			AIRCRAFT			
1969	1	0.11	9	1.03	0	0
1970	1	0.11	4	0.45	0	0
1971	0	0	3	0.35	3	0.35
1972	0	0	5	0.57	0	0
1973	1	0.13	4	0.50	0	0
1974	0	0	6	0.80	0	0
1975	0	0	4	0.52	0	0

* Number seen per 10^5 catcher-ton-days, March to September, or number seen per 12×10^3 miles flown, April to September.

RIGHT WHALES ALONG THE SOUTHERN COAST OF SOUTH AFRICA

An aerial survey of the south coast between Lamberts Bay on the west coast and Bashee River Mouth on the east coast (i.e. between the latitude of about 35° 15′S on either coast) was carried out between 29 September and 7 October 1975. For the first time since 1971 a single-engined aircraft (Cessna 206) was used. Survey techniques were otherwise exactly the same as for all surveys since 1969, and the two observers present for the entire survey had both had previous experience of right whale surveys. A total of 139 right whales was seen, including 31 calves. Within the limits of the normal survey area (Muizenberg to Woody Cape), a total of 124 whales was seen, including 27 calves. The proportion found outside this area (10.8%) is higher than in 1972 (6.2%), when the entire coast south of about 28°30′S was searched, or in 1970 (2.9%), when exactly the same area was covered as in 1975. It is therefore possible that the right whale population, besides increasing within the normal survey limits (see below), is extending its range northwards in southern African waters during the winter and spring.

The increase in numbers of both calves and adults since 1969 seems to be linear, and regressions fitted to the data (both of which are significant at the 5% level) indicate a similar relative growth rate. In the case of adults the 1975 population is estimated to be 2.13 times, and in the case of calves 1.99 times the 1969 population. The ratio of calves to adults has therefore remained more or less constant, at 1:3.24 in 1969 and 1:3.47 in 1975. The mean annual instantaneous rate of increase is calculated as 0.130 for calves and 0.146 for adults.

An estimate of the Area III stock of right whales (i.e. those migrating to Southern Africa in winter) can be made using the same assumptions as before regarding the number missed on the survey due to overflying and the proportion of the population offshore (assumed to be all juvenile), but with a new factor $\frac{1}{0.9}$ to account for the proportion of the population outside the normal survey area. From the regressions of calf and adult numbers against time, there are estimated to have been 102 adults and 29 calves in the population surveyed in 1975, and from this an estimate of 386 whales is obtained for the Area III stock.

Extrapolation of this to the Southern Hemisphere (exclusive of Area I), using Japanese sightings data in the Antarctic during summer as an index of relative abundance of the Area III stock (Best and Roscoe 1974), gives an estimate of 4,765 animals

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Methods of the Assessment of Net Recruitment and Time of Possible Recovery of Whale Stocks to the MSY Level

R. Borodin

In accordance with the accepted criteria the regime of whaling to be chosen must provide for exploitation of the stocks at MSY level. Hence, regulation of whaling is to facilitate the approach of the whale stocks to the level of MSY. Therefore, an attempt to evaluate the possible time during which the stocks reach the MSY level under various levels of annual catch may be of some interest. Determination of the possible recovery time for the intensively exploited stocks of whales is particularly important.

The possible recovery rate assessment requires to know the annual recruitment rate. If we have reliable values of fishing effort (F) and catch (C), then the relative net recruitment rate (r – M) may be assessed as follows:

Let us assume that the catch per unit of effort is in direct proportion to the average value of the stock ($\overline{N}$), i.e.

$$\frac{C_i}{F_i} = \overline{N}_i . q,$$

Where

q = proportional coefficient (catchability rate)

We shall also consider that (q) and the net recruitment (r – M) for two successive years are constant.

Then having $N_{i+1} = N_i K_i - C_i$

$$\text{and } N_i = \overline{N}_i - \frac{C_i}{2},$$

where $K_i = 1 + (r - M)_i$

we have

$$\frac{C_{i+1}}{F_{i+1} \cdot q} - \frac{C_2}{2} = \left(\frac{C_i}{F_i \cdot q} - \frac{C_i}{2}\right) Ki - Ci$$

from where

$$q = \frac{\frac{C_{i+1}}{F_{i+1}} - \frac{C_i}{f_i} . K_i}{\frac{C_{i+1}}{2} - C_i\left(\frac{K_i}{2} - 1\right)}$$

Likewise, for the next pair we have

$$q = \frac{(C_{i+2}/F_{i+2}) - (C_{i+1}/F_{i+1}) . K_{i+1}}{(C_{i+2/2}) - C_{i+1} \cdot [(K_{i+1/2}) - 1]}$$

Making the left and the right parts of both equations equal, and believing that $K_i = K_{i+1}$, we can find the value of K having solved a square equation

$$AK^2 + BK + C = O,$$

$$\text{where } A = C_i\left(\frac{C_{i+1}}{F_{i+1}} - \frac{C_i}{F_i}\right),$$

$$B = 2\frac{C_{i+1}}{F_{i+1}} . C_i - \frac{C_i}{F_i}(C_{i+1} + C_{i+1}) - \frac{C_{i+2}}{F_{i+2}} . C_i,$$

$$C = \frac{C_{i+2}}{F_{i+2}}(C_{i+1} - 2C_i) + \frac{C_{i+1}}{F_{i+1}}(2C_{i+1} - C_{i+2}).$$

We can assess in this way the net recruitment (r – M) and its trends for all years for which reliable catch and fishing effort data are available.

To calculate the time of possible restoration of whale stocks we have used a formula which can be derived as follows:

$$N_2 = N_1 K_1 - C_1$$

$$N_3 = (N_1 K_1 - C_1) K_2 - C_2$$

$$N_i = N_1 K_1 . K_2 \ldots K_{i-1} - (C_1 K_2 \ldots K_{i-1} + \ldots + C_{i-1})$$

$$N_n = N_1 \prod_{l=1}^{n-1} K_i - \sum_{j=1}^{n-1} C_j \prod_{C=j+1}^{n-1} K_i$$

where $K_i = 1 + (r - M)_i$

In the case when $N_n = N_{MSY}$ the n index will correspond to the time of possible stock recovery from the present level to the level of MSY under various regimes of whaling (C and r – M not constant).

If K and C are constant, then this equation can be rewritten as:

$$N_n = N_1 K^{n-1} - C(K^{n-2} + K^{n-3} + \ldots + K + 1)$$

In this case always K > 1, as a result of which this series is not in closed form. Factoring out of the parenthesis the term K^{n-2} we get

$$\left(1 + \frac{1}{K^1} + \frac{1}{K^2} + \ldots\right) = \frac{1}{1 - \frac{1}{K}} = \frac{K}{K - 1}$$

Substituting the expression for the sum of the series we find

$$N_n = \left(\frac{N_1 (K - 1) - C}{K - 1}\right) K^{n-1}$$

From which we get

$$n = 1 + \frac{\ln[N_n(r - M)] - \ln[N_1(r - M) - C]}{\ln[1 + (r - M)]}$$

For instance, using this formula the time of possible recovery of the mature stocks of sei whales in Area III of the Antarctic from the present level to the MSY level is assessed as being 10 years ((r – M) = 0.04).

The size of the sei whale stock in Area II was assessed to be 17,000 (Chapman, 1976). The catch taken in this sector during the 1975–76 season was 500 whales. The difference between the net recruitment (1,200) and the catch was used for recovery. By the 1976–77 season the size of mature stock will be approximately 8% lower than the level of MSY.

Hence, the sei whale stocks will keep recovering under this whaling regime.

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SC/28/Doc 6

Analysis of the Antarctic Fin Whale Stock in Area I

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INTRODUCTION

Fin whale catches in Area I have been quite low since the 1962–63 Antarctic season and have precluded any useful population analysis using catch and effort data. Furthermore, most of Area I was a sanctuary before the 1955–56 season and the majority of the catch was from land stations. During the three seasons from 1955–56 to 1958–59 over 12,000 fin whales were taken in Area I, including 631 whales taken by Chilean and Peruvian land stations. Due to the small catches prior to this period it can be assumed that the fin whale stock was in more or less an equilibrium state and the decline in catch per effort during these three seasons should reflect the change in the Area I stock abundance. Sei whale catches were small relative to fin whale catches during this period – except for the 1957–58 season when 23% of the fin and sei catch were sei whales. This paper examines population estimates based on a modified DeLury model and various assumptions about the recruitment rate and the resulting extrapolated population estimates. Catches from Peruvian and Chilean land stations are also accounted for in the extrapolations and estimates.

CPUE DATA

Shown in Table 1 are the pelagic and land station catches of fin whales in Area I for the 1946–47 to 1975–76 Antarctic baleen whale seasons. Prior to the 1955–56 season the pelagic catch was practically nil, and the land station catches averaged about 282 fin whales per season. Since catches were small and relatively constant, it is assumed that the stock was at equilibrium during this time.

Pelagic catch and effort data for the 1955–56 to 1961–62 seasons are given in Table 2 (Omura, 1973). Effort has been corrected to take into account the increasing tonnage of the fleet. Sei catches were relatively small during the last three seasons but accounted for an increasingly large proportion of the combined sei and fin whale catch during the last three seasons. The catch per unit effort (CPUE) data show a rather sharp decrease during the first three seaons and level off during the last three, most likely due to the sei whale effort combined with the fin whale effort.

METHODOLOGY

Initial population size estimates were obtained using the CPUE data for Table 2 and the total catch (pelagic + land station). A modified DeLury model (Chapman 1974a; Tillman and Breiwick 1974) was employed which minimizes the sum of the squared differences between the observed and expected CPUEs. The basic assumption is that

$$\mathrm{CPUE}_t = q\bar{P}_t \qquad (1)$$

holds throughout the period. Here

q = constant of proportionality (catchability coefficient)
$\bar{P}_t$ = average population size during season t.

The following equation, due to Allen (1966), was used to derive the expected population sizes:

$$P_{t+1} = (P_t - C_t)e^{-M} + R_{t+1}, \qquad (2)$$

where P_{t+1} = stock size at the beginning of season t + 1
C_t = total catch during season t
R_{t+1} = recruitment during season t + 1 (= rP_{t-t_r}, where r is the gross recruitment rate and t_r is the age at recruitment)
M = instantaneous natural mortality rate.

The average population size during season t was approximated by $P_t - \frac{C_t}{2}$ and e^{-M} by $1 - M$. Since the initial population is assumed to be at equilibrium, the net recruitment rate, $r - M$, equals 0 and $R_{t+1} = MP_{t-t_r}$. The commonly used values of $M = 0.04$ and $t_r = 5$ were used in this study.

Table 1

Area I fin whale catch by season.
(Source: Bureau of International Whaling Statistics)

Season	Pelagic	Land (Chile + Peru)	Total
1946–47	0	228	228
1947–48	0	88	88
1948–49	0	289	289
1949–50	0	219	219
1950–51	462	274	736
1951–52	0	279	279
1952–53	0	423	423
1953–54	98	301	399
1954–55	0	434	434
1955–56	4,108	359	4,467
1956–57	5,615	203	5,818
1957–58	1,843	69	1,912
1958–59	0	74	74
1959–60	412	70	482
1960–61	373	52	425
1961–62	2,520	16	2,536
1962–63	1,373	34	1,407
1963–64	34	11	45
1964–65	66	136	202
1965–66	17	416	433
1966–67	44	430	474
1967–68	0	123	123
1968–69	130	208	338
1969–70	0	74	74
1970–71	0	88	88
1971–72	131	40	171
1972–73	36	9	45
1973–74	160	11	171
1974–75	228	0	228
1975–76	206	0	206

Table 2

Pelagic catch and effort data for fin whales in Area I for the 1955–56 to 1961–62 Antarctic seasons.

Season	Average tonnage per catcher	Corrected effort[1]	Catch	CPUE	Sei catch: Fin catch
1955–56	513	890	4,108	4.67	.004
1956–57	545	1,904	5,615	2.95	.049
1957–58	570	924	1,843	1.99	.293
1958–59	599	0	0	–	–
1959–60	633	328	412	1.26	.386
1960–61	639	322	373	1.16	.273
1961–62	657	2,248	2,520	1.12	.643

[1] Corrected effort = (CDW x Average tonnage)/1,000.

Additional estimates were made by minimizing the sum of the squared differences between the observed catches and the expected catches and by dividing the estimate of q in (1) into the observed CPUE.

EXTRAPOLATION

Initial stock size estimates for the start of the 1955–56 season were extrapolated forward to the start of the 1976–77 season using equation (2) with various assumptions about the nature of the recruitment. In each case gross recruitment was made proportional to the stock size five years earlier:

$$R_{t+1} = rP_{t-5}$$

Case 1

r = M = 0.04 for all years.

Case 2

r = M = 0.04 for the first six seasons and r = 0.08 for the remaining seasons.

Case 3

r = M = 0.04 for the first six seasons and increasing linearly to 0.08 thereafter. The times to reach the maximum of 0.08 were 3, 5, 7, 9, 11 to 13 years. Once r reached the maximum value it was kept at that value for the remaining seasons.

RESULTS AND DISCUSSION

Estimates of the 1955–56 initial stock size are given in Table 3. The estimates based on CPUE data were made using the modified DeLury model while those using catch were based on minimizing the sum of the squared differences between observed and expected catches.

The two estimates of 14,900 and 15,000 (using CPUE and catch data respectively) were rejected as too low since they resulted in negative extrapolated population sizes with the exception of recruitment Case 2. In extrapolating, Case 1 clearly underestimates the population size since the rate of recruitment is not allowed to vary in a compensatory manner as the stock size decreases. Likewise Case 2 is clearly an overestimate since the stock responds immediately to a population decline after six years by a jump in the rate of recruitment to 0.08. Between these two situations lie the more realistic assumption of Case 3 where the rate of recruitment responds gradually to the changing stock size.

The estimate of 15,600 was also deemed low since extrapolations for Case 1 were negative for the 1974–75 season. Extrapolations using Case 2 resulted in a 1976–77 estimate of 1,666 and Case 3 estimates varied from 926 (r = 0.04 to 0.08 in three years) to 229 (r = 0.04 to 0.08 in 13 years).

The best estimate was judged to be 16,700 obtained using the modified DeLury model. Though only 3 data points were used in the regression, it was significant at the 5% level and effort during this period was largely directed toward fin whales. A further estimate of 16,800 was made by dividing the observed CPUE by the estimated catchability coefficient and accounting for the catch during the season. These estimates are in agreement with Chapman's (1970) estimate of 16,730 for the start of the 1955–56 season.

Table 3

Estimates of the population of fin whales in Area I at the start of the 1955–56 season.

Seasons used	Variable minimized	q (x 10^{-5})	Pop. size (1,000s)
1955–56 & 1957–58	CPUE	32*	16.7
1955–56 & 1961–62	CPUE	37	14.9
1955–56 & 1957–58	Catch	37	15.6
1955–56 & 1961–62	Catch	40	15.0

* Indicates significance at P = .05 level (for CPUE data only).

Table 4

Area I fin whale extrapolation–constant recruitment rate = 0.04.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	292
1963–64	2,823	45	2,667	234
1964–65	2,901	202	2,591	249
1965–66	2,840	433	2,310	248
1966–67	2,558	474	2,001	249
1967–68	2,249	123	2,041	162
1968–69	2,203	338	1,791	113
1969–70	1,903	74	1,756	116
1970–71	1,872	88	1,713	114
1971–72	1,826	171	1,589	102
1972–73	1,692	45	1,581	90
1973–74	1,671	171	1,440	88
1974–75	1,528	228	1,248	76
1975–76	1,324	206	1,073	75
1976–77	1,148			

For the purpose of extrapolation, a starting value of 17,000 was used in the tables. Table 4 gives the extrapolation for Case 1 and Table 5 for Case 2 (1,148 and 3,873 respectively, for the start of the 1976–77 Antarctic season). Due to the nature of recruitment for these two cases these estimates can be viewed as lower and upper bounds for the 1976–77 initial stock size given that the equilibrium stock size was 17,000. Chapman (1974b) gives an estimate of 6,300 for the start of the 1961–62 season which compares quite well with the extrapolated value of 6,218 given in Tables 4–11. His estimate of 4,300 for the start of the 1970–71 season is higher than any of those given in Tables 4–11 and could be due to using only pelagic catches in the extrapolation.

The recruitment function of Case 3 gives extrapolated values of the 1976–77 initial stock size of 3,010 for a 3-year period of increase to 2,042 for a 13-year period of increase. Thus the final extrapolated value is not very sensitive to the length of the period of increasing recruitment. Due to the large catches made during the

Table 5

Area I fin whale extrapolation – recruitment rate constant at 0.04 for first 6 years and 0.08 thereafter.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	1,017
1962–63	4,552	1,407	3,019	584
1963–64	3,603	45	3,415	468
1964–65	3,883	202	3,534	498
1965–66	4,032	433	3,455	495
1966–67	3,951	474	3,338	497
1967–68	3,835	123	3,564	364
1968–69	3,928	338	3,446	288
1969–70	3,734	74	3,514	311
1970–71	3,825	88	3,587	323
1971–72	3,910	171	3,589	316
1972–73	3,905	45	3,706	307
1973–74	4,013	171	3,688	314
1974–75	4,002	228	3,623	299
1975–76	3,922	206	3,567	306
1976–77	3,873			

Table 6

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 3 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	389
1963–64	2,920	45	2,760	390
1964–65	3,150	202	2,830	498
1965–66	3,328	433	2,779	495
1966–67	3,275	474	2,689	497
1967–68	3,186	123	2,941	323
1968–69	3,264	338	2,809	234
1969–70	3,043	74	2,850	252
1970–71	3,102	88	2,893	266
1971–72	3,160	171	2,869	262
1972–73	3,131	45	2,963	255
1973–74	3,217	171	2,925	261
1974–75	3,186	228	2,839	243
1975–76	3,083	206	2,762	248
1976–77	3,010			

Table 7

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 5 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	350
1963–64	2,881	45	2,723	328
1964–65	3,050	202	2,734	398
1965–66	3,133	433	2,592	446
1966–67	3,038	474	2,461	497
1967–68	2,959	123	2,722	323
1968–69	3,046	338	2,599	230
1969–70	2,830	74	2,646	244
1970–71	2,890	88	2,689	251
1971–72	2,940	171	2,658	243
1972–73	2,901	45	2,742	237
1973–74	2,979	171	2,695	244
1974–75	2,939	228	2,603	226
1975–76	2,829	206	2,518	231
1976–77	2,749			

Table 8

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 7 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	334
1963–64	2,864	45	2,707	301
1964–65	3,007	202	2,693	356
1965–66	3,049	433	2,511	389
1966–67	2,901	474	2,330	426
1967–68	2,756	123	2,528	300
1968–69	2,828	338	2,390	229
1969–70	2,620	74	2,444	241
1970–71	2,684	88	2,492	244
1971–72	2,736	171	2,463	232
1972–73	2,695	45	2,544	220
1973–74	2,764	171	2,490	226
1974–75	2,716	228	2,388	210
1975–76	2,598	206	2,296	215
1976–77	2,511			

Table 9

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 9 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	324
1963–64	2,855	45	2,698	286
1964–65	2,984	202	2,670	332
1965–66	3,002	433	2,467	358
1966–67	2,825	474	2,256	387
1967–68	2,643	123	2,420	270
1968–69	2,689	338	2,257	203
1969–70	2,460	74	2,291	225
1970–71	2,516	88	2,331	240
1971–72	2,571	171	2,304	226
1972–73	2,530	45	2,386	211
1973–74	2,597	171	2,329	215
1974–75	2,544	228	2,224	197
1975–76	2,420	206	2,126	201
1976–77	2,327			

Table 10

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 11 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	318
1963–64	2,849	45	2,692	277
1964–65	2,969	202	2,656	317
1965–66	2,973	433	2,438	338
1966–67	2,776	474	2,210	362
1967–68	2,572	123	2,351	250
1968–69	2,601	338	2,172	186
1969–70	2,359	74	2,193	205
1970–71	2,398	88	2,218	216
1971–72	2,434	171	2,173	212
1972–73	2,385	45	2,246	206
1973–74	2,452	171	2,190	208
1974–75	2,398	228	2,083	189
1975–76	2,272	206	1,983	192
1976–77	2,175			

1955–56 and 1957–58 seasons (over 12,000) the time at which maximum recruitment is reached might be considerably less than 13 years, possibly as little as 3 to 5 years.

Table 11

Area I fin whale extrapolation – recruitment rate increased linearly from 0.04 to 0.08 in 13 years.

Season	Initial pop. size	Total catch	Pop. size at end of year	Recruitment
1955–56	17,000	4,467	12,032	680
1956–57	12,712	5,818	6,618	680
1957–58	7,298	1,912	5,170	680
1958–59	5,850	74	5,545	680
1959–60	6,225	482	5,514	680
1960–61	6,194	425	5,538	680
1961–62	6,218	2,536	3,535	508
1962–63	4,043	1,407	2,531	314
1963–64	2,845	45	2,688	270
1964–65	2,958	202	2,646	306
1965–66	2,952	433	2,419	324
1966–67	2,743	474	2,178	344
1967–68	2,522	123	2,303	236
1968–69	2,540	338	2,114	175
1969–70	2,289	74	2,126	191
1970–71	2,317	88	2,140	200
1971–72	2,340	171	2,082	194
1972–73	2,276	45	2,142	186
1973–74	2,328	171	2,071	195
1974–75	2,266	228	1,957	183
1975–76	2,140	206	1,856	185
1976–77	2,042			

Despite the fact that the models used fail to take into account such things as a higher natural mortality rate for immature whales than for mature whales, several conclusions can be drawn. Over 12,000 fin whales were taken in Area I during the first three seasons after the sanctuary was opened, and this alone would tend to make the possibility of an equilibrium stock size of less than 16,000 doubtful. Also, for every recruitment model examined, the present (1976–77) stock level is much less than half the equilibrium level (pre-1955–56) and suggests that the fin whale stock in Area I should be classified as a 'protected stock'.

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SC/28/Doc. 7

Comparison of Linear and Step Partial Catch Procedures for Stock 'Near' but Below the MSY Level

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At its meetings in 1974–75 at La Jolla and London the Scientific Committee of the International Whaling Commission introduced several ideas which I will here refer to as 'safety factors' into its considerations of recommendations into stock classifications or catch limits. These include the proposal to limit the recommended catch limit for a stock at the maximum sustainable yield level (SY stocks) as well as for initial stocks to 90% of the estimated maximum sustainable yield. Also included is the proposal for a sliding scale for the catch limit for stocks estimated to be in the range between the level giving maximum sustainable yield and a level 100 (1 – Z)% below that. The value that should be assigned to Z in this safety factor was the subject of much debate, and in addition some alternative variations were proposed for the sliding scale. We note here the two primary proposals after introducing some notations. Let the population level expected to provide sustainable yield be denoted N_m and let the maximum sustainable yield be Y_m. Then the proposals are defined as follows:

Linear: recommended catch limit from estimated population level $(1 - x)N_m$ to be

$$(0.9)Y_m \frac{Z-x}{Z} \quad (0 \leqslant x \leqslant Z)$$

Step: recommended catch limit for estimated population initially at level $(1-x)N_m$ to be $(0.9)\ Y_m$ $(1 - \frac{x}{2z})$ $(0 \leqslant x \leqslant z)$ *until the population reaches level* N_m.

The aim of the safety factors is at least twofold:

1. All catch limit and classification recommendations are based on estimates which are subject to error. The safety factor is thus designed to reduce the effects of these errors of estimate.
2. Recommendations are expected to change in the future as estimates are refined and as populations change in response to changes in the level of exploitation. The safety factor may be designed to reduce the abruptness of such future transitions.

Any evaluation of these or other proposed rules must be made from these two points of view. The first consideration relates to concerns for conservation to avoid overexploitation of the stock and thus reduction in the total yield available to mankind.

The second consideration relates to the orderly functioning of the whaling industry since abrupt changes cause problems for the operations – particularly abrupt decreases. In this respect rule 2 seems to offer more chance for an abrupt change than rule 1 since at the values of $N = (1 - Z)N_m$ and $N = N_m$, rule 2 has discontinuities. As the estimated population changes from slightly below $(1 - Z)N_m$ to slightly above, the catch limit recommendation changes from 0 to $0.45Y_m$. However this assumes that the changes in the estimated population size are small. If these changes are large, the step rule can lead to smaller changes than the linear rule. For example, suppose the population estimate is changed by 10% from just above the level giving MSY to just above the upper limit defining a protection stock. In this case the linear rule would lead to a decrease in the catch limit of almost 100%, while the step rule would cause a decrease only half as great. Obviously then there is no clearcut comparison between the two rules on the basis of the second consideration.

Turning back to the first consideration, the problem has similarities to the determination of Z, the 'safety factor' which defines the range below N_m where partial catches are recommended. As noted in the discussion on Z given in a paper at the 1976 La Jolla (Chapman 1976) meeting and at the Scientific Committee meeting in London in 1975 (IWC 1976), there are two opposing types of considerations:

1. loss through underutilization of available resources,
2. loss through excessive harvesting that reduces the population below optimum levels.

Evaluation of these two types of loss are complicated by the consideration of the discount rate, of prior probabilities and the uncertainties associated with the evaluation of the

Table 1

Growth of population from $(1 - Z)N_m$ to N_m for $Z = 0.10$, $N_m = 100.000$, $r - M = 0.04$.

Catches taken according to step rule

Population size	Population growth increment	Catch	Net increment
90,000	3,600	1,800	1,800
91,800	3,672	1,800	1,872
93,672	3,747	1,800	1,947
95,619	3,825	1,800	2,025
97,644	3,906	1,800	2,106
99,750	3,990	1,800	2,190
101,940			

By linear interpolation N_m (100,000) is reached in 5.11 years.

Catches taken according to linear rule

Population size	Population growth increment	Catch	Net increment
90,000	3,600	0	3,600
93,600	3,744	1,296	2,448
96,048	3,842	2,177	1,665
97,713	3,908	2,777	1,131
98,804	3,954	3,184	770
100,138	3,985	3,461	524

Time to reach N_m (100,000) is 5.74 years.

status of the population and of the estimated yield both now and in the future. We consider these factors later, but discuss first an analysis similar to that given in SC/27/30. In that paper a formula was given for the loss in taking a catch from a stock below the level giving maximum sustainable yield (which we denote N_m). That formula was a first order approximation based on the assumption that yield for the values of population size of interest is given by $(r - M)N$. Actually, if the population responds to the changed densities resulting from exploitation, then this could underestimate the recruitment which should be a non-linear function of population size. For the logistic model the yield is proportional to the product $N(M - N)$ where M is the unexploited population level. In the neighborhood of the maximum sustainable yield level ($N_m = M/2$) the yield changes very slightly as N changes. For example, as N changes from M/2 by 10%, the yield is decreased only 1%. This of course assumes that the population responds immediately to density changes, which is unlikely for a mammalian population.

In the absence of a theory that is sufficiently sensitive to detect differences between the linear and the step system of adjustment in the range of $(1 - Z)N_m$ to N_m, we show two numerical evaluations. These show the catches and losses for two models of population growth – logistic and constant $(r - M) = 0.04$ (Table 1).

Similar calculations can be made for other values of $r - M$ and also for other growth models, in particular for the logistic with maximum growth at $N_m = 100{,}000$. We can then compare the difference between a rule permitting partial catches versus a rule permitting no catches until N_m is reached. However we note that we need to consider two situations: catches at 100% of Y_m at N_m and catches at 90% of Y_m at N_m according to the present management procedure. The results are shown in Table 2.

Table 2

Losses according to different models and different catch rules with $N_m = 100{,}000$.
Initial N = 90,000.

Catch rule

Model	100% Linear	100% Step	90% Linear	90% Step	Length of time to reach N_m Linear	Length of time to reach N_m Step
Constant r – M = 0.04	305	522	−919	−450	5.74	5.11
Constant r – M = 0.02	204	503	−1,166	−459	12.62	10.13
Logistic	17	36	−1,063	−792	5.20	4.58

Losses are calculated according to the formula:

[(Difference in time to reach N_m between partial catch and no catch) x catch expected at N_m] – catch taken during period to reach N_m.

It should be noted that the loss is negative, i.e. there is a gain from the partial catches when only 90% of Y_m is taken after N_m is reached. The 'safety factor' involved in the 90% rule provides a buffer against overestimation of the maximum sustainable yield, but such a safety factor also has a cost. This is emphasized in Table 2.

From the point of view of comparison of the two proposed partial catch rules – linear and step – it is seen that the losses are less with the linear rule. However the differences are small – from 1 to 10% of the total series of catches involved. This is much less than losses due to errors of estimates, etc.

We now turn to other considerations in the 'safety factors'. Much of the criticism of the Commission has been concerned with the uncertainty of the estimates of population and of sustainable yield. It is pointed out that the estimates of sustainable yield, and particularly of maximum sustainable yield, depend on models which are very difficult to verify. It is possible that the response of whale populations to exploitation will have a long lag. This might be suggested by the right whale stocks which have not yet rebuilt after severe exploitation. On the other hand, the California gray whale suggests the opposite situation with relatively rapid population growth after being heavily exploited. Because of uncertainty and/or excessive catch limits, the stocks of blue, humpback and fin whales have been exploited well beyond their MSY level. Since in all these cases loss has resulted from overexploitation in the sense of reducing the yield available to mankind and even in some cases threatening the stocks with possible extinction, it is more reasonable to place heavier weight, i.e. larger prior probabilities on this risk and consequent loss rather than the losses through underexploitation.

With this in mind the step rule seems to have disadvantages as compared with the linear rule. At values of the population near $(1 - Z)N_m$, the catch limit prescribed by the step rule is $0.45Y_m$, which is much larger than that permitted by the linear rule. If the estimate of Y_m is grossly in error or if the lags in the system are such that the population yield is much below Y_m, then the larger catch will have a more serious impact. Clearly any safety rule should permit smaller catches as the population is apparently further below N_m so as to reduce the probability of still further reduction. Thus, in the absence of assurances as to the model and its validity, the linear rule appears to offer greater safety at any moment in time.

One essential difference between the two alternatives that are compared above is that under the linear formula the catch limit will change each time the estimated population changes. The step formula is supposed to give a fixed catch limit for a period of years until the stock rebuilds to the level N_m. It is not clear what should happen under this formula if the population level is re-estimated and the previous catch limit is found to be inappropriate.

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SC/28/Doc 8

A Note on Quota Determination for Sustained Management Stock below MSY Level

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This topic is, still now, somewhat puzzling to me. I made a reservation against the majority view in La Jolla in 1974 with which the IWC Technical Committee later agreed, and submitted a document on a scientific basis for its solution to the effect that the Z-value shall depend not only upon the management scheme for SM stock below MSY level, but also upon the population characteristics and the amount of information available for the stock concerned (Fukuda 1976). Reviewing the proceedings on this topic, however, I have now realized that the Commission has made an independent decision on a different basis from what the Scientific Committee had, I believed, sought for since the La Jolla 1974 meeting. The United Kingdom proposal seems to have made it clearer what the Commission's decision was, with which I think it appropriate now to start. So far as I understand, the Commission had decided the Z-value of 10%, quite independently of the management scheme for SM stock below MSY level, as a reasonable allowance for MSY level in the light of uncertainty involved in estimation. Upon this understanding, theoretically speaking, a variety of relevant schemes could be proposed in addition to those two so far presented.

The scheme of linear increase, originating from the La Jolla 1974 meeting, as we all know, was very much concerned with as smooth as possible a transition of the stock from one category to another. Unfortunately or not, during the last annual meeting, on the first application of the new principles and procedures, it became clear that this scheme would bring about an unexpectedly drastic reduction of quotas in the case of the southern sei whales, although probably such drastic changes in quota would not take place again, at least in principle, once we adapted ourselves to the new management scheme. It is evident on the other hand that the UK scheme has an advantage under such circumstances as transition from the old to the new management scheme, because it was accepted as a remedy against drastic reduction of quotas anticipated from the scheme of linear increase.

The UK scheme, I think, presents two interesting ideas and has additional advantages over the scheme of linear increase. The one is, to define a transitional period, with the same annual quota throughout, when a stock for the first time falls anywhere in 'Sustained Management Stock' below MSY level. The proposal does not generally indicate how to define this transitional period, but in case of the sei whale it is assumed to be five years, roughly twice as long as the recovery time of the stock 10% below to the MSY level under no whaling. These past few years the Commission has successively applied new management procedures such as quota by species, by area, and by sex, leaving little time for adaptation by the whaling industry. No one can deny that this has been considerably damaging to the industry. Therefore, the industry would very much appreciate a transitional period, say of five years, with constant annual quota. The scheme plans all the species stocks so classified to recover to the MSY level in the same number of years. I feel it an advantage that stock assessment with more data and sufficient time of analysis is expected to be thoroughly and satisfactorily reviewed in five years.

The other point is the underlying thought that the total catch during the period should be unaffected. This is in a sense synonymous to, or derived from, the previous idea. It allows a variety of quota sequences so far as this condition can be satisfied by the sum of the annual catches for the period. This is, I think, an appreciable advantage over the former scheme, under which the population level is, it is implicitly assumed, annually reviewed and the length of the transitional period, although estimated, is left open. 'Quota by area', introduced a few years ago, has brought about much difficulty in negotiation of quota allocation among the countries concerned, coupled with reasonable programming of the whaling operation, for instance, in the vast Antarctic. Probably most of it would be resolved by setting more or less flexible allowances to the quotas by area on this principle. It goes without saying that this principle underlying the UK proposal could be readily applied as well to other stocks above the MSY level inclusive of 'Initial Management Stock'.

From a viewpoint of safety, the scheme of linear increase might be slightly favored. At this opportunity, however, I dare say that safety considerations have already been paid, rather ridiculously, at every corner in stock assessment and in formulation of the management scheme, and that it is time to drive out of the Scientific Committee mere safety concern without any substantial contribution.

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SC/28/Doc 9

A Note on Management of Sperm Whaling: Operational Constraint and Target Formulation

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At the sperm whale meeting in La Jolla (IWC 1977) we learned very much about the behavior of the population model for sperm whales, accepted as useful for the last few years. And it was also discussed from the biological point of view how such a polygamous animal population as the sperm whale could be affected by commercial whaling in the breeding season. Reviewing the proceedings and discussions in La Jolla, I have realized that one important consideration was omitted during the meeting. Indeed, there was no evaluation of available means, such as catch limits, closure of seasons and/or grounds, or size limits, to coordinate them to an effective management scheme. In this connection it seems an operational constraint, that is, how selectively each sex can be taken, was completely outside of consideration in La Jolla. Theoretically, the questions below should be taken up in the Technical Committee, but I presume to raise them here at the Scientific Committee under such circumstances that they are not only deeply coupled with scientific aspects of management but the Commission itself has been more inclined to stick to the recommendations from the Scientific Committee.

1. INHERENT LIMITATIONS OF THE PRESENT POPULATION MODEL

Strictly speaking, T. Smith's model, with age structures taken into account, might be better than the one the Scientific Committee has adopted these few years, but in the light of biological information available, the latter, I believe, is practically useful to derive scientific advice for management of sperm whaling, even if some ambiguity may be inevitably involved. Either model, however, has two kinds of inherent limitations, significant in practical application, although I feel it difficult to resolve them theoretically without any detailed information of sperm whale ecology.

The one is, these models have not taken into account the sex ratio in the breeding population (socially mature male and mature female) as a factor possibly affecting the pregnancy rate and/or mortality rate. I realize that it is difficult to incorporate this factor into the model at the present stage of knowledge, but I would like to note here that it is rather more significant in the course of managing to bring the sperm whale population from the present state to some target level than in target formulation, where it does not matter once some favorable sex ratio or ratios can be defined.

The other limitation is, these models have implicitly assumed that each sex of sperm whale can be taken selectively at will, but past experience indicates that it is impossible to take each sex selectively over certain size ranges and that the sex ratio in the catch depends essentially on ecological segregation, coupled with size selection.

Let us consider a numerical example for better understanding. This is one of the SPVAP outputs in the La Jolla Report (IWC 1977, Table 11). With some of the parameters given as follows,

Age at recruitment: 20 years for male, 13 years for female
Age at social maturity of male: 25 years
Age at maturity of female: 10 to 8 years against decreasing female mature population
Harem size: 10 without any reserve
Natural mortality rate for older than 2: 0.050
Pregnancy rate increasing 0.190 to 0.270 against decreasing female mature population
(See Table II for other parameters),

the Table indicates that the maximum combined yield in weight is generated at 95% of the initial mature female population. Assuming it to be 10,000, the catch by sex to sustain the population at this level is calculated as 193 for male $\geqslant 20$ years and 12 for female $\geqslant 13$ years. It is to be noted here that, remarkably contrasted with the sex composition in the allowable catch, the exploitable population is defined as 1,892 for males and 6,000 for females.

Generally, mature females are not always segregated from immature males and therefore an amount of female catch to sustain the female population at a particular level will necessarily result in an incidental catch of immature males before recruitment as defined, the amount of which depends on the sex composition on the ground under consideration. A necessary modification of the framework to cover these incidental catches, that is, a reduction of age at recruitment for males can be readily done but more important is that the generally much smaller amount of allowable female catch will evidently limit the whaling operation there on the ground under consideration. In the Southern Hemisphere, it seems to be well confirmed, mature females do not migrate farther south than 40°S, while the corresponding situation does not hold in the North Pacific. If no grounds could be found for a certain stock where males are clearly segregated from females, there seem to be no alternatives other than to seek for a different sustained level as a target. A size limit will allow the male catch alone, it is true, but it is evident that a different sustained level will be realized by giving up the female allowable catch.

It was discussed mainly from biological points of view how the breeding population, or more exactly breeding animals, might be affected by commercial whaling around the breeding season. In this connection, however, it must be taken into account that the allowable female catch is in this case a negligible fraction of the mature female population (12/9500) and that no more than a few of 950 harems might be disturbed. Harem bulls can be taken at will by size selection, but note that their occurrence on the ground under consideration is much less than one-tenth, as derived from harem size. It is difficult to reasonably assume that more than ten times the effort would be steadily expended to hunt for harem bulls, about three times as large as mature females in weight.

In summary, each sex of sperm whale cannot always be taken selectively at will. Feasible sex composition in the catch will vary from ground to ground and will be further affected by size limits. In other words, in analysis of the population model, such parameters as ages at recruitment for males and females should not be arbitrarily given and some additional constraints must be imposed between the catches of both sexes at the present stage of whaling technology. Deliberate programming could probably make it feasible to take both sexes in whatever composition, but only implicitly at additional costs to move around from one ground to another.

2. MANAGEMENT TARGET

Since last year, the Scientific Committee has been rapidly inclining to favor as a management target such a level as giving the maximum combined yield in weight. And at the sperm whale meeting in La Jolla, 'the view was taken that since the industry is concerned with yield of products, a weight basis for assessment is more appropriate'. Since then, however, I have begun to have some doubts on this. Evidently the industry is as well, or even more, concerned with cost of production. One of the SPVAP outputs, referred to above, indicates that there exist considerable differences in cost of production between sexes. At the level giving the maximum combined yield, the male yield in weight is still about 60% more expensive than the corresponding female yield. In addition, as some technical considerations in the above have indicated, there are more or less substantial costs involved in reasonable sperm whaling, although, unfortunately, they are concealed under the present population models and it is difficult to figure out under the present state of knowledge available. Appreciable differences in cost between sexes might be improved by lowering the age at recruitment for males, which may as well be useful to relieve technical constraints, but it is to be further studied.

More important in this connection is that the maximum combined yield in weight seems to be what the industry might seek for only under sole ownership of the resources (although the industry can make whatever options under such circumstances). Otherwise the concept seems to be to the industry concerned no more than a point of theoretical interest. Indeed, the industry is always trying to maximize yield of products, but as a matter of course only within the given framework – economical, technical and jurisdictional. What the industry is really seeking for differs by industry (e.g. between land-based and pelagic whaling) and by country under different economic circumstances. In other words, once a cost-benefit consideration be introduced, it is extremely difficult to reach any uniquely determined target. I presume that those cost-benefit issues should be essentially left to the options of those concerned, so far as an aggregate of their options would not endanger the stock under consideration.

3. MANAGEMENT TARGET VERSUS CRITERIA FOR CLASSIFICATION

Generally speaking, recent discussions among the scientists, I feel, have so often drifted out into one or another different domains of study. Management of sperm whaling seems to have been exactly one of such cases. We all know that the Commission has long established its management practice with the maximum sustained yield in number as a target. When putting into force the so called Australian Resolution in 1974, what the Commission referred to the Scientific Committee, I remember, was not any new definition of its management target, but some scientific criteria for classification of the stock. And I believe the Scientific Committee has adopted the level of the maximum sustained yield in number as the criterion or part of the criterion for classification. We failed to define the level of endangering the stock, but I understand that the level of the maximum sustained yield in number is reasonably based on population dynamics as a criterion for classification, because below that level, theoretically speaking, any equilibrium is no more stable.

During the last meeting, the Scientific Committee adopted the maximum combined yield level as the criterion for classification of the sperm whale stocks. I feel now, however, something was mixed up at that time. Conditionally as it is, the female stock can be categorized in the same way as the baleen stocks, but it does not seem to be exactly the case with the male stock. The present population model determines the male population level through a favorable balance in the breeding population. It is reasonable to set some allowances on both side of the male population level so determined. However, for instance, I feel it doubtful to classify the male stock exceeding the allowance into 'Initial Management Stock'. Such a male stock is completely different in its implication from the baleen stocks so classified. With such dependency of the favorable male population level in mind, I presume that the level of the maximum female yield in number can be reasonably taken as a criterion for classification of the sperm whale combined stock. In other words, the male quota is specified by way of a rider without categorizing the male stock.

No one can doubt that hasty application of new principles has been seriously damaging to the commercial whaling. The Scientific Committee shall be more prudent in drafting its recommendations.

REFERENCE

International Whaling Commission. 1977. Report of the Sperm Whale Meeting. La Jolla, California, 16–25 March 1976. SC/28/Rep. 1 (published in this volume).

Whale Management Policy

S. J. Holt

FAO/ACMRR/UNEP Marine Mammal Project

The *Ad Hoc* Group on Large Cetaceans of the ACMRR Working Party on Marine Mammals met in La Jolla, California in March 1976, immediately after the special meeting of the IWC Scientific Committee on Sperm Whales. Most of the participants had also attended the latter meeting. The Group discussed some of the implications of following the Commission's new management policy in cases where there is considerable uncertainty as to the identity and status of stocks. Extracts from the reports of the Group on this matter are appended; see particularly Supplement 1, paragraph 3, and General Conclusions, paragraph 2. The Group recommended that the reports' several suggestions for improvement of management in certain respects be transmitted to the IWC as well as to the Scientific Consultation, *Mammals in the Seas*, being convened by FAO in Bergen, Norway, and that I should submit a more extended explanation to both meetings. Such an explanation follows.

The new management policy provides that whale stocks be identified and then categorized according to whether they are below, at or near, or above levels from which maximum sustainable yields can be taken. That having been done, rather simple rules determine the annual quotas. The Commission itself, if only by including the term 'near' in the 1974 decision which established the policy, recognized the existence of some uncertainty in the above determinations, and the Scientific Committee went further in elaborating rules to regulate the 'bluntness' of the knife-edge between a Sustained Management Stock and a Protection Stock, as well as adding a safety factor whereby in certain circumstances only 90% of the estimated sustainable yield would be allowed to be taken. These rules, which were accepted in 1975 by the Commission, are intended to take some account of uncertainty, to allow for asymmetry in the consequences of erring on one side or the other, and to ensure an element of caution in management. They seem likely to serve those purposes when knowledge of stock dynamics is sufficient to determine fairly well the size (and composition) of a stock in relation to a curve (or surface) of equilibrium yield as a function of stock size (and composition) as calculated from a realistic model. If however there is a high degree of uncertainty of the model, of the state of the stock, or of both, rigid application of the policy and rules might not serve the intended purpose.

Before elaborating the reasoning behind this statement, mention should be made of the problem of stock identification. In many cases virtually nothing is known directly about stock identity within a species; inference is made from other species inhabiting the same general region, and knowledge even about those species is far from adequate. Marking experiments show a fairly clear separation of stocks of some baleen whales in the Southern Hemisphere; they also show that the separation is not complete. It seems that Northern and Southern Hemisphere stocks do not mix, nor do North Pacific and North Atlantic stocks.

Even when stock separation is fairly clear, practically never has it been possible to estimate the vital parameters of each stock of a species separately; most if not all of the parameters are assumed to have the same value in all stocks, or in a group of stocks, the only variable being the number of animals in the stock. (In memoranda to the Chairman of the Scientific Committee in 1974–75, I drew attention to some of the consequences of such a procedure.) Practical application of the management policy is really, then, to *presumed stocks* on the basis, at best, of knowledge about the population biology of *the species.*

The situation with respect to sperm whales is especially serious. In terms of weight and value of catches, number of countries involved in exploitation, breadth of geographical distribution and, presumably, the size of present stocks, the sperm whale is by far the most important species of whale. Furthermore, it has been exploited 'pelagically' over a period of time much longer than has any other species. Yet, for a number of reasons, present assessments are extremely uncertain. The effects of whaling in the 19th century and in the first half of the 20th century have not been estimated in terms of numbers, sex ratio, size and age composition, range of distribution, or social structure; the catch per unit effort is a poor index of abundance; the social structure is such that the simpler population models are not at all applicable. Apart from uncertainty as to the present stock sizes and their rates of natural mortality and reproduction, the relation between stock size and age composition in the 'base year' used by the Scientific Committee – 1946 – and the 'initial' sizes and compositions has not been evaluated. The high ages of maturity and recruitment imply long time-lags in the system which complicate both assessment and management of the whaling operations. Recovery periods, if whaling is unwittingly permitted to be too intensive for even a few years, might be very long, especially the recovery not only of numbers but of biomass and group structure. Further, when considering a period of exploitation of nearly two centuries, we cannot rule out the possibility of significant trends in environmental conditions, affecting sperm whales in such a way that, even if there had been no whaling, the stocks would neither be constant in numbers nor have steady-state age and size compositions. Lastly, apart from the fact that they consume a lot of deep water squid, practically nothing is known or can even be reasonably surmised about the dynamics of the ecosystems in which the sperm whale has a significant rôle. So, for this species, it seems particularly important to examine carefully the possible consequences of a more or less automatic application of the new policy and rules using central, or so-called 'best', estimates of stock state. It is necessary here to examine the concept of 'best estimate' and the implications of using it to establish quotas.

If there is only one estimate available, and the procedure of determining it is not such that a statistically valid measure of error can be attached to it (which is practically always the case), then it is not appropriate to call it the 'best' one, certainly not in any scientific sense. Any statement concerning the likelihood of it being within a certain distance of the 'true' value must be purely subjective. If several estimates are available they are normally obtained by a variety of methods and combinations of methods. There is no scientific way of combining these to give a 'best' estimate, although we may assume that the group of estimates is a sample from a probability distribution and treat them accordingly to obtain, as *central value*, a median, mode, arithmetic mean or some other kind of average. We may assume further that the probability distribution is peaked, having a maximum somewhere between the observed extreme values, and try to estimate the location of this maximum to obtain a *most probable* ('best') value. But even then we have no idea of how flat-topped the distribution is, and certainly have no reason to suppose it is like a normal curve. Thus it is entirely possible that the most probable ('best') value is hardly more probable ('better') than other quite different values; indeed, it might be a defensible procedure to assume that all values within an observed range (perhaps even somewhat beyond it) are equally probable ('equally good'). I suggest that on present evidence, estimates differing from the central values (which the Scientific Committee is in process of determining) by 50% or more either way may, for practical purposes, be equally as good as each other and as the central value.

If a single general assessment is applied to give a set of central values for a group of stocks – say the several sperm whale stocks presumed in the Southern Hemisphere – which are then used to determine quotas, the quotas are more likely than not to be *all* in error in the same direction. If the error is in the conservative direction, sperm whaling might be unduly restricted (in terms of the Commission's declared management objectives) but, given the present state of knowledge and the nature of the species, this might only be noticeable after many years of monitoring, as an unexpected increase in availability. If, on the other hand, the error is in the direction of 'optimism', it would be possible, even likely, that the stocks would all be seriously over-exploited for some years before the reduced availability could be monitored, with a danger of a catastrophic decline in recruitment a decade or so later. In such cases – and especially if the complex social structures necessary for efficient reproduction had been disrupted – even a reduction in stock to below minimal survival size could be possible. In any case most, if not all, of the stocks would probably be similarly stressed, though not necessarily to the same degree.

However, suppose that, fortuitously, a set of quotas were applied such that there were no detectable changes in stocks over a long period. In that case there would be practically no gain in knowledge of the population dynamics of the stocks of the species nor, if stability were attained, would it even be known if they were at or near maximum yield levels.

This is the crux of the matter: only by changing the populations can their dynamics be determined, particularly the crucial density-dependence of natural mortality and/or reproductive rates or other natural regulatory mechanisms. Furthermore, attempts to unravel these mechanisms from the more or less haphazard historical changes during periods of intensive whaling – whether 'managed' or not – have not been particularly successful.

One approach to management in a situation of great uncertainty has been the proposal for the cessation of whaling for a period during which more research would be done and, specifically, changes in stocks would be monitored. Such an approach would theoretically give important data on the recovery rate and hence on the population dynamics of species and stocks which had been substantially reduced by whaling. It would not tell us anything about stocks which might *not* have been much affected by whaling, except perhaps the numbers of animals in them. In general, a total moratorium, whatever its pros and cons on other grounds, is not the most efficient way to better understanding of whale population dynamics, even if it were accompanied by a new research and monitoring programme of unprecedented scale and scope. In any case, such an approach has not been found to be politically acceptable at this time.

An alternative approach, and the one here recommended, is to set quotas for different stocks of the same species on the basis of a wide range of estimates of the state of the stocks. Thus, for one stock or group of stocks, an 'optimistic' estimate might be applied, creating a definite risk that it would be over-exploited, whereas another, not considered necessarily to be in a state essentially different from the former, would be regulated in accordance with the more pessimistic view; this would mean a very small quota or, in all likelihood, a zero quota. Such a regulatory regime would have to be maintained for several years in order to give a chance of detecting stock changes and making comparisons – but this is true also of the simplistic approach to stock classification. A third stock or group might be regulated according to a central value, but this would not, it seems to me, give us much more information.

This is not, of course, the first time that experimental regulation of the exploitation of a marine resource has been suggested – Burkenroad and others did so in the 1940s and after, and there have been attempts to put this idea in practice. However, this approach is normally to a single stock and does not include a 'control' situation. The problem is different with most fish, in any case, because having generally shorter life-spans their responses to changes in exploitation are more rapid. Ideally I suppose one would devise an experimental design to give comparisons both over time and as between different stocks so that the conclusions would not depend too much on an assumption either that environmental conditions did not change over time, or that all of a group of stocks could, over the experimental period, be described by the same model with the same parameter values.

Put another way, this alternative approach would mean that very different rates of exploitation were permitted on stocks which there was no reason to believe were in different categories.

In the long run, taking a calculated risk of depleting one or more stocks need not be a departure from the principle of management for sustained yields, provided that the experimental regime is applied as a whole to a group of stocks which are not *completely* separated. Such a group might be the sperm whale stocks in the Southern Hemisphere. So, if one or more of them became depleted, and eventually had to be protected, the danger of irreversible depletion would be lessened by the possibility of migration into them of individuals or groups of whales from another stock which had been subjected to a much more conservative regime. In any case, neither the species as a whole nor any group of stocks of that species would become endangered, although there is a risk that genetic diversity in the species might be somewhat reduced.

There are, of course, some practical problems. Different stocks are of interest to different countries, especially to those having land station operations, and their interests would have to be protected. The experimental regime would be applied mainly to pelagic operations, which are in any case the ones in which faulty regulation is most likely to endanger the resource. A diversified, experimental regime could in fact be a net advantage to pelagic operations, since they might be permitted a total quota not much different from the one they would secure under the present management rules, but they would be able to take the whole quota or most of it from a smaller area. The table below shows, purely for illustration purposes, how the Southern Hemisphere sperm whale quotas were in fact allocated in 1975–76 and how they might have been allocated on an experimental basis.

	As allocated		Experimental approach	
Division	Males	Females	Males	Females
3, 4	1,420	1,140	0	0
5	900	630	0	0
6	0	270	0	0
7	450	360	0	0
3–7	2,770	2,400	0	0
8	1,260	810	2,380	1,600
9, 1, 2	1,840	1,660	3,490	3,270
8–2	3,100	2,470	5,870	4,870
All	5,870	4,870	5,870	4,870

These higher quotas in Divisions 8 to 2 may be greater than would be compatible with even the most 'optimistic' estimates, in which case they would have to be lowered somewhat; whether such a reduction should be balanced by small quotas in Divisions 3 to 7 depends on the economic and enforcement considerations mentioned below, and on the location of the central estimates originally used within the range of estimates.

Of course other, perhaps better, formulae could be developed than the calculation of a total quota from central estimates and then reallocating this by Divisions. One consideration in this connection must be whether it is true, as has been said, that from the point of view of scientific knowledge even a small quota is much better than zero. It seems to me that the difficulties that have been met in interpreting data from very small samples, and small effort by few whaling units, are such that any such theoretical advantages would be outweighed by the ease of implementing – and generating confidence about the implementation of – zero quotas in some areas, as well as by the economic advantage of taking all the permitted catch in one region.

The new management policy has been referred to as a compromise between those seeking a total moratorium on commercial whaling for a certain period and those seeking the continuation of relatively unrestrained whaling: that is whaling until it can be proven that a stock has already been reduced below some 'optimal' level. However, other considerations than simply pessimism or optimism in the assessment of stocks, or even of the 'ethics' of whaling, have arisen. Thus, in some places 'whale watching' is now an activity of great economic value. This means that the economic interests of different social groups (the balance being reflected in the policies of nations) can be qualitatively different. This is not to say that all the different interests are necessarily incompatible – whale-watchers and whalers both need an abundance of whales – but they may be willing to accept different levels of risk of depletion. The 'blunt knife-edge' classification system is not really a compromise between such different interests – a stock is now only protected when it seems practically certain that it is depleted; that is, reduced to well below its MSY-level. It is significant that the whale stock for which 'whale-watching' is of the greatest economic value at present – the California gray whale – is not depleted – but is still protected only because it, with other previously protected species, was arbitrarily exempted for the time being from the new management policy. Experimental application of a diversified regime offers the possibility of compromise between different kinds of 'valuation' of whales, as well as between the optimists and the pessimists.

My last point concerns specifically the sperm whale. Its very wide distribution, and the fact that it does not yet appear to have been depleted as severely as most of the baleen whales, make it particularly suitable for application of a diversified management regime. In addition, however, it is used essentially to provide industrial products rather than human food. Vegetable substitutes for these are already available from several sources on a pilot scale. At the same time, although I am not aware of any current research on this matter, there seems to be a possibility of making sperm-whale meat more acceptable for general human consumption than its normal taste, and possibly its contaminant content, presently allow. By the time an experimental regime has shown results – a minimum of 5–10 years, I think – the technical and economic possibilities of substitution of the sperm oil and processing of the protein will have been clarified and the management regime could be reviewed in the light of this, and of the further knowledge we should have by then about the ecology and behaviour of what some people suspect is a species of exceptional intelligence.

APPENDIX

From: *Report Supplement 1*

8. Management of whale stocks

The group agreed that a thorough, wide-ranging and, hopefully, creative discussion should take place at Bergen on the scientific aspects of management problems (and, necessarily, of the relation of these to the definition of objectives and the application of procedures) as provided under Item 5 of the Provisional Agenda for the Consultation, in the proposed Working Groups 16, 17 and 18. The experience and current problems of whale management obviously provide an important – perhaps the most important – input to that discussion.

The history of whale research shows that, being constrained to learn mainly from casual observations during, and as a result of, whaling operations, many gaps are left in the knowledge required for the application of a scientifically based policy for sustained use of the resource, or even for developing an appropriate policy. Thus the application by the IWC of its new management policy requires very detailed information such as precise and calibrated effort measures which can give satisfactory abundance estimates, about species selection in whaling, etc. It is, therefore, quite essential that the industry be required to provide such information as the scientific advisers may specify – promptly, fully and accurately. However, while such information and improved research along traditional lines – including the intensive development and use of methods of census and population study which do not depend on whaling – are necessary components of the total management activity, they will still not be sufficient to provide the reliable assessments that are required satisfactorily to implement even present policies. Such knowledge as we have of density-dependent changes in vital rates – and that, it must be admitted, is very little – comes almost entirely from observations of stocks which have been changed drastically by whaling, yet it is such changes that determine the existence, and levels, of sustainable yields. This leads to a dilemma when an attempt is made to stabilize exploitation stocks at 'optimal' levels.

IWC scientists, and others, fully recognize the inadequacy of present assessments, but naturally feel bound to work for consensus on estimates in a central range, to hedge these with conservative margins of 'safety', and to propose management decisions on the basis of them. Such a procedure may be acceptable if 'central' estimates are judged to be not only the 'best' but significantly better than other estimates within the possible range. This may be so in some cases but is evidently not so in others, where there may be a wide range of equally unreliable estimates, or only a few or even a single – and not very good – one. In these situations scientists can explore the sensitivity of assessment models, but each management decision, by present practice, must finally be based on a single value. Not only is this value then applied to one stock, but it is usually being applied, in effect, to a number of stocks of the same species, since separate sets of parameter values for the various stocks are practically never available. This means that the management decision is as likely as not to lead either to unintentional under-exploitation or to overexploitation of all or several stocks. If a 'best' estimate turns out to be, even by chance, close to a 'correct' one, application of it will presumably lead to stabilization of the stock, but by the very nature of this process, knowledge of the dynamics will hardly be improved. In particular, success in holding a stock at a particular sustainable level tells us little or nothing about other, possibly more productive, sustainable levels.

The group suggests that some alternative procedures should be considered. For example, one set of assessment results might be applied to one stock, and another set to another stock, and the consequences observed. Management in such a way would be an approach to a controlled experiment, and intelligently done could lead to a quantum jump in knowledge of stock responses. A whole range of alternatives are possible – one stock could be protected and another, not judged to be in a very different state, could be exploited, possibly quite intensively. The set of decisions might be chosen, for example, in such a way that the total quota was not much different from that which would be determined from a single 'best' estimate. This approach might also have other advantages. It would be far less likely that all stocks of a species in an ocean region would be unintentionally overexploited. The permitted catches would be taken in a more limited area and therefore, possibly at less cost. Even different objectives of management upheld by different groups of people might be accommodated and conflict between them correspondingly reduced. On the other hand, the strategy adopted must give due weight to the fact that a whale stock can be reduced very much faster than it can grow. These are however, to us, secondary questions; the main aim is to manage so that knowledge is sure to be improved at the same time as the resource is used. Other possible patterns of management than that suggested above should be looked into, such as exploiting a series of stocks in turn. This, and others, would require a decision-making process longer in term than the present one, and the implications of this also need consideration.

The group agreed that these suggestions should be put to the forthcoming meeting of the IWC as well as to the Bergen Consultation, and that to this end the present report should be transmitted, followed by a more extended explanation which S. Holt was invited to write.

From: *General Conclusions*

3. Management

Whaling has been carried on throughout recorded history. As technology developed, the intensity and range of catching operations increased, so that whaling has extended from the slow swimming species near shore to the fast rorquals in distant polar seas. Various major episodes can be identified, such as the Greenland or northern fishery for right whales, the southern fishery for sperm whales, and the Antarctic pelagic fishery of modern times. Each of these fisheries has shown similar patterns of development, expansion, and eventual collapse, in nearly all cases as a result of overexploitation. In the case of the rorquals this sequence has been associated with successive shifts of primary interest to smaller and smaller species, a process which it seems cannot go any further, unless there is an unexploited and, as yet, unrecognized 'resource' of an even smaller species of whale. Apart from partial protection afforded to right whales and the gray whales, they were all essentially unregulated, other than by economic factors, until the International Whaling Commission was set up by the convention signed in 1946. Even then the IWC exerted little influence on the national and commercial interests until the stocks of the major baleen whale species had been very seriously depleted. The regulations promulgated by the IWC apply, of course, only to its Member States, which states now take about 90% of the world catch of whales by weight. The IWC set up the Committee of Three Scientists to provide independent assessment and advice in the early 1960s, and procedures relating to the concept of maximum sustainable yield (MSY) developed then, and subsequently within the Scientific Committee, have formed the basis of an increasingly restrictive policy designed to manage more effectively the exploitation of whale stocks, whatever their location or state. This has now reached the point where complete protection is automatically afforded to much reduced populations; catches not exceeding 90% of the estimated maximum sustainable yield are permitted by the Commission, on the advice of the Scientific Committee, from populations judged to be at or above levels appropriate for MSY; and rules are being developed for restraining the exploitation of currently unexploited stocks while scientific information is being obtained about them. Application of such a policy places heavy responsibilities on scientists, industry and governments with regard to the collection, analysis and interpretation of statistical and scientific information.

In fact, not all the necessary catch and effort data relating to the whaling operations carried out even by members of the IWC are available for such analysis, and the biological responses of populations to exploitation are insufficiently understood to produce knowledge adequate to ensure the intent of the new management policy is in fact fulfilled. Thus, there are some doubts about the validity of the assessments and of the models, and the implementation of the conclusions. Nevertheless, this policy is a considerable advance on the position taken in earlier years. It clearly requires a considerably increased and improved scientific input based upon expanded research and better data from industry. It is also necessary that all whaling activity – including the 10% not conducted by IWC members – should be bound by the same set of decisions so that management is fully effective for all whale stocks throughout the world, no matter by whom these stocks are used. This set of decisions could, the Group believes, with advantage be far more flexible than is envisaged by the new management procedure of the IWC, and specifically should be such as to lead to substantially better understanding of the dynamics of whale populations. This might be done by viewing every regulation essentially as an element of a large-scale controlled experiment. We suggest that, properly planned, this approach could be acceptable both to whaling industries and to those scientists and others who believe that in our present ignorance we could well be endangering the resource while acting on 'best' – which might be more appropriately labelled 'least bad' – estimates of stock sizes and of sustainable yields. The Group recommends that the virtues of, and the difficulties associated with, such an approach should be explored more thoroughly than has been done so far (see more detailed consideration of this matter in section 8 of ACMRR/MM/SC/2 Suppl. 1).

The Working Party may be expecting the Group to make explicit judgement of the assessments that have been made by the Scientific Committee of the IWC and on which the Commission is currently acting. The Group does not feel able to make any general statement of this kind, because the various assessments are of greatly varying quality and are continually being corrected, refined and reanalyzed. Several valid general criticisms of the present situation can be made, and they are reflected in our summary and in the full report: the inadequacy of some statistics, the insufficiency of the effort for research and analysis in relation to the demands made for scientific advice.

With respect to particular assessments it cannot be said that they are in general too optimistic or too pessimistic; if we make a criticism it is that the Scientific Committee, whether or not by intent, but certainly by the manner in which it has, under pressure, communicated its conclusions, tended to obscure the uncertainties of its deductions and calculations. This has an understandable origin – too often in the past honest uncertainty has been taken as a sign of weakness, and management decisions or non-decisions have been inappropriate to the situation. We believe that ignorance must be honestly faced and appropriate decision procedures developed which take account of it. It is better than nothing, but still not sufficient, merely to take 'central' values for assessments – usually arrived at by a process which is less than scientific – and then to adjust them by some unmeasured – and probably unmeasurable – margin of error.

The problem is not only in estimating the parameters of models; it is equally in the construction of realistic models. It may well be that some attitudes to management criteria are demanding more than science can provide at the present stage. This too must be taken into account when management of whaling operations is discussed.

SC/28/Doc 11

Questions About the Sex-Ratio in Catches of Rorquals

S. J. Holt

The discussion in the 1975 meeting of the IWC Scientific Committee of the consequences of 'unbalanced' sex ratios in recent Southern Hemisphere catches of minke whales led me to look at this ratio in historical series for other species.

Females have practically throughout the period of 'modern whaling' contributed more, by weight, to rorqual catches than have males (Table 1). This is mainly because they are on the average bigger. There is a slight tendency for the female contribution relatively to increase over the period 1932–33 to 1972–73.

The sex-ratio by number (% females) is usually less than 50. When all species are taken together this percentage, over the period considered, varies from the mid-40s to the mid-50s but averages 48. There is, however, an increase to beyond 50 in the decade 1954–55 to 1963–64, followed by a decline to below 50. These shifts, and perhaps some of the smaller movements of the ratio, result from the progressive shifts in the species compositions of catches.

Table 2 shows the sex-ratios in blue and fin whale catches. In both cases there is a clear trend of increase in the relative numbers of females, especially in the Antarctic. Such a trend was noted in Antarctic fin whale catches by Allen (1972). It leads, together with the size difference between the sexes in both species, to females eventually contributing to the yield from 20 to 50% more, by weight, than the males in each year.

The mean weight of whales in catches of the heavily exploited rorqual species declined over the period of exploitation, though not by so much as in the male sperm whale because of the different pattern of growth in the exploited phase of life. This decline in size has scarcely affected, however, the trend of sex-ratio by weight, because it has in each species occurred to relatively about the same degree in both sexes.

The sex-ratio trend in Antarctic sei whale catches, over a shorter and later period, is different (Table 3). In this

Table 1

Sex ratios in rorqual catches (% ♀♀)

	All species except minke					
	World		Antarctic		Antarctic pel.	
Years, seasons	By No.	By Wt.	By No.	By Wt.	By No.	By Wt.
1932–33 – 1941–42	47.6	50.2	47.8	50.5	47.4	50.2
1942–43 – 1951–52	49.1	51.5	48.6	51.2	47.8	51.1
1952–53 – 1961–62	50.9	54.1	52.0	55.0	51.8	54.8
1962–63 – 1971–72	49.1	53.2	48.8	53.1	48.7	52.9
1972–73	49.0	51.3	47.5	51.1	47.5	51.1
All	48.0	52.7	49.3	52.4	49.0	52.3
Mean ratio of mean weight, ♀/♂		1.10		1.06		1.07

Table 2

Sex ratios in catches of blue and fin whales (% ♀♀)

	Blue whale						Fin whale					
	World		Antarctic		Antarctic pel.		World		Antarctic		Antarctic pel.	
Years, seasons	By No.	By Wt.	By No.	By Wt.	By No.	By Wt.	By No.	By Wt.	By No.	By Wt.	By No.	By Wt.
1932–33 – 1936–37	47.2	49.8	47.1	49.8	46.9	49.6	47.0	49.7	46.8	50.0	46.6	49.9
1937–38 – 1941–42	47.8	51.0	49.0	52.7	47.7	51.0	46.8	49.6	46.9	50.0	46.1	49.6
1942–43 – 1946–47	51.4	54.3	51.3	54.6	51.0	54.4	49.9	51.9	47.1	49.7	45.6	48.6
1947–48 – 1951–52	46.7	49.6	46.7	49.6	46.6	49.5	47.9	50.9	47.8	51.0	47.4	50.6
1952–53 – 1956–57	50.9	54.4	51.8	55.3	51.8	55.3	49.6	52.8	49.6	52.9	49.5	52.8
1957–58 – 1961–62	51.0	54.4	52.5	55.8	52.4	55.8	51.9	54.5	52.4	55.9	52.2	55.8
1962–63 – 1966–67							53.4	56.9	54.2	58.0	54.1	57.8
1967–68 – 1971–72							51.8	54.8	52.5	55.8	52.5	55.7
1972–73							49.5	52.8			50.5	53.8
All	49.1	52.1	49.8	52.9	49.5	52.6	49.8	52.6	49.7	52.9	49.4	52.8
Mean ratio of mean weight, ♀/♂		1.06		1.06		1.06	1.14			1.15		1.14

species females predominated initially, both by number and by weight. The predominance continued until 1962–63, and to such a degree that females yielded, on the average, 77% more by weight than the males (108% more in the pelagic catches); in 1958–59 the weight of females was as much as 2.7 times the weight of males (3.9 times, in the pelagic catches). From 1963–64 on there was such a sharp and sustained drop in the proportion of females that they yielded *less* than the males by weight in most years; this happened despite the fact that female sei whales in pelagic catches averaged as much as 9% heavier than males.

In five seasons of intensive hunting of minke whales in the Antarctic the sex ratio has moved considerably, from below 50 to over 50 (Holt 1976).

The consistency and degree of trend noted for blue and fin whales suggests that further investigation would be worthwhile to determine the consequences for stock assessment of all species. It seems clear that population trends and calculated net increase rates, and perhaps even 'classification' of some fin and sei whale stocks, might be significantly different if data for females rather than for both sexes combined were used in the models. Such a study has not yet been completed, but I wish to draw the attention of the Committee members to the problem for their appraisal and suggestions.

Several hypotheses can be suggested to account for the pattern of trend in the numerical sex ratio in the blue and fin whales. It seems unlikely that the females were deliberately *under*-represented in earlier catches; being rather bigger than the males one would expect that, if anything, they would be preferably sought. Suppose these stocks had in the early 1930s not yet been drastically affected by whaling. The female sex-ratio of about 47% in blue whale catches and 46% in fin whale catches could arise if:

(a) the recruited numbers of each sex were about equal, but thereafter the natural mortality rate of females was slightly (about 15%) higher than that of males; or
(b) the natural mortality rates were the same but male recruitment exceeded that of females by about 15%; or
(c) recruitment numbers and natural mortality rates *both* differed as between sexes.

In the cases of hypotheses (a) and (b) the increasing percentage of females over the period of intensive exploitation can be accounted for if the mortality due to whaling was considerably higher (by roughly 25%) for males than for females. This seems to imply surprisingly big differences in availability or vulnerability of male and female whales, but Allen considered that in fin whales such differences could be a consequence of protection of lactating females, under IWC regulations; he calculated revised recruitment rates in accordance with this hypothesis, but the Scientific Committee has not yet used them in its assessments.

Under hypothesis (c) the pattern of changes can be accounted for by assuming F♂ = F♀

but M♀ exceeding M♂ by about 25%
and R♀ exceeding R♂ by about 15%.

In most aquatic vertebrates the male grows to a larger size and relatively faster than the female, and has a higher natural mortality rate. It does not seem unreasonable to suppose that the converse is true in rorquals. There is, however, a difficulty which is that it would be expected that the higher natural mortality rate would apply also to the pre-recruit phase. This would imply a sex-ratio at or soon after birth very considerably in favour of males and, as far as I know, there is no evidence of this.

It may be that the sexes are to some extent segregated geographically, or seasonally, and that changes in area or

Table 3

Sei whales % females in Antarctic catches

Season	All catches By No.	All catches By Wt.	Pelagic only By No.	Pelagic only By Wt.	Total catch
1949–50	62.1	65.1	77.2	79.2	1,284
1950–51	56.8	59.6	51.8	55.2	886
1951–52	57.0	60.5	–	–	530
1952–53	60.9	64.0	73.9	76.4	621
1953–54	55.4	58.6	58.6	63.0	1.029
1954–55	56.1	59.7	52.1	56.0	569
1955–56	63.6	66.6	68.8	71.7	560
1956–57	64.7	67.9	65.6	68.4	1,692
1957–58	65.2	68.4	68.1	71.3	3,309
1958–59	69.9	72.9	77.6	79.7	2,421
1959–60	63.9	66.8	67.7	70.3	4,309
1960–61	57.9	61.2	58.7	62.0	5,102
1961–62	61.6	64.7	62.9	65.8	5,196
1962–63	56.3	59.2	56.3	59.2	5.503
1963–64	49.2	52.2	49.1	52.0	8,655
1964–65	44.0	46.7	43.9	46.5	20,380
1965–66	As pelagic		42.0	43.8	17,587
1966–67			47.7	50.1	12,368
1967–68			45.4	47.7	10,357
1968–69			45.2	47.2	5,776
1969–70			46.6	48.5	5,857
1970–71			48.5	50.6	6,153
1971–72			46.4	48.3	5,456
1972–73			46.1		3,864
1973–74			45.0		4,392
1974–75			42.4		3,859
1975–76			45.6		1,820
Mean 1949–50–1971–72			54.9	59.7	

season of whaling can account, at least in part, for the observed sex ratios and changes in them. Shifts in whaling from one stock of a species to another might have similar consequences.

If the proportion of females in catches increases over the whaling period the decline in catch of females per unit effort will be less steep than that of total catch per unit effort, and it will have been caused by a relatively lower rate of catch in the early period, and a relatively higher rate later on. To the extent that declining recruitment has been observed it must have been caused by a change in female numbers relatively less than the change in total numbers; MSY as calculated from simple models using data only for females would be predicted at a rather higher stock level than when calculated, as is usual, from data for both sexes together.

The opposite trend in sei whales might be accounted for by an initial deliberate selection by whalers of larger individuals of the species, in areas primarily searched for fin whales. Later, as fin whales declined further, the area for whaling became chosen at least as much for the presence of sei whales as for the presence of fin whales and, as the female sei whales were removed, the sei sex-ratio moved to the range of values previously found in the larger species (45–50%). In any case, the change has been so drastic in the sei whale over the 20 years of intensive pelagic hunting in the Antarctic that it seems essential to take it into account in assessments. In fact with a change in sex ratio from about 70% to about 45% over the period, the reproductive capacity of the stocks, in terms of the number of adult females, might have declined much further than is indicated by indices of total catch per unit effort, with potentially serious imminent consequences as such decline becomes reflected in the new influx of recruits.

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SC/28/Doc 15

A Preliminary Study of Variations in Age at Sexual Maturity of the Fin Whale with Year Class, in Six Areas of the Southern Hemisphere

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INTRODUCTION

In a paper by Lockyer (1972), the age at sexual maturity of Southern Hemisphere fin whales was examined. The mean age at sexual maturity for whales taken in the catches during the 1960s was estimated directly from an examination of the gonad maturity and the age as determined from ear plug growth layers. For fin whales of both sexes, taken in the region 60°W–70°E, the mean age was found to be 6–7 years. The mean ages at sexual maturity for different year classes were also found. These were calculated from an analysis of the number of growth layers formed up to and including the transition layer between early widely spaced, sometimes irregular layers of the immature growth phase and the later more closely spaced even layers of the mature period. The plotting out of the number of growth layers up to and including the transition layer by year class revealed that the mean age at sexual maturity had remained fairly stable at about 10 years from the early 1900s to the 1930s. However, after this time, a decline was apparent. These findings were unexpected in view of other earlier but still recent estimates of age at sexual maturity, which centred around 10 years, for catches of fin whales in the 1950s from other regions in the Antarctic.

A programme of examining ear plug material collected during the 1950s and the 1970s was started, and planned to include data from other regions outside 60°W–70°E, in order to check all these findings, and up-date them further.

MATERIAL AND METHODS

The sources of the fin whale ear plug samples examined are listed in Table 1. Samples from recent seasons were kindly loaned to the Whale Research Unit by the Far Seas Fisheries Research Laboratory, Japan, and I am indebted to Dr S. Ohsumi and Dr Y. Masaki for arranging this facility. Because only the mature animals are of interest for this analysis, not all of the material in these collections has been used, and only random sub-samples of the 1970s collections have been examined. The Japanese material overlaps some of the regions covered during the early seasons, and also includes new Areas not previously sampled.

The age (from total number of ear plug growth layers), age at sexual maturity (from the number of layers up to and including the transition layer) and sex of the whale sampled were recorded. Where ear plug material collected by the Far Seas Fisheries Research Laboratory was examined, a comparison was made of their total age counts and those of the Whale Research Unit. Very few major discrepancies between age counts were found. Some of these may have been due to a mix-up of material. Generally there was good agreement on total age. The year class of origin for each whale was then calculated from the total age and year of capture. The age at sexual maturity was then plotted by sex and Area, for each year class, as far as data permitted (some samples were too small for this procedure). Data were also later pooled for comparative purposes.

RESULTS AND DISCUSSION

The age at sexual maturity has been plotted by year class (average age at transition phase by year class) in the following Antarctic Area categories:

Area I = 120°W– 60°W
Area II = 60°W– 0°
Area III = 0° – 70°E
Area IV = 70°E–130°E
Area V = 130°E–170°W
Area VI = 170°W–120°W.

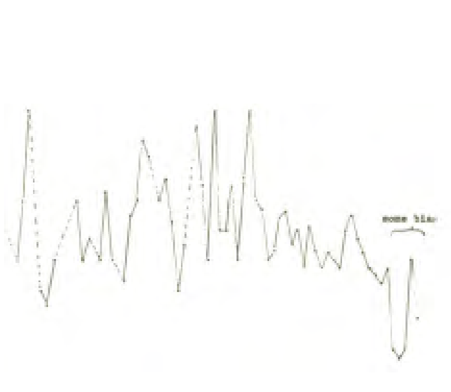
Area III also includes data from Durban, South Africa. Areas I, II and III have been treated individually, and sexes have been shown separately. Areas IV and V have been combined, and these Areas and Area VI show sexes together. These combinations of data are a consequence of small sample size, and as regards Areas IV, V and VI, results only indicate trends rather than accurate findings.

The graphs of mean age at sexual maturity by year class are shown and discussed later. For the most recent year classes considered there is some biass in the frequency distributions of the ages at sexual maturity. The older maturing whales are under-represented or not represented at all, owing to the method of back calculation of the age at sexual maturity, and the estimated means are thus lower than the real averages. The means are, in any case, rather variable, owing to patchy sample sizes.

Area I

Referring to Fig. 1 the general impression is that the age at sexual maturity has remained stable for males. The variability of the means is reduced in the years after 1920 because of the larger numbers of animals within each year class examined after this time. The females in Fig. 2 however, show an obvious decline in trend in the mean age at sexual maturity commencing during the 1930s, and possibly even earlier.

Combining data for both sexes and grouping years in order to gain larger sample sizes, the mean ages at sexual maturity together with the 95% confidence limits have been plotted in Fig. 3. These show that despite the apparent fall in the mean between pre-1916 and 1916–30 year classes, the drop is not significant. The post-1930 mean is significantly lower than the earlier ones. This represents a fall from 11.6 to 10.0 years, not a large difference, between about 1860 and 1940. The year classes beyond 1940 are excluded because of some biassed data as explained earlier. The most recent mean for the 1940 year class would be about 9.5 years in males (Fig. 1), and 8.8 years in females.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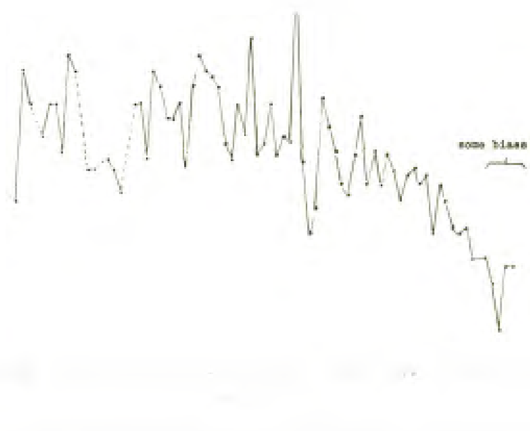
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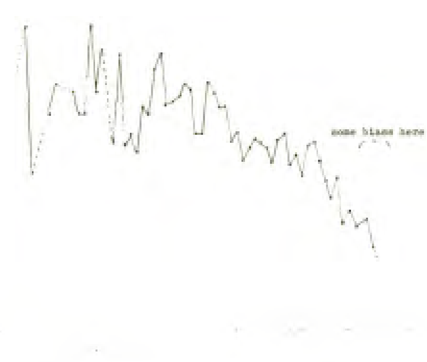
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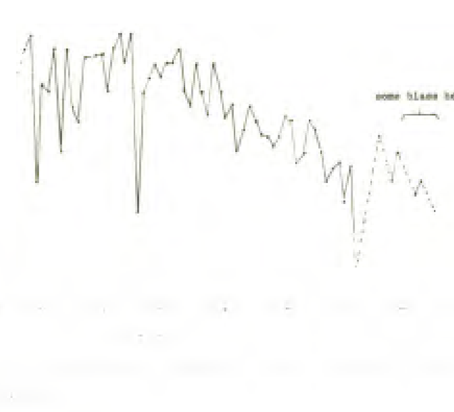
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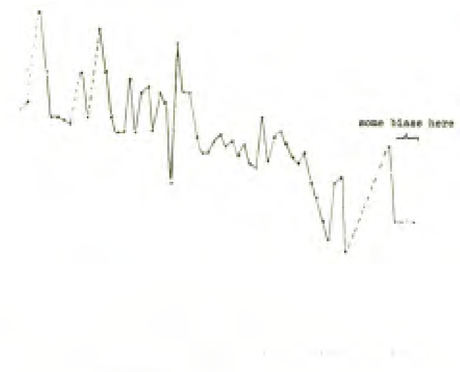
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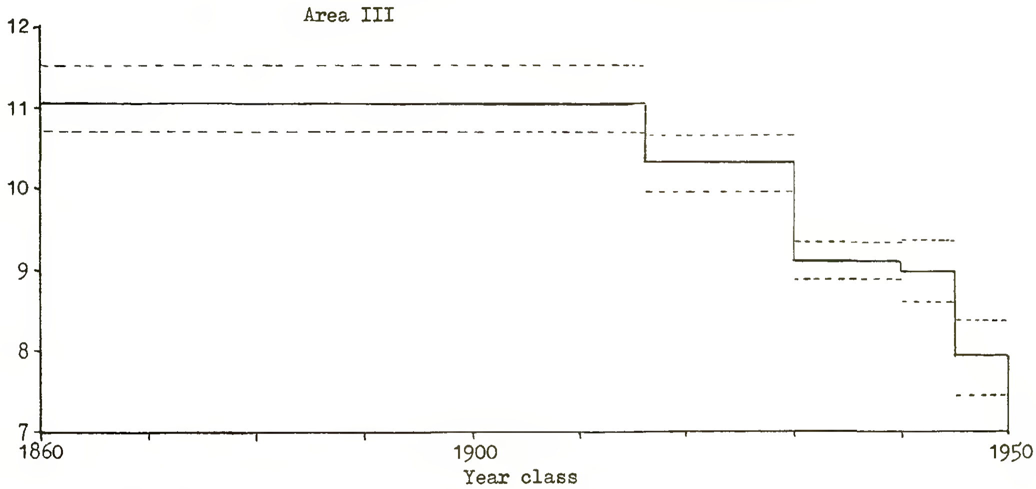


Fig. 9. Mean age at transition phase for blocks of year classes, with 95% confidence limits.

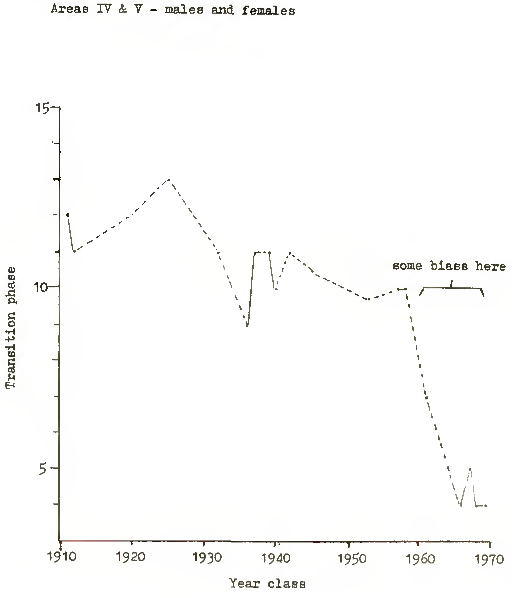


Fig. 10. Average age at transition phase for each year class (data from 26 whales).

a 98% limit is applied, the pre-1939 and post-1939 year classes' means are as follows: 10.6–13.3 years, and 9.3–10.9 years, respectively. The overlap of ranges suggests that the decline in age at sexual maturity is barely significant at the 95% limit, and may prove to be negligible with larger data samples. The average age at sexual maturity is probably around 10–12 years, regardless of year class.

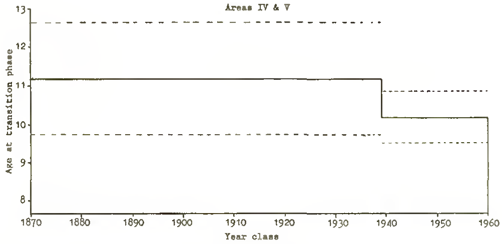


Fig. 11. Mean age at transition phase for blocks of year classes, with 95% confidence limits.

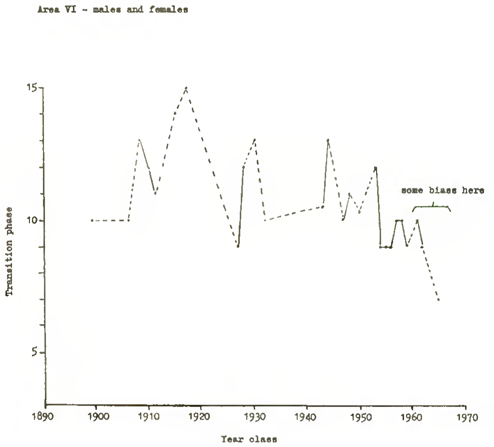
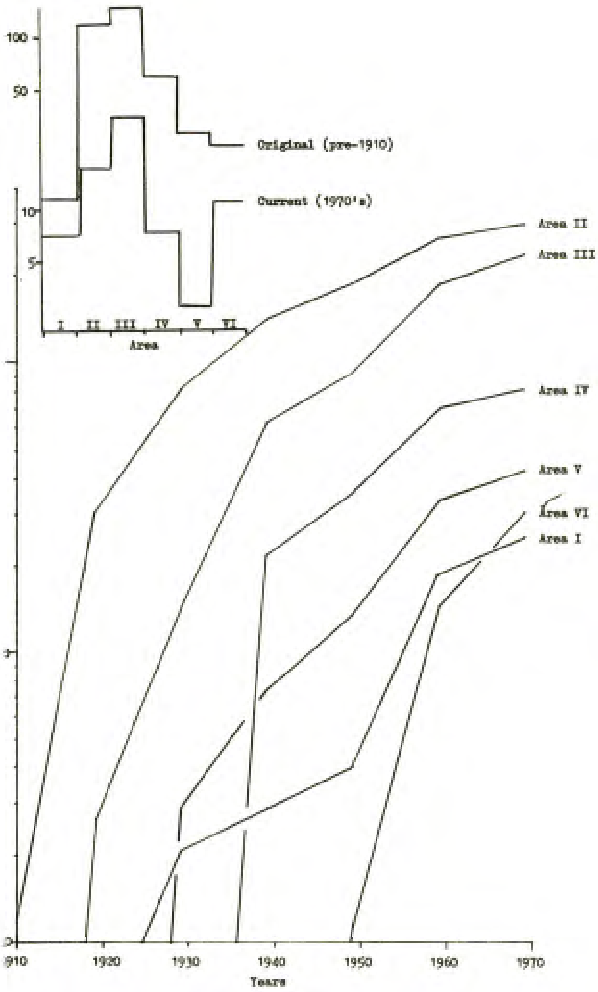


Fig. 12. Average age at transition phase for each year class (data from 34 whales).

CONCLUSIONS

Fig. 14 shows a comparison of all the Areas considered. The range of mean age at sexual maturity considering all Areas, is about 10–13 years up to the 1910 year class, and is only slightly different up to the 1930 year class. Referring back to Figs. 3, 6, 9, 11 and 13, the average age at sexual


100
50
Original (pre-1910)
Current (1970's)
10
5
I
II
III
IV
V
VI
Area
Area II
Area III
Area IV
Area V
Area VI
Area I
0
1910
1920
1930
1940
1950
1960
1970
Years

SC/28/Doc 17

Japanese Pelagic Whaling and Whale Sighting in the Antarctic, 1975–76

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SUMMARY OF EXPLOITATION IN 1975–76 ANTARCTIC SEASON

Whaling expeditions were cut to two for USSR and three for Japan in the 1975–76 season. A Japanese expedition only to take minke whales did not operate in this season.

Area catch limit system for four species of whales (fin, sei, minke and sperm whales) became effective in this season.

Fin whale catch were only permitted in Area I, and sei whales in Area III and male sperm whales in the region of the eastern side of Australia (Division 6) were also prohibited to capture in this season.

Six area catch limit system and unusually bad weather in the Western Hemisphere affected the pelagic whaling in this season. Table 1 shows total catch and effort of the Japanese and USSR pelagic whaling based on the information from BIWS.

It must be noted that these effort statistics have an important problem. They are shown as effort in each 10° square by month, but the dates of attainment of quota are different in each whale species and area. The calculation of effort by each species and by each area are needed.

CPUE

Japanese expeditions took sperm and minke whales during the baleen whale season. This should affect the real effort for sei and fin whales in this season, and it must be careful to compare the CPUEs with previous seasons. Especially, as there are no Japanese catch data of fin whales in Area I in recent years and the efforts are not separated into each species of whales, it is very difficult to compare yearly and area changes of CPUE for each species. The decline of CPUEs of the sei whale in the Pacific Sector (Areas V and VI) in this season (Table 2) are largely influenced by the unusually bad weather conditions.

The rapid rationalization of whaling operation in recent years must be also taken into consideration in the consideration of the apparent CPUE.

WHALE SIGHTING

Whale sighting has been carried out by scouting boats which belong to the Japanese expeditions since 1965–66 season. Tables 3–6 show a summary of research distances (miles) and number of whales sighted by species (fin, sei, sperm, minke, blue, humpback and right) by sector in the waters south of 30°S in the 1975–76 season. Tables 7–23 show the estimation of abundance for each of the seven species of whales by year by area and by sector.

Research distance

Total research distance was 147,400 miles in the 1975–76 season. It is 4,100 miles shorter than the previous season. The investigation in Sectors IE, IIE, IIIA, VA and VID was not so extensive and no data are available for Sectors IIIE, IIID, VB and VIE. Furthermore, the whale sighting data in Sectors IE, ID, IIB and VIE have not yet accumulated so much.

Estimation of abundance of whales by means of sighting

On the basis of Doi's (1971) theory, abundance of whales by year, by sector and by species were calculated as shown in Tables 7–23.

Tables 13–17 show the estimations of abundance of minke whales which were calculated using the approach which were shown in the previous document (Masaki 1976).

Fin whale

Total and average abundances during years 1965–66 to 1975–76 are shown in Tables 7–8.

Total abundance varies from 16,100 to 96,900 whales. As is shown in this Table, area changes in the abundance of the fin whale have been observed. The average abundance in Areas II and VI was relatively small and those in Areas III and IV was considerably larger.

Total abundance in this season shows the second smallest estimate. The cause was mainly the result of unusually bad weather conditions.

Average abundance of the fin whale is estimated to be 80,900 whales during the seasons from 1965–66 to 1975–76.

Neither increasing nor decreasing tendency has been observed in the abundance of fin whales during these years.

Sei whale

Total abundance of sei whales shows large yearly fluctuation from 115,500 to 554,100 whales during the seasons 1965–66 to 1975–76 (Table 9). But, as compared with the case of fin whale, area average abundance of the sei whale except Area I do not show large variations.

The abundance of sei whale in the whole area in the waters south of 30°S is estimated to be 259,600 whales, that is the average value during the past eleven years (Table 10).

Yearly total abundance of sei whales in the Antarctic south of 30°S in summer shows a little decreasing trend in recent years.

Sperm whale

Yearly change in the abundance of sperm whales has not been clearly observed. But, area average abundance shows large differences from each other, that is, the abundance in Areas III, IV and V show small values (Table 11). Furthermore, there are large differences among zones, and the sperm whales distribute more abundantly in the waters of the lower latitudinal waters in summer (Table 12).

Total abundance varies from 153,900 to 302,200 whales, and the average abundance is estimated to be 208,200 whales (Table 12).

Minke whale

As reported previously (Masaki 1976), the minke whales distribute most abundantly in Zone B in summer (Table 14). Therefore, the present report also calculates the total abundance of minke whales on the three cases the same as the previous report.

(a) Case I
Yearly total abundance has shown a little increasing tendency (Table 13). Total abundance varies from 285,700 to 1,068,200 whales, and the average abundance is estimated to be 561,200 whales.

(b) Case II
Large yearly fluctuation has not been observed in the total abundance (Table 15), but it varies from 339,100 to 650,100 whales. On the other hand, there are large differences among areas and the average abundance in Areas II, III and IV indicates large value. Also, as large differences in abundance are recognized among Zones E, D, A and B (Table 16) and the minke whales concentrate in the waters along the pack-ice, the present value may be overestimated.

(c) Case III
Calculated abundances are largely different among seasons, and the abundance of minke whales is estimated to be at least 561,200 whales (Table 17).

For the purpose of the estimation of abundance of minke whales, further detailed analysis of population size by means of whale sighting may be necessary to calculate by much smaller area in Zone B along the pack ice edge.

Prohibited species

Total abundance and average abundance by year and by sector of the prohibited species (blue, humpback and right whales) during the 1965–66 to 1975–76 seasons are shown in Tables 18–23. Yearly changes in the abundance of these prohibited species have not shown any clear trends in these Tables. The average abundance of blue, humpback and right whales in the Antarctic south of 30°S in summer are estimated to be 14,450, 4,170 and 3,860 whales, respectively.

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Table 1

Results of pelagic whaling in the 1975–76 Antarctic season

Area		I	II	III	IV	V	VI	Total
In baleen whale season								
CDW		905	1,274	526	855	911	1,100	5,571
Fin		206	–	–	–	–	–	206
Sei		198	513	–	466	393	251	3,319
Sperm	Males	91	572	430	335	326	488	2,242
	Females	–	235	–	28	69	9	340
Minke whales								
CDW		1,003	1,274	736	1,057	989	1,256	6,315
Minke		1,045	1,164	2,154	881	631	159	6,034
Sperm whales outside baleen whale season								
CDW		98	510	729	548	237	474	2,596
Males		5	703	405	295	129	243	1,780
Females		–	754	424	416	259	831	2,684

Table 2a

CPUE for the sei and fin whales of Japanese expeditions in 1975/76 Antarctic season.

Zone \ Area	I	II	IV	V	VI	Total
Sei whale						
D	0.771	0.628	1.764	0.905	0.071	1.012
A	0.485	0.595	2.222	0.286	0.571	0.550
B	0.000	0.550	–	–	0.091	0.197
C	–	0.000	–	–	–	0.000
Total	0.299	0.564	1.782	0.820	0.429	0.704
Fin whale						
A	0.316	–	–	–	–	0.316
B	0.386	–	–	–	–	0.386
Total	0.339	–	–	–	–	0.339

Excluding CDW(70) in Sector IIIB.

Table 2b

CPUE for the fin and sei whales of Japanese expeditions in the Antarctic.

Sector		1968–69	1969–70	1970–71	1971–72	1972–73	1973–74	1974–75
Fin whale								
II	D	–	0.039	–	–	–	–	0.000
II	Total	–	0.039	–	–	–	–	0.000
III	D	0.498	0.837	1.026	0.456	0.717	0.418	0.322
III	A	–	–	–	0.674	–	–	0.000
III	Total	0.498	0.837	1.026	0.494	0.717	0.418	0.310
IV	D	0.372	0.044	0.156	0.099	0.047	0.057	0.059
IV	A	1.285	1.377	0.776	1.220	0.712	0.057	0.674
IV	Total	0.780	0.663	0.228	0.326	0.213	0.057	0.205
V	D	0.254	–	–	0.002	0.000	0.020	0.005
V	A	0.000	–	–	–	0.000	0.000	0.591
V	B	–	–	–	–	0.633	–	–
V	Total	0.250	–	–	0.002	0.075	0.020	0.176
VI	D	0.000	–	–	–	–	–	0.000
VI	A	0.048	–	–	–	1.155	0.345	0.176
VI	B	0.168	–	–	–	0.675	0.397	–
VI	Total	0.094	–	–	–	1.027	0.355	0.115
Total		0.527	0.601	0.517	0.348	0.386	0.233	0.197
Sei whale								
II	D	–	1.665	–	–	–	–	0.250
II	Total	–	1.665	–	–	–	–	0.250
III	D	0.665	0.601	0.399	0.502	0.557	0.388	0.178
III	A	–	–	–	0.075	–	–	–
III	Total	0.665	0.601	0.399	0.432	0.557	0.388	0.178
IV	D	0.890	2.707	2.127	1.925	1.727	1.280	1.132
IV	A	0.337	0.134	0.101	0.063	0.313	0.029	0.090
IV	Total	0.643	1.513	1.891	1.548	1.374	1.200	0.884
V	D	2.029	–	–	2.077	2.089	1.481	1.217
V	A	0.000	–	–	–	0.000	0.000	0.000
V	B	–	–	–	–	0.000	–	–
V	Total	2.000	–	–	2.077	1.759	1.438	0.862
VI	D	0.273	–	–	–	–	–	1.359
VI	A	1.422	–	–	–	0.150	0.797	0.580
VI	B	1.273	–	–	–	0.525	0.595	–
VI	Total	1.802	–	–	–	0.250	0.757	0.846
Total		1.013	1.153	1.352	1.174	1.082	0.868	0.741

Table 3

Research distance (miles) by scouting boats in the Antarctic, 1975–76

Zone Area	E	D	A	B	Total
I	1,338	2,026	5,623	11,693	20,680
II	202	14,595	4,111	2,057	20,965
III	–	–	359	6,385	6,744
IV	4,149	24,182	8,784	3,805	40,920
V	5,387	36,533	1,673	–	43,593
VI	–	1,731	8,445	4,330	14,506
Total	11,076	79,067	28,995	31,097	147,408

Table 4

Accumulated figures of research distances (miles) by scouting boats in the Antarctic from 1965–66 to 1975–76 season.

Zone Area	E	D	A	B	Total
I	1,338	2,641	10,271	13,845	28,095
II	11,017	120,302	25,548	4,552	161,419
III	44,381	445,720	40,611	12,765	543,477
IV	133,477	256,904	188,395	16,274	595,050
V	53,639	248,121	22,442	16,066	340,268
VI	672	38,548	80,827	36,179	156,226
Total	244,524	1,112,236	368,094	99,681	1,824,535

Table 5

Number of whales sighted by scouting boats in the Antarctic in the 1975–76 season.

Sector		Fin	Sei	Minke	Sperm	Blue	Hump.	Right
I	E	–	–	1	11	–	–	–
I	D	–	39	–	12	–	–	1
I	A	28	20	8	6	–	–	–
I	B	31	17	341	25	44	1	–
II	E	–	–	–	–	–	–	–
II	D	–	242	7	249	–	–	71
II	A	64	12	29	9	–	–	–
II	B	–	28	97	3	11	3	–
III	E	–	–	–	–	–	–	–
III	D	–	–	–	–	–	–	–
III	A	–	–	–	1	–	–	–
III	B	2	–	2,475	8	–	36	–
IV	E	1	19	8	155	–	–	–
IV	D	7	414	38	410	–	1	57
IV	A	4	10	28	1	–	–	9
IV	B	–	–	420	13	–	1	–
V	E	–	42	9	158	–	4	–
V	D	7	376	54	500	42	3	5
V	A	–	–	2	–	3	–	–
V	B	–	–	–	–	–	–	–
VI	E	–	–	–	–	–	–	–
VI	D	–	5	9	46	–	–	–
VI	A	8	99	29	14	12	–	2
VI	B	11	9	171	16	2	2	–

Table 6

Accumulated number of whales sighted by scouting boats in the Antarctic from 1965–66 to 1975–76 season.

Sector		Fin	Sei	Minke	Sperm	Blue	Hump.	Right
I	E	0	0	1	11	0	0	0
I	D	0	39	0	12	0	0	1
I	A	28	41	12	6	0	0	0
I	B	33	17	723	31	44	2	0
II	E	3	119	13	29	0	0	8
II	D	106	4,506	29	657	3	18	98
II	A	159	139	471	41	0	8	1
II	B	0	28	540	12	12	3	0
III	E	55	1,030	71	855	21	7	4
III	D	5,185	9,777	847	4,495	1,244	35	48
III	A	538	27	187	86	20	14	0
III	B	11	0	5,375	50	0	37	0
IV	E	53	2,891	308	3,728	33	23	64
IV	D	1,117	12,424	1,000	5,258	490	53	598
IV	A	6,763	2,213	4,484	401	76	46	15
IV	B	12	9	1,729	70	2	11	0
V	E	8	1,143	76	2,364	24	5	3
V	D	178	8,955	462	2,977	110	19	44
V	A	338	224	147	40	4	0	2
V	B	91	66	597	77	6	7	0
VI	E	0	0	0	0	0	0	0
VI	D	23	1,328	30	609	0	2	1
VI	A	532	1,960	440	151	14	67	10
VI	B	465	528	719	77	7	54	1

Table 7

Abundance of fin whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	9,240	2,150	28,220	25,190	11,390	8,170	84,360
1966–67	9,240	3,730	15,640	56,690	3,940	4,520	93,760
1967–68	10,810	4,590	12,900	42,550	1,920	2,720	75,490
1968–69	10,810	4,590	25,320	24,390	3,940	7,680	76,730
1969–70	9,240	5,560	20,650	27,440	11,390	8,170	82,450
1970–71	10,810	4,590	54,540	10,690	11,180	5,100	96,910
1971–72	10,810	4,590	13,090	9,260	10,910	8,170	56,830
1972–73	10,810	4,590	33,810	9,430	2,500	29,130	90,270
1973–74	1,570	1,710	5,390	1,440	1,980	3,980	16,070
1974–75	830	3,450	4,700	15,030	32,340	3,870	60,220
1975–76	13,140	9,330	11,280	670	1,900	1,370	37,690
Average	10,810	4,590	20,740	25,200	11,390	8,170	80,900

Table 8

Average abundance of fin whales in the Antarctic during season 1965–66 to 1975–76.

Zone \ Area	I	II	III	IV	V	VI	Total
E	0	210	1,140	300	100	0	1,750
D	0	650	10,020	3,210	510	370	14,760
A	1,570	3,730	9,260	21,510	9,020	3,290	48,380
B	9,240	0	320	180	1,770	4,520	16,030
Total	10,810	4,590	20,740	25,200	11,400	8,180	80,920

Table 9

Abundance of sei whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	5,740	50,270	29,390	63,310	49,850	41,180	239,740
1966–67	58,070	49,800	162,400	64,340	125,490	36,250	554,110
1967–68	17,730	43,780	79,370	60,900	72,890	94,010	368,680
1968–69	17,730	43,780	43,360	44,570	73,150	36,720	259,310
1969–70	15,280	20,520	22,560	83,800	49,850	41,180	233,190
1970–71	17,730	43,780	15,710	70,780	38,960	8,610	195,570
1971–72	17,730	43,780	13,810	36,100	109,420	41,180	262,020
1972–73	17,730	43,780	24,430	34,010	345,030	30,560	495,540
1973–74	12,640	38,720	29,250	15,880	33,420	41,140	171,050
1974–75	10,180	9,100	6,190	16,420	22,460	18,090	164,340
1975–76	21,490	6,660	43,120	17,950	17,270	8,960	115,450
Average	17,730	43,780	43,600	63,310	49,850	41,180	259,450

Table 10

Average abundance of sei whales in the Antarctic during season 1965–66 to 1975–76.

Zone \ Area	I	II	III	IV	V	VI	Total
E	0	9,100	22,900	17,400	14,800	0	64,200
D	10,200	29,600	20,200	38,300	27,300	22,700	154,300
A	2,500	3,500	500	7,500	6,400	13,000	33,400
B	5,100	1,600	0	100	1,400	5,500	13,700
Total	17,800	43,800	43,600	63,300	49,900	41,200	259,600

Table 11

Abundance of sperm whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	9,800	4,400	9,000	58,600	60,500	17,400	159,700
1966–67	9,800	2,800	21,800	32,500	84,900	150,400	302,200
1967–68	14,800	11,800	49,100	68,900	39,600	14,700	198,900
1968–69	14,800	11,800	86,800	42,800	24,700	8,800	189,700
1969–70	14,300	16,100	32,900	48,700	60,500	17,400	189,900
1970–71	14,800	11,800	57,700	45,800	56,000	7,500	193,600
1971–72	14,800	11,800	36,900	62,100	68,800	17,400	211,800
1972–73	14,800	11,800	62,400	37,100	69,700	15,500	211,300
1973–74	14,500	14,800	44,500	29,700	47,400	3,000	153,900
1974–75	15,500	3,700	147,200	54,700	63,800	17,700	170,100
1975–76	29,900	21,800	44,100	63,300	46,100	28,300	231,500
Average	14,800	11,800	44,900	58,600	60,500	17,400	208,200

Table 12

Average abundance of sperm whales in the Antarctic during season 1965–66 to 1975–76.

Area Zone	I	II	III	IV	V	VI	Total
E	8,500	3,200	27,100	32,000	43,600	0	114,400
D	4,500	6,200	13,300	23,100	13,000	14,900	75,000
A	500	1,500	2,300	2,000	1,600	1,400	9,300
B	1,300	1,000	2,200	1,600	2,300	1,100	9,500
Total	14,800	11,900	44,900	58,700	60,500	17,400	208,200

Table 13

Abundance of minke whales by means of whale sighting in the Antarctic south of 30°S. (Case I).

Area	I	II	III	IV	V	VI	Total
1965–66	39,100	53,200	297,200	83,000	33,400	19,200	525,100
1966–67	39,100	76,400	304,900	52,300	24,600	13,200	510,500
1967–68	40,400	76,100	303,200	101,200	22,800	15,000	558,700
1968–69	40,400	76,100	332,100	106,800	23,600	4,200	583,200
1969–70	40,800	60,400	307,500	35,900	33,400	19,200	497,200
1970–71	40,400	76,100	310,100	64,000	39,500	13,200	543,200
1971–72	40,400	76,100	26,200	91,400	32,400	19,200	285,700
1972–73	40,400	76,100	182,700	59,300	27,100	23,700	409,300
1973–74	231,700	143,900	612,100	31,100	37,200	12,200	1,068,200
1974–75	4,400	136,700	307,100	90,400	56,200	17,900	612,700
1975–76	215,500	29,800	279,200	57,800	27,200	35,400	644,900
Average	40,400	76,100	309,100	83,000	33,400	19,200	561,200

Table 14

Average abundance of minke whales in the Antarctic during season 1965–66 to 1975–76. (Case I).

Area Zone	I	II	III	IV	V	VI	Total
E	1,000	1,700	2,800	3,300	1,700	0	10,500
D	0	300	3,100	5,400	2,500	900	12,200
A	1,300	20,800	6,100	26,900	7,400	5,100	67,600
B	38,100	53,200	297,200	47,400	21,800	13,200	470,900
Total	40,400	76,000	309,200	83,000	33,400	19,200	561,200

Table 15

Abundance of minke whales by means of whale sighting in the Antarctic south of 30°S. (Case II).

Area	I	II	III	IV	V	VI	Total
1965–66	40,400	68,000	243,600	80,900	27,300	19,100	479,300
1966–67	39,100	69,600	245,300	62,200	26,100	18,300	460,600
1967–68	40,400	69,700	241,200	101,200	25,000	15,800	493,300
1968–69	40,400	69,700	249,000	78,100	25,100	14,900	477,200
1969–70	40,800	60,100	245,400	74,100	27,300	19,100	466,800
1970–71	40,400	69,700	247,900	66,100	26,700	12,900	463,700
1971–72	40,400	69,700	247,700	69,400	27,000	19,100	473,300
1972–73	40,400	69,700	178,900	59,300	27,100	23,700	399,100
1973–74	231,800	101,100	247,000	27,400	28,200	12,900	648,400
1974–75	2,300	136,600	238,900	91,700	38,700	28,400	536,600
1975–76	215,500	31,500	284,900	74,100	27,100	16,900	650,100
Average	40,400	69,700	246,000	80,900	27,300	19,100	484,000

Table 16

Average abundance of minke whales in the Antarctic during 1965–66 to 1975–76. (Case II).

Zone \ Area	I	II	III	IV	V	VI	Total
E	1,000	1,700	3,000	3,100	1,200	0	10,000
D	0	700	3,000	5,800	2,300	800	12,600
A	1,300	14,100	5,500	22,400	2,000	5,400	50,700
B	38,100	53,200	235,100	49,600	21,800	12,900	410,700
Total	40,400	69,700	246,600	80,900	27,300	19,100	484,000

Table 17

Abundance of minke whales by means of whale sighting in the Antarctic south of 30°S. (Case III).

Area	I	II	III	IV	V	VI	Total
1965–66	0	0	0	–	–	–	0+
1966–67	0	2,300	1,700	4,800	1,100	0	9,900
1967–68	–	–	6,100	101,200	22,800	15,000	145,100+
1968–69	–	–	34,900	59,400	1,800	4,200	100,300+
1969–70	1,700	7,200	10,300	35,900	–	–	55,100+
1970–71	–	–	12,800	16,500	10,300	0	39,600+
1971–72	–	–	26,200	91,500	3,200	–	120,900+
1972–73	–	–	182,700	59,300	27,100	23,700	292,800+
1973–74	229,500	241,800	612,100	31,100	15,400	12,200	1,142,100
1974–75	3,500	134,900	9,900	90,400	56,200	28,400	323,300
1975–76	215,500	29,800	273,400	57,800	5,400	35,400	617,300
Average	40,400	76,100	309,100	83,000	33,400	19,200	562,200

Table 18

Abundance of blue whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	1,840	980	2,810	2,790	1,240	230	9,890
1966–67	1,840	940	3,780	1,220	1,320	100	9,200
1967–68	1,840	3,590	7,730	640	3,150	0	16,950
1968–69	1,840	3,590	9,210	2,010	170	640	17,460
1969–70	1,840	940	8,830	1,710	1,240	230	14,790
1970–71	1,840	3,540	6,670	1,920	4,220	620	18,810
1971–72	1,840	3,540	2,130	1,610	460	230	9,810
1972–73	1,840	3,540	3,030	2,910	0	0	11,320
1973–74	0	2,830	400	2,240	250	0	5,720
1974–75	0	0	1,700	2,590	1,420	0	5,710
1975–76	2,180	1,910	4,250	0	3,000	1,310	12,650
Average	1,840	3,590	4,760	2,790	1,240	230	14,450

Table 19

Average abundance of blue whales in the Antarctic during 1965–66 to 1975–76.

Area Zone	I	II	III	IV	V	VI	Total
E	0	0	650	280	430	0	1,360
D	0	2,650	3,600	2,110	470	0	8,830
A	0	0	520	360	160	130	1,170
B	1,840	940	0	40	170	100	3,090
Total	1,840	3,590	4,770	2,790	1,230	230	14,450

Table 20

Abundance of humpback whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	530	270	1,280	560	240	930	3,810
1966–67	530	1,050	1,290	230	490	500	4,090
1967–68	530	430	1,160	270	70	560	3,020
1968–69	530	430	1,040	2,980	130	3,750	8,860
1969–70	530	700	1,690	1,010	240	930	5,100
1970–71	530	430	1,510	490	130	570	3,660
1971–72	530	430	540	260	160	930	2,850
1972–73	530	430	400	710	110	1,480	3,660
1973–74	300	370	640	380	530	1,190	3,410
1974–75	0	0	1,040	960	510	1,330	3,840
1975–76	320	330	2,020	90	640	160	3,560
Average	530	430	1,470	560	240	930	4,160

Table 21

Average abundance of humpback whales in the Antarctic during 1965–66 to 1975–76.

Area Zone	I	II	III	IV	V	VI	Total
E	0	0	140	120	60	0	320
D	0	110	60	150	50	30	400
A	0	180	230	140	0	400	950
B	530	150	1,040	150	130	500	2,500
Total	530	440	1,470	560	240	930	4,170

Table 22

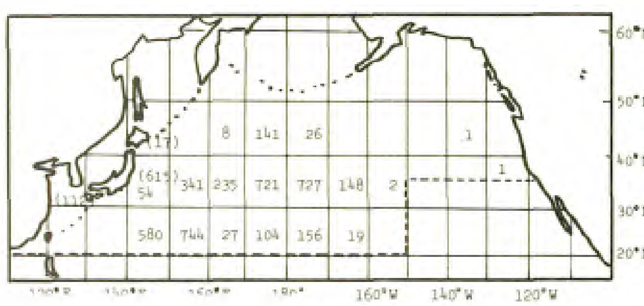
Abundance of right whales by means of whale sighting in the Antarctic south of 30°S.

Area	I	II	III	IV	V	VI	Total
1965–66	0	70	100	2,030	200	80	2,480
1966–67	0	2,620	100	150	30	10	2,910
1967–68	230	1,140	120	320	240	170	2,220
1968–69	230	1,140	40	30	360	190	1.990
1969–70	230	1,020	190	1,880	200	80	3,600
1970–71	230	1,140	410	980	150	10	2,920
1971–72	230	1,140	50	1,480	180	80	3,290
1972–73	230	1,120	300	1,550	40	30	3,270
1973–74	230	1,140	230	1,690	440	0	3,730
1974–75	230	550	70	1,430	210	0	2,490
1975–76	230	3,430	170	2,250	90	110	6,280
Average	230	1,140	170	2,030	200	80	3,850

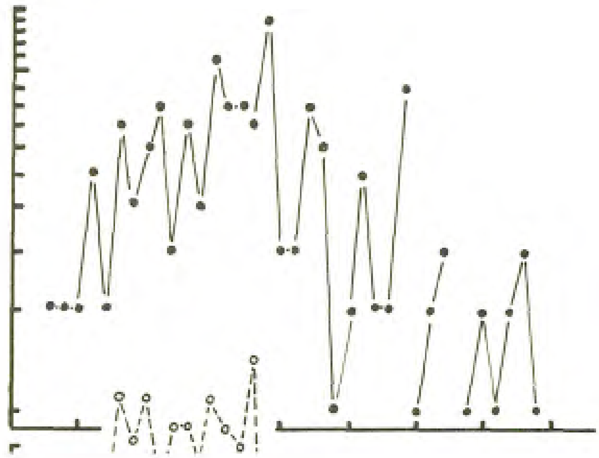
Table 23

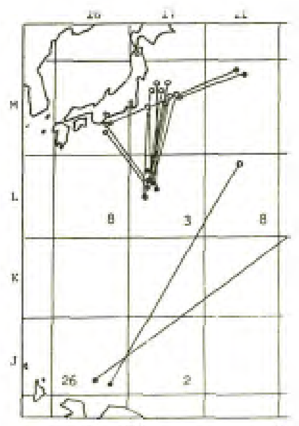
Average abundance of right whales in the Antarctic during 1965–66 to 1975–76.

Area Zone	I	II	III	IV	V	VI	Total
E	0	550	80	340	30	0	1,000
D	230	570	90	1,640	120	20	2,670
A	0	20	0	50	50	60	180
B	0	0	0	0	0	10	10
Total	230	1,140	170	2,030	200	90	3,860



60°N
50°N
40°N
30°N
20°N
(17)
8
141
26
1
(615)
54
341
235
721
727
148
2
1
(11)
580
744
27
104
156
19
160°W
140°W
120°W

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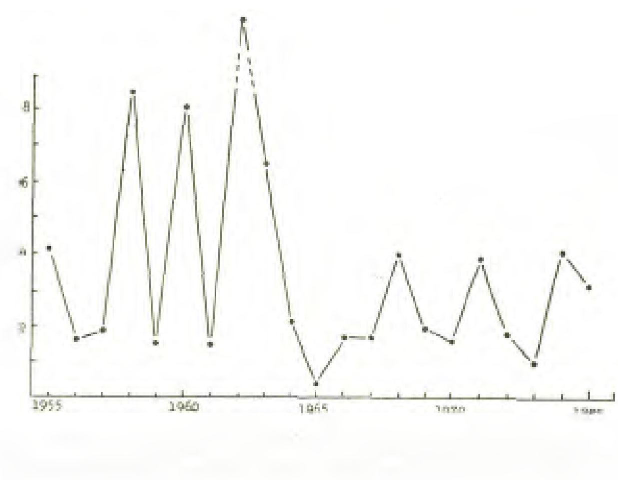

8
6
1955
1960
1965

Numbers of whales marked and recovered were already shown in Table 8 of the previous paper, and numbers of surviving marked whales were also calculated in the same way as used in that paper for each marked year class.

Table 1 shows the result of calculation.

The population sizes thus estimated are similar to each other, and they are about 14,000.

Ninety-three Bryde's whales were marked in the pelagic whaling ground from 1972 to 1975 as shown in Fig. 3, and two whales were recovered from them in 1975. By use of these data, another estimation of population size was made as shown in Table 2.

The estimated population size in 1975 thus calculated is much larger than the above figures.

Table 1

Estimated fishing rates and population sizes of Bryde's whales from the marked whales in Bonin Is. area from 1949 to 1952.

Years	Surviving marked whales	Recovered whales	Fishing rate	Average catch	Average size of population
1949–54	246.8	5	0.020	–	–
1955–59	264.4	3	0.011	153.2	13,900
1960–64	158.6	3	0.019	273.2	14,400
1965–69	95.3	–	0.000	78.8	–
1970–75	51.0	3	0.059	797.2	13,500

Table 2

Estimation of fishing rate and population size of Bryde's whales by use of marked whales in pelagic whaling ground from 1972 to 1975.

Year	Marked	Surviving	Recovered	Fishing rate	Catch	Population size
1972	8	8.0	–	0.000	201	–
1973	24	31.3	–	0.000	728	–
1974	9	37.7	–	0.000	1,363	–
1975	52	86.7	2	0.023	1,433	62,100

Whale sighting

Bryde's whales were included with sei whales in the whale sighting records by scouting boats until very recent years. Fig. 6 shows average indices of abundance of sei and Bryde's whales during years, 1970–74 by 5° squares. Index of abundance (I) in given square (i) is represented as follows:

$$I_i = n_i \, A_i / D_i$$

n: Number of whales sighted

A: Size of square

D: Research distance

Research area of scouting boats has not yet covered lower latitudinal waters where the Bryde's whale is estimated to be abundant even in summer.

It is a problem to separate the indices of abundance of the Bryde's whale from those of sei and Bryde's whales combined. As one way, it is regarded that catch ratio of sei and Bryde's whales represents the ratio of both species which are distributed in the area. Table 3 gives the numbers of sei and Bryde's whales caught by Japanese and USSR whaling expeditions in each 10° square from 1970 to 1975.

Total ratios of indices of abundance of sei and Bryde's whales thus divided are 1.00 sei:0.83 Bryde's. Considering the lack of sighting data in lower latitudinal waters, the real ratio of Bryde's whale must be much higher than this calculated figure. According to Tillman (1975), average population size of the North Pacific sei whale during years, 1970–74 is 10,900. Then, the population size of the Bryde's whale should be much higher than 9,100 in 1972.

Modified DeLury method

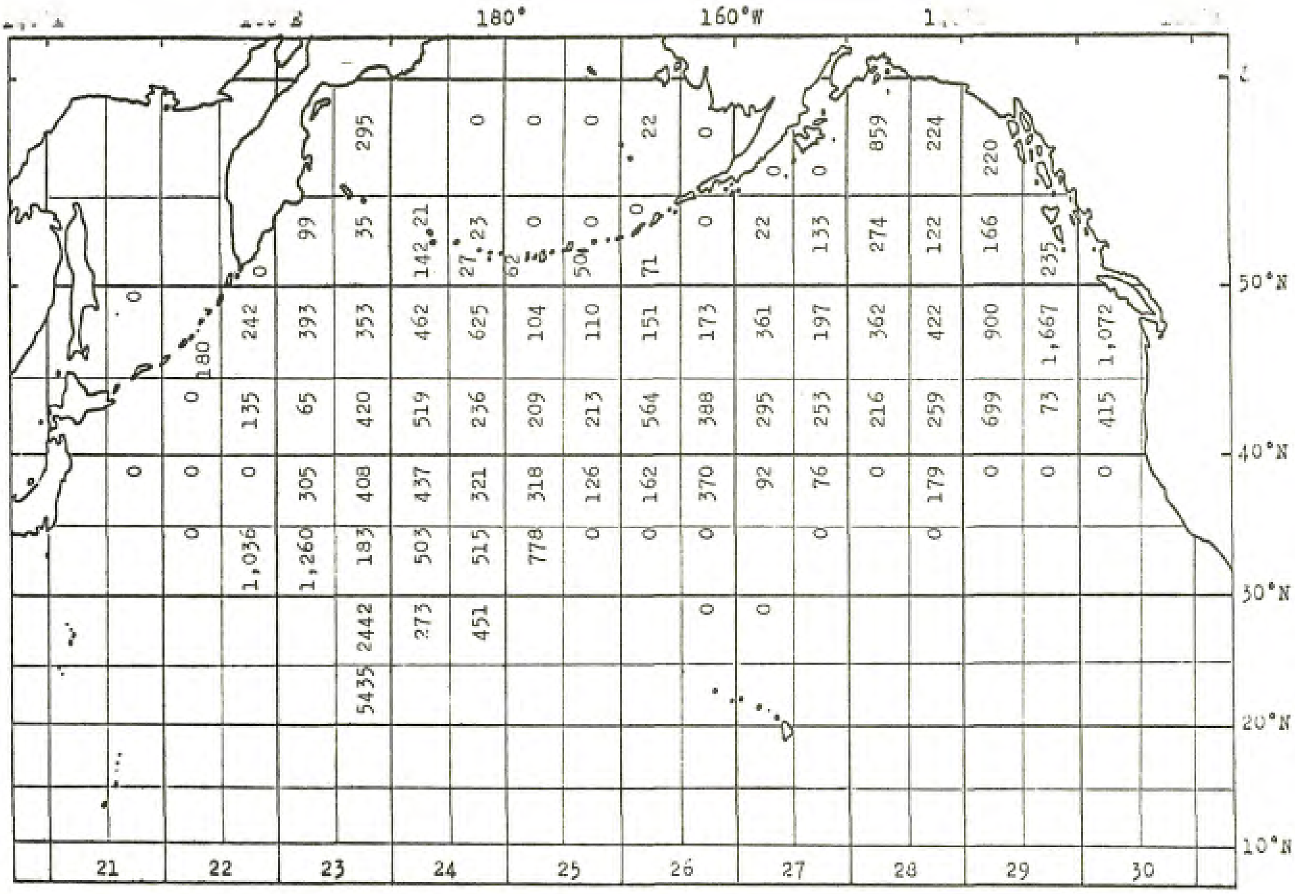
Table 4 shows total catch, Japanese effort and catch by pelagic whaling by years. CPUE has a tendency to decrease gradually from 1971 to 1975.

Population sizes were estimated by use of Chapman's (1974) modified DeLury method and this table. Japanese pelagic catch and CPUE are very small in 1972 and 1973. Excluding these data, the population size in 1971 is calculated to be 18,200. When the data in 1971 when the Japanese catch and effort were relatively small were also excluded because of lesser reliability, the population size in 1974 is estimated to be 29,200. The population size in 1971 is extrapolated to be 30,400.

Synthesis

Population sizes were estimated by means of three methods. Among them, 62,100 in 1975 from mark recovery in pelagic ground is too high, and data are still premature. On the other hand, 9,100 in 1972 from whale sighting results is too low as discussed in the section. These figures may be omitted.

The estimation of population size, 13,900–14,400 in 1955–64 which was obtained by use of marked whales in Bonin Is. in 1949–52 has some doubts because the marking and catching areas were very limited considering the wide distribution of the Bryde's whale in the North Pacific. The results by means of modified DeLury method have also a weak point that the years are only two or three.



180°
160°W
50°N
40°N
30°N
20°N
10°N
21
22
23
24
25
26
27
28
29
30

Table 4

Catch, effort and CPUE of the Bryde's whale in the pelagic whaling ground.

	Japanese pelagic				Adjusted cumulative
Year	Catch	CDW	CPUE	Total catch	catch (M = 0.085)
1971	109	139	0.784	909	460
1972	5	453	0.011	201	940
1973	2	343	0.006	728	1,320
1974	522	763	0.684	1,363	2,230
1975	688	1,061	0.648	1,433	3,390

Although enough data have not yet accumulated, 20,900 as the average of 14.2, 18.2 and 30.4 thousands may be estimated as the best available population size in 1972 in the present stage of knowledge.

When 20,900 is regarded to be the initial population size, the population size in 1976 is estimated using the following formula:

$$N_{i+1} = (N_i - C_i)\, e^{-M} + N_o M$$

It is calculated to be 18,000, and it is about 86% below the level of initial.

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Estimation of Population Sizes of the Southern Hemisphere Minke Whale at the Initial and 1976–77 Levels

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A Sub-Committee to estimate stock sizes of Southern Hemisphere minke whales was established at the 27th Annual Meeting of IWC, Scientific Committee in 1975, and it reported on the estimation of the stock sizes at initial and current level (IWC, 1976).

The first whaling to take the Southern Hemisphere minke whale started in the 1971–72 Antarctic season, and only five years have passed. Then, the present situation is still premature, so that more accurate assessment of population will be obtained year by year.

The present paper re-estimates the population size in Area IV in 1971–72 by the same manner as Ohsumi (1976), adding the data in 1975–76, and extrapolates it to other areas by multiplying the normalized index of abundance in each area as adopted by the Sub-Committee last year.

CORRECTION OF FISHING EFFORT

In practice, it is difficult to obtain a reliable fishing effort in the case of whaling. In my previous paper, catcher's hour's work (CHW) was used instead of CDW, and this was further standardized by the correction of wind forces and operation period.

The time in hours from the start of operations until the completed catch of the last whales, excluding the time to be used pulling carcasses to floating factory, was reported daily from each catcher boat, and it is regarded as CHW.

The effects of wind forces and operation periods for the catching operation were corrected by the same method and correction coefficients as shown in the previous paper.

Table 1 shows numbers of minke whales caught, CHW, wind force correction, operation period correction, corrected CHW by these correction coefficients and CPUE by area and by season.

ESTIMATION OF POPULATION SIZES IN AREA IV

Area IV has the longest catch data from 1971–72 to 1975–76. The initial population size was re-estimated by use of these data and Chapman's (1974) modified DeLury method. Here, the value of 0.127 which was estimated by Ohsumi and Masaki (1975) was adopted as the natural mortality coefficient.

The new estimation is 36,600. This is higher than the previous result (23,700). The higher value of CPUE in 1975–76 provides the difference of results. This phenomenon may mean that more correction of fishing effort will be needed, but the present result will be more reliable than the previous one.

Yearly change in population size in Area IV was estimated by two methods, the same as in the previous paper. They are shown in Table 2. The population size in 1975–76 is estimated to be 27,300–34,400, but 27,300 may be more reliable.

ESTIMATION OF POPULATION SIZES IN AREA II

There is a three-year series of catch data in Area II from 1973–74 to 1975–76. Population size in 1973–74 was estimated by the same method as in Area IV. (Table 3).

There remain some problems in this Area. One is whether the minke whales which are caught off Brazil and the Antarctic minke whales belong to the same stock unit or not. Another is the difference of whaling seasons in both whaling grounds. In this paper, I used total catches both from Brazil and the Antarctic.

The population size in 1973–74 was thus estimated to be 20,500. This is not an initial population size in Area II, for the Brazilian catch has been continuing since the 1960s.

Modified DeLury method cannot be applied for other Areas as shown in Table 1.

COMPARISON OF INDICES OF ABUNDANCE AMONG AREAS

If CPUE in each Area represents the relative density of populations, population size in each Area will be estimated by comparison of indices of abundance and from known population size in one Area.

The most reliable population size is estimated in Area IV at present. For the comparison of CPUE, the average in recent three seasons is used in each Area, because it will be more accurate than that in a single year. Then, index of abundance is calculated by use of relative size of Area. Results are shown in Table 4.

Whale sighting data will be used as another independent index of abundance. The calculated indices of abundance in each Area by use of sighting data from 1970–71 to 1974–75 are used for this purpose. Table 5 shows the result of estimation of population sizes from whale sighting.

SYNTHESIS OF VARIOUS RESULTS

Estimated population sizes should be arranged in the same season. Figures in Tables 4 and 5 represent population sizes in 1974–75 and 1972–73 seasons, respectively, and the result in Area II by use of DeLury method is that in 1972–73. I choose 1972/73 season for synthesis of various results of population estimation, and they are calculated by use of the following equation:

$$N_{i+1} = (N_i - C_i)\,e^{-M} + N_o M$$

Table 6 shows the comparison of population sizes in 1972–73.

Table 1

Catch and effort of the Southern Hemisphere minke whale.

Season	Total catch pelagic (land)	Japanese Catch	Japanese CHW	Correction Wind	Correction Period	Corrected CHW	CPUE
Area I							
1971–72	–	–	–	–	–	–	–
1972–73	–	–	–	–	–	–	–
1973–74	1,257	–	–	–	–	–	–
1974–75	1,870	–	–	–	–	–	–
1975–76	1,045	577	1,025	0.665	1.047	714	0.808
Area II							
1971–72	– (900)	–	–	–	–	–	–
1972–73	– (702)	–	–	–	–	–	–
1973–74	176 (650)	163	234	0.458	0.830	89	1.831
1974–75	806 (765)	800	883	0.661	0.778	454	1.762
1975–76	1,164 (1,038)	405	1,042	0.380	0.644	255	1.588
( ): Catch in Brazil.							
Area III							
1971–72	– (199)	–	–	–	–	–	–
1972–73	1,187 (135)	–	–	–	–	–	–
1973–74	1,698 (173)	1,494	1,989	0.750	0.904	1,349	1.107
1974–75	1,359 (115)	1,359	2,061	0.755	1.034	1,609	0.845
1975–76	2,154 (110)	1,021	855	0.727	0.778	484	2.110
( ): Catch in South Africa							
Area IV							
1971–72	2,659	2,659	2,815	0.705	0.973	1,930	1.378
1972–73	4,557	2,091	2,216	0.674	1.025	1,531	1.366
1973–74	4,569	2,043	2,948	0.696	0.933	1,914	1.067
1974–75	2,231	841	2,100	0.548	0.910	1,047	0.803
1975–76	881	435	515	0.688	0.949	336	1.295
Area V							
1971–72	–	–	–	–	–	–	–
1972–73	–	–	–	–	–	–	–
1973–74	–	–	–	–	–	–	–
1974–75	734	500	921	0.648	0.922	550	0.909
1975–76	631	420	515	0.668	0.915	315	1.333
Area VI							
1971–72	–	–	–	–	–	–	–
1972–73	–	–	–	–	–	–	–
1973–74	13	13	+	–	–	–	–
1974–75	–	–	–	–	–	–	–
1975–76	159	159	628	0.662	0.890	370	0.430

Table 2

Estimation of population sizes ($\times 10^{-3}$) in Area IV by modified DeLury method.

Season	CPUE	Catch	Adjusted catch	Population size N	N′
1971–72	1.378	2,659	1,330	36.57	36.57
1972–73	1.366	4,557	4,620	36.25	34.51
1973–74	1.067	4,569	8,361	28.32	31.02
1974–75	0.803	2,231	10,491	21.31	27.93
1975–76	1.295	881	10,663	34.37	27.27
1976–77					27.89

Table 3

Estimation of population sizes ($\times 10^{-3}$) in Area II by modified DeLury method.

Season	CPUE	Catch	Adjusted catch	Population size
1973–74	1.831	826	413	20.54
1974–75	1.762	1,571	1,513	
1975–76	1.588	2,164	3,107	

Table 4

Comparison of CPUE and estimation of population size ($\times 10^{-3}$) in each area in 1973–74 to 1975–76.

Area	I	II	III	IV	V	VI
CPUE	0.808	1.727	1.354	1.055	1.121	0.430
Relative size of area	6	6	7	6	6	5
Index of abundance	4.848	10.362	9.478	6.330	6.726	2.15
Population size	22.01	47.05	43.03	*28.74*	30.54	9.76

Table 5

Comparison of index of abundance by whale sighting and estimation of average population size ($\times 10^{-3}$) in each area in 1970–71 to 1974–75.

Area	I	II	III	IV	V	VI
Index of abundance	1.539	2.448	3.966	0.923	0.449	0.291
Population size	55.56	88.37	143.17	*33.32*	16.21	10.51

Table 6

Comparison of population size ($\times 10^{-3}$) in 1972–73 estimated by different methods.

Area	I	II	III	IV	V	VI
From CPUE	23.1	47.1	45.1	*34.5*	30.5	9.8
From whale sighting	55.6	88.4	143.2	*34.5*	16.2	10.5
From DeLury method		21.3		34.5		
From Sub-Committee	27.9	49.1	56.9	*34.5*	19.7	13.5

Table 7

Initial and current population sizes ($\times 10^{-3}$) and the current level of the Southern Hemisphere minke whale.

	Population size		MSY level		Ratio (current/MSY)	
Area	Initial	Current	0.5	0.6	0.5	0.6
I	36.1	34.0	18.1	21.7	1.88	1.57
II	52.3	49.0	26.2	31.4	1.87	1.56
III	51.3	46.9	25.7	30.8	1.82	1.52
IV	36.6	27.9	18.3	22.0	1.52	1.27
V	22.1	21.3	11.1	13.3	1.92	1.60
VI	11.3	11.2	5.7	6.8	1.96	1.65
Total	209.3	190.3	104.9	125.8	1.81	1.51

The estimated population sizes which were reported by the Sub-Committee last year are also revised based on the newly estimated population size in Area IV. They are shown in Table 6.

The average of these results is as follows ($\times 10^{-3}$):

Area	I	II	III	IV	V	VI
Pop.	36.1	51.6	81.7	34.5	22.1	11.3

The highest value in Area III is derived because the estimation of population size there was too high by means of whale sighting. Excluding this figure, the average becomes 51,000.

INITIAL AND CURRENT POPULATION SIZES

The initial and current population sizes are estimated by use of above equation and catch statistics. The populations in Areas II and III were extrapolated to 1965 using catch data in Brazil and South Africa, and the initial levels are regarded as the beginning of pelagic whaling in other areas. Table 7 shows the result.

The current population levels in all areas are above the ratio of 1.20, and then all the stocks should be classified as Initial Management Stocks, though the stock in Area IV was classified as a Sustained Management Stock in the 27th Annual Meeting last year.

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SC/28/Doc 20

Catch of Minke Whales in the Coastal Waters of Japan

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HISTORY OF CATCH

Minke whales have been caught around the coast of Japan for many years by small-type whaling catcher boats. Beside them, they were also caught in the waters along the coast of Korea and Kuril Is. before the end of World War II (Matsuura, 1936). After the War, Japan lost these whaling grounds, and then, South Korea, China and perhaps North Korea began whaling mainly to take minke whales off the coast of the Korean Peninsula and in the Yellow Sea.

Japanese small-type whaling was freely licensed, except in Chiba Prefecture. It became necessary to regulate this type of whaling, because many operators appeared in succession to take middle and small-sized whales by this time. The Japanese Government established a license system through the Minister of Agriculture and Forestry under a ministerial ordinance on 5 December 1947. Since then, minke whale capture has been permitted only by small-type whaling in the adjacent waters to Japan, and it has been regulated under the many items of ordinance. A brief review on small-type whaling in Japan was reported by Ohsumi (1975).

Small-type whaling catcher boats have been gradually reduced in number, and only seven have been operating since 1973, though ten have been licensed (Fig. 2). A *Peder Huse* like factory catcher boat was built in 1973, and the Government permitted to operate an experimental whaling to take minke and Baird's beaked whales along the coast of Japan and in Okhotsk Sea for three years, 1973–75.

WHALING GROUND AND STOCK UNITS

Although the minke whale is distributed widely in the North Pacific, minke whaling has been limited in the western part such as Pacific side of Japanese coast, Okhotsk Sea, Sea of Japan, Yellow Sea and a part of East China Sea. Fig. 1 shows the estimated whaling grounds of the minke whale, based on Matsuura (1936), Omura and Sakiura (1956), and recent information.

The main reason why the whaling ground is restricted within the coastal waters is that the small-type whaling catcher boats are small, and they usually start at port in the early morning, and come back to port in the evening of the same day, so that the whaling ground is limited to the coastal waters.

Omura and Sakiura (1956) think that there are two stocks of the minke whale in the waters around Japan, the one in the waters west of Honshu and the other on the east coast of Honshu. It may be considered at present that the minke whale in the coastal waters of Korea and China belong to a different stock from those around the coast of Japan, because the whaling seasons are almost the same as each other, and the influence of the large amount of catch in South Korea in recent years has not appeared in the CPUE of the minke whale in the waters around Japan.

The fundamental catch of minke whale has not started in the central and eastern part of the North Pacific. It will be natural to consider that the minke whales in these waters are different from the stock around Japan.

CATCH AND EFFORT OF MINKE WHALES

Good catch statistics of the minke whale were not available in Japan before 1948. According to Matsuura (1936), a whaling company caught 20, 18 and 45 minke whales from the waters around Japan, Korea and Kuril Is. in 1932, 1933 and 1934, respectively, and some small-type whaling catcher boats in Ayukawa, Sanriku Area, caught 20–30 minke whales in those years. There is another record of a catch of 22 minke whales by four catcher boats in 1941 (Japan Whaling Association, 1944). Then, it may be estimated that about 50–100 minke whales were caught every year before World War II.

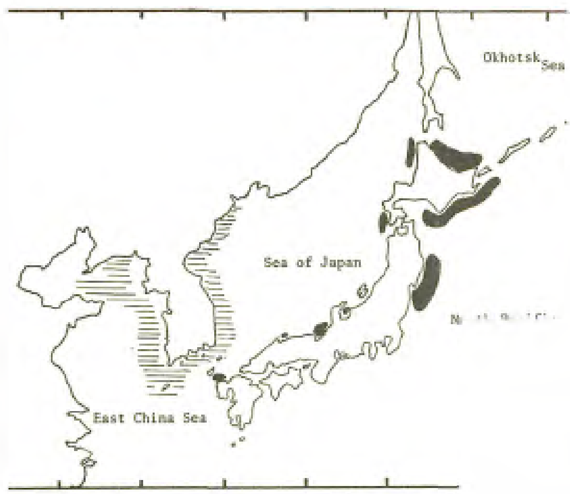
Ohsumi (1975) listed catch statistics of smaller cetaceans caught by Japanese small-type whaling from 1948 to 1972. They are quoted in Table 1. The same type of catch statistics from 1973 to 1975 are shown in Table 2 A and B. The lowest catch was 184 in 1949, and the highest was 541 in 1973.

The catch statistics of the minke whale in South Korea are now available since 1962. They are shown in the International Whaling Statistics Nos. 73 and 75. According to them, catch has increased remarkably since 1970, and it attained 882 in 1973. The catch statistics of the minke whale are not yet available from China and North Korea.

As to the fishing effort statistics, we have only numbers of catcher boats which operated in each year since 1948 and the total tonnages since 1952. According to information from whalers, the operation is largely influenced by the weather conditions, and the actual operation days are different year by year, but they are usually 90–130 days. In the present situation we ought to use numbers of catcher boats as the fishing effort. In general, catching efficiency is related to the size of catcher boat. Then, the total tonnages of the operated catcher boats will be more useful as an efficiency corrected fishing effort. I use them in the present paper.

YEARLY CHANGE IN CPUE

Trend of population density of the minke whale in the adjacent waters to Japan is estimated from the yearly change in CPUE. The catch results of *Miwa Maru* are excluded in the calculation of CPUE, because it is different from the ordinary type of catcher boats, and its main whaling ground was also different from the ordinary ground (northern part of Okhotsk Sea).


Okhotsk Sea
Sea of Japan
East China Sea

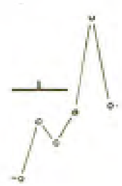


Table 1

Number of whales caught by Japanese small-type whaling.

	Catcher boat		Number of whales					
Year	Number	Tonnage	Minke	Baird's	Pilot	Killer	Others	Total
1948	73	–	285	76	725	48	41	1,175
1949	–	–	184	95	890	44	49	1,262
1950	80	–	259	197	715	24	18	1,213
1951	68	–	334	242	618	66	34	1,294
1952	65	954	485	322	335	58	39	1,239
1953	58	870	406	270	460	66	37	1,239
1954	54	864	365	230	75	100	33	803
1955	47	776	427	258	61	85	40	871
1956	54	945	532	297	297	38	46	1,210
1957	46	851	423	186	174	78	37	898
1958	35	683	512	229	197	73	178	1,189
1959	32	657	280	186	144	36	391	1,037
1960	25	525	253	147	168	48	178	794
1961	23	510	332	133	133	54	305	957
1962	20	469	238	145	80	47	377	887
1963	19	475	220	160	228	43	179	830
1964	18	446	301	189	217	99	434	1,240
1965	17	522	334	172	288	169	71	1,034
1966	18	542	365	171	199	137	220	1,092
1967	17	522	285	107	237	101	294	1,024
1968	10	338	239	117	166	22	274	818
1969	10	338	234	138	130	16	56	574
1970	9	313	320	113	152	12	29	626
1971	9	320	285	118	181	10	25	615
1972	9	320	341	86	91	3	17	538

Table 2

Number of whales caught by Japanese small-type whaling from 1973 to 1975.

	Catcher boats		Number of whales					
Year	Number	Tonnage	Minke	Baird's	Pilot	Killer	Others	Total
A. Ordinary catcher boats								
1973	7	264	423	31	77	–	2	533
1974	7	264	291	32	62	2	1	388
1975	7	264	290	41	53	4	4	392
B. Factory catcher boat *Miwa Maru*								
1973	1	200	118	1				119
1974	1	200	81	–				81
1975	1	200	80	5				85

a more practical measure of regulation will be effort regulation instead of the quota system. When the numbers, sizes, equipments of catcher boats and whaling season are kept in the same level as those in recent years, the minke whale population will be managed safely.

Recent large amount of catch of minke whales by South Korea should be carefully observed on its effect for the minke whale stock around Japan in future. Population assessment of the minke whale in the western North Pacific must be developed urgently. The most important matter will be the stock relationship among the minke whales in western waters. If they belong to the same stock unit, the regulation measure will not be effective only by Japanese whaling.

The whale research of the minke whale in the central and eastern North Pacific is also urgently needed for the rational utilization of the stocks. When a reliable population assessment will be presented, additional quota will be set for these waters.

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SC/28/Doc 21

Stocks and Trends of Abundance of the Sperm Whale in the North Pacific

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Population assessment work for the sperm whale in the North Pacific commenced by the North Pacific Working Group which was established in 1961, and many documents have been presented for the meetings of the group, annual meetings of the Scientific Committee, or special meetings on the sperm whale since then.

Population assessment has developed rapidly through the discussions in these meetings, and the North Pacific sperm whale has been set a quota since 1971 based on the results of the assessments. The quota has been set for the North Pacific as a whole, though it has been set by sexes since 1973.

However, Tillman (1976) pointed out that treating population components in aggregate often leads to incorrect conclusions about the status of individual stocks in the special meeting on sperm whale population assessment in La Jolla, March 1976; he emphasized the need to establish appropriate stock areas for the North Pacific sperm whale. The special meeting reported that the question will be reviewed again at the annual meeting of the Scientific Committee.

STOCK UNITS

It has been imagined that three stock units (American, Central and Asian) of the sperm whale may exist in the North Pacific since the beginning of North Pacific Working Group, but the boundary of the stocks was not shown. Masaki (1970) assumed three stock units: west of 170°E, east of 150°W and 180°–160°W, based on analysis of marking data, blood types, catch distributions, whale sighting and size compositions. Tillman (1976) defined three stock areas, adopted from Masaki's paper and considering catch history.

The present paper will re-examine this problem by use of several methods. Population genetics approach will provide more reliable results, and biochemical analysis is now developing in our laboratory. The result will be reported in near future.

Catch distribution

Figs. 1 and 2 show accumulated catches of male and female sperm whales, respectively, which were caught by Japanese pelagic whaling from 1954 to 1975. Large numbers of males were caught in the waters around Aleutian Is. Chain. According to Ohsumi (1966), the sperm whales in these waters are segregated surplus males. The high density area is only seen in these areas as shown in Fig. 1. This suggests that the North Pacific surplus males segregate and migrate into these waters from most areas, even if there are some stock units. As the surplus males of all stock units intermingle in these waters at least in summer, it is difficult to separate the males in these waters into each stock unit, and the separation of stock areas by use of catch distribution of males is impossible.

On the contrary, four main whaling grounds may be recognized from the catch distribution of females: (25°N–35°N, 170°E–165°E), (40°N–65°N, 165°E–180°), (40°N–50°N, 150°W–125°W) and (50°N–60°N, 160°W–135°W). Former two and latter two grounds seems to be able to combine with each other, respectively, and these two groups will be separated by a longitudinal boundary of 165°W–160°W.

This phenomenon becomes more clear, when sex ratios of the sperm whale catch are calculated by 5° squares as shown in Fig. 3. The distribution of squares where 90% and over are males divide the catch distribution into west and east in the broad central area.

Movements of marked whales

Figs. 4 and 5 show the movements of male and female sperm whales which were marked and recovered during years 1949–75. In the case of males, they moved very long distances in the North Pacific, and intermingle with each other in the central part. On the other hand, there are not so many examples of long movement in the females. Many female sperm whales were marked in the waters adjacent to Japan, but no whales have been recovered in the eastern waters of the North Pacific.

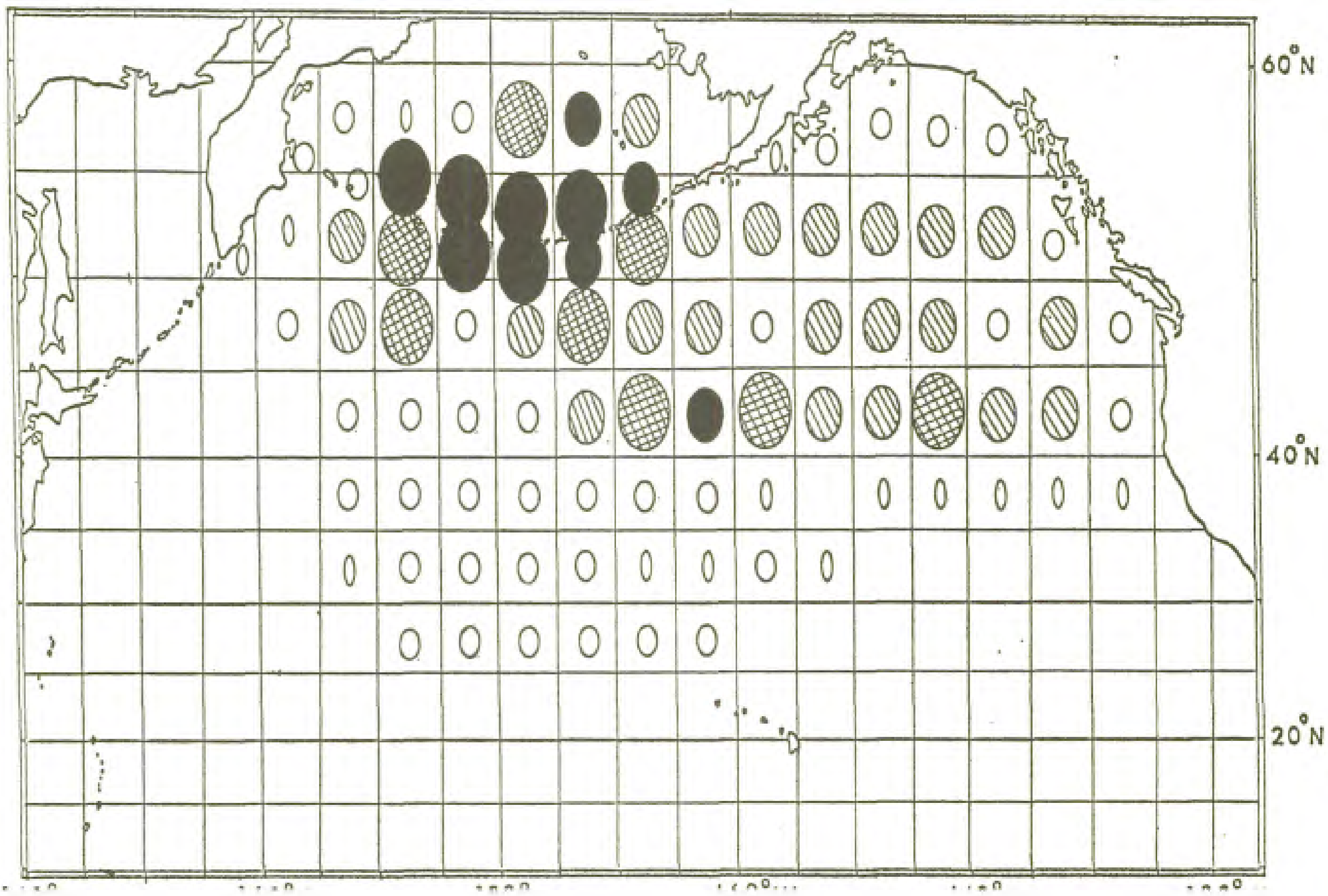
CPUE

Fig. 6 shows the longitudinal distribution of CPUE of females which were caught by Japanese pelagic whaling from 1966 to 1975. The density to the west of 160°W is clearly different from that in the waters east of 160°W. This suggests the existence of two different stocks.

Pregnancy rate

Fig. 7 shows the average pregnancy rate of the sperm whale in each area. There are two year classes of the foetus between conception and parturition seasons, so that year class of foetus must be separated to calculate the true pregnancy rate. In the present paper, we separated the foetuses which were fertilized in one year from those in the previous year by use of distribution of size of foetuses in each decade. Thus the ratio of pregnant females of which foetuses were fertilized in one year to the total sexually mature females which were determined by examination of ovaries was calculated in each area. It represents a true pregnancy rate.

The pregnancy rates in Areas IV and V are the same as each other (19.8%), but those in Areas II and III are 16.1% and 14.8%, respectively. This phenomenon also suggests the possibility that two stocks are divided at 160°W, and the higher value of pregnancy rate in western stock represents the longer history of exploitation than the eastern stock.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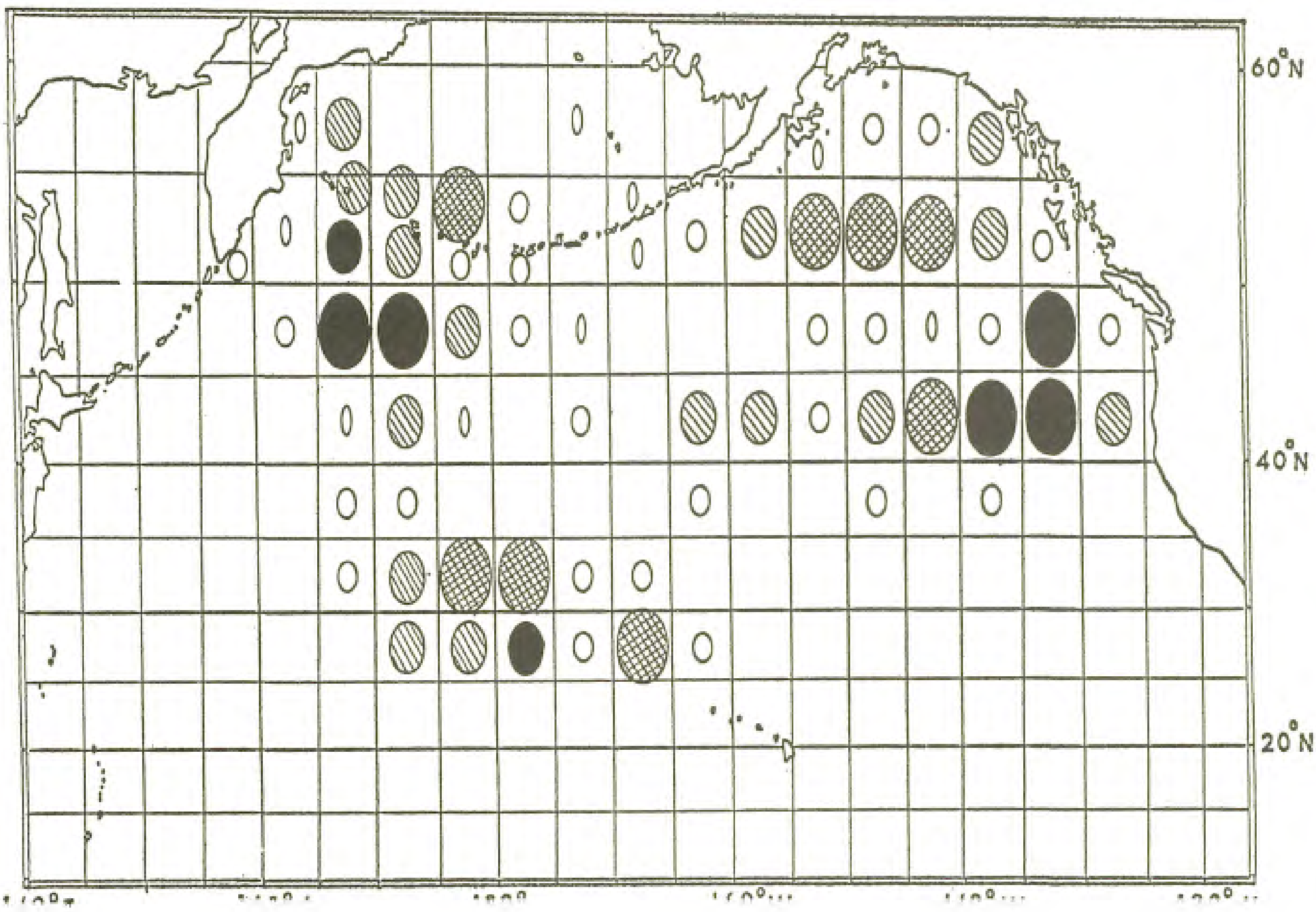
40°N
20°N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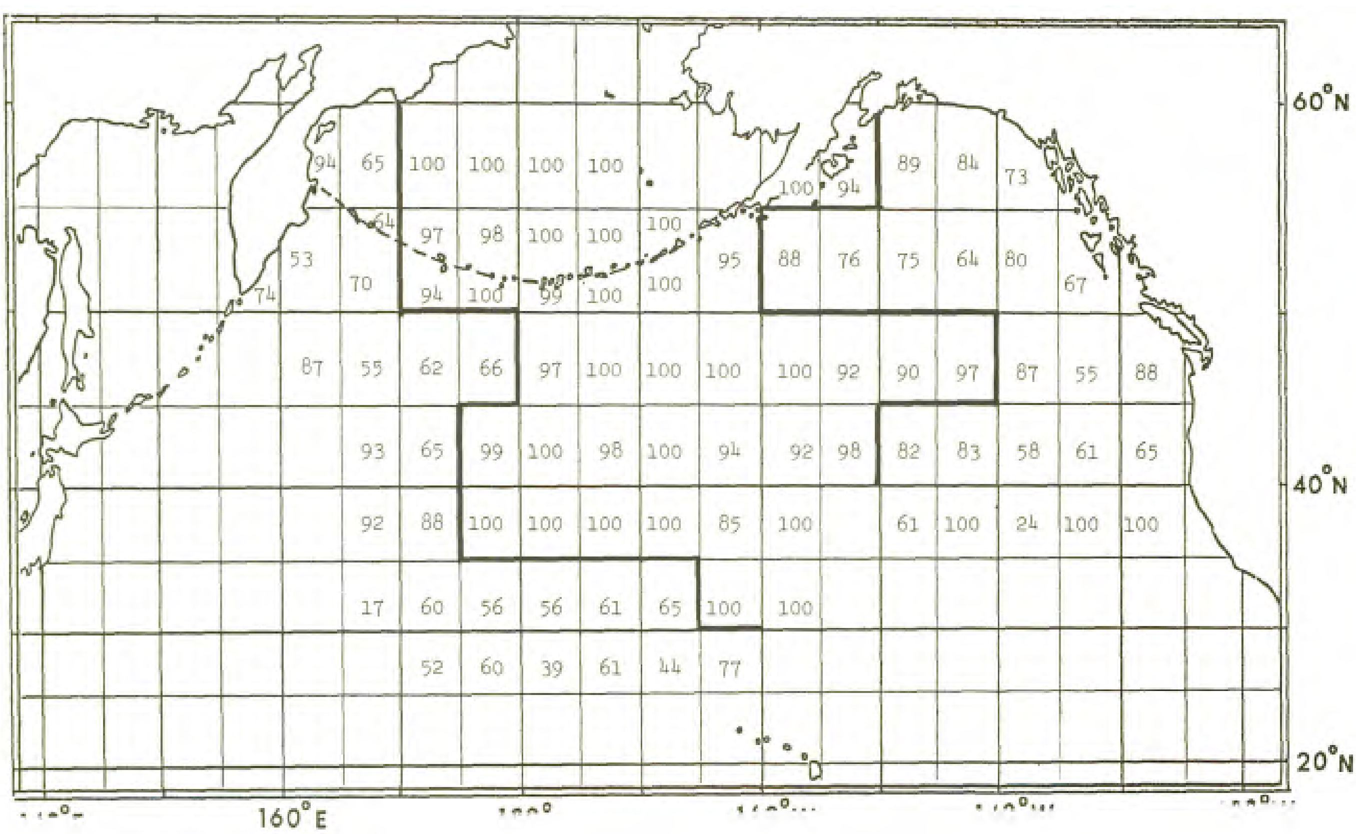

60°N
40°N
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160°E
94 65 100 100 100 100 100 94 89 84 73
97 98 100 100 100 64
53 70 74 94 100 99 100 100 95 88 76 75 64 80 67
87 55 62 66 97 100 100 100 100 92 90 97 87 55 88
93 65 99 100 98 100 94 92 98 82 83 58 61 65
92 88 100 100 100 100 85 100 61 100 24 100 100
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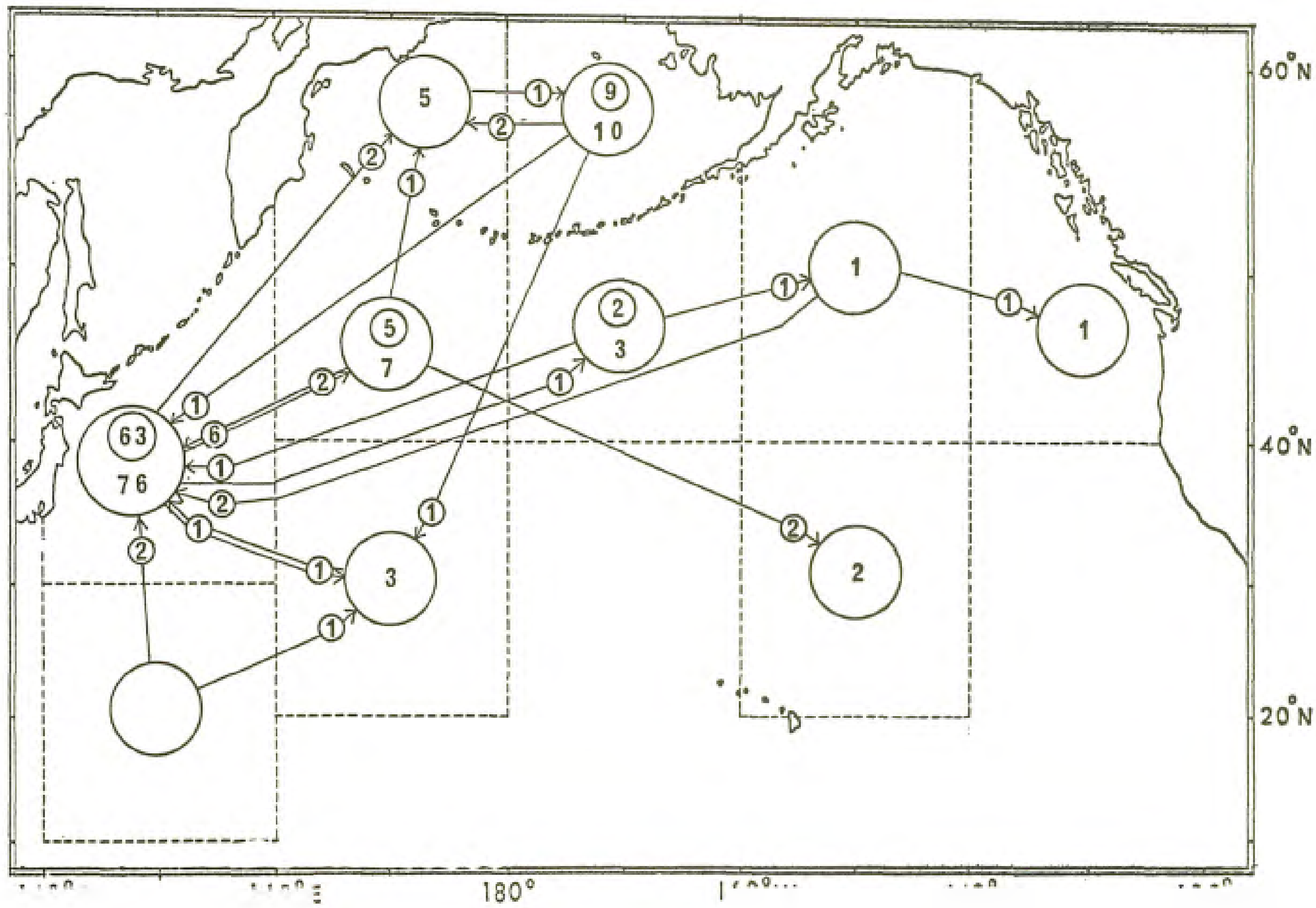
52 60 39 61 44 77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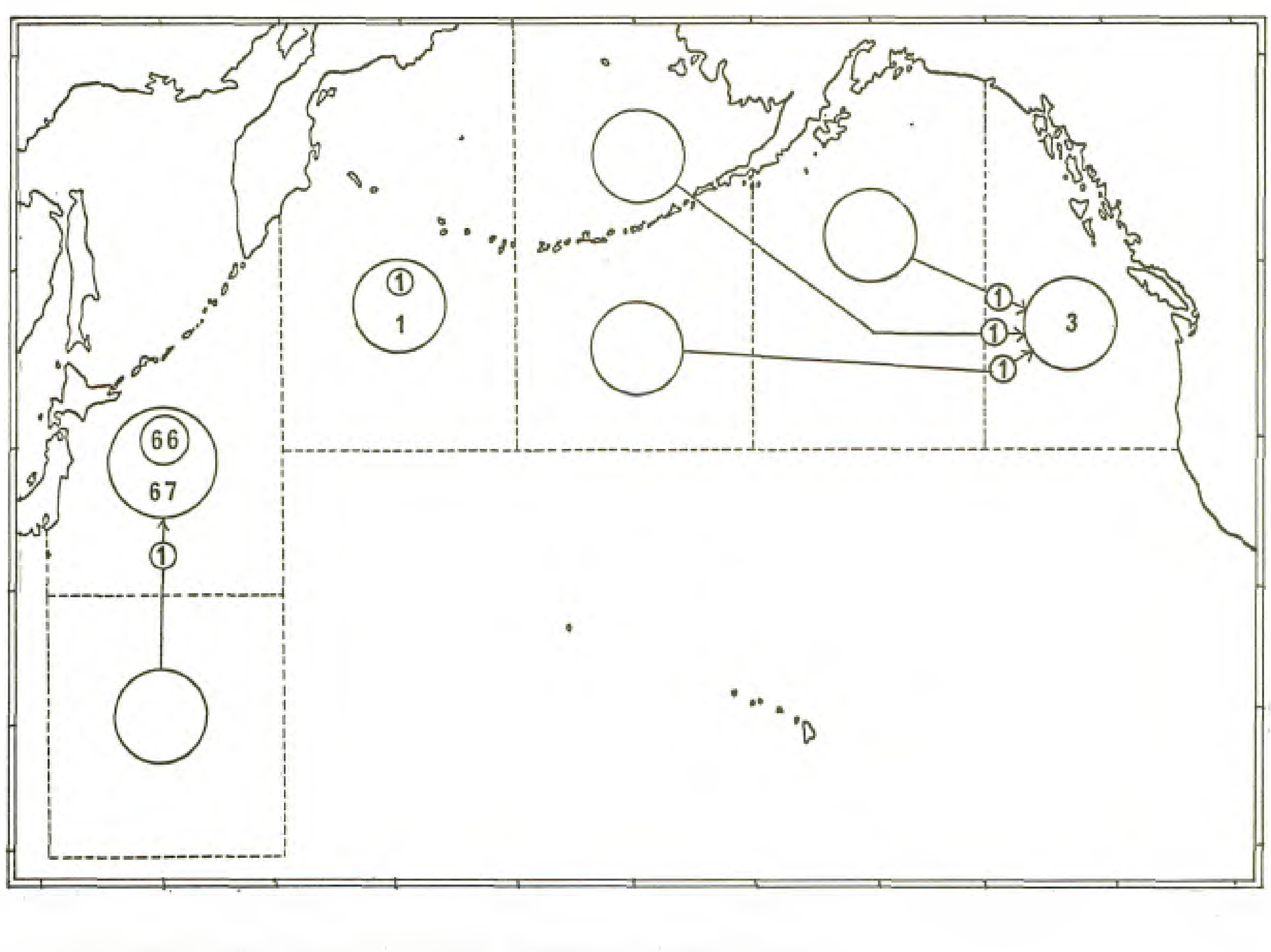
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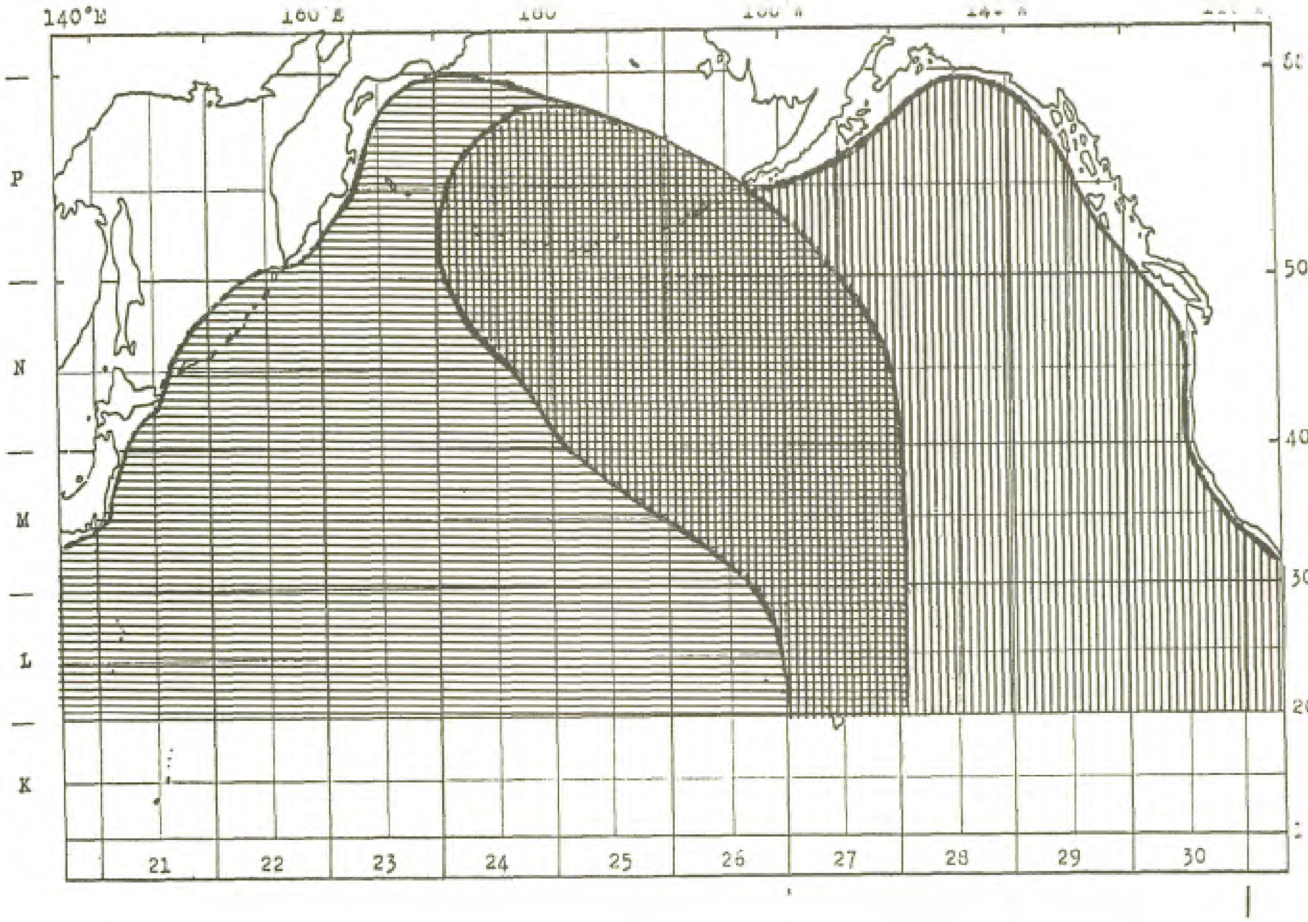
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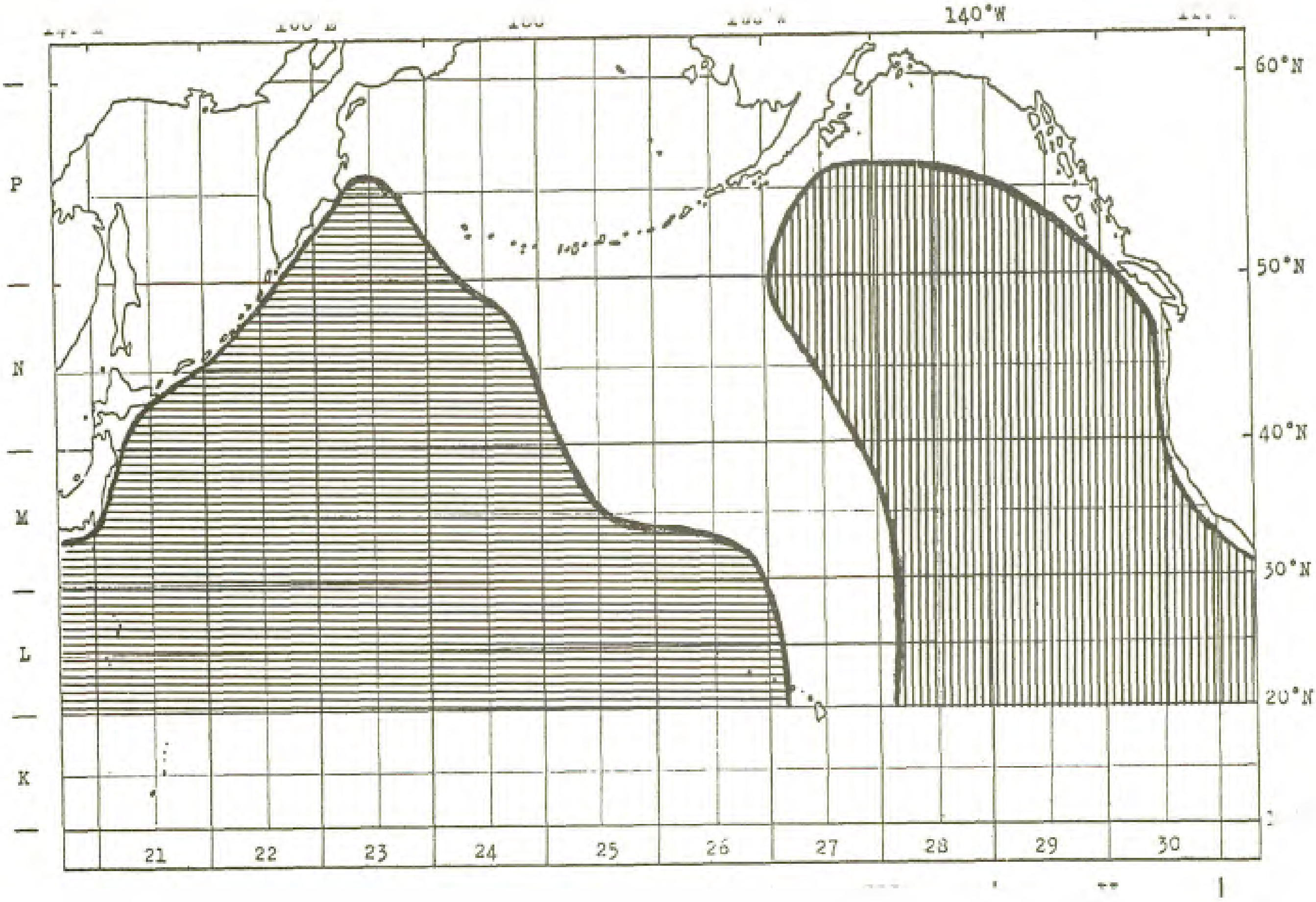
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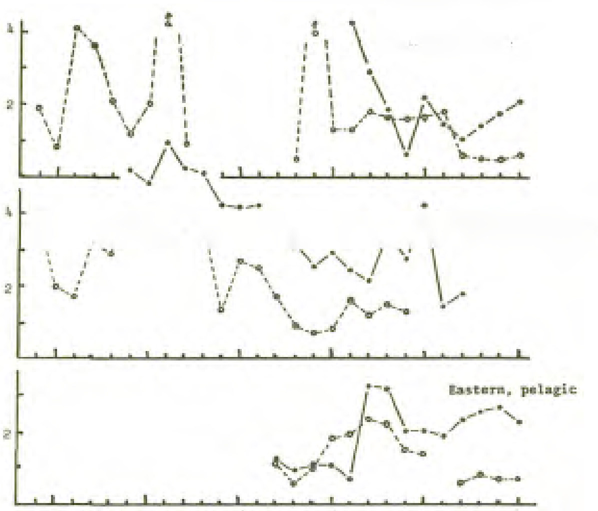
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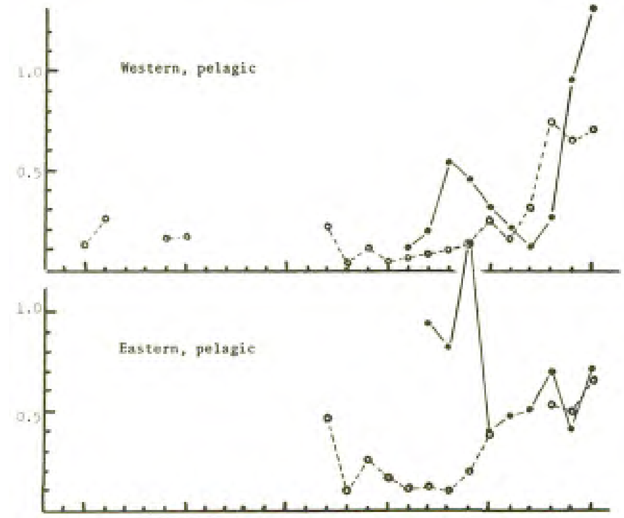
2
4
2
Eastern, pelagic
2


1.0
Western, pelagic
0.5
1.0
Eastern, pelagic
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females. Then, the MSY of male population will be 3,910–5,750 in the North Pacific as a whole.

As examined in the previous chapter, the recent catch of the sperm whale in the North Pacific has not influenced the level of CPUE. This feature will also support the view that the recent catch level can be maintained in the near future.

The population assessment of males by each stock unit is urgently needed for more rational management, though it is very difficult.

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SC/28/Doc 23

Estimates of Stock Size for the North Pacific Bryde's Whale

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Although the identity of the North Pacific Bryde's whale, *Balaenoptera edeni*, eluded scientists until 1952, Omura (1974) indicated that it undoubtedly had been taken by Japanese coastal whalers for over 200 years. Initial assessments of this population were based upon analyses of increased catches from land stations after World War II as well as from early Japanese pelagic whaling around the Bonin Islands. In their review of Japanese research in the North Pacific, Omura and Ohsumi (1974) indicated a stock size of 5,000–18,000 from which a yield of 300–600 Bryde's whales could be taken safely. Ohsumi (1974) later treated this population as two stocks and, utilizing mark-return data, estimated that the coastal stock (west of 150°E) contained 10,000 whales while the pelagic stock (east of 150°E) contained 10,000–20,000. He further noted that the total population of 20,000–30,000 would sustain a maximum yield of 500–1,050.

Since the time of Ohsumi's (1974) estimates, another year of pelagic data has become available. Thus, the purpose of this paper was to utilize this new information and refine the estimates of size and sustainable yield for the pelagic stock. Additionally, the coastal data were re-analyzed utilizing Tillman's (1974) approach of formulating indices of stock abundance based upon latitudinal statistical zones in the North Pacific.

CATCH PER UNIT EFFORT DATA

Following Ohsumi (1974), the North Pacific Bryde's whale was treated as two separate stocks, coastal and pelagic, divided at 150°E longitude. Omura (1974) reviewed the evidence for sub-dividing the population in this manner. The coastal stock area thus extends west of 150°E and includes waters surrounding the Bonin Islands and the east coast of Japan. Pelagic catches between 150°E and 150°W longitude currently are limited to waters north of 20°N latitude. Since the Bryde's whale is known to occur in tropical waters south of the current limit (Ohsumi, 1974), a portion of the pelagic stock probably is not being harvested.

Coastal stock data

Table 1 lists catches of Bryde's whales taken from each statistical zone of the coastal stock area during 1946–75. The catches from pelagic whaling around the Bonin Islands during 1946–52 were presumed to be Bryde's whales. According to Ohsumi (1974), 1955 was the first year that an accurate account was kept of Bryde's whale catches at land stations. Thus, 1955–75 was used as the basis for analyzing the coastal stock.

During the study period, most of the catch of this species came from Zone M. Thus, catch and effort data for this zone were used to develop indices of abundance for the coastal stock. Following Ohsumi (1974), effort in terms of catcher-days work (CDW) was adjusted by average horsepower to account for annual changes in efficiency. Table 2 gives catches, effort in CDW, and the horsepower adjusted catch per unit efforts (CPUE) for Zone M.

Table 1

Catch of Bryde's whales by statistical zone from the Coastal Stock Area (West of 150°E)

	Catch by Zone			
Year	L	M	N	Total
1946	29	42	–	71
1947	150	9	–	159
1948	105	2	–	107
1949	116	27	–	143
1950	243	–	–	243
1951	280	–	–	280
1952	411	1	–	412
1953	–	46	1	47
1954	–	2	–	2
1955	–	93	2	95
1956	–	23	4	27
1957	–	43	–	43
1958	–	301	–	301
1959	–	304	1	305
1960	–	401	6	407
1961	–	172	–	172
1962	–	499	5	504
1963	–	206	4	210
1964	–	71	3	74
1965	–	8	–	8
1966	–	63	–	63
1967	–	63	–	63
1968	–	170	1	171
1969	–	86	3	89
1970	–	73	–	73
1971	–	167	5	172
1972	–	121	4	125
1973	–	71	–	71
1974	–	180	7	187
1975	–	115	1	116

Although fluctuations occur in the Zone M CPUE data, a peak is seen during 1958–62 followed by a rapid decline between 1963–67. This downward trend apparently was associated with increased catches occurring between 1958–63 at an average of 315 per year. Smoothing the CPUE data with running averages of three gave Fig. 1, which brings out the observed downward trend. It also points out that the stock apparently has stayed at a constant level for the past 12 years (discounting 1965–66 when catches were quite small). Catches for the last 9 years of this period of stability have averaged 120 Bryde's whales per year.

Table 3

Pelagic catch by national fleet of fin, sei and Bryde's whales in 3 statistical zones of interest and in total overall.

		Japan			USSR			
Year	Species	L	M	N	L	M	N	Total pelagic
1970	Fin	–	–	286	–	–	412	930
	Sei	–	–	3,071	–	–	781	4,015
	Bryde's	–	–	–	–	–	66	66
1971	Fin	–	–	335	–	–	190	732
	Sei	–	–	2,287	–	15	281	2,715
	Bryde's	–	–	109	–	638	–	747
1972	Fin	–	9	215	–	1	240	676
	Sei	–	803	1,221	–	25	44	2,112
	Bryde's	–	5	–	–	71	–	76
1973	Fin	–	4	195	–	1	155	417
	Sei	–	613	1,089	–	22	81	1,813
	Bryde's	–	2	–	526	125	–	653
1974	Fin	–	9	179	–	23	78	389
	Sei	–	346	837	–	13	25	1,231
	Bryde's	7	515	–	344	310	–	1,176
1975	Fin	–	3	80	–	9	24	151
	Sei	–	197	252	–	17	7	478
	Bryde's	192	495	1	561	68	–	1,317

Table 4

Catch and effort for Bryde's whales taken by pelagic vessels in two statistical zones and combined.

		Catch			CDW		
Year	Country	L	M	L & M	L	M	L & M
1971	Japan	–	–	–	–	–	–
	USSR	–	638	638	–	1,577	1,577
1972	Japan	–	5	5	–	654	654
	USSR	–	71	71	–	755	755
1973	Japan	–	2	2	–	572	572
	USSR	526	125	651	633	1,924	2,557
1974	Japan	7	515	522	14	637	651
	USSR	344	310	654	909	1,892	2,801
1975	Japan	192	495	687	193	714	907
	USSR	561	68	629	1,583	1,434	3,017

Table 5

Average tonnage of pelagic vessels taking Bryde's whales.

Year	Japan	USSR
1971	–	843
1972	712	844
1973	737	843
1974	745	844
1975	745	844

Table 6

Catch per unit effort, adjusted for tonnage, for Bryde's whales taken pelagically.

	Japan			USSR		
Year	L	M	L & M	L	M	L & M
1971	–	–	–	–	0.48	0.48
1972	–	0.01	0.01	–	0.11	0.11
1973	–	0.01	0.01	0.99	0.08	0.30
1974	0.67	1.09	1.08	0.45	0.19	0.28
1975	1.34	0.93	1.02	0.42	0.08	0.25

Table 7

Coastal data used to fit the modified DeLury model.

Year	Smoothed CPUE	Adjusted cumulative catch
1959	1.21	152.5
1960	.99	484.1
1961	1.23	718.6
1962	.96	992.2
1963	.85	1,249.7
1964	.31	1,283.3

Table 8

Pelagic data used to fit the modified DeLury model.

Year	CPUE	Adjusted cumulative catch
1973	0.30	326.5
1974	0.28	1,188.8
1975	0.25	2,293.1

stock of large cetaceans was in general about 0.04, assuming $F = r - M$. Since the coastal Bryde's whale stock has had a long history of exploitation, this same value might very well apply. If so, $\bar{N}$ is estimated as 3,000 (since $\bar{N} = C/F$) and would be the equilibrium stock size during 1964–75.

It should be emphasized that the above estimate is speculative in nature. Nevertheless, that a decline in CPUE occurred following average catches of only 315 animals and that abundance apparently has remained constant while recent catches averaged 120 suggests that this stock is numerically small. Consequently, one might best consider the above estimate to be a minimum.

In determining permissible yields for the coastal stock, the important consideration is that the recent average catch of 120 Bryde's whales apparently has given rise to a stable situation. Thus, the prudent course of action would be to classify this stock as a Sustained Management Stock and to set the catch limit at the present average of 120 as provided for in Section 6 (a) of the Schedule.

Pelagic stock size

Equation (1) was fitted to the data given in Table 8. It should be noted that only the 1973–75 series of Soviet combined Zone L and M CPUEs were used since the combined Japanese data were too few to fit a regression relation. The model gave the following results:

$$a = 0.30904$$
$$\hat{q} = -b = 2.5504 \times 10^{-5}$$
$$\hat{N}_{1973} = a/b = 12{,}120$$

Equation (2) gave $\hat{N}_{1973} = 12{,}095$. The regression relation obtained was highly significant having a calculated $t = 22.59$.

The above estimates support Ohsumi's (1974) previous estimate of 10,000, or more, for this stock. Based upon the larger value, one might extrapolate to 1970 and 1976 using the total pelagic catches from Table 3 and the following recursion formula (Tillman, 1974):

$$N_i = (N_{i-1} - C_{i-1})(1 - M) + M\hat{N}_{73}.$$

The following results were obtained:

1970	13,100
1973	12,100
1976	9,400

If it is assumed that the MSY level occurs at 60% of the initial level (IWC 1976b), then the MSY level for this stock would be 7,860.

However, one should recall that a portion of the pelagic stock resides in more southern, tropical waters. Thus, the above extrapolations should be considered minimum values since they do not account for this unknown segment. Until further information is obtained concerning the size of this southern segment, estimating sustainable yields for the total pelagic stock will be problematical. Until more data become available, the above estimates do suggest that the stock is still an Initial Management Stock, and a prudent course of action would be to harvest no more than 5% of the 1973 estimate, 600 Bryde's whales, as provided for in Section 6 (b) of the Schedule.

CONCLUSIONS

The analysis of CPUE data in this paper provided a minimum estimate of abundance for the exploitable Bryde's whale population of at least 15,000. This number was allocated to the two stock areas as follows:

Coastal (West of 150°E)	3,000
Pelagic (East of 150°E)	12,000

Due to its long history of exploitation and the recent 12 year period of stability, the coastal stock probably should be classified as a Sustained Management Stock. Since exploitation of the pelagic stock has not yet affected it significantly, it should probably be classified as an Initial Management Stock. Given these classifications, the following catch limits should be allowed for each:

Coastal: Recent average catch	120
Pelagic: 5% of exploitable stock	600
	720

When new data became available, particularly with respect to the number of Bryde's whales in more southern pelagic waters, these values should be reviewed.

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SC/28/Doc 25

Estimates of Stock Size for Exploitable North Pacific Male Sperm Whales

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Previous estimates of abundance for male North Pacific sperm whales, *Physeter macrocephalus,* utilized indices of abundance for the total population. Ohsumi and Fukuda (1972) estimated the initial population of male sperm whales to be 167,000 in 1910 with a current size of 69,000 in 1971. In an update of their 1972 analysis, Ohsumi and Fukuda (1974) utilized biological parameters derived at the Parksville Meeting (IWC, 1973) to estimate 195,000 exploitable males in 1910 with 90,900 in 1973. Their latter estimates assumed that the original (1910) population of mature females was 250,000.

However, Tillman (1977) reviewed the evidence for dividing the North Pacific population into three stock areas and suggested a scheme for allocating catches and efforts to each for assessment purposes. The purpose of the present study was to estimate the initial and current numbers of exploitable males in each of the suggested stock areas based upon analyses of catch per unit effort (CPUE) data and age-length data.

CATCH PER UNIT EFFORT DATA

Utilizing the scheme of Tillman (1977), catch, effort, and length distribution data (NP1, NP2, and NP3 data forms) exchanged by the North Pacific Working Group were allocated by stock area. The Western Stock included Japanese coastal whaling, the Central Stock incorporated most pelagic whaling by Japan and the USSR, while the Eastern Stock included Canadian and American coastal whaling as well as some pelagic whaling by Japan and the USSR.

In developing indices of abundance from catch and effort data, coastal effort was defined as total catcher-days work (CDW) for those land stations at which sperm whales were taken. Pelagic effort for Japanese operations was defined as total CDW for sperm whales while that for Soviet operations as total CDW for all species.

Although sperm whales were subject to exploitation by coastal operations in the Western Stock area prior to World War II, harvest of this population did not become significant until after the war. Heavy exploitation of the Western Stock began in 1948, of the Central Stock in 1954, and of the Eastern Stock in 1962. The stock levels in these years were assumed to be the initial sizes for each area.

In each stock area, a southward shift of harvesting effort apparently occurred through the years. Consequently, indices of abundance were formulated by latitudinal zone to account for this shift in emphasis. For a given stock, representative CPUEs were assumed to be those derived from the latitudinal zone in which the majority of the national fleet's catch of male sperm whales was taken. The catch and effort data used are given in Tables 1–3. CPUEs were corrected by average catcher tonnage to account for annual improvements in catcher efficiency.

To validate estimates derived for stocks individually, an analysis of the total population was also undertaken. In this case, only the total pelagic data were used to derive CPUEs, i.e., total pelagic catch divided by total pelagic effort (total sperm effort for Japanese whaling, total all species for Soviet whaling). These data are given in Table 4.

It should be noted that CPUEs beyond 1972 were not used in any analysis. This was done to account for the change in minimum length of sperm whales from 40 to 35 ft. (35 to 30 ft. for coastal whaling), which occurred in 1973 in the North Pacific. This measure also accounted for operational difficulties induced by changing worldwide economic conditions after 1972.

MODIFIED DELURY ASSESSMENT

During the period between the onset of exploitation of each stock and the start of the 1972 season, it might be assumed that recruitment into each occurred at the equilibrium level produced while in an unexploited state. This situation can be assumed since the average age at recruitment of male North Pacific sperm whales, estimated to be 20 years for pelagic whaling and 15 for coastal (IWC, 1973), exceeds the period of exploitation. This assumption is poor, however, for the Western Stock since it was exploited at moderate levels prior to World War II.

Given the above assumption and using the natural mortality rate $M = 0.05$ (IWC, 1977), it is possible to estimate initial stock sizes and q, the catchability coefficient, with the modified DeLury model (Chapman, 1974; Tillman and Breiwick, 1977). This model generally relates CPUEs to catch removals and constant recruitments by means of simple linear regression techniques, the estimates being derived from the regression coefficients (a, b):

$$\hat{q} = -b$$

$$\hat{N}_0 = a/\hat{q}$$

A direct estimate of stock size during season i can also be obtained using the estimated q and the appropriate CPUE:

$$\hat{N}_i = U_i/\hat{q} + 1/2\, C_i \qquad (1)$$

Western Stock

Only the 1966–72 Soviet zone N CPUE data (Table 1) gave

Table 1

Total catches and catch-effort data for the Western Stock of male sperm whales. TCM = total catch males, CM = catch males, E = effort in catcher days, M = average catcher tonnage.

		Sov. Pel. Zone N			Jap. Coast. Zone M			Jap. Coast. Zone N		
Year	TCM	CM	E	M	CM	E	M	CM	E	M
1948	1,332	–	–	–	–	–	–	–	–	–
1949	2,014	–	–	–	309	2,265	240	128	921	240
1950	2,541	–	–	–	276	1,664	298	544	1,868	298
1951	2,587	–	–	–	534	2,061	310	390	1,643	310
1952	2,345	–	–	–	351	1,854	320	334	1,802	320
1953	2,761	–	–	–	332	1,706	335	478	1,761	335
1954	2,648	–	–	–	435	1,614	355	509	1,834	355
1955	2,704	–	–	–	400	1,390	345	468	1,583	345
1956	3,421	–	–	–	451	1,619	401	775	1,768	401
1957	3,323	–	–	–	411	1,566	383	628	1,793	383
1958	4,078	–	–	–	429	1,717	360	810	1,871	360
1959	3,545	–	–	–	397	1,900	362	525	1,545	362
1960	2,702	–	–	–	398	1,852	357	599	1,756	357
1961	2,110	–	–	–	459	2,062	358	520	1,470	358
1962	1,718	–	–	–	217	1,616	370	399	1,470	370
1963	1,749	–	–	–	317	1,406	408	443	1,191	408
1964	2,492	–	–	–	330	1,577	372	618	1,041	372
1965	1,685	512	399	780	–	–	–	–	–	–
1966	2,897	1,306	724	845	–	–	–	–	–	–
1967	3,934	2,330	1,372	845	–	–	–	–	–	–
1968	3,288	1,444	1,220	844	–	–	–	–	–	–
1969	3,159	780	751	844	–	–	–	–	–	–
1970	2,334	432	385	844	–	–	–	–	–	–
1971	2,527	473	429	844	–	–	–	–	–	–
1972	1,713	212	244	844	–	–	–	–	–	–
1973**	1,271	–	–	–	–	–	–	–	–	–
1974	1,253	–	–	–	–	–	–	–	–	–
1975	1,457	–	–	–	–	–	–	–	–	–

** Size limit changed.

a regression relation having a significant t-test. Fitting the DeLury model gave the following results:

$a = 2.195$
$q = -b = 7.216 \times 10^{-5}$
$S_{y/x} = 0.1686$
$t = 5.58$ (significant for 5 degrees of freedom)
$\hat{N}_{66} = \underline{30{,}420}.$

Assuming $R = M \hat{N}_{66}$, it was possible to extrapolate $\hat{N}_{72} = \underline{15{,}350}$ using the approximate recursion model

$$N_i = (N_{i-1} - C_{i-1})(1 - M) + R. \qquad (2)$$

Forward extrapolation to 1948 was not attempted due to the previously noted problem of assuming constant R for this stock.

The q method, equation (1), gave direct estimates for 1966 and 1972. All results are summarized as follows:

Year	DeLury Method	q Method
1966	30,420	30,965
1972	15,350	15,130

Central Stock

Only the Japanese pelagic CPUE data for zone P (1956–66) and zone N (1967–72) gave a significant regression relation.

Fitting the DeLury model to those values (Table 2) gave the following results:

$a = 5.460$
$q = -b = 6.931 \times 10^{-5}$
$S_{y/x} = 0.6349$
$t = 8.11$ (significant for 15 degrees of freedom)
$\hat{N}_{56} = \underline{78{,}775}.$

Assuming $R = M\hat{N}_{56}$, equation (2) was used to extrapolate N_{54}, the start of exploitation, N_{66}, N_{71}, and N_{72} for comparison with other estimates and other stocks. The above estimated q for Japanese pelagic whaling was applied to appropriate CPUEs to estimate N_{66}, N_{71}, and N_{72}. Assuming that the Soviet pelagic q for the Western Stock also applied to the Central Stock, two more direct estimates of N_{71} were obtained from Soviet pelagic CPUEs given in Table 2. All results are summarized as follows:

Year	DeLury method	DeLury q Japanese Pel. CPUEs	Soviet q Western Stock Soviet Pel. CPUEs Zone N	Zone M
1954	83,455	–	–	–
1956	78,775	90,345	–	–
1966	50,960	50,715	–	–
1971	28,625	27,905	29,130	27,050
1972	25,815	28,680	–	–

Table 2

Total catches and catch-effort data for the Central Stock of male sperm whales.

		Jap. Pelagic[1]			Soviet Pel. Zone P			Soviet Pel. Zone N		
Year	TCM	CM	E	M	CM	E	M	CM	E	M
1948	75	–	–	–	–	–	–	–	–	–
1949	108	–	–	–	–	–	–	–	–	–
1950	81	–	–	–	–	–	–	–	–	–
1951	165	–	–	–	–	–	–	–	–	–
1952	237	–	–	–	–	–	–	–	–	–
1953	377	–	–	–	–	–	–	–	–	–
1954*	490	490	211	448	–	–	–	–	–	–
1955	1,162	1,074	494	458	–	–	–	–	–	–
1956	1,787	1,593	461	557	–	–	–	–	–	–
1957	2,054	1,678	492	611	–	–	–	–	–	–
1958	1,663	1,499	423	650	–	–	–	–	–	–
1959	2,674	1,792	582	661	–	–	–	–	–	–
1960	3,517	1,798	566	676	–	–	–	–	–	–
1961	3,614	1,741	526	679	–	–	–	–	–	–
1962	3,557	2,406	972	690	1,117	697	780	–	–	–
1963	5,024	2,367	952	684	2,364	2,819	780	–	–	–
1964	4,070	2,286	994	693	1,388	2,174	780	–	–	–
1965	6,556	2,267	903	686	1,126	1,499	780	3,143	2,819	780
1966	7,935	2,265	1,041	671	–	–	–	3,340	3,101	845
1967	6,644	1,416	531	668	–	–	–	3,562	2,110	845
1968	6,244	1,413	775	682	–	–	–	3,279	1,786	844
1969	5,324	620	868	703	–	–	–	2,843	1,674	844
1970	7,273	1,636	833	688	–	–	–	2,842	1,755	844
1971	5,597	1,090	886	706	–	–	–	2,146	1,337	844
1972	1,673	562	410	712	–	–	–	–	–	–
1973**	2,130	–	–	–	–	–	–	–	–	–
1974	2,322	–	–	–	–	–	–	–	–	–
1975	2,319	–	–	–	–	–	–	–	–	–

[1] 1954 – 66 Zone P CPUEs
1967 – 72 Zone N CPUEs

* Significant exploitation began.
** Size limit changed.

The estimates for 1954–56 indicate an initial size in the vicinity of 80–90,000. The intermediate estimates for 1966 are in good agreement. The recent estimates for 1971–72 all indicate a current size of about 28,000.

Eastern Stock

Only the 1967–70 Soviet zone N CPUEs (Table 3) gave a significant regression relation. Fitting the DeLury model gave the following results:

$a = 2.653$
$q = -b = 17.014 \times 10^{-5}$
$S_{y/x} = 0.1730$
$t = 5.41$ (significant for 2 degrees of freedom)
$\hat{N}_{67} = \underline{15{,}590}$

Assuming $R = M\hat{N}_{67}$, extrapolated values were obtained for N_{62}, the first year of exploitation, N_{66}, N_{70}, and N_{72}. The q method, equation (1), was used to obtain direct estimates of N_{67} and N_{70}. The results are summarized as follows:

		q Method	
	DeLury	Soviet Pelagic CPUEs	
Year	method	Zone N	Zone M
1962	26,490	–	–
1966	17,730	–	–
1967	15,590	15,015	15,190
1970	7,950	7,985	–
1972	8,130	–	–

The intermediate values for 1966–67 are in good agreement so that extrapolation to 1962, the initial year of exploitation, is probably reasonable. Recent estimates (1970–72) indicate a current size of about 8,000.

Total Male Population

In this case only the 1956–72 Japanese pelagic CPUE data (Table 4) gave a significant regression relation. Results of fitting the DeLury model were

$a = 5.340$
$q = -b = 3.4405 \times 10^{-5}$
$S_{y/x} = 0.5850$
$t = 7.83$ (significant value for 15 degrees of freedom)
$\hat{N}_{56} = \underline{155{,}210}$.

Assuming $R = M\hat{N}_{56}$, values were extrapolated for N_{48}, the start of exploitation, N_{54}, N_{66}, and N_{72}. The estimated q was also used to obtain direct estimates of N_{56}, N_{66}, and N_{72} from appropriate Japanese pelagic CPUEs. The results are summarized as follows:

Year	DeLury Method	q Method
1948	183,195	–
1954	162,955	–
1956	155,210	173,275
1966	100,770	97,170
1972	57,375	60,440

The intermediate values (1954–56) suggest a population size of 160,000, so that extrapolation to an initial size in

Table 3

Total catches and catch-effort data for the Eastern Stock of male sperm whales.

		Soviet Pel. Zone N			Soviet Pel. Zone P		
Year	TCM	CM	E	M	CM	E	M
1948	60	–	–	–	–	–	–
1949	97	–	–	–	–	–	–
1950	40	–	–	–	–	–	–
1951	163	–	–	–	–	–	–
1952	122	–	–	–	–	–	–
1953	268	–	–	–	–	–	–
1954	215	–	–	–	–	–	–
1955	304	–	–	–	–	–	–
1956	116	–	–	–	–	–	–
1957	161	–	–	–	–	–	–
1958	84	–	–	–	–	–	–
1959	231	–	–	–	–	–	–
1960	14	–	–	–	–	–	–
1961	83	–	–	–	–	–	–
1962*	708	–	–	–	413	378	780
1963	1,996	–	–	–	1,384	2,417	780
1964	1,777	–	–	–	1,181	1,802	780
1965	2,998	1,639	903	780	1,060	1,037	780
1966	2,138	1,015	572	845	857	472	845
1967	2,406	1,227	618	845	737	366	845
1968	3,187	2,767	1,499	844	–	–	–
1969	2,845	2,022	1,684	844	–	–	–
1970	1,629	873	845	844	–	–	–
1971	303	–	–	–	–	–	–
1972	646	–	–	–	–	–	–
1973**	1,204	–	–	–	–	–	–
1974	844	–	–	–	–	–	–
1975	485	–	–	–	–	–	–

*Significant exploitation began.
**Size limit changed.

1948 of 180–185,000 seems reasonable. This estimated initial range is also in agreement with the values reported by Ohsumi and Fukuda (1972; 1974). The 1972 estimates are quite close, as are those for 1966, and indicate a current population of about 60,000.

Comparison of Totals

Estimates of the three stocks were averaged where appropriate, then summed and compared to the estimated total population for validation purposes. Of particular concern were the estimates derived for the Western Stock since the recruitment assumption of the DeLury analysis may not apply to it, i.e., due to exploitation prior to World War II, recruitment after the war may have been affected in a compensatory manner rather than remain constant. The results are summarized as follows:

Year	Western	Central	Eastern	Sum of stocks	Estimated total
1966	30,695*	50,840*	17,730	99,265	98,970*
1972	15,240*	27,250*	8,130	50,620	58,910*

*Average of DeLury and q methods.

Agreement between the sum of stock sizes and the estimated total is quite good in 1966 with about 100,000 indicated. The agreement is not as good in 1972, though the estimated total is only 16% greater than the sum of the individual stocks. Since exploitation of the Western Stock began prior to 1948, it is unlikely that a constant rate of recruitment (r) of 0.05 was still in effect during 1966–72. This factor may account for the above difference between the sum and estimated total for 1972. Intuitively one might expect a higher value of r and, consequently, lower estimates of stock size than indicated by a DeLury analysis.

VARIABLE RECRUITMENT RATE ANALYSIS

The computer programs developed by Allen (1966; 1977) were utilized to examine the question of variable recruitment rates. Japanese and Soviet male sperm whale length-frequencies were combined for each of the three stocks and cumulative age distributions and the proportion of new recruits in the catch then calculated for each year using a refined North Pacific male sperm whale age-length key from Ohsumi (1977). The estimated proportions of new recruits were obtained using a value of T = 1.0 (the ratio of the survival rate of the recruited part of the younger year classes to that of the older animals) and also using a value estimated by the computer program.

Stock sizes were estimated for the same periods as before using Allen's Least Squares Model. Given annual recruitment rates and a value of M, this routine solves for the initial population size and catchability coefficient which minimize the sums of squares of differences between actual and expected catches. A value of 20 was used as the age at full recruitment. Constant recruitment rates of r = M = 0.05 and the average of the yearly recruitment rates (T = 1.0) were also used to estimate stock sizes. These estimates, as well as the previous DeLury estimates, are presented in Table 5.

Table 4

Total catches and catch-effort data for the North Pacific population of male sperm whales.

		Jap. Total Pelagic			Soviet Total Pelagic		
Year	TCM	CM	E	M	CM	E	M
1948	1,467	–	–	–	–	–	–
1949	2,219	–	–	–	–	–	–
1950	2,662	–	–	–	–	–	–
1951	2,915	–	–	–	–	–	–
1952	2,704	–	–	–	–	–	–
1953	3,076	–	–	–	–	–	–
1954	3,353	490	211	448	–	–	–
1955	4,170	1,080	498	458	–	–	–
1956	5,324	1,593	487	557	–	–	–
1957	5,538	1,700	509	611	–	–	–
1958	5,825	1,499	423	650	–	–	–
1959	6,046	1,798	589	661	–	–	–
1960	6,233	1,798	566	676	–	–	–
1961	5,807	1,765	556	679	–	–	–
1962	5,983	2,540	1,119	690	1,614	1,233	780
1963	8,769	2,692	1,300	684	4,558	5,935	780
1964	8,339	2,443	1,197	693	4,575	5,465	780
1965	11,239	2,434	1,078	686	7,652	6,858	780
1966	12,970	2,832	1,351	671	8,967	7,033	845
1967	12,984	2,665	1,217	668	8,936	5,659	845
1968	12,739	2,415	1,119	682	9,031	5,554	844
1969	11,328	2,015	1,507	703	7,425	5,689	844
1970	11,236	2,353	1,160	688	7,238	5,355	844
1971	8,427	1,517	1,200	706	5,052	3,351	844
1972	4,032	1,342	937	712	1,311	2,599	844
1973**	4,605	1,442	770	737	2,046	3,934	844
1974	4,419	1,342	651	741	1,883	4,068	844
1975	4,261	1,222	577	745	1,768	3,377	844

**Size limit changed.

Table 5

North Pacific male sperm whale stock estimates by area, year and method.

			Variable recruitment		Constant recruitment	
Stock	Year	DeLury	T estimated	T = 1.0	Ave. r[1]	r = M = .05
					r = .14	
Western	*$\hat{N}_{66}$	30,420	17,604 (.97)[2]	16,091 (.97)	14,611 (.98)	24,515 (.98)
	$\hat{N}_{72}$	15,350	6,308	4,722	6,558	9,538
					r = .06	
Central	$\hat{N}_{54}$	83,455	120,610	72,371	61,881	73,806
	*$\hat{N}_{56}$	78,775	116,181 (.97)	73,558 (.53)	61,663 (.56)	72,286 (.60)
	$\hat{N}_{72}$	25,815	29,348	9,079	13,212	19,784
					r = .08	
Eastern	$\hat{N}_{62}$	26,490	21,377	19,992	20,759	24,575
	*$\hat{N}_{67}$	15,590	14,318 (.98)	13,848 (.98)	12,094 (.97)	13,809 (.97)
	$\hat{N}_{72}$	8,130	6,432	6,272	5,512	6,197
					r = .05	*r = .06*
Total stocks	$\hat{N}_{48}$	183,195			204,862	162,840
	*$\hat{N}_{56}$	155,210			179,261	152,257
	$\hat{N}_{72}$	57,375			83,108	72,921

[1] Average recruitment rate for T = 1.0.

[2] R value (see text).

*Year for which estimate applies – other values are extrapolations.

As a measure of the goodness of fit of the model, the proportion of the variation in catches accounted by the model was calculated (Pella and Tomlinson, 1969):

$$R = \frac{\Sigma(C-\bar{C})^2 - \Sigma(C-\hat{C})^2}{\Sigma(C-\bar{C})^2}$$

where R is an analogue of the correlation coefficient of regression theory.

Western Stock

The two estimates using variable recruitment rates agree well, though they are considerably lower than the DeLury estimate of 30,420. The average recruitment rate was relatively high ($r = 0.14$) and gave an even lower estimate of stock size. These results would seem to confirm that a value of 0.05 for r is too low for this stock. Nevertheless, the constant recruitment model with $r = M = 0.05$ also has a high goodness of fit. The difference between the DeLury estimate with $r = 0.05$ and Allen model with the same rate is due to the minimization criteria used by each: CPUEs versus catches. The averages of the four Allen model estimates from Table 5 are $N_{66} = 18{,}205$ and $N_{72} = 6{,}780$.

Central Stock

The three Allen model estimates with $T = 1.0$, average $r = 0.06$, and $r = 0.05$ are in fair agreement, but the R values are quite low–less than 60% of the variation in catches is explained by the model. Although giving a significantly higher initial estimate than the DeLury model, the Allen model with estimated value of T appears to be most satisfactory due to its high R value. The extrapolated 1972 value of this estimate is 14% greater than that for the DeLury model.

Eastern Stock

The Allen model estimates are all in good agreement with each other and averaging gives $N_{62} = 21{,}675$, $N_{67} = 13{,}515$, and $N_{72} = 6{,}105$. There is good agreement with the DeLury estimates. The average recruitment rate is estimated to have been 0.08.

Total Male Population

The DeLury model gave an initial (1948) population estimate of 183,195, while the Allen model, with $r = 0.05$ and 0.06, provides estimates about 12% higher and lower respectively. However, the agreement between extrapolated estimates for 1972 is not as good. The Allen estimates of total population for this year seem high, particularly if one notes that the sum of the 'best' estimates for individual stocks is 42,235. By comparison, the sum of averaged DeLury results for individual stocks in 1972 was also low: 50,620.

ESTIMATED CURRENT, INITIAL, AND MSY LEVELS

If one assumes that the initial sizes of the Central and Eastern Stocks, respectively 1954 and 1962, occurred in 1948, the initial size of the Western Stock might be estimated by subtraction from an estimate of total population size. Combining the DeLury and Allen estimates of total population for 1948 gave a value of 183,630. Subtracting the combined DeLury and 'best' Allen estimates of initial sizes for the Central and Eastern Stocks gave an initial size of 57,515 for the Western Stock. Current stock sizes were obtained by combining averaged DeLury results with the 'best' Allen estimates for 1972. Following Ohsumi and Fukuda (1974), MSY levels were estimated as 30% of initial levels. All results are summarized as follows:

Stock size	Western	Central	Eastern	Total
Initial	57,515	102,030	24,085	183,630
Current	11,010	28,300	7,120	46,430
MSY	17,255	30,610	7,225	55,090

From the above results, the Central and Eastern Stocks are slightly below their MSY levels and the Western Stock is much lower. Of course, this assessment depends critically upon the procedure used for estimating initial size of the Western Stock. A more desirable approach would be to directly extrapolate this value utilizing recruitment data, if it were available. Moreover, estimates derived from sightings and mark-recapture data should be incorporated in future assessments.

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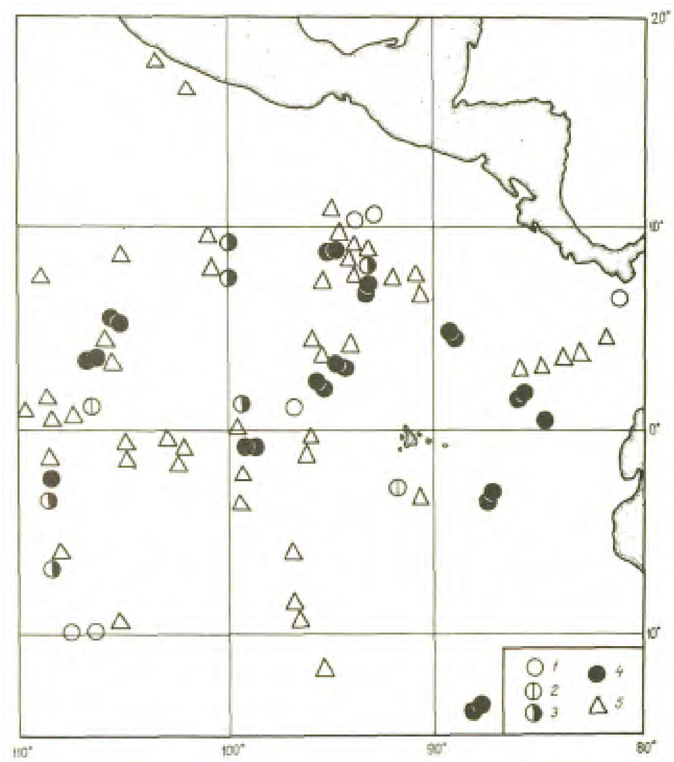

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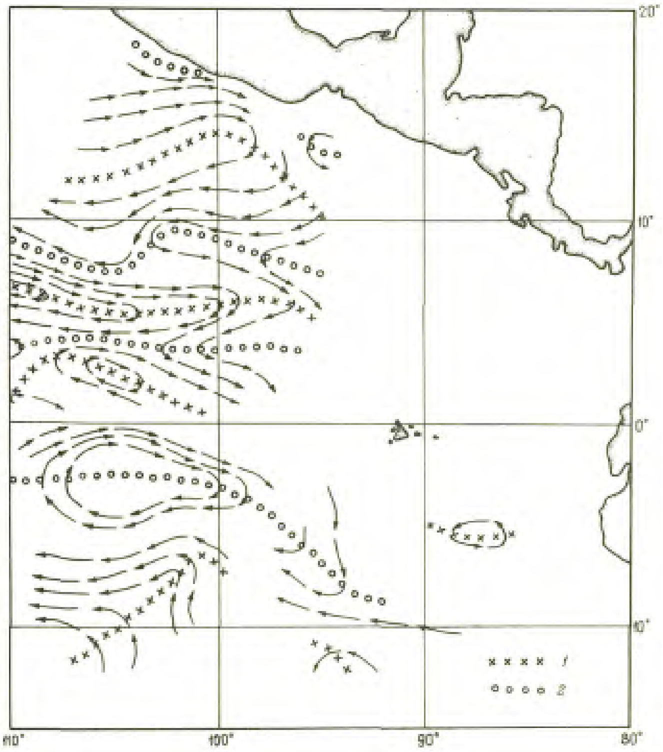

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seen in the night time attracted by light, large species and those adherent to deeper waters (*Berryteuthis magister*, species of *Architeuthis*, etc.) almost without exception do not come up to the surface and are not registered by echosounders and their existence usually becomes known only after the stomachs of caught sperm whales are opened. Thus, the only indicator of places of probable concentrations of sperm whales might have been zones of convergence, but for one circumstance.

It is known that due to the inclination of isopycnic surfaces convergence zones with increasing depth considerably shift in space and at a certain depth are displaced by divergence zones. Therefore the location of surface convergence does not always point to the location of areas with conditions favourable for the formation of sperm whale concentrations. And conversely, concentrations of sperm whales are often observed in areas where there is no convergence observed on the surface.

An example of a positive relationship between concentrations of sperm whales and aggregations of epipelagic squids of the Ommastrephidae family can be served by the water area north of the Equator (up to 11°N) and east of 100°W. Aggregations of squids of the above family were found here and several groups of sperm whales totalling about 750 animals were also observed here.

In other places of sperm whale concentrations there were no considerable squid aggregations observed and sometimes there were no squid aggregations at all. Thus, southeast of the Columbus Islands there was registered a large concentration of group sperm whales not fewer than 300 animals in number, but there were no squids in sight. The pattern of the distribution of hydrological characteristics does not allow anything definite to be said about the causes of the formation of sperm whale concentrations in this region.

Thus, direct relationship between concentration of squids and sperm whales was traced only in one part of the water area under investigation. Two variants may offer explanation: either the bulk of sperm whales observed were migrating and in this case concentrations of squids are not obligatory, or they fed on deep sea species of squids which were not registered. The predominance of cases of 'latent' relationship (as differentiated from direct relationship) between the distribution of sperm whales and food objects suggests that the spectrum of food of sperm whales in this zone of the Pacific Ocean is dominated by species of deep sea fauna.

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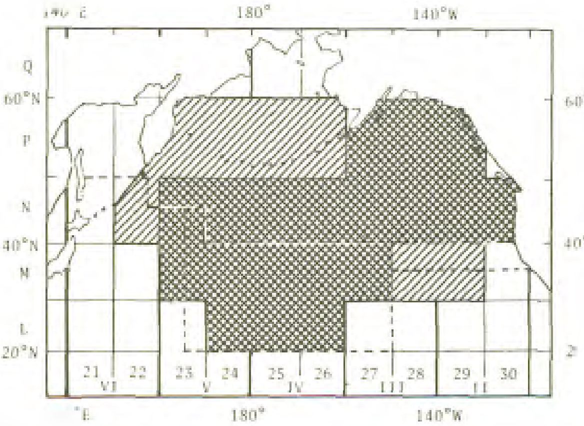
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Table 2

Effort, catch and CPUE of Japanese pelagic whaling.

	Corrected CDW				Catch				CPUE			
Year	Fin	Sei	Bryde's	Sperm	Fin	Sei	Bryde's	Sperm	Fin	Sei	Bryde's	Sperm
1966	–	1,194	–	952	1,266	2,208	–	3,000	1.06	1.85	–	3.15
1967	–	1,245	–	813	844	3,474	–	3,000	0.68	2.79	–	3.69
1968	–	1,211	–	755	729	3,819	–	3,000	0.60	3.15	–	3.97
1969	–	1,523	–	1,059	576	3,591	–	3,000	0.38	2.36	–	2.83
1970	–	2,008	–	798	518	3,235	–	2,700	0.26	1.62	–	3.38
1971	–	1,896	98	847	542	2,419	109	1,803	0.29	1.27	1.11	2.13
1972	–	1,706	323	664	426	2,041	5	1,567	0.25	1.20	0.02	2.36
1973	1,166	1,395	353	567	256	1,710	2	1,803	0.22	1.23	0.01	3.18
1974	851	1,552	564	482	216	1,190	522	1,803	0.25	0.77	0.93	3.74
1975	394	819	785	434	118	454	688	1,803	0.30	0.55	0.88	4.15

Table 3

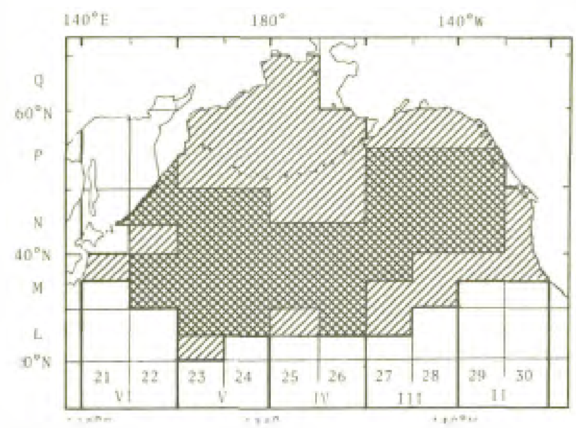
Indices of abundance of the commercial whales by use of catch and effort data of the Japanese expeditions in the North Pacific.

	VI	V	IV	III	II	Total
A. Fin						
1966	132	1,078	1,454	495	436	3,595
1967	171	645	392	297	239	1,744
1968	377	542	655	497	239	2,310
1969	132	488	754	162	239	1,775
1970	40	199	383	318	155	1,095
1971	132	452	372	238	182	1,376
1972	119	597	528	111	111	1,466
1973	107	480	523	324	147	1,581
1974	132	546	519	234	400	1,831
1975	132	546	581	312	221	1,792
B. Sei						
1966	624	2,100	2,404	1,417	793	7,338
1967	627	2,940	1,953	1,083	608	7,211
1968	2,472	2,938	2,433	2,674	608	11,125
1969	624	2,078	1,520	2,002	608	6,832
1970	25	1,843	1,145	825	998	4,836
1971	624	1,615	667	619	711	4,236
1972	623	1,441	1,253	823	70	4,210
1973	623	1,503	860	952	374	4,312
1974	624	1,156	1,016	439	365	3,600
1975	624	1,015	1,192	401	58	3,290
C. Male sperm						
1966	26	3,198	5,877	3,233	1,677	14,011
1967	21	2,729	5,096	4,586	1,677	14,109
1968	26	3,675	4,440	4,060	1,585	13,786
1969	26	3,614	3,300	2,636	1,702	11,278
1970	26	4,738	4,570	3,390	1,401	14,125
1971	26	3,023	4,137	2,951	1,603	11,740
1972	36	2,514	3,750	3,239	2,213	11,752
1973	22	3,695	3,208	3,755	2,198	12,878
1974	26	4,229	4,343	5,504	1,712	15,814
1975	26	3,247	7,268	2,917	793	14,251
D. Female sperm						
1966	10	1,352	1,255	708	1,101	4,426
1967	10	1,102	1,309	1,149	1,101	4,671
1968	10	1,902	1,268	1,141	1,229	5,550
1969	10	1,937	1,278	795	1,773	5,793
1970	10	1,548	1,342	573	690	4,163
1971	10	1,463	1,250	548	962	4,233
1972	28	843	1,210	863	650	3,594
1973	0	1,188	628	795	973	3,584
1974	10	1,458	2,230	672	1,139	5,509
1975	10	1,602	1,423	815	536	4,386
E. Bryde's						
1971	–	909	941	0	7	1,857
1972	–	331	480	0	0	811
1973	–	312	941	0	0	1,253
1974	–	941	958	0	7	1,906
1975	–	701	926	0	64	1,691

Table 4

Indices of abundance of whales by means of whale sighting by Japanese scouting boats in the North Pacific.

	VI	V	IV	III	II	Total
A. Fin						
1965	1,830	2,680	17,380	4,740	8,790	35,420
1966	2,140	10,180	5,840	2,880	1,510	22,550
1967	2,040	3,520	6,110	3,610	3,610	18,890
1968	3,480	5,740	8,160	3,280	2,530	23,190
1969	1,730	3,500	8,150	2,220	2,230	17,830
1970	2,150	3,390	9,690	3,580	1,150	19,960
1971	220	1,050	9,430	1,980	1,020	13,700
1972	1,150	2,500	7,990	2,370	1,540	15,550
1973	1,610	2,200	7,080	2,870	1,730	15,490
1974	1,460	2,230	7,700	2,400	4,710	18,500
1975	940	2,560	8,610	3,230	1,070	16,410
B. Sei						
1965	1,720	24,590	11,780	10,620	6,380	55,090
1966	1,720	29,990	6,800	6,470	3,490	48,470
1967	1,810	34,680	11,610	4,840	4,700	57,640
1968	4,120	31,210	6,890	16,030	4,440	62,690
1969	1,320	24,790	13,280	13,640	2,870	55,900
1970	1,500	24,410	4,470	5,730	9,780	45,890
1971	2,760	25,950	3,340	3,510	4,020	39,580
1972	190	23,270	4,010	4,260	2,050	33,780
1973	1,720	20,380	5,170	4,060	1,750	33,080
1974	5,880	20,340	4,180	1,700	960	33,060
1975	580	26,470	4,720	3,830	1,890	37,490
C. Sperm						
1965	5,860	47,170	31,660	25,730	59,240	169,660
1966	8,020	51,870	27,690	17,720	54,000	159,300
1967	5,800	63,600	30,370	23,520	56,910	180,200
1968	6,630	70,060	28,080	60,160	72,560	237,490
1969	7,290	56,480	21,100	21,470	77,110	183,450
1970	6,080	39,750	24,620	21,480	32,480	124,410
1971	7,420	42,350	16,140	27,470	88,940	182,320
1972	300	32,270	16,140	23,940	43,230	115,880
1973	8,170	117,410	30,960	8,670	73,650	238,860
1974	11,550	48,840	20,420	19,030	52,250	152,090
1975	1,150	51,970	38,230	7,740	42,560	141,650
D. Minke						
1966	160	1,240	710	860	260	3,230
1967	140	1,560	1,160	830	1,050	4,740
1968	140	1,190	1,270	120	300	3,020
1969	160	840	1,450	580	50	3,080
1970	160	3,160	1,950	830	750	6,850
1971	140	1,330	1,120	700	900	4,190
1972	0	1,800	1,040	480	410	3,730
1973	100	2,450	5,280	1,230	90	9,150
1974	360	6,890	2,570	140	50	10,010
1975	1,200	2,170	2,900	4,080	1,780	12,130
E. Blue						
1965	70	550	1,110	570	380	2,680
1966	70	350	240	270	330	1,260
1967	60	190	650	270	380	1,550
1968	110	850	410	240	360	1,970
1969	40	360	280	300	220	1,200
1970	220	410	90	600	550	1,870
1971	140	330	190	0	860	1,520
1972	100	240	770	220	330	1,660
1973	80	190	100	410	140	920
1974	250	940	180	930	1,240	3,540
1975	30	500	180	570	250	1,530
F. Humpback						
1965	80	110	290	800	240	1,520
1966	80	90	1,370	1,030	0	2,570
1967	80	70	670	1,770	130	2,720
1968	210	170	260	970	230	1,840
1969	50	170	500	840	110	1,670
1970	50	130	510	1,670	730	3,090
1971	50	80	520	460	0	1,110
1972	0	380	670	2,020	110	3,180
1973	160	170	640	3,590	290	4,850
1974	0	200	600	1,050	730	2,580
1975	30	190	680	330	110	1,340



140°E
180°
140°W
Q
60°N
P
N
40°N
M
L
30°N
21
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VI
V
IV
III
II

Appendix Table 1

Corrected CDW and catch of whales by Japanese pelagic whaling in the North Pacific, 1975.

10° square	Corrected CDW				Number of whales caught				
	Fin	Sei	Bryde's	Sperm	Fin	Sei	Bryde's	Sperm	
								Male	Female
N 23	68.6	78.3	14.5	–	36	26	–	–	–
N 24	118.3	136.3	19.3	–	10	77	–	–	–
M 23	8.4	65.3	69.9	20.9	1	53	41	21	–
M 24	26.4	136.1	201.7	47.2	1	99	153	128	69
L 24	–	–	34.5	25.7	–	–	69	48	88
Area V total	221.7	416.0	339.9	93.8	48	255	263	197	157
N 25	23.9	14.2	–	14.5	1	30	–	25	–
N 26	3.6	23.8	15.1	14.7	–	5	–	55	–
M 25	4.8	89.9	181.6	67.0	1	37	266	126	140
M 26	–	17.2	49.2	38.3	–	8	35	149	–
L 25	–	4.8	78.0	40.7	–	–	115	66	111
L 26	–	–	25.2	50.6	–	–	8	223	114
Area IV total	32.3	149.9	349.1	225.8	2	80	424	644	365
P 27	10.1	10.1	–	5.0	–	–	–	–	6
P 28	30.2	33.8	–	20.2	14	2	–	92	19
N 27	15.7	76.8	54.6	27.7	9	92	–	135	–
N 28	24.4	48.7	3.6	15.7	4	16	–	40	9
M 27	–	–	25.8	23.6	–	–	–	44	–
L 27	–	–	4.3	4.3	–	–	–	–	–
Area III total	80.4	169.4	88.3	96.5	27	110	0	311	34
P 29	29.5	33.1	–	–	21	3	–	21	10
N 29	12.2	32.9	3.6	3.6	–	6	1	–	–
N 30	17.8	17.8	3.6	14.2	20	–	–	49	15
Area II total	59.5	83.8	7.2	17.8	41	9	1	70	25
All area total	393.9	819.1	784.5	433.9	118	454	688	1,222	581

Appendix Table 2

Scouting distance (miles) and number of whales sighted by Japanese scouting boats in the North Pacific, 1975.

5° square	Scouting distance (miles)	Number of whales sighted							
		Fin	Sei	Sperm	Bryde's	Minke	Blue	Hump.	Right
P 22 S NP	268	0	0	0	0	2	0	0	0
N 22 N	479	4	0	0	0	5	0	0	0
M 22 N	790	0	1	3	0	1	0	0	0
M 22 S	512	0	0	0	1	0	0	0	0
Area VI total	2,049	4	1	3	1	8	0	0	0
N 23 N	2,194	1	6	0	0	4	1	2	0
N 23 S	2,023	0	2	4	0	1	0	0	0
N 24 N	440	0	1	0	0	0	0	0	0
N 24 S	2,452	0	1	11	0	2	4	0	0
M 23 N	4,447	0	11	15	2	3	0	0	0
M 23 S	2,310	0	15	24	5	2	2	0	0
M 24 N	4,439	0	24	25	9	9	1	0	0
M 24 S	3,550	0	17	15	31	10	0	0	0
L 23 N	362	0	12	65	0	0	0	0	0
L 24 N	197	0	1	11	0	0	0	0	0
Area V total	22,414	1	90	170	47	31	8	2	0
N 25 S	319	0	0	62	0	0	0	0	0
N 26 S	1,406	0	2	4	0	14	0	0	0
M 25 N	288	0	0	0	0	0	0	0	0
M 25 S	1,556	0	6	0	8	1	0	0	0
M 26 N	639	1	0	0	0	2	0	0	0
M 26 S	324	0	0	1	0	0	0	0	0
L 25 N	621	0	0	0	2	0	0	0	0
L 26 N	270	0	0	4	6	0	0	0	0
Area IV total	5,423	1	8	71	16	17	0	0	0
P 27 S	210	0	0	3	0	0	0	0	0
P 28 S	418	4	0	3	0	0	0	0	0
N 27 N	694	3	1	0	0	1	2	0	0
N 27 S	1,489	0	2	0	0	13	0	0	0
N 28 N	937	1	13	0	0	1	0	0	0
N 28 S	1,169	2	0	0	0	20	0	0	2
M 27 N	794	0	0	20	0	1	0	0	0
Area III total	5,711	10	16	26	0	36	2	0	2
P 29 S	409	0	0	0	0	3	0	0	0
N 29 N	1,037	0	2	1	0	7	0	0	0
N 29 S	208	0	0	0	0	0	0	0	0
Area II total	1,654	0	2	1	0	10	0	0	0
All area total	37,251	16	117	271	64	102	10	2	2

Evidence that the Northern Bottlenose Whale is Depleted

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INTRODUCTION

The bottlenose whale is a member of the family Ziphiidae, which comprises five genera and 18 nominal species. One species of the bottlenose whale is found in the Southern Hemisphere (*Hyperoodon planifrons*), the other in the north Atlantic (*Hyperoodon ampullatus*). Therein lies one part of the problem I describe here, that is, the northern Atlantic bottlenose whale occurs solely in the northern Atlantic basin, where it has been exploited throughout its range. This is a relatively small ocean, and the distribution of the species is from arctic to temperate waters, from the European to the North American coast.

The northern bottlenose is a deep and long diver, schools in small pods and apparently has a complicated social structure. There is a marked sexual dimorphism such that the males become very large, bulbous-headed and develop a white collar around the head and neck with increased age (allowing visual recognition of them at sea). Perhaps there are limited numbers of these large, possibly dominant bulls in each of the small pods.

Much knowledge of bottlenose whales is based upon experiences of whalers such as Captain David Gray. These data comprise much of the existing information about its behaviour and distribution.

The fishery for this species was begun by Scots, then Norwegians took the highest catches, between 1890 and 1900.

After the initially high catches of the 1890s (Fig. 1) catches dropped to 20–100 in the 1920s and 1930s; then peaked again up to 700 in the 1960s (Fig. 2) but present catches are nil. There have been two peaks in the fishery, the first when it was mainly or exclusively a single species fishery, the last as part of the 'small whale quartet' (Mitchell, 1975a) of minke, bottlenose, killer and pilot whales.

The history of exploitation clearly shows a second trend. During the second peak of catching, the fishery itself moved progressively from the eastern to the western Atlantic between 1938 and 1971 (Christensen, 1975).

Another important aspect of this fishery is its multi-species nature. As catches of bottlenose decreased, some vessels in the fleet apparently began taking minke whales (*Balaenoptera acutorostrata*) in the early 1920s and 1930s. Catches of these peaked at 4,300 per annum in the 1950s, and have been maintained at high levels of over 2,000 per annum since the 1940s (Fig. 2). However, the maintenance of this high catch has been supported in part by the westward expansion of the fleet from the Norwegian coast west to the North American coast through apparently different stock areas.

The multi-species catch includes not only the bottlenose and minke whales, but two other smaller peaks from catches of an additional two species (Fig. 2). One of these was the pilot whale (*Globicephala melaena*), apparently taken by whalers to supplement catches when other whales were not available. Catches of killer whales (*Orcinus orca*) peaked in the 1960s–1970s with catches in the low hundreds annually when the fishery was centered north of the Faeroes and extended to Icelandic waters. Any attempt to unravel catch per unit effort, selection of species by whalers depending on economic conditions, or other factors relating to technology, distribution of the fleet and the like, must all take into account the complex interplay between the four species in the landed catch made by the Norwegian small whale fishing fleet between 1882 and 1970 and the market value of the quite different products from odontocetes and mysticetes.

It is not certain whether the progressive westward movement of Norwegian effort on bottlenose is due to depletion of bottlenose grounds closer to Norway, or to expansion westward of the fishery for the 'small whale quartet' as minke stocks may have been depleted. Since bottlenose whales approach ships and were therefore easy to exploit, it is possible that a once sizeable North Atlantic population is now much diminished (Mitchell, 1975a).

My views of the status of the bottlenose have been given, along with summary of some data, in various papers (Mitchell, 1974b,c; 1975a; 1976a,b).

DISTRIBUTION AND STOCK UNITS

Bottlenose whale distribution is summarised from Mitchell (1976b). In the north east Atlantic distribution is from the Arctic Ocean, White and Barents Seas, Spitzbergen and Greenland Sea to the Baltic and Mediterranean Seas, possibly to Cape Verde; in the northwest Atlantic, from Davis Strait to the Gulf of St Lawrence, and Rhode Island. Summer migration is not precisely known in the west, but in the east, the species migrates south from the Norwegian Sea in July and by August the main body has left for lower latitudes. Winter migrations are mainly unknown, but in the northwest the population may forage into Northeast Channel and the Gulf of Maine on the southward migration to winter off Nova Scotia and New England.

It occurs mainly in offshore waters, with highly concentrated local areas of abundance widely scattered along the continental slope, around submarine canyons or related to other local features. It feeds mainly on squid, but some fish are also taken, and sometimes sea stars. Apparently the species dives to great depths, and is probably the deepest diver amongst smaller Cetacea, certainly diving for longer periods of time than other cetaceans.

There is no published evidence for, or against, separate biological populations of this species. In summer months, it is highly concentrated in widely scattered areas of local abundance. A convenient definition of two statistical areas is Cape Farewell, Greenland, to divide west and east North Atlantic catches.

SEEKING BEHAVIOUR

In my experience at sea in the north west Atlantic, bottlenose approach ships. Commonly this occurs when the vessel is completely dead in the water, and I have used this tactic to observe them, in the Gulley off Sable Island, eastern Canada, even in foggy weather. Bottlenose have also been seen from my research vessels at close range when underway, not having been otherwise observed before the contact. This ship-approach or 'seeking behaviour' has been observed by others:

> 'The sight and hearing of the bottlenose are very good. Often it may be observed how a 'shoal' far down on the horizon shape their course to the ship and stop first when close alongside it. Commonly they go many times backwards and forwards and underneath it in order to examine the strange object. If not attacked, they go away after a few minutes, when their curiosity has been satisfied. As proof of its fine hearing I will mention that I have more than once seen it appear close beside the ship when the propeller was set in motion, even if it had been impossible to detect a single one for many hours' (Ohlin, 1893, p. 7).

There is no published evidence whether 'seeking' is more common in one sex or age class. This behaviour is not documented for southern bottlenose whales. Thus, for both bottlenose and minke whales, North Atlantic populations commonly contain 'seekers', Southern Hemisphere populations apparently do not, so far as determined.

In my experience, the entire pod seeks the ship. Thus, if the early fishery depended in part on this behaviour as I outline below, it would not necessarily bias the catch except as pod composition and the strength of the behaviour would vary with season and locale.

EPIMELETIC BEHAVIOUR

Knowledge of bottlenose population structure is sparse, but this is of special importance since their epimeletic or care-giving behaviour was exploited by whalers. Mother-young ties as well as 'standing-by' behaviour between adults are strong in many species of odontocetes.

In my experience, two bottlenose were captured off Cape Chidley in June 1969 from one pod (Mitchell, 1974a) and although the kills were made hours apart, the pod remained around the stationary ship and standing by behaviour was clearly observed in calm weather conditions.

This particular behaviour attracted the interest of some early naturalists like Gray (1882):

> 'They are gregarious in their habits, going in herds of from four to ten. It is rare to see more than the latter number together, although many different herds are frequently in sight at the same time. The adult males very often go by themselves; but young bulls, cows and calves, with an old male as a leader, are sometimes seen together.
>
> They are very unsuspicious, coming close alongside the ship, round about and underneath the boats, until their curiosity is satisfied. The herd never leaves a wounded companion so long as it is alive; but they desert it immediately when dead; and if another can be harpooned before the previous struck one is killed, we often capture the whole herd, frequently taking ten, and on one occasion fifteen, before the hold of them was lost. They come from every point of the compass towards the struck one in the most mysterious manner.
>
> They have great endurance, and are very difficult to kill, seldom taking out less than from three to four hundred fathoms of line; and strong full-grown males will run out seven hundred fathoms, remaining under water for the long period of two hours, coming to the surface again as fresh as if they had never been away; and if they are relieved of the weight by the lines being hauled in off them before they receive a second harpoon and a well-placed lance or two, it often takes hours to kill them. They never die without a hard struggle, lashing the sea white about them, leaping out of the water, striking the boats with their tails, running against them with their heads and sometimes staving the planks in, frequently towing two heavy whale-boats about after them with great rapidity'.

The early catch may have included proportionately more of a given sex or age class if this epimeletic behaviour is stronger in *e.g.* adult females or dominant bulls as is the case in some other odontocete species.

POLYGYNY

Although all the evidence is not in, it appears that the bottlenose is polygynous like the sperm whale, and there is some evidence for harem behaviour (Gray, 1882). In old, presumably dominant males, the upper lip becomes bulbous, the osseous maxillary crests enlarge, and the head and neck become whiter. The enlargement of the maxillary crests in old males may allow them to act as accoustic baffles or shields (Mitchell and Kozicki, 1975). The bottlenose may side-swim, and possibly use a side-scan mode of searching to bottom feed. The sexual dimorphism represented by the enlargement of the male's melon may have a special function in foraging and feeding behaviour, if the social structure of the pod is as complex as I suspect.

The breeding season is in the spring and early summer.

The analogy with sperm whales is a useful hypothesis and the bottlenose may be the 'sperm whale' of the Ziphiidae. There may have been some selection in the early fishery for the dominant bulls in pods during the breeding season. If this were the case, then some females in the pod may not have been fertilised in that season. Removal of 'harem masters' might have resulted in precipitously declining pregnancy rates in the population.

METHOD OF CATCHING

The standard technique of fishing was to sail or steam to a predetermined spot based on past experience where bottlenose whales were known to aggregate over submarine canyons or other bathymetric features. Here the ship would be stopped. With no way on, the bottlenose might come first to the bow, to the stern or to the waist of the vessel. Thus, the Norwegians developed the technique of mounting two cannons, at the bow and the stern, and ultimately some vessels mounted some at the waist. The *Flora* of Bergen, a 45 ton sloop, was typical:

> 'The majority of the Norwegian Bottlenose whalers are similar to the *Flora*, each carrying two guns in the bow, two in the stern, as well as two boats with a gun each . . . this year thirty craft will prosecute the trade' (Gray, 1941).

Once the pod was located, the whalers took advantage of the epimeletic behaviour of the animals. This standing-by behaviour is extremely marked in the bottlenose. With the first whale killed, the remainder of the pod usually continued to give aid to successive animals shot and played on lines. A measure of catch per effort as measured in boat days might not reflect true abundance in this type of fishery, since this statistic assumes random distribution of individuals whereas whales exhibiting epimeletic behaviour are clumped.

Bottlenose may dive for up to two hours. Such dives would appear to make the beast extremely elusive but this is not necessarily the case. As with sperm whales (*Physeter catodon*), bottlenose often resurface within a few hundred metres of the diving slick. The whaler waits. It may help to bang on the side of an otherwise silent vessel, in order to attract the whale's attention (Mitchell, 1974b), but they will usually approach a non-moving vessel. As Captain Gray (1882) and R. W. Gray (1941) emphasized, they approach moving or stationary ships; and remain until wounded animals die.

SELECTION

As mentioned above, there may have been selection for sex and/or age classes of bottlenose that showed 'seeking' behaviour, strong epimeletic behaviour or were of large size (harem masters). Although undocumented, whalers may have selected calves or young animals first in order to hold the mother and thus the remainder of the pod through care-giving behaviour. Selection for calves or for harem masters would have affected recruitment or pregnancy rates, respectively.

One of the products from the fishery was head oil. Apparently, a reservoir of oil was present in females, but was smaller and/or solid in males (Gray, 1882; Mitchell and Kozicki, 1975). The whalers knew of these differences and may have selected for them. Full grown males gave 2 tons of oil and 2 hundredweight of spermaceti (Gray, 1882; Mueller, 1883). Captured in bulk, oil yield was under 400 kilos but careful extraction would give 1,000 kilos, and old males produced up to 2,500 kilos but were rare (*sjeldne*; Collett, 1907). Blubber yield averaged 1½ tons, up to 4 tons in old males (*spaeck*; Munsterhjelm, 1915).

GEOGRAPHIC EXPANSION

The early fishery apparently expanded westward from British and Norwegian waters to Denmark Strait by the early 1880s, and into Davis Strait soon after. The Scots took 535 on East Greenland in 1883 (Lubbock, 1937; Mitchell, 1975a, table, p. 48) and commonly fished for them off Labrador and Baffin Island in the early 1880s (*e.g.* Lindsay, 1911). This fishery collapsed between 1910 and 1930 (Fig. 1).

The second bottlenose fishery began as a catch ancillary to the Norwegian minke whale take. This started on the coast of Møre in the late 1920s (Jonsgård, 1968), soon expanded north and west of Norway, then to East Greenland by 1959 and to Labrador and Newfoundland by 1969 (Christensen, 1975). It was based mainly on minke whales, in approximately the same numbers as in the earlier bottlenose fishery (compare Figs. 1 and 2), at their peaks both taking 2,000 to over 3,000 whales annually. The present decline in bottlenose catch follows steadily increasing catches from 1937 to a peak of almost 700 in 1965. This peak catch and a subsequent high catch in 1969–70 were comprised to a great extent of catches from grounds in Denmark Strait and Davis Strait that had not been exploited heavily for over fifty years.

Thus, at least twice, 60–70 years apart, peak catches in two episodes of bottlenose catching have been supported by transfer of effort from European seas to the North American coast. If bottlenose are ultimately found to be segregated into biological races or stocks (and all odontocetes so far studied have been found to be so differentiated; Mitchell, ed. 1975), then the distinct possibility must be considered that populations have been successively depleted, east to west, from the 1880s–1920s and again from 1930–1970s.

MULTISPECIES ASPECTS

The early fishery (1877–1920s) took bottlenose in two categories. Some vessels in the fleet which comprised more than 80 vessels in 1891 (Fig. 1), caught only bottlenose. Others took bottlenose as well as other species (bowhead, beluga or other cetaceans; seals; and fish, etc.).

In Figs. 1 and 2, I have combined the number of vessels taking bottlenose as a side catch (Christensen's 1976 'Combined Catchers') and those taking only bottlenose, as total vessels. If bottlenose were a desirable target species, vessels of opportunity would catch them as if they were regular bottlenose whalers. Conversely, when other species were not available, 'combined catchers' would hunt bottlenose even if it was not the most desirable catch. Bottlenose whalers may have become 'combined catchers' seasonally due to bad weather or on depletion of local bottlenose stocks, with the taking of only a few seals or one other kind of whale.

The catch (Christensen, 1976) per boat was of the order of 33–52 in the early fishery (1887–91, 1894–96; average of 40). However, in the peak years of the later fishery, the catch per boat was less; for 1962–71 range of 17–46, average of 27. Does this reflect a reduction in pod size or diminution in the number of pods encountered?

The presence of 'combined catchers' throughout this early fishery is important. It indicates that, if depletion of local populations occurred, the depletion might have been excessive. Since the vessels could make profitable voyages by taking other species, they could field the technology to hunt remnants of pods and sparsely distributed populations. In this respect the situation resembled the later Blue Whale Unit system in the Antarctic, allowing trade-offs between species to maintain catch at high levels.

The end of the early bottlenose fishery in the late 1920s (Fig. 1) corresponds in time to the beginning of the later, multispecies fishery based on minke whales, which Jonsgård (1968) indicated began in the late 1920s. It is not clear if the same vessels and hunters were involved. However, when the Norwegian licensing system began in 1938 the resulting statistics showed 252 vessels operating in that year, taking a total of 1,487 minke, bottlenose, killer and pilot whales.

Ruud (1937) indicated that about 400 bottlenose were taken by 16 boats in 1917. This fact indicates that the early bottlenose fishery persisted through World War I until near the time when the minke whale fishery began in the 1920s off the Norwegian coast. In view of the absence of evidence to the contrary, it can be assumed that there was a transfer of effort from the early bottlenose whaling fleet to other species when the bottlenose fishery collapsed between 1913–1920s.

At the earliest recorded time, the modern fishery for the 'small whale quartet' took comparable numbers of odontocetes (bottlenose, killer, pilot) and much higher numbers of mysticetes (minke, possibly other rorquals on an opportunity basis in early years).

The role that the two species of delphinids have played in this fishery needs to be examined critically. It is relatively clear that catches of pilot and killer would have been mainly to supplement the bottlenose catches, in that the same kinds of products were involved. For example the meat of odontocete whales cannot be used for human consumption in Norway. The meat products from bottlenose, killer and pilot are similar, whereas the meat from minke whales is mainly for human consumption. Further, different kinds of oils result from odontocetes and the minke, such that the odontocete oil is mainly for lubricating oils and related products whereas the oil from minke is for food. Thus, if there is a trade-off between targets of opportunity within this modern fishery, there would be presumably more comparability between catches of bottlenose, pilot and killer than between any one of these and the minke whale.

The reciprocal catches of odontocetes and minke are clearly shown in Fig. 2. The number of vessels peaked in 1948 at 340 and declined to 80 in 1975. The number of minke caught peaked at 4,338 in 1958 and declined to 1788 in 1975. However, the number of odontocetes taken (bottlenose, killer, pilot combined) peaked during the period of these declining minke catches, indicating that while vessel numbers were also declining, effort switched to targets of opportunity. As a result, either minke became less abundant or economic conditions changed so that odontocetes were proportionately more desirable than previously.

Thus, in the modern episode taking the small whale quartet, during the period 1955–75, minke catches peaked and declined, number of vessels declined, but bottlenose catches steadily climbed to peak at 695 in 1965, killer catches steadily climbed to peak at 246 in 1970, and pilot whale catches peaked twice, in 1960 at 331 and in 1966 at 339 (Fig. 2).

The high pilot whale catches were taken mainly in the grounds newly encountered in Danish Strait as the multispecies fishery moved west (Christensen 1975, Table 2). It is not known whether the stock in Danish Strait is separate from the stock fished at Newfoundland (Sergeant, 1962), which was depleted from an initial stock size of approximately 50,000 (Mitchell, 1974a) or less than 60,000 (Mercer, 1975) to extremely low levels (Mitchell, 1973).

The high killer whale catches (Jonsgård and Lyshoel, 1970) were similarly taken from new grounds opened up with the westward expansion. Heaviest catches were made, from east to west, in 1956–63 (95) in the Shetland and Faroe Island area, in 1962–66 (167) in the East Iceland and Jan Mayen area, in 1959–71 (248) in Denmark Strait and finally 17 were taken in 1972 off Newfoundland (Christensen 1975, Table 2).

Removals were greatest around Iceland where fishing mortality was supplemented by a kill of 'hundreds' by the U.S. military in the one year for which information is available (Anon. 1956).

Little is know about killer stock identity. The combination of great sexual dimorphism (size, dorsal fin shape, etc.) and the presence of clearly dominant males in pods comprised mainly of females and young of both sexes, leads me to believe the killer is analogous to the sperm in having a complex social structure, especially in maintaining harems, having a complex group hunting behaviour, and possibly in having differing migration patterns with age and sex. Thus, extended killer schools may comprise separate stocks as Fraser (1966) suggested for other odontocetes, and this local intense exploitation may have had a substantial impact on the number of schools extant. On the other hand, if killer migration is influenced in part by migrations of prey such as mysticetes, pinnipeds and herring, then lengthy, variable and mainly opportunistic movements may characterise killer migrations.

For the four species taken in the modern fishery, separate stock areas are assumed or known for minke (Rørvick and Brown, eds. 1977), pilot (Mitchell, 1975a; Mercer, 1975), killer (assumption of extended schools as stock units, this paper) and bottlenose (east and west of Cape Farewell, assumed on basis of differing catch history). Analysis of the impact of the multispecies fishery is needed for each species and stock area by season and year.

ECONOMIC FACTORS

Most arguments regarding trends of catches, and of effort in terms of number of vessels sailing, come back ultimately to economics. Not all of the economic data are available but some are published. These include figures for some years in various articles in the *Norsk Hvalfangst-tidende* (many authored by Østby or Anon., some of these cited by Mitchell, 1975a), Ingram (1948), Anon. (1969, Table 129), Christensen (1976, Fig. 4) and Jonsgård (1976). To facilitate comparisons, I here reproduce Table 129 from Anon. (1969) as my Table 1.

Additional statistics available from published sources cited above supplementing this Table include: 1938, Total Quantity (2,982), Total Value (1,250?), Meat Quantity (2,130), Blubber Quantity (852). 1940, Total Quantity (1,012), Meat Quantity (697), Blubber Quantity (315).

There are very few breakdowns by species of these statistics published. Those that I could locate in the *Norsk Hvalfangst-tidende* are presented in Table 2.

For 1955, the following breakdown is also available: Total Value (9,046), Meat Quantity (5,183), Blubber Quantity (2,217), Bone Quantity (78).

Limited data are published on the odontocetes. From the same sources, those available for bottlenose, killer and pilot, combined, are presented as prices in kroner in Table 3.

In 1958, in a special season, the vessels captured 21 bottlenose for a value of 83,000 kr (average of 3,952 kr/whale).

These data, and the figures in Christensen (1976) and Jonsgård (1976) comprise the available data. I make the following points:–

(a) The drop in odontocete catches began in 1971 and continued in 1972 (Fig. 2), before restrictions in England against import of Norwegian and other whale meat in 1972–1973 (Jonsgård, 1976). The relative value of a bottlenose compared to a minke was higher in 1969–1971 than in 1968 (Jonsgård, 1976, Fig. 1; Christensen, 1976, Fig. 4). Why did the bottlenose and killer catch decline in 1971 and 1972 if not due to depletion?

(b) Prices for odontocete meat or blubber (Table 3) did not appear to affect the catch levels of bottlenose (Fig. 2), for the period 1961–1966.

(c) The value of minke products doubled between 1958 and 1966; the minke catch dropped by 50% in the same period (Table 2). Prices for minke products do not appear to affect the catch levels of minke for the period 1958–1966.

Table 1

Small-whale catching.

Year	Vessels	Whales caught	Production							
			Total		Meat		Blubber		Bone etc.	
			Quantity Tonn	Value 1,000 kr.	Quantity Tonn	Value 1,000 kr.	Quantity Tonn	Value 1,000 kr.	Quantity Tonn	Value 1,000 kr.
1939	–	1,012	1,977	460	1,393	422	584	38	–	–
1946	268	1,937	3,650	3,403	2,591	3,119	967	270	92	14
1947	264	2,716	5,363	4,983	3,854	4,457	1,428	514	81	12
1948	300	3,606	6,855	6,645	4,952	5,925	1,843	708	60	12
1949	350	4,178	8,718	8,044	6,217	7,189	2,422	843	79	12
1950	198	2,055	3,406	2,462	2,278	1,940	1,064	513	64	9
1951	236	2,854	4,862	4,333	3,253	3,052	1,574	1,275	35	6
1952	225	3,398	6,383	6,740	4,503	6,087	1,872	652	8	1
1953	169	2,492	4,132	2,915	2,838	2,398	1.292	517	2	0
1954	186	3,517	6,269	6,124	4,312	5,315	1,897	800	60	9
1955	193	4,491	7,961	9,446	5.461	8,383	2,423	1,053	77	10
1956	198	3,966	7,762	7,937	5,264	6,690	2,390	1,230	108	17
1957	197	3,935	7,489	7,606	5,138	6,479	2,322	1,122	29	5
1958	192	4,741	8,926	8,451	6,132	7,245	2,784	1,203	10	3
1959	185	3,478	6,769	7,774	4,706	6,815	2,059	958	4	1
1960	183	4,035	7,703	10,503	5,281	9,361	2,411	1,132	11	10
1961	178	3,712	6,735	8,201	4,674	7,403	2,050	792	11	6
1962	168	3,774	7,428	9,451	5,151	8,525	2,273	925	4	1
1963	156	3,661	7,272	9,235	5,056	8,280	2,171	918	45	37
1964	144	3,170	6,535	9,828	4,507	8,864	2.000	939	28	25
1965	139	3,295	7,864	12,005	5,216	10,489	2,620	1,485	28	31
1966	115	2,993	5,906	11,031	3,995	9,978	1,882	1,019	29	34

Table 2

Minke whale catches and production.

Year	Number of Minke	Mean weight Minke meat	Mean value Minke meat, blubber and bone
1955	4,328	1,216	2,103
1956	3,658	1,327	2,000
1957	3,644	1,306	1,933
1958	4,341	1,321	1,780
1959	3,091	1,403	2,235
1960	3,429	1,359	2,603
1961	3,219	1,317	2,209
1962	3,286	1,324	2,504
1963	3,233	1,364	2,523
1964	2,732	1,379	3,105
1965	2,467	1,454	3,648
1966	2,153	1,415	3,686

Table 3

Value (N. kr.) of small whale fishery products.

Year	Mean meat price	Mean blubber price
1961	0.91	0.95
1962	0.90	0.86
1963	0.77	0.89
1964	1.02	0.75
1965	1.28	0.70
1966	1.30	0.67

(d) During the same period, 1958–1966, the value of a bottlenose decreased to and then stabilised at the same level as a minke whale (Jonsgård, 1976, Fig. 1). Bottlenose catches rose during this period to their peak level of 695 in 1965.

(e) The total number of whales caught decreased between 1958–1966 (Table 1). But total production, and meat and blubber production increased. However total value fluctuated somewhat (Table 1). There appear to have been trade-offs between species in order to maintain production (Fig. 2).

(f) Given these trade-offs, and the rise in product value during the 1960s, the drop in catches of bottlenose from 1965 to 1967 east of Cape Farewell might represent stock depletion. (Westward expansion accounted for the 1970 peak.)

It would be useful to have the price of meat products from bottlenose, and oil (especially machine oil) prices from bottlenose during the period 1880–1975. Presumably oil prices would have paralleled those of sperm whale oil. If there is no decline in the prices of these products during this period, this will contrast strongly with the decline in catches.

INITIAL STOCK SIZE

The present state of the stock of bottlenose is not known. Mitchell (1975a) considered it the most critically depleted of all the small cetaceans currently or formerly exploited.

Population estimates are few (Mitchell, *et al.*, 1976). Mitchell (1975a, pp. 48, 50) made two cumulative catch estimates, one for seven peak years (estimate 17,155), and one for eleven peak years (estimate 25,796). Because of the late age at first ovulation (9–14 growth layers) and the presumed lengthy calving interval (2–3 years), the latter may be a reasonable minimum population estimate. Christensen (1976) revised these, taking into account a loss of 25–35% and gave the initial size as 40–50,000.

The losses in the fishery need to be examined critically. Assumptions regarding the magnitude of the loss rate, applied as a correction to cumulative catch estimates, can substantially affect estimates of initial population size.

The loss rate in this fishery might have been high in the initial phase of the fishery, but subsequently could have been quite low for most boats. The epimeletic behaviour of the species ensured that many were available for capture. There was not a wild chase of animals, resulting in separation of carcasses. Few carcasses would be lost because of distance from the centre of whaling activity. The early fishery was developed using equipment such as bombs, grenades, very strong harpoons and rope, and the Norwegians developed additional, sophisticated techniques to preclude loss due to drawing out of the harpoon, the breaking of foregoers and failures in the spring line and other parts on the catchers. Subsequent, complex Norwegian regulations governing the small whale fishery stipulated, for example the number of backup harpoons carried aboard vessels, the actual diameter of the foregoer, and the like (Foote, 1975). Obviously, problems of loss were early on recognised, and the technology was soon developed to ensure that as few whales as possible were lost. The loss rate in the modern episode was reduced to approximately 3% (Christensen, 1976).

There is also the question whether in such technology all whales struck and lost can be considered killed, or whether some of the whales struck live. The loss rate might have been 25–35% but certainly some survived.

I here revise my eleven year cumulative catch estimate of 25,796 to account for an average annual "lost-and-killed" rate of 10%: 25,796 + 2,580 = 28,376.

It is interesting to note that in this bottlenose whale fishery, there was much interest in the development of new harpoons, and American experimenters travelled to Europe, expecially Norway, to go out on these vessels and try out their harpoons with chemical tips, bomb lances, and grenades. We need information on the use of these techniques in the bottlenose fishery in order to obtain better estimates of loss rates.

Life history parameters have been estimated by Benjaminsen (1972) and Christensen (1973). Length and age at sexual maturity, length at birth and gestation period are listed. Christensen (1976) used 2.0 years as the calving interval, but it may be 2–3 years (Mitchell, ed., 1975), and even this is uncertain, as are some other parameters.

If bottlenose were fished out in a relatively short time (less than two decades), and if extended pods were localised and removals were of entire pods, any supposed density-dependent response may not have operated unless dispersal was rapid enough for pods to expand to newly depopulated feeding/breeding grounds. Available evidence indicates instead that pod movements were consistent and their occurrence predictable by the whalers.

Tillman and Bertrand (1976) point out that for the early fishery the number of trips per vessel per season would more accurately reflect true effort than would total number of vessels per season. Likewise, effort statistics in the modern episode should be treated with caution, as Bertrand (1976) and Rørvik and Brown (eds. 1977) have outlined for the minke whale in the same, multispecies fishery.

Catching effort must be separated out by vessel and by species in order to have a "clean" data base for any species in the modern multispecies fishery. This has not been attempted to date for the modern bottlenose statistics.

In the period 1886–1911, catch efficiency undoubtedly increased as a rapidly evolving whale-catching technology saw the development of: whaling cannons, experimentation with chemical, explosive and other harpoon heads, more efficient barbs on harpoon heads, bombs and grenades, lighter and stronger foregoers, spring systems to prevent breakage of lines when playing whales, motorised vessels, and many other innovations.

The ship-approach or 'seeking' behaviour of bottlenose, combined with epimeletic behaviour subsequent to harpooning the first animal, diminished dependence of catch rates on weather, especially fog.

I am concerned with traditional catch per unit effort measures (*i.e.* catch per catcher days work, or catch per vessel) for bottlenose and minke on ethological grounds. My own experience, and whaler's knowledge, indicate that both approach ships. I remain unconvinced that the same techniques of evaluating catch per catcher days work or catch per boat as used for pelagic whaling for large cetaceans can give meaningful estimates, if the whale is in fact helping the whalers by approaching the vessel to be shot. Some alternative effort measure must be available to account for behaviour and technological changes and it could be even more complex if particular sex or age and sex classes of each of the two species have different tendencies to approach vessels.

New methods of measuring effort must be devised. Since the Norwegian fleet has steadily expanded westward, completely across the Atlantic over the last eighty years, perhaps a simple tabulation of distance steamed from the home port to catching grounds through time will reflect real effort. Some account should be taken of the change of whaling grounds, as this may document the successive depletion of near-shore, middle and finally far-distance grounds for bottlenose and minke.

Methods of obtaining useful sightings data should be developed in order to assess present population size, either in absolute terms or relative to abundance of minke, fin and other cetaceans. Correction factors and different census techniques should be developed to account for ship-approach or 'seeking' behaviour, and lengthy duration of dives. Census cruises should then be run using some of the tracks already proposed (Mitchell and Brown, eds., 1976).

I believe present bottlenose population size is small, because during the period 1958–1966:

(1) Minke value doubled.
(2) Minke catches dropped by 50%.
(3) The fishery expanded in 1959 for the first time to Denmark Strait.
(4) Bottlenose value approached minke value.
(5) Bottlenose catches rose to the highest peak in the modern fishery, in 1965.
(6) Total production declined slightly.
(7) Total value increased slightly.

I conclude from these points that, since vessels steaming to Denmark Strait could also hunt coming and going but had to move far westward, bottlenose whale stocks were depleted east of Denmark Strait or catches would have been larger.

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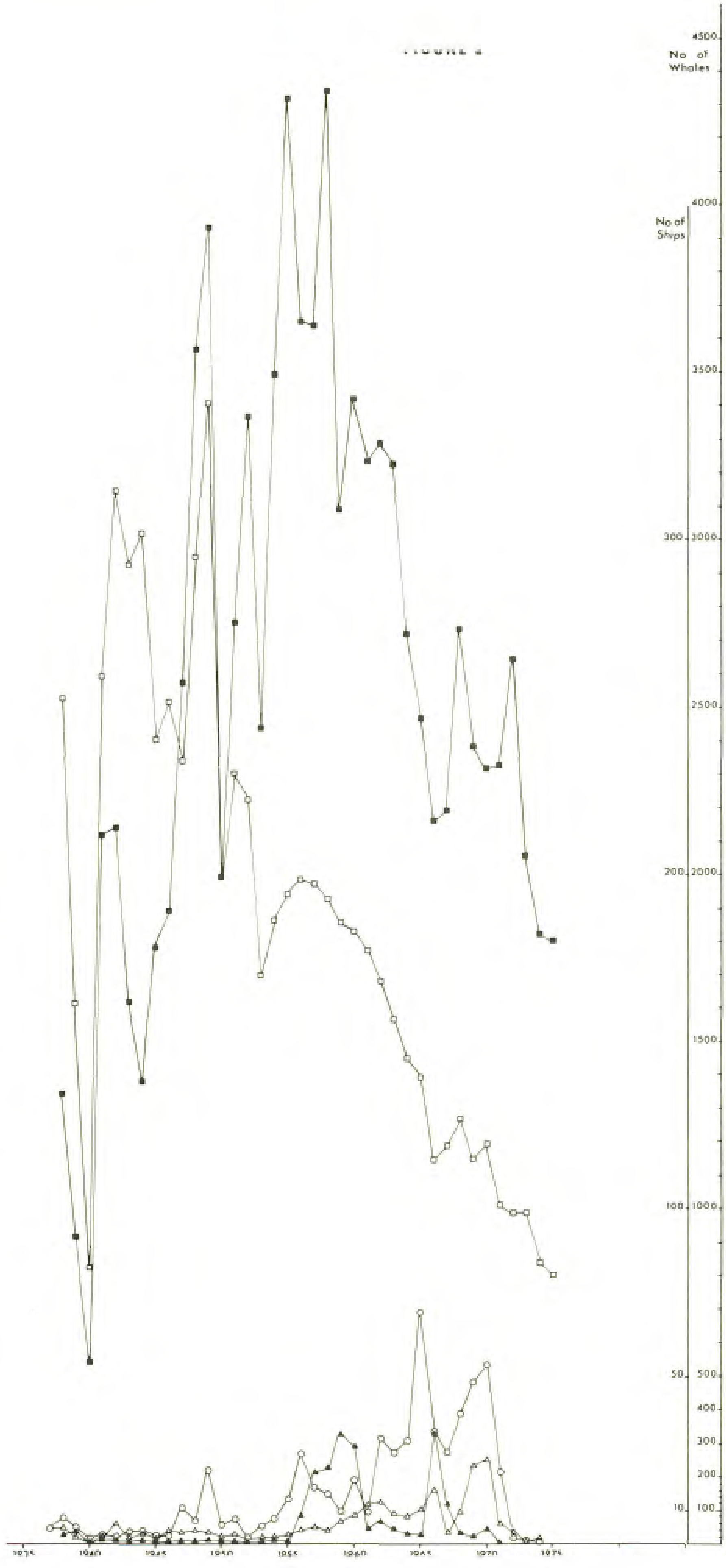

No of Whales
No of Ships
4500
4000
3500
300 3000
2500
200 2000
1500
100 1000
50 500
400
300
200
10 100
1935
1940
1945
1950
1955
1960
1965
1970
1975

SC/28/Doc 31

A Preliminary Note on Japanese Records on Death-Times for Whales Killed by Whaling Harpoon

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The Fisheries Agency, Japanese Government, requested whaling companies to report records on death-times for whales killed by explosive harpoons.

I was not concerned with this research plan, so that I do not know the details of the plan, but I would like to introduce the records which I brought with me as one set of data to discuss humane killing of whales.

The records were collected and reported from captains of three catcher boats which belonged to two whaling expeditions in the 1973–74 Antarctic season. The times from hit of a harpoon to death of a whale were noted to be recorded. It is in practice difficult to detect a sign of death of a whale as Best (1975) noted.

WHALING HARPOON

Recently, Japanese catcher boats are equipped with 75mm cannons. A harpoon is 45 kg in weight, and has a flat-topped grenade of 3 kg weight. This is lighter than 90 mm harpoon (60 kg). The reasons why the harpoon changed from 90 mm to 75 mm in diameter are that:

(1) main whale species changed from larger whales such as blue and fin whales to smaller such as sei and minke whales,
(2) 90 mm harpoon sometimes goes through the body of a smaller whale, and takes more time to death,
(3) smaller part of whale meat is damaged by 75 mm harpoon than by 90 mm one,
(4) 75 mm harpoon is easier to handle by small Japanese crew.

DEATH-TIMES

Tables 1, 2 and 3 shows the frequency distributions of death-times recorded for fin, sei and minke whales, respectively.

For the fin whale, the death-times distribute from 0 to 25 min, and the average time was 5.52 min. The death-times differ with the skillfulness of the gunners. One gunner takes 3.35 min on average, on the contrary another gunner takes 9.51 min.

The death-times of the sei whale are shorter than those of the fin whale. All the sei whales were killed within 15 min, and the average time was 3.91 min. The difference of skill of the gunners is observed in this species, i.e. the better gunner takes more whales and within shorter time, the same as for the fin whale.

The maximum death-time was recorded to be about 30 min. in the case of the minke whale, though 86.5% of minke whales were killed within 5 min, and the average death-time was 3.72 min.

The reason for the longer death-time in the case of minke whales is that the "cold grenade" is used, for preventing extensive damage to the whale meat caused by the explosion of the grenade.

Table 1

Death-times for fin whales killed by whaling harpoons

Time (Min)	Kyo-maru No. 1		Kyo-maru No. 11		Total	
	whales	%	whales	%	whales	%
0– 5	58	73.4	8	18.6	66	54.1
5–10	19	24.1	20	46.5	39	32.0
10–15	2	2.5	8	18.6	10	8.2
15–20	–	–	5	11.6	5	4.1
20–25	–	–	2	4.7	2	1.6
Total	79		43		122	
Average Time (Min)	3.35		9.51		5.52	

Table 2

Death-times for sei whales killed by whaling harpoons

Time (Min)	Kyo-maru No. 1		Kyo-maru No. 11		Total	
	whales	%	whales	%	whales	%
0– 5	129	81.7	56	45.2	185	65.6
5–10	28	17.7	60	48.4	88	31.2
10–15	1	0.6	8	6.4	9	3.2
Total	158		124		282	
Average Time (Min)	2.72		5.44		3.91	

Table 3

Death-times for minke whales killed by whaling harpoons

Time (Min)	Fumi-maru No. 5	
	whales	%
0– 5	818	86.5
5–10	101	10.7
10–15	18	1.9
15–20	6	0.6
20–25	2	0.2
25–30	1	0.1
Total	946	
Average Time (Min)	3.72	

REMARKS

The records on the number of harpoons fired into each whale were not brought with me, but it has been reported by whalers that most were one per whale.

Japanese whalers have very much in mind to get fresher whale meat. For this purpose, the death-time should be as short as possible. On the other hand, they want to damage whale meat as little as possible for the purpose of producing as much as possible within the limited number of whales permitted to be caught, so that they consider the use of "cold grenade" is needed for minke whales.

Drug immobilisation cannot be considered by whalers, for the most whale products are used for human consumption, and drug might be dangerous for people to eat them.

The death-times are somewhat different among gunners. The development of the skill of the gunners will be useful to decrease the death-times. More data will become available in the near future, and will be used to revise these figures.

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SC/28/Doc 32

Does the Bottlenose Whale Necessarily have a Sustainable Yield, and if so is it Worth Taking?

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Assume that the stock in, say, the 1880s had been essentially unaffected by whaling and was in a steady state. It recruited at 2 years of age, the females matured at 11, and there was a constant natural mortality, not age-dependent. The sex ratio was 0.5 and mature females gave birth every second year.

Then $r = M = e^{-2M}. 0.5. 0.5. e^{-M(11-2)}$

from which $M = 0.091$ (round to 0.09)

and the percentage mature females of total recruited females is 44.

Such a value is not inconsistent with the numbers in the Labrador sea in 1971, given by Christensen, 1973, Fig. 7.

Now suppose whaling takes place for a few years and it takes a significant proportion of that stock. The age-composition changes such that if the age at maturity remains the same the percentage mature would be reduced, and the number of births per recruited female correspondingly. If whaling were now to stop, this stock would continue to decline, but not to extinction; the age composition re-adjusts and the stock settles at some new level. Such a model shows unstable equilibrium.

However, we would expect *some* density-dependent change in the birthrate, otherwise the stock would have behaved very erratically in the past and not be likely to have survived for long. In one reasonable model, applied to other whales, it would be assumed that female whales grow faster and mature earlier in a reduced stock. We can calculate how strong such a response would need to be to maintain $r = M = 0.09$. We can write in this case

$$e^{-0.09(11.2)} = e^{-(F+0.09)(Am-2)}$$

Where Am is the new age at sexual maturity. We can find, for example:

F =	For Am =
0.011	10
0.026	9
0.045	8
0.072	7
–	–
0.720	3

If, with the stock reduced by an F of say 0.026, the age at maturity became less than 9 years, the stock would begin to increase when whaling stopped, i.e. there would be a sustainable yield at that level of stock. If the age at maturity went down, but only say to 10 years, there would be no sustainable yield and the stock would continue to decline for a time after whaling stopped.

It is not necessary to maintain the assumption of a one live birth every two years per mature female. Suppose in the unexploited stock live births are only 80% of the maximum theoretically possible (observed pregnancy rate of 0.4). Such a stock would attain equilibrium with $M = 0.081$ (round to 0.08).

Such a value is not inconsistent with the age distributions for Labrador 1971 given by Christensen1973, Fig. 7. There, in a small sample of 128 whales, the percentage mature was 48% in each sex; accepting the ages at maturity cited by the author, M is about 0.065. With $M = 0.08$ one expects a ratio of 41%; such discrepancies are certainly not significant. If M had been 0.065 in the eastern North Atlantic, then balance would be achieved with a birthrate 53% of the maximum possible (pregnancy rate = 27%).

Now, if such a stock was reduced by whaling there could be a density-dependent response by an increase in pregnancy rate–but a limited increase, obviously– as well as a shift in the age at maturity, as noted in baleen whales. Depending on the rate and balance of these responses we can generate sustainable yields, 'negative sustainable yields', or none. Nevertheless, over a wide range of possible values the stock would not proceed to extinction after whaling stopped; it could rise somewhat, continue to decline for a time, or stay as it was at the time whaling stopped.

Is such a model compatible with the observed course of bottlenose whaling in the Northern Atlantic? I think it is. From Christensen (1976, Fig. 5), by drawing a straight line between the points for 1885–1897, we can see, very roughly, that a cumulative catch of about 25,000 caused the stock index to decline from 49 to 40 i.e. by just under 20%. This suggests an "initial" stock size of about 130,000 whales, if the natural deaths and births continued to balance each other during the period. Actually, because of the 2 year recruitment time lag, with M constant the number of natural deaths could have been a little less than the recruits – approximately 2,000 whales less over the period. Without this small 'supplement' the stock would have been reduced slightly more than was observed; we should therefore adjust the calculated initial stocks downwards, but not much. The number left in 1896 would be about 100,000; F over the decade averaged 0.022.

Now, in the next decade intensive whaling continued. A cumulative catch of about 19,000 whales 'caused' a decline in catch per vessel from 40 to 27, that is by 32%. This would suggest an 1896 stock level of 60,000 whales declining to 40,000 by 1960 whereas on the evidence of the first decade we should have expected 100,000 to decline to 81,000. From a 'simple' population model the decline would have been less than this because of a density-dependent response of r. However, by now the number of recruits can be declining faster than the number of natural deaths, because the change in age-composition has begun. With no other density-dependent reactions the percentage mature could have declined from 44% to 36%, that is by a factor of 0.83.

If we take 100,000 as the 1896 value, then by 1906 it reduced, by 32%, to 68,000 i.e. by 32,000 whales of which only 19,000 are accounted for by capture. Is the other 13,000 a 'recruitment gap'?

The average annual number of recruits to the stock in the first decade is $\frac{(130{,}000 + 100{,}000)}{2} \times 0.09 = 10{,}350$ and 10,350 and 17% [i.e. (1–0.83) 100] of this is 1760. In the next decade the recruitment gap could therefore have been nearly 18,000 whales – enough to account for the stock decline being steeper than expected from the catch rate.

Actually, it is only after 1913 that the catch per vessel value begins to behave very erratically. So we can look at the longer period 1896 to 1913 throughout which whaling was intense although it began to fall off in the last years of the period. In this period catch per vessel declined from 40 to about 25; the cumulative catch was 25,000, this gives, crudely, an 1896 stock of 67,000 declining to 42,000. If the 1896 stock was really 100,000, the 1913 stock would have been 63,000, a decrease of 37,000 whales of which 25,000 is accountable to catch. A 'recruitment gap' can easily account for the remaining 12,000 (1760 × 17 years = 30,000) even if there had been a partial compensatory change in age at maturity, in pregnancy rate, or in both.

Between 1914 and 1966 (a cut-off date taken to exclude the Labrador catches) the total catch was about 7,000 whales averaging about 135 whales a year. The average catch per bottlenose whaler in successive periods was–

(1913)	25
1914–1927	23
1930–1939	14
1946–1949	12
1953–1961	16
1962–1966	40

These figures do not tell us much. The jump up in the 1960s is too great and sudden to attribute to "stock recovery". The level did seem to decline in the 4 or 5 decades after the end of the first world war; it *might* have begun rising in the 1950s.

In the 1914–1927 period the average annual catch was 190 whales. This could have exceeded any sustainable yield at the time, accounting for a lower catch per unit effort over the next 3 decades during which the average annual catch was only 51 whales. If 51 was below the sustainable yield of the surviving stock we might expect some subsequent increase in catch per unit effort, but not so suddenly as it occurred. Let us suppose there had been a density-dependent reaction as a change in age at maturity, say from 9 to 6 years. This leads to an $r - M = 0.11 - 0.07 = 0.02$. The sustainable yield of a stock of 63,000 would have been 126 whales. If only 52 were taken the stock would have increased, over 3 decades, by 30–35%. This does not seem to have happened. We can suppose stronger responses of $r - M$, but then the expected recovery would be so rapid that surely we would see it reflected in the catch per vessel.

Between 1913, when the stock might have been 63,000, and when whaling stopped in 1970, 8,000 whales were taken (excluding Labrador). Is the stock now about 63,000–8,000 = 55,000, less than that number, or more and, if either, by about how much?

'Logistic' theory predicts that if the SY of the 1914 stocks was greater than 100–150 the stocks would have started to recover; if less, to decline further. The catches per vessel in later years, taken at their face value, do not suggest a very full recovery, if any; such a view is supported by the fact that effort that was put into whaling further west. If r had risen by an amount only one-quarter of the natural mortality rate, with the intervening catches at less than half of the SY, one could look for an increase in stock size by nearly 5% over the period; there is no indication of such a trend. In fact, the catch rates in the intervening years (1914–39) suggest that the stock was further reduced, by continued whaling at a lower level (a decline perhaps supplemented in the early few years by a recruitment lag), to around 38,000 whales. This would put the present number at no more than 40,000 whales. Whether the 51 whales taken annually from 1940 to 1966 were much less than MSY we have no means of knowing. By the criteria established under the new management policy, which relate not to SY levels but to relative *stock* levels, it seems the bottlenose would be placed in the Protection Stock category, at least in the eastern North Atlantic.

As to what the present sustainable yield, if any, is and certainly as to an MSY level of stock these data are, I think, inconclusive. They are not, however, incompatible with a hypothesis that the stock is now no more than 50% of its initial value; and is most likely less than that, possibly considerably less; it could have been (in 1961) 28% or less of its initial value; the present SY is 300 whales or less, and quite possibly it has never been much higher than that, if at all.

The values of stock sizes quoted in this note, and of SYs, would all be decreased if there was any increasing trend in 'whaling power per unit effort' over the period, especially between 1885 and 1906.

THE EFFECT OF UNBALANCED SEX RATIOS

Benjaminsen (1972) gives in Tables I and III data for the sizes and numbers of mature and immature whales by sex in a 1967 sample of 51 whales from NE Iceland, which are summarised below:–

	Numbers			Mean lengths (ft.)		
	♂	♀	♂ + ♀	♂	♀	♂ + ♀
Mature	17	12	29	26.8	24.2	25.7
Immature	15	7	22	21.4	21.3	21.4
All	32	19	51	24.3	23.1	23.9

53% of the males and 63% of the females were mature. The numbers are, of course, very small, and we do not know if it was a random sample of the catch. I simply note that the ratio of 63% mature females would be consistent for $M = 0.09$ with a reduction in age at maturity from 11 to 7 years. Males were bigger than females (by about 16% by weight if weight is roughly proportional to the cube of the length) and more numerous in catches.

Benjaminsen's Figs. 4 and 5 show that over the period 1938–69 very roughly 20% more males than females were taken at Svalbard, and at Iceland the males exceeded females by 2:1. Fig. 6 shows that the mean length of males exceeded that of females in catches in all areas. The difference was clearest at Iceland and Svalbard but was about 2 ft in all of them. The mean length of females in all areas except Labrador was about 23–24 ft; of males 25–26 ft. In Labrador the length might have been higher; this would be consistent with the fact that exploitation at Labrador began much later, and that half of the growth in length (95% by weight) occurs after recruitment at 2 years.

So, in the eastern North Atlantic the mean lengths in catches of females exceeded those of males by about 10%.

However, the size of females at a given age exceeds that of males by 15–20% (growth curves given by Benjaminsen, Fig. 10), which is more than enough to account for the mean size differences in catches, without postulating major differences in the age composition of the sexes. Considering the wide overlap of the size distributions, relative to the differences between their means, it does not to me seem significant, except insofar as the sexes are segregated in May and June in Iceland.

Without information on the *changes* in sex ratio over a long period – including the early years of whaling, further interpretation is difficult. If males were selectively hunted over a period we should expect the sex ratio to shift away from the unexploited ratio in favour of females. There is no evidence of this having happened. It seems quite likely, however, that the proportion of females in the stock in the post-war period is less than 50% and, considering that 1,711 were taken at Svalbard and 2,125 at Iceland, might be as low as 38%. This means that values of r quoted would need to be reduced by a factor of 0.76 and r–M values accordingly. To maintain stability, and give sustainable yields at a given level, the density–dependent responses, by changes in pregnancy rates and/or ages at maturity, would have to be stronger than I have postulated.

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Current Status of the Gray Whale

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The gray whale, *Eschrichtius robustus* (Lilljeborg, 1861), is the only member of the family Eschrichtiidae and the most primitive living baleen whale. The gray whale is an important species from the standpoint of scientific interest, aesthetic appeal, and economic significance. This paper discusses its current status.

DISTRIBUTION OF STOCKS

There were probably two stocks in the North Atlantic Ocean (Mitchell, 1974). An eastern population is known from sub-fossil remains found in Sweden, the Netherlands, and England and a historical record in Iceland (Rice and Wolman, 1971; Fraser, 1970). The western population is known only from historical accounts of New England whaling (Dudley, 1725) and sub-fossil and recent remains found from New Jersey to South Carolina (Mitchell and Mead, pers. comm.).

There are two geographically isolated populations in the North Pacific Ocean (Rice and Wolman, 1971). These two stocks are usually referred to as the eastern Pacific or 'California' stock and the western Pacific or 'Korean' stock. The California stock migrates along the western North American coast between winter calving areas in Baja California and summer feeding areas in the Bering Sea and adjacent Arctic Ocean (Gilmore, 1960). The Korean stock migrates along the eastern Asian coast between its summer feeding grounds in the Okhotsk Sea and its winter calving grounds around the southern shores of the Republic of Korea (Andrews, 1914). During the last century, part of this stock probably used the Seto Inland Sea, Japan, as a calving area (Omura, 1974).

ESTIMATES OF FORMER AND CURRENT POPULATION SIZES

No former estimates are available for the two North Atlantic populations. They are now extinct.

Scammon (1874) believed that the California stock numbered approximately 30,000 to 40,000 whales during the early years of the gray whale fishery and estimated that it had been reduced to between 8,000 and 10,000 by 1874. However, Henderson (1972) made a careful analysis of the historical data from the fishery and concluded that this stock only numbered between 15,000 and 20,000 at the start of the fishery. An original population level of 15,000 plus was estimated by Ohsumi (1976) by using historical catch data from Henderson (1972) and recent catch data from Rice (1975) in a population model. The total present population is estimated to be 11,000 (± 2,000) whales (Rice and Wolman, 1971).

No original population estimate is available for the Korean stock. By the early part of this century, gray whales were absent from the Seto Inland Sea, but Rice and Wolman (1971) estimated that between 1,000 and 1,500 whales still occurred around the Korean peninsula. Some authors have considered this stock extinct due to severe over-exploitation (Mizue, 1951; Bowen, 1974). However, recent reports suggest it still exists in small numbers (Berzin, 1974; Berzin and Kuz'min, 1975; Kuz'min and Berzin, 1975; and Brownell and Chun, In press).

HISTORY OF EXPLOITATION

Both North Atlantic populations are extinct. A major factor responsible could have been over-exploitation (Mitchell, 1974). During most of the year, gray whales occur in coastal waters and therefore could have been taken even by primitive whalers.

Aboriginal people living on the shores of the northern Bering Sea and the Chukchi Sea have hunted gray whales since prehistoric times (Rice and Wolman, 1971). Indian tribes on Vancouver Island and in the State of Washington traditionally hunted gray whales (Rice and Wolman, 1971).

American whalers exploited gray whales in the eastern Pacific from 1846 until about 1900. Henderson (1972) estimated that the total catch during this period was about 9,600. Exploitation was light during the first half of the 20th century, with modern-style whaling starting in 1905 (Rice and Wolman, 1971). A total of 181 gray whales were taken off Baja California, between 1925 and 1929, and factory ships operated in the Bering and Chukchi seas between 1933 and 1946 taking 681 gray whales (Rice and Wolman, 1971). Complete protection except for catches by or on behalf of Aborigines was established in November 1948 when the International Convention for the Regulation of Whaling went into effect.

A total of 316 gray whales has been collected for scientific purposes, between 1959 and 1969 (Rice and Wolman, 1971). No Soviet catches have been reported between 1947 and 1964, but from 1965 to 1974 the catch by the Soviets on behalf of the Siberian Aborigines (Table 1) has averaged 162 per year. A small number (less than five per year) are taken by Alaskan Eskimos.

Table 1.

Recent Soviet catches of Gray Whales taken on behalf of the Siberian Aborigines

1965	175
1966	194
1967	125
1968	135
1969	154
1970	146
1971	150
1972	182
1973	178
1974	181

In the western Pacific, whaling in Japanese waters dates back more than a thousand years. Net whaling was established in 1677 (Omura, 1974). This type of whaling was started in Taiji and whaling spread rapidly to the south and west coast of Japan. This method combined driving, netting, and harpooning. Gray whales were regularly taken in this area at least until 1896 (Omura, 1974).

Some American whalers took gray whales in the Okhotsk Sea, along with bowheads, during the 19th century (Henderson, 1972). In the waters around Korea, modern style whaling started about 1899 by the Oriental Whaling Company of Osaka, Japan. Records are not available for the early years, but between 1910 and 1933 a total of 1,474 gray whales were taken off Ulsan, Korea. Between 1948 and 1966 at least 67 were taken in Korean waters by Korean whalers (Brownell and Chun, In press).

ANTICIPATED FUTURE POPULATION TRENDS

In the eastern Pacific, the California stock is now apparently stable. Land based gray whale counts from Monterey last year (1975–76) were the highest ever during the past nine years. These figures are presented below and are from the US Progress Report (SC/28/Prog Rep 11):

1967–68	3,120	1970–71	3,034	1973–74	3,492
1968–69	3,081	1971–72	2,588	1974–75	3,348
1969–70	3,064	1972–73	3,304	1975–76	3,797

These counts of southward migrating whales have been adjusted for bad weather and night migration. The resulting best estimate of the California stock is approximately 11,000 (Rice and Wolman, 1971). The high 1975–76 count is believed due to exceptionally good weather conditions and not to any marked increase in the stock size. The difference between the 1974–75 and 1975–76 counts is 449 whales. The reverse trend in counts is noted between 1970–71 and 1971–72 when the total dropped 446 whales.

In the western Pacific, the Korean stock was hunted to such low levels by the early 1900's that the continued small catches during the past fifty years may have prevented recovery. The present condition of the summer and winter grounds required by this stock is unknown. Without meaningful international protection, the Korean stock is likely to become extinct. The basic question seems to be: is this stock above or below its 'critical population size'? Simberloff and Abele (1976) stated that "critical population sizes must differ between species, as must the area necessary to support a large enough population to be relatively immune to fast extinction". It is clear that the Korean stock has been reduced to such a low level that it can no longer function as a significant part of its ecosystem.

PROBLEMS OF PROTECTION

The eastern Pacific stock is accorded complete protection from commercial whaling under the Schedule of the International Whaling Commission. However, a small number (less than five gray whales per year) are taken by Alaskan Eskimos, and an average of 162 have been taken each year between 1965 and 1974 by the Soviets on behalf of the Siberian Aborigines. Ohsumi (1976) reported in his population assessment of this stock that the current sustainable yield is calculated at only 194 whales. According to Ivashin (pers. comm., June 1976) the USSR sets a quota of approximately 200 gray whales a year for its aborigines.

The main calving grounds of this stock are:

(1) Laguna Ojo de Liebre (Scammon Lagoon) and the adjacent Laguna Negro;
(2) Laguna San Ignacio;
(3) Bahia Magdalena, and adjacent waters (including Bakia Almejas, Canal San Carlos, Estero Soledad, Estero Santo Domingo, and Estero Las Animas);
(4) an open coast area south of Yavaros, Sonora;
(5) Bahia Reforma, Sinaloa (Gilmore, 1960; Gilmore *et al.*, 1967).

Henderson (1972) stated that there is no evidence that gray whales ever used San Diego Bay, California, as a calving area.

The two most serious threats to the California stock at present appear to be:

(1) present and future industrial development in and around the calving lagoons which may result in the loss of critical habitat;
(2) the repeated harassment of whales in their calving lagoons, which may deleteriously affect mother–young relationships and reproductive success.

Another concern is that possible oil spills in the waters adjacent to the critical feeding habitat could cause food supplies to be reduced.

Gard (1974) reported aerial counts of gray whales conducted during the winters of 1970 and 1973 at major calving and mating grounds in Baja California. The total number of whales on four wintering grounds did not change appreciably between 1964 and 1973. However, there was a marked shift in local distribution. In Scammon Lagoon, the number of whales decreased, probably due to increased boating activity, but numbers increased in Guerrero Negro Lagoon after commercial shipping terminated in 1967. Along the mainland coast of Mexico, the small population at Yavaros remained stable or decreased slightly while that at Bahia Reforma decreased markedly (Gard, 1976).

The first excursion boat entered Scammon Lagoon in 1970. This type of whale-watching proved successful and at least 8 excursion boats followed in 1971, 16 during 1972, and approximately 30 during 1973 (Gard, 1974). Sand barges also make twice daily round trips into the lagoon and increased visits by yachts, fishing boats, and small boats transported in by trailer could be a serious disturbance to the whales during the calving and mating season.

In February 1972, the Mexican Government established a National Whale Refuge at Scammon Lagoon, and since 1 January 1974, tour boats and yachts have been prohibited from entering the refuge. However, outboard boats may still enter Scammon Lagoon from the shore. Their number is expected to increase now that the new Baja California highway has provided easy access to the lagoon. There are presently no boat restrictions at any of the other calving lagoons.

The western Pacific stock is not accorded complete protection by the Regulations of the International Whaling Commission because several nations which could exploit it (People's Republic of China, Democratic People's Republic of Korea, and Republic of Korea) are not signatories to the Convention.

APPROPRIATENESS OF CURRENT 'PROTECTION STOCK' DESIGNATION

Since the California stock of the gray whale is now apparently stable and near its upper possible population limit, it is not presently endangered. However, future plans for industrial development in and around all calving and mating grounds are uncertain and regulations to reduce harassment on these grounds and along the migratory route are inadequate. The gray whale is a coastal species and without the proper protection in the near future from further human encroachment on its limited breeding habitat, the population cannot be expected to remain stable. I recommend that additional research be undertaken to preserve and better understand this unique species which is of limited distribution and exceptional scientific and aesthetic value. The gray whale is a vulnerable species and should remain as a protected species.

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SC/28/Doc 34

Summary of North Pacific Sperm Whale Assessments

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Two papers (Ohsumi and Masaki, 1977; Tillman and Breiwick, 1977) were presented to the meeting updating the results of the latest catches and providing analyses in greater depth than previously made. The paper by Tillman and Breiwick uses catch/effort data utilizing both modified DeLury and Allen procedures to reach reasonably consistent estimates of the 1972 male population level. Ohsumi and Masaki explore a variety of methods and note many difficulties. However the estimates of Tillman and Breiwick are in reasonable agreement with earlier estimates given by Ohsumi and Fukuda (1972). Before tabulating these estimates it is to be noted that they refer to the exploitable male population in 1972 prior to the change in size limits.

Table 1 shows some data on average sizes and median sizes of recruitment in the three seasons up to 1972 and the three seasons following 1972. This table suggests that the median age of recruitment has decreased about 6 years (19 to 13); consequently the present exploitable stock consists of males 13 and over in contrast to the situation prior to 1972 when the exploitable stock consisted of males 19 and over. Hence it is necessary to have a formula that converts the size of the 19+ stock to a 13+ stock.

Denote N_{13-18} = number of males of ages 13–18 years

N_{19+} = number of males of age 19 years and over

Table 1.

Mean sizes in the catches, median size and age at recruitment of male sperm whales in the North Pacific and Southern Hemisphere.

North Pacific

	Mean size (ft.)			
	Japan Coastal	Japan Pelagic	USSR	
1970	35.1	45.6	41.2	
1971	38.6	46.9	42.5	
1972	38.1	45.8	46.2	
1973	37.7	45.4	39.2	
1974	26.1	45.1	39.1	
1975	37.0	42.7	38.7	
Average				
1970–72	35.3	46.1	43.3	
1973–75	36.9	44.3	39.0	
Difference	1.4	1.8	4.3	
Median size of recruitment 1975	33–34ft.	34–35ft.	33–34ft.	Approx age 13 yrs
Median size of recruitment prior to 1972 size limit reduction	35ft.	38–39ft.	39ft.	19 yrs

Southern Hemisphere

			Mean size (ft.)		
	Australia	S. Atlantic	Ind. Ocean	S. Pacific	S. Africa
1969–70	43.8	42.0	41.9	43.4	38.0
1970–71	43.7	41.8	41.4	42.6	38.3
1971–72	42.3	41.8	41.8	43.4	40.1
1972–73	42.4	41.1	41.1	38.6	38.3
1973–74	41.8	43.0	42.7	41.5	38.0
1974–75	41.0	44.8	40.0	41.4	36.9
Average					
1969–70 to 1971–72	43.3	41.9	41.7	43.1	38.8
1972–73 to 1974–75	41.7	43.0	41.3	40.5	37.7
Difference	1.6	−1.1	0.4	2.6	1.1 Ave 1.0
Median size of recruitment 1974–75	35ft.	42ft.	41–42ft.	36–37ft.	32–33ft.
Med ave age	Coastal 11–17 yrs.		Pelagic 16–22 yrs.		

From the theoretical model, in 1972 prior to exploration of the 13–18 year old component

$$\frac{N_{13-18}}{N_{19+}} = \frac{1 - e^{-6M}}{1 - e^{-M}} \; \frac{1 - e^{-(M+F)}}{e^{-6M}}$$

Here M = natural mortality rate and F = exploitation rate prior to 1972. The agreed figure for M is 0.05 but the figure for F is more difficult to determine since the stock was not in an equilibrium situation prior to 1972. The average catch of the decade prior to 1972 was 10,400 which suggests an average F of about 0.12; substituting in these values gives:

$$\frac{N_{13-18}}{N_{19+}} = 1.2$$

Now the 1972 estimates in Tillman and Breiwick (1977) are 46,000 (Allen's method) and 61,000 (modified DeLury). Averaging these and adding on the 13 to 18 year old component gives an estimate of the total exploitable male population to be 118,000. This is well within the range given in Ohsumi and Masaki, (1977) – 68,800 to 148,800 and is in fact reasonably close to the midpoint of that range, which is 109,000.

It should be noted that whereas both sets of authors provide an analysis using separate stocks they do not use the same subdivision and hence it is difficult to compare them without combining the stock estimates. Whereas it is desirable to provide recommendations by stocks, the North Pacific stock division remains sufficiently uncertain as to preclude this at this time.

In regard to the mature female sperm whale stock, we have no estimates except those in Ohsumi and Masaki (1977) and those given by Ohsumi and Fukuda (1972 and 1974). The range of initial estimates for a total female population is 170,000 to 250,000 (midpoint 210,000). The range of estimates of current stock size is 137,000 to 216,000 (midpoint 178,000). Ohsumi and Masaki (1977) give the following estimates of MSY:

Male	3,900 to 5,800	(midpoint 4,800)
Female	2,600 to 3,800	(midpoint 3,200)

The estimates of original and current size suggest that these should be classified as Initial Management Stocks.

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SC/28/Doc 35

Assessment of Southern Hemisphere Minke Whales

S. J. Holt

The Scientific Committee, at its 1975 meeting, calculated the relation between initial and current stock size in each area assuming that incoming recruits each year were a constant fraction of the number in the *initial* stock, i.e. a constant number. The same assumption is contained in the calculations made during the 1976 meeting with a modified formula. However, the stocks have now began to decline as a result of whaling and it is more 'conservative' and, I think, more reasonable to assume that recruitment is declining with stock size. A simple and perhaps extreme assumption is that the number of recruits is proportional to the stock size A_m years earlier, If there had in fact been a significant and instantaneous density-dependent response of the rate of reproduction to the decline in stock-size, this procedure would slightly underestimate the recruitment. Although we cannot say where the true value would lie, it seems likely to be nearer that given by the proportional assumption than that given by an assumption that recruitment is essentially independent of stock size. It would be prudent to assume proportionality until such time as evidence is available (e.g. changes in pregnancy rate and/or age of maturity) that there has in fact been a density-dependent change.

I have calculated the consequences for Area II where whaling has been going on for the longest time, applying the expression:

$$N_i = (N_{i-1}) e^{-M} + (1 - e^{-M}) N_{i-A_m}$$

and taking $M = 0.125$, and $A_m = 6$.

The calculation is not sensitive to the value of A_m if the the stock is not declining very quickly. The results are shown in the Table 1, column B, including an extrapolation to future years.

The estimation procedure used by the Scientific Committee is such that it is appropriate, for this Area, to adopt the current stock size also in applying my model. This leads to a slightly *higher* estimate of initial stock number (and hence higher quota as calculated from the rules for Initial Management Stocks) and hence a lower ratio current/initial stock size. The difference is not yet very much, but it will be seen that in the coming years the two series diverge rather rapidly.

It would be more reasonable, in fact, to assume that the recruitment is proportional to the number of *females* rather than to the total number. This only makes a difference if the rates of depletion of females and males are different, but this seems to have been the case in general, and especially in Area II, where the proportion of females in catches differs substantially from 50% and also has changed with the beginning of pelagic operations in the area (Table 2). I have calculated the consequences (Column D), assuming that the proportion of females at birth is 0.50 and the natural mortality rates of females and males are equal; over the range of stock sizes considered the calculation is not sensitive to these assumptions. Again, the effect is not yet great, but can soon become significant.

Table 1.

Southern Hemisphere Minke Whales – Area II

Years	Stock sizes in thousands A	B	C	D (% Females)
1965–66	37.1	37.7	37.7	37.8 (50)
1976–77	31.5	31.5	31.5	31.5 (47)
1977–78	30.5	30.2	30.3	30.3 (46)
1978–79	29.6	29.1	29.2	29.1 (45)
1979–80	28.9	28.0	28.2	28.0* (45)
1980–81	28.2	27.0*	27.1*	26.9 (44)
1981–82	27.6	25.8	26.0	
1982–83	27.1	24.8	25.0	
1983–84	26.6*	23.7	24.0	
1984–85	26.2	22.5	23.0	
1985–86	25.9	21.4	22.0	
MSY level (60%)	22.3	22.6	22.6	

Notes to Table 1

* Year in which stock enters "Sustained Management" category under IWC rules (20% more than MSY level of 60% of initial).

(A) Recruitment constant; annual catch from 1976–77 on = 37.1 × 0.05 = 1855

(B) Recruitment proportional to preceding stock number (males plus females); catch from 1976–77 on = 37.7 × 0.05 = 1885

(C) As (B), but with a quota of 1855 as in (A).

(D) Recruitment proportional to preceding number of females only, and assuming no change in sex selectivity of whaling, so percentage females in pelagic plus land station catches = 66. Future catch = 37.8 × 0.05 = 1890

Simulation of future changes under the IWC rules is, in this case, not so straightforward but can be done under the simple assumptions that the differences between the sex ratio in catches in early years, by land stations and by pelagic operations, and the ratio 0.5 effectively measure the catching selectivity whatever the cause of it (presumably segregation of sexes or their differing vulnerability). On this assumption the sex ratio in future catches can be calculated; it tends to move towards the ratio in the unexploited population, and can pass it, which is what has been noted in the history of whaling for other baleen species. In fact in Area II the land station catch has every year contained 67–68% females. The pelagic catch ratio in the Antarctic as a whole has been more variable, averaging 56%.

To predict future stock sizes in the short term I have taken the sex ratio as 66% in consideration of the increased proportion of total catch taken by pelagic operations and of the necessarily changing sex ratio in the stock (see last column of table).

It will be noted that these more "conservative" calculations lead to *higher* catch quotas. This is partly because the modified DeLury model was applied to Area IV (a procedure which is not objectionable because whaling has been

Table 2.

Percent Females in Southern Hemisphere Catches

	Antarctic Pelagic		Pelagic plus land stations
Season	All Areas	Area II	Area II
1969–70	–	–	68.1
1970–71	–	–	68.0
1971–72	46	–	68.0
1972–73	50	–	67.9
1973–74	62	60.2	66.3
1974–75	61.0	60.0	63.8
1975–76	57.3	67.9	67.9

conducted for only 5 years in that Area) and the current stock numbers in the other Areas calculated from that; if the DeLury method is applied to a longer series then it underestimates the initial, and overestimates the current, stock sizes.

In view of the conclusion that at the present level of whaling the Area II minke whale stock will soon need to be reclassified as a Sustained Management Stock, it may be timely to calculate the highest optimistic but reasonable MSY that it might be possible to take from it. Following the arguments in Holt (1977) we find, for the 60% level:

$$\text{MSY} = 0.177\ \text{MP} = 840$$

This estimate depends, of course, critically on the value of M, and one might ask how confident we feel that in the Southern Hemisphere minke whale M is as high as 0.125; that is, double the value used for sei whale assessments (0.06) and three times the fin whale estimate (0.04). The effects of assuming a somewhat lower value M = 0.08 are that an initial stock of 38,400 whales, declining to 31,500 by 1976–77, enters the Sustained Management category by 1979–80 (the same year as indicated in column D). In this case, however, the 'reasonable optimistic' MSY is only 540 whales.

A further factor for future consideration is the nature of the expected density-dependent change in the recruitment rate as the stock is reduced. If this was mainly caused by a decrease in the age at maturity, the effect is to change the lag of 6 years assumed for all the above calculations. At first we would expect the annual recruitment to be boosted by addition numbers as the generations are caused to overlap; that is in a particular year soon after exploitation starts the normal number of mature animals 6 years of age will be augmented by some born a year later and maturing at 5 years. This effect is soon dissipated however, and the stock declines faster than would be expected if age at maturity were constant.

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SC/28/Doc 36

Simulation of Southern Hemisphere Sei Whale Stocks

S. J. Holt

At its 1975 meeting the IWC Scientific Committee used for purposes of advice on stock classification estimates summarised by Chapman (1976). These estimates were of a total initial number of 161,700, reduced to 89,000 by 1974–75, i.e. to 55% of the initial numbers of mature animals. Almost exactly these figures are obtained if, starting with N_o = 162,000 whales (in 1949–50) we apply the expression

$$N_i = (N_{i-1} - C_{i-1})\, e^{-M} + (1 - e^{-M})\, N_o \qquad (1)$$

where C_i is the actual catch in year i
and assuming $M = 0.06$

The results are shown in Table 1, column 1, where the stock in each year is expressed, for convenient comparison, as a percentage of the initial value. There is, however, no reason to suppose that density-dependent response in reproductive rate can be so strong as to maintain recruitment constant despite declining stock size. I have therefore applied an alternative expression in which recruitment is assumed to be proportional to the number of mature animals at the time of birth of each year class:

$$N_i = (N_{i-1} - C_{i-1})\, e^{-M} + (1 - e^{-M})\, N_{i-A_M} \qquad (2)$$

and putting $A_M = 8$

It is permissible to apply this to pooled data for several stocks if they are all assumed to have the same M values. Thus if, for stock x, we write

$${}_xN_i = ({}_xN_{i-1} - {}_xC_{i-1})\, e^{-M} + (1 - e^{-M})\, {}_xN_{i-A_M}$$

then for all stocks

$$N_i = \Sigma_x N_i = (\Sigma_x N_{i-1} - \Sigma_x C_{i-1})\, e^{-M} + (1 - e^{-M})\, \Sigma_x N_{i-A_M}$$
$$= (N_{i-1} - C_{i-1})\, e^{-M} + (1 - e^{-M})\, N_{i-A_M}$$

The results are shown in column 2 of Table 1. The ratio of current to initial stock is of course lower than in column 1. If there had been *some* density-dependent change in reproduction the value of the ratio would lie between the values of columns 1 and 2. I would expect it to lie nearer to 2 than to 1 since I find it difficult to imagine how such response could be so strong and so immediate as to lead to the recruitment being maintained at near the unexploited level. A conservative approach such as the Scientific Committee has been trying to adopt could imply that recruitment would be presumed proportional to the size of the parent stock unless there were concrete evidence of a density-dependent response and an estimate of the strength of it.

Furthermore, I have pointed out (Holt, 1977a) that females predominated in the Antarctic sei whale catches until 1963–64, and that therefore, in calculating the population trend, it would be appropriate to treat the sexes separately. This I have done, taking the initial percentage of females in the (mature) population as 50, and assuming that the recruitment of males and females is proportional to the number of female parents. The results are given in column 3 of Table 1. They show that the southern sei whale stocks could be in a worse state even than suggested by the figures in column 2. The calculated sex-ratios in the population show the pattern of change expected, but are consistently higher than 50 in recent years.

We might expect the ratio in pelagic catches to approach the ratio in the sea in later years – when the stock had been considerably reduced, when land stations no longer contributed significantly to the catch, and when the sei whale had become the most valuable of the baleen species so that its distribution tended to be the main factor governing the distribution of whaling effort.[1] The simulation in column 3 predicts a recent ratio in the stock of 51, whereas in the catches it was 45[2].

Such a discrepancy can be corrected by relaxing the constraint that $M_♂ = M_♀$ but retaining an average M for the two sexes of 0.06 and a 50:50 sex ratio at birth. Column 4 shows the results of putting, for example, $M_♂ = 0.055$ and $M_♀ = 0.065$, which gives a proportion of females in the unexploited mature stock of

$$100\, \frac{e^{-8 \times 0.065/0.065}}{e^{-8 \times 0.065/0.065} + e^{-8 \times 0.055/0.055}} = 43.9.$$

The iteration expression for males is

$${}_♂N_i = ({}_♂N_{i-1} - {}_♂C_{i-1})\, e^{-{}_♂M} + {}_♀N_{i-A_M}\, (1 - e^{-{}_♀M})$$

A further correction can be made for the effects of Southern Hemisphere land station catches *outside* the

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[1] In Antarctic pelagic catches in 1964–65 the total catch by weight, and hence the oil and meat yield, from sei whales exceeded that from fin whales by 7%. It remained higher than fin until and including 1967–68 (average 60% higher) after which a steady ratio was established at least until 1973–74, in which fin exceeded sei yield by 30%.

[2] The sex ratio in Antarctic land station catches is variable but usually high. It was 48.6 in 1964–65, but before that over the whole period 1949–50 to 1963–64 it averaged 55.3. In earlier seasons in which substantial catches were made, (in the period 1934–35 to 1948–49) it fluctuated even more, but averaged 56 to 57. This is presumably a matter of differential accessibility. We should expect the land station ratio to be a function of this and of the sex ratio in the stock. This is in accordance both with the data and the simulation of column 3 which shows a steady trend downwards from the initial 50 to the lowest value, reached in 1964–65, of 47.9. Over this period there is a definite downward trend in the observed ratio in land station catches from around 58 to around 50. The exceptionally high ratio in the early pelagic catches is perhaps a result both of concentration in fin whale areas where more female sei whales than males are found, and of selection of the bigger individuals which were more likely to be females than males.

Table 1.

Calculated relative stock sizes of Southern Hemisphere sei whales (% of an 'Initial' 162,000)

Season	1	2	3	%♀	4	%♀	5	%♀	6[5]	7[6]
1949–50	100	100	100	(50)	100	(43.9)	100	(43.9)	100	–
1961–62	89.1	88.9	88.7	(48.4)	89.3	(43.0)	84.6	(42.4)	87.1	86.9
1965–66	69.5	68.9	68.6	(48.8)	66.0	(41.9)	61.7	(41.2)	65.1	64.5
1966–67	61.0	60.2	60.0	(50.1)	57.3	(42.4)	52.1	(41.4)	55.8	55.1
1967–68	56.1	55.1	54.7	(50.4)	51.9	(42.2)	46.5	(41.1)	50.7	49.7
1968–69	52.7	51.3	50.9	(50.9)	47.9	(42.4)	42.5	(41.2)	47.3	45.9
1969–70	52.1	50.3	49.7	(51.2)	46.6	(92.8)	41.4	(41.7)	47.0	45.1
1970–71	51.4	49.1	48.4	(51.4)	45.1	(43.0)	40.1	(42.0)	46.6	44.1
1971–72	50.7	47.7	46.8	(51.5)	43.3	(43.8)	38.5	(42.0)	46.1	42.8
1972–73	50.4	46.7	45.6	(51.7)	41.8	(43.6)	37.2	(42.3)	46.1	41.9
1973–74	51.0	46.3	45.1	(51.8)	41.1	(44.0)	36.6	(42.7)	47.0	41.6
1974–75	*51.3*	*45.1*	*43.9*	(52.0)	39.5	(44.4)	35.1	(42.9)	*47.5*	*40.4*
1975–76	51.9	43.7	42.6	(52.4)	37.8	(44.9)	33.5	(43.3)	48.3	39.1
1976–77	53.7	43.3	42.2	(52.4)	37.2	(45.3)	33.0	(43.5)	50.2	38.7
$\frac{1974-75}{1961-62}$	57.6[1]	50.7	49.4	–	45.6	–	41.5	–	54.5	46.5
Replacement catch										
1975–76	4,816[3]	1,136	1,220	–	1,072	–	957	–	–	–
1976–77	4,642[3]	798	864	–	964	–	915	–	–	–
1977–78a[2]	55.3	42.7	41.7	–	37.2	–	33.0	–	52.1	38.1
1977–78b[4]	55.1	42.8	41.7	–	36.9	–	32.7	–	52.1	38.1
Allowable catch for (b)										
	2,158	1,759	1,714	–	1,496	–	1,327	–	–	–

[1] Note that the ratio $\frac{1972-73}{1961-62}$ in this simulation is 56.6; this is the lowest in the series. Thereafter the stock starts to increase again because of the excessively large number of recruits and the dwindling catches. With slightly lower initial numbers the ratio of 55 is reached, but the increasing trend starts sooner. With initial number 160,000, 55% of the 1961–62 stock is reached in 1972–73, but the stock increases thereafter. Such discrepancies are not significant in the present exploration of various models.

[2] 1977–78a – assuming 1,820 whales taken in 1976–77 season.

[3] Replacement catch in column 1 is very high because the assumption of constant recruitment implies the stock has been increasing in recent years.

[4] 1977–78b – if allowable catch is set at 0.029 × 0.856 × (1976–77 stock).

[5] Column 6 – same as column 1 except taking into account land station catches outside Antarctic.

[6] Column 7 – same as column 2 except taking into account land station catches outside Antarctic.

Antarctic. This is done in column 5 of Table 1 by repeating simulation 4 but using total Southern Hemisphere catches.

The table also gives the results of calculations of the replacement yield last year and this year. For column 1 this is given by

$$C_R = (N_o - N_{i-1})(e^M - 1)$$

and for the other columns by

$$C_R = (N_{i-A_M} - N_{i-1})(e^M - 1)$$

using for columns 4 and 5 the pair of natural mortality rates. Row (a) gives the expected stock levels next year on the assumption that the 1976–77 allowable catch is set at the same level as the 1975–76 catch and is taken. If the 1976–77 replacement yield is taken the stock levels remain, of course, the same as in 1975–76 in all simulations.

The 1975–76 allowable catch was actually set at a level of 0.029 x (1974–75) stock in the areas which were not classified as protection stocks; that is 0.144 of the *total* stock size. If this proportion were adopted to calculate allowable catches in the 1976–77 season (if none of the stock classifications are changed), and if these were taken, the 1977–78 situation can be calculated; the results are given as (b) in the table.

A further refinement could be made by increasing N_{i-A_M} in each case by the ratio of the initial pregnancy rate P_o to an estimate of that rate in the later years P_{i-A_M}. Since the pregnancy rate has increased since the beginning of Antarctic whaling for sei whales this would give values intermediate between columns 1 and 2, 3, 4 or 5 as the case may be. However, it has been said that the reproductive rate has increased not only – or even mainly – because of a change in the abundance of sei whales but because of changes in stocks of all rorqual species. Evaluation in this case therefore would require a simulation of all these stocks simultaneously, and is beyond the scope of this note.

The discrepancies between simulation 1 and the others are of such magnitude that it is necessary to make simulations separately for the six Areas to see which reclassifications of stock may be suggested. In any case it seems likely that the present *total* stock is well below the *combined* MSY levels, even if these are taken as 50% rather than 60% of initial, and the 'initial' date is taken as 1961–62 instead of 1949–50. Before being too firm in this conclusion, however, it is desirable to examine the sensitivity of some of the simulations to the values of certain parameters. In doing this I have used the figures for stock sizes at the beginning of the 1973–74 season as given by Chapman (1977), and calculated the stocks at the beginning of the 1960–61 season according to 2 hypotheses:

(a) recruitment was constant over that period

(b) recruitment each year was proportional to the stock 8 years before.

I then calculate the ratios

$$\frac{1973-74}{1960-61} \quad \text{and} \quad \frac{1976-77}{1960-61}\,.$$

(The constant recruitment model is that which the Committee has previously applied to minke whales, and about which the Committee has expressed reservations as to its validity when extrapolated to stocks substantially affected by whaling for a period exceeding the delay between birth and sexual maturity.)

With respect to the value of M, an example is given for Area I in Table 2, using the constant recruitment model.

Table 2.

Area I

M =	0.4	0.5	0.6	0.7	0.8
A 1960–61	15.5	15.3	15.1	14.9	14.7
B 1973–74	*12.7*	*12.7*	*12.7*	*12.7*	*12.7*
C 1976–77	10.9	11.0	11.1	11.1	11.2
B/A%	81.8	83.1	84.3	85.3	86.3
C/A%	70.1	71.8	73.4	74.8	76.0

Note M = 0.06 is the value adopted by the Scientific Committee in the calculations made at the La Jolla 1974 meeting (IWC, 1976), and since. M = 0.04 was the value proposed by Borodin at the La Jolla meeting.

The 1973–74 figure was altered from 12.7 to 11.8 in a revision before publication of Chapman (1977). This change does not alter the deductions made in the present paper.

Next it should be noted that the values given for ratios of recent to starting numbers are all *overestimates* because there was some pelagic catching prior to the 1960–61 season, and in some areas there were also substantial land station catches. The simulations depend, of course, on the value used in each case for the stock at the beginning of the 1973–74 season; Table 3 shows the effects of taking different values. In the analysis for the entire Antarctic given in the first part of this paper the values determined at La Jolla in 1974 were used. For this reason I show the consequences of using the value for Area I determined there (42,000), as well as possible higher values.

Table 3.

Area I.

	(M = 0.06) Constant recruitment			Constant r		
A 1960–61	6.7	15.1	17.4	7.0	15.5	17.8
B 1973–74	*4.2*	*12.7*	*15.0*	*4.2*	*12.7*	*15.0*
C 1976–77	2.7	11.1	13.4	2.2	10.6	13.1
B/A%	64.6	84.3	86.4	59.6	81.4	84.1
C/A%	40.0	73.4	76.9	31.2	68.7	73.0

Next we can see whether simple graphical interpolation between the constant recruitment and constant r models in steady state conditions gives a reasonable approximation to the model for linear dependence of r on density. Again taking Area I as an example, the results are set out in Table 4 for M = 0.06 and age at maturity = 8 years.

Table 4.

Area I.

	Constant recruitment	Constant r	linear (s = 1) MSY at 50% calculated	interpolated
A 1960–61	15.1	15.5	15.2	15.2
B 1973–74	*12.7*	*12.7*	*12.7*	*12.7*
C 1976–77	11.1	10.6	10.9	–
B/A%	84.3	80.9	83.4	–
C/A%	73.4	68.2	72.0	72.0

There are no differences between the last two columns, so for the rest of this paper I have used interpolation.

The values given in the right hand column of Table 4 are 'optimistic' in that they relate to the strongest degree of linear density dependence which does not imply that over some range of stock size, within the period of calculation, the absolute recruitment has actually *increased* with declining stock size (see Holt, 1977c). If the density-dependence is non-linear in such a manner that MSY is at a stock level more than 50% of initial stock, and/or we make more conservative assumptions (neutral optimism-pessimism), the ratios are all lower.

A further possible source of error is in the age at maturity. Table 5 shows the consequences of taking 10 or 6 instead of 8 years in the constant r model.

Table 5.

Area I.

Model – Constant r; M = 0.06 A_m =	6	8	10
A 1960–61	15.7	15.5	15.4
B 1973–74	*12.7*	*12.7*	*12.7*
C 1976–77	10.5	10.6	10.7
B/A%	78.6	80.9	82.2
C/A%	66.6	68.2	69.5

All Southern Hemisphere land station catches outside the Antarctic show a preponderance of females. The table in Holt, (1977b) shows that females were also preponderant in pelagic catches until the 1964–65 season, after which they settled to a steady level just under 50%. In 1959–60, the year in which my simulations start, females exceeded males in the ratio 4:1; the ratio declined steadily thereafter. The present simulations would be affected by the sex ratio changes in the period 1959–60 to 1967–68. In all cases the ratios of present stock to starting stock are lower if the sex ratios and changes in them are taken into account, but particularly for the areas in which relatively large pelagic catches were taken in the early 1960's, i.e. Areas I and VI.

Table 6 shows that the consequences of taking the sex ratio into account are negligible in Area I and not very great in Area VI. For the purposes of this paper they are therefore ignored, noting only the direction of error involved in doing that.

Table 6.1

Area I (Chilean catches included, Peruvian excluded)

Model	M = 0.06 Constant recruitment	M = 0.06 Constant r applied to both sexes	M = 0.06 Constant r applied to females	M♂ = 0.055 M♀ = 0.065 Constant r applied to females
A 1960–61	14.9	15.5	15.7	15.7
B 1973–74	*12.7*	*12.7*	*12.7*	*12.7*
C 1976–77	10.3	10.6	10.6	10.5
B/A%	85.2	81.4	81.0	80.9
C/A%	69.0	68.7	67.4	67.0

For the remaining calculations (Table 7) the sex-ratio change was not, therefore, taken into account.

The effect of error in A_m is clearly not great in these calculations. With this background, we can proceed to

Table 6.2

Area VI

Model	M = 0.06 Constant recruitment	M = 0.06 Constant r applied to both sexes	M = 0.06 Constant r applied to females	M♂ = 0.055 M♀ = 0.065 Constant r applied to females
A 1960–61	19.3	20.0	22.9	20.5
B 1973–74	*16.0*	*16.0*	*16.0*	*16.0*
C 1976–77	13.1	12.8	12.6	12.5
B/A%	82.9	80.0	69.9	78.0
C/A%	67.9	64.0	55.0	61.0

simulate the area histories one by one. The results are summarised in the following tables. In interpreting them it should be borne in mind that the effects of differential capture of the two sexes have not been taken into account.

In suggesting a category for each stock I have followed the recommendation of the Scientific Committee with respect to the sei whale that the 60% level should be adopted, especially because, as pointed out earlier, the values given for the ratio of 1976–77 stock to 'initial' stock are all, for a number of reasons, overestimates.

I have finally calculated replacement catches which, if taken in 1976 and the 1976–77 season would leave the stock unchanged, again assuming the model for MSY at 60% and, 'reasonable optimism' for density dependence. These values can in fact be derived with good approximation by taking the arithmetic mean of the replacement catches according to the constant recruitment and constant r models.

Table 7.1

Area I

Model	Constant recruitment	Constant r	Interpolated MSY at 50%	Interpolated MSY at 60%
A 1960–61	15.1	15.5	15.2	15.3
B 1973–74	*12.7*	*12.7*	–	–
C 1976–77	11.1	10.6	–	–
B/A%	84.3	80.9	–	–
C/A%	73.4	68.2	72.0	71.5
1976–77 as percent above or below MSY level			+41	+19
MSY			228	162
Present SY			184	148
Category – Sustained Management				
Allowable catch (Quota) – 90% of MSY = 146				
Replacement catch = 193				

In reviewing Table 7.1 it must be borne in mind that although a proportion of the catches reported by Chile for the period 1960–71 for which they were available have been taken into account, no allowance has been made for any sei whales in the catches of sei + Bryde's whales reported by Peru. Table 7.1 bis shows the effect of including 10% of the Peruvian catches as sei whales.

Table 7.1 bis

Model	M = 0.06 Constant recruitment Peru excl.	M = 0.06 Constant recruitment 10% Peru incl.	M = 0.06 Constant r Peru excl.	M = 0.06 Constant r 10% Peru incl.
A 1960–61	15.1	15.4	15.5	15.8
B 1973–74	*12.7*	*12.7*	*12.7*	*12.7*
C 1976–77	11.1	11.0	10.6	10.6
B/A%	84.3	82.5	80.9	80.1
C/A%	73.4	71.6	68.2	67.3

The interpolated 60% MSY sustainable value for C/A, 10% of Peru catches included, is 69.5, i.e. 16% above MSY level.

Table 7.2

Area II

Model	Constant recruitment	Constant r	Interpolated MSY at 50%	Interpolated MSY at 60%
A 1960–61	49.5	51.9	50.5	50.5
B 1973–74	*23.5*	*23.5*	–	–
C 1976–77	27.3	22.2	–	–
B/A%	47.5	45.3	–	–
C/A%	55.2	42.7	50.5	48.5
1976–77 as percent above or below MSY level			+1	–19
MSY			757	536
Present SY			757	518
Category – Protection stock				
Replacement catch			659	

The simulated 1960–61 stock is rather lower than the value (55.4) given by Chapman (1977), but about equal to the La Jolla figure of 50 (IWC, 1976). The discrepancy with the former is probably related to the fact that the stock has not been near steady state, and the recruitment rate before 1960–61 was different from that during the period for which this calculation is made.

Table 7.3

Area IV

Model	Constant recruitment	Constant r	Interpolated MSY at 50%	Interpolated MSY at 60%
A 1960/61	31.1	31.4	31.2	31.5
B 1973/74	*17.8*	*17.8*	–	–
C 1976/77	17.4	16.5	–	–
B/A%	57.3	56.6	–	–
C/A%	55.9	52.6	54.5	53.5
1976/77 as percent above or below MSY level			+9	–11
MSY				334
Present SY				332
Category – Protection Stock				
Replacement catch			639	

In Area IV we find a situation similar to that in Area V, in that if the stock levels given by Chapman (1977) are accepted, the stock is calculated to have declined from 1960–61 to 1973–74 by an amount (19.6) greater than the catch removed from it (18.1). The 1974 La Jolla report suggested a decline from 33.8 to 19.7 i.e. of 14.1. I have not calculated the changed recruitment necessary to account for these discrepancies; their effect is, as in Area V, to confirm that the stock should be classified as 'Protected'.

Table 7.4

Area V

Model	Constant recruitment	Constant r	Interpolated MSY at 50%	Interpolated MSY at 60%
A 1960/61	25.6	26.2	25.7	25.9
B 1973/74	*16.6*	*16.6*	–	–
C 1976/77	16.8	15.9	–	–
B/A%	64.8	63.5	–	–
C/A%	65.7	60.7	64.0	63.5
1976/77 as percent above or below MSY level			+51	+6
MSY			386	275
Present MSY			355	271
Category – Sustained Management				
Allowable catch (Quota) 90% MSY				= 248
Replacement catch			= 295	

Table 7.5

Area VI

Model	Constant recruitment	Constant r	Interpolated MSY at 50%	Interpolated MSY at 60%
A 1960/61	20.7	21.3	20.8	20.9
B 1973/74	*16.0*	*16.0*	–	–
C 1976/77	14.8	14.4	–	–
B/A%	77.3	75.3	–	–
C/A%	71.7	67.5	70.5	71.0
1976/77 as percent above or below MSY level			+41	+18
MSY			312	221
Present SY			260	203
Category – Sustained Management				
Allowable catch (Quota) – 90% of MSY				= 199
Replacement catch			= 221	

Area V is anomalous in that the back-calculation, even for constant r, gives substantially lower 1960–61 values than does Chapman (1977)–30.4, and even slightly lower than the report of the 1974 La Jolla meeting (IWC, 1976)–27.5. This implies that r actually *declined* over the period, or at least was lower during that period than in the years before 1960–61. Table 7.4. bis shows the simulation with this change which makes the 1960–61 and 1973–74 stock values equal to those given by Chapman.

Table 7.4 bis

Model	Constant recruitment		Constant r	
A 1960/61	25.6	*30.4*	26.2	*30.4*
B 1973/74	*16.6*	*16.6*	*16.6*	*16.6*
C 1976/77	16.8	16.2	15.9	15.3
B/A%	64.8	54.7	63.5	54.8
C/A%	65.7	53.3	60.7	50.4

The implication of the differences evident in Table 7.4 bis is that r was less (by 25% in the constant r model) than would be expected in an initial steady-state stock of 30.4 or, in the constant recruitment model corresponding with a stock of 21.6 rather than 30.4 (i.e. 29% less). Both models indicate the current stock is 11% below the 60% MSY level; it would be protected therefore if the estimate of 30.4 in 1960–61 were maintained. The MSY of this stock would be about 27% lower than originally estimated, i.e. 201, and the present SY = 234.

If, as seems likely, the sei whales were not in a steady state but were increasing in numbers up to 1960 (Smith, 1975) the simulations are all biassed in that the incoming recruits in the earlier years of the series must have been more numerous than has been calculated from equation 2. The detailed consequences of this are complex and remain to be computed. The rate of decline under intensive exploitation in the 1960s would have been slower than here deduced, and from a somewhat higher 1960–61 level. However, since we do not know towards what higher asymptotic level the stocks (other than the Area III stock, which had been exploited intensively for many years before that) were increasing in 1960–61, we are not in a position to make a general statement about the expected MSY and MSY stock levels except that both were higher than has been calculated. That the sustainable yields would be higher does not mean the quotas would all be higher because it could well be that other stocks (e.g. Area V) would be found to be at less than 60% of the asymptotic level and hence might properly be classified as Protection Stocks.

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Updated Estimates of Fin Whale Stocks

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For those stocks for which no additional data or population models are available at the 1976 Meeting of the Scientific Committee, recommendations as to classification and yield should logically be based on the assumption that they have changed in numbers during the past year in accordance with the model which was used in assessing their relation to MSY level and yield in 1975.

The model which has been used in updating the stock estimates is a generalised logistic of the form

$$P_{76} = (P_{75} - C_{75})e^{-M} + \left\{R_0\left[1 - \left(\frac{P_{75-L}}{P_x}\right)^{n+1}\right] + M\left(\frac{P_{75-L}}{P_x}\right)^{n+1}\right\}P_{75-L}$$

where P_{76}, P_{75} and C_{75} are the populations at the beginning of the 1976 and 1975, or 1976–7 and 1975–6 seasons and the catch in the 1975 or 1975–6 season, P_{75-L} is the parent population L years back where L is the mean age at recruitment, P_x is the initial population, R_0 is the net recruitment rate at zero population level and n is the density dependence exponent. For this model n can be calculated by solving

$$\frac{P_{MSY}}{P_x} = \left(\frac{1}{n+2}\right)^{\frac{1}{n+1}}$$

and then R_0 obtained from

$$R_0 = \frac{MSY}{P_{MSY}} \cdot \frac{n+2}{n+1} + M$$

For fin whales the lag time for recruitment has been taken as five years. The parent stock sizes have been approximately calculated by subtracting from the 1975 stock level five times the current recruitment calculated as above, and adding the catches during the five year period. This procedure ignores any changes in the annual net recruitment during these years. Most stocks had been reduced to low levels at the beginning of this period and remained fairly stable within it, although in the earlier years recruitment was sometimes being derived from larger stocks. Any errors introduced in this way are likely to have only a minimal effect on the calculated recruitment for 1976. M has been taken as 0.04.

The values of P_x, P_{75}, P_{MSY} for the fin whale stocks in the Southern Hemisphere, North Pacific and western North Atlantic areas, have been taken from Annex D of the 1975 Report of the Scientific Committee. From these n, R_0 and P_{76} have been calculated as described above. Southern Hemisphere Area I has been excluded since a separate analysis has been made for this stock. The results, and the corresponding categories for the various stocks are set out in Table 1. The figure in brackets after the category for the North Atlantic Newfoundland stock is the permitted catch under the existing procedure.

Table 1.

Steps in the calculation of 1976 fin whale stock levels for the areas for which data are available

	Southern Hemisphere						N. Atlantic	
	II	III	IV	V	VI	N. Pacific	NS	Nfd
n	0.84	0.84	0.84	0.84	0.84	1.65	1.10	1.10
R_0	0.095	0.095	0.095	0.095	0.095	0.101	0.145	0.145
P_x	124	152	60	28	24	44	1.2	2.4
P_{MSY}	70	86	34	16	14	27	0.7	1.4
MSY	2.51	3.07	1.21	0.57	0.48	1.2	0.05	0.1
P_{70}	13.5	30.2	7.4	2.4	9.7	19.7	0.4	1.5
P_{75}	17.5	34.7	7.4	2.7	11.2	17.0	0.4	1.6
Catch	0	0	0	0	0	0.2	0	0
Recruitment	1.3	2.8	0.7	0.3	0.8	1.9	0.05	0.3
P_{76}	18.1	36.1	7.8	2.9	11.6	18.0	0.43	1.9
% P_{MSY}	26	42	23	18	83	67	61	133
Category	P	P	P	P	P	P	P	I(.09)

SC/28/Doc 38

A Comment on Analysis of Area I Fin Whale Stock

Y. Fukuda

In Breiwick's (1977) analysis, the progress during a few years just after the sanctuary was opened in the 1955–56 season evidently has played a key role in evaluating the present status of the stock. In this connection this note just intends to indicate there remain some points to be more deliberately considered, since the Breiwick estimates, even if they seem to be more favoured than those the Scientific Committee has so far presented in the procedures of analysis, suggest a drastic change in evaluation.

The first point is that the Japanese fleet had an extraordinary success in whaling in the 1955–56 season within a rather limited ground of Area I. The catch and effort statistics of the Japanese fleet for the three seasons are given in Table 1.

Table 1

Catch and effort of the Japanese fleet for the three seasons 1955–56 through 1957–58 in Area I

Season	Effort (CDW)	Catch of Fin (Sei)	Main ground
1955–56	355	1,281 (2)	Zone B, 110°W – 120°W
1956–57	636	946 (2)	,, 80°W – 120°W
1957–58	487	616 (30)	,, 80°W – 120°W

With some correction as Breiwick applied, although it may not be appropriate to apply an overall tonnage correction, the corrected CPUEs are given in Table 2.

Table 2.

Corrected CPUEs for the Japanese and other fleets in Area I.

Season	Japanese	Others	Combined
1955–56	7.04	3.99	4.67
1956–57	2.73	3.00	2.95
1957–58	2.22	1.90	1.99

The difference in CPUE between the Japanese and the other fleets is remarkable in the 1955–56 season. Unfortunately, further breakdown of the Japanese catch and effort statistics are not available now, but it seems mostly due to the fact that their main whaling ground in that season was a rather limited region adjacent to Area VI.

Table 3 shows the catch statistics for the pelagic whaling in Areas VI and I in more detail (Omura, 1973; Table 6). The table, it seems, presents another point to be more deliberately considered. It may not be preferable to compare them among the years, because the CPUEs are not

Table 3.

Catch of fin whales, Catcher days work, and uncorrected CPUE for Area VI and Area I

		Area VI					Area I					
Season		170°–160°W	160°–150°W	150°–140°W	140°–130°W	130°–120°W	120°–110°W	110°–100°W	100°–90°W	90°–80°W	80°–70°W	70°–60°W
1955–56	C	247	902	9	176	1,206	886	247	344	1,652	854	125
	E	381	804	30	75	485	340	144	156	613	406	56
	C/E	0.65	1.12	0.30	2.35	2.49	2.61	1.72	2.21	2.70	2.10	2.23
1956–57	C	226	794	2,285	1,129	618	369	259	790	1,538	1,538	1,070
	E	117	567	1,250	726	471	293	294	667	811	921	480
	C/E	1.93	1.40	1.83	1.56	1.31	1.26	0.88	1.18	1.90	1.67	2.23
1957–58	C	228	776	1,014	1,162	586	229	131	371	766	319	27
	E	118	336	555	642	502	165	118	371	547	357	63
	C/E	1.93	2.31	1.83	1.81	1.17	1.39	1.11	1.00	1.40	0.89	0.43
1958–59	C	233	595	226	45	–	–	–	–	–	–	–
	E	276	312	192	36	–	–	–	–	–	–	–
	C/E	0.84	1.91	1.18	1.25	–	–	–	–	–	–	–
1959–60	C	124	129	25	8	17	14	–	61	7	267	106
	E	150	213	64	16	16	32	–	36	18	187	173
	C/E	0.83	0.61	0.39	0.50	1.06	0.44	–	0.44	0.39	1.43	0.61
1960–61	C	290	580	1,046	290	211	1	3	9	5	185	170
	E	422	586	1,014	334	294	36	18	54	54	161	181
	C/E	0.69	0.99	1.03	0.87	0.72	0.03	0.17	0.17	0.09	1.15	0.94
1961–62	C	122	430	190	290	77	152	226	216	683	691	393
	E	211	792	276	382	138	172	264	465	656	795	534
	C/E	0.58	0.54	0.69	0.76	0.56	0.88	0.86	0.46	1.04	0.87	0.84
1962–63	C	72	89	70	83	27	43	78	97	355	356	223
	E	102	155	155	113	72	87	76	193	518	569	492
	C/E	0.71	0.57	0.45	0.73	0.38	0.49	1.03	0.50	0.69	0.63	0.45

corrected. However, it is relevant to compare them among the 10° divisions year by year. The table indicates that the possibly principal concentrations in Area I are found rather consistently around, or east of, 90°–80°W, and that those higher concentrations adjacent to Area VI, variable as they are year by year, should be considered to be a part of Area VI stocks, although the point is to be further studied, taking into account the biological date available.

These are two points I would like to draw to the Scientific Committee's attention, and to suggest that more deliberate consideration be given to them. However, roughly speaking, simple exclusion of 120°–110°W division adjacent to Area VI from consideration does not seem to bring about any substantial change on the present status of the stock (differently as it is defined), except somewhat larger estimates are given to the initial and the present stock levels.

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SC/28/Doc 39

Sperm Whale Maximum Length Limit: Proposed Protection of 'Harem Masters'

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The sperm whale *(Physeter catodon)* is very different from most large whales. It apparently maintains more complicated social structure in schools than does any other whale. The males relate to harems and there are numerous 'bachelor bulls' that do not take part in the maintenance of harems but may play a role, not yet readily understood, in the social maturation of the males that may later become 'harem masters' (Caldwell, Caldwell and Rice, 1966; Ohsumi, 1971; Best *in press*).

After a time in 'nursery' schools, puberal males between 35–38 ft. aggregate in schools of small bachelors. On attainment of large size, aggregations of medium bachelors of 40–45 ft. begin lengthy latitudinal migrations polewards of 40° North and South (Gilmore, 1959). Upon sexual maturity at 25 years and at length approximately 45 ft. and over, bachelor bulls undergo testosterone-induced aggressiveness resulting in territorial spacing of aggregations of large bachelors. There is apparently competition between these large bachelors for dominance. The successful bull remains with the harem school during the breeding season between 40°N–40°S; the 'reservoir' of unsuccessful bulls migrates to latitudes higher than 40° resulting in allopatric distribution that avoids further male encounters and competition for food. This is summarized in Fig. 1, based on published data (Best, *in press*; Ohsumi, 1971; Bartholomew, 1970; and other sources).

Some important details of this behaviour are unknown. Behavioural processes occurring during the rendezvous between bulls and schools of mature females are unknown, as is the possibility of replacement of breeding bulls during the mating season. It is not certain whether the 'idle' bulls take turns at being harem master and whether there is a succession as in fur seals, or whether bulls, once they reach this 'idle' status and assume lengthy, high-latitude migrations, are ever again candidates for 'harem master' status.

For example, the 19th century American sperm whale fishery may have selected for the largest whale in pods; and in equatorial and temperate waters these were, seasonally, probably 'harem masters'. If behavioural and distributional factors insured that after competition for harems, the successful harem master would be the only male servicing a harem (and perhaps only he would be received by them throughout the season), then the removal of the harem master could reduce the pregnancy rate in that school drastically. Assuming that no replacement by other bulls is possible, as surplus animals may be too far away to service the harem in that season, and that this selective procedure was widespread in the fishery, it is possible that the techniques of the early American fishery, coupled with the complex social behaviour of the sperm whale, might have resulted in reduction of the population over decades far out of proportion to reduction judged from the landed catch or oil yield alone.

There are also uncertainties regarding harem size, number of reserve bulls present in the breeding season between 40°N and 40°S, and how these factors may have varied between stocks at initial, exploited and present levels.

In view of these unknowns, I propose that the presumed breeding bulls, the harem masters, be protected during the breeding season. This could easily be accomplished by setting a maximum size limit seasonally in subtropical and temperate waters, as the disparity in sizes is great, whalers can easily estimate the length differences involved, and the bull is often also recognizable on the basis of external pigmentation and scars, and behaviour.

Further, since breeding and calving peaks in the Southern Hemisphere fall within a period greater than the four months presently allowed as a closed season in the IWC Schedule (Anon, 1975), the season for the taking of sperm whales might be reduced from eight months to six continuous months to ensure that breeding bulls in harems, and calving and nursing females would not be disturbed during crucial periods (Gambell, ed, 1977 Ms). I believe that the maximum length limit represents the minimum precaution that should be taken, and that in addition to this, longer closed seasons also should be considered.

CONCLUSION

A maximum length limit of 45 ft. between 40°N–40°S is proposed to protect harem master bulls during the breeding seasons.

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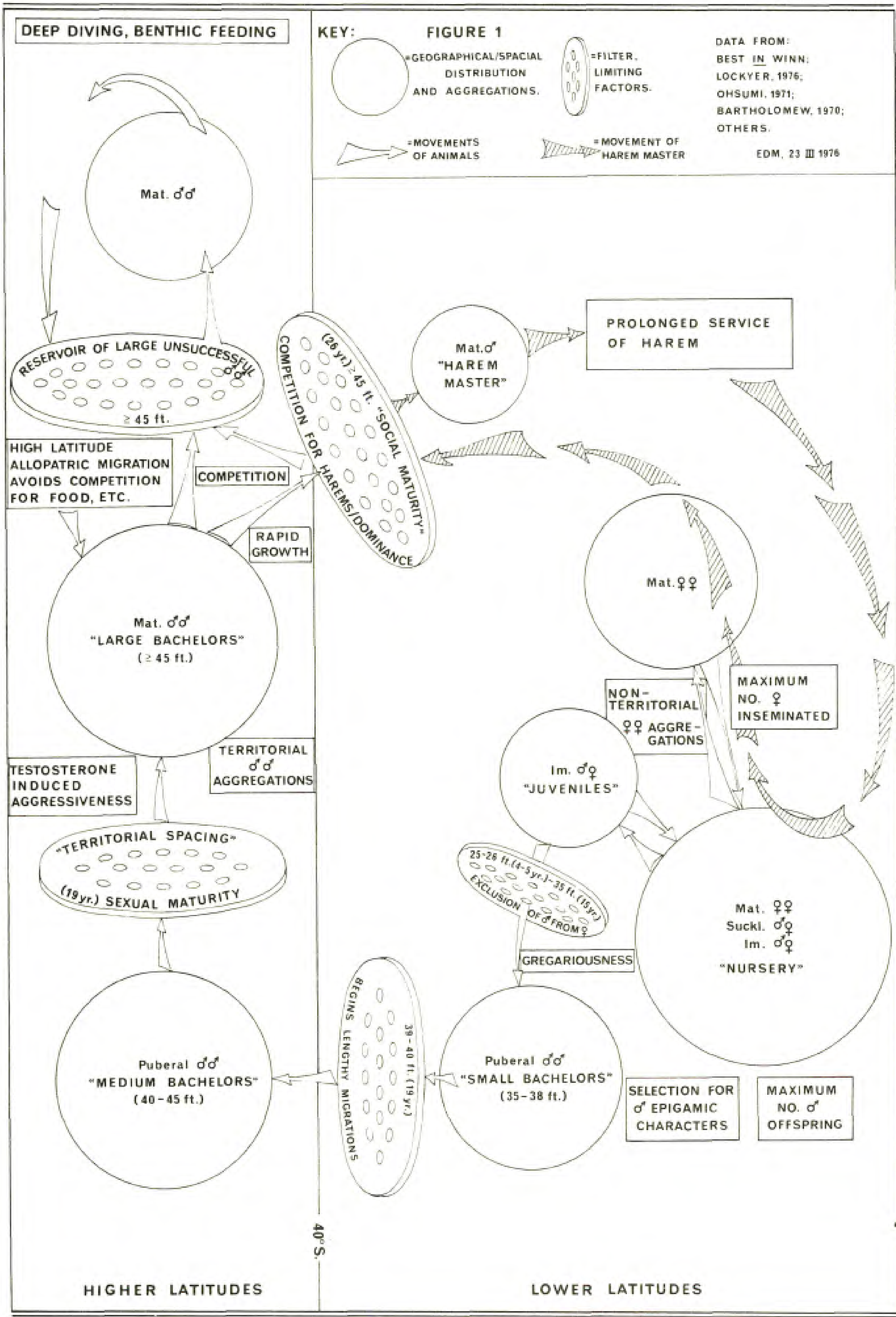

DEEP DIVING, BENTHIC FEEDING
KEY:
FIGURE 1
=GEOGRAPHICAL/SPACIAL DISTRIBUTION AND AGGREGATIONS.
=FILTER, LIMITING FACTORS.
=MOVEMENTS OF ANIMALS
=MOVEMENT OF HAREM MASTER
DATA FROM: BEST IN WINN; LOCKYER, 1976; OHSUMI, 1971; BARTHOLOMEW, 1970; OTHERS.
EDM, 23 III 1976
Mat. ♂♂
RESERVOIR OF LARGE UNSUCCESSFUL ♂♂
≥ 45 ft.
HIGH LATITUDE ALLOPATRIC MIGRATION AVOIDS COMPETITION FOR FOOD, ETC.
COMPETITION
RAPID GROWTH
(26 yr.) ≥ 45 ft. "SOCIAL MATURITY"
COMPETITION FOR HAREMS/DOMINANCE
Mat. ♂ "HAREM MASTER"
PROLONGED SERVICE OF HAREM
Mat. ♂♂ "LARGE BACHELORS" (≥ 45 ft.)
Mat. ♀♀
MAXIMUM NO. ♀ INSEMINATED
NON-TERRITORIAL ♀♀ AGGREGATIONS
TERRITORIAL ♂♂ AGGREGATIONS
TESTOSTERONE INDUCED AGGRESSIVENESS
Im. ♂♀ "JUVENILES"
"TERRITORIAL SPACING"
(19 yr.) SEXUAL MATURITY
25-26 ft. (4-5 yr.)-35 ft. (15 yr.)
EXCLUSION OF ♂ FROM ♀
Mat. ♀♀
Suckl. ♂♀
Im. ♂♀
"NURSERY"
GREGARIOUSNESS
39-40 ft. (19 yr.)
BEGINS LENGTHY MIGRATIONS
Puberal ♂♂ "MEDIUM BACHELORS" (40-45 ft.)
Puberal ♂♂ "SMALL BACHELORS" (35-38 ft.)
SELECTION FOR ♂ EPIGAMIC CHARACTERS
MAXIMUM NO. ♂ OFFSPRING
40°S.
0°
HIGHER LATITUDES
LOWER LATITUDES

SC/28/Doc 40

Some Notes Concerning the Bottlenose Fishery in the North Atlantic After the Second World War, with Particular Reference to the Westward Expansion

Ivar Christensen, Åge Jonsgård and Carl Jakob Rørvik

1. The great majority of the bottlenose whaling vessels in 1938–71 come from Møre on the West Coast of Norway. The distance from Alesund on the Møre Coast to Spitsbergen, Jan Mayen, North and East of Iceland is nearly the same. In fact the vessels need one more day (4) to sail from Alesund to Spitsbergen, where bottlenose whaling started after the Second World War, than to the North of Iceland (3). The catches off the Norwegian coast were fairly constant in this period up to about 1962 (Christensen and Ugland in prep.). If we exclude the catches in the Coastal areas which were of less importance than those off Spitsbergen and North Iceland, a westerly expansion with an increasing distance from home port has not taken place in the period 1946–68.

2. Catch per vessel, in the period 1946–61, when the coastal areas and Spitsbergen were the main grounds, shows a fairly constant trend (Christensen and Ugland in prep.; Table 2 in Christensen, 1975). In the period 1962–63 the ground between North Iceland and Jan Mayen became the most important, but some years substantial catches were also taken off Spitsbergen. (Table 2, Christensen 1975). This accounts for the increase in catch per vessel in the period 1962–68 compared with 1946–61. Christensen (1975) mentions that after a few years the bottlenose was scarcely seen in the North Iceland – Jan Mayen area. We cannot explain why the transfer of effort from Spitsbergen to these waters did occur in the 1960s, but the available data do not indicate any depletion off Spitsbergen.

3. The year 1969 is critical. In this year 150 bottlenose whales were caught off Spitsbergen, well above the average (71.3) for the years 1946–69. In 1969, 5 vessels made one trip each to Labrador, that is 231/5 = 46.2 bottlenose per catcher. The corresponding figures for 1970 and 1971 are (936–99)/9 = 37.4 and 151/4 = 37.8. The 1970 value is corrected for the catch (99) and the trip made by the combined factory and catcher *Peder Huse* which is not comparable in effort with the other ships. These data do indicate a reduced but not depleted stock off Labrador after 1972, although we see the need for a scrutiny of logbooks in order to take the weather into account which can have affected the trend greatly in the short period 1969–71.

4. The direct bottlenose fishery stopped in 1972 when only *Peder Huse* was catching bottlenose. Only three bottlenose were caught in 1973 and none in subsequent years. The reasons for the stop in bottlenose whaling are entirely due to economic reasons, and not a sudden lack of whales. For details see Jonsgård (1977) on the value of bottlenose whales in relation to minke whales in postwar seasons, and the influence of the market situation and the prices on Norwegian whaling activity.

5. How could sailing from Norway to Labrador to catch bottlenose be profitable compared with sailing to Spitsbergen or North Iceland?

The sailing distance between Alesund (62°N, 6°E) on the Norwegian coast to Labrador (62°N, 60°W)–south of Cape Farwell (60°N, 44°W)–is 1,900 nautical miles. With a mean speed of 10 knots this distance can be sailed in 1,900/24 x 10 = 7.9 ≈8 days.

The distance from Alesund to the grounds off North Iceland (69°N, 18°W) is 703 nm, or 2.9 ≈ 3 days sailing time. The sailing time to Spitsbergen (78°N, 5°E) is 960 nm, or 4 days sailing.

A trip usually lasts 4–5 weeks, for the following considerations, say 30 days. That means that the average available time for whaling on these grounds would be:

30 – 2 x 8 = 14 days off Labrador
30 – 2 x 4 = 22 ,, Spitsbergen
30 – 2 x 3 = 24 ,, North Iceland

If the vessels could catch, say, 2 whales per day off Spitsbergen and North of Iceland a trip would result in 44 and 48 whales respectively. Suppose the availability of bottlenose off Labrador is 75% higher than on the other two grounds, that is, an expected catch of 3.5 whales per day – a 30 day trip to Labrador would result in an expected catch of 49 bottlenose whales; thus it would be more profitable to sail to Labrador than the old grounds.

The longer time spent on the whaling ground the less important is the distance to the ground. It should also be noted that the main limiting factor of the duration of the trip is not the time from departure of the port, but the quality of the whalemeat, which depends on the elapsed time after the first whale is shot. According to the calculations above, the trips to Labrador can then be 4–5 days longer than those to the old bottlenose grounds in the North East Atlantic, and these extra days can, if necessary, be spent on the ground.

The essence of these considerations is that the transfer of whaling effort in 1969–71 to the Western North Atlantic does not necessarily lead to the conclusion that a depletion of the stocks had occurred in the North East Atlantic, but simply that the whalers in 1969 realised that the availability of bottlenoses off Labrador were the necessary amount greater in order to make the transfer of effort economically profitable in spite of the greater distances. The large catches of bottlenose off Labrador indicate that this was indeed the case.

6. Why did not the catching off Labrador start earlier?

Norwegian fishermen fishing off Labrador had reported large concentration of bottlenose in that area already in the

1950s. However, the whaling vessels at that time were not considered to be large enough. It should be noted that the weather on the route across the Atlantic, especially in the waters south of Cape Farewell, is known to be rough.

In the 1950s only one vessel above 100 ft. was registered, but during the 1960s larger boats entered the fishery. (Christensen and Ugland in prep.)

The average length of the vessels participating in the bottlenose fishery in 1969 to 1971 is: (excluding *Peder Huse*)

	Whaling off Labrador	Not Whaling off Labrador
1969	109 ft. (4 boats)	92 ft. (12 boats)
1970	105 ft. (8 boats)	84 ft. (8 boats)
1971	112 ft. (4 boats)	90 ft. (2 boats)

It might be concluded that the expansion of the bottlenose fishery westward was made possible by the introduction of larger vessels (as for the minke whaling) in the fleet in the 1960s.

Conclusion

We are aware of the fact that a reduction in abundance of bottlenose might have taken place in the North Atlantic in the period 1946–72. In the light of the arguments put forward by our colleagues we clearly see need for a more refined analysis, with catch and effort data broken down by area, time and preferably corrected for weather conditions from log books. However, the available data clearly indicate that the expansion westward was not caused by a drastic depletion of the stock or stocks in the North East Atlantic, and that the bottlenose whaling stopped of economic reasons.

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SC/28/Doc 42

Additional Considerations on Antarctic Sei Whale Stocks

D. G. Chapman

At the special meeting of the Scientific Committee held in La Jolla in December 1974 (IWC, 1976), among other matters a thorough review was made of sei whale data and analyses. At that meeting it was noted that the mean age of recruitment has fallen from about 15 years in the early and mid 1960s to a recent value of 11 years. Thus during this period there has been an additional recruitment to the exploited stock that was not considered in the analyses that were prepared for that meeting. In addition, sei whale catches in Area II had not been negligible prior to 1964–65 so that recruitment in this Area could have changed in response to exploitation in contradiction to the assumptions of the analyses. Finally, it was pointed out by Gambell (1975) the sei whale recruitment could have responded in response to exploitation of other whale species in advance of its own exploitation. For these reasons we need to review the models that have been the basis of the previous assessments (see IWC, Sci. Rep. 1976, pp. 81–2). However, we begin by noting several significant comparisons – of CPUE between the mid 1960s and the present, and between abundance indices from sightings data over the same time period, shown in Tables 1, 2 and 3.

The sightings indices apply to all series north of 30°S while the CPUE values apply only to the Series south of 40°S (Table 2) or Series D (Table 3). The CPUE values are distorted by the varying interest of the industry in sei whales relative to other species, though as was pointed out by Chapman (1974, P. 284), the CPUE for Series D should be a better index of stock abundance than in the whole of the Antarctic. All of the ratios suggest that in Area II and Area III the present stock level is a small fraction of the level at the initiation of heavy pelagic exploitation. With respect to Areas IV and V the situation is now confusing since the sighting indices suggest these stocks are also low levels while the CPUE indices indicate little reduction since the initial exploitation levels. In any case stocks in Areas II and III should be classified as Protection Stocks.

A full re-examination of the estimates of the sei whale stock along the lines of Chapman (1974) or Tillman and Breiwick (1976) but taking into account the changes in the size of the exploited stock and other possible recruitment effects will require more computing facilities than are available at this time. However, we can make the following improvement on the analysis given in IWC Sci. Rep. 1976 (p. 80). We note that initially the age of recruitment was 15 years and the unexploited component of the mature stock was initially 38.4% of the exploited component. As the age of recruitment was reduced to 11 years the unexploited component became about 30% of the exploited component. We note that is calculated as the ratio:

$$\frac{1-e^{-3M}}{1-e^{-M}} \quad \frac{1-e^{-(M+F)}}{e^{-3M}}$$

taking $M = 0.06$ $F = 0.06$

Applying the percentages to the figures given in Chapman (1974) we have the results shown in Table 4.

While the estimates are for the beginning of the 1973–74 season we note that catches in Areas IV and V were in the three subsequent seasons 3,074 and 1,419 males respectively. In Area IV the catches exceeded the sustainable yield while in Area V the catches were close to the

Table 1

Comparison of Abundance Indices from Sightings

(From Masaki, Y. 1977, Table 9, all figures divided by 1,000)

AREA		I	II	III	IV	V	VI
Initial period		1965–66 to 1966–67	1965–66 to 1966–67	1965–66 to 1967–68	1966–67 to 1967–68	1966–67 to 1967–68	1966–67 to 1967–68
Average initial index	(A)	32	50	90	63	99	65
Average recent index	(B)	15	18	20	17	24	19
Ratio	B/A	0.47	0.36	0.22	0.27	0.24	0.29

The recent index is the average of the latest available three seasons, excluding those seasons where no sightings were made and which have been filled in with the eleven year average in the source report.

Table 2

Comparison of CPUE 1964–65 to 1966–67 with 1973–74 to 1975–76

AREA		I	II	III	IV	V	VI
CPUE – mid 60s	(A)	0.46	1.63	0.89	0.87	0.51	0.46
CPUE – recent	(B)	0.47	0.14	0.24	0.78	0.55	0.46
Ratio	B/A	1.02	0.09	0.27	0.90	1.08	1.00

Table 3

Comparison of CPUE 1965–66 to 1968–69 with 1973–74 to 1975–76 in Series D

	I	II	III	IV	V	VI
1965–66	–	2.38	1.59	0.71	0.33	–
1966–67	–	1.65	1.80	1.24	0.17	–
1967–68	–	1.18	1.16	1.66	2.28	2.17
1968–69	–	1.59	0.79	0.87	2.03	0.27
Average (A)	–	1.70	1.33	1.12	1.20	1.22
Average of highest two seasons	–	2.02	1.70	1.45	2.16	1.22
1973–74	0.54	–	0.38	1.26	0.79	0.10
1974–75	1.42	(0.04)	0.18	1.13	0.91	0.27
1975–76	(0.77)	0.30	–	0.88	0.67	–
Average (B)	0.98	0.30	0.28	1.09	0.79	0.18
Ratio B/A	–	0.15	0.16	0.97	0.66	0.15

(Figures in parenthesis are based on relatively small levels of effort and not included in averages)

Table 4

Sei Whale Population Levels

Area	Component 15 years and older	Total mature stock	MSY level (60%)	1973–74 Component 11 years and older	1973–74 mature stock	1973–74 as % of MSY level
II	40	55.4	33.2	17.0	23.5	71
III	25	34.6	20.8	6.4	8.8	42
IV	27	37.4	22.4	12.9	17.8	79
V	22	30.4	18.2	12.0	16.6	91

sustainable yield. Thus, we may assume that the stocks in Areas IV and V are no higher than in 1973–74. The Area IV stock should be classified as a Protection Stock but Area V may be a Sustained Management Stock. It is possible that there have been further changes in the age of sexual maturity but we have no data. It is clear that all of these considerations should be taken into account in further studies.

Finally, we comment on Areas I and VI sei whale stocks. In Chapman (1974) the stocks of these Areas were estimated by extrapolating from Areas II to V assuming that Areas I and VI had only 10% of the stocks in other Areas. It is now suggested that the sighting indices from Masaki (1977) can be used for the extrapolation. From Table I the indices are as follows:

Area	Sighting index
I	15
II–V	79
VI	19

Using the 1973–74 mature population total of 66,700 for Areas II–V in Table 4 yields estimates of 11,800 and 16,000 for Areas I and VI respectively. Catches in these Areas in the past ten years have been 3,700 and 5,800 respectively (Area I catches include those from Chile where known). Thus the initial stocks in these two Areas may have been about 14–16,000 and 18–21,000 respectively. If this is so, MSY levels will be 8,400–9,600 and 10,800–12,600 respectively. Both stocks would be classified as Initial Management stocks on this basis. According to present guidelines catch limits should not exceed 346 and 454 respectively in the two Areas.

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SC/28/Doc 43

A Possible Basis for Determining Limits to the Allowable Catch when the Degree of Density Dependence of the Net Recruitment Rate is not Known

S. J. Holt

1. This note is concerned mainly with whales classified as Initial Management Stocks and with steady-state situations. The management of recovering or depleted stocks could be analysed by corresponding methods. Consideration of models with time lags between birth and recruitment involves no basically different principles, only more complicated arithmetic. The natural mortality rate M is assumed to be constant.

2. An assumption that annual recruitment in a reduced stock remains at the same level as in an unexploited stock in steady-state implies that the birth rate and the sustainable yield increase steadily as the stock level declines. This situation is illustrated in line A of Figure 1. The figure is drawn such that the properties of the various models can be seen irrespective of the values of M and of the initial stock size, P. A feature of the model illustrated by line A is that for any given decrement in stock size the rate of recruitment, r, increases more than proportionally. This could, I suggest, only be expected in a situation where there were, initially, severe overcrowding with consequent stunted growth and other biological stresses. This is the model implied by the simple DeLury procedure for estimating stock size, which is generally satisfactory only if data are used for periods shorter, or not very much longer, than the time-lag between birth or recruitment and maturity. It leads to highly 'optimistic' predictions when applied to whale populations.

3. Model A could be made slightly more plausible by modifying it as in A^1 if, as for whales, the highest possible value of r can be estimated from biological data. This theoretical possibility is however not relevant to the discussion of management under the Commission's present procedure.

4. Model B is a 'pessimistic' one. It implies there is no density-dependent response to stock reductions caused by whaling so that r is the same at all stock levels. Such a stock would be unstable, having no sustainable yield at *any* level. Stability is introduced, however, giving sustainable yields at all stock levels, if there is only a very small increase in reproductive rate with declining stock; an example is shown as B^1. In this case, however, responses to minute changes in exploitation rate or natural parameters would show extremely slow returns to equilibrium. B^1 represents, of course, only one of the innumerable possibilities of the simple logistic model. Line C represents one of the more usual versions of the simple logistic. It has, as always, MSY at 0.5 P, but is peculiar for stock sizes between 0.475 and 1.0 P in that the recruitment is higher *in absolute numbers* in that range of stock sizes, than in the unexploited stock. I suggest that in the absence of definite evidence or plausible arguments to the contrary, a model having such a property should not be applied to whales in order to calculate quotas.

5. Line D is drawn with a slope at P equal to that of the hyperbola, line A, implying that the maximum population growth rate in residual stocks would be equal to MP. This model could still be regarded as representing the upper limit of 'reasonable optimism'. Any other line (not necessarily straight) lying between D and B would then be 'reasonable'[1] unless other biological constraints were seen. In choosing between the various possibilities it might be presumed that, when initial management stocks are under consideration, an attitude of watchful optimism would be acceptable, and D might be taken as the applicable model, at least for management guidance. The properties of the various models outlined are summarised in Table 1.

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[1] Allen (1977) pointed out that this suggestion to consider as 'reasonable' only models which do not predict increases in recruitment with decreasing stock size, is essentially to impose an additional constraint on the 'more flexible model' described in Allen (1976). In that model the following relations hold (using my notation):

$$\left(\frac{r}{M}\right) = \left(\frac{r}{M}\right)_0 - \left[\left(\frac{r}{M}\right)_0 - 1\right] p^{\alpha}$$

$$p_{msy} = \left(\frac{1}{\alpha + 1}\right)^{\frac{1}{\alpha}}$$

$$\text{and} \quad s = \alpha \left[1 - \left(\frac{r}{M}\right)_0\right]$$

where α is a density-dependence exponent in the model. α can take values from -1 to $+\infty$.

For the simple, symmetrical logistic with $p_{msy} = 0.05$, $\alpha = 1$.

For the special case $s = 1$ we find

$$\left(\frac{r}{M}\right)_0 = \frac{\alpha + 1}{\alpha}$$

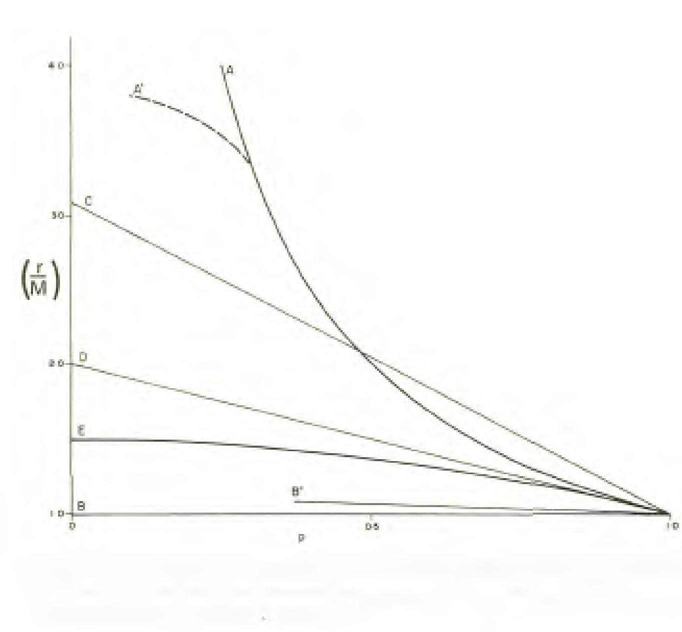
$$\left(\frac{r}{M}\right)_{msy} = \frac{\alpha + 2}{\alpha + 1}$$

$$\text{and} \quad \frac{MSY}{PM} = \left(\frac{1}{\alpha + 1}\right)^{\frac{\alpha + 1}{\alpha}}$$

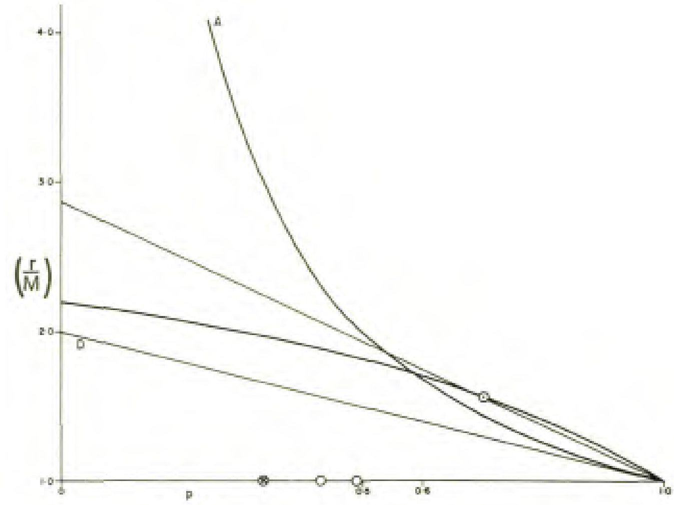
The table shows selected values for these quantities

α	p_{msy}	$\left(\frac{r}{M}\right)_0$	$\left(\frac{r}{M}\right)_{msy}$	$\frac{MSY}{PM}$
5.0	0.70	1.20	1.17	0.116
2.4	0.60	1.42	1.29	0.177
2.0	0.58	1.50	1.33	0.192
1.0	0.50	2.00	1.50	0.250
0.2	0.40	6.00	1.83	0.335
0	0.37	∞	2.00	0.368
−0.5	0.25	∞	3.00	0.500

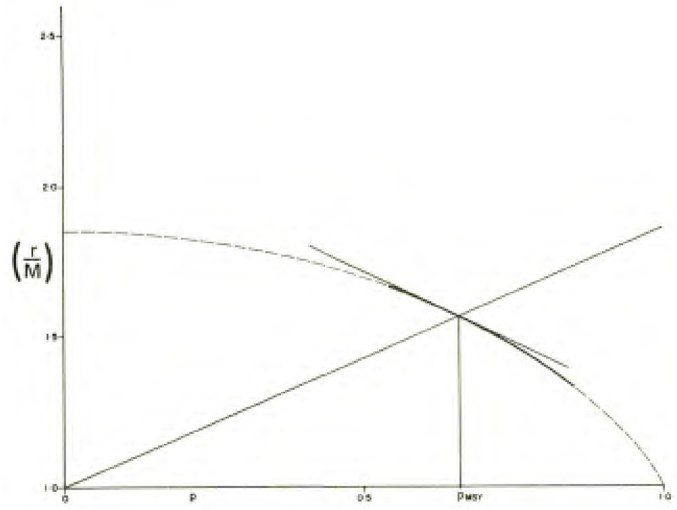
With the constraint $S = 1$ the model for $\alpha = -1$ becomes the hyperbola (A) of Figure 1.



4.0
3.0
2.0
1.0
A
A'
C
D
E
B
B'
$\left(\frac{r}{M}\right)$
0
0.5
1.0
p



A
D
4·0
3·0
2·0
1·0
(r/M)
0
p
0·5
0·6
1·0


2.5
2.0
1.5
1.0
$\left(\frac{r}{M}\right)$
0
P
0.5
P_{MSY}
1.0

SC/28/Doc 44

Comments on a Stock Recruitment Relationship Proposed in SC/28/DOC 43

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Paper SC/28/Doc 43 put forward the proposition that it is unreasonably optimistic to expect that the gross recruitment can be greater at any lower population level than it is at the unexploited population level. It examined the implications of this proposition for the net recruitment rate at the MSY level and examined its application to a set of recruitment curves. The object of the present note is to analyse the effects of applying the same proposition to a generalised population model. It does not involve any implication either for or against the biological validity of the proposition.

Allen (1976) described a 'more flexible' model for baleen whale populations which was based on a density-dependent recruitment rate determined by a generalised logistic equation such that the net recruitment rate at population level P is given by

$$(r - M)_P = (r - M)_0 \left[1 - \left(\frac{P}{P_x}\right)^{n+1}\right]$$

where $(r - M)_0$ = net recruitment rate at zero population level

P_x = unexploited population level

n = density dependence exponent

In this model the population level for MSY relative to unexploited level is entirely determined by the value of n and is given by

$$P_{MSY} = P_x \left[\frac{1}{n+2}\right]^{\frac{1}{n+1}}$$

In SC/28/Doc 43 all the recruitment curves shown in the figure, other than A and A′, belong to this family of curves. For curves B, B′, B″, C, D, n = 0 and $\frac{P_{MSY}}{P_x} = 0.5$. For curve E n = 1.0 and $\frac{P_{MSY}}{P_x} = 0.577$.

The concept that the number of recruits can, at no population level, exceed that at the unexploited level has a limiting case, illustrated in curves D and E of SC/28/Doc 43, in which the number of recruits in the vicinity of the unexploited population level is independent of population size.

Applying this constraint, and making the natural mortality rate, M, independent of population size and therefore equal to r at unexploited population level, it is quite easily shown that

$$r_0 = M\left(\frac{n+2}{n+1}\right)$$

and $(r - M)_{MSY} = \frac{M}{n+2}$

where r_0 is the net recruitment rate at zero population level (equivalent to r in SC/29/Doc 43), and therefore

$$MSY = P_x M \left(\frac{1}{n+2}\right)^{\frac{n+2}{n+1}}$$

The yield relative to MSY population level $\left(\frac{MSY}{P_M}\right) = A_m$

or relative to unexploited level $\left(\frac{MSY}{P_x}\right) = A_x$

may both be expressed as proportions of M which depend solely on n, and are given by

$$\frac{A_m}{M} = \frac{1}{n+2}$$

and $\frac{A_x}{M} = {\frac{1}{n+2}}^{\frac{n+2}{n+1}}$

It is therefore simple to calculate the yield rates relative to M corresponding to any desired MSY level as in the following table.

n	$\frac{r_0}{M}$	$\frac{P_{MSY}}{P_x}$	$\frac{A_x}{M}$	$\frac{A_M}{M}$	
0	2	0.500	0.250	0.500	SC/28/Doc 43–Curve D
1	1.500	0.577	0.192	0.333	SC/28/Doc 43–Curve E
1.4	1.417	0.601	0.177	0.294	
2	1.333	0.630	0.157	0.250	
3	1.258	0.669	0.134	0.200	
4	1.200	0.699	0.116	0.167	
5	1.167	0.723	0.103	0.143	

Note that in this document P_x is equivalent to P_0 in the notation of SC/28/Doc 43.

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SC/28/Doc 46

Big Whale Populations on the Atlantic Coasts of Spain and the Western Mediterranean

Summary[1]

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The two species of big cetaceans studied in this paper are *Balaenoptera physalus* (fin whale) and *Physeter macrocephalus* (sperm whale).

Balaenoptera physalus (fin whale):

Two populations are to be considered:

(1) A winter population, including females and new born or small calves.
(2) A summer population, which seem more numerous, specially in the Genoa Gulf, between Nice and Corsica and off north west Corsica. The most abundant sightings occur in July and August.

Other populations are to be seen too off the Atlantic coasts of Spain.

From Mr. Riddell's observations (Table 1 and 2), between 1966 and 1974 5 catchers were operating between 43° and 45°N, 5° and 11°W, the annual returns reaching about 500 fin and sperm whales.

Table 1
Fin whale sightings by years and months from one catcher, between 43° and 45° N, 5° and 11° W.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
May	2	–	7	1	0	0	0	0	–	10
June	1	13	8	2	12	3	5	1	–	45
July	7	3	11	6	6	3	11	6	–	53
August	2	3	0	9	47(+)	1	6	1	–	29
September	0	0	3	5(A)	6	5	2	3	1	25
October	2	0	3	4	1	3	1	0	0	14
November	0	0	0	4	2	2	0	0	–	8
Total	14	19	32	31	74(+)	17	25	11	1	184

(–: no whaling; A: including three calves; +: including a school of 40)

Table 2
Sightings and catches of fin whales. Years and sex-ratio

	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
Sightings	14	19	32	31	74	17	25	11	1	184
Catches	12	10	21	26	27	16	22	11	1	146
♀/♂	8/4	2/8	9/12	6/20	10/17	9/7	9/13	4/7	–	57/78

In 1925 and 1926, the annual catches per boat were 161 fin whales (Table 3). The last season's returns were only 18 fin whales per catcher (Table 2). In 1974, there was no whaling on account of the lack of fin whales.

Table 3
Catches of fin whales at Corcubion, for 1925 and 1926
(average catch per catcher)

	J	F	M	A	M	J	J	A	S	O	N	D	Total
1925	12	14	3	13	11	17	31	21	14	19	3	–	158
1926	–	–	–	16	28	21	33	28	25	13	–	–	164

Up to 1970, schools of about forty fin whales could be seen. In 1974, only stragglers or very small groups were observed.

I suggest from Table 1 that the North Atlantic stock of fin whales when migrating north passes off Gibraltar about May-June, and part of the schools usually enter into the Mediteranean. The depletion of catches along the Atlantic Spanish coasts is a clear indication of the whole fin whale stock depletion.

Physeter macrocephalus (sperm whale).

From 1966 to 1974, i.e. in 8 years, 547 sperm whales had been captured along the Atlantic Spanish coast, by one catcher; it means 335 annually by the 5 catchers (Table 4).

Table 4
Sperm whale sightings and catches. Years and sex-ratio

	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
Sightings	74	98	105	88	100	89	75	61	11	701
Catches	50	76	72	37	83	87	70	61	11	547
♀/♂	0/50	3/73	3/69	16/21	11/72	20/67	3/67	15/46	0/11	71/476

A striking reduction of catches can be noted here, as well as off Madeira and possibly the Azores. Moreover, observations of sperm whales in the Mediterranean are less and less numerous, and there is also an obvious size reduction of stranded specimens.

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[1] Viale, D. (in press). Contribution à l'ètude des grands Cétacés en Mèditerranée et sur la côte atlantique d'Espagne. *Mammalia.*

SC/28/Doc 47

A Note on the Revised Estimates of the Southern Sei Whale Stocks

S. Ohsumi and Y. Fukuda

The Japanese scientists still have some questions about validity of population analysis simply based on catch and effort statistics. It is because the mid 1960s were the period when the target species was shifting from the fin to the sei whale and the recent three years period (1973–74 to 1975–76) was the period when the whaling industries were, under increased cost of fuel, hastening to adjust themselves to successive introduction of species quota, area regulation and a new management scheme, accompanying rather drastic reduction of quota. One of the authors has already been collecting some relevant data, which indicate that especially recent CPUE figures, even if ordinarily corrected, have been no more representative of the stock abundances but give appreciable underestimates of them. Under the circumstances, however, that he was unable to submit a relevant report on that matter to this meeting, we followed the same procedures critically taking into account comments in Chapman (1977) to revise the estimates, as follows;

Revised Estimates of the Southern Sei Whale stocks (in 1,000s)

	Initial Exploitable	Initial Total mature	MSY level 60% Initial	73/74 Exploitable	76/77[5] Exploitable	76/77 total mature	% above or below MSY L	MSY[6]
Area I	13.7[2]	13.7 + 2.7[3] = 16.4	9.8	9.2[2]	8.0	8.0 + 2.7[4] = 10.7	+9	0.392
II	40.0[1]	40.0 + 7.9[3] = 47.9	28.7	17.0[1]	20.5	20.5 + 7.9[4] = 28.4	–1	1.148
III	25.0[1]	25.0 + 5.0[3] = 30.0	18.0	6.4[1]	9.3	9.3 + 5.0[4] = 14.3	–21	0.720
IV	27.0[1]	27.0 + 5.2[3] = 32.2	19.4	12.9[1]	12.7	12.7 + 5.2[4] = 17.8	–7	0.776
V	22.0[1]	22.0 + 4.4[3] = 26.4	15.8	12.0[1]	12.5	12.5 + 4.4[4] = 16.9	+7	0.632
VI	18.3[2]	18.3 + 3.6[3] = 21.9	13.1	11.6[2]	10.9	10.9 + 3.6[4] = 14.5	+11	0.524
Total	146.0	174.9	104.8	69.1	73.9	73.9 + 28.8 = 102.8		4.292

1. From Chapman (1976).
2. Revised as in Chapman (1977), derived from comparison of sighting indices.
3. The proportion of unexploitable mature ages 8 to 10 to the exploitable mature ages 11 and over is revised as 19.7% instead of 25%, which is derived from the formula $(1 - e^{-3M})/e^{-3M}$ by putting $M = 0.06$.
4. The size of 'unexploitable mature' is taken as same as at the initial. SC/28/Doc 42 assumes that it is related to the current size of exploitable mature population But the La Jolla Sei Whale meeting (SC/27/Rep 6) concluded that there appeared to be no trend to the mean age at recruitment with time over these periods (1966–67 to 1972–73) and IWC/27/4, Annex I, took a view that the age at recruitment did not change over these periods to be at 11. Basically it should have been determined 8 to 11 years ago, and therefore the view of IWC/27/4, Annex I, would be favoured for the present.
5. Extrapolated by the formula $N_{i+1} = (N_i - C_i)e^{-M} + R_{i+1}$.
6. Calculated as 4% of MSY level, apparently conservative.

REFERENCES

Chapman, D. G. 1976. Estimates of Stocks (Original, Current, MSY Level and MSY) as revised at Scientific Committee Meeting June 1975. *Rep. int. Whal. Commn., (Sci. Rep.),* 26: 44–7.

Chapman, D. G. 1977. Additional Consideration on Antarctic Sei Whale Stocks. Paper SC/28/Doc 42 (published in this volume).

Comparison of Existing and Proposed Quota Systems for Male Sperm Whales

K. Radway Allen

CSIRO Division of Fisheries and Oceanography, Cronulla, N.S.W., Australia.

The Scientific Committee has been asked to compare the effects on Initial Management Stocks of male sperm whales of taking catches calculated in accordance with the existing procedure with the effects of catches calculated under a procedure proposed by the Japanese delegation.

In order to simplify the calculations the effects have been examined only for a stock of sperm whales following the SPDYN model with an initial mature female stock of size of 10,000 and having values for the population parameters adopted at the La Jolla Special Meeting as standard for Southern Hemisphere Divisions 1 to 8, except that the reserve male ratio has been set at 0.3.

To further simplify the analysis the number of mature females and therefore the annual number of male recruits has been held constant. Two cases representing opposite extremes for correctly managed stocks have been examined. In the first case the mature female population has been set at the unexploited level (10,000) giving 296 male recruits annually; in the second case the mature females were set at the MSY level (7,900) giving 249 recruits.

Successive male population sizes have been calculated as

$$P_{i+1} = (P_i - Q)e^{-M} + R, i = 0,1,2, \ldots$$

where R is the number of recruits and Q is the permitted catch, determined under the alternative procedures by

Procedure A – Existing system

$$Q = 0.9 \text{ MSY if } P > P_{MSY}$$

Procedure B – Japanese proposal

$$Q = \text{MSY} + 0.1 (P - P_{MSY}) \text{ if } P > 1.2P_{MSY}$$

$$Q = 0.9 \text{ MSY if } P_{MSY} < P < 1.2P_{MSY}$$

The main population components in this model can therefore be summarised as

Mature female unexploited	population size = 10,000 R = 296
Mature female MSY	population size = 7,900 R = 249
Exploitable male initial	population size = 6,065
Exploitable male MSY	population size = 6,065 × .324 = 1,965
Exploitable male SM	population size (= 1.2 MSY level) = 2,358 MSY = 156

TIME TO SUSTAINED MANAGEMENT LEVEL

The first point of interest is the time which an unexploited male stock would take to reach the Sustained Management level (1.2 MSY level) under the two procedures. Table 1 shows the series of annual population and catch levels in each case.

Under the Japanese proposal the population reaches SM level (1.2 MSY level) after 31 and 16 years for the two cases.

Under the existing scheme it remains at or above this level indefinitely.

STABILIZATION LEVELS

It is also of interest to determine the levels at which the male populations would stabilize under the two systems. Stabilization occurs at the level at which the population does not change from year to year, i.e.

$$(P - Q)e^{-M} + R = P$$

and therefore $P = \dfrac{R - Qe^{-M}}{1 - e^{-M}}$

Under procedure A (Existing system)

$$Q = 0.9 \text{ MSY}$$

and $P = \dfrac{R - 0.9\text{MSY } e^{-M}}{1 - e^{-M}}$

Under procedure B (Japanese proposal)

$$Q = \text{MSY} + 0.1 (P - P_{MSY})$$

and $P = \dfrac{R - \text{MSY } e^{-M} - 0.1 (P - P_{MSY})e^{-M}}{1 - e^{-M}}$

from which $P = \dfrac{R - e^{-M} (\text{MSY} - 0.1 P_{MSY})}{1 - 0.9e^{-M}}$

The calculated exploited male stock levels at which stability would occur under the two schemes and for the two levels of mature female populations are shown in Table 2.

Under the existing scheme a male stock with females maintained at unexploited level stabilizes at 1.7 MSY level, and with females maintained at MSY level it stabilizes at 1.2 MSY level. Under the Japanese proposal the stabilization levels are below the upper limits of the Sustained Management category, although above MSY level. The stocks would therefore stabilize at Sustained Management level, as a result of the quota changing to 0.9 MSY. If the female population was at the unexploited level, the male stock would tend to increase under the quota of 0.9 MSY which should be imposed when it was at the SM level, and therefore oscillation about this level would theoretically occur.

Similar series of population levels and catch limits were calculated for a situation in which no recruitment was taking place, i.e. the mature female population was at the zero level. In Fig. 1 under the Japanese proposal, the time required to reach Sustained Management level is plotted against initial male population level for each of the three mature female population levels.

Table 1

Annual exploitable male population levels (P) and permitted catches (Q) under the existing scheme, and the Japanese proposal for cases in which the mature female population is maintained at the unexploited and at the MSY level.

Case	1 – Female Population at Initial Level				2 – Female Population at MSY Level			
Quota Procedure	A (existing)		B (Japanese)		A (existing)		B (Japanese)	
Year	P	Q	P	Q	P	Q	P	Q
0	6,065	140	6,065	556	6,065	140	6,065	566
1	5,932	140	5,527	512	5,885	140	5,480	507
2	5,805	140	5,066	466	5,713	140	4,979	457
3	5,684	140	4,672	427	5,550	140	4,550	414
4	5,569	140	4,334	393	5,395	140	4,183	378
5	5,460	140	4,045	364	5,247	140	3,868	346
6	5,356	140	3,797	339	5,107	140	3,599	319
7	5,258	140	3,585	318	4,973	140	3,369	296
8	5,164	140	3,404	300	4,846	140	3,172	277
9	5,074	140	3,249	284	4,725	140	3,003	260
10	4,989	140	3,116	271	4,610	140	2,858	245
11	4,908	140	3,002	260	4,501	140	2,734	233
12	4,831	140	2,905	250	4,397	140	2,629	222
13	4,758	140	2,821	242	4,298	140	2,538	213
14	4,689	140	2,750	234	4,203	140	2,460	206
15	4,622	140	2,689	228	4,114	140	2,394	199
16	4,559	140	2,636	223	4,029	140	SM	–
17	4,499	140	2,591	219	3,948	140	–	–
18	4,442	140	2,553	215	3,871	140	–	–
19	4,388	140	2,520	212	3,797	140	–	–
20	4,337	140	2,492	209	3,661	140	–	–
21	4,288	140	2,468	206	3,598	140	–	–
22	4,241	140	2,447	204	3,538	140	–	–
23	4,197	140	2,430	202	3,481	140	–	–
24	4,154	140	2,415	201	3,427	140	–	–
25	4,114	140	2,402	200	3,375	140	–	–
26	4,076	140	2,391	199	3,326	140	–	–
27	4,040	140	2,381	198	3,279	140	–	–
28	4,005	140	2,373	197	3,235	140	–	–
29	3,972	140	2,366	196	3,192	140	–	–
30	3,941	140	2,360	195	3,152	140	–	–
31	3,911	140	SM	–	3,114	140	–	–
32	3,883	140	–	–	3,077	140	–	–
33	3,856	140	–	–	3,043	140	–	–
34	3,830	140	–	–	3,010	140	–	–
35	3,806	140	–	–	2,978	140	–	–
36	3,783	140	–	–	2,949	140	–	–
37	3,761	140	–	–	2,920	140	–	–
38	3,740	140	–	–	2,893	140	–	–
39	3,720	140	–	–	2,868	140	–	–
40	3,701	140	–	–	2,843	140	–	–

Table 2

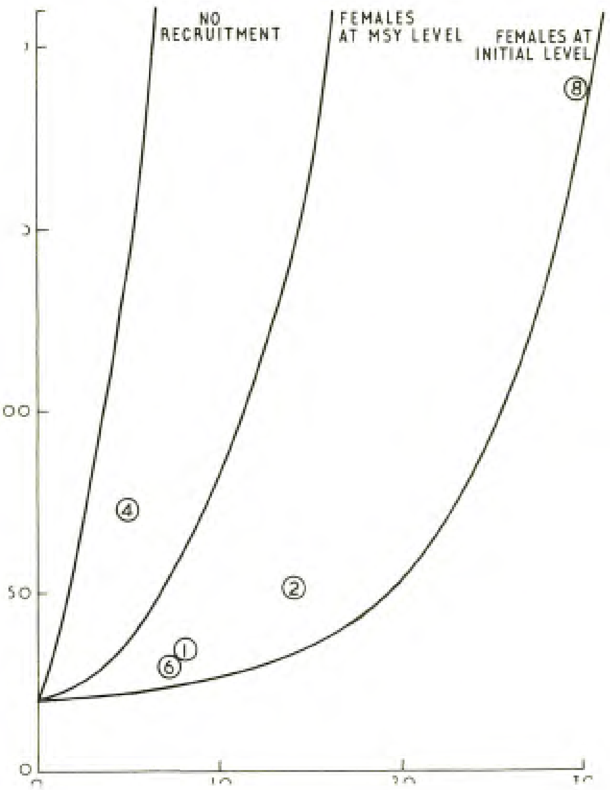
Levels at which the exploitable male population will stabilize under the existing scheme and the Japanese proposal, for two levels of the mature female population.

Quota Scheme	A (= Existing)	B (= Japanese)
Female Stock Level		
Unexploited	3,331	2,324
MSY	2,367	1,998

Table 3

Times required for the exploitable male population to reach the Sustained Management levels under the Japanese proposal for the Divisions having Initial Management stocks

Division	Male % over MSY level	Female % over MSY level	Time (Years)
1	33	16	8
2	50	20	14
4	72	−28	5
6	28	18	7
8	187	26	30



NO RECRUITMENT
FEMALES AT MSY LEVEL
FEMALES AT INITIAL LEVEL
8
4
2
1
6
0

Annex J
SC/28/Rep 1

Report of the Sperm Whale Meeting

La Jolla, California
16–25 March 1976

1 INTRODUCTION

The Scientific Committee of the International Whaling Commission recommended at its June 1975 meeting that a special meeting should be convened to carry out stock assessments and to discuss other matters relating to sperm whales. This recommendation was endorsed by the Commission, and the meeting was held by the kind invitation of the U.S. National Marine Fisheries Service at the Southwest Fisheries Center. Special thanks are due to the Acting Director and his staff for the excellent facilities and assistance which were provided.

2 AGENDA AND DOCUMENTATION

The agenda adopted for the meeting is attached as Appendix 1. A list of working documents submitted is given in Appendix 2.

3 PARTICIPANTS

Australia	K. R. Allen J. L. Bannister
Canada	E. D. Mitchell
Japan	Y. Fukuda S. Ohsumi
United Kingdom	R. Gambell (Chairman)
USA	W. Aron G. A. Bertrand D. G. Chapman W. W. Fox W. F. Perrin T. D. Smith M. F. Tillman
USSR	R. G. Borodin M. V. Ivashin V. K. Vasilyev
FAO	P. B. Best L. K. Boerema S. J. Holt

4 STOCK ASSESSMENTS – GENERAL

4.1 Stock units

Southern hemisphere

Japanese sightings records made by scouting boats (Doc 15) do not give much evidence for any concentrations of sperm whales corresponding to the nine Divisions of the Southern Hemisphere adopted at the Parksville meeting (IWC, 1973). However, these Divisions were based mainly on data from lower latitudes including the breeding grounds. The recent Japanese sightings were mainly in the Antarctic zone, and so might not necessarily be expected to show similar concentrations.

Mark recoveries under the Soviet scheme (Doc 20/2), as well as the International Whale Marking Scheme show mainly north-south movements, with rather few (3 out of 17 in the Soviet marking) records indicating movements between Divisions.

There seems no reason to change the basic nine Divisions as working approximations of stock units.

North Pacific

Japanese sightings from scouting boats (Doc 15) do not show any obvious concentrations within the region. Soviet morphological studies (Doc 20/1) suggest variations between either side of the ocean, but this work is at an early stage yet.

Doc 19 summarizes the evidence assembled by Masaki (1970) which points to the existence of three stocks – Asian, American, and Central. It was decided at this meeting to adopt the three new stock divisions developed by Tillman (Doc 19), also to carry out assessments for the total North Pacific, but the question will be reviewed again at the June 1976 meeting of the Scientific Committee.

North Atlantic

Distribution evidence is inconclusive. The only recovery of a marked sperm whale is a bull marked off Nova Scotia in 1966 and found off Spain in 1973 (Mitchell, 1975). This single return, out of 109 sperm whales marked off Nova Scotia, Greenland and in the mid-Atlantic ridge area, suggests that there may be substantial mixing within the North Atlantic. A single stock should therefore be considered.

4.2 Size compositions

The data examined at the meeting were:

Southern Hemisphere, pelagic, by Areas, 1932–33 onwards; land stations, Durban and Albany;

North Pacific, total only, 1946 onwards;

Antarctic, mean lengths by series by Area, 1932–33 to 1972–73.

4.3 Age compositions

Age-length keys examined at the meeting were:

Southern hemisphere: Western Australia 1964–65, 1974–75, Durban 1962–7;

North Pacific: Japan 1950s onwards, unrefined and refined keys (Doc 12).

4.4 Biological parameters

(published data sources are given in Best, 1974)

4.4.1 Harem structure

The number of mature females in a mixed group is observed to range from 11.7 to 23.4 with a mean of 14.6. The number of harem master bulls associated with each group on the South African west coast grounds averaged 1.5, so that the number of mature females per bull ranges from 8 to 16, with a mean of 10 (Doc 5).

These data are in accord with the observations made in other areas (e.g. Docs 3; 20/7; Ohsumi, 1971; Gambell, 1972).

4.4.2 Number of 'surplus' bulls

The number of socially mature bulls not actively engaged in breeding actively may be up to 3.9 times the number of harem masters in an unexploited population (Doc 5). There is no evidence to indicate to what level this ratio could decline under exploitation. A reasonable ratio might be 1:1, thus allowing a harem-master to hold a harem every second year, or alternatively no reserve might be necessary.

4.4.3 Reproduction rate

The pregnancy rate appears to reach a maximum and then to decline with age. Lactation may also be longer in older females (Doc 6). Because of the age dependent pregnancy rate, the change in age composition that results from exploitation would cause the pregnancy rate to increase. Trial calculations show however that if the overall rate is 18.4% of mature females in an unexploited stock, the overall rate would increase only to 19.7% in a stock subjected to a fishing mortality of 0.04, after equilibrium has been reached (age at recruitment = 10 years in both cases). Apart from this, the pregnancy rate might be expected to increase under exploitation as observed in southern baleen whales and some odontocetes (Gambell, 1973; Perrin, *et al.*, 1976) because of a greater frequency of ovulations, particularly at the mid-lactation and end-of-lactation oestrous periods. Ovulation appears to be spontaneous in this species (Doc 20/6).

Although the pregnancy rate is expected to increase in exploited sperm whale populations, there have been no observations on reduced sperm whale stocks, and it would be useful to analyse the pregnancy rates from recent catches in various oceans and areas. It was agreed to ask Mr Vangstein to prepare tabulations showing the number of pregnant females and total females by mother's length, with foetuses less than and more than 2 m in length, by nation and month for the nine Divisions of the southern hemisphere and the six Areas of the North Pacific.

4.4.4 Age and mortality

Age readings.

Three new sets of evidence were considered pointing to the accumulation of a single dentinal growth layer throughout most of the life-span: edge type analysis in southern hemisphere whales, recovered marked whale data in the North Pacific, and the tetracycline marking of dolphin teeth (Docs 4, 10, 13).

Age readings will continue to be available from Australia, Japanese and Soviet Antarctic and North Pacific catches, and Iceland. The new method of tooth reading by Mikhalev (Doc 20/3) was noted.

The growth curves developed by several authors were compared by Ohsumi (Doc 12) and appeared very similar. However, the North Pacific age-length keys were found to be different from those available for the southern hemisphere; in particular, the mean ages at length were higher for bigger males. In addition, the refined North Pacific key slightly underestimates the mean age at length in bigger whales by comparison with the raw key.

In view of the differences between the Western Australian and Durban age-length keys, it was decided to use the combined Western Australian keys for predominantly Antarctic catches.

Age at maturity

For the purposes of population calculations, what is needed is the mean age at first parturition, and this is in fact what is referred to throughout this report when age at maturity is given. A reduction in this parameter might be expected to occur in exploited populations, as has been observed in southern fin and sei whales. The presently observed age at first parturition in sperm whales in both the southern hemisphere and the North Pacific averages 10 years. It has been assumed that this age may decline to 8 years with increased growth in a reduced population.

The age at social maturity in males has been observed to be 25 years. Increased growth in a reduced population will give a lower age if body size is the controlling factor. A reduction in age to 22 years, therefore, seems reasonable.

Mortality

Mortality estimates must take account of differential segregation of components of the sperm whale populations.

The mature natural mortality rate is usually estimated from the oldest age groups in existing fisheries, and has been taken as 0.05 in both sexes. From general population theory, a small change might be expected to occur in natural mortality in a reduced stock but as it is already so low in the sperm whale, there would seem little capacity for change, and a constant value has been adopted for all stock levels.

The value of the immature mortality rate in unexploited stocks cannot be measured directly at present, but is computed to balance the other parameters of pregnancy rate, mature mortality rate and age at maturity so as to assure the population is indeed stable. The change in the immature mortality rate as the population is decreased is conjectural. While it could decrease because of better feeding conditions, it could increase if there is significant exploitation of lactating females and consequent reduced survival of calves in their first year of life.

4.5 Catch data

Materials examined at the meeting were:

Southern Hemisphere, by Divisions, 1945–6 onwards (Doc 8).

North Pacific, by three areas, 1948 onwards (Doc 19).

4.6 Effort data

The only records available at present for pelagic operations are the net catcher day statistics. The meeting urges that because of the uncertainty in what they represent, better data should be collected in the future which give a more precise measure of effort to include days of zero catch

4.6.1 Tonnage/horsepower factor

Analyses of Japanese Antarctic pelagic sperm whale data showed that fishing power is proportional to catcher tonnage (Doc 14), as found in the Durban coastal fishery (Gambell, 1975).

The Western Australian land station operation is exceptional because of the nature of the fishery so that tonnage/horsepower does not appear to be a significant factor to incorporate (Bannister, 1969).

4.6.2 Asdic correction

Japanese pelagic operations show an overall increase of efficiency of x 1.26 since the introduction of Asdic (Doc 14). Allen reviewed that data (Doc 2) and derived a value of x 1.38 for recent years.

Western Australian data show an increased efficiency due to Asdic of x 1.19 (Doc 3).

Asdic is not used in Soviet operations.

4.6.3 Selection effects

Higher output per whale, selection of the larger whales available, economic control of operation, coupled with the introduction of geographical quotas and the change of the minimum size limit in 1972 suggest that this might be a useful cutoff point in time series analyses.

5 EXTENSION OF POPULATION ANALYSES TO INCLUDE WEIGHTS

The population estimates resulting from the Parksville meeting (IWC, 1973) were used at that time to calculate the maximum sustainable yields of male and female sperm whales combined. This combination was expressed in 'male units' – the ratio of the cubes of the approximate mean lengths of male and female catch data was used as an approximation of the relative weights of the two sexes. Subsequent advice to the Commission developed by the Scientific Committee at the 1973 La Jolla meeting on suggested catch levels (IWC, 1976), was based on a straight combination of numbers of the two sexes, pending further study of the incorporation of a weight factor to take account of the great difference in the size and weight of the exploited animals of each sex and of the changes of these with exploitation.

At the present meeting, the view was taken that since the industry is concerned with yield of products, a weight basis for assessment is more appropriate. The weight component was incorporated in the dynamic model (Doc 1G) using the von Bertalanffy growth curve parameters which gave the best fit to the Western Australian and Japanese North Pacific age-length key data over the exploited size range. The values were:

	W	K	T
Male	40 tons	0.84	0.00
Female	16 tons	0.95	–4.40

6 ASSESSMENTS

A. ESTIMATES OF 1946 MALE POPULATIONS

6.1 Southern Hemisphere

The meeting had available to it estimates of the 1946 populations of exploitable males by Division in Docs 2, 21 and 22. Additional computations were carried out at the meeting, and all the estimates developed are shown in Table 1.

Table 1

Estimates of 1946 exploitable male population sizes, southern hemisphere (x 10^{-3})

				Division					Total		
1	2	3	4	5	6	7	8	9	(3 – 7) [3 – 8]	Source	Method[1]
13.6	–	–	18.7	20.7	12.9	19.7	–	–	–	Doc 2	CHPOP USSRTC
–	–	26.8	17.4	19.4	12.6	17.5	–	–	(93.7)	Doc 2	CHPOP JTC
–	–	24.6	12.5	17.4	9.8	13.3	24.7	–	(77.6) [102.3]	Doc 2	CHPOP JAC
–	–	62.3	26.5	12.6	11.2	11.4	–	–	(124)	Meeting	CHPOP JAI
–	73.9	68.7	53.2	52.1	–	–	69.9	49.9	–	Doc 2	CHPOP UKAC
–	–	16.1	14.3	9.5	–	17.6	–	–	–	Meeting	CHPOP JTI
–	–	39.8	–	–	–	–	–	–	–	Meeting	CHPOP Durban[2]
–	–	–	–	17.0	–	–	–	–	–	Doc 3	CHPOP AlbanyA/C[3]
–	–	–	–	22.8	–	–	–	–	–	Doc 3	CHPOP AlbanyC/E[3]
11.2	33.5	47.2	19.2	25.2	12.0	20.1	?	53.3	(123.7)	Doc 22	Allen (1966) APOBS
–	–	22	–	–	–	–	–	–	[50]	Doc 21	Mean length change Series A & B
–	–	24.30	10–12	12–15	9	12	?	–	(67–78)	Meeting	Derived from mat. ♀ pop. sizes & SPDYN output, selecting mat. ♀ pops. by change of F method.
12.4	53.7	38.4[4]	23.1[4]	21.9[4]	11.3	15.9	47.3	51.6	(110.6) 275.6		Overall mean
15*	34	39	34	30	10	15*	35*	45	(128) 257	IWC (1973)	See Parkesville meeting

1 USSR Japanese (J) and UK catch data used for following areas and q values:
T = temperate zone A = Antarctic C = combined q I = individual q

2 Catch per 10^5 catcher-ton-days asdic-corrected males 40ft. (later adjusted to mean age at recruitment = 15 years), 1954–71

3 Aircraft sightings 1962–75, CPUE asdic-corrected 1970–74

4 Excluding change of F result

* Based on 500 males per degree of longitude

Least squares estimates

The estimates in Docs 2 and 22 are both based on the least squares procedure which estimates parameters so as to minimise the sums of squares between observed and expected catches. The differences are as follows:

(a) In Doc 2 the effort used is corrected for tonnage and in the case of Japanese effort for Asdic. In Doc 22 the effort measure is net catcher days.
(b) Doc 2 assumes constant recruitment while in Doc 22 recruitment is assumed to increase after 18 seasons.
(c) Doc 2 gives separate estimates based on effort by national groups while Doc 22 uses combined effort. Also Doc 2 uses two methods: one assuming the catchability coefficient per unit area is constant over all divisions vs. an individual catchability coefficient in each division.
(d) In Doc 2 the minimisation of the sum of squares is between observed and expected catches for known effort by nationality; in Doc 22 the effective effort is estimated for the total catch and then the minimisation of the sum of squares is applied to the total catch.

The methods used in Doc 2 based on the CHPOP (catCH and effort POPulation estimation from the actual and expected catches) programme were also applied to some additional sets of data from South African and Australian land stations.

Dynamic model estimates

Another approach was developed during the meeting using the programme SPDYN (SPerm whale DYNamic pool model) given in Doc 1. This programme calculates a time series of the population sizes by sex. It requires as input parameters: the 1946 number of mature females, pregnancy rates, mortality rates (adult and juvenile), harem size, harem reserve, age of parturition, age of male social maturity, ages of recruitment, density dependent coefficient and the von Bertalanffy parameters. After exploration of the sensitivity of the programme to variations in the several parameters, a minimal set of parameter possibilities was determined together with a set of possibilities for the 1946 female mature population size. These were entered into the computer using known catches in each Division to obtain a number of time series of population sizes and fishing mortality coefficients (F). Many of the series were eliminated because they led to negative populations or unacceptably high fishing mortality coefficients (F>0.4).

The meeting considered ways of using the goodness of fit of the dynamic model to observed events as a means of obtaining population estimates. In particular, it compared the changes with time of calculated F values for various 1946 population levels with the corresponding changes in effort. The calculated value of F normally increases more rapidly in the model as the 1946 population is decreased. The method used was to compare the slopes of fitted linear regressions for the logarithms of F and effort against time and to try to determine the population level at which they were similar. Only one set of population parameters, other than the 1946 population size, was used. The results are given in Table 2. Using graphical interpolation and extrapolation, population estimates were obtained for most Divisions and these are included in Table 1. In making the extrapolations, it was noted that the slope of the F line must become infinite at the 1946 population level at which a collapse to zero occurs when the actual catches are applied.

Change in mean size

In Doc 21 a new method was developed which uses catches and mean size of whales in catches, but not effort data. This was applied to changes in mean size of males between 1947–48 and 1960–61 in Area III E, Series A and B (data from Appendix 3). It gave a figure for recruited males over 22.5 years old (42 feet and over) in Division 3 in 1947–48 of about 14,500–15,000 decreasing to 3–4,000 or less by 1960–61. This latter figure is however very sensitive to the size and age at recruitment used in the calculations, and little weight can be given to it. The CHPOP programme applied to Japanese data for Series A and B only for Division 3 gave a similar 1947–48 value of 17,000, reducing to 3–4,000 by 1961–62. The equivalent values for males in 1946, over 15 years old (comparable with SPDYN values and others in Table 1) are 22,000 and 25,000 respectively.

The change in length method was applied to Divisions 3 to 8 combined, giving a value of about 50,000. This is lower than the corresponding estimates from CHPOP, and from SPDYN, but about the same as those from the change of F method.

For comparison purposes the estimates adopted by the

Table 2

Slope of linear regression of logarithm of effort against time compared with slope of regression of logarithm of F against time calculated for different values of initial population size.

Division	Period	Slope of regression of log effort	Initial Population Size (1,000s) 15	22.5	30	35	37.5	40	45	50	52.5	60	70	87.5	105
			Slope of regression of log F												
3	59–67	0.173	–	–	–	–	–	–	∞	0.088	–	0.058	–	–	–
	59–70	0.090	–	–	–	–	–	–	∞	0.094	–	0.064	–	–	–
4	58–71	0.148	∞	0.113	0.099	–	0.083	–	–	–	–	–	–	–	–
5	50–73	0.156	–	∞	0.113	–	–	0.093	–	0.074	–	–	–	–	–
6	50–64	0.181	0.103	0.093	0.088	–	0.089	0.087	–	–	–	–	–	–	–
	50–70	0.070	0.135	0.107	0.098	–	0.096	0.090	–	–	–	–	–	–	–
7	52–65	0.140	∞	0.108	0.096	–	0.093	0.088	–	–	–	–	–	–	–
	52–75	0.102	∞	0.165	0.120	–	0.105	0.097	–	–	–	–	–	–	–
8	52–59	0.312	–	–	∞	0.376	–	–	–	–	0.381	–	0.365	0.343	0.362

special meeting at Parksville (IWC, 1963) are shown in Table 1.

Sightings density index

The application of population models gave, *inter alia,* estimates of total numbers of whales in each Division in each year. As an independent check, these were compared with estimates of relative abundance derived from Japanese sightings data given in Doc 15, over the period 1965–66 to 1973–74.

For each Division there was calculated a density index, expressed as whales sighted per 1,000 nautical miles steamed for series D + E and A + B (40°–50°S + 30°–40°S and 50°–60°S + 60°–70°S). These are shown in Table 3.

The densities in each Division were converted to a population index by multiplying each value in series D + E by the area of D + E in that Division, and adding the product of density in series A + B and the area of those series. The total for each Division was then expressed as a percentage of the total of all Divisions (Table 4, column a) and the total of Divisions 3–8 (column b).

The 1970 total population estimates computed from the SPDYN dynamic model programme for the mature female population levels indicated by the effort comparison are also given in Table 4 as percentages by Division of the total of all Divisions and Divisions 3–8 (columns a and b respectively).

Comparison of these results shows that the relative abundance of the stocks in the various Divisions as estimated by the two methods of sightings and population estimation are broadly similar, with the outstanding exception of Division 2. From the sightings it appears that 90% of the southern hemisphere sperm whales were in Divisions 3–8. On the other hand, only 66% of the total catches of males have come from these Divisions in the period 1945–46 to 1973–74.

The northern series D + E contained seven times as many whales as the southern series A + B, as shown in Table 5. With the exception of Division 2 (for which sightings in D + E seem to have been abnormally infrequent), the densities in the two sets of series are correlated, so that a high abundance from sightings in more northerly latitudes tends to be associated with high values in more southerly latitudes, and vice versa.

These comparisons indicate where there are anomalies which call for future investigation and explanation, but the general agreement appears to add confidence to the results obtained. However, it should be noted that the sightings data are as well related to the catches used as input to the SPDYN model, as to the estimates of population numbers (see last two pairs of columns in Table 4, although in this case Division 8 is clearly anomalous).

Table 3

Density of sperm whales in southern hemisphere from Japanese sightings (from Doc. 15) 1965–66 – 1973–74

Division	Area[1] D + E	Area[1] A + B	Miles steamed Series D + E	Miles steamed Series A + B	Whales seen Series D + E	Whales seen Series A + B	Density (per 1,000 miles) Series D + E	Density (per 1,000 miles) Series A + B
1	408	298	74,731	11,389	375	8	5.0	0.7
2	752	496	119,188	19,694	362	65	3.0	3.3
3	568	397	313,048	24,649	3,695	85	11.8	3.4
4	456	298	255,216	159,931	4,245	348	16.6	2.2
5	543	397	337,305	31,810	4,321	99	12.8	3.1
6	351	298	110,482	11,132	1,280	27	11.6	2.4
7	434	298	95,669	17,320	2,368	57	24.8	3.3
8	1,065	695	28,942	85,295	437	148	15.1	1.7
9	440	386	615	4,930	0	2	0	0.4
Total			1,335,196	366,150	17,083	839		

[1] Square equatorial degrees

Table 4

Comparison of estimates of southern hemisphere stocks from Japanese sightings (1965–66 – 1973–74, Doc 15) and from the analyses for which male values are given in Table 1 (calculated as at 1970)

Division	Sightings (a)	Sightings (b)	Population estimates (a)	Population estimates (b)	Total catches (a)	Total catches (b)	Pelagic catches (a)	Pelagic catches (b)
	Percent of southern hemisphere whales in each Division							
1	3.5	–	6.6	–	7.4	–	10.6	–
2	6.0	–	16.1	–	9.2	–	15.3	–
3	12.5	13.8	16.6	25.1	24.5	36.1	15.0	20.5
4	12.8	14.1	11.7	17.6	8.3	12.2	13.5	18.4
5	12.7	14.0	10.8	16.4	12.0	17.7	10.0	13.6
6	7.4	8.2	5.7	8.6	5.1	7.6	10.1	13.8
7	18.2	20.2	7.9	11.9	15.4	22.7	21.6	29.6
8	26.8	29.6	13.5	20.4	2.5	3.6	3.0	4.1
9	0.2	–	11.1	–	15.6	–	1.0	–

Total number (thousands) 987 653
%3 – 8 90.2 66.2

B. SENSITIVITY TESTS

The meeting had access to a computer programme (SPVAP – SPerm whale VAriable Population model, Doc 1G) which provided calculations of sustainable yields at equilibrium levels given an initial number of mature females and a suite of nine biological parameters – ratio of juvenile mortality rate at zero population level to rate at unexploited level, adult natural mortality rate, age of females at first parturition, age of males at social maturity, harem size, harem reserve bulls, pregnancy rate, age at recruitment and a density dependent exponent. Any of these parameters could be varied and its effect on yield and population levels tested. Due to a lack of time and in order to limit output to reasonable levels, manipulations of these parameters were confined mainly to testing the effects of changing pregnancy rate and its density dependent exponent, the age at social maturity and the age at recruitment. Other parameters were arranged in two sets which were considered to represent the most conservative parameters, giving the

Table 5

Relative abundance of sightings in northern (D + E) and southern (A + B) series by Division

Division	Abundance relative to series total (%) D + E	A + B	Abundance ratio (D + E) / (A + B)
1	3.6	2.6	9.8
2	4.0	20.2	1.4
3	11.9	16.6	5.0
4	13.4	8.1	11.5
5	12.3	15.2	5.7
6	7.2	8.8	5.7
7	19.1	12.1	11.0
8	28.5	14.6	13.6
9	0	1.9	–
	100	100	7.0

lowest absolute yields (the 'worst parameters'), and most optimistic parameters, giving the highest absolute yields (the 'best parameters'). Each variation of the four main parameters was tested in the two situations of 'best' and 'worst' parameters. The results are shown in Tables 6, 7 and 8. Where a range of parameter values are given in these tables, the first value is that used for the initial unexploited mature female stock, the second value is that assumed to hold as the stock level approaches zero. The variations of the parameters with respect to stock size as a fraction of initial size depends on the value of the density dependent exponent; it is linear when the exponent is zero.

Yield of males

With the density-dependent exponent = 0, giving a linear relation between the parameters and population size, male yield is almost exclusively dependent on harem size and harem reserve. With an increasing exponent, this yield increases with pregnancy rate, although this is only really significant at extremes of expected pregnancy rate increase and density dependent exponent. Yield is little affected by changes in the age at recruitment but would increase significantly if the age at social maturity should decrease under exploitation.

The population level giving maximum male yield is not significantly affected by changes in the age at recruitment, the age at social maturity, or the sets of 'best' and 'worst' parameters. At the lower expected pregnancy rate changes, this level corresponds closely to that of the unexploited mature female population i.e. maximum yields are achieved without exploiting the female population. The greater the extent to which the pregnancy rate is expected to change, however, and the larger the density dependent exponent, the lower the mature female population giving maximum male yield.

Yield of females

The yield of females is set almost exclusively by the extent of pregnancy rate change, its density dependent ex-

Table 7

Sensitivity tests of pregnancy rate variations, using most conservative parameters

Output in same format as in Table 6.

'Worst' parameters are: Juvenile mortality ratio = 1.2; natural mortality = 0.05; harem size = 10; harem reserve = 1; age at sexual maturity in females = 10 years.

Pregnancy rate	Density dependent exponent 0		1.40		4.05	
	Level	No/wt	Level	No/wt	Level	No/wt
0.19→0.25	10,000	189	10,000	189	9,000	199
	5,000	32	6,000	53	7,000	73
	10,000	4,699	8,600	4,953	8,400	5,625
0.19→0.33	9,500	189	99,000	212	8,000	261
	5,000	83	6,000	139	7,000	191
	7,700	5,225	7,300	6,820	7,700	8,450
0.19→0.38	8,250	197	7,500	248	8,000	304
	5,000	115	6,000	193	7,000	264
	7,000	5,887	7,100	8,088	7,600	10,215

Table 6

Sensitivity tests of pregnancy rate variations, using most optimistic parameters

In the following tables, the three rows of output in each block are as follows:

Row 1 – Level giving maximum catch of males by number, and the maximum catch
Row 2 – Level giving maximum catch of females by number, and the maximum catch
Row 3 – Level giving maximum weight of the two sexes combined, and the maximum combined weight of catch in tonnes.

All levels are in numbers of mature females, from a starting population of 10,000.

'Best' parameters are: juvenile mortality ratio = 0.8; natural mortality = 0.05→0.04; harem size = 15; harem reserve = 0; age at sexual maturity in females = 10→8 years.

Male age at recruitment = 20 years, and social maturity = 25 years held constant.

Pregnancy rate	Density dependent exponent 0		1.40		4.05		Pregnancy rate	Density dependent exponent 0		1.40		4.05	
	Level	No/wt	Level	No/wt	Level	No/wt		Level	No/wt	Level	No/wt	Level	No/wt
0.19→0.25	10,000	273	8,500	285	8,000	330	0.25→0.30	10,000	273	8,750	280	8,250	319
	5,000	98	6,000	169	7,000	236		5,000	90	6,000	157	7,000	219
	8,300	6,103	7,300	7,744	7,700	9,618		8,600	6,001	7,400	7,459	7,700	9,212
0.19→0.33	9,250	275	7,500	337	7,500	418	0.25→0.33	10,000	273	8,250	292	8,000	344
	5,000	157	6,000	273	7,000	383		5,000	107	6,000	187	7,000	263
	7,000	7,136	6,900	10,004	7,500	12,863		8,000	6,229	7,200	8,114	7,600	10,195
0.19→0.38	8,000	286	7,000	375	7,500	477	0.025→0.38	10,000	273	7,500	317	7,750	387
	5,000	193	6,000	338	7,000	475		5,000	134	6,000	239	7,000	336
	6,600	7,889	6,700	11,406	7,500	14,804		7,300	6,721	6,900	9,228	7,500	11,813

ponent and any reduction in the age at first parturition.

The female population level giving maximum yield of females is only significantly affected by changes in the density dependent exponent. When this is zero the maximum sustainable yield (MSY) is taken at 50% of the initial mature population size, but as the exponent increases, the level giving MSY moves nearer to initial population size. It is completely unaffected by values given to the pregnancy rate or the range of expected change.

Maximum combined yield by weight

The population level giving maximum combined yield of males and females by weight is largely affected by the extent of pregnancy rate change in females and its density dependent exponent. The size of the actual yield is correlated most closely with harem size and the density dependent exponent of pregnancy rate.

Table 8

Sensitivity tests of male age of social maturity and age of recruitment

Output in same format as in Table 6.

'Worst' parameters used as in Table 7, using pregnancy rate range $0.25 \rightarrow 0.33$.

Age of social maturity	Age of recruitment male and female			
	15		20	
	Level	No/wt	Level	No/wt
20	10,000	213	10,000	203
	5,000	25	5,000	25
	10,000	5,116	10,000	5,546
25	10,000	156	10,000	142
	5,000	25	5,000	25
	10,000	4,039	10,000	4,183

Table 9

Estimates of current (1975) exploitable male and mature female populations

Stock	Division 1	2	3	4	5	6	7	8	9	Total	Method
Exploitable males 1946	12.4	33.0	38.4	23.1	21.9	11.3	15.9	37.7	36.2	229.9	See Table 1 and text
Mature females 1946	20.3	54.1	63.0	37.9	35.9	18.5	26.1	58.5	46.4	360.7	See Table 10 and text
Exploitable males 1975	5.3	15.8	12.1	12.7	7.3	4.6	4.2	32.8	11.5	106.3	From SPDYN tables using factor 1 below
Mature females 1975	18.6	51.1	51.7	21.4	34.3	17.2	20.8	58.3	24.9	298.3	From SPDYN tables using factor 2 below
% males 1975–1946	42.7	47.9	31.5	55.0	33.8	41.1	26.4	91.9	31.8	46.2	
% females 1975–1946	91.6	94.5	82.1	56.5	95.5	93.0	79.9	99.7	53.7	82.7	

1. Exploitable males 1946 – (expl. males 1946 – expl. males 1975) at nearest mature females 1946 figure
2. Mature females 1946 – (mat. females 1946 – mat. females 1975) at nearest mature females 1946 figure

C. EXPLORATORY DEVELOPMENT OF THIS ANALYSIS

For the purpose of further analysis, arithmetic means of the southern hemisphere Divisional estimates of the 1946 exploitable male populations were adopted, except that two corrections were applied as follows. The means of two estimates for each of Divisions 2, 8 and 9 were all heavily dependent on the UKAC (Antarctic combined q) estimates, which were much higher than most other estimates in all Divisions. The UK estimates for Divisions 2, 8 and 9 were therefore reduced by the ratio of the sum of the means for Divisions 3, 4 and 5 to the sum of the UKAC estimates for these same Divisions.

The Division 8 estimate from the JAC analysis, and the Divisions 2 and 9 estimates from the APOBS analysis were similarly adjusted (again using the sum of the Divisions 3, 4, 5 values as reference), and new averages for Divisions 2, 8 and 9 were calculated.

The resulting corrected values for the 1946 exploited male populations in each Division are shown in Table 9. The corresponding numbers of males at present in each Division, and the 1946 and present mature females are also given, derived from the appropriate SPDYN output as shown in Table 10 (male age at social maturity = 25 years, male age at recruitment = 20 years, except in Division 9 where recruitment age taken as 15 years).

Expressed as percentages of the 1946 populations, the present number of males and females were compared with the SPVAP determination of population levels giving the maximum sustainable yields by number and weight for each sex separately and combined.

For Divisions 1–8 where the age at recruitment is taken as 20 years (Table 11), the maximum sustainable combined yield in weight is generated at 95% of the initial mature female stock size. The corresponding male population is calculated by reference to the fishing effort, $F = 0.102$. Then the exploitable male calculation at the level of maximum sustainable combined yield is $M/(F+M)$ or $0.05/(0.102 + 0.05) = 33\%$ of the initial population size.

For Division 9, with a recruitment age of 15 years, the SPVAP output (Table 12) also gives a maximum sustainable combined yield by weight at 95% of the initial female stock, and at $0.05/(0.072 + 0.05) = 41\%$ of the initial exploitable male population.

The estimates of the present population levels are extremely sensitive to the 1946 populations adopted, and it will be necessary to explore the sensitivity of the estimates before conclusions on any stock status can be evaluated.

Table 10

Estimates of 1946 mature female population sizes

Division									Total	Method
1	2	3	4	5	6	7	8	9		
20.3	54.1	63.0	37.9	36.5	18.5	26.1	58.5	46.4	367.8	See Footnote
–	–	40–50	17–20	20–15	15	20	–	–	–	Change of F method
19	44	50	44	38	13	19	45	58	330	IWC (1973) Parkesville

Footnote: SPDYN using corrected initial male populations (shown as first line in Table 9) divided by 0.61 except for Div. 9 where factor used of 0.78.

Table 11

SPVAP output of population levels and yields by number and weight for each sex separately and combined, Divisions 1–8

Catches and fishing mortality rates of males (CM, FM) and females (CF, FF) and weight of catch by sex separately (WM, WF) and combined (WC)

For decreasing populations (POP)
Unexploited populations size - 1,000

Age at recruitment – male = 20 years
Age at recruitment – female = 13 years

Age at social maturity – male = 25 years
Harem size = 10

Reserve per harem male = 0.000
Density dependence exponent = 0.000

Age for juvenile mortality = 2 years
Natural mortality rate = 0.050 Unexploited, = 0.050 25%. = 0.050 Zero population

Pregnancy rate = 0.190 Unexploited, = 0.250 25%, = 0.270 Zero population
Age at maturity – female = 10.0 Unexploited, = 8.5 25%, = 8.0 Zero population

Juvenile mortality rate = 0.133 Unexploited, = 0.133 25%, = 0.133 Zero population
Growth parameters – male W (INF) = 40.0, K = 0.084, T(0) = 0.00

Growth parameters female W (INF) = 16,0, K = 0.095, T (0) = 4.40

POP	CM	CF	FM	FF	WM	WF	WC
10,000	197	0	0.100	0.000	5,433	0	5,433
9,500	193	12	0.102	0.002	5,293	163	5,456
9,000	187	24	0.104	0.003	5,138	309	5,447
8,500	182	34	0.106	0.005	4,970	438	5,408
8,000	175	42	0.108	0.007	4,788	550	5,338
7,500	168	50	0.109	0.008	4,591	645	5,236
7,000	161	56	0.111	0.010	4,382	722	5,103
6,500	153	61	0.113	0.012	4,158	782	4,940
6,000	144	65	0.115	0.014	3,920	825	4,745
5,500	135	67	0.116	0.016	3,669	850	4,520
5,000	126	68	0.118	0.018	3,404	859	4,263
4,500	116	68	0.120	0.021	3,125	850	3,975
4,000	105	66	0.121	0.023	2,833	824	3,657
3,500	94	63	0.123	0.025	2,527	781	3,307
3,000	82	58	0.124	0.028	2,207	720	2,927
2,500	70	52	0.126	0.030	1,873	642	2,516

Table 12

SPVAP output of population levels and yields by number and weight for each sex separately and combined, Division 9

Catches and fishing mortality rates of males (CM, FM) and females (CF, FF)
and weight of catch by sex separately (WM, WF) and combined (WC)

For decreasing populations (POP)
Unexploited population size = 1,000

Age at recruitment – male = 15 years
Age at recruitment – female = 13 years

Age at social maturity – male = 25 years
Harem size = 10

Reserve per harem male = 0.000
Density dependence exponent = 0.000

Age for juvenile mortality = 2 years
Natural mortality rate = 0.050 Unexploited, = 0.050 25%, = 0.050 Zero population

Pregnancy rate = 0.190 Unexploited, = 0.250 25% = 0.270 Zero population
Age at maturity – female = 10.0 Unexploited, = 8.5 25%, = 8.0 Zero population

Juvenile mortality rate = 0.133 Unexploited, = 0.133 25%, = 0.133 Zero population
Growth parameters – male W(INF) = 40.0, K = 0.084 T(U) = 0.00

Growth parameters – female W(INF) = 16.0, K = 0.095 T(U) = –4.40

POP	CM	CF	FM	FF	WM	WF	WC
10,000	222	0	0.071	0.000	5,265	0	5,265
9,500	217	12	0.072	0.002	5,129	163	5,293
9,000	211	24	0.073	0.003	4,980	309	5,289
8,500	205	34	0.074	0.005	4,817	438	5,255
8,000	198	42	0.075	0.007	4,641	550	5,191
7,500	190	50	0.076	0.008	4,451	645	5,095
7,000	182	56	0.077	0.010	4,247	722	4,969
6,500	173	61	0.078	0.012	4,031	782	4,813
6,000	164	65	0.080	0.014	3,801	825	4,625
5,500	153	67	0.081	0.016	3,557	850	4,408
5,000	143	68	0.082	0.018	3,300	859	4,159
4,500	131	68	0.083	0.021	3,030	850	3,880
4,000	119	66	0.084	0.023	2,746	824	3,570
3,500	106	63	0.085	0.025	2,450	781	3,230
3,000	93	58	0.086	0.028	2,139	720	2,860
2,500	79	52	0.087	0.030	1,816	642	2,459

6.2 North Pacific

Lack of time at the meeting prevented a thorough examination of North Pacific data in the same way as that carried out for the southern hemisphere.

The only analysis performed was a least squares estimate using the CHPOP programme and catch data tabulated by Tillman. The results are shown in Table 13. It will be noted that there are wide variations between the estimates based upon the Japanese and Soviet pelagic catch data. It was not possible in the time available to understand or narrow the discrepancy between these estimates, although it was noted that the Japanese pelagic results were broadly in line with recent Japanese assessments (Ohsumi & Fukuda, 1974).

Table 13

North Pacific population estimates of initial (1948) and final (1975) exploitable males from CHPOP analysis.

Stock		Japanese pelagic	Soviet pelagic
Eastern	Initial	Failed	Failed
	Final	Failed	Failed
	q	Failed	Failed
Central	Initial	94,000*	463,000
	Final	37,000*	412,000
	q	5.25×10^{-5}	0.32×10^{-5}
Western	Initial	No data	53,000
	Final	No data	11,000
	q		6.66×10^{-5}
Total	Initial	230,000	541,000
	Total	133,000	450,000
	q	1.6×10^{-5}	0.27×10^{-5}

*Sum of squares considerably better

7 EFFECTS OF CHANGE IN MINIMUM SIZE LIMITS

The meeting was asked to consider this matter as the Soviet scientists considered that the majority of pregnant females should be protected from capture, to prevent the depletion of the reproductive stock.

The catches of males and females are at present regulated by separate quotas. Other participants considered that this system should be continued, and the use of a minimum size limit to regulate the catch of females is not considered to be a desirable alternative. A higher size limit would encourage whalers to take only the largest animals from many groups, and there are grounds for encouraging the capture of smaller numbers of whole schools of whales, with a consequent reduction in the socially disruptive effect on the whales of the catching operations.

Minimum size limits may have a more important role to play in maximising yield, but the growth curve of both males and females is very flat in the main exploited age groups. The use of a cohort analysis technique may provide the basis for recommendations in the future.

There is now a strong economic incentive to select the larger whales available, and some companies impose their own limit above the present legal size. However, there could be some value in imposing a maximum size limit, say of 43 ft, to protect the breeding bulls during the breeding season.

8 SPERM WHALE OPEN SEASONS

There is no biological reason for any close season south of 40°S, because only 'idle' bulls are present in this region.

The North Pacific oceanographic situation and sperm whale distribution are more complex than in the southern hemisphere. In particular, the females penetrate into much higher latitudes than in the south.

Concern was expressed for the disruptive effects on the social structure caused by hunting during the conception and calving season. Removing harem bulls during the summer mating period may depress reproduction if all the potential replacements have already gone to polar waters and do not return during the pairing season. There are no quantitative data on the effects of chasing females accompanied by young calves, but this may cause mortality at an early critical period of life, as well as by killing lactating mothers when milk is the only food taken by the calves.

Therefore, it might be prudent to protect sperm whales during the mating and calving seasons in temperate waters. In the southern hemisphere this period is broadly November to April, and in the North Pacific, March to August.

9 ECOSYSTEM AND ENERGY FLOW CONSIDERATIONS

Three papers were available bearing on these factors. Whales caught under special permit in the North Pacific (Doc 16) showed some variation in stomach contents between the two sexes, perhaps due to differences in the feeding behaviour of the males and females. All of the squid observed are not subject to direct fisheries at present, but may be taken by other animals in the ecosystem.

Assessments to date assume that any relative reduction in male sperm whale stocks produces no density dependent effects in the female stocks, i.e. that these two sexes are independent parts of the ecosystem. This assumption needs further investigation, as well as the interaction between components of the population.

Juvenile sperm whales in general eat smaller squids than adults. This may be an effect of selective feeding or the vertical distribution of the squid (Doc 6).

The estimates of the sperm whale energy budgets at various phases of the life cycle (Doc 11) suggest that the energy demands of lactation may require an increase in the food intake of about 50%. However, the depletion of the blubber store and its subsequent restoration may serve to buffer and spread this effect beyond the strict limits of the lactation period.

Much more information is required before a fuller understanding of the role of the sperm whale in the ecosystem can be achieved, as well as the influence of the environment on the whale at various stages of its life history (Doc 20/4, 20/5).

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Appendix 1

AGENDA

1. Introduction
2. Appointment of chairman
3. Arrangements for preparation of meeting report
4. Stock assessments – general
    4.1 Stock units
    4.2 Size compositions
    4.3 Age compositions
    4.4 Biological parameters
        4.4.1 Harem structure
        4.4.2 Number of 'surplus' bulls
        4.4.3 Reproduction rate
        4.4.4 Age and mortality
    4.5 Catch data
    4.6 Effort data
        4.6.1 Tonnage/horsepower factor
        4.6.2 Asdic correction
        4.6.3 Selection effects
5. Extension of population analyses to include weights
6. Assessments
    6.1 Southern hemisphere
    6.2 North Pacific
    6.3 North Atlantic
7. Effects of change in minimum size limits
    7.1 Sex ratio
    7.2 Sex composition
    7.3 Weight
8. Sperm whale open seasons
9. Ecosystems and energy flow considerations

Appendix 2

DOCUMENTS SUBMITTED TO THE MEETING

SP/Doc 1. Allen, K. R. Some computer programmes applicable to sperm whale population analysis.
    1A. A computer programme to calculate age distributions of animals of known length (TAGK).
    1B. A computer programme for the estimation of new recruits in the catch (CP0P).
    1C. A simplified computer programme for the estimation of exploited populations (CHP0P).
    1D. A new programme for the estimation of exploited populations (CHP0PR).
    1E. A computer programme to calculate sustainable yield and fishing mortality for a stable population of female sperm whales (SPFST).
    1F. A computer programme to calculate sustainable yield and fishing mortality for male sperm whales (SPMST).
    1G. A computer programme to calculate sustainable yields and fishing mortality for sperm whale populations (SPVAP) of variable size.
    1H. Programme to calculate time series of sperm whale population components for given catches (SPDYN).
    1I. A sperm whale poulation model based on cohorts (SPCOH).
2. Allen, K. R. Size estimates of southern hemisphere male sperm whale population.
3. Bannister, J. L. Sperm whales off Albany, Western Australia.
4. Best, P. B. Tetracycline marking and the rate of growth layer formation in the teeth of a dolphin *(Lagenorhychus obscurus). S. Afr. J. Sci.* 72: 216–8, 1976.
5. Best, P. B. Social organisation in sperm whales, *Physeter catodon.* In *Behaviour of Marine Animals,* 3. Winn and Olla (ed.).
6. Best, P. B., Canham, P. A. S. and MacLeod, N. Juvenile sperm whales *(Physeter catodon).*
7. Fox, W. W. Some effects of stock mixing on management decisions.
8. Gambell, R. Southern hemisphere sperm whale catch and effort data.
9. Gambell, R. Further analyses of tonnage corrected catch per unit effort data for male sperm whales in the southern hemisphere.
10. Gambell, R. Dentinal layer formation in sperm whale teeth. *Deep Sea Res.* 1977.
11. Lockyer, C. Estimates of growth and energy budget for the sperm whale, *Physeter catodon.* Mammals in the Sea. FAO-ACMRR/MM/SC/38.
12. Ohsumi, S. Age-length key of the male sperm whale in the North Pacific and comparison of growth curves.
13. Ohsumi, S. Criticism on growth curves of male sperm whale by means of whale marking.
14. Ohsumi, S. Sperm whale catch efficiency by Japanese pelagic whaling catcher boats in the Antarctic.
15. Ohsumi, S., Masaki, Y. and Wada, S. Seasonal distribution of sperm whales sighted by scouting boats in the North Pacific and southern hemisphere.
16. Ohsumi, S. and Satake, Y. Provisional report on investigation of sperm whales off the coast of Japan under a special permit.
17. Rice, D. Sperm whales in the equatorial Eastern Pacific: Population size and social organisation.
18. Smith, T. A matrix model of sperm whale populations.
19. Tillman, M. Trends in abundance of sperm whales in three areas of the North Pacific.
20. Brief information on the USSR investigation of sperm whales, 1972–1975.
    20/1. Berzin, A., Lagerev, S. and Isakov, G. Materials on population morphology of sperm whales in the Pacific. *Morskie Mlekopitayushchie.* pt. 1: 28–30 Kiev. 1975.

20/2. Ivashin. M. Tagging of sperm whales in the southern hemisphere.

20/3.. Mikhalev, J. Method for graphical record of surface relief of decalinated sections of sperm whale teeth with the aim to determine their age.

20/4. Tormosov, D. Ecological aspects of differential distribution of sperm whales.

20/5. Tormosov, D. Ecologo-physiological basis of different structures of sperm whale concentrations. *Morskie Mlekopitayushchie.* pt. 2 127–9, Kiev, 1975.

20/6. Tormosov, D. Characteristics of ovulation in sperm whales. *Morskie Mlekopitayushchie,* pt. 2: 129–31, Kiev, 1975.

20/7.. Tormosov, D. and Sazhinov, E. Nuptial behaviour of the sperm whale *(Physeter catodon). Zool. Zh.* 53(7): 1105–6, 1974.

21. Holt, S. J. An attempt to estimate sperm whale population sizes from changes in the mean size of whales in catches.

22. Borodin, R. G. Estimation of initial stock and catchability coefficient of male sperm whales in the southern hemisphere.

MEAN LENGTHS IN FEET (AND NUMBER) OF MALE SPERM WHALES IN ANTARCTIC PELAGIC CATCHES (Data from Bureau of International Whaling Statistics, Norway)

Season	Area I				Area II W				Area II E				Area III W				Area III E				Area IV				Area V				Area VI				Total			
	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C
1932–33	(0)	(0)	(0)	(0)	(0)	(0)	55.0 (2)	(0)	(0)	53.2 (26)	53.1 (7)	(0)	(0)	54.2 (6)	53.5 (37)	(0)	(0)	54.8 (6)	53.6 (17)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0;	(0)	(0)	(0)	(0)	53.6 (38)	53.5 (63)	(0)
1933–34	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	53.3 (27)	48.0 (10)	(0)	(0)	53.1 (16)	51.8 (12)	(0)	(0)	53.5 (99)	53.6 (181)	(0)	(0)	(0)	54.0 (168)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	53.4 (142)	53.6 (371)	(0)
1934–35	(0)	(0)	(0)	(0)	(0)	53.4 (5)	47.0 (2)	(0)	52.0 (1)	53.3 (71)	53.6 (15)	(0)	(0)	53.6 (22)	50.9 (11)	(0)	48.7 (13)	54.6 (156)	53.0 (73)	(0)	(0)	53.0 (102)	53.6 (66)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	48.9 (14)	53.8 (356)	53.1 (167)	(0)
1935–36	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	55.0 (1)	54.2 (66)	50.0 (1)	(0)	(0)	53.0 (63)	53.3 (43)	(0)	(0)	54.0 (74)	54.5 (59)	(0)	(0)	54.5 (59)	54.4 (21)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	55.0 (1)	54.0 (262)	54.0 (124)	(0)
1936–37	(0)	(0)	(0)	(0)	(0)	55.0 (5)	51.4 (14)	(0)	(0)	52.9 (178)	54.3 (26)	(0)	(0)	53.5 (111)	53.1 (77)	(0)	(0)	53.1 (139)	53.2 (125)	(0)	(0)	51.8 (4)	52.6 (174)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	53.1 (437)	52.9 (416)	(0)
1937–38	(0)	(0)	(0)	(0)	(0)	53.4 (20)	50.4 (29)	(0)	(0)	53.0 (92)	53.0 (27)	(0)	52.2 (5)	54.6 (69)	53.9 (9)	(0)	53.3 (4)	53.2 (247)	53.4 (128)	(0)	(0)	52.7 (78)	53.1 (97)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	52.7 (9)	53.3 (506)	53.0 (290)	(0)
1938–39	(0)	(0)	(0)	(0)	(0)	53.3 (28)	50.9 (101)	(0)	(0)	53.6 (185)	54.4 (34)	(0)	(0)	54.0 (158)	54.9 (94)	(0)	(0)	53.5 (149)	52.5 (411)	(0)	(0)	52.8 (101)	52.5 (1,094)	(0)	(0)	(0)	53.8 (106)	(0)	(0)	(0)	(0)	(0)	(0)	53.5 (621)	52.6 (1,840)	(0)
1945–46	(0)	(0)	(0)	(0)	(0)	52.8 (6)	51.1 (16)	(0)	(0)	51.5 (167)	53.0 (1)	(0)	(0)	52.8 (13)	(0)	(0)	(0)	(0)	51.5 (12)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	51.6 (186)	51.3 (29)	(0)
1946–47	(0)	(0)	(0)	(0)	(0)	47.4 (22)	49.0 (29)	(0)	(0)	49.9 (33)	52.2 (23)	(0)	(0)	51.4 (32)	49.8 (86)	(0)	51.1 (18)	50.8 (442)	49.9 (154)	(0)	(0)	50.1 (44)	51.5 (413)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	51.1 (18)	50.7 (573)	50.8 (705)	(0)
1947–48	(0)	(0)	(0)	(0)	(0)	(0)	49.0 (7)	(0)	(0)	49.6 (126)	51.7 (127)	(0)	(0)	51.8 (141)	50.2 (23)	(0)	(0)	51.7 (436)	51.1 (290)	(0)	(0)	50.8 (227)	50.8 (947)	(0)	(0)	(0)	51.9 (145)	(0)	(0)	(0)	(0)	(0)	(0)	51.2 (930)	51.0 (1,539)	(0)
1948–49	(0)	(0)	(0)	(0)	(0)	49.1 (18)	50.8 (133)	(0)	(0)	51.1 (157)	50.7 (235)	(0)	(0)	50.8 [1](428)	50.9 (44)	(0)	(0)	51.2 (999)	50.7 (661)	(0)	(0)	50.3 (152)	50.2 (387)	(0)	(0)	(0)	52.5 (638)	(0)					(0)	51.0 (1,754)	51.2 (2,098)	(0)
1949–50	(0)	(0)	(0)	(0)	(0)	48.5 (24)	50.6 (40)	(0)	(0)	50.6 (478)	51.2 (153)	(0)	(0)	49.6 (169)	50.0 (22)	(0)	(0)	49.9 (566)	49.7 (250)	(0)	(0)	49.7 (16)	49.8 (621)	(0)	(0)	(0)	50.7 (191)	(0)	(0)	(0)	52.3 (23)	(0)	(0)	50.1 (1,253)	50.1 (1,300)	(0)
1950–51	(0)	(0)	(0)	(0)	(0)	51.9 (49)	50.3 (98)	(0)	(0)	50.7 (695)	49.0 (60)	(0)	(0)	50.8 (280)	51.3 (21)	(0)	(0)	50.3 (865)	50.1 (399)	(0)	(0)	49.6 (237)	49.1 (1,040)	(0)	(0)	(0)	50.8 (840)	51.6 (87)	(0)	(0)	50.1 (40)	52.3 (12)	(0)	50.4 (2,126)	49.9 (2,498)	51.6 (99)
1951–52	(0)	(0)	(0)	(0)	(0)	50.6 (123)	50.3 (44)	(0)	(0)	50.6 (625)	49.8 (56)	(0)	(0)	50.6 (541)	50.4 (57)	(0)	(0)	49.6 (695)	49.8 (762)	(0)	(0)	47.6 (63)	49.1 (1,021)	(0)	(0)	(0)	50.2 (1,194)	51.2 (61)	(0)	(0)	50.6 (69)	50.1 (15)	(0)	50.2 (2,047)	49.8 (3,203)	51.0 (76)
1952–53	(0)	(0)	(0)	(0)	(0)	49.0 (1)	50.1 (109)	(0)	(0)	50.1 (397)	50.3 (60)	(0)	(0)	49.4 (247)	48.8 (38)	(0)	(0)	48.8 (228)	50.2 (565)	(0)	(0)	49.7 (7)	49.6 (253)	(0)	(0)	(0)	50.4 (226)	(0)	(0)	(0)	51.7 (41)[2]	(0)	(0)	49.6 (880)	50.1 (1,292)	(0)
1953–54	(0)	(0)	(0)	(0)	(0)	49.3 (63)	50.1 (127)	(0)	(0)	50.0 (430)	50.9 (43)	(0)	(0)	50.6 (376)	49.5 (27)	(0)	(0)	48.6 (194)	47.8 (594)	(0)	(0)	50.3 (11)	48.2 (353)	(0)	(0)	49.5 (2)[3]	49.5 (310)	(0)	(0)	(0)	49.9 (156)	(0)	(0)	49.9 (1,076)	48.7 (1,610)	(0)
1954–55	(0)	(0)	(0)	(0)	(0)	48.9 (44)	48.6 (45)	(0)	48.7 (7)	49.9 (805)	49.4 (280)	(0)	44.8 (8)	49.7 (330)	49.3 (63)	(0)	(0)	48.4 (602)	48.6 (1,670)	(0)	(0)	48.6 (228)	48.6 (902)	(0)	(0)	(0)	48.9 (517)	(0)	(0)	(0)	49.1 (157)	(0)	46.6 (15)	49.2 (2,009)	48.8 (3,634)	(0)
1955–56	(0)	50.2 (344)	(0)	(0)	(0)	52.2 (12)	49.2 (175)	(0)	49.0 (21)	48.8 (648)	49.3 (392)	(0)	49.4 (9)	48.9 (232)	49.0 (90)	(0)	48.0 (1)	47.3 (503)	47.9 (1,184)	(0)	(0)	48.3 (76)	47.8 (1,671)	(0)	(0)	(0)	48.8 (1,147)	(0)	(0)	(0)	48.8 (319)	48.6 (21)	45.7 (31)	48.3 (1,471)	48.4 (5,322)	48.6 (21)
1956–57	(0)	43.7 (3)	49.8 (752)	(0)	(0)	48.3 (64)	48.7 (206)	(0)	46.4 (16)	48.8 (1,009)	49.3 (86)	(0)	(0)	50.4 (70)	50.3 (17)	(0)	44.4 (8)	47.9 (221)	48.3 (487)	(0)	(0)	46.4 (26)	47.0 (401)	(0)	(0)	(0)	48.5 (729)	(0)	(0)	48.0 (31)	49.3 (205)	(0)	45.7 (24)	48.7 (1,424)	48.7 (2,883)	(0)
1957–58	(0)	(0)	48.1 (284)	(0)	(0)	46.9 (77)	48.3 (129)	(0)	43.6 (88)	47.8 (1,153)	46.8 (51)	(0)	46.9 (19)	49.4 (195)	50.0 (98)	(0)	47.5 (15)	47.5 (317)	47.0 (1,420)	(0)	43.5 (2)	46.8 (134)	47.0 (979)	(0)	44.3 (10)	49.8 (17)	47.8 (887)	(0)	(0)	(0)	48.4 (421)	(0)	44.6 (134)	47.8 (1,893)	47.5 (4,269)	(0)
1958–59	(0)	49.6 (10)	49.7 (27)	(0)	(0)	50.0 (31)	49.1 (66)	(0)	44.7 (15)	48.2 (731)	48.2 (62)	(0)	41.0 (17)	47.8 (261)	47.8 (139)	(0)	42.9 (23)	46.3 (400)	46.7 (1,025)	(0)	(0)	47.4 (317)	47.0 (997)	(0)	(0)	46.3 (14)	47.3 (681)	(0)	(0)	(0)	47.7 (612)	(0)	42.8 (55)	47.6 (1,764)	47.2 (3,609)	(0)
1959–60	(0)	(0)	49.1 (182)	(0)	47.0 (54)	49.1 (99)	48.3 (91)	(0)	46.2 (5)	48.2 (480)	50.4 (7)	(0)	(0)	47.7 (153)	47.3 (46)	(0)	(0)	45.8 (339)	46.4 (619)	(0)	41.4 (29)	47.2 (398)	46.9 (727)	(0)	42.0 (2)	45.5 (54)	47.8 (749)	(0)	(0)	(0)	47.8 (88)	(0)	45.0 (90)	47.3 (1,523)	47.3 (2,509)	(0)
1960–61	(0)	49.0 (16)	48.6 (150)	(0)	45.1 (18)	47.5 (227)	49.5 (119)	(0)	47.7 (6)	46.7 (608)	49.2 (53)	(0)	42.5 (76)	46.3 (393)	49.0 (69)	(0)	41.7 (7)	45.9 (508)	46.4 (421)	(0)	42.3 (23)	46.6 (455)	46.5 (383)	(0)	43.9 (96)	47.5 (342)	47.3 (632)	(0)	(0)	(0)	47.5 (41)	(0)	43.4 (226)	46.7 (2,549)	47.3 (1,868)	(0)
1961–62	39.4 (14)	50.7 (18)	47.7 (115)	(0)	42.5 (132)	46.7 (283)	48.8 (34)	(0)	44.3 (68)	47.2 (1,488)	49.3 (11)	(0)	40.8 (40)	47.1 (263)	48.4 (61)	(0)	42.2 (165)	45.3 (770)	45.8 (252)	(0)	44.0 (100)	46.2 (249)	46.1 (222)	(0)	47.5 (2)	40.0 (2)	47.6 (354)	(0)	(0)	(0)	48.4 (46)	(0)	42.7 (521)	46.6 (3,073)	47.0 (1,095)	(0)
1962–63	47.1 (27)	47.5 (41)	48.3 (189)	(0)	44.4 (408)	48.5 (152)	48.7 (92)	(0)	46.4 (84)	47.8 (877)	48.2 (16)	(0)	45.8 (85)	44.9 (64)	(0)	(0)	42.2 (391)	45.9 (572)	46.6 (91)	(0)	44.1 (135)	46.6 (211)	47.5 (445)	(0)	41.3 (85)	45.3 (54)	49.2 (521)	(0)	(0)	49.0 (1)	46.8 (112)	(0)	43.7 (1,215)	47.0 (1,972)	48.2 (1,466)	(0)
1963–64	(0)	(0)	(0)	(0)	49.0 (17)	48.9 (151)	49.0 (3)	(0)	47.1 (29)	47.9 (821)	48.8 (5)	(0)	44.3 (97)	45.2 (233)	48.1 (10)	(0)	45.0 (1,030)	44.6 (315)	46.8 (69)	(0)	42.8 (332)	46.2 (189)	46.7 (877)	(0)	44.0 (1,526)	47.3 (124)	47.9 (457)	(0)	(0)	(0)	(0)	(0)	44.3 (3,031)	46.9 (1,833)	47.1 (1,427)	(0)
1964–65	44.3 (94)	45.8 (64)	(0)	(0)	43.3 (477)	47.7 (303)	(0)	(0)	47.5 (147)	47.6 (256)	(0)	(0)	42.9 (101)	44.7 (23)	(0)	(0)	44.1 (162)	44.5 (88)	45.3 (88)	(0)	45.5 (435)	46.0 (268)	45.9 (91)	(0)	46.0 (1,109)	46.9 (194)	46.9 (200)	(0)	44.4 (16)	48.7 (6)	(0)	(0)	45.2 (2,541)	46.8 (1,202)	46.3 (379)	(0)
1965–66	(0)	48.2 (11)	(0)	(0)	47.0 (374)	48.5 (41)	(0)	(0)	47.2 (79)	48.8 (358)	48.9 (54)	(0)	43.3 (54)	46.3 (127)	48.0 (133)	(0)	42.1 (183)	40.0 (1)	46.8 (36)	(0)	42.0 (67)	(0)	46.9 (544)	(0)	42.0 (762)	47.4 (443)	48.5 (524)	(0)	48.3 (7)	48.9 (31)	49.2 (209)	(0)	43.6 (1,526)	47.9 (1,012)	47.9 (1,500)	(0)
1966–67	46 (1)	(0)	(0)	(0)	43.5 (254)	46.2 (5)	(0)	(0)	49.3 (23)	48.5 (204)	48.5 (12)	(0)	43.7 (85)	47.3 (92)	48.8 (69)	(0)	42.0 (396)	47.0 (19)	47.9 (482)	(0)	42.8 (145)	47.5 (104)	47.3 (477)	(0)	43.7 (924)	48.4 (18)	48.3 (1,000)	50.2 (114)	(0)	(0)	49.7 (347)	49.5 (84)	43.3 (1,828)	47.9 (442)	48.3 (2,387)	49.9 (198)
1967–68	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	47.3 (174)	47.9 (27)	(0)	42.2 (33)	47.1 (27)	(0)	(0)	44.0 (215)	46.4 (73)	47.4 (141)	(0)	44.2 (45)	46.6 (36)	46.9 (295)	(0)	42.3 (853)	47.9 (18)	47.9 (502)	(0)	(0)	42.2 (12)	49.2 (60)	(0)	42.7 (1,146)	46.9 (340)	47.6 (1,025)	(0)
1968–69	(0)	(0)	49.0 (110)	(0)	(0)	(0)	50.0 (1)	(0)	43.9 (35)	48.4 (15)	49.8 (5)	(0)	45.6 (117)	45.1 (40)	(0)	(0)	44.0 (145)	45.9 (23)	46.3 (152)	(0)	46.6 (12)	47.4 (481)	46.7 (80)	(0)	44.0 (866)	46.1 (134)	48.1 (184)	(0)	(0)	45.1 (8)	49.0 (155)	(0)	44.2 (1,175)	46.9 (701)	47.9 (687)	(0)
1969–70	(0)	(0)	(0)	(0)	48.0 (6)	(0)	(0)	(0)	43.4 (62)	(0)	(0)	(0)	42.8 (196)	(0)	(0)	(0)	43.8 (742)	47.1 (37)	49.5 (19)	(0)	43.5 (174)	48.0 (176)	48.1 (533)	(0)	43.0 (630)	47.8 (14)	48.1 (346)	(0)	45.7 (31)	43.9 (8)	48.6 (11)	(0)	43.4 (1,841)	47.7 (235)	48.1 (909)	(0)
1970–71	(0)	(0)	(0)	(0)	42.1 (355)	49.0 (157)	(0)	(0)	47.7 (48)	47.8 (4)	(0)	(0)	41.0 (96)	(0)	(0)	(0)	42.0 (510)	(0)	(0)	(0)	43.9 (122)	47.1 (124)	46.3 (129)	(0)	43.5 (1,187)	(0)	47.2 (69)	(0)	(0)	48.8 (10)	48.7 (48)	(0)	43.0 (2,318)	48.2 (295)	47.0 (246)	(0)
1971–72	(0)	48.2 (13)	47.4 (257)	(0)	42.8 (621)	48.2 (209)	(0)	(0)	43.5 (19)	49.5 (68)	50.5 (70)	(0)	42.3 (122)	49.0 (79)	(0)	(0)	42.7 (741)	47.5 (55)	47.8 (113)	(0)	41.6 (23)	48.2 (39)	47.9 (297)	(0)	44.5 (469)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	43.2 (1,995)	48.4 (463)	48.0 (737)	(0)
1972–73	(0)	45.0 (1)	48.4 (149)	(0)	39.5 (437)	47.7 (34)	49.4 (25)	(0)	52.0 (1)	50.9 (61)	50.9 (33)	(0)	43.4 (93)	47.5 (26)	49.5 (30)	(0)	42.5 (320)	47.2 (487)	47.8 (354)	(0)	43.1 (52)	48.8 (32)	48.6 (505)	(0)	42.4 (524)	47.1 (7)	48.0 (391)	(0)	40.2 (334)	(0)	50.8 (4)	(0)	41.4 (1,761)	47.7 (648)	48.3 (1,491)	(0)

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[1] Includes 3 caught in Series D

[2] Including 18 caught in Area I

[3] Including 1 caught in Series D

Some Computer Programmes Applicable to Sperm Whale Population Analysis

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The following programmes have been developed which can be used in the estimation of sperm whale population parameters, and in modelling populations.

A. AGE AND RECRUITMENT ANALYSIS

A.1 Age distribution (TAGK)

This programme computes the age distribution from an age/length key and a length distribution. It can conveniently be used to produce a number of age distributions for different length distributions from the same key. It also calculates the Heincke estimate of total mortality for the animals older than each age in the distribution.

A.2 Recruitment rates (CPOP)

This calculates the proportion of new recruits in each age class and in the sample as a whole by comparing the age distributions for successive pairs of years. It also calculates the mean age at recruitment.

B. POPULATION ESTIMATION

B.1 Actual and expected catch method (CHPOP)

This is the programme which has been used for a number of years for the estimation of whale populations. It has now been modified in two ways which may be useful in considering sperm whale populations. First provision is made for deriving estimates on the assumption that there is in each year a constant number of recruits which is a known proportion of the unknown initial population. Secondly provision is made for combining data for a series of areas or stocks on the assumption that the value of q per unit area is the same in all regions and that the area of the regions is known.

B.2 Modified actual and expected catch method – Maximum Likelihood (CHPOPR)

This is a new programme which uses the same population model to compute expected catches and compare them with the actual catches, as in CHPOP. By using maximum likelihood techniques however, this programme also derives estimates of the standard error for both initial population and q. It can be used either for variable annual recruitment, where this is known, or for fixed recruitment as a known proportion of the initial population. It can not yet be used to obtain estimates for a number of stocks using a common value of q per unit per unit area.

C. POPULATION MODELS – STABLE

C.1 Stable yields for given population parameters – Female (SPFST)

This programme calculates the stable catch of females and fishing rate for a population with various values of pregnancy rate, natural mortality rate, age at maturity, and age at initial exploitation. The programme has been extended from that used to produce the tables in Document SC/24/2 to include estimates of weight, as well as number of catch.

C.2 *Stable yields for given population parameters – Male* (SPMST)

This programme produces similar tables to those above for stable male yield and fishing mortality rate.

C.3 *Relation between yield and population level* (SPVAP)

This programme produces estimates of number and weight of yield for the sexes separately, and in combination, for a population at various levels relative to the unexploited level. It has been developed from the programme used to produce Table C in SC/24/2. In addition to the inclusion of weight of yield, it now makes provision for a reserve mature male stock to be required, and for the variation of the density dependent factors with population size to be non-linear.

D. POPULATION MODELS – DYNAMIC

D.1 Dynamic Pool Model (SPDYN)

This programme enables the changes in a population over a series of years to be simulated. It assumes a known initial mature female population size and the values of the various parameters. The natural mortality rate, juvenile mortality rate, pregnancy rate and female age at maturity may be density dependent. The programme simulates changes in the population in response to given annual male and female catches. This programme was used to produce Table D in SC/24/2. It has been further modified by providing for reserve mature males and for density dependence to be non-linear.

D.2 Cohort simulation model (SPCOH)

This is a new programme which enables a population to be simulated in a similar way to SPDYN, but treats each cohort separately. It maintains an age-length matrix for the population, year by year. This enables the size distribution of the catch, as well as its total number, to be taken into account in computing annual changes. It also enables a better estimate of population biomass to be maintained. The population has otherwise the same characteristics as that in SPDYN, except that density dependence operates upon population biomass and not on number of mature females.

SP/Doc 1A

A Computer Programme to Calculate Age Distributions for Animals of Known Length (TAGK)

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DESCRIPTION

The programme computes the age-distribution of a sample of animals of which the lengths are known, by combining it with another sample (age-length key) for which both lengths and ages are known for all individuals. As usually employed, the first sample will be large and is commonly assumed to be representative of a population or catch, while the second sample is smaller and not assumed to be representative in any respect other than the age-length relationship. The programme can, of course, be used for computing the distribution of any parameter, when two samples are available fulfilling these requirements.

Provision is made in the programme for applying the same age-length key to as many length-distributions as desired, and for combining any number of age-length keys to form a single master key, and similarly for combining any number of length distributions before applying the age-length key to the result.

Any number of combined age-length keys can be used, but each can only be applied to the set of length distributions following it in the input. To apply more than one key to the same length distribution in the same run it would be necessary to repeat the length data cards.

DATA REQUIREMENTS

Age-length key

A separate series of cards is used for each length group in the data, the number in each age group being punched in successive columns across the cards; there is capacity for 84 age groups (0–83). Four options are provided:

Option 1:
Up to 999 at any one length and up to 99 at each age at each length; data are punched on up to 3 cards, for age-ranges 0–27, 28–55, 56–83.

Option 2:
Up to 9999 at any one length, and up to 999 at each age at each length; data are punched on up to 5 cards, for age-ranges 0–17, 18–35, 36–53, 54–71, 72–83.

Option 3:
Up to 999 at any one length, and up to 99 at each age at each length; data are punched on up to 4 cards, for age ranges 0–20, 21–41, 42–52, 53–83.

Option 4:
Up to 999 at any one length, and up to 99 at each age at each length; data are punched on up to 4 cards, for age ranges 0–26, 27–53, 54–80, 81–83.

For each option the first card at any length must be punched, since only this contains the total number in the length group, but continuation cards need only be punched if data actually occur in that age range. Note, however, that the correct continuation number for the age range must always be punched in Column 79.

If a length occurs in the length distribution which is not represented in the age-length key the programme will seek the nearest length, either above or below, which is represented, and will apply the age-distribution at this length. If represented lengths are found equidistant above and below (e.g., at the middle value of a gap of three lengths in the key), the distributions for these two lengths will be pooled and applied. A note is printed of any lengths which have been included by interpolation or extrapolation in this way. To enable age distributions to be calculated in some cases in which the true ages had been combined in pairs in compiling the key an option is provided in which the missing age frequencies are estimated by interpolating between the values calculated from the key.

LENGTH DISTRIBUTION

Each card records the number of animals of each length in the sample; in some options the total number in the sample is also entered. There are three options available. The first two allow 32 consecutive length groups, the last allows 35. The value assigned to the first length group can be varied as desired.

Option 1:
Up to 999 in sample, and up to 99 at any one length. All data are entered on one card.

Option 2:
Up to 9999 in sample, and up to 999 at any one length. Data are entered on two cards covering length groups 1–20 (blank in Column 79) and 21–32 (punched 1 in Column 79). The first card must always be punched but the second is only required if data in that range actually occur. The total number in the sample is punched on the first card only.

Option 3:
Up to 99 at any one length, with no other restriction on total number in sample. Data are entered on one card. Total number on card is not entered.

If several distributions are to be combined, the value assigned to the first size on the card must be the same for all of them.

Checks on data:

In each length distribution under Options 1 and 2 and at each length in the age-length keys under all options the actual number of observations is checked against the total stated on the data cards.

If an error is encountered the operation affected is abandoned, a note of the nature of the error is printed, the next key or length distribution (as may be appropriate) is sought, and execution is resumed.

OUTPUT

Printed output:

(a) The combined age length key is printed in a two-dimensional table showing the actual number of occurrences at each age at each length, and the total number at each length.

(b) Each set of combined length-distribution data which is used to compute an age distribution is printed as a one-dimensional table showing the number at each length in the combined sample, and the total number in the sample.

(c) The computed results are printed in a table which shows for each age:

  (1) the estimated number at that age in the sample
  (2) the estimated proportion at that age
  (3) the number in the sample at that age and older
  (4) the proportion in the sample at that age and older
  (5) the natural logarithm at the proportion at each age and older
  (6) the Heincke estimate of the total annual mortality rate from each age upwards.

Card output:

Card outputs are available for the combined age-length key, the combined length distribution, and the computed age distribution. They are called for if desired by appropriate instructions on the control cards. When output cards are punched, a note to this effect is printed.

(a) The combined age-length key is punched on a single series of cards using format Option 2. For deck identification 7 is punched in Column 80.

(b) Each combined length distribution used to compute an age distribution is punched on 2 cards in format Option 2. Deck identification 8 in Column 80.

(c) The first column of the computed age distribution (i.e., the estimated number at each age in the combined length distribution) is punched on a series of 10 cards in the format (A12, F7.2, 9F6.2); columns 13–19 on the first card are used for the total number in the sample and are blank on subsequent cards; the following 9 fields are used for age groups in succession from 0–83; the continuation cards are identified by 1 to 9 successively in Column 79, which is blank in the first card. Deck identification 9 in Column 80.

SOURCE DATA

On all input and output cards a number of columns at the left of the card are reserved for information regarding the source of the data being processed. The information to appear on the output cards is fed in through control cards; this information will be the same on the length distribution and age distribution cards, but may be different from that on the age-length key. If output cards are punched the note recording this also states the source data which appears on them.

ASSEMBLY OF DATA

Data cards are assembled in the following order:

A. Age-length keys

(1) One card containing descriptive information about the key, this will be printed as punched.

(2) One card containing source information, starting length, format of cards, call for age-length key output cards and call for interpolating routine if the key contains only alternate ages.

(3) Age-length key data cards in any order.

(4) END-OF-KEY card, must be punched in first column.

B. Length distributions

(1) One card containing descriptive information about the distributions, this will be printed as punched.

(2) One card containing source information, format of cards, and call for length distribution and/or age-distribution output cards.

(3) Length distribution cards in any order.

(4) Text for end of data card. If a further set of length data using the same age-length key is to follow, punch E in column 1. If a new age-length key is required punch N in column 1. If end of data, punch S in column 1.

(N.B. If it is desired to compute age distributions from more than one length distribution, using the same age-length key, as many decks as desired may be inserted one after the other; each must be complete as to parts B(1) to B(4) above.)

Details of the arrangement and format of the cards are given in Appendix 1.

APPENDIX 1

DATA INPUT

One set of the following

(i) *Title for A/L Key* (Format: A80) Contains HAGE (title).

(ii) *Controls for A/L Key* (Format: A12, I4, 4X, 3I4) Contains DATAK (source data for A/L Key), KLEN (initial length, *minus 1*)
IFM (format control for data cards, i = option i, i = 1 . . . 4), ICRD (call for output cards, 1 = required, 0 or blank otherwise), K6 (interpolation if original key is for alternate age groups, 1 = interpolation, 2 = no interpolation).

(iii) *A/L Key data: N Cards*

Option 1 (28 ages per card)
Format: 1A1, 12X, I2, I3, 28I2, 4X, I1. Contains ITEST (test for end of key data, E signifies), LEN (length), SGK (No. on card), AGK (No. at each age), KONT (Continuation, 0–2).

Option 2 (18 ages per card)
Format: 1A1, 12X, I2, I4, 18I3, 5X, I1. Contains ITEST, LEN, SGK, AGK, KONT (0–4)

Option 3 (21 ages per card)
Format: 1A1, 10X, I2, 21I2, I3. Contains ITEST, LEN, AGK, SGK

Option 4 (27 ages per card)
Format: 1A1, 10X, I2, 27I2, I3. Contains ITEST, LEN, AGK, SGK

(iv) *End of A/L Key data* (Format: A1) Contains ITEST (= E)

X sets of the following

(v) *Title for length distribution* (Format: A80) Contains HLEN (title)

(vi) *Controls for length distribution* (Format: A12, 4X, 2I4) Contains DATAL (source data for length dist.) IFL (control for format of data cards, i = option, i, i= 1 . . . 3), IPUN (call for output cards, 0 or blank = not required, 1 or 2 = length distribution, 2 or 3 = age distribution)

(vii) *Length distribution data. M cards*

Option 1 (32 lengths on one card)
Format: 1A1, 11X, 32I2, I3. Contains ITRY (test for end of data), DLEN (No. at each length), SLEN (No. in sample)

Option 2 (20 lengths per card up to maximum of 32)
Format: 1A1, 11X, 20I3, I4, 2X, I1. Contains ITRY, DLEN, SLEN, KTL (continuation 0 or 1)

Option 3 (35 lengths per card)
Format: 1A1, 7X, 35I2. Contains ITRY, DLEN

(viii) *Test for end of data* (Format: A1) Contains ITRY,
Either E if same key used for next distribution,
or N if new key required,
or S if there are no more cards.

The complete set as above must be repeated for each age length key in the data.

Number of cards for each key = N + 3 + (M + 3)X.

A Computer Programme for the Estimation of New Recruits in the Catch (CPØP)

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INTRODUCTION

This programme obtains from age distribution data an estimate of the proportion of new recruits in the catch using the method described by Allen (1, 2, 3). It uses data on:

(a) The cumulative age group proportions for each sex and year.
(b) The age at full recruitment.
(c) An estimate of T, the ratio between the survival rate of the recruited part of the younger year classes and that of older animals.

The programme is written in CDC 7600 FORTRAN.

SCHEME OF OPERATION

The programme consists of the following sub-routines:

(a) CPOP: Reads in the control variables, and controls the operations of the other sub-routines.
(b) CYEAR: Reads in the cumulative age group proportion data, calculates age group proportions.
(c) CCRT2: Calculates the proportion of new recruits in the catch for each year. Two estimates are obtained; one by using the supplied value of T, and the other from a value of T estimated from the data (4).

Any number of independent complete sets of data with appropriate controls can be processed in one run.

RESTRICTION

The total period covered must not exceed 40 years.

INPUT DATA

The data deck is made up as follows:

(a) *Title of job* (Format: 80A1) Printed out at head of each section exactly as entered on card.
(b) *Value of T* (Format: 12A1, F6.4) Contains an estimate of T. Columns 1–12 are used for card identification data only.
(c) *Control Parameters* (Format: 12A1, 5X, 4I5) Contains, successively, the first and last years for recruitment estimate, age at full recruitment and the minimum age on recruitment data cards in Columns 18–37. Columns 1–12 are used for card identification data only.
(d) *Recruitment data deck.* For each sex, consists of the proportion of animals aged x years or more, for up to 84 consecutive values of x for each year. Data for each year are contained in 10 cards.

Card 1 (Format: A1, A1, 3A1, I2, 5A1, 7X, 9F6.4) contains:

(i) Sex in column 2 (M or F).
(ii) Year, coded as last two digits in columns 6–7.
(iii) Cumulative age group proportions for the first 9 ages in columns 20–73.

N.B. The remaining columns in 1–12 are used for card identification data only.
Cards 2–9 (Format: 19X, 9F6.4) contains cumulative age group proportions for ages 10–81, 9 per card in columns 20–73.
Card 10 (Format: 19X, 3F6.4) contains cumulative age group proportions for ages 82–84 in columns 20–37.

The programme requires data for both sexes, the males being read in before the females. The last data set of each sex is followed by a blank card. If there are no data for either sex, a blank card is inserted for that sex, i.e. male data only is followed by 2 blank cards, female data only is both preceded and followed by a single blank card.

(e) Blank card.

Items (a)–(d) can be repeated indefinitely for additional sets of data. The blank card (e) terminates execution.

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SP/Doc 1C

A Simplified Computer Programme for the Estimation of Exploited Populations (CHPØP)

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INTRODUCTION

This programme estimates the number of animals in an exploited population using the method of comparing actual and expected catches (1, 2). It uses data on:

(a) The number caught of each sex, the number caught by a known amount of effort, the known effort, an effort modifier, variable from year to year to permit adjustment for weather or similar factors, and the proportion of females (if any) excluded from catching.

(b) The proportion of new recruits in the catch by sex each year.

(c) The natural mortality rate for each sex. Up to ten values may be used in a single run with the same catch, effort and recruitment data.

The programme is written in CDC 7600 FORTRAN.

The estimate is based on minimising the sums of squares of differences between actual and expected catches with known effort and may use all or any continuous part of the submitted data. As an option these estimates may be extrapolated forwards or backwards for any additional period covered by catch and recruitment rate data.

A further option provides an additional estimate obtained by the same basic approach but with the additional constraint that the expected total catch for the whole period is equal to the actual total.

Two additional options are available. The first allows the assumption that recruitment each year is a constant multiple of the initial population size. The second allows the assumption that for data sets from different areas a common value of q per unit area operates. If this option is selected, data from more than one area must be included, and only one natural mortality rate per area may be assumed.

SCHEME OF OPERATION

The programme consists of the following sub-routines:

(a) CHPØP: Reads in the control variables, and controls the operations of the other sub-routines.

(b) CCEFF: Reads in catch and effort data, makes yearly estimates of total effort and catch per unit effort.

(c) CECCY: Reads in recruitment data for each sex in each year. The recruitment data are in the form of proportions of new recruits in the catches.

(d) CSTSQ: Computes population estimates for a selected period of years, using the catch and recruitment data read in by the preceding sub-routines.

(e) CXTRP: Extrapolates forward or backward from the period for which population estimates are made to cover selected periods for which catch and recruitment data are also available.

(f) ZXPØWL and UERTST perform minimisation for calculation of estimates with common q per unit area.

(g) FUNCT calculates sums of squares to be minimised by above sub-routines.

Any number of independent complete sets of input data with appropriate controls can be processed in one run.

RESTRICTIONS

(a) The total period covered, including extrapolations, must not exceed 40 years.

(b) The number of animals of either sex caught, or the amount of effort, in any year must be less than 10^9. Coding by means of a multiplier would be permissible.

INPUT DATA

N.B. Programme expects data input on logical unit 8, *not card reader.*

The data deck is made up as follows:

(a) *Title of job* (Format: 80A1). Printed out at head of each section exactly as entered on card.

(b) *Area of region and options* (Format: 1X, F10.0, 3X, 2I1) Area of region, '1' if constant q estimation required ('O' otherwise), '1' if iterations in constant q estimation to be printed.

(c) *Natural Mortality Rate* (Format: 1X, I1, 10X, I2, 10F6.4) Accommodates up to 10 values of M; one card for each sex. Variables are, sex (1 for male, 2 for female), number of values of M, values of M.

(d) *Range of years* (Format: 17X, 4I5) The four values are, successively, first and last years for population estimate and first and last years for extrapolation. Range for population estimate must not go outside that for which data are provided.

(e) *Control Parameters* (Format: 12X, F5.3, 3I2) Contains the proportion of exploitable female population protected from exploitation; controls for options to print intermediate sums of squares and products, to obtain estimates with equal total catches, and to obtain estimates with constant recruitment option (1 calls option in each case).

(f) *Catch and effort data deck* (Format: 1X, A1, 3X, I2, 5X, 5F10.1, F6.4, 2F6.0) Contains successively, on one card for each season.

   (i) End of file control variables.
   (ii) The year, coded as the last two digits.
   (iii) Total catch of males.
   (iv) Total catch of females.
   (v) Catch of males by the known effort.
   (vi) Catch of females by the known effort.
   (vii) Known component of effort.

(viii) Effort modifier
(ix) Catch of males outside normal season.
(x) Catch of females outside normal season.

This part of data ends with a card with 9 in column 2.

(g) *Recruitment data deck* – Either (g) or (h) (if constant recruitment option desired) (Format: 5A1, I2, 5A1, F7.4) contains the following variables on two cards for each sex for each year.

(i) Sex in column 2 (male = 1, female = 2).
(ii) Year, coded as last two digits in columns 6 and 7 (N.B. The remaining columns in 1–12 are used for card identification data only.)
(iii) Proportion of new recruits in columns 13–19.

This section of data must end with a card with 9 in column 2.

(h) (Format: 1X, 3F10.0) Recruitment rates for total, male and female populations.
(i) 9 in Column 1.

Items (a)–(i) can be repeated indefinitely for additional sets of data.

REFERENCES

1. Allen, K. R. Some methods for Estimating Exploited Populations. *J. Fish. Res. Bd. Can.* 23: 1553–74.
2. Allen, K. R. An Application of Computers to the Estimation of Exploited Populations. *J. Fish. Res. Bd. Can.* 26: 179–89.

SP/Doc 1D

A New Program for the Estimation of Exploited Populations (CHPØPR)

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INTRODUCTION

This program estimates the catchability coefficient and number of animals in an exploited population, together with their standard errors. These maximum likelihood estimates are calculated from a probability model describing the expected catches with known effort. It uses data similar to that used in the program CHPØP as follows:

(a) The total number caught, the number caught with known effort, the known effort, and an effort modifier variable from year to year.
(b) The proportion of new recruits in the catch each year.
(c) The natural mortality rate.

The program is written in CDC 7600 FORTRAN.

An option is provided which allows the assumption that recruitment each year is a constant multiple of the initial population size. If this option is not selected, recruitment rates for each year must be provided.

The estimates may use all or any continuous part of the submitted data. Another option allows these estimates to be extrapolated forwards or backwards for any additional period covered by catch and recruitment data.

INPUT DATA

The data deck is made up as follows:

(a) *Title of job* (Format: 8A10).
(b) *Natural mortality rate* (Format: 10X, F5.0).
(c) *Number of data points* (Format: 10X, I5).
(d) *Catch and effort data deck* (Format: I5, 4F10.0) Year, total catch, catch with known effort, known effort, effort modifier.
(e) *Recruitment option* (Format: I1) '1' calls for constant recruitment option.
(f) *Recruitment data deck* (Format: F10.0).
    Either (a) constant recruitment rate.
    or (b) variable recruitment, yearly rates, 1 per card.
(g) *Initial solution estimates* (Format: 10X, 3F10.0, I5).

Initial estimates of population size, Q, Var (Q), and option for printing of intermediate calculations (1).

Only the population size estimate need be reasonably good, the other two should be non-zero and of the right order of magnitude, if anything slightly too low.

SP/Doc 1E

A Computer Programme to Calculate Sustainable Yield and Fishing Mortality for a Stable Population of Female Sperm Whales (SPFST)

K. Radway Allen

Division of Fisheries and Oceanography, CSIRO, Cronulla, NSW, Australia

DESCRIPTION

This programme calculates the sustainable yield in numbers (C) and weight (W) and fishing mortality rate (F) for female sperm whales in a stable population of 10,000 mature females for various values of the basic parameters. The method of calculating C and F was described in Allen (1973). The weight of the catch is calculated from the mean individual weight, which is given by:

$$\bar{W} = W_\infty \left(1 - \frac{3Ze^{-K(t_r - t_o)}}{Z + K} + \frac{3Ze^{-2K(t_r - t_o)}}{Z + 2K} - \frac{Ze^{-3K(t_r - t_o)}}{Z + 3K}\right)$$

The programme is written in CDC 7600 FORTRAN.

INPUT DATA

The input data deck consists of 5 cards. The first four (Format: 10X, 2F10.3, I10) contain the initial value, increment, and number of iterations for, respectively:

(a) Age of initial exploitation.
(b) Age at maturity.
(c) Pregnancy rate.
(d) Natural mortality rate.

The fifth card (Format: 10X, F5.1, 5X, F5.3, 5X, F5.2) contains the Von Bertalanffy growth parameters, W_∞, K, t_o.

REFERENCE

Allen, K. R. 1973. The Computerized Sperm Whale Population Model. *Rep. int. Whal. Commn.*, 23: 70–4.

SP/Doc 1F

A Computer Programme to Calculate Sustainable Yield and Fishing Mortality for Male Sperm Whales (SPMST)

K. Radway Allen

Division of Fisheries and Oceanography, CSIRO, Cronulla, NSW, Australia

DESCRIPTION

This programme calculates the sustainable yield in numbers (C) and (W) and fishing mortality rate (F) for male sperm whales in a stable population with 10,000 mature females for various values of the basic parameters. The method of calculating C and F is detailed in Allen (1973). The weight of the catch is calculated from the mean individual weight which is given by:

$$\bar{W} = W_\infty \left(1 - \frac{3Ze^{-K(t_r - t_o)}}{Z + K} + \frac{3Ze^{-2K(t_r - t_o)}}{Z + 2K} - \frac{Ze^{-3K(t_r - t_o)}}{Z + 3K}\right)$$

The programme is written in CDC 7600 FORTRAN.

INPUT DATA

The input data consists of 7 cards. The first 5 cards (Format: 10X, 2F10.3, I10) contain the initial value, increment, and number of iterations for:

(a) Age of initial exploitation.
(b) Age of social maturity.
(c) Size of harem.
(d) Pregnancy rate.
(e) Natural mortality rate.

The sixth card (Format: 10X, F5.1, 5X, F5.3, 5X, F5.2) contains the Von Bertalanffy growth parameters W_∞, K and t_o.

The last card (Format: I1) contains the value of programme option parameter K10. If K10 = 1, the number of iterations required for the iterative calculation of the fishing mortality rate is printed. Otherwise K10 = 2.

REFERENCE

Allen, K. R. 1973. The Computerized Sperm Whale Population Model. *Rep. int. Whal. Commn.*, 23: 70–4.

SP/Doc 1G

A Computer Programme to Calculate Sustainable Yields and Fishing Mortality for Sperm Whale Populations (SPVAP) of Variable Size

K. Radway Allen

Division of Fisheries and Oceanography, CSIRO, Cronulla, NSW, Australia

DESCRIPTION

This programme calculates the sustainable yields in numbers and weight, and fishing mortality rates for both sexes from a mature female population which is progressively reduced from an initial value of 10,000.

The pregnancy rate, natural mortality rate, juvenile mortality rate and age for female maturity are allowed to vary with population size in the following way. If, for example, the natural mortality rate at zero population is MO, and at unexploited level PU is MU, then the rate at population P is

$$M = MO + (MU - MO)(1 - P/PU)^{(Z+1)} \text{ for given Z.}$$

The method of calculating number caught and the fishing mortality rate is detailed in Allen (1973). The weight of the catches is calculated from the mean individual weight which is given by:

$$\bar{W} = W_\infty \left(1 - \frac{3Ze^{-K(t_r - t_o)}}{Z + K} + \frac{3Ze^{-2K(t_r - t_o)}}{Z + 2K} - \frac{Ze^{-3K(t_r - t_o)}}{Z + 3K}\right)$$

The programme produces a table showing, for various female population levels, the sustainable catches by weight and number of each sex, the combined weight for both sexes, and the mean individual weights for each sex, and combined sexes. A more detailed table is also produced allowing the population levels corresponding to maximum sustainable catches by weight for each sex separately and combined sexes to be determined.

The programme is written in CDC 7600 FORTRAN.

INPUT DATA

The data deck consists of the following:

(i) *Title* (Format: 10X, 70A1).

(ii) *Natural mortality rates* (Format: 10X, I5, 10F5.3) Contains up to 5 pairs of natural mortality rates for unexploited and zero population levels, with the number of pairs in columns 11–15.

(iii) *Pregnancy rates* (Format: 10X, I5, 10F5.3) Contains up to 5 pairs of pregnancy rates for unexploited and zero population levels, with the number of pairs in columns 11–15.

(iv) *Female age at maturity* (Format: 10X, I5, 10F5.0) Contains up to 5 pairs of female ages at maturity for unexploited and zero population levels, with the number of pairs in columns 11–15.

(v) *Harem size* (Format: 10X, I5, 10F5.0) Contains up to 5 pairs of harem sizes for unexploited and zero population levels, with the number of pairs in columns 11–15.

(vi) *Juvenile mortality rate* (Format: 10X, I5, 10F5.3 Contains up to 5 pairs of juvenile mortality rates for unexploited and zero population levels, with the number of pairs in columns 11–15.

(vii) *Reserve per harem male* (Format: 10X, I5, 10F5.3) Contains up to 10 values of reserve per harem male, with the number of values in columns 11–15.

(viii) *Density dependence exponent* (Format: 10X, I5, 10F5.3) Contains up to 10 values of density dependence exponent, with the number of values in columns 11–15.

(ix) *Age of male recruitment* (Format: 10X, F10.2).

(x) *Age of social maturity* (Format: 10X, F10.2).

(xi) *Age of female recruitment* (Format: 10X, F10.2).

(xii) *Last age for juvenile mortality* (Format: 10X, F10.2).

(xiii) *Growth parameters (male)* (Format: 10X, F5.1, 5X, F5.3, 5X, F5.2) Contains the values for males of the von Bertalanffy growth curve parameters W_∞, K, T_o.

(xiv) *Growth parameters (female)* (Format: 10X, F5.1, 5X, F5.3, 5X, F5.2) Contains the values for females of W_∞, K, T_o.

(xv) *Control Parameter* (Format: I1) If this contains 2 in column 1, the programme writes out an initial index giving the table number for each combination of parameters. If column 1 contains 1 the table is by-passed.

REFERENCE

Allen, K. R. 1973. The Computerized Sperm Whale Population Model. *Rep. int. Whal. Commn.*, 23: 70–4.

SP/Doc 1H

Programme to Calculate Time Series of Sperm Whale Population Components for Given Catches (SPDYN)

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DESCRIPTION

The programme computes changes in the size of the components of an initially balanced sperm whale population of any desired parameters when exposed to a given series of catches of each sex. It can be used to simulate the history of an actual exploited population. The original method of calculation as described in Allen (1973) is revised in the Appendix.

The programme is written in CDC 7600 FORTRAN.

INPUT DATA

The data deck is made up as follows:

(a) *Programme options* (Format: 2I1) Contains 1 or 2 in columns 1 and 2. 1 in column 1 prints length of iterations in the calculation of fishing mortalities. 1 in column 2 bypasses write out of index of requested groups of parameter values.

(b) *Starting and finishing years for calculations* (Format: 10X, I2) Contains last two digits of starting and finishing years.

(c) *Ratios of juvenile mortality rates for unexploited and zero population* (Format: 10X, I5, 10F5*) Accommodates up to 10 ratios. Variables are: number of values, and actual values.

(d) *Natural mortality rates* (Format: 10X, I5, 10F5*) Accommodates up to 5 pairs of natural mortality rates for unexploited and zero population levels. Variables are: number of pairs, and pairs of values.

(e) *Pregnancy rates* (Format: 10X, I5, 10F5*) Accommodates up to 5 pairs of pregnancy rates for unexploited and zero population levels. Variables are: number of pairs, and pairs of values.

(f) *Female ages at maturity* (Format: 10X, I5, 10F5*) Accommodates up to 5 pairs of female ages at maturity for unexploited and zero population levels. Variables are: number of pairs, and pairs of values.

(g) *Duration of juvenile mortality rate* (Format: 10X, F10.0).

(h) *Age of social maturity for males* (Format: 10X, F10.0).

(i) *Age of recruitment for males* (Format: 10X, F10.0).

(j) *Age of recruitment for females* (Format: 10X, F10.0).

(k) *Size of Harem* (Format: 10X, F10.0).

(l) *Reserve per harem male* (Format: 10X, F10.3).

(m) *Density dependence exponent.* (Format: 10X, F10.3).

(n) *Initial female population size* (Format: 10X, I5, 6F10.0) Accommodates up to 6 initial population sizes. Variables are: number of values, and values.

(o) *Male catch data deck* (Format: 9X, I1, 5 (I3, F7.0)) Contains the male catches by year, with up to 5 values per card. Variables are: II, year, and male catch, where if more than one card is required, II must be non zero, with the exception that in the last card, II must be zero.

(p) *Female catch data deck* (Format: 9X, I1, 5(I3, F7.0)) Contains the female catches by year as in (m).

(q) *Title* (Format: 80A1) Any title.

(r) *End of data:* 9 in column 1.

* F5 = Free field of length 5 with decimal point.

RESTRICTION

The total period covered must not exceed 50 years.

REFERENCE

Allen, K. R. 1973. The Computerized Sperm Whale Population Model. *Rep. int. Whal. Commn.*, 23: 70–4.

APPENDIX

REVISED CALCULATIONS FOR TIME SERIES OF SPERM WHALE POPULATIONS (PROGRAMME SPDYN)

The symbols used in the following calculations are:

MJ_t = juvenile mortality rate in year t
M_t = natural mortality rate in year t
p_t = pregnancy rate in year t
h = harem size
P = mature female population
t_j = duration of juvenile mortality rate
TMF_j = female age at maturity in year t
t_{mm} = age of social maturity of males
t_{rf} = female age at recruitment
t_{rm} = male age at recruitment.

The parameters MJ_t, M_t, P_t and TMF_t are assumed to vary with the mature female population size in year t.

The components at the beginning of each year which are traced are:

Females –

juvenile, unexploited	($PFJU_t$)
young, unexploited	($PFYU_t$)
immature, unexploited	($PFIU_t$)
mature, unexploited	($PFMU_t$)
mature, exploited	($PFME_t$)
mature, total	($PFMT_t$)

Males –

juvenile, unexploited	($PMJU_t$)
young, unexploited	($PMYU_t$)
immature, unexploited	($PMIU_t$)
immature, exploited	($PMIE_t$)
mature, exploited	($PMME_t$)
harem masters	(PMH_t)
surplus to breeding needs	($PMMS_t$)

In setting up the model, the initial population is stabilized by adjusting MJ_1 from the relationship

$$MJ_1 = \frac{1}{t_j}\left(\ln\left(\frac{p_1}{2(1-e^{-M_1})}\right) - M_1\,(TMF - t_j)\right)$$

where M_1 and TMF_1 are given the appropriate values for an unexploited population.

If a separate juvenile mortality rate is not included in the desired model, stabilization is achieved by adjusting the unexploited value of M_1 by solving the equation:

$$\frac{p_1}{2}\, e^{-M_1 . TMF_1} + e^{-M_1} - 1 = 0$$

For each run, the original mature female population at the beginning of the first year ($PFMT_1$) is supplied and the initial sizes of the other components are calculated as below.

$$PFJU_1 = PFMT_1 . \frac{p_1}{2} . \frac{1-e^{-MJ_1\, t_j}}{1-e^{-MJ_1}}$$

$$PFYU_1 = PFMT_1 . \frac{p_1}{2} . \frac{(1-e^{-M_1(TMF_1-t_j)})}{1-e^{-M_1}}\, e^{-MJ_1 . t_j}$$

$$PFIU_1 = PFJU_1 + PFYU_1$$

$$PFMU_1 = PFMT_1 . \frac{p_1}{2} . \frac{(1-e^{-M_1(t_{rf}-TMF_1)}) . e^{-[MJ_1 t_j + M_1(TMF_1 - t_j)]}}{1-e^{-M_1}}$$

$$PFME_1 = PFMT_1 . \frac{p_1}{2} . \frac{e^{-(MJ_1 t_j + M_1(t_{rf}-t_j))}}{1-e^{-M_1}}$$

$$PMJU_1 = PFJU_1$$

$$PMYU_1 = PFMT_1 . \frac{p_1}{2} . \frac{(1-e^{-M_1(t_{mm}-t_j)})}{1-e^{-M_1}} . e^{-MJ_1 t_j}$$

$$PMIU_1 = PMJU_1 + PMYU_1$$

$$PMIE_1 = PFMT_1 . \frac{p_1}{2} . \frac{(1 - e^{-M_1(t_{mm} - t_{rm})}) . e^{-[MJ_1 t_j + M_1(t_{rm} - t_j)]}}{1 - e^{-M_1}}$$

$$PMME_1 = PFMT_1 . \frac{p_1}{2} . \frac{e^{-[MJ_1 t_j + M_1(t_{mm} - t_j)]}}{1 - e^{-M_1}}$$

$$PMH_1 = \frac{PFMT_1}{h}$$

$$PMMS_1 = PMME_1 - PMH_1$$

Subsequently the size of each component at the beginning of each year is calculated from that at the beginning of the previous year as follows, where CM_t and CF_t are the catches of males and females respectively in year t.

$$PFJU_{t+1} = PFJU_t + B_{t+1} - DFJU_t - RFJ_{t+1}$$

where B_{t+1} = female or male births at the beginning of year t+1

$$= PFMT_t \frac{p_t}{2}$$

RFJ_{t+1} = juvenile females becoming young at the beginning of year t+1

$$= PFMT_{t+1-t_j} . \frac{p_{t+1-t_j}}{2} . \exp\left[-\sum_{i=t+1-t_j}^{t} MJ_i\right]$$

and $DFJU_t$ = natural deaths of juvenile unexploited females in year t

$$= PFJU_t (1 - e^{-MJ_t})$$

$$PFYU_{t+1} = PFYU_t + RFJ_{t+1} - DFYU_t - RFY_{t+1}$$

where $DFYU_t$ = natural deaths of young unexploited females in year t

$$= PFYU_t (1 - e^{-M_t})$$

and RFY_{t+1} = young females becoming mature at the beginning of year t+1

$$= PFMT_{t+1-TMF_t} \cdot p_{t+1-TMF_t} \cdot \exp\left[-\sum_{i=t+1-TMF_t}^{t-TMF_t+t_j} MJ_i - \sum_{i=t+1-TMF_t+t_j}^{t} M_i\right]$$

$$PFIU_{t+1} = PFJU_{t+1} + PFYU_{t+1}$$

$$PFMU_{t+1} = PFMU_t + RFY_{t+1} - DFMU_t - RFM_{t+1}$$

where $DFMU_t$ = natural deaths of mature unexploited females in year t

$$= PFMU_t (1 - e^{-M_t})$$

and RFM_{t+1} = mature females becoming exploitable at the beginning of year t+1

$$= PFMT_{t+1-t_{rf}} \cdot \frac{p_{t+1-t_{rf}}}{2} . \exp\left[-\sum_{i=t+1-t_{rf}}^{t-t_{rf}+t_j} MJ_i - \sum_{i=t+1-t_{rf}+t_j}^{t} M_i\right]$$

$$PFME_{t+1} = PFME_t + RFM_{t+1} - CF_t - DFME_t$$

where $DFME_t$ = natural deaths of mature exploitable females in year t

$$= \frac{M_t}{FF_t + M_t} . PFME_t . (1 - e^{-(FF_t + M_t)})$$

and FF_t is calculated by solving for FF_t

$$CF_t = \frac{FF_t}{FF_t + M_t} . PFME_t (1 - e^{-FF_t - M_t})$$

$$PMJU_{t+1} = PFJU_{t+1}$$

$$PMYU_{t+1} = PMYU_t + RMJ_{t+1} - DMYU_t - RMY_{t+1}$$

where $RMJ_{t+1} = RFJ_{t+1}$

$DMYU_t$ = natural deaths of young unexploited males in year t

$$= PMYU_{t+1} (1 - e^{-M_t})$$

and RMY_{t+1} = unexploited young males becoming exploited at the beginning of year t+1

$$= PFMT_{t+1-t_{rm}} \cdot \frac{p_{t+1-t_{rm}}}{2} \cdot \exp\left[-\sum_{i=t+1-t_{rm}}^{t-t_{rm}+t_j} MJ_i - \sum_{i=t+1-t_{rm}+t_j}^{t} M_i\right]$$

$$PMIU_{t+1} = PMJU_{t+1} + PMYU_{t+1}$$

$$PMIE_{t+1} = PMIE_t + RMY_{t+1} - CMI_t - DJE_t - RMM_{t+1}$$

where CMI_t = catch of immature males in year t

$$= \frac{CM_t \; PMIE_t}{PMIE_t + PMME_t}$$

DIE_t = natural deaths of immature exploited males in year t

$$= \frac{M_t}{FM_t + M_t} \cdot PMIE_t \cdot (1 - e^{-(M_t + FM_t)})$$

RMM_{t+1} = males becoming mature at the beginning of year t+1

$$= RMI_{t+1-t_{mm}+t_{rm}} \cdot \exp\left[-\sum_{i=t+1-t_{mm}}^{t-t_{mm}+t_{rm}} M_i - \sum_{i=t+1-t_{mm}+t_{rm}}^{t} FM_i\right]$$

and FM_t is calculated from CM_t, $(PMIE_t + PMME_t)$ and M_t as for FF_t

$$PMME_{t+1} = PMME_t + RMM_{t+1} - CMM_t - DME_t$$

where CMM_t = catch of mature males in year t

$$= CM_t - CMI_t$$

and DME_t = natural deaths of mature males in year t

$$= \frac{M_t}{FM_t + M_t} \cdot PMME_t \cdot (1 - e^{-(M_t + FM_t)})$$

$$PMH_{t+1} = \frac{PFMT_{t+1}}{h}$$

$$PMMS_{t+1} = PMME_{t+1} - PMH_{t+1}$$

SP/Doc 11

A Sperm Whale Population Model Based on Cohorts (SPCOH)

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This model is essentially similar to that previously described but a cohort approach is used to enable the size composition of the population to be examined and its biomass calculated.

The population is divided into the following components:

Juveniles – subject to a juvenile natural mortality rate different from that for older animals.
Young – post-juveniles, but sexually immature and unexploited.
Immature exploited males.
Mature exploited males.
Harem masters.
Reserve males, required to enable the harem masters to function effectively.
Surplus males, mature males in excess of harem masters and reserves.
Mature unexploited females.
Mature exploited females.

The density dependent parameters are, as before, the juvenile mortality rate, the normal mortality rate, the pregnancy rate, and the female age at maturity. The model differs from its predecessor in that:

(a) density dependent factors are dependent on total population biomass and not on number of mature females.
(b) dependence is not necessarily linear, being in the form

$$x_B = x_o + (x_u - x_o)\left(\frac{B}{B_u}\right)^{1+z}$$

where x_B, x_o and x_u are parameter values at biomass level B, and at zero and unexploited population levels; B_u is the biomass at unexploited level. Z is the density dependence exponent; where $Z = 0$, dependence becomes linear as in the Schaefer model, while at $Z = 1.4$ the maximum rate of population increase occurs where $B \doteqdot 0.6B_u$.

The model incorporates von Bertalanffy type growth with the length distribution at any age being normally distributed with a mean given by the growth equation and with standard deviation a constant proportion of the mean. Weight is taken to be exponentially dependent on length.

In setting up the model an age-length matrix is constructed for an initial unexploited population corresponding to a given number of mature females. This is then transferred from year to year by subtracting the number caught at each size, reducing the number at each age as a result of natural mortality and recalculating the new length distribution of each cohort resulting from growth. The numbers in each population component, and the total population biomass are then calculated for each succeeding year.

The model has been incorporated in a computer programme SPCOH. The details of the methods of calculation used in the programme are given in Appendix 1, and operating instructions in Appendix 2.

APPENDIX 1

Calculations for Sperm Whale Cohort Model Programme SPCOH

1. The symbols used in the following calculations are:

MJO, MJU, MJ = juvenile mortality rates at zero, unexploited and prevailing population level.
MO, MU, M = natural mortality rates at zero, unexploited and prevailing population level.
PO, PU, P = pregnancy rates at zero, unexploited and prevailing population level.
TMFO, TMFU, TMF = ages at female maturity at zero, unexploited and prevailing population level.
TJ = duration of juvenile mortality.
TMM = age of social maturity for males.
TRM = age of recruitment for males.
TRF = age of recruitment for females.
H = harem size.
R = reserve per harem male.
Z = density dependence experiment.
BU, B = biomasses at unexploited and prevailing population levels.

The parameters MJ, M, P, TMF are assumed to vary with total biomass. For example, if the natural mortality rate at population biomass B is M, then

$$M = MO + (MU - MO)\left(\frac{B}{BU}\right)^{1+z}$$

MJ and TMF are calculated in a similar fashion, while

$$P = PO - (PO - PU)\left(\frac{B}{BU}\right)^{1+z}$$

The components, at the beginning of each year, which are traced are:

Females –	
juvenile unexploited	(PFJU)
young, unexploited	(PFYU)
immature, unexploited	(PFIU = PFYU + PFJU)
mature, unexploited	(PFMU)
mature, exploited	(PFME)
mature, total	(PFMT = PFME + PFMU)
Males –	
juvenile, unexploited	(PMJU)
young, unexploited	(PMYU)
immature, unexploited	(PMIU = PMJU + PMYU)
immature, exploited	(PMIE)
mature, exploited	(PMME)
harem masters	(PMH)
reserve males	(PMR)
surplus males	(PMS = PMME – PMH – PMR)

In setting up the model, the initial population is stabilized by calculating MJU from the relationship

$$MJU = (\ln(PU/2(1 - e^{-MU})) - MU([TMFU] - TJ))/TJ$$

where [x] = least integer greater than or equal to x.

2. BUILD UP OF INITIAL MATRIX

(a) Initial age vector

Number of recruits (age o)
$= AGE(o)$
$= PFMT.PU/2$

No. at age t in juveniles
$= AGE(t) = AGE(o)e^{-MJU.t}$

No. at age [TJ] = AGE ([TJ])
$= AGE(o).\exp(-MJU.TJ + MU([TJ] - TJ))$

No. at age t at later ages
$= AGE(t) = AGE(t-1)e^{-MU}$

No. at last age
$= AGE(t_e) = AGE(t_e - 1)e^{-MU}/(1 - e^{-MU})$

These formulae apply for both sexes.

(b) Initial weight length vector

For each sex,

$WL(L) = WLA.L^{WLB}$ $\quad L = 1, 2, \ldots$

where WLA, WLB are sex dependent parameters.

(c) Initial average lengths at age

For each sex,

$AVLATA(t) = L_\infty(1 - e^{-K(t-t_0)})$ $\quad t = 0, 1, 2,$

where L_∞, K, t_0 are sex dependent von Bertalanffy growth parameters.

(d) Stock components

For male population,

$$PMJU = \sum_{t=0}^{t=[TJ]-1} AGE(t)$$

$$PMYU = \sum_{t=[TJ]}^{t=[TRM]-1} AGE(t)$$

$$PMIU = PMYU + PMJU$$

$$PMIE = \sum_{t=[TRM]}^{t=[TMM]-1} AGE(t)$$

$$PMME = \sum_{t=[TMM]}^{t=\infty} AGE(t)$$

$$PMH = PFMT/H$$

$$PMR = PMH.R$$

$$PMS = PMME - PMH - PMR$$

For female population,

$$PFJU = PMJU$$

$$PFYU = \sum_{t=[TJ]}^{t=[TMFU]-1} AGE(t)$$

$$PFIU = PFYU + PFJU$$

$$PFMU = \sum_{t=[TMFU]}^{t=[TRF]-1} AGE(t)$$

$$PFME = \sum_{t=[TRF]}^{t=\infty} AGE(t)$$

$$PFMT = PFMU + PFME.$$

(e) Age-length matrix

The age-length matrix is calculated by distributing the total number at each age over lengths according to a normal distribution.

For each sex,

No. of length L and age t =

$$AL(t,L) = \left| AVLATA(t), SL \right|_{L-0.5}^{L+0.5} . AGE\ (t)$$

where $\left| AVLATA(t), SL \right|_{L-0.5}^{L+0.5}$

is the normal integral with mean AVLATA(t) and standard deviation $SL = SDL(1-e^{-K(t-t_o)})$, where SDL is a sex dependent parameter.

(f) Initial year length vector

For each sex,

$$PLDTN\,(L,1) = \sum_{t=0}^{\infty} AL(t,1) \qquad L = 0,1,2,\ldots$$

(g) Initial biomass

For each sex,

$$B = \sum_{1=o}^{\infty} PLDTN\ (L,1)\ .\ WL(L)$$

3. TRANSFER TO FOLLOWING YEAR

(a) Recalculate parameters

Recalculate values of MJ, M, P, TMF for new value of total biomass.

(b) Calculate mean length from age length matrix

For each sex,

$$AVLBS(t) = \frac{\sum_{L=o}^{\infty} L.AL(t,L)}{\sum_{L=o}^{\infty} AL(t,L)}$$

(c) Subtract catches

For each sex, catches are subtracted from each cell of age length matrix by distributing the catch at each length in proportion to the numbers at each age at that length.

(d) Calculate mean lengths after catches subtracted

For each sex,

$$AVLAS(t) = \frac{\sum_{L=o}^{\infty} L.AL(a,L)}{\sum_{L=o}^{\infty} AL(a,L)}$$

(e) Transfer to new age group

For each sex,

$$\text{new } AGE\ (t) = \text{old } AGE\ (t-1).e^{-M \text{ or } MJ} \qquad t = 2,3,\ldots$$

$$\text{new } AGE\ (1) = PFMT.P/2$$

(f) New average lengths at age after growth

$$\text{new } AVLATA(t) = \text{old } AVLATA(t-1)\ .\ \frac{AVLAS(t-1)}{AVLBS(t-1)} . \frac{(1-e^{-K(t-t_o)})}{(1-e^{-K(t-1-t_o)})} \qquad \text{for } t = 2,3,\ldots$$

$$\text{new } AVLATA\ (o) = L_{\infty}(1-e^{+Kt_o}).$$

Steps 2(e) to 3(f) are repeated over the range of years represented in the data, using the appropriate values of the biomass varying parameters.

4. COMPARISON OF CATCH AND POPULATION SIZE DISTRIBUTIONS

For each year and sex, the population and catch percentage size distributions over the size limit are calculated to enable comparisons.

APPENDIX 2

A Computer Programme to Calculate a Series of Stock Components of a Sperm Whale Population Using a Cohort Model (SPCOH)

DESCRIPTION

The programme calculates a series of stock components of an initially balanced sperm whale population of any desired parameters. Although related to the programme SPDYN, this programme is based on a cohort model. Centre of the model is an age length matrix for each sex in which the numbers in each cell are changed from year to year in response to a given series of catch length distributions of each sex. Recruits are added in year 1 and subsequent age groups are calculated by transfer from the previous age and adjusted for natural mortality and catches. The numbers in each age group are distributed among length classes in accordance with given probability distributions of lengths.

Tables of comparisons of catch and population size distributions are also calculated from population size distributions built up each year.

The juvenile and adult mortality rate, pregnancy rate and age of female maturity are assumed to vary non linearly with population biomass.

An option is provided allowing catch data to be in the form of numbers caught in each year. If this is selected, catches are distributed among lengths according to the population age-length distribution.

INPUT DATA

(1) *Title* (Format: 8A10).

(2) *Ratios of juvenile mortality rates* (zero to unexploited population level) (Format: 10X, I5, 10F5.0) Contains the number of ratios, and up to 10 ratios of juvenile mortality rates.

(3) *Natural mortality rates* (Format: 10X, I5, 10F5.0) Contains the number of pairs, and up to 5 pairs of natural mortality rates at zero and unexploited population levels.

(4) *Pregnancy rates* (Format: 10X, I5, 10F5.0) Contains the number of pairs, and up to 5 pairs of pregnancy rates at zero and unexploited population levels.

(5) *Age at female maturity* (Format: 10X, I5, 10F5.0) Contains the number of pairs, and up to 5 pairs of ages at female maturity at zero and unexploited population levels.

(6) *Initial female mature populations* (Format: 10X, I5, 10F5.0) Controls the number of values and up to 10 values of the initial female mature populations.

(7) *Duration of juvenile mortality* (Format: 10X, F5.0).

(8) *Age at male maturity* (Format: 10X, F5.0).

(9) *Age at male recruitment* (Format: 10X, F5.0).

(10) *Age at female recruitment* (Format: 10X, F5.0).

(11) *Harem size* (Format: 10X, F5.0).

(12) *Reserve per harem male* (Format: 10X, F5.0).

(13) *Density dependence exponent* (Format: 10X, F5.0).

(14) *Male growth parameters* (Format: 10X, 6F5.0) Contains von Bertalanffy parameters L_o, K, T_o, together with standard deviation of length distribution, at age where length equals L_∞ and two parameters A and B of the weight length relationship W = AL**B.

(15) *Female growth parameters* (Format: 10X, 6F5.0) as for males.

(16) *Maximum age* Format: 10X, I5).

Catch length data

(17) *Controls* (Format: 10X, 4I5) Contains overall minimum and maximum lengths in catches of each sex in any year, and the starting and finishing years for which data are included.

If the option to include only total catch each year is required, the minimum length must be the size limit, and the maximum length left blank.

For each sex and each year

(18) *Sex and year* (Format: 10X, 2I5).

(19) *Catch length distribution* (Format: 5X, 16F5,0) Contains for lengths ranging from the minimum and maximum length of (17), numbers at each length with 16 entries per card. The last entry is followed immediately by the sum of the entries to be used as an edit check. If there are more than 16 lengths in the distribution, it will extend on to further cards. More than one distribution can be entered for a single year and sex, provided each is preceded by a card (18).

(20) Catch data is followed by card with 9 in column 15.

Data sets (1)–(20) may be repeated indefinitely.

OUTPUT

(a) Table Index (one table for each set of parameters).
For each table,

(b) An array of stock components for each year, and

(c) An array of comparisons of catch and population length distributions.

SP/Doc 2

Size Estimates of Southern Hemisphere Male Sperm Whale Populations

K. Radway Allen

CSIRO, Cronulla, Australia

Gambell (1977) has recently provided tabulations of Southern Hemisphere catch and effort for male sperm whales by country and division. These cover separately catch and effort north of 40°S, and catch and effort in the Antarctic before and after the baleen season. He has also provided tabulations of average catcher tonnage by country by year and of total catch of sperm whales by division and year. These data enable population estimates to be made by the method of comparing actual and expected catches. Separation of the data for individual countries removes some of the problems associated with possible national differences in efficiency.

Ohsumi (1977) has also provided data on the effect of the introduction of Asdic on the efficiency of Japanese sperm whaling. His data show clearly that, over the period 1959–69, there was a progressive increase in efficiency as experience in the use of the equipment was gained and the proportion of vessels so equipped increased. To obtain an appropriate conversion factor for use in population estimates, the mean relative efficiency of Asdic-equipped vessels in each year (averaged over the expeditions) has been multiplied by the proportion of the fleet so equipped. The results have been slightly smoothed for application to the population estimates. These conversion factors are shown in Table 1.

Table 1

Changes in the overall relative efficiency of Japanese sperm whale catchers resulting from the introduction of asdic.

	Efficiency with asdic	Proportion with asdic	Overall efficiency	Smoothed value
1956–57	.96	.04	1.00	1.00
1957–58	.84	.09	.99	1.00
1958–59	1.38	.18	1.02	1.00
1959–60	1.32	.25	1.10	1.10
1960–61	1.49	.30	1.10	1.11
1961–62	1.35	.55	1.27	1.21
1962–63	1.38	.63	1.22	1.24
1963–64	1.38	.63	1.24	1.24
1964–65	1.38	.65	1.25	1.25
1965–66	1.38	.75	1.29	1.29
1966–67	1.38	.80	1.30	1.30
1967–68	1.38	.86	1.33	1.33
1968–69	1.38	.97	1.37	1.37
1969–70	1.38	.97	1.37	1.37

In view of the difficulty of obtaining good estimates of the annual recruitment rate to the male sperm whale population, the present population estimates are based on the assumption that, over the period considered, the actual number of recruits for any given stock has remained constant. Provided that the female population has not changed greatly, this is probably a justifiable assumption. In Divisions 1, 4, 5, 7, 8, the number of females caught prior to about 1962–63 was negligible. It seems unlikely to have had any effect on the number of recruits. Even in Divisions 2 and 3 the total numbers of females caught prior to 1962–63 are probably small relative to the initial population size (2,100 and 4,100 respectively) and have probably had little effect on recruitment. Only in Division 9 does the female catch seem large enough to have had any possible effect on recruitment.

Since it is assumed for the purpose of these estimates that the populations were in an approximately unexploited condition in 1946, it is appropriate to set the value of the initial recruitment rate equal to the natural mortality rate. The value used for these parameters was 0.05 in accordance with the report of the Parksville meeting.

The method used in making the estimates allows for the series of divisions to be handled simultaneously on the assumption that the value of q per unit area is the same in all of them. The method then calculates the combination of initial population sizes in the various divisions and the common q per unit area which, over the whole series, minimizes the sum of squares of differences between actual and expected catches.

For this purpose it is necessary to provide a figure for the area within which each population is distributed. For the present analysis this has been assumed to be the entire sea area in each division between the Equator and 70°S latitude. These areas in units of square equatorial degrees (c. 3,600 sq. nautical m.) are given in Table 2.

Only some of the national series of catch and effort data contained sufficiently long series to be suitable for examination. In the Antarctic these were the data for Japan, USSR, UK and Norway, and in the waters north of 40°S those for Japan and USSR. Test runs showed that, for both the Norwegian and USSR data in the Antarctic, none of the divisions showed a sufficiently declining tendency in CPUE to enable estimates to be obtained by this method. For the USSR data north of 40°S, satisfactory estimates were obtained for the combination of Divisions 1, 4, 5, 6, 7, but

Table 2

Approximate sea areas in square equatorial degrees (c. 3,600 sq.n.m.) in each Division between the equator and 70°S.

Division	1	2	3	4	5	6	7	8	9	Total
Area	970	2,491	1,558	1,615	1,804	1,132	1,592	3,769	1,549	16,483

Table 3

Population estimates (in 1,000s) by Divisions for those national data series giving reasonable (i.e. non-negative) results. The lines labelled LYE are the estimates for the last year of the time series analysed, when this was not 1975. The 1975 estimates were obtained by extrapolation.

	Division								
	1	2	3	4	5	6	7	8	9
N. of 40°S									
Japan 1946	–	–	26.8	17.4	19.4	12.6	17.5	–	–
LYE	–	–	5.6 (71)	–	6.5 (72)	–	–	–	–
1975	–	–	1.9	7.6	5.5	6.4	6.4	–	–
USSR 1946	13.6	–	–	18.7	20.7	12.9	19.7	–	–
LYE	–	15.1*	9.4*	–	–	–	–	–	–
1975	6.9	–	–	9.0	8.6	6.7	8.7	–	–
Antarctic									
Japan 1946	–	–	24.6	12.5	17.4	9.8	13.3	24.7	–
LYE	–	–	4.8 (70)	3.6 (70)	4.1	–	9.7 (64)	22.2	–
1975	–	–	1.7	2.3	3.4	3.5	2.1	23.1 (65)	–
UK 1946	–	73.9	68.7	53.2	52.1	–	–	69.9	49.9
LYE	–	60.0 (64)	55.9 (60)	49.5 (59)	48.0 (59)	–	–	69.4 (56)	27.9 (61)
1975	–	58.6	44.5	44.1	38.9	–	–	68.3	–
Mean 1946	–	–	25.7	16.2	19.2	11.8	16.8	24.7	–

* Estimates (mean for 1963–69) obtained by applying standard q per unit area to catch per unit effort for these Divisions.

not for Divisions 2 and 3. For the Japanese and for the UK Antarctic data, satisfactory estimates were obtained for the combinations of all divisions with useful time series. The results of these analyses are given in Table 3.

There is considerable agreement in the estimates derived from the USSR and two Japanese sets of data. However those obtained from the UK Antarctic data are substantially higher than any of the others. It is a consequence of the technique that the relative size of the estimates from the different sources tends to be the same for all divisions. On the other hand, there is also a noticeable degree of consistency between the sources in the relative size of the estimated populations for the different divisions, and this does not result from the technique, but probably represents real differences in population level. The mean estimates for 1946 populations in Table 3 exclude values based on UK data.

Table 4 compares the estimates of q per unit area from the various sources. There is some variation in the estimates, although the two Japanese values do not differ greatly. The very low value for the UK north of 40°S data is correlated with the high population estimates for this data site.

Table 4

Values of q per unit area by countries and zones.

	N. of 40°S	Antarctic
Japan	.2246	.2806
USSR	.1373	–
UK	–	.0575

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Gambell, R. 1977. Southern Hemisphere Sperm Whale Catch and Effort Data. Paper SP/Doc 8 (published in this volume).

Ohsumi, S. 1977. Sperm Whale Catch efficiency by Japanese Pelagic Whaling Catcher Boats in the Antarctic. Paper SP/Doc 14 (published in this volume).

SP/Doc 3

Sperm Whales off Albany, Western Australia

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The following sections deal briefly with recent catch and research results relevant to particular agenda items.

ABUNDANCE (Agenda Item 6.5, 6.6)

As described earlier (Bannister, 1975) detailed catch, effort and aircraft sightings data exist for the sperm whaling operations off Albany, Western Australia, from 1962.

Unweighted catch per unit effort for bulls ⩾35 ft. (Table 1(a)) indicate some decline to 1967, an increase to 1970, and some levelling out thereafter. Changes in catcher tonnage or horsepower over the period have already been shown (Bannister, 1969) to have had little consistent effect on catcher efficiency; more recent analyses do not alter this conclusion. The observed changes appear, however, to be related to changes in the whaling operation, since there was an alteration in spotter aircraft in 1967, and sonar was introduced as well as more efficient aircraft/catcher co-ordination (e.g. by the use of DME equipment) from 1970.

The sighting rate of bulls from the spotter aircraft, per mile flown in standard weather conditions, has been taken as the best index of abundance year to year in the Albany operation. The values indicate a decline until 1967, a levelling out thereafter, but some decrease in the last two years (Table 1(b)). This index does not, however, allow directly for the probability that as the area of search has increased there has been an increase in its extent seawards. Since the continental shelf off Albany is a concentration area for sperm whales moving north from colder waters and then west parallel to the coast, abundance would be expected to drop off the more seawards the search, and there is evidence from the spotter pilots that this has occurred, at least within the past two or three years, and thus possibly accounting for some of the decrease in sighting rate in 1974 and 1975. Similarly, the noticeable drop in sighting rate between 1965 and 1968 may be connected directly with a change in the size of area 'swept' and the non-random distribution of animals within it.

However, the effect of the introduction of sonar on the catching operation can be estimated by examining 'exploitation' rates, obtained as the ratio

$$\frac{\text{catch (of bulls} \geqslant 35 \text{ ft.)}}{\text{sightings of bulls}}$$

in each year. The average values of these ratios for the years 1967–69 (pre-sonar) and 1970–74 (post-sonar) are 0.36 and 0.43 respectively, indicating that sonar has increased catching efficiency by at least 19% in the Albany operation. This factor can be used to weight catcher effort, over the period 1967–75, with the results shown in Table 1(c).

Table 1

Sperm whale (Bulls ⩾35 ft.) Abundance, Albany, W.A., 1962–75

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
(a) Catch per hunting hour	.21	.17	.17	.13	.13	.14	.16	.15	.23	.22	.19	.20	.20	.20
(b) Bulls seen per effective searching mile (aircraft data)	.41	.36	.36	.34	.25	.18	.19	.17	.15	.15	.15	.14	.09	.10
(c) Catch per hunting hour, weighted for effect of sonar	–	–	–	–	–	.14	.16	.15	.19	.18	.16	.17	.16	.17

SIZE COMPOSITION (6.2)

The average length of males ⩾35 ft. caught off Albany in 1975 was slightly lower than before, falling below 42 ft. for the first time (Table 2(a)). There was also a marked reduction in the proportion of 'medium-large' (44–47 ft.) and large (⩾48 ft.) males in the catch ⩾35 ft. (Table 2(b)). This is coupled with a very marked increase in the proportion of small (35–38 ft.) males, presumably resulting from the reduction of the size limit to 30 ft. from 1973 and an increasing concentration on small whales (including females) in meeting quota requirements.

Changes in abundance of the various length groupings show much the same trend (Table 2(c)).

The effect of the reduction in length, limit and the increase in female quota, on the total catch, is illustrated by comparing the percentages of each sex in the catch over recent years (Table 3). This shows a very considerable decrease in the proportion of males from around 95% to as low as 58% since the length limit was reduced in 1973.

AGE COMPOSITION (6.3)

From teeth (front mandibular) collected from males and females in 1973 and 1974, sectioned and counted at the

Table 2

(a) Average length of males ⩾35 ft.

1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
43.6	43.2	42.7	42.6	43.6	43.3	42.9	43.3	43.9	43.8	42.7	43.0	42.9	41.8 ft.

(b) Percentage of the male catch ⩾35 ft. at various length groupings

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
35–38 ft.	10	15	15	16	10	12	18	17	11	13	23	22	23	31
39–43 ft.	40	36	42	43	38	39	38	32	33	34	23	33	29	37
44–47 ft.	35	34	29	28	37	32	28	34	31	31	24	22	23	15
48 + ft.	15	15	14	13	15	17	15	17	25	22	20	23	25	17
Catch ⩾35 ft.	555	570	697	633	592	559	570	630	777	810	761	648	574	633
Catch <35 ft.	0	7	20	14	3	1	13	6	5	8	33	36	55	59

(c) Abundance (in comparable effort units, sonar corrected) of the male catch ⩾35 ft. at various length groupings

1967	1968	1969	1970	1971	1972	1973	1974	1975
.01	.04	.02	.01	.02	.07	.10	.17	.16
.18	.30	.28	.26	.24	.36	.39	.50	.52
.58	.63	.53	.66	.61	.54	.57	.49	.62
.47	.45	.56	.59	.56	.39	.38	.41	.26
.24	.25	.27	.50	.40	.31	.40	.40	.28

Table 3

Changes in sex ratio on reduction of length limit in 1973.

	1969	1970	1971	1972	1973	1974	1975
(1) Total ♂ catch	636	687	818	793	684	629	692
(2) ♂ Catch ⩾35 ft.	630	682	810	760	648	574	633
(3) Total ♀ catch	42	23	41	160	287	450	480
(4) ♀ Catch ⩾35 ft.	31	16	36	68	126	224	188
% ♂	95	98	96	92	70	58	59
Percentage derived from	$\frac{(2)}{(2)+(4)}$	$\frac{(2)}{(2)+(4)}$	$\frac{(2)}{(2)+(4)}$	$\frac{(2)}{(2)+(4)}$	$\frac{(1)}{(1)+(3)}$	$\frac{(1)}{(1)+(3)}$	$\frac{(1)}{(1)+(3)}$

Institute of Oceanographic Sciences, UK, an age-length distribution has been obtained. An age-length key for males should be available at the meeting. It is unlikely that a key can be usefully derived for females because of the wide range of ages over the very much more restricted length range.

HAREM SIZE (6.4.1)

Records of the number of bulls sighted, usually designated as 'large' or 'small', and 'cows plus juveniles', are available from the spotter aircraft operations. The term 'bull' has in the past been used only for animals of catchable (i.e. until 1973, ⩾35 ft.) males, although the majority, being recorded as in schools not associated with cows or juveniles, are likely to be 38 ft. or more in length.

Aircraft records from 1972–75 have been examined for the months September to December – that part of the year when breeding activity is most likely to be occurring off Albany (see Bannister, 1969) – for sightings of bulls, either 'large' or 'medium', but excluding 'small', associated directly with schools of cows and juveniles. Only those records of five or fewer bulls in the school have been included since it seems unlikely that bulls in larger numbers would be actively seeking females.

In 49 records available, the average number of cows and juveniles per bull is 22.9.

The reduction in length limit since 1973 has led to almost no bias against females in the length classes below 38 ft. Thus, as Gambell (1972) has pointed out, the proportion of females in the catch of all whales 38 ft. long or less should be close to that in nature, assuming such animals are all associated in the schools of 'cows and juveniles' reported. From 1972, the female proportion of the catch ⩽38 ft. is 1,377/2,099 = 62.3%. Applying that figure to the 22.9 animals per bull gives an average number of females in a school associated with one medium or large bull as 14.3.

REPRODUCTION RATE (6.4.3)

An analysis of ovaries for 145 mature females collected at Albany in 1964–65 gave an annual ovulation rate of 0.375, from the best-fit straight line relating age (tooth laminations) and corpora number for whales aged 14–30 laminations. This corresponds to one ovulation every 2–7 years. The age at first ovulation was calculated as 11.8 laminations or 10.8 years.

A similar analysis on 200 ovaries collected from Albany in 1973–74, from animals of age-range 15–33 laminations, gives a rather anomalous result. The calculated annual ovulation rate has decreased (to 0.248, i.e. one every 4.0 years) and so has the average age at first maturity (to 5.8 laminations or 4.8 years). Under heavy exploitation, one might have expected the age of females at first maturity to have decreased, or the ovulation rate to have increased, or both; but one would not have expected both to decrease.

Table 4

Proportions of sexual classes in catch of mature females.

	Pregnant	Lactating	Resting	Doubtful*	Total
1964–65 (June–October)					
Number	21	12	35	6	74
%	29	16	47	8	100
1973–74 (March–December)					
Number	57	22	177	53	309
%	19	7	57	17	100

* Those with an active corpus luteum but no foetus.

The recorded proportions of the various classes of mature females in the catch in 1973 and 1974 are also rather different from those recorded earlier (Table 4).

Noticeable in the more recent data are the higher proportions 'Resting' and 'Doubtful', and the lower proportions 'Pregnant' and 'Lactating', although the proportions 'Pregnant' plus 'Doubtful' are similar in each case. The extension of sampling through the whole season latterly, coupled with the larger sample, may have affected the result. Making allowance for very large foetuses in the early season data in 1973–74 gives a pregnancy rate (excluding 'doubtful' cases) of only 17%.

MOVEMENT OF WHALES INTO THE ALBANY AREA FROM COLDER WATERS (6.1, 6.4.4)

Since 1971, Albany stomach content samples have been examined for the presence of the beaks of the cold water squid *Moroteuthis ingens*. Of 802 samples examined, 82 or 10.2% contained *M. ingens* beaks. Almost all positive records came from males, the greatest majority of which were 'medium large' or 'large' (Table 5).

While the numbers with positive records in any one month are small, plots of the proportions in the examined sample indicate two main peaks of occurrence – in autumn (April/May) and spring (August/September).

Table 5

Records of *M. ingens* beaks in stomachs.

	<35 ft.	35–38 ft.	39–43 ft.	44–47 ft.	48 + ft.	Total
No. examined	26	141	257	186	190	802
Number with *M. ingens* beaks in stomach	2	7	11	28	34	82
% positive	8	5	4	15	18	10

The catch was also examined for the presence of the Antarctic diatom *Cocconeis ceticola*. Somewhat similar results were obtained, but with a rather larger proportion on smaller males and females. Strangely, however, there were very few whales with positive records both of diatoms and squid beaks. The squid data should give better evidence of those whales that have arrived most recently in Albany waters, since it is unlikely that beaks are retained in the stomachs for more than a short time.

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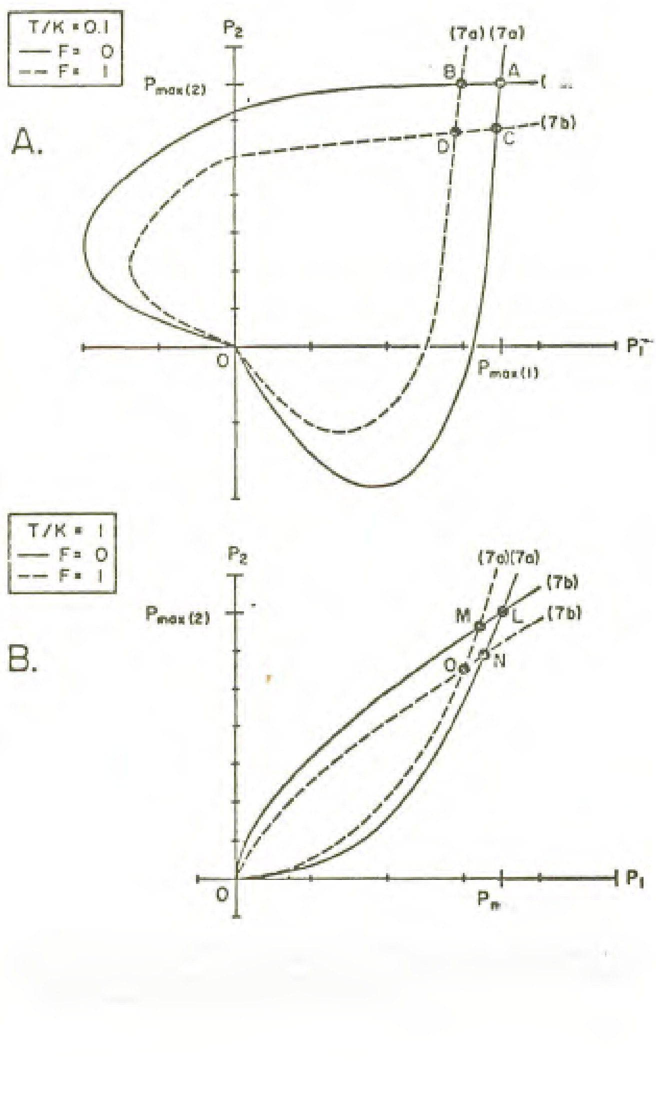
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(7a) (7a)
B
A
Pmax(2)
(7b)
D
C
A.
O
Pmax(1)
P1
T/K = 1
F = 0
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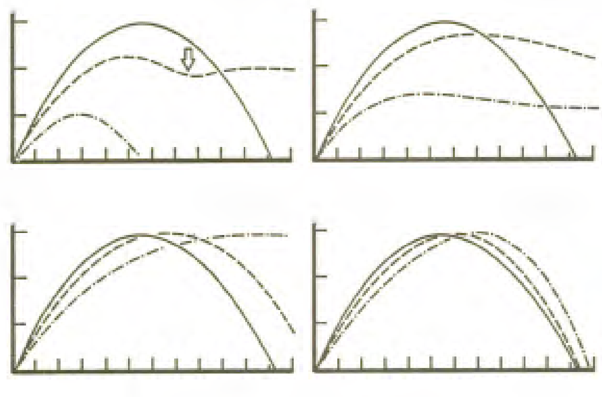
P2
(7a)(7a)
(7b)
Pmax(2)
M
L
(7b)
B.
O
N
O
P1



SUMMARY

The formulation of the mixing model has considerable impact on the yield relationship. The model formulation presented here, along with the assumed parameter values, indicates that knowledge of the mixing relationship can be critical to good management, which can be highly influenced by the distribution of fishing effort (hence quota levels) among stocks. It remains to be seen, however, how well such a model can describe an actual fishery situation.

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SP/Doc 8

Southern Hemisphere Sperm Whale Catch and Effort Data

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The accompanying tables show the numbers of sperm whales caught and the net catcher days worked by nations, divisions and seasons. The data are derived from the 10° 'square' statistics prepared by the Bureau of International Whaling Statistics, omitting the recent records for the 'squares' when minke whales were also caught.

Summary tables of catch per net catcher day are also included, by nations, divisions and seasons. Antarctic pelagic catches per net catcher day worked of female sperm whales outside the baleen whale season are omitted because of the few records concerned.

The tables comprise the following material:

Table 1. Antarctic pelagic catches of *male* sperm whales outside the baleen whale season and net catcher days worked, by nation and division (Japan, Norway, South Africa, Netherlands, UK, USSR).

Table 2. Ditto for *female* sperm whales (Japan, USSR).

Table 3. Pelagic catches of *male* sperm whales north of 40°S in the southern hemisphere and net catcher days, by nation and division (Japan, USSR).

Table 4. Ditto for *female* sperm whales (Japan, USSR).

Table 5. Antarctic pelagic catches of *male* sperm whales per net catcher day worked outside the baleen whaling season, by nation and division (Japan, Netherlands, Norway, South Africa, UK, USSR).

Table 6. Pelagic catches of *male* sperm whales per net catcher day worked north of 40°S in the southern hemisphere, by nation and division (Japan, USSR).

Table 7. Ditto for *female* sperm whales (Japan, USSR).

Table 1

Antarctic pelagic catches of *male* sperm whales outside the baleen whale season and net catcher days worked, by nation and division.

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
									JAPAN											
1947–48	–	–	–	–	–	–	–	–	–	–	2	6	–	–	–	–	–	–	2	6
1948–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1949–50	–	–	–	–	–	–	–	–	55	48	117	120	–	–	–	–	–	–	172	168
1950–51	–	–	–	–	–	–	–	–	308	288	101	99	–	–	–	–	–	–	409	387
1951–52	–	–	–	–	–	–	144	157	230	303	217	211	292	283	78	149	–	–	961	1,203
1952–53	–	–	–	–	–	–	–	–	–	–	55	45	61	105	4	15	–	–	120	169
1953–54	–	–	–	–	–	–	–	–	127	114	103	104	209	299	156	130	–	–	595	647
1954–55	–	–	–	–	–	–	–	–	321	246	261	208	228	260	157	221	–	–	967	935
1955–56	–	–	–	–	–	–	72	80	349	260	202	195	437	450	247	255	–	–	1,307	1,240
1956–57	–	–	–	–	–	–	–	–	321	279	170	168	559	462	309	489	68	105	1,427	1,503
1957–58	–	–	–	–	–	–	153	111	676	504	318	351	549	564	423	428	–	–	2,119	1,958
1958–59	–	–	–	–	16	24	95	126	472	386	299	312	396	360	639	468	–	–	1,917	1,676
1959–60	–	–	–	–	–	–	348	342	595	540	188	201	90	153	88	84	–	–	1,309	1,320
1960–61	–	–	–	–	190	228	302	402	457	455	273	235	328	300	–	–	–	–	1,550	1,620
1961–62	–	–	–	–	369	314	313	440	112	157	78	101	8	39	–	–	–	–	880	1,051
1962–63	–	–	11	36	432	507	262	306	46	77	252	187	–	–	–	–	–	–	1,002	1,113
1963–64	–	–	80	55	295	345	231	107	196	110	85	50	264	80	–	–	–	–	1,151	747
1964–65	–	–	4	37	87	108	112	36	–	–	–	–	–	–	27	70	3	10	233	261
1965–66	26	28	13	34	123	127	35	26	–	–	–	–	–	–	–	–	–	–	197	215
1966–67	–	–	14	24	201	144	99	36	–	–	–	–	–	–	–	–	–	–	314	204
1967–68	–	–	–	–	–	–	11	36	20	36	–	–	–	–	–	–	–	–	31	72
1968–69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969–70	5	12	–	–	–	–	–	–	13	39	–	–	–	–	–	–	–	–	18	51
1970–71	–	–	–	–	–	–	–	–	13	26	140	104	–	–	–	–	–	–	153	130
1971–72	–	–	–	–	–	–	–	–	–	–	64	70	–	–	–	–	–	–	64	70
1972–73	–	–	–	–	–	–	–	–	11	54	80	54	–	–	–	–	–	–	91	108
1973–74	–	–	–	–	–	–	–	–	–	–	30	9	–	–	–	–	–	–	30	9
1974–75	–	–	–	–	–	–	–	–	–	–	36	21	–	–	–	–	–	–	36	21

Table 1 – *continued*

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
NORWAY																				
1946–47	–	–	8	16	269	328	94	117	59	72	–	–	–	–	–	–	–	–	430	533
1947–48	–	–	71	138	121	267	52	126	21	45	–	–	–	–	–	–	–	–	265	576
1948–49	–	–	251	344	286	406	106	194	137	159	19	41	80	110	33	55	–	–	912	1,309
1949–50	2	14	219	182	324	465	159	214	72	138	–	–	–	–	–	–	–	–	776	1,013
1950–51	39	60	298	465	581	795	158	326	310	394	169	194	135	293	–	–	–	–	1,690	2,527
1951–52	118	297	285	518	747	904	388	552	125	246	132	123	132	157	–	–	1	14	1,928	2,797
1952–53	4	34	115	198	193	286	7	39	–	–	–	–	–	–	–	–	–	–	319	557
1953–54	–	–	207	239	65	150	48	27	42	36	–	–	–	–	–	–	–	–	362	452
1954–55	17	39	872	807	926	839	330	292	216	169	–	–	–	–	–	–	–	–	2,361	2,146
1955–56	4	31	797	914	407	574	161	238	294	188	336	190	105	108	–	–	–	–	2,104	2,243
1956–57	50	66	704	879	597	514	8	12	–	–	–	–	–	–	–	–	130	222	1,489	1,693
1957–58	24	50	918	896	923	687	156	135	29	48	–	–	–	–	–	–	–	–	2,050	1,816
1958–59	2	10	514	592	497	473	250	226	79	108	–	–	–	–	–	–	–	–	1,342	1,409
1959–60	28	44	157	198	357	261	–	–	–	–	–	–	–	–	–	–	148	136	690	639
1960–61	25	27	333	453	194	230	3	11	21	33	–	–	–	–	–	–	129	162	705	916
1961–62	–	–	377	395	101	113	–	–	–	–	–	–	–	–	–	–	25	27	503	535
1962–63	–	–	399	299	67	131	–	–	–	–	–	–	–	–	–	–	–	–	466	430
1963–64	16	25	242	240	–	–	–	–	–	–	–	–	–	–	–	–	–	–	258	265
1964–65	27	10	157	191	–	–	–	–	–	–	–	–	–	–	–	–	–	–	184	201
1965–66	33	50	153	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	186	182
1966–67	63	32	157	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	220	164
1967–68	–	–	4	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	5
SOUTH AFRICA																				
1946–47	–	–	–	–	4	24	36	108	8	48	–	–	–	–	–	–	–	–	48	180
1947–48	–	–	–	–	115	182	46	116	42	72	–	–	–	–	–	–	–	–	203	370
1948–49	–	–	–	–	146	205	139	124	–	–	–	–	–	–	–	–	–	–	285	329
1949–50	–	–	–	–	151	149	–	–	–	–	–	–	–	–	–	–	–	–	151	149
1950–51	–	–	–	–	257	375	14	45	–	–	–	–	–	–	–	–	–	–	271	420
1951–52	–	–	223	368	125	210	–	–	–	–	–	–	–	–	–	–	–	–	348	578
1952–53	–	–	82	160	39	48	–	–	–	–	–	–	–	–	–	–	–	–	121	208
1953–54	–	–	66	65	18	26	–	–	–	–	–	–	–	–	–	–	–	–	84	91
1954–55	–	–	34	65	237	143	–	–	–	–	–	–	–	–	–	–	–	–	271	208
1955–56	–	–	–	–	383	390	62	90	–	–	–	–	–	–	–	–	–	–	445	480
1956–57	13	30	31	40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	44	70
NETHERLANDS																				
1947–48	–	–	67	136	–	–	–	–	–	–	–	–	–	–	–	–	–	–	67	136
1948–49	–	–	1	10	70	130	–	–	–	–	–	–	–	–	–	–	–	–	71	140
1949–50	–	–	83	99	2	11	–	–	–	–	–	–	–	–	–	–	–	–	85	110
1950–51	–	–	175	156	60	72	–	–	–	–	–	–	–	–	–	–	–	–	235	228
1951–52	–	–	20	60	249	228	76	84	–	–	–	–	–	–	–	–	–	–	345	372
1952–53	–	–	17	12	24	24	–	–	–	–	–	–	–	–	–	–	–	–	41	36
1953–54	–	–	–	–	95	48	45	24	–	–	–	–	–	–	–	–	–	–	140	72
1954–55	–	–	118	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	118	60
1955–56	90	72	11	36	20	72	35	72	81	162	2	18	–	–	–	–	13	18	252	450
1956–57	10	14	42	42	20	56	–	–	–	–	–	–	–	–	–	–	–	–	72	112
1957–58	–	–	6	14	128	140	–	–	–	–	–	–	–	–	–	–	–	–	134	154
1958–59	–	–	34	24	103	84	27	12	–	–	–	–	–	–	–	–	–	–	164	120
1959–60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1960–61	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1961–62	–	–	16	45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	45
1962–63	–	–	167	132	–	–	–	–	–	–	–	–	–	–	–	–	–	–	167	132
1963–64	2	11	112	121	35	33	–	–	–	–	–	–	–	–	–	–	–	–	149	165

Table 1 – *continued*

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
UK																				
1946–47	10	30	25	50	64	63	90	63	–	–	–	–	–	–	–	–	–	–	189	206
1947–48	–	–	32	60	82	135	63	149	50	47	–	–	–	–	–	–	–	–	227	391
1948–49	–	–	77	121	393	385	92	163	–	–	–	–	–	–	–	–	–	–	562	669
1949–50	–	–	196	234	266	153	26	34	45	68	–	–	–	–	–	–	–	–	533	489
1950–51	–	–	364	355	72	80	72	76	90	105	80	108	101	180	–	–	–	–	779	904
1951–52	–	–	547	655	121	251	36	99	102	135	184	222	96	192	–	–	–	–	1,086	1,554
1952–53	–	–	216	337	355	302	161	126	76	92	–	–	–	–	24	98	10	42	842	997
1953–54	–	–	366	325	339	250	10	28	–	–	–	–	–	–	–	–	–	–	715	603
1954–55	–	–	121	234	593	358	187	144	31	56	–	–	–	–	–	–	–	–	932	792
1955–56	26	84	150	210	341	400	186	144	–	–	–	–	–	–	–	–	312	406	1,015	1,238
1956–57	7	35	141	168	–	–	–	–	–	–	–	–	–	–	55	66	169	205	372	474
1957–58	1	13	69	192	256	144	69	72	9	12	–	–	–	–	74	104	89	260	567	797
1958–59	26	48	165	240	138	144	126	168	81	84	–	–	–	–	–	–	–	–	536	684
1959–60	28	66	43	64	–	–	–	–	–	–	–	–	–	–	–	–	32	55	103	185
1960–61	24	33	27	55	–	–	–	–	–	–	–	–	–	–	–	–	4	22	55	110
1961–62	2	22	51	77	7	11	–	–	–	–	–	–	–	–	–	–	–	–	60	84
1962–63	3	9	91	54	–	–	–	–	–	–	–	–	–	–	–	–	–	–	94	63
USSR																				
1948–49	–	–	16	108	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	108
1949–50	–	–	30	112	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	112
1950–51	–	–	40	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	40	150
1951–52	–	–	136	555	–	–	–	–	–	–	–	–	–	–	–	–	–	–	136	555
1952–53	–	–	56	390	24	150	–	–	–	–	–	–	–	–	–	–	–	–	80	540
1953–54	79	315	104	420	–	–	–	–	–	–	–	–	–	–	–	–	–	–	183	735
1954–55	54	195	147	660	–	–	–	–	–	–	–	–	–	–	–	–	–	–	201	855
1955–56	9	60	219	735	–	–	–	–	–	–	–	–	–	–	–	–	–	–	228	795
1956–57	90	360	17	72	–	–	–	–	–	–	–	–	–	–	–	–	17	32	107	432
1957–58	72	192	347	552	15	24	–	–	–	–	7	48	40	48	–	–	–	–	481	864
1958–59			174	312	239	336	108	192	–	–	–	–	–	–	–	–	10	24	531	864
1959–60	54	54	47	154	75	168	33	134	140	206	491	740	–	–	–	–	–	–	840	1,456
1960–61	93	234	108	394	118	384	50	140	71	188	79	216	300	522	–	–	16	36	835	2,114
1961–62	302	451	279	340	63	146	40	162	53	50	59	96	23	32	–	–	–	–	819	1,277
1962–63	405	574	62	95	62	149	–	–	19	38	24	114	5	38	48	152	60	114	685	1,274
1963–64	–	–	79	105	318	387	227	435	141	85	648	483	–	–	–	–	–	–	1,413	1,495
1964–65	40	42	–	–	34	119	199	238	58	34	524	297	132	84	–	–	150	147	1,137	961
1965–66	53	80	76	225	–	–	–	–	–	–	9	19	905	505	21	80	11	20	1,075	929
1966–67	102	100	38	60	11	30	16	19	–	–	161	260	712	620	–	–	–	–	1,047	1,091
1967–68	–	–	86	104	–	–	–	–	–	–	257	342	611	594	–	–	–	–	952	1,040
1968–69	–	–	–	–	16	36	–	–	–	–	187	340	860	680	9	17	–	–	1,072	1,073
1969–70	–	–	9	17	83	119	3	17	–	–	235	150	435	289	9	17	–	–	765	592
1970–71	33	24	–	–	–	–	–	–	–	–	12	17	510	425	–	–	–	–	555	466
1971–72	109	143	–	–	–	–	–	–	–	–	–	–	149	136	–	–	–	–	258	279
1972–73	176	99	–	–	78	93	21	31	–	–	–	–	72	102	–	–	–	–	347	325
1973–74	336	294	4	52	15	34	1	34	–	–	216	238	1,025	918	457	408	–	–	2,054	1,978
1974–75	79	101	–	–	–	–	–	–	–	–	76	105	330	320	146	153	1	15	632	694

Table 2

Antarctic pelagic catches of *female* sperm whales outside the baleen whale season and net catcher days worked, by nation and division.

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
JAPAN																				
1970–71	–	–	–	–	–	–	–	–	0	26	20	104	–	–	–	–	–	–	20	130
1971–72	–	–	–	–	–	–	–	–	–	–	62	70	–	–	–	–	–	–	62	70
1972–73	–	–	–	–	–	–	–	–	0	54	28	54	–	–	–	–	–	–	28	108
1973–74	–	–	–	–	–	–	–	–	–	–	0	9	–	–	–	–	–	–	0	9
1974–75	–	–	–	–	–	–	–	–	–	–	21	21	–	–	–	–	–	–	21	21
USSR																				
1970–71	13	24	–	–	–	–	–	–	–	–	4	17	55	425	–	–	–	–	72	466
1971–72	22	143	–	–	–	–	–	–	–	–	–	–	8	136	–	–	–	–	30	279
1972–73	42	99	–	–	0	93	0	31	–	–	–	–	0	102	–	–	–	–	42	325
1973–74	118	294	0	52	0	34	0	34	–	–	71	238	383	918	134	408	–	–	706	1,978
1974–75	0	101	–	–	–	–	–	–	–	–	136	114	141	320	9	153	0	15	286	703

Table 3

Pelagic catches of *male* sperm whales north of 40°S in the southern hemisphere and net catcher days, by nation and division.

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
									JAPAN											
1962–63	–	–	–	–	–	–	147	218	8	22	60	66	–	–	–	–	–	–	215	306
1963–64	–	–	–	–	–	–	655	476	9	11	80	100	301	270	–	–	–	–	1,045	857
1964–65	–	–	–	–	40	95	346	384	16	11	–	–	625	420	14	10	–	–	1,041	920
1965–66	–	–	–	–	55	84	134	84	–	–	–	–	–	–	–	–	–	–	189	168
1966–67	–	–	–	–	46	84	36	48	–	–	–	–	–	–	–	–	–	–	82	132
1967–68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1968–69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969–70	–	–	44	60	122	108	43	84	–	–	–	–	–	–	–	–	–	–	209	252
1970–71	–	–	–	–	–	–	118	168	131	197	30	26	213	195	–	–	–	–	492	586
1971–72	–	–	–	–	–	–	–	–	212	213	68	40	75	90	–	–	–	–	355	343
1972–73	–	–	–	–	–	–	–	–	–	–	217	135	131	108	–	–	–	–	348	243
1973–74	–	–	–	–	–	–	–	–	–	–	–	–	130	113	–	–	–	–	130	113
1974–75	–	–	–	–	–	–	157	88	–	–	59	18	115	113	–	–	–	–	331	219
									USSR											
1962–63	–	–	240	420	7	51	–	–	1	19	–	–	–	–	–	–	–	–	248	490
1963–64	–	–	143	120	286	554	65	161	–	–	–	–	–	–	–	–	–	–	494	835
1964–65	–	–	22	68	195	412	672	751	931	1,188	173	169	228	168	42	84	28	63	2,275	2,903
1965–66	53	60	30	75	130	120	78	140	751	1,288	42	40	–	–	–	–	–	–	1,084	1,723
1966–67	–	–	229	555	–	–	471	820	252	520	–	–	29	60	–	–	–	–	981	1,955
1967–68	24	52	319	485	267	360	451	666	106	216	–	–	9	54	–	–	–	–	1,176	1,833
1968–69	–	–	612	942	324	487	124	187	17	17	–	–	–	–	–	–	–	–	1,077	1,633
1969–70	–	–	822	983	288	405	247	356	241	358	36	70	60	102	–	–	–	–	1,694	2,274
1970–71	–	–	843	937	373	272	433	629	88	119	18	34	133	136	–	–	–	–	1,888	2,127
1971–72	403	481	740	663	932	1,190	131	153	79	102	6	17	452	408	–	–	–	–	2,743	3,014
1972–73	643	611	105	345	265	219	106	119	–	–	–	–	77	340	–	–	–	–	1,196	1,634
1973–74	563	636	12	34	148	75	123	90	338	327	86	170	73	187	–	–	–	–	1,343	1,519
1974–75	997	1,336	8	26	109	75	23	30	164	169	14	62	51	187	186	160	345	346	1,897	2,391

Table 4

Pelagic catches of *female* sperm whales north of 40°S in the southern hemisphere and net catcher days, by nation and division.

	1		2		3		4		5		6		7		8		9		Total	
Divn	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD	No.	NCD
									JAPAN											
1962–63	–	–	–	–	–	–	185	218	21	22	104	66	–	–	–	–	–	–	310	306
1963–64	–	–	–	–	–	–	908	476	37	11	83	100	754	270	–	–	–	–	1,782	857
1964–65	–	–	–	–	61	95	550	384	0	11	–	–	1,120	420	18	10	–	–	1,749	920
1965–66	–	–	–	–	1	84	4	84	–	–	–	–	–	–	–	–	–	–	5	168
1966–67	–	–	–	–	15	84	4	48	–	–	–	–	–	–	–	–	–	–	19	132
1967–68	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1968–69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969–70	–	–	0	60	93	108	44	84	–	–	–	–	–	–	–	–	–	–	137	252
1970–71	–	–	–	–	–	–	298	168	36	197	23	26	264	195	–	–	–	–	621	586
1971–72	–	–	–	–	–	–	–	–	214	213	70	40	221	90	–	–	–	–	505	343
1972–73	–	–	–	–	–	–	–	–	–	–	215	135	148	108	–	–	–	–	363	243
1973–74	–	–	–	–	–	–	–	–	–	–	–	–	240	113	–	–	–	–	240	113
1974–75	–	–	–	–	–	–	243	88	–	–	20	18	173	113	–	–	–	–	436	219
									USSR											
1962–63	–	–	10	420	1	51	–	–	2	19	–	–	–	–	–	–	–	–	13	490
1963–64	–	–	0	120	13	554	1	161	–	–	–	–	–	–	–	–	–	–	14	835
1964–65	–	–	1	68	25	412	12	751	20	1,188	1	169	0	168	0	84	0	63	59	2,903
1965–66	3	60	0	75	25	120	13	140	181	1,288	26	40	–	–	–	–	–	–	248	1,723
1966–67	–	–	38	555	–	–	43	820	42	520	–	–	7	60	–	–	–	–	130	1,955
1967–68	7	52	25	485	33	360	19	666	18	216	–	–	0	54	–	–	–	–	102	1,833
1968–69	–	–	61	942	14	487	22	187	6	17	–	–	–	–	–	–	–	–	103	1,633
1969–70	–	–	85	983	40	405	28	356	24	358	15	70	55	102	–	–	–	–	247	2,274
1970–71	–	–	53	937	19	272	23	629	7	119	3	34	47	136	–	–	–	–	152	2,127
1971–72	52	481	82	663	90	1,190	27	153	6	102	2	17	77	408	–	–	–	–	336	3,014
1972–73	692	611	848	345	129	219	22	119	–	–	–	–	942	340	–	–	–	–	2,633	1,634
1973–74	684	636	0	34	22	75	11	90	43	327	431	170	485	87	–	–	–	–	1,676	1,519
1974–75	1,258	1,336	27	26	0	75	0	30	39	169	76	62	583	187	53	160	68	346	2,104	2,391

Table 5

Antarctic pelagic catches of *male* sperm whales per net catcher day worked outside the baleen whaling season, by nation and division. ( ) less than 100 NCD.

Divn	1	2	3	4	5	6	7	8	9
JAPAN									
1946–47	–	–	–	–	–	–	–	–	–
1947–48	–	–	–	–	–	(0.333)	–	–	–
1948–49	–	–	–	–	–	–	–	–	–
1949–50	–	–	–	–	(1.146)	0.975	–	–	–
1950–51	–	–	–	–	1.069	(1.020)	–	–	–
1951–52	–	–	–	0.917	0.759	1.028	1.032	0.523	–
1952–53	–	–	–	–	–	(1.222)	0.581	(0.267)	–
1953–54	–	–	–	–	1.114	0.990	0.699	1.200	–
1954–55	–	–	–	–	1.305	1.255	0.877	0.710	–
1955–56	–	–	–	(0.900)	1.342	1.036	0.971	0.969	–
1956–57	–	–	–	–	1.151	1.012	1.210	0.632	0.648
1957–58	–	–	–	1.378	1.341	0.906	0.973	0.988	–
1958–59	–	–	(0.667)	0.754	1.223	0.958	1.100	1.365	–
1959–60	–	–	–	1.018	1.102	0.935	0.588	(1.048)	–
1960–61	–	–	0.833	0.751	1.004	1.162	1.093	–	–
1961–62	–	–	1.175	0.711	0.713	0.772	(0.205)	–	–
1962–63	–	(0.306)	0.852	0.856	(0.597)	1.348	–	–	–
1963–64	–	(1.455)	0.855	2.159	1.782	(1.700)	(3.300)	–	–
1964–65	–	(0.108)	0.806	(3.111)	–	–	–	(0.386)	(0.300)
1965–66	(0.929)	(0.382)	0.969	(1.346)	–	–	–	–	–
1966–67	–	(0.583)	1.396	(2.750)	–	–	–	–	–
1967–68	–	–	–	(0.306)	(0.556)	–	–	–	–
1968–69	–	–	–	–	–	–	–	–	–
1969–70	(0.417)	–	–	–	(0.333)	–	–	–	–
1970–71	–	–	–	–	(0.500)	1.346	–	–	–
1971–72	–	–	–	–	–	(0.914)	–	–	–
1972–73	–	–	–	–	(0.204)	(1.481)	–	–	–
1973–74	–	–	–	–	–	(3.333)	–	–	–
1974–75	–	–	–	–	–	(1.714)	–	–	–
NETHERLANDS									
1946–47	–	–	–	–	–	–	–	–	–
1947–48	–	0.493	–	–	–	–	–	–	–
1948–49	–	(0.100)	0.538	–	–	–	–	–	–
1949–50	–	(0.838)	(0.182)	–	–	–	–	–	–
1950–51	–	1.122	(0.833)	–	–	–	–	–	–
1951–52	–	(0.333)	1.092	(0.905)	–	–	–	–	–
1952–53	–	(1.417)	(1.000)	–	–	–	–	–	–
1953–54	–	–	(1.979)	(1.875)	–	–	–	–	–
1954–55	–	(1.967)	–	–	–	–	–	–	–
1955–56	(1.250)	(0.306)	(0.278)	(0.486)	0.500	(0.111)	–	–	(0.722)
1956–57	(0.714)	(1.000)	(0.357)	–	–	–	–	–	–
1957–58	–	(0.429)	0.914	–	–	–	–	–	–
1958–59	–	1.417	(1.226)	(2.250)	–	–	–	–	–
1959–60	–	–	–	–	–	–	–	–	–
1960–61	–	–	–	–	–	–	–	–	–
1961–62	–	(0.356)	–	–	–	–	–	–	–
1962–63	–	1.265	–	–	–	–	–	–	–
1963–64	(0.182)	0.926	(1.061)	–	–	–	–	–	–
NORWAY									
1946–47	–	(0.500)	0.820	0.803	(0.819)	–	–	–	–
1947–48	–	0.514	0.453	0.413	(0.467)	–	–	–	–
1948–49	–	0.730	0.704	0.546	0.862	(0.463)	0.727	(0.600)	–
1949–50	(0.143)	1.203	0.697	0.743	0.522	–	–	–	–
1950–51	(0.650)	0.641	0.731	0.485	0.787	0.871	0.461	–	–
1951–52	0.397	0.550	0.826	0.703	0.508	1.073	0.841	–	(0.071)
1952–53	(0.118)	0.581	0.675	(0.179)	–	–	–	–	–
1953–54	–	0.866	0.433	(1.778)	(1.167)	–	–	–	–
1954–55	(0.436)	1.081	1.104	1.130	1.278	–	–	–	–
1955–56	(0.129)	0.872	0.709	0.676	1.564	1.768	0.972	–	–
1956–57	(0.758)	0.801	1.161	(0.667)	–	–	–	–	0.586
1957–58	(0.480)	1.025	1.344	1.156	(0.604)	–	–	–	–
1958–59	(0.200)	0.868	1.051	1.106	0.731	–	–	–	–
1959–60	(0.636)	0.793	1.368	–	–	–	–	–	1.088
1960–61	(0.926)	0.735	0.843	(0.273)	(0.636)	–	–	–	0.796
1961–62	–	0.954	0.894	–	–	–	–	–	(0.926)
1962–63	–	1.334	0.511	–	–	–	–	–	–
1963–64	(0.640)	1.008	–	–	–	–	–	–	–
1964–65	(2.700)	0.822	–	–	–	–	–	–	–
1965–66	(0.660)	1.159	–	–	–	–	–	–	–
1966–67	(1.969)	1.189	–	–	–	–	–	–	–
1967–68	–	(0.800)	–	–	–	–	–	–	–

Table 5 – *continued*

Divn	1	2	3	4	5	6	7	8	9
SOUTH AFRICA									
1946–47	–	–	(0.167)	0.333	(0.167)	–	–	–	–
1947–48	–	–	0.632	0.397	(0.583)	–	–	–	–
1948–49	–	–	0.712	1.121	–	–	–	–	–
1949–50	–	–	1.013	–	–	–	–	–	–
1950–51	–	–	0.685	(0.311)	–	–	–	–	–
1951–52	–	0.606	0.595	–	–	–	–	–	–
1952–53	–	0.513	(0.813)	–	–	–	–	–	–
1953–54	–	(1.015)	(0.692)	–	–	–	–	–	–
1954–55	–	(0.523)	1.657	–	–	–	–	–	–
1955–56	–	–	0.982	(0.689)	–	–	–	–	–
1956–57	(0.433)	(0.775)	–	–	–	–	–	–	–
UK									
1946–47	(0.333)	(0.500)	(1.016)	(1.429)	–	–	–	–	–
1947–48	–	(0.533)	0.607	0.423	(1.064)	–	–	–	–
1948–49	–	0.636	1.021	0.564	–	–	–	–	–
1949–50	–	0.838	1.739	(0.765)	(0.662)	–	–	–	–
1950–51	–	1.025	(0.900)	(0.947)	0.857	0.741	0.561	–	–
1951–52	–	0.835	0.482	(0.364)	0.756	0.829	0.500	–	–
1952–53	–	0.641	1.175	1.278	(0.826)	–	–	(0.245)	(0.238)
1953–54	–	1.126	1.356	(0.357)	–	–	–	–	–
1954–55	–	0.517	1.656	1.299	(0.554)	–	–	–	–
1955–56	(0.310)	0.714	0.853	1.292	–	–	–	–	0.780
1956–57	(0.200)	0.839	–	–	–	–	–	(0.833)	0.824
1957–58	(0.077)	0.359	1.778	(0.958)	(0.750)	–	–	0.712	0.342
1958–59	(0.542)	0.688	0.958	0.750	(0.964)	–	–	–	–
1959–60	(0.424)	(0.672)	–	–	–	–	–	–	(0.582)
1960–61	(0.727)	(0.491)	–	–	–	–	–	–	(0.182)
1961–62	(0.091)	(0.662)	(0.636)	–	–	–	–	–	–
1962–63	(0.333)	(1.685)	–	–	–	–	–	–	–
USSR									
1946–47	–	–	–	–	–	–	–	–	–
1947–48	–	–	–	–	–	–	–	–	–
1948–49	–	0.148	–	–	–	–	–	–	–
1949–50	–	0.268	–	–	–	–	–	–	–
1950–51	–	0.267	–	–	–	–	–	–	–
1951–52	–	0.245	–	–	–	–	–	–	–
1952–53	–	0.144	0.160	–	–	–	–	–	–
1953–54	0.251	0.248	–	–	–	–	–	–	–
1954–55	0.277	0.223	–	–	–	–	–	–	–
1955–56	(0.150)	0.298	–	–	–	–	–	–	–
1956–57	0.250	(0.236)	–	–	–	–	–	–	(0.531)
1957–58	0.375	0.629	(0.625)	–	–	(0.146)	(0.833)	–	–
1958–59	–	0.558	0.711	0.563	–	–	–	–	(0.417)
1959–60	(1.000)	0.305	0.446	0.246	0.680	0.664	–	–	–
1960–61	0.397	0.274	0.307	0.357	0.378	0.366	0.575	–	(0.444)
1961–62	0.670	0.821	0.432	0.247	(1.060)	(0.615)	(0.719)	–	–
1962–63	0.706	(0.653)	0.416	–	(0.500)	0.211	(0.132)	0.316	0.526
1963–64	–	0.752	0.822	0.522	(1.659)	1.342	–	–	–
1964–65	(0.952)	–	0.286	0.836	(1.706)	1.764	(1.571)	–	1.020
1965–66	(0.663)	0.338	–	–	–	(0.474)	1.792	(0.263)	(0.550)
1966–67	1.020	(0.633)	(0.367)	(0.842)	–	0.619	1.148	–	–
1967–68	–	0.827	–	–	–	0.751	1.029	–	–
1968–69	–	–	(0.444)	–	–	0.550	1.265	(0.529)	–
1969–70	–	(0.529)	0.697	(0.176)	–	1.567	1.505	(1.118)	–
1970–71	(1.375)	–	–	–	–	(0.706)	1.200	–	–
1971–72	0.762	–	–	–	–	–	1.096	–	–
1972–73	(1.778)	–	(0.839)	(0.677)	–	–	0.706	–	–
1973–74	1.143	(0.077)	(0.441)	(0.029)	–	0.908	1.117	1.120	–
1974–75	0.782	–	–	–	–	0.711	1.031	0.954	(0.067)

Table 6

Pelagic catches of *male* sperm whales per net catcher day worked north of 40°S in the southern hemisphere, by nation and division. ( ) less than 100 NCD

Divn	1	2	3	4	5	6	7	8	9
JAPAN									
1962–63	–	–	–	0.674	(0.364)	(0.909)	–	–	–
1963–64	–	–	–	1.376	(0.818)	0.800	1.115	–	–
1964–65	–	–	(0.421)	0.901	(1.455)	–	1.488	(1.400)	–
1965–66	–	–	(0.655)	(1.595)	–	–	–	–	–
1966–67	–	–	(0.548)	(0.750)	–	–	–	–	–
1967–68	–	–	–	–	–	–	–	–	–
1968–69	–	–	–	–	–	–	–	–	–
1969–70	–	(0.733)	1.130	(0.512)	–	–	–	–	–
1970–71	–	–	–	0.702	0.665	(1.154)	1.092	–	–
1971–72	–	–	–	–	0.995	(1.417)	(0.833)	–	–
1972–73	–	–	–	–	–	1.607	1.213	–	–
1973–74	–	–	–	–	–	–	1.150	–	–
1974–75	–	–	–	(1.784)	–	(3.278)	1.018	–	–
USSR									
1962–63	–	0.571	(0.137)	–	(0.053)	–	–	–	–
1963–64	–	1.192	0.516	0.404	–	–	–	–	–
1964–65	–	(0.324)	0.473	0.895	0.784	1.024	1.357	(0.500)	(0.444)
1965–66	(0.883)	(0.400)	1.083	0.557	0.583	(1.050)	–	–	–
1966–67	–	0.413	–	0.574	0.485	–	(0.167)	–	–
1967–68	(0.462)	0.658	0.742	0.677	0.491	–	–	–	–
1968–69	–	0.650	0.665	0.663	(1.000)	–	–	–	–
1969–70	–	0.836	0.711	0.694	0.673	(0.514)	0.588	–	–
1970–71	–	0.900	1.371	0.688	0.739	(0.529)	0.978	–	–
1971–72	0.838	1.116	0.783	0.856	0.775	(0.353)	1.108	–	–
1972–73	1.052	0.304	1.210	0.891	–	–	0.226	–	–
1973–74	0.885	(0.353)	(1.973)	(1.367)	1.034	0.506	0.390	–	–
1974–75	0.746	(0.308)	(1.453)	(0.767)	0.970	0.468	0.273	1.163	0.997

Table 7

Pelagic catches of *female* sperm whales per net catcher day worked north of 40°S in the southern hemisphere, by nation and division. ( ) less than 100 NCD.

Divn	1	2	3	4	5	6	7	8	9
JAPAN									
1962–63	–	–	–	0.849	(0.955)	(1.576)	–	–	–
1963–64	–	–	–	1.908	(3.364)	0.830	2.793	–	–
1964–65	–	–	(0.642)	1.432	(–)	–	2.667	(1.800)	–
1965–66	–	–	(0.012)	(0.048)	–	–	–	–	–
1966–67	–	–	(0.179)	(0.083)	–	–	–	–	–
1967–68	–	–	–	–	–	–	–	–	–
1968–69	–	–	–	–	–	–	–	–	–
1969–70	–	(–)	0.861	(0.524)	–	–	–	–	–
1970–71	–	–	–	1.774	0.183	(0.885)	1.354	–	–
1971–72	–	–	–	–	1.005	(1.750)	(2.456)	–	–
1972–73	–	–	–	–	–	1.593	1.370	–	–
1973–74	–	–	–	–	–	–	2.124	–	–
1974–75	–	–	–	(2.761)	–	(1.111)	1.531	–	–
USSR									
1962–63	–	0.024	(0.020)	–	(0.105)	–	–	–	–
1963–64	–	(–)	0.023	0.006	–	–	–	–	–
1964–65	–	(0.015)	0.061	0.016	0.017	0.006	(–)	(–)	(–)
1965–66	(0.050)	(–)	0.208	0.093	0.141	(0.650)	–	–	–
1966–67	–	0.068	–	0.052	0.081	–	(0.117)	–	–
1967–68	(0.135)	0.052	0.092	0.029	0.083	–	(–)	–	–
1968–69	–	0.065	0.029	0.118	(0.353)	–	–	–	–
1969–70	–	0.086	0.099	0.079	0.067	(0.214)	0.539	–	–
1970–71	–	0.057	0.070	0.037	0.059	(0.088)	0.346	–	–
1971–72	0.108	0.124	0.076	0.176	0.059	(0.118)	0.189	–	–
1972–73	1.133	2.458	0.589	0.185	–	–	2.771	–	–
1973–74	1.075	(–)	(0.293)	(0.122)	0.131	2.535	2.594	–	–
1974–75	0.942	(1.038)	(–)	(–)	0.231	(1.226)	3.118	0.331	0.197

Further Analyses of Tonnage Corrected Catch Per Unit Effort Data for Male Sperm Whales in the Southern Hemisphere

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INTRODUCTION

For the purposes of assessment and management, the sperm whales in the Southern Hemisphere have been divided into nine longitudinal Divisions which are thought to approximate to stock units (IWC, 1973). In an earlier study (Gambell, 1976), the catch and effort data relating to the operations of all the pelagic whaling fleets combined were analysed. Additional information has now been obtained from the Bureau of International Whaling Statistics which allows the catch per unit effort trends of each nation to be distinguished.

METHOD

Male sperm whales have formed the main part of the pelagic fishery for this species. The catches in the Antarctic since 1946–47 and in the temperate zone north of 40°S since 1962–63 have been tabulated together with the catching effort. The effort is expressed in terms of net catcher days worked, which are defined as the number of days with a catch of sperm whales times the number of catchers in the fleet concerned. This measure of effort is by no means the most desirable one to use, but is the only statistic available other than the gross number of days of operation. It is not clear how well net catcher days reflect changes in sperm whale abundance, but short of complete information on the activities of each individual catching vessel, it seems the best unit of effort to use at present even though it may underestimate the true effort expended.

A tonnage correction has been applied to correct for the increases in size and efficiency of the catchers which have occurred over the years (Table 1). Baleen whale catching power in the Antarctic (Hylen, 1964) and sperm whale catching power at Durban (Gambell, 1975) have both been shown to be proportional to catcher tonnage, and it has been assumed therefore that a similar tonnage factor can be applied directly in the pelagic sperm whale fishery as well. The catch per net catcher day is thus divided by the average tonnage of the catchers of each nation concerned, to give the catch per catcher ton day.

Asdic equipment is used for tracking sperm whales underwater by the Japanese catchers. Because information

Table 1

Average gross tonnage of whale catchers operating with pelagic fleets in the Southern Hemisphere.

Season	Norway	S. Africa	UK	Japan	USSR	Netherlands	Panama	Total
1945–46	307	339	323	–	–	–	–	316
1946–47	318	288	365	327	326	316	–	328
1947–48	339	325	384	349	326	321	–	347
1948–49	382	397	462	344	400	401	–	399
1949–50	414	442	496	340	387	400	–	424
1950–51	438	448	498	356	381	464	700	454
1951–52	462	484	503	383	376	499	687	473
1952–53	499	484	512	393	376	532	692	494
1953–54	511	535	540	416	375	532	–	498
1954–55	522	535	527	422	375	531	691	511
1955–56	517	510	515	451	375	594	690	513
1956–57	549	637	530	535	437	666	–	545
1957–58	563	–	533	587	551	662	–	570
1958–59	565	–	533	597	779	718	–	599
1959–60	600	–	544	600	804	712	–	633
1960–61	585	–	548	603	816	709	–	642
1961–62	592	–	550	602	821	706	–	657
1962–63	688	–	654	609	823	701	–	703
1963–64	687	–	–	603	843	701	–	709
1964–65	681	–	–	615	843	–	–	715
1965–66	721	–	–	647	843	–	–	743
1966–67	718	–	–	667	843	–	–	757
1967–68	745	–	–	688	843	–	–	769
1968–69	–	–	–	710	843	–	–	783
1969–70	–	–	–	760	843	–	–	805
1970–71	–	–	–	803	843	–	–	824
1971–72	–	–	–	784	843	–	–	817
1972–73	–	–	–	817	843	–	–	833
1973–74	–	–	–	783	843	–	–	820
1974–75	–	–	–	731	843	–	–	801

is not yet available on the dates or rates of its introduction to the fleets, no correction can be applied at present, although it is known to have made a significant improvement to the catches at Durban (Best, 1973; Gambell, 1975).

Data records in which catches of other species beside sperm whales appear are excluded, because of the difficulty of separating the effort in a multi-species fishery. This means the exclusion of the catches during the Antarctic baleen whale season, and of overlapping catches of minke and sperm whales at other times.

RESULTS

The catches of male sperm whales per catcher ton day are plotted in the accompanying graphs for eight of the nine Divisions of the Southern Hemisphere for each nation which has more than 100 net catcher days effort recorded in at least four seasons. Insufficient pelagic data exist by these criteria to make a plot for Division 9.

Regressions have been calculated by the least squares method to test the significance of any trends indicated by the data. The regression coefficients are shown in Tables 2 and 3.

Table 2

Regression coefficients of national catches per catcher ton day (x10^{-4}) of male sperm whales in the Antarctic.

	Nation	Seasons	No.	Regression
Division 1 SW Atlantic	USSR	53/54–74/75	12	+ 0.026 ± 0.008*
Division 2 SE Atlantic	Netherlands	47/48–63/64	5	– 0.021 ± 0.032
	Norway	47/48–66/67	20	– 0.017 ± 0.015
	UK	48/49–58/59	11	– 0.061 ± 0.037
	USSR	48/49–67/68	16	+ 0.012 ± 0.011
Division 3 SW Indian	Japan	60/61–66/67	7	+ 0.041 ± 0.062
	Norway	46/47–62/63	17	– 0.020 ± 0.025
	S Africa	47/48–55/56	7	+ 0.068 ± 0.084
	UK	47/48–58/59	10	+ 0.031 ± 0.079
	USSR	52/53–69/70	9	+ 0.015 ± 0.019
Division 4 C Indian	Japan	51/52–63/64	8	– 0.011 ± 0.091
	Norway	46/47–58/59	10	+ 0.017 ± 0.038
	USSR	58/59–64/65	6	+ 0.058 ± 0.050
Division 5 SE Indian	Japan	50/51–63/64	12	– 0.065 ± 0.044
	Norway	48/49–58/59	7	+ 0.030 ± 0.088
Division 6 E Australia	Japan	49/50–70/71	13	– 0.067 ± 0.023*
	USSR	59/60–74/75	11	+ 0.019 ± 0.039
Division 7 N. Zealand	Japan	51/52–60/61	10	– 0.071 ± 0.049
	Norway	48/49–55/56	4	+ 0.029 ± 0.096
	USSR	60/61–74/75	11	+ 0.003 ± 0.032
Division 8 C Pacific	Japan	51/52–58/59	7	+ 0.011 ± 0.109

*Indicates significantly different from zero at 5% level of probability.

The results indicate a broad similarity between the density values recorded in the Antarctic and the temperate pelagic zones by fleets of the same nation. There are also some interesting differences between the catch per unit effort data for the various countries. In general, the Soviet density values tend to lie below those for the other countries which have operated pelagic fleets in the southern hemisphere. This feature accounts for a number of changes in the conclusions based on the analysis of the data for all nations combined (Gambell, 1976), and those which are now drawn from the present records.

Table 3

Regression coefficients of national catches per catcher ton day (x10^{-4}) of male sperm whales in the temperate zone of the Southern Hemisphere.

	Nation	Seasons	No.	Regression
Division 1 SW Atlantic	USSR	65/66–74/75	5	– 0.006 ± 0.021
Division 2 SE Atlantic	USSR	62/63–72/73	10	+ 0.006 ± 0.038
Division 3 SW Indian	USSR	63/64–72/73	9	+ 0.062 ± 0.034
Division 4 C Indian	Japan	62/63–70/71	4	– 0.092 ± 0.103
	USSR	63/64–72/73	10	+ 0.037 ± 0.018
Division 5 SE Indian	USSR	64/65–74/75	8	+ 0.048 ± 0.017*
Division 7 N. Zealand	Japan	63/64–74/75	6	– 0.069 ± 0.026*
	USSR	64/65–74/75	7	– 0.127 ± 0.043*

* Indicates significantly different from zero at 5% level of probability.

It should be noted that there may have been a greater increase in the catching efficiency of the Soviet fleets during the period considered, compared with the other nations, because of their lower starting level. Thus the tonnage correction applied may not be large enough in this case, producing positive regression trends which are significant in two Divisions.

Division 1, SW Atlantic, 60°–30°W

Only sufficient Soviet data are available to plot in this Division. The Antarctic records show a significant increase in density, but the temperate zone data indicate no trend.

Division 2, SE Atlantic, 30°W–20°E

The Antarctic records from four nations separately show no significant trends, although there was a decline apparent when they were considered in combination. The Soviet temperate zone data also show no trend.

Division 3, SW Indian, 20°–60°E

The plots for the five nations which have operated in the Antarctic and the single temperate zone record all show no significant trends. This is in accord with the independent Asdic and tonnage corrected catch records from Durban which are also shown. Neither the total catches of males per unit of effort nor of the larger males over 38 ft. in length show any trend in this land station operation (Gambell, 1976).

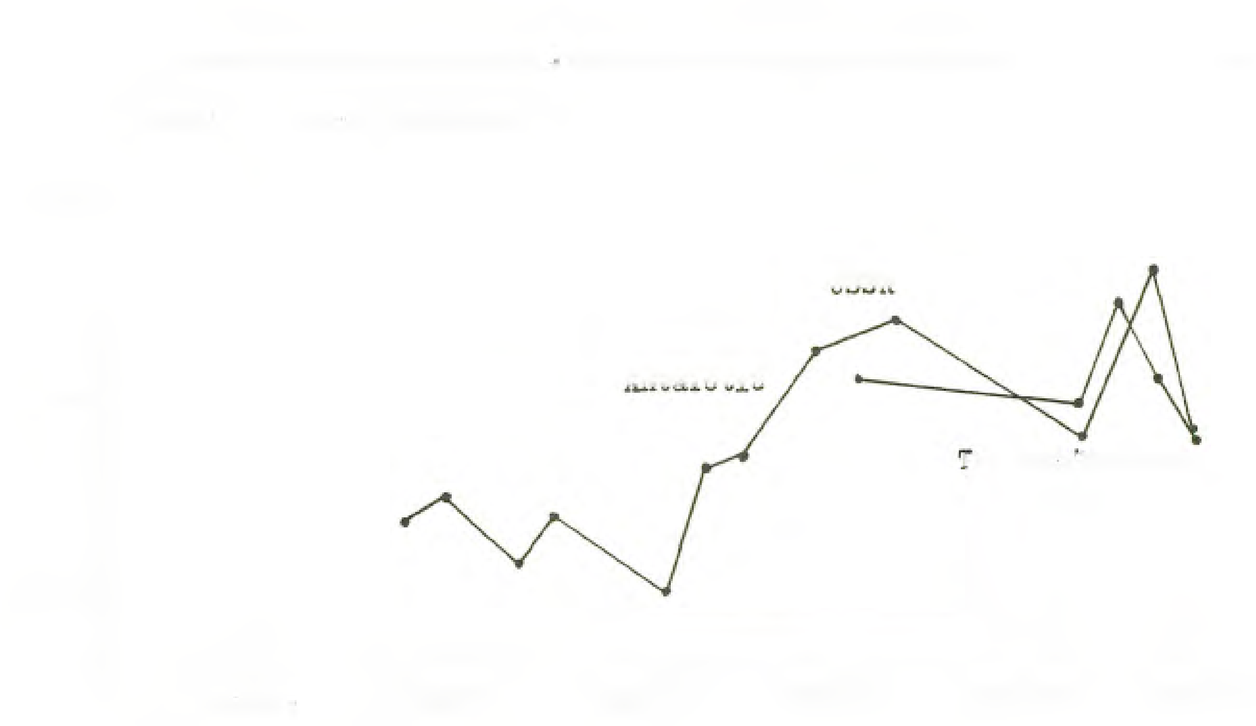
Division 4, Central Indian, 60°–90°E

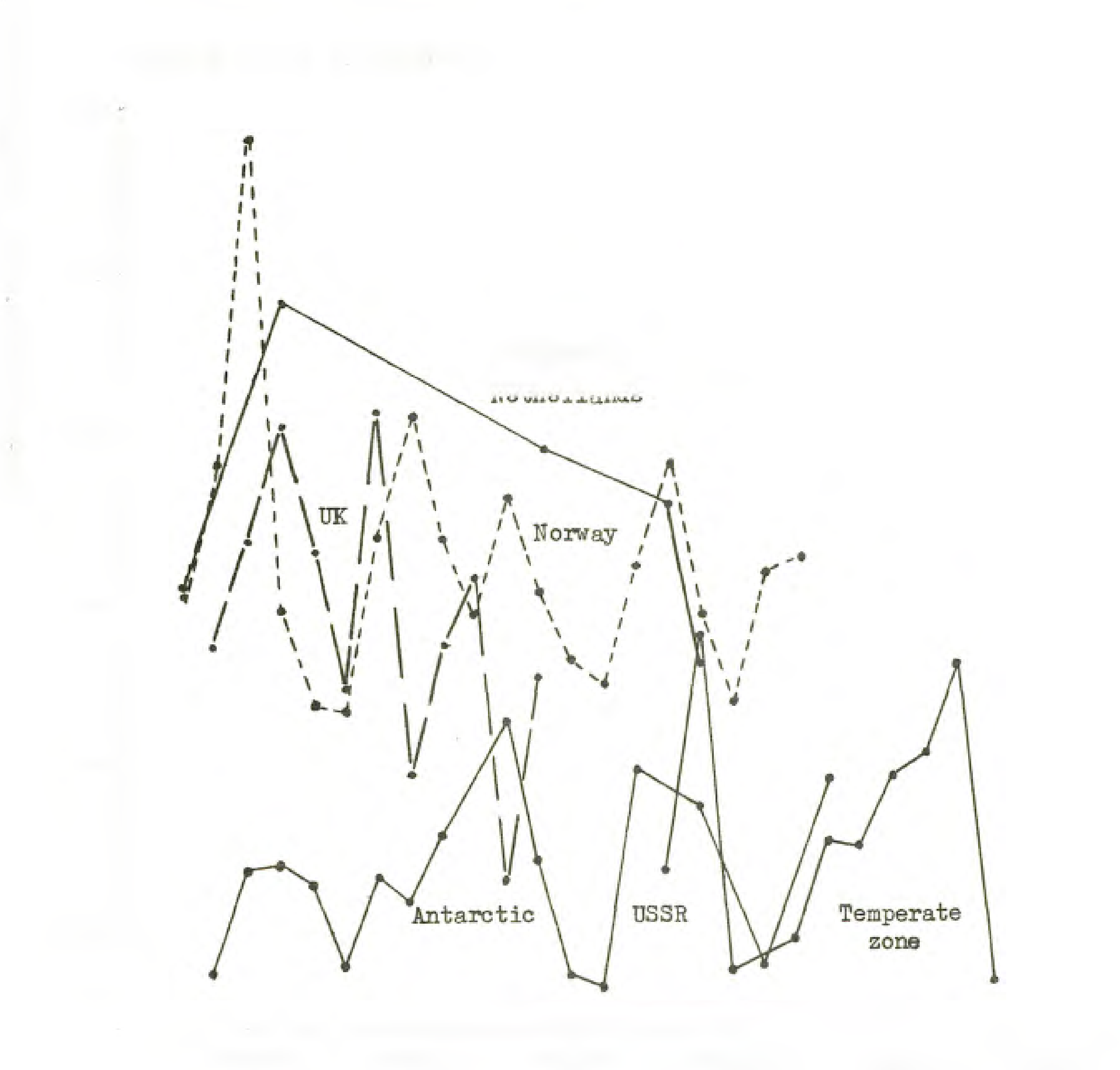
None of the three Antarctic or two temperate zone national series show any significant trends. This is in contrast to the earlier combined Antarctic data which suggested an apparent decline in abundance.

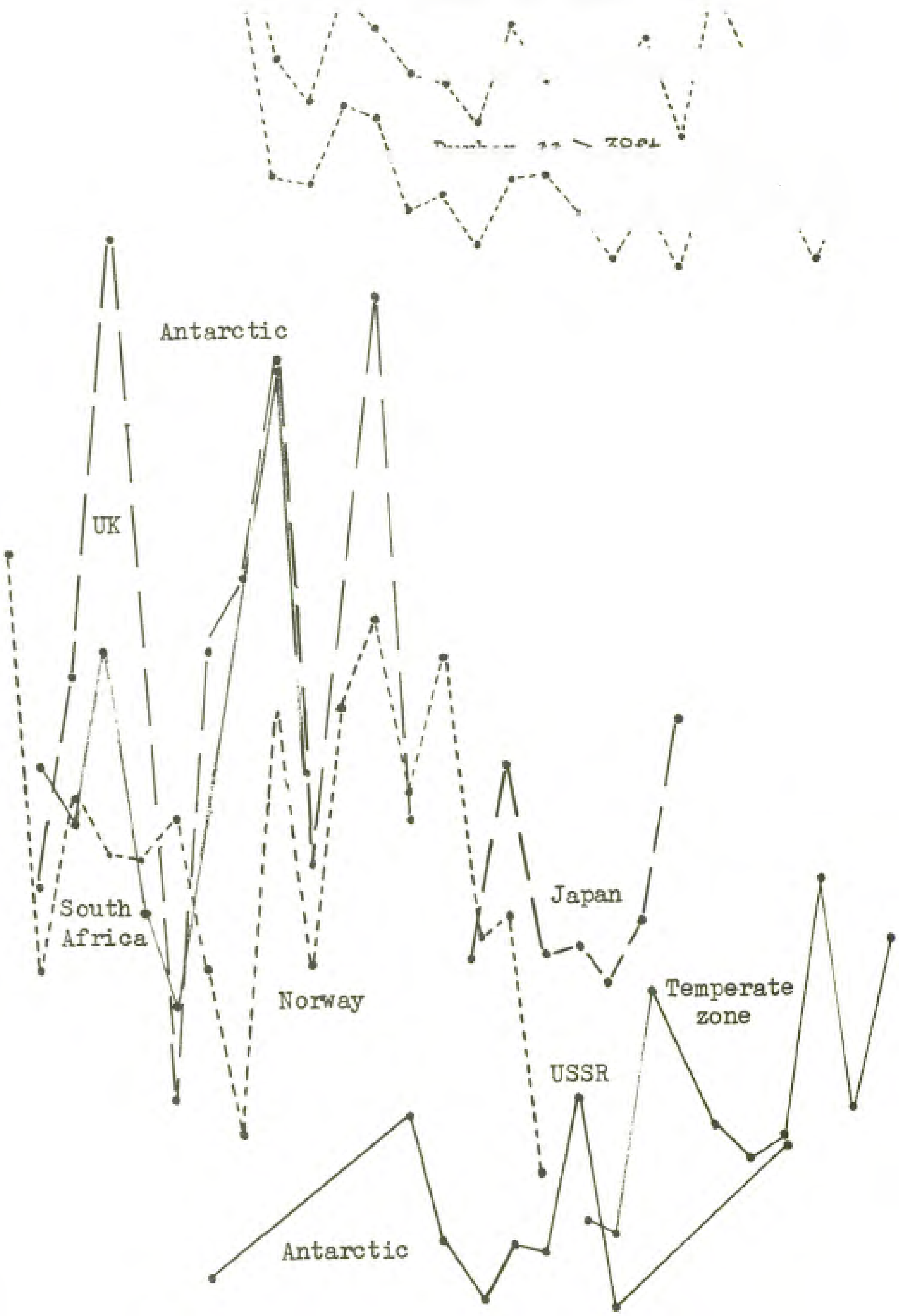
Division 5, SE Indian, 90°–130°E

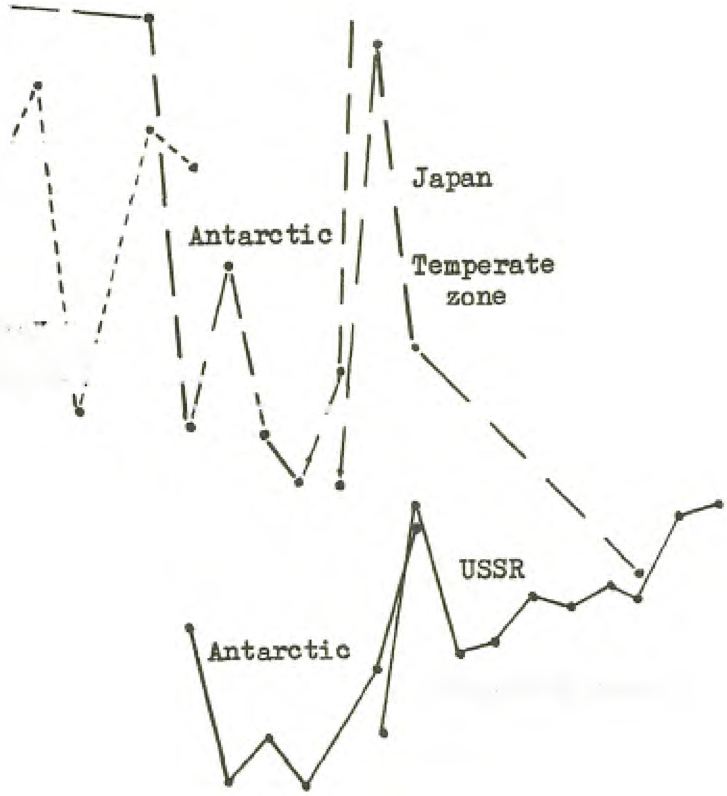
The Japanese and Norwegian Antarctic data show no significant trends up to the early 1960s. More recent Soviet temperate zone data, in spite of an initial decline, indicate an overall significant increase in abundance.

Independent aircraft sightings records from the land station operation off Western Australia (Bannister, 1975) also indicate a significant decline in the sighting index of




UK
Norway
Antarctic
USSR
Temperate
zone


Antarctic
UK
South Africa
Norway
Japan
Temperate zone
USSR
Antarctic



Japan
Antarctic
Temperate
zone
USSR
Antarctic

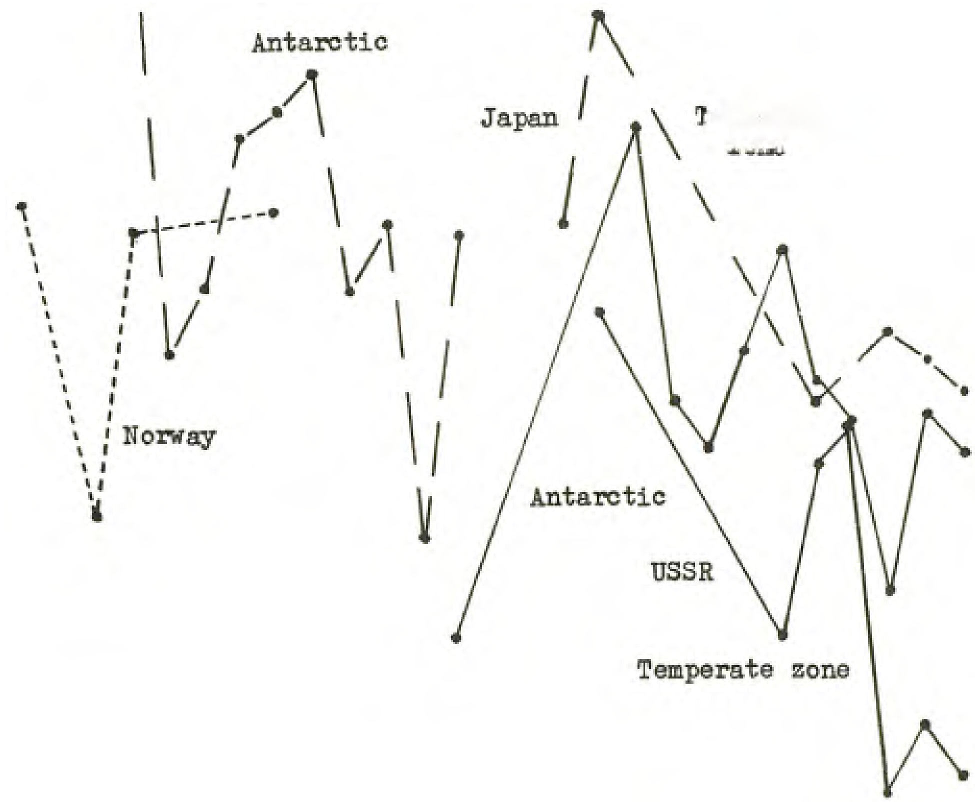

Antarctic
Japan
Norway
Antarctic
USSR
Temperate zone

Table 4

Total catches of male sperm whales in each Division of the Southern Hemisphere.

	Division									
Year*	1	2	3	4	5	6	7	8	9**	Total
1945–46	79	220	452	–	–	–	–	–	–	751
1946–47	184	174	736	413	214	4	–	–	3,023	4,748
1947–48	135	501	1,082	806	416	145	–	–	2,587	5,672
1948–49	364	980	1,928	412	313	258	346	34	416	5,051
1949–50	220	935	1,180	332	311	139	52	23	628	3,820
1950–51	373	1,200	1,826	378	980	469	458	52	5,940	11,676
1951–52	308	1,503	1,615	730	519	628	627	84	630	6,644
1952–53	258	925	1,014	241	108	79	147	31	1,027	3,830
1953–54	370	876	1,137	198	176	103	209	156	2,482	5,707
1954–55	172	1,497	2,514	675	587	277	240	157	1,245	7,364
1955–56	282	1,387	1,752	1,017	1,064	592	557	340	1,893	8,884
1956–57	356	1,514	1,159	140	443	170	559	433	3,049	7,823
1957–58	435	2,001	2,024	559	997	325	589	497	2,799	10,226
1958–59	320	1,637	1,694	930	812	299	396	639	2,954	9,681
1959–60	344	1,239	1,528	479	1,018	703	102	88	2,988	8,489
1960–61	560	1,623	1,433	364	1,005	373	697	41	2,758	8,854
1961–62	591	2,598	1,817	667	773	205	156	64	2,926	9,797
1962–63	732	1,967	1,871	591	1,027	670	164	154	2,663	9,839
1963–64	460	1,923	2,317	1,814	1,334	1,101	1,506	–	1,624	12,079
1964–65	1,182	1,193	1,651	1,457	2,009	1,517	1,013	83	885	10,990
1965–66	499	1,400	1,715	508	1,683	646	1,125	247	777	8,600
1966–67	304	1,117	1,748	1,053	1,143	301	1,755	432	518	8,371
1967–68	38	580	1,632	727	850	395	987	72	807	6,088
1968–69	1	791	1,456	565	940	257	927	234	878	6,049
1969–70	36	1,129	2,041	1,190	1,154	500	586	50	853	7,539
1970–71	525	991	1,850	894	1,088	210	1,439	58	784	7,839
1971–72	1,257	1,098	2,812	549	1,096	260	810	79	1,134	9,095
1972–73	1,161	349	2,118	525	1,022	575	772	338	1,014	7,874
1973–74	923	112	1,166	219	1,070	361	1,571	603	1,368	7,393
Average	430	1,154	1,630	658	[863]	413	[684]	192	[1,809]	7,613

*1945–46 Antarctic season + 1946 temperate zone season, etc.

**Assuming males comprised half of unsexed catch records from Chile and Peru.

DISCUSSION

More than 200,000 male sperm whales have been caught in the Southern Hemisphere during the last three decades, but this appears to have caused rather little change in the whale densities as measured by the national fleet catches per unit effort data presented here. In Divisions 1, 2, 3, 4 and 8 there are no significant reductions in abundance indicated. This suggests that the average catches in these Divisions, shown in Table 4, are no greater than the replacement yields of these stocks under the prevailing catching regimes.

In Division 5 the aircraft sightings from Western Australia suggest a decline in male sperm whale abundance in the early 1960s. This trend may have started earlier, if the Japanese Antarctic value for 1964–65 has been inflated by the use of Asdic equipment which was starting to be introduced about that time. However, the most recent sightings and catch data show no further decline, in spite of the fact that the average catches since 1961–62 of 1,163 males a year are about double the earlier average of 598 males a season.

The catch data from Division 6 also suggest a decline in abundance up to the early 1960s, which has since halted. Catches throughout the whole period show no uniform tendency to increase or decrease in number.

The increased catches in Division 7, which have risen to 1,135 males per season since 1963–64 compared with 353 in the preceeding years, have clearly reduced the stock abundance. This is the one Division of the Southern Hemisphere where the latest catch level indicated can be seen to be greater than the replacement yield of the stock.

No pelagic catch records are available for Division 9 by which to assess the current status of this stock. The total catch data in Table 4 clearly show the reduced level of the catching operations in this Division since 1964–65, with average catches of 850 males a year compared with 2,313 in the previous seasons. It is probable that the earlier level was greater than the stock could sustain.

CONCLUSIONS

The recent average catches of male sperm whales are not causing observable reductions of stock densities in the Southern Hemisphere, except in Division 7.

The addition of a correction factor for the introduction of Asdic to the Japanese fleets in the mid 1960s is not likely to modify this conclusion, because of the span of data concerned. A more important consideration is likely to be the effect of greatly increased catches of female sperm whales, particularly since 1972–73, on the sustainable yields of the male component of the stocks. Modification of the reproductive and social equilibria will take more years to detect by the method used in this analysis than are at present available for study.

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Age-Length Key of the Male Sperm Whale in the North Pacific and Comparison of Growth Curves

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The age-length key is one of the basic tables in the ecological study of animals. It is used for conversion of size distribution into age distribution as well as for drawing the growth curve.

The age of the sperm whale is determined by counting growth layers in the dentine of maxillary or mandibular teeth, and the rate of the layer formation has been considered to be annual by Ohsumi, Kasuya and Nishiwaki (1963), Best (1970) and Gambell (1972).

It is necessary to collect data of age and body length from as many whales as possible to make a good age-length key. The Whales Research Institute and the Far Seas Fisheries Research Laboratory have been collecting these data from the North Pacific since the 1950s.

The age-length key of the female sperm whale is not useful to convert size distribution into age distribution, for growth of females stops at 34–36 ft. of body length on average. The legal size limit was 35 ft. in coastal whaling and 38 ft. in pelagic whaling until 1972, and is now 30 ft. in both types of whaling, which are regulated by quota.

Therefore, the present paper deals with an age-length key of males only as a step to convert size distribution into age distribution for cohort analysis of the male sperm whale population in the North Pacific.

RAW AGE-LENGTH KEY

By use of 3,043 data on age which were estimated from counting growth layers in dentine of maxillary teeth and body length of the individual male sperm whales caught in the North Pacific, a raw age-length key was tabulated as shown in Table 1.

There is large apparent individual variation in this table. It is considered that there are many causes for the apparent variation. One of them is the mistake of counting layers, and the second is the mistake of labelling of the materials in collection or processing of the materials.

Then, it is necessary to refine it for making an ideal key.

REFINED AGE-LENGTH KEY

Smoothing is needed to refine a raw age-length key. As the first step in this, smoothing of size distribution at each age was examined.

It will be natural to consider that sizes of animals are distributed normally by the individual variation of body lengths of the animals, and the size distributions change gradually with ages.

Size distributions in all ages are drawn by use of Table 1. Fig. 1 shows an example of the figures. Smoothing the size distributions in each age was then carried out, considering the above conditions of ideal distribution. The examples are also shown in Fig. 1. Accordingly, a processed age-length key is obtained as shown in Table 2.

The next process of refinement of age-length key is smoothing of age distribution at each class of body lengths. Age distribution must be smooth and it changes gradually with change in body lengths in an ideal age-length key, though it is not distributed like a normal distribution in this case.

Processed age distributions in all size classes are drawn by use of Table 2. Fig. 2 shows an example of the figures. Under the above consideration, age distributions in each size class are smoothed as shown in Fig. 2. Thus, a refined age-length key is made as shown in Table 3.

Repetition of such processes will be useful to make a more ideal age-length key.

For the conversion of size distribution into age distribution, calculation of percentages of each age in each size class is needed, but the percentage figures are not presented in the present paper.

COMPARISON OF GROWTH CURVES

Several authors have drawn growth curves of the sperm whale. Here, I pick up three growth curves of the male sperm whale to compare with the present result. Berzin (1964) shows a growth curve based on counting dentinal growth layers. Although he considers the formation rate of the layers is bi-annual, I use the figures of relationship with number of dentinal layers and body lengths for comparison with other curves which are based on the annual formation rate of the layers. His materials come from the North Pacific. Best (1970) and Gambell (1972) also draw growth curves for the male sperm whale off South Africa based on dentinal growth layers.

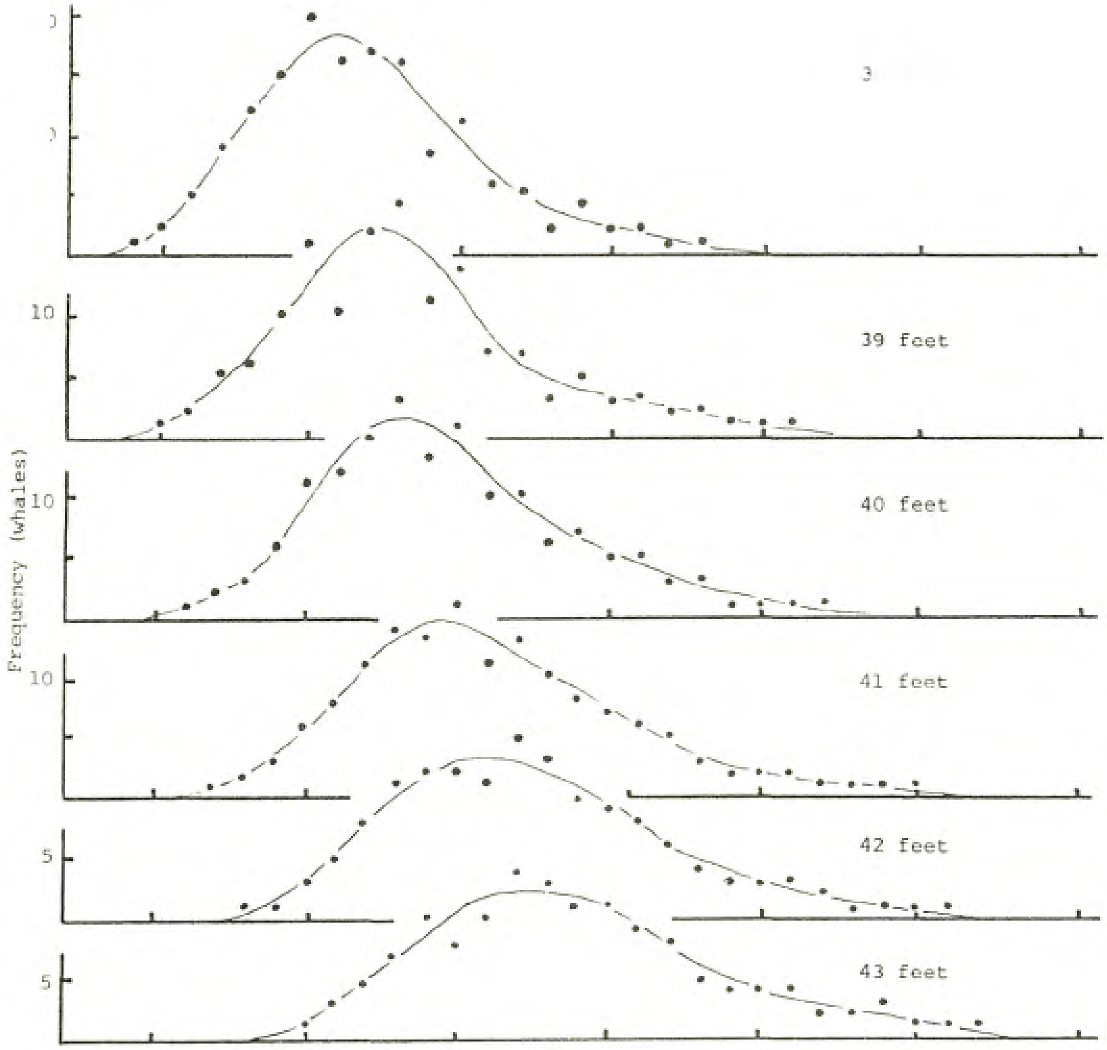
Calculating average body length in each age by use of the refined age-length key which was made in the previous section, a growth curve of the male sperm whale from the North Pacific is drawn as shown in Fig. 3. In this figure three growth curves by above authors are also shown.

In general, the four curves are similar to each other, but the present result coincides most with the curve by Gambell among the four curves.

According to the present result, the growth of the male sperm whale stops mostly at 50.0 ft. after 40 years of age on average. This is the same as the conclusion by Gambell, but the male may grow very slowly after the attainment of physical maturity, and attain to 50.5 ft. after 55 years of age. The mean maximum body lengths of the other two curves are 52 ft.

The accelerated growth which is shown typically in a curve by Best is recognized in the present result, and the inflection point is estimated at 37.5 ft and 16 years of age in the present result, whereas it is at about 38 ft. and 19 years in the curve by Best. According to him, this inflection point coincides with the attainment of puberty in the male.

From the comparison of four growth curves, it may be



3
39 feet
40 feet
41 feet
42 feet
43 feet
Frequency (whales)
10
10
10
5
5

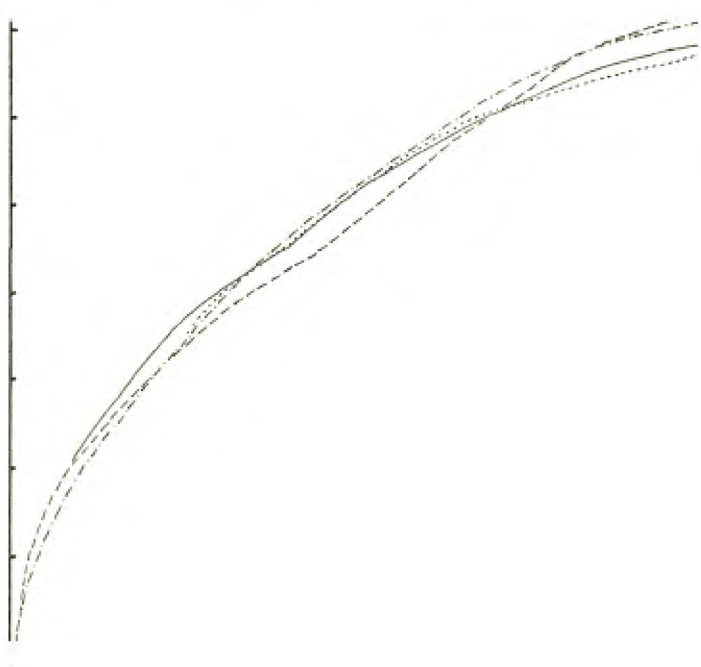


Table 1. Raw age-length key of the Male sperm whale in the North Pacific

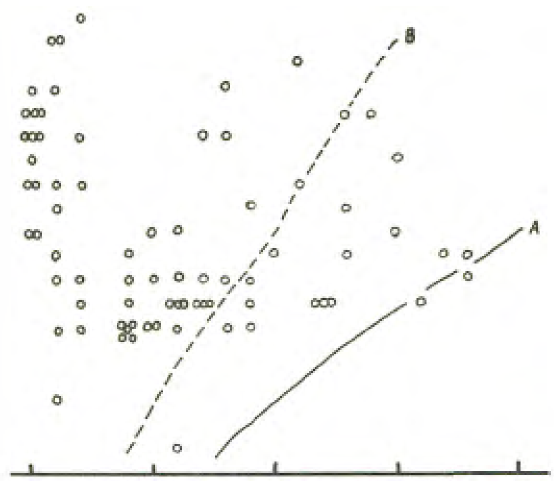
Length (ft.)	Age (years)																																																												Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60≦	
19	-	2																																																											2
20	1	-																																																											1
21	-	-				1		1																																																					2
22	-	-	1			-		-																														1																							2
23	-	-	2	1		-	1	-			1																											-																							5
24	-	-	-	4	1	-	-	-	1		1																											-																							7
25	1	-	-	-	-	2	-	-	2		-																											-																							5
26		-	-	2	3	3	6	-	1	1	-																											-																							16
27		-	-	4	2	3	3	2	1	1	-			1																								-																							17
28		1	-	-	3	5	5	4	1	2	1		1	-				1																				-																							24
29			1	-	1	5	3	6	2	-	1		2	-				-																				-																							21
30			-	1		2	3	4	12	5	5	3	-	1	1			-												1								-																							38
31			-	-		4	5	5	11	8	9	7	2	3	3	2	1	1					1							-								-																							62
32			-	-		2	1	5	5	10	11	7	4	1	1	-	4	-			1		-							-								-																							52
33			-	-		1	1	7	12	17	13	16	14	7	5	4	4	5	2	2	1		-		1	2				-					1			-																							115
34			-	-		1	3	2	3	9	13	9	13	11	5	5	4	-	5	5	3		4		-	1	1			-	1				-			-																							98
35			1	-		1	2	1	9	18	21	18	16	22	17	10	9	11	6	6	3	4	1	3	-	2	-		1	-	1				-			-												1											184
36				1		2	1	-	4	4	13	19	21	19	18	18	6	8	8	5	4	4	2	1	5	3	1		4	1	-				1	1		1				1	2						1	-											179
37				1			1	1	1	5	6	14	11	16	18	15	14	4	8	7	6	2	1	3	2	2	1		-	1	1		1		2	-		1			1	-	1						-	-											147
38								2	-	2	1	9	14	12	18	14	16	18	4	9	6	7	2	4	2	1	-	1	-	1	1		1		-	-		2			-	-	-						-	-											147
39								-	2		3	2	5	11	17	15	15	14	12	16	9	6	2	8	3	2	-	4	1	-	-	1	-		-	2	1	2	1		-	-	-	1					-	-											155
40								-			1	1	3	2	13	10	18	18	11	14	12	10	6	9	5	5	4	-	1	1	-	1	1	1	2	1	-	-	-	1	-	-	3	-					-	-											154
41								1				1	3	4	2	11	8	18	14	14	4	14	12	7	8	2	5	4	2	2	3	1	-	2	-	1	-	1	-	1	-	-	1	-					-	-											146
42												-	-	2	2	2	8	8	13	13	9	14	12	8	8	3	7	5	3	5	2	3	1	1	2	2	1	-	-	-	-	-	-	-			1	1	-	-							1				137
43												-	1		2	5	3	6	8	8	11	14	7	12	8	3	8	7	4	4	5	2	3	3	1	1	2	1	1	1	2	-	-	1	1	1	-	1	-	-							-				137
44												-			-	-	2	5	7	4	7	13	3	5	12	12	7	1	4	3	3	4	2	2	1	3	1	-	1	-	1	1	-	-	1	-	-	-	1	-							-				106
45												-			1	-	-	4	4	3	9	9	14	14	10	8	5	3	4	7	5	3	2	5	2	3	1	1	-	-	1	-	-	-	-	-	-	-	-	-							-				118
46												1				-	-	2	2	3	6	9	5	9	6	10	8	5	5	7	5	4	7	6	8	2	4	6	2	2	4	2	3	1	1	1	-	-	-	-	1		1				-			1	139
47												-				-	2		1		4	5	2	5	6	10	15	4	6	7	5	10	12	12	7	9	4	2	3	4	6	5	1	3	1	1	-	1	2	-	-	2	1	1	1	1	1			-	162
48												1				-			1		1	2	1	2	5	7	3	3	3	7	3	9	3	3	8	4	6	5	5	7	2	4	2	4	4	1	2	3	1	2	1	-	2	3	-	1	-			1	122
49												-				-					1	-	-	2	-	1	4	5	5	7	12	7	3	10	7	9	5	4	9	6	8	9	8	3	4	3	5	5	2	4	2	10	2	1	-	3	2	1	1	4	174
50												-				1					1	1	1	1	1	1	2	4	4	2	9	3	4	2	5	6	2	7	10	6	8	3	5	6	6	8	8	6	4	4	2	4	4	1	-	1	1	1	1	5	151
51												-									1					3	1	-	2	2	3	1	3	2	4	7	2	4	6	6	7	3	2	3	1	5	4	3	3	-	5	5	2	4	7	4	2	1	1	9	118
52												1									1					-	1	-	2	1	1			2	1	2	-	5	4	1	3	3	7	3		2	2	1	1	3	3	5	1	2	2	1		2	4	5	72
53																										-		1	-	1					-	1	1						2	2				1	-	1		-	1	3				1		2	17
54																										1			1						1								1					1	-	1		1						1			8
55																																											1						-									1			2
56																																																	-												-
57																																																	-												-
58																																																	1												1
Total	2	3	5	14	10	32	35	41	67	82	100	109	109	112	123	112	114	123	106	109	100	114	76	93	82	79	73	47	52	60	60	49	43	51	53	54	30	43	42	35	43	31	39	27	19	22	22	23	16	16	14	27	14	15	10	11	7	8	7	27	3,043

Table 2. Processed age-length key of the male sperm whale in the North Pacific

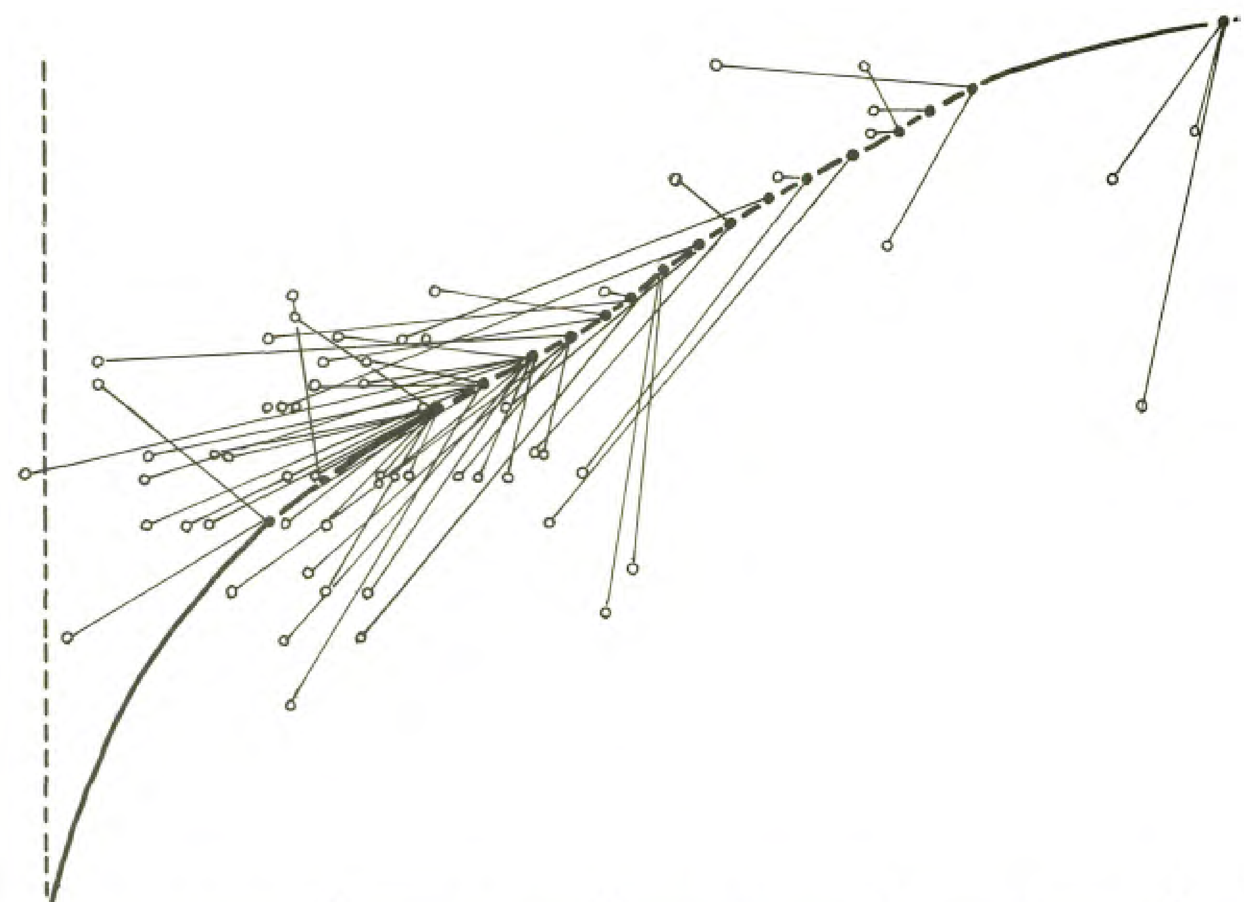
Length (ft.)	Age (years)																																																				Total
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	
24	1	1																																																					2
25	1	2	1																																																		4
26	2	3	2	1																																																	8
27	3	4	4	2	1																																																14
28	2	5	5	3	2	1	1																																														19
29	1	5	5	4	3	2	2	1																																													23
30		4	5	5	6	5	5	2	1																																												33
31		3	5	6	9	8	8	5	3	1																																											48
32		2	4	5	11	12	11	8	6	3	2	1	1																																								66
33		1	3	4	10	14	13	13	10	7	5	3	3	1	1																																						88
34		1	2	3	9	13	15	17	15	12	10	7	5	3	2	2																																					116
35			1	2	7	11	14	18	18	17	15	10	7	5	3	4	1	1	1																																		135
36				1	4	8	11	17	18	19	20	14	10	8	5	5	3	2	1	1	1																																148
37					2	5	8	13	15	18	21	16	14	12	6	7	4	3	1	2	1	1																															149
38					1	2	5	9	12	15	20	16	17	16	8	11	6	5	2	4	2	2	1	1																													155
39						1	2	5	6	10	16	10	17	19	11	14	7	7	3	5	3	3	2	2	1	1	1																										146
40							1	2	3	6	11	12	15	18	13	16	10	10	6	7	5	5	3	3	1	1	1	1																									150
41								1	2	3	6	8	11	14	13	16	11	13	10	8	7	6	5	3	2	2	2	1	1	1	1																						147
42									1	1	3	5	8	11	12	12	11	15	13	10	9	8	6	4	3	3	3	2	1	1	1	1																					144
43											1	3	4	7	10	8	10	14	13	11	11	9	8	5	4	4	4	2	2	2	3	1	1	1																			138
44												1	2	5	7	5	9	13	11	11	11	10	9	5	5	5	5	3	3	4	4	2	1	1	1	1	1																135
45													1	3	5	3	7	10	8	10	10	11	10	6	5	6	6	5	5	5	5	3	2	2	1	1	1	1	1	1	1												135
46														1	2	2	5	7	5	7	8	10	9	5	6	7	6	7	6	7	6	4	3	3	2	2	3	2	1	1	1	1	1	1	1				1					133
47															1	1	3	5	3	5	6	8	8	5	5	7	7	8	6	8	8	6	4	4	3	4	5	4	3	3	3	1	1	2	1	1	1	1	1	1	1	1	1	146
48																	1	3	2	3	4	6	6	4	5	6	6	8	5	8	8	8	5	5	5	6	6	6	4	4	4	3	3	4	2	2	2	3	1	2	1	1	1	153
49																		1	1	2	2	4	4	3	4	5	5	6	4	6	6	8	5	5	6	7	7	6	6	5	5	4	5	5	3	3	3	5	2	3	2	2	1	151
50																			1	1	1	3	2	2	3	4	4	3	3	4	5	7	4	6	9	6	7	5	6	5	4	5	6	5	3	4	4	6	2	4	3	3	1	141
51																					1	2	1	2	2	2	3	2	2	3	3	5	3	5	9	4	6	3	6	4	3	4	4	3	2	3	4	6	1	4	2	3	1	108
52																						1	1	1	2	2	2	2	2	2	3	3	2	5	7	3	4	2	4	3	2	2	2	2	1	2	3	4	1	2	2	2	1	77
53																								1	1	1	1	1	1	1	2	2	1	3	4	1	2	1	3	2	1	1	1	1	1	1	2	2	1	1	1	1		42
54																												1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1			1	1		1				22
55																																		1	1																			2
Total	10	31	37	36	65	82	96	111	110	112	130	106	115	123	99	106	88	109	81	87	82	89	75	52	49	56	56	52	42	53	56	51	32	43	50	36	43	31	35	29	25	22	24	24	14	16	20	28	10	18	12	13	6	2,978

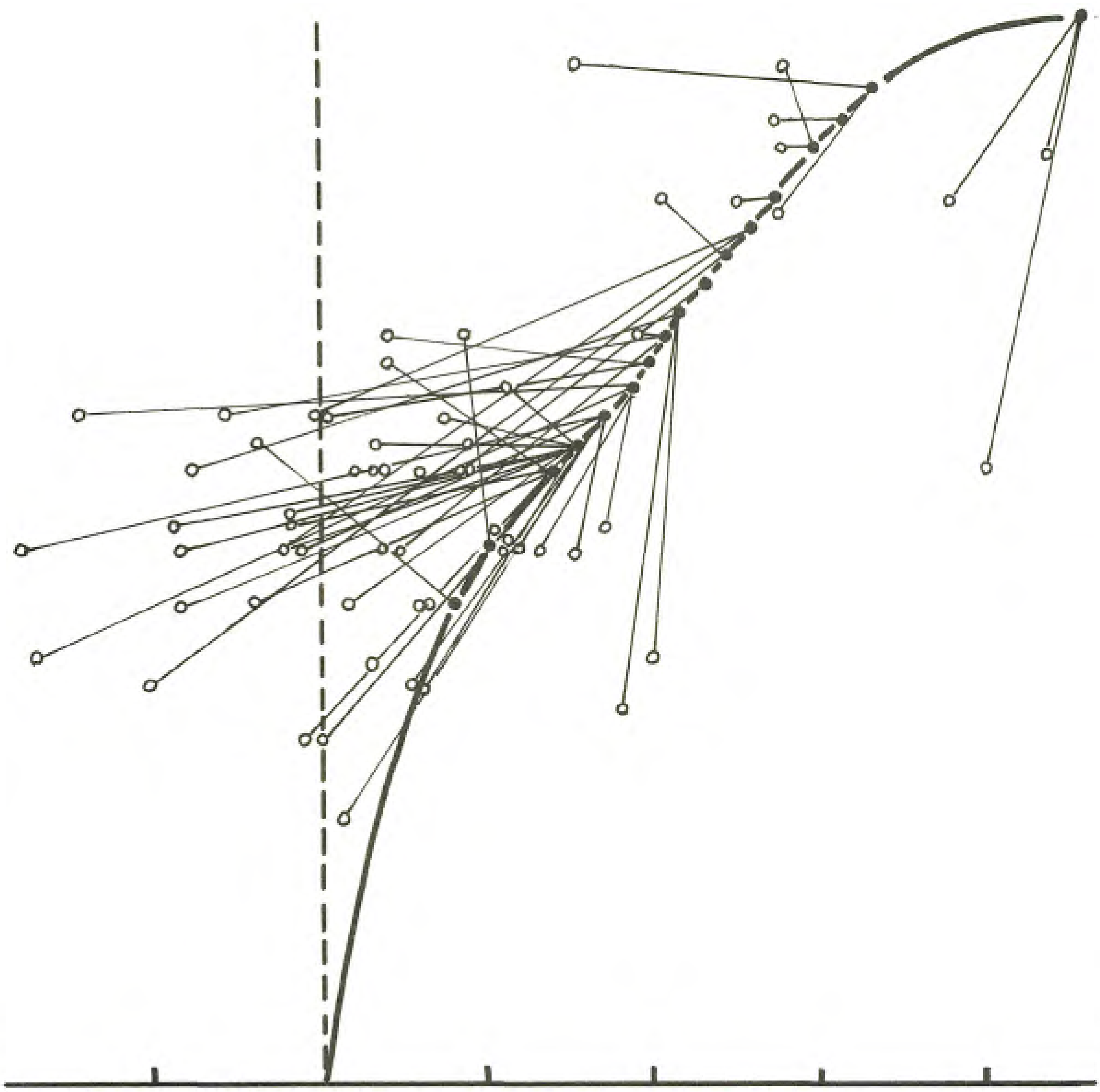
Table 3. Refined age-length key of the male sperm whale in the North Pacific

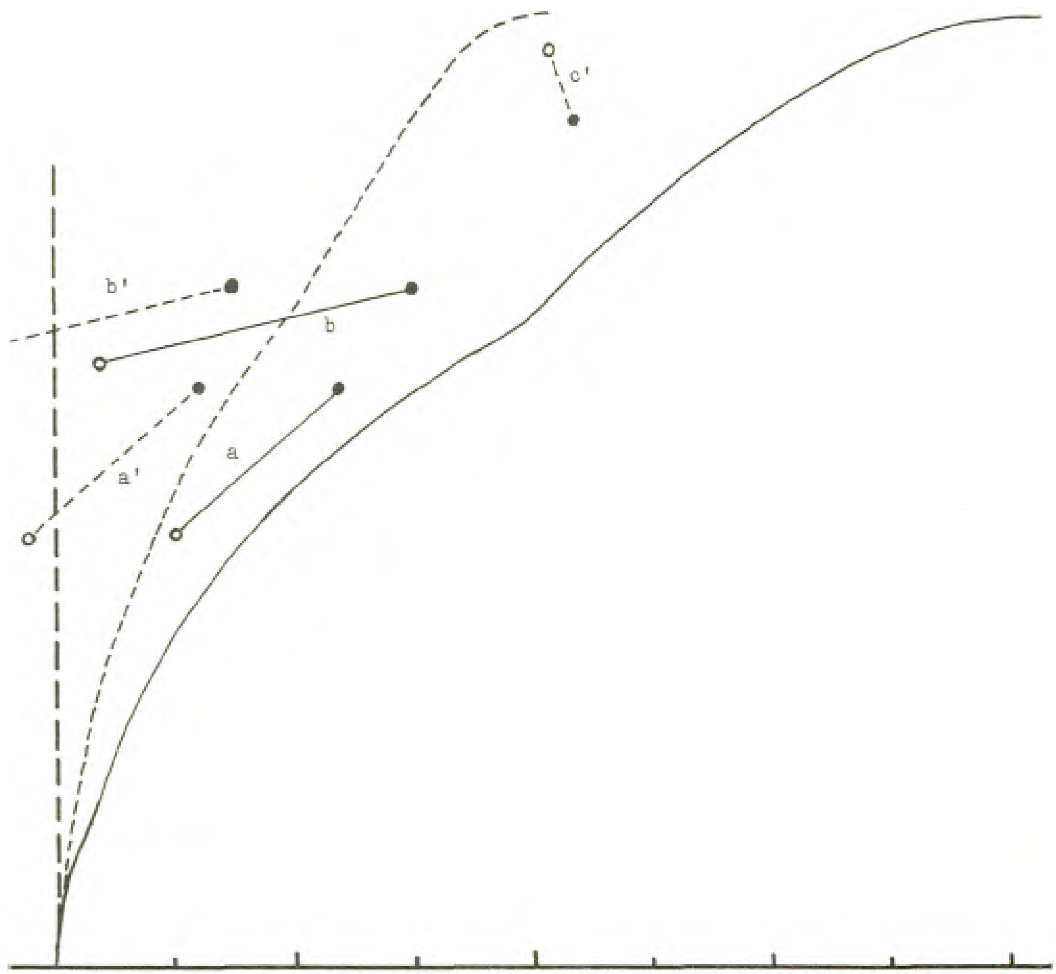
	Age (years)																																																						
Length (ft.)	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	Total
23		0.5	0.5																																																					1.0
24	0.5	1.0	1.0	0.5																																																				3.0
25	1.0	1.5	2.0	1.0	0.5																																																			6.0
26	1.0	2.0	3.0	2.0	1.0	0.5																																																		9.5
27	1.5	3.0	4.0	3.5	2.0	1.0	0.5																																																	15.5
28	1.0	2.0	5.0	4.5	3.0	2.0	1.0	0.5																																																19.0
29	0.5	1.5	4.5	5.0	4.0	3.0	2.0	1.0	0.5	0.5																																														22.5
30		1.0	3.5	5.5	6.0	6.0	5.5	4.5	3.0	1.5	1.0	0.5																																												38.0
31		0.5	2.5	5.0	7.0	8.0	8.5	7.5	5.0	2.5	1.5	1.0	0.5																																											49.5
32			1.0	3.5	6.5	11.0	12.0	11.0	8.0	5.5	3.0	2.0	1.0	0.5	0.5																																									65.5
33			0.5	2.5	5.0	10.0	13.0	14.0	12.0	10.0	7.0	5.0	3.0	2.5	1.5	0.5																																								86.5
34			0.5	2.0	4.5	8.0	11.5	15.5	16.5	15.0	12.5	9.5	7.0	5.0	3.0	2.0	1.0	0.5																																						114.0
35				1.0	3.0	6.5	10.0	14.0	17.0	18.0	17.0	15.0	10.0	7.0	5.0	3.5	2.5	1.5	1.0	0.5																																				132.5
36					1.0	4.0	7.5	11.0	15.0	19.5	20.0	18.5	14.5	10.0	8.0	5.5	4.0	3.0	2.0	1.0	1.0	0.5																																		146.0
37					0.5	2.0	5.0	8.0	12.0	15.5	18.0	18.5	17.5	14.5	11.0	8.0	5.5	4.0	3.0	2.0	1.5	1.0	0.5																																	148.0
38						1.0	2.5	5.0	8.5	12.0	15.0	17.5	18.5	17.0	14.5	11.5	9.5	7.0	5.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5																														158.5
39						0.5	1.0	2.5	5.0	7.5	10.0	12.5	16.0	17.5	16.5	14.5	11.5	8.0	6.0	5.0	4.0	3.0	2.5	2.0	1.5	1.0	1.0	0.5																												149.5
40							0.5	1.0	2.0	3.0	6.0	10.0	13.0	15.5	16.0	15.5	13.5	11.0	9.0	7.5	6.0	5.0	4.0	3.0	2.5	2.0	1.0	1.0	0.5																											148.5
41								0.5	1.0	2.0	3.0	5.5	8.5	11.0	13.0	14.5	14.0	12.5	11.5	10.0	8.0	7.0	6.0	4.5	3.5	3.0	2.5	2.0	1.5	1.0	0.5																									146.0
42										0.5	1.5	3.0	5.0	8.0	10.5	12.0	13.0	13.0	12.5	12.0	11.0	9.0	7.5	6.0	4.5	3.5	3.0	2.5	2.0	1.5	1.0	0.5	0.5																							143.5
43											0.5	1.0	2.5	4.5	7.0	9.0	10.5	12.0	12.5	12.5	12.0	10.5	9.0	7.0	5.5	4.5	3.5	3.0	2.5	2.5	2.0	1.5	1.0	0.5	0.5																					137.5
44												0.5	1.0	2.5	4.5	6.0	8.0	9.5	10.5	11.5	11.5	11.0	9.5	8.0	7.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	1.0	0.5																			135.0
45													0.5	1.0	2.5	4.0	6.0	7.5	8.5	10.0	10.5	10.5	10.0	9.5	8.0	7.0	6.0	5.5	5.0	4.5	4.0	3.0	2.5	2.0	1.5	1.5	1.0	1.0	0.5	0.5	0.5															134.5
46														0.5	1.0	1.5	2.5	4.0	5.0	6.5	7.5	8.0	9.0	9.5	9.0	8.5	8.0	7.5	7.0	6.0	5.5	5.0	4.5	3.5	3.0	2.5	2.0	1.5	1.5	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5									136.0
47															0.5	1.0	1.5	2.5	3.5	4.5	5.5	6.5	7.0	7.5	8.0	8.5	8.5	8.5	8.0	8.0	7.0	6.5	6.0	5.5	5.0	4.5	4.0	4.0	3.5	3.0	2.5	2.0	2.0	1.5	1.5	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	154.5
48																	0.5	1.0	2.0	3.0	3.5	4.5	5.0	5.5	6.0	6.5	7.0	7.0	7.5	8.0	7.5	7.0	7.0	6.5	6.5	6.0	5.5	5.0	4.5	4.5	4.0	4.0	3.5	3.5	3.0	2.5	2.5	2.0	1.5	1.5	1.5	1.0	1.0	1.0	1.0	160.5
49																		0.5	1.0	1.5	2.0	2.5	3.0	4.0	4.5	5.0	5.0	5.5	6.0	6.5	7.0	7.0	7.5	7.5	7.0	6.5	6.5	6.0	6.0	5.5	5.5	5.0	4.5	4.5	4.0	3.5	3.5	3.0	3.0	2.5	2.5	1.5	1.5	1.5	1.5	161.0
50																			0.5	1.0	1.0	1.5	2.0	2.5	3.0	3.0	3.5	4.0	4.5	5.0	5.5	5.5	6.0	6.5	6.5	7.0	7.0	6.5	6.5	6.0	5.5	5.5	5.0	5.0	4.5	4.5	4.0	4.0	4.0	3.5	3.5	3.0	3.0	2.5	2.5	154.5
51																					0.5	1.0	1.5	1.5	2.0	2.0	2.0	2.5	3.0	3.5	3.5	4.0	4.5	5.0	5.5	5.5	6.0	5.5	5.0	5.0	4.5	4.5	4.0	4.0	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	119.5
52																							0.5	1.0	1.0	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	4.0	4.5	5.0	5.0	4.5	4.0	3.5	3.5	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	87.5
53																								0.5	0.5	1.0	1.0	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5	3.0	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	50.5
54																											0.5	0.5	1.0	1.0	1.0	1.0	1.5	1.5	2.0	2.0	2.0	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5				27.0
55																																0.5	0.5	0.5	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5														7.0
56																																				0.5	0.5																			1.0
Total	5.5	13.0	28.0	36.0	44.0	63.5	80.5	96.0	105.5	113.0	116.0	120.0	118.5	117.0	115.0	109.0	103.5	97.5	93.5	92.0	88.5	84.0	79.0	73.5	67.5	63.0	59.5	58.0	56.5	55.0	52.5	49.0	49.5	47.0	46.5	46.0	44.0	38.5	36.0	33.0	30.5	28.5	25.5	24.0	22.0	18.5	18.0	16.5	15.5	14.5	14.5	12.5	12.0	11.5	11.5	3,069.0
Av. B.L. (ft.)	26.20	27.00	28.20	29.78	31.25	32.50	33.43	34.18	34.98	35.82	36.35	37.02	37.82	38.61	39.37	40.08	40.79	41.51	42.19	42.84	43.29	43.79	44.31	44.92	45.37	45.86	46.34	46.71	47.21	47.54	47.90	48.32	48.68	49.05	49.38	49.67	49.25	49.78	49.86	49.89	49.89	50.00	49.88	49.98	50.02	49.92	49.92	50.12	50.29	50.34	50.34	50.56	50.50	50.52	50.52	



B
A







b'
b
a
a'
c'

Sperm Whale Catch Efficiency by Japanese Pelagic Whaling Catcher Boats in the Antarctic

Seiji Ohsumi

Far Seas Fisheries Research Laboratory

The catch efficiency by whaling catcher boats was examined mainly for baleen whales at the time of the Committee of Three in the early 1960s (Chapman, 1964). At that time the size of catcher boat – tonnage or horse power – was analysed for the correction of fishing effort by catch efficiency of catcher boats.

Recently the need to obtain the true fishing effort has been revived in the study of population dynamics of whales. Best (1973) and Gambell (1975) examined catch efficiency of ASDIC as well as tonnage of catcher boat for the correction of fishing effort of the sperm whale by shore-based whaling off South Africa.

On the catch efficiency of the sperm whale by Japanese pelagic whaling catcher boats, Nemoto (1964) studied the relation between tonnage and catching power for the pelagic whaling in the northern part of the North Pacific. The present paper will deal with the same problem with special reference to tonnage and ASDIC for the Antarctic pelagic whaling.

CATCHING POWER OF TONNAGE

Pelagic whaling is carried out by a whaling expedition as a unit. Tonnage, catch amount of male sperm whales and catcher's day's work (CDW) in the sperm whaling season (before the beginning of baleen whaling season) in 1955–56 and 1957–58 Antarctic seasons were used as materials for this work by catcher boat, by expedition and by season. During these seasons, whaling ground was limited to the south of 59°S, catcher boats of relatively wide range of tonnage were engaged in operation, and most catcher boats had no ASDIC.

Regression lines fitted by the least squares method on the relation between tonnage and CPUE of each catcher boat were calculated by expedition and by season. The ASDIC equipped catcher boats were excluded from the calculation. It is no use to gather all the data of different expeditions and seasons and calculate a single line, for CPUE may be different among expeditions and seasons. Equation of the regression line is as follows:

$$Y = \mathrm{CPUE} = a\,T + b \qquad (1)$$

where, Y is catch efficiency, T is tonnage, and 'a' and 'b' are constants.

CPUE is calculated as C/X, where C is catch amount and X is CDW.

Table 1 shows the correlation coefficient, 'a' and 'b' for each regression line. Among 12 expeditions, excluding an expedition in which many catcher boats were equipped with ASDIC, three show bad correlation, but others have correlation coefficients of 0.46 and more. The average of 12 coefficients is 0.46.

The values of 'a' vary between –0.00023 and 0.00933, and the average is 0.00220. The values of 'b' also widely ranged between –2.7487 and 1.3164, and the average is –0.1905.

It is rather difficult to estimate a single formula from the above result, but it may be concluded as follows:

$$Y = 0.0022\,T - 0.1905 \qquad (2)$$

Nemoto (1964) shows the following formula as a sperm whale catch efficiency for the North Pacific pelagic whaling:

$$Y = 0.00341489\,T + 0.11436$$

According to Gambell (1975), the catching power for the coastal whaling at Durban is as follows:

$$Y = 0.00096\,T + 0.06965$$

The difference in the figures for 'a' between the Antarctic and the North Pacific may mean the difference of

Table 1

Regression lines of sperm whale catching power by tonnage of catcher boats in the Antarctic.

		Catcher boats				
Season	Expedition	Number	Tonnages	Correlation coefficient	a	b
1955–56	A	7	307–647	0.580	0.00175	–0.0472
	B	9	392–647	0.067	0.00034	1.3164
	C	10	367–471	0.731	0.00933	–2.7487
1956–57	A	8	392–650	0.545	0.00182	–0.0770
	B	10	397–647	0.460	0.00666	–2.3690
	C	9	367–743	0.803	0.00235	–0.2481
	D	8	356–746	–0.072	–0.00023	0.8451
	E	10	375–710	0.583	0.00059	–0.0247
1957–58	A	10	368–753	0.603	0.00133	–0.0881
	B	8	437–753	0.123	0.00046	0.4862
	C	6	392–751	0.523	0.00070	0.6639
	D	8	424–650	0.555	0.00133	0.0053

density of sperm whale populations in both waters; that between the Antarctic and Durban may mean the difference of types of pelagic and coastal whaling, that is, pelagic whaling is more efficient than coastal whaling.

CATCHING POWER OF ASDIC

A prototype of ASDIC was made in Japan in 1951, and it had been tested by a catcher boat. An ASDIC was imported from the UK in 1955, and then ASDIC were rapidly distributed in Japanese catcher boats. As shown in Table 2, ASDIC equipped catcher boats engaged in Japanese pelagic whaling in the Antarctic in the 1956–57 season for the first time, and 75% of catcher boats had ASDIC by the 1965–66 season. The catcher boats which do not have ASDIC have been used mainly for whale sighting or whale towing since the 1960s.

Table 2

Numbers of catcher boats with ASDIC in Japanese Antarctic whaling expeditions.

Season	Number of expeditions	Number of catcher boats				
		With ASDIC (A)	No ASDIC (B)	Cargo*	Total	%**
1955–56	3	–	39	–	39	0.0
1956–57	5	2	50	3	55	3.8
1957–58	6	6	60	2	68	9.1
1958–59	6	12	56	–	68	17.6
1959–60	6	17	51	1	69	25.0
1960–61	7	21	49	1	71	35.7
1961–62	7	47	39	5	91	54.7
1962–63	7	50	29	–	79	63.3
1963–64	7	49	29	2	80	62.8
1964–65	7	47	25	3	75	65.3
1965–66	5	39	13	–	52	75.0
1966–67	4	36	9	1	46	80.0
1967–68	4	36	6	1	43	85.7
1968–69	3	37	1	1	39	97.4
1969–70	3	34	1	2	37	97.1
1970–71	3	34	1	4	39	97.1
1971–72	4	36	1	2	39	97.3
1972–73	4	32	1	1	34	97.1
1973–74	4	29	1	–	30	96.7
1974–75	4	27	1	–	28	96.4

* Mainly used for meat carrier, but used as scouting boat in a part of its navigation, so that regarded as a catcher boat.
** A/A + B × 100.

Best (1973) and Gambell (1975) examined the catching power of ASDIC from the relation between percent of catchers with ASDIC and catch per catcher-ton-days. When the population density is constant during the examined years, this method is useful, but if it is not so, the apparent line does not represent the true power, for the percent of catchers with ASDIC increases gradually year by year.

In the present paper, average CPUE′ of ASDIC equipped catcher boats is compared with that of catchers without ASDIC in the same expedition in each season. CPUE′ of each catcher boat is calculated by use of formula (2) and the following equation:

$$\mathrm{CPUE}' = C/Y.X \qquad (3)$$

The materials used were the data of tonnage, CDW, and the catch amount of male sperm whales in the waters south of 40°S before the start of baleen whaling during seasons 1956–57 to 1962–63. After 1962–63 most catcher boats without ASDIC were used for towing or sighting of whales.

Table 3 shows the results of calculation. The ratio of CPUE′ of ASDIC-equipped boats to that of boats without ASDIC will represent the catching power of ASDIC. The values of the ratios vary from 0.56 to 2.91, and the average is 1.26. This average value is smaller than 2.3 which was estimated by Best (1973) and Gambell (1975). Reviewing the figures in Table 3, it is clear that those in expeditions A and B are mostly higher than those of other expeditions. The average ratios in expeditions A, B, C, D, E and F are 1.74, 1.83, 1.06, 0.88, 1.08 and 1.00, respectively. Expeditions A and B belonged to the same company. The operation manner is different by companies, and it may affect this phenomenon. Detailed information on the operation of each catcher boat in each day will be needed to examine the difference of the apparent catching power by expeditions.

Table 3

Ratios of CPUE′ of ASDIC-equipped catchers to those of catchers without ASDIC.

Expedition	1956–57	1957–58	1958–59	1959–60	1960–61	1961–62	1962–63
A	–	–	–	–	2.12	1.05	2.06
B	–	–	1.42	2.91	1.50	2.59	0.74
C	0.91	–	0.96	1.11	1.06	–	1.25
D	–	0.87	–	0.84	1.25	0.56	–
E	–	–	0.82	1.06	0.66	1.77	–
F	1.01	0.81	1.18	0.99	–	–	–

They say that it takes several years for an ASDIC operator to be full-fledged. The figures in expeditions C, D and F include the seasons 1956–57 and 1957–58 when ASDIC were first introduced into the Antarctic whaling. They may influence the lowness of the ratios in these expeditions.

The catch of female sperm whales was excluded in the present examination. Diving behavior of the sperm whale is different by sex. The difference of catching powers in the present result and Durban whaling may be affected by this factor. Catching power of ASDIC should be examined by sex or by school size.

It is clear that ASDIC is powerful in whaling operation. The rapid spread of this equipment to catcher boats shows it. Since the introduction of ASDIC to whaling, whale chasing methods have changed. Whalers can watch the movement of whales under the water by use of ASDIC. When they find a school of sperm whales, they can easily catch whales, if they want. Whalers say that they cannot imagine the operation without ASDIC nowadays.

The correction of fishing effort by catch efficiency of catcher boats is only a part to get the true fishing effort. Whaling operation is very complex, and many factors are concerned in it. The detailed analysis of operation is needed to get the true fishing effort.

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SP/Doc 15

Seasonal Distribution of Sperm Whales Sighted by Scouting Boats in the North Pacific and Southern Hemisphere

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The Far Seas Fisheries Research Laboratory has been collecting reports of whale sightings by scouting boats which belong to Japanese whaling expeditions in the North Pacific and Southern Hemisphere since 1965.

The accumulated figures of research distances and sperm whales sighted by 5° square are shown in Appendix Tables I–IV on the North Pacific, 1965–74 and the Southern Hemisphere, 1965–66 to 1973–74 seasons, respectively. Similar tables were also made by month.

By use of these tables, the distribution maps of density of sperm whales represented as number of whales sighted per 10,000 miles were drawn, as shown in Fig. 1 a–g and Fig. 2 a–g.

AVERAGE DISTRIBUTION FROM SPRING TO AUTUMN

Figs. 1a and 2a show total area covered and average density distribution from April to September in the North Pacific and from October to April in the Southern Hemisphere, respectively.

In the North Pacific, whale sighting area has not yet sufficiently covered the waters south of 30°N, Okhotsk Sea and Japan Sea. In the Southern Hemisphere, whale sighting area has also not yet covered the waters of the eastern Pacific, and not covered enough in the waters north of 30°S.

Distribution density is high even in the higher latitudinal waters in the North Pacific, whereas the density becomes remarkably low in the waters south of 45°S in the Southern Hemisphere, though it is relatively high in the waters south of 60°S. As reported by Ohsumi and Nasu (1968), topography and oceanic structure are simple in the Southern Hemisphere, but on the contrary, the North Pacific has complex topography and oceanic structure, and a warm water current extends to the higher latitudinal waters. The distribution of females and young sperm whales are concerned with the warm water masses, and their population size is much higher than the adult males which are distributed in the higher latitudinal waters in summer. The above phenomena represent these features in both oceans.

It seems difficult to divide waters by the difference of distribution density in both oceans. Sperm whales are distributed almost evenly in the North Pacific. The density of sperm whales in the Atlantic sector seems to be low, compared with those in the Indian and Pacific sectors in the Southern Hemisphere.

From Fig. 2b it will be estimated that adult males are distributed or migrate in the high latitudinal waters even in spring.

SEASONAL CHANGE IN DENSITY IN EACH LATITUDINAL WATERS

The oceanic structures are different in each waters even in the same class of latitude. For example, the density in the waters south-east of New Zealand is high compared with other waters, as shown in Fig. 2a. This phenomenon may be concerned with the distribution of the Antarctic Convergence, for it inclines toward the south in these waters.

However, here, average values of density in total 5° class latitudinal waters used to estimate seasonal changes in density or north-south migration of the sperm whale.

Tables 1 A and B show the figures, and Figs. 3–6 are drawn by use of Table 1 for easier representation of the seasonal change. There seems to be no clear tendency of seasonal change, but it may be estimated that the density becomes high in summer in both oceans. The seasonal change in density in middle latitudinal waters is remarkable in the North Pacific compared with that in the Southern Hemisphere.

Table 1

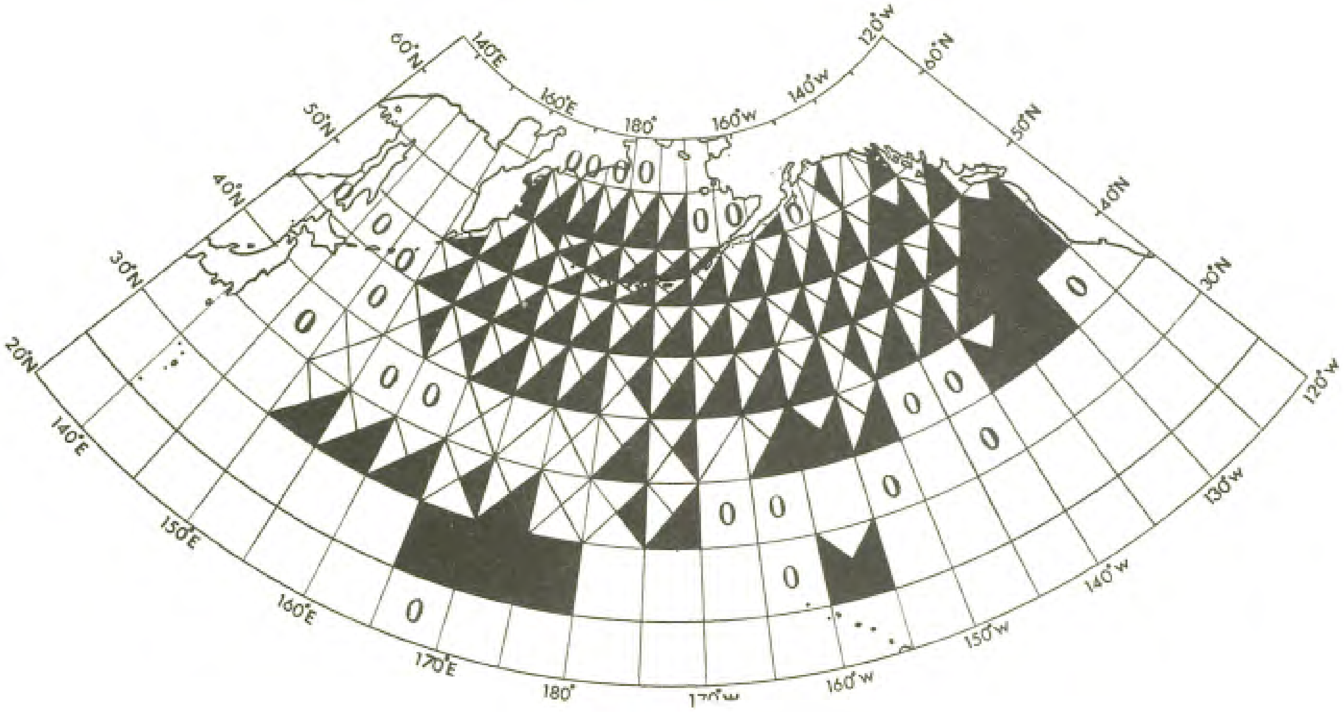
Latitudinal distribution of sperm whales sighted per 10,000 miles navigation by scouting boats in each month.

A. North Pacific

Latitude	April	May	June	July	August	September	Total
60°–65°N	-	-		–	0	–	0
55°–60°N	–	323	122	304	203	–	220
50°–55°N	–	396	261	250	251	9	269
45°–50°N	27	390	191	182	193	136	226
40°–45°N	143	161	74	219	468	388	212
35°–40°N	–	27	18	51	576	251	76
30°–35°N	–	263	96	153	6	277	204
25°–30°N	–	1,173	–	–	594	2,375	1,378
Total	136	232	154	217	301	311	220

B. Southern Hemisphere

Latitude	October	November	December	January	February	March	Total
20°–25°S	0	29	–		–	–	23
25°–30°S	220	149	-	--	–	–	169
30°–35°S	1,236	415	408		–	0	518
35°–40°S	351	159	154	104	194	168	178
40°–45°S		171	112	160	76	71	125
45°–50°S		28	49	31	76	64	56
50°–55°S	–	10	9	12	19	18	15
55°–60°S	–	3	26	28	25	43	28
60°–65°S	–	23	92	31	30	8	37
65°–70°S		–	30	36	15	–	30
Total	916	202	113	83	59	57	106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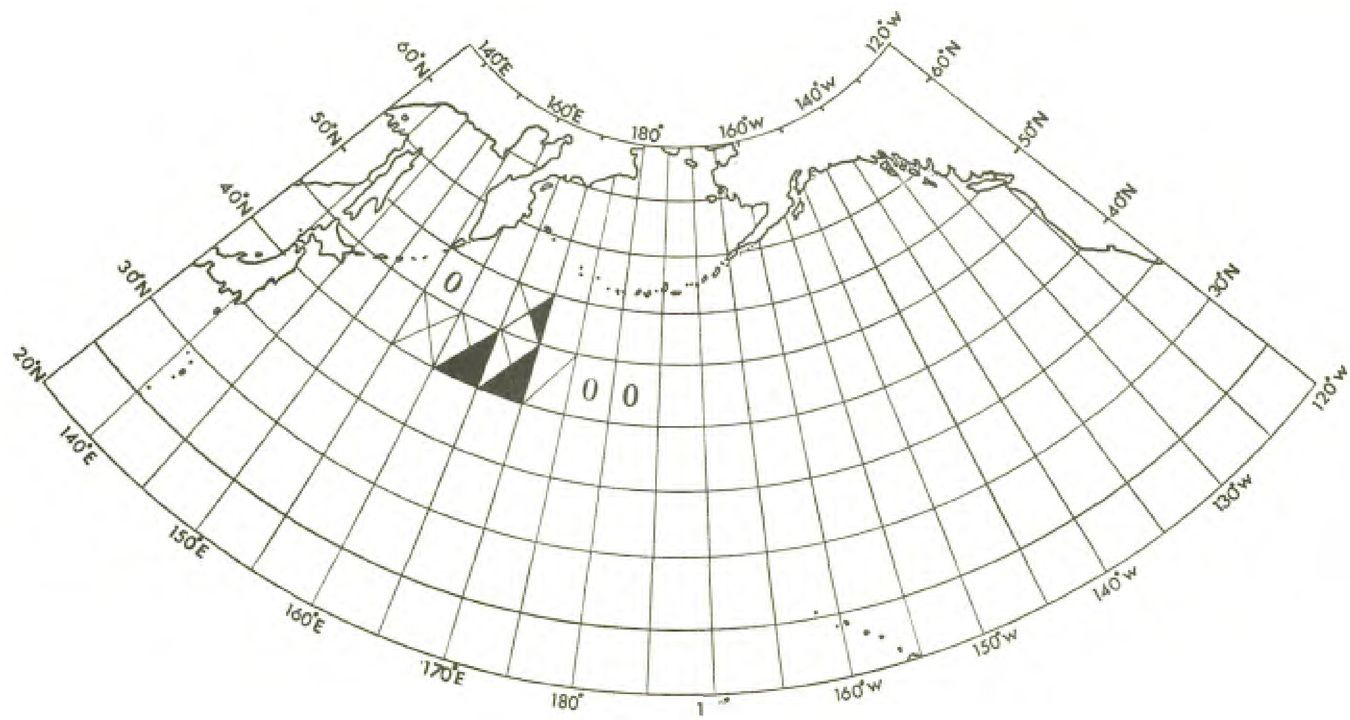
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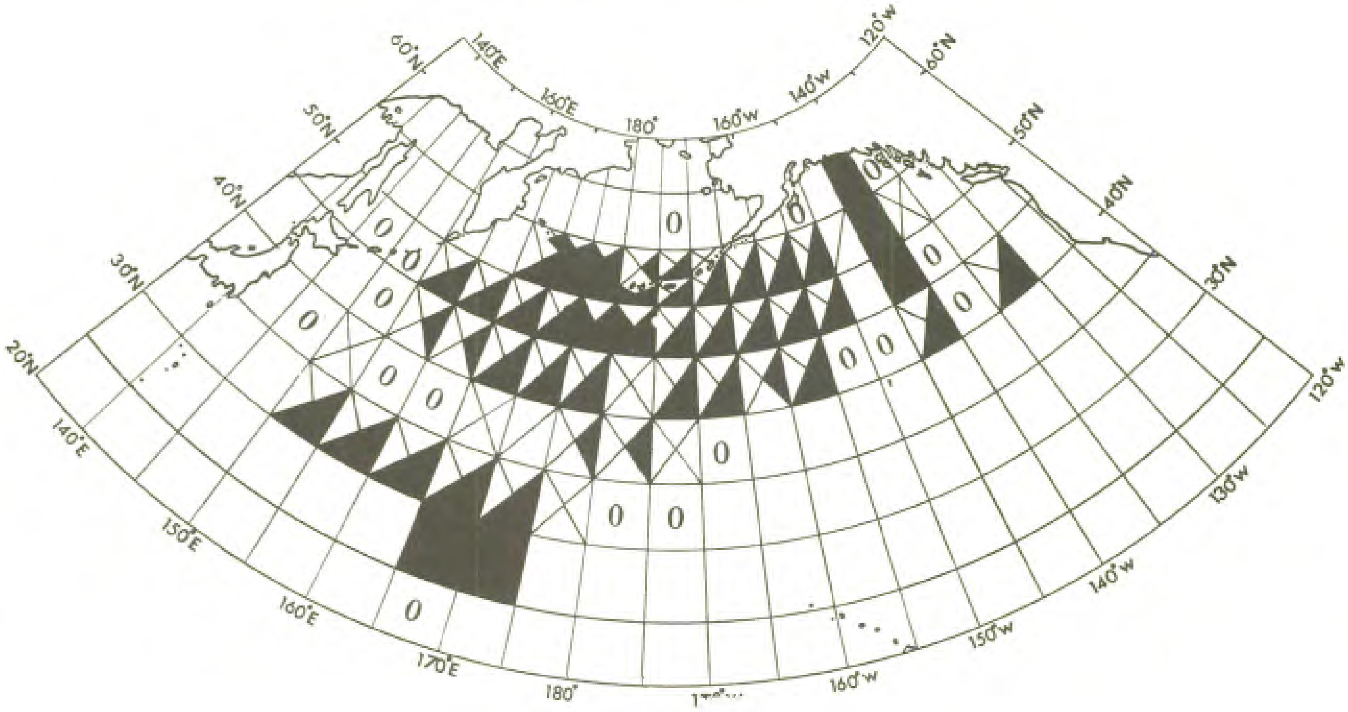
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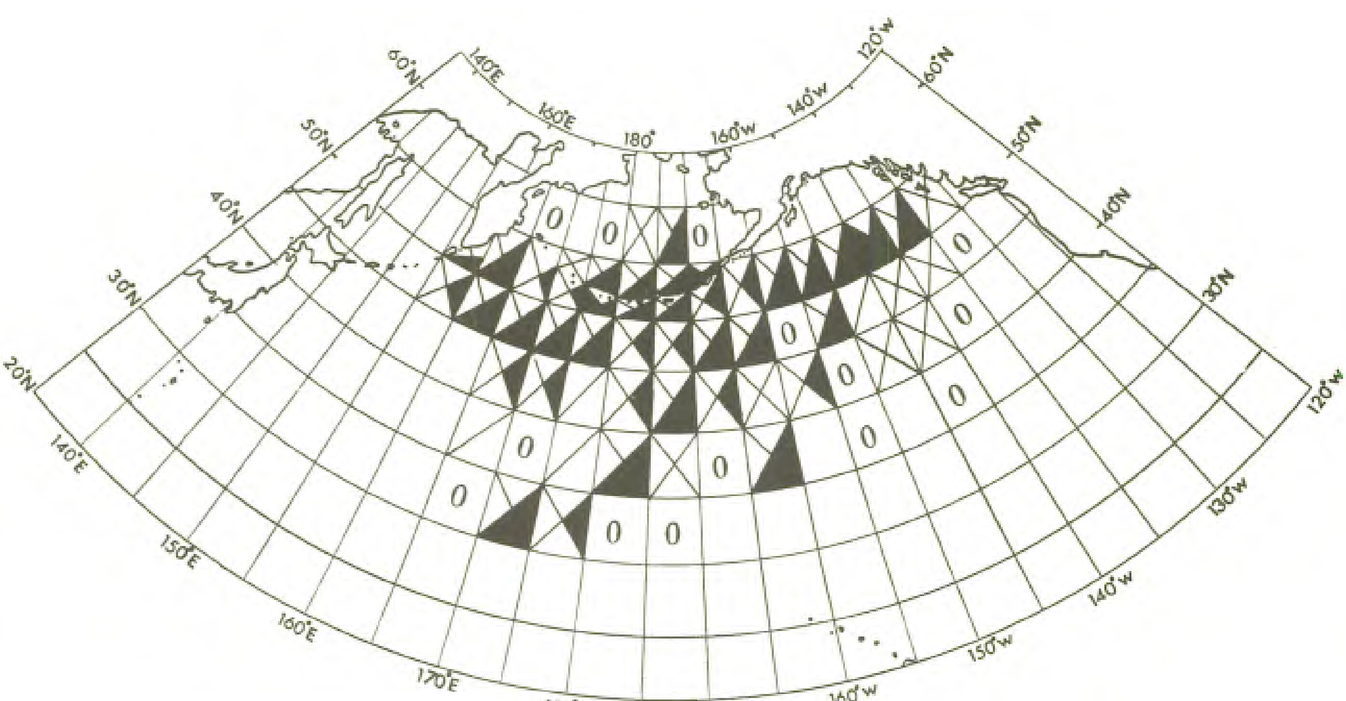
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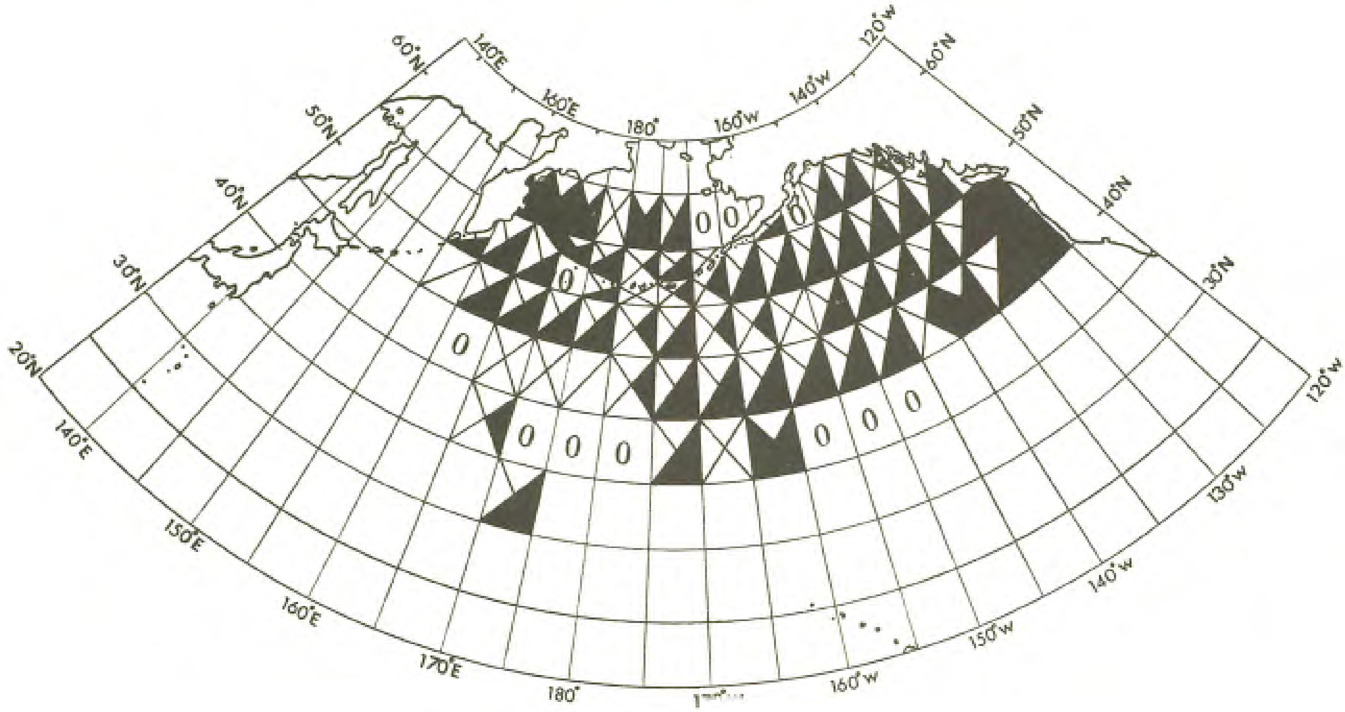
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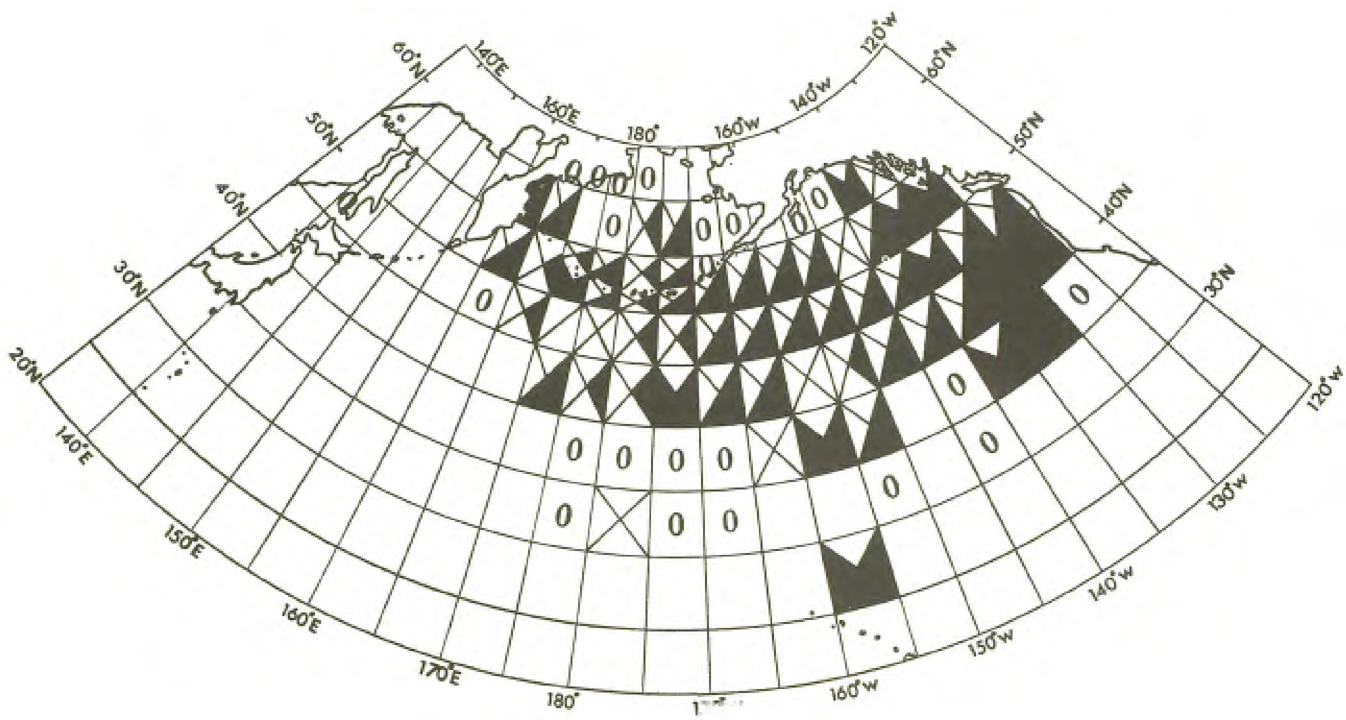
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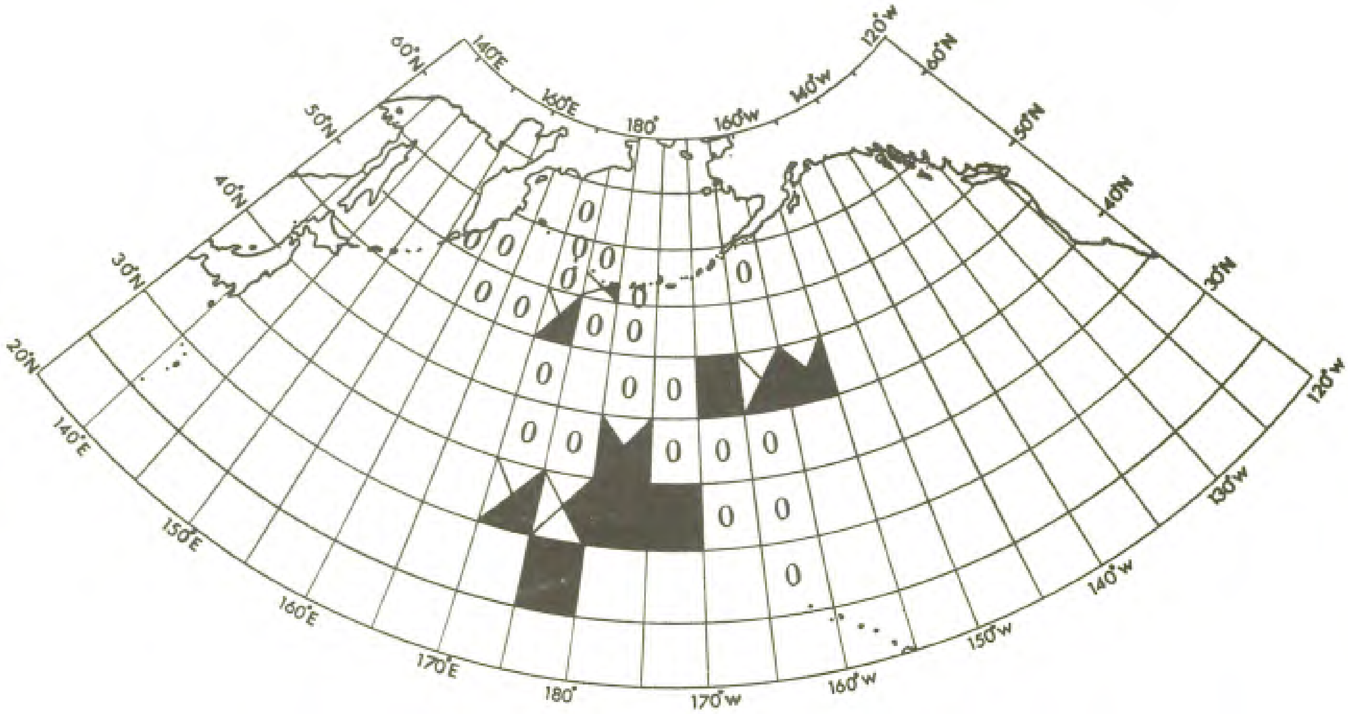

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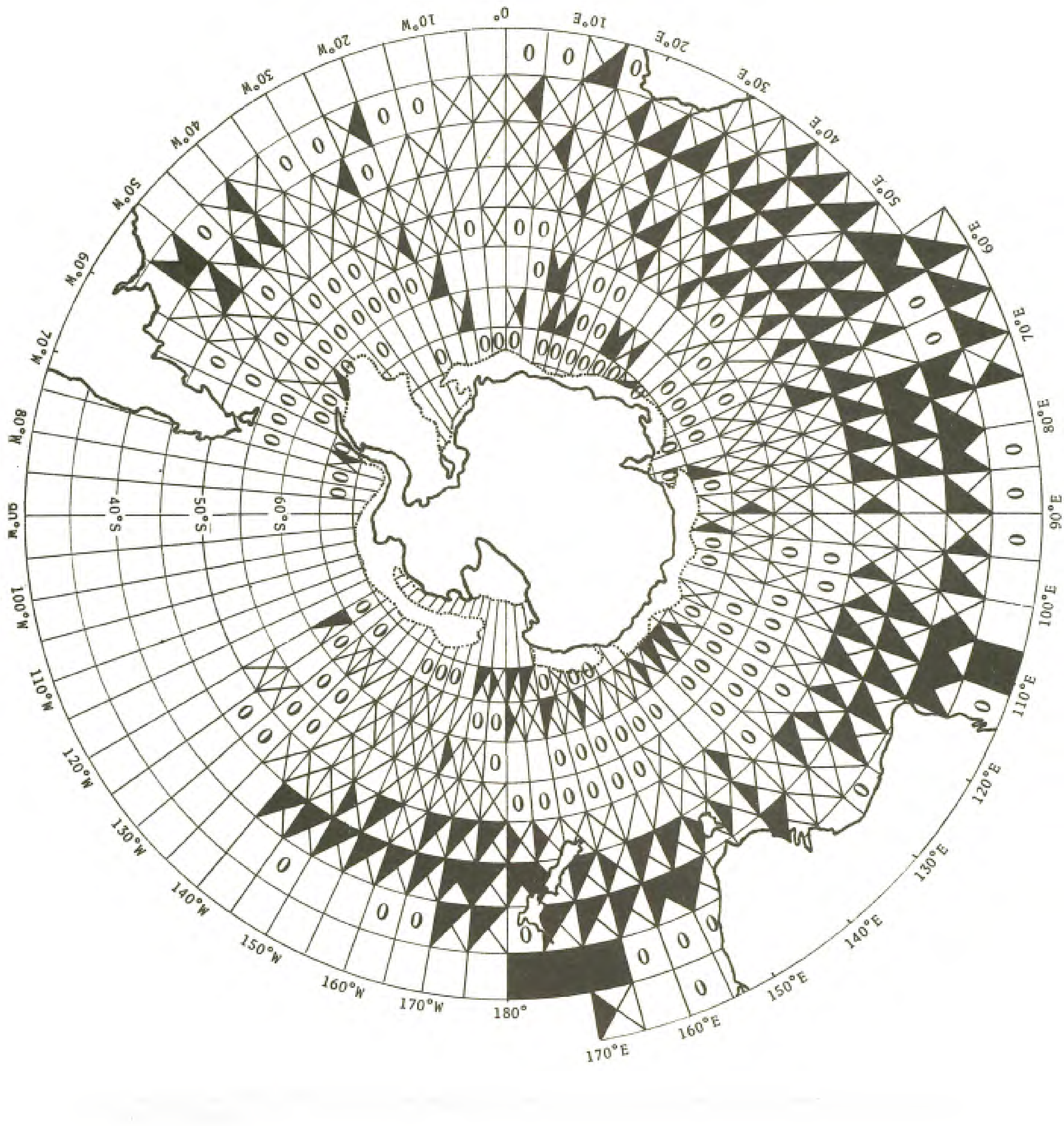
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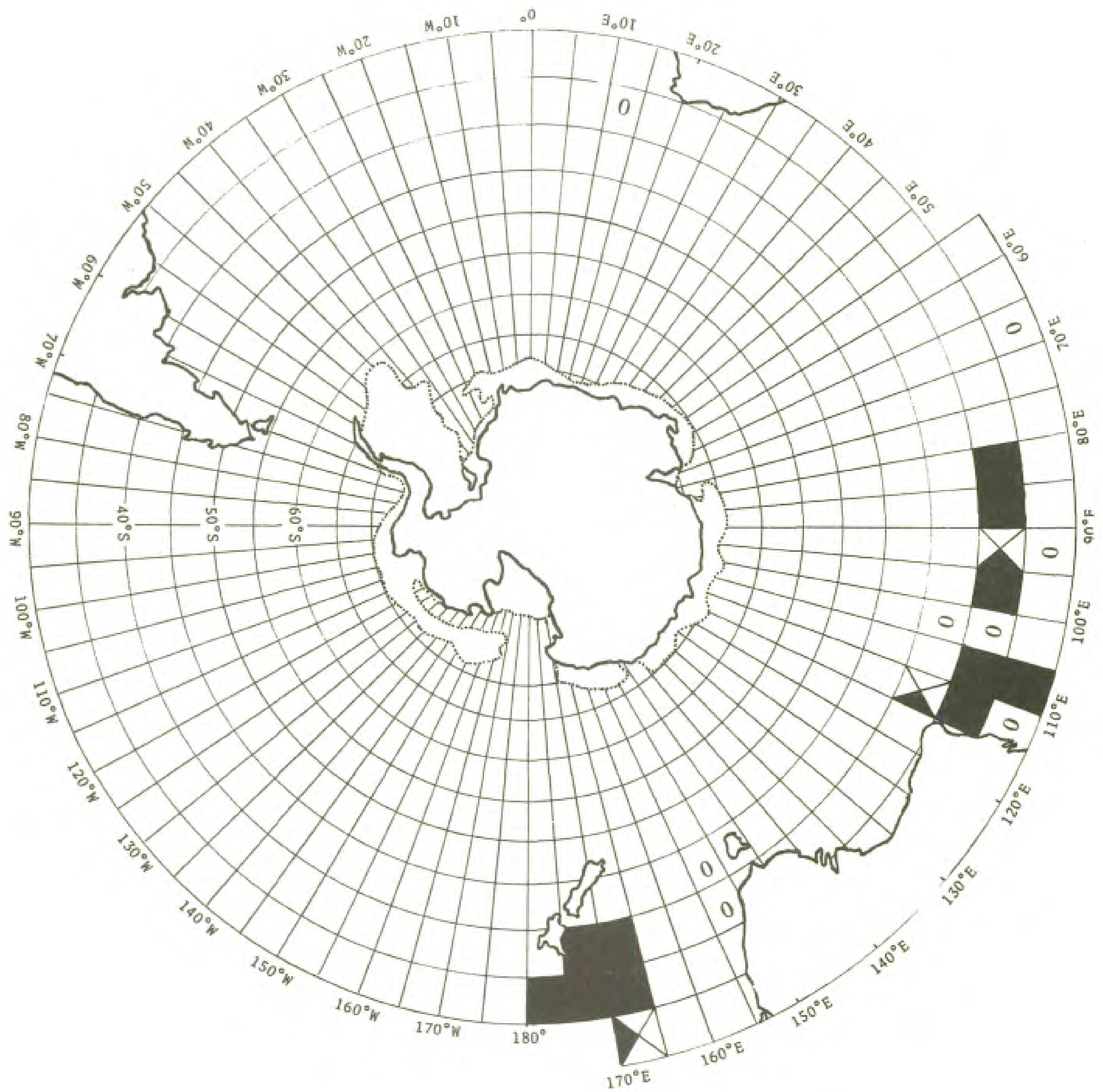
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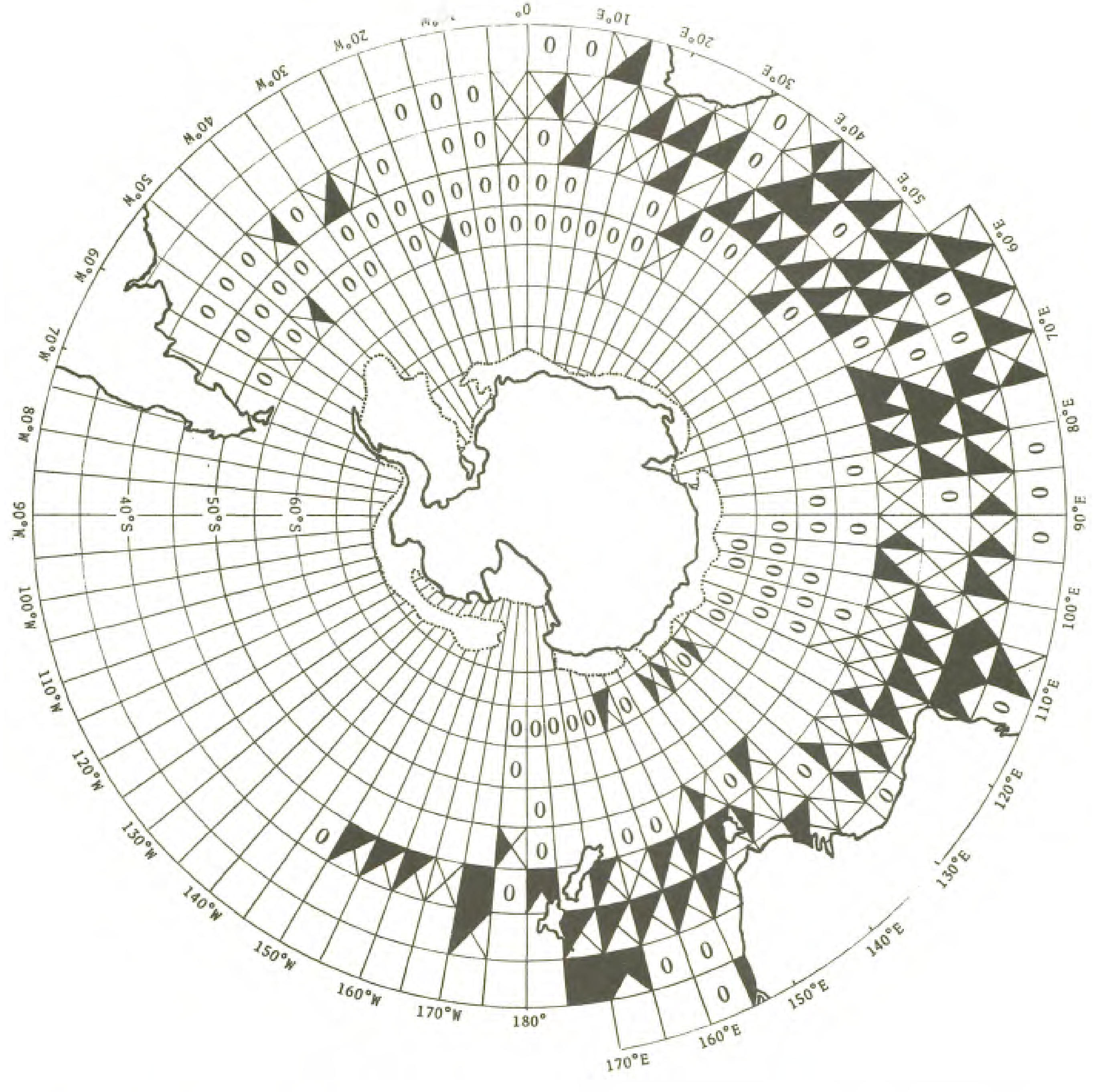

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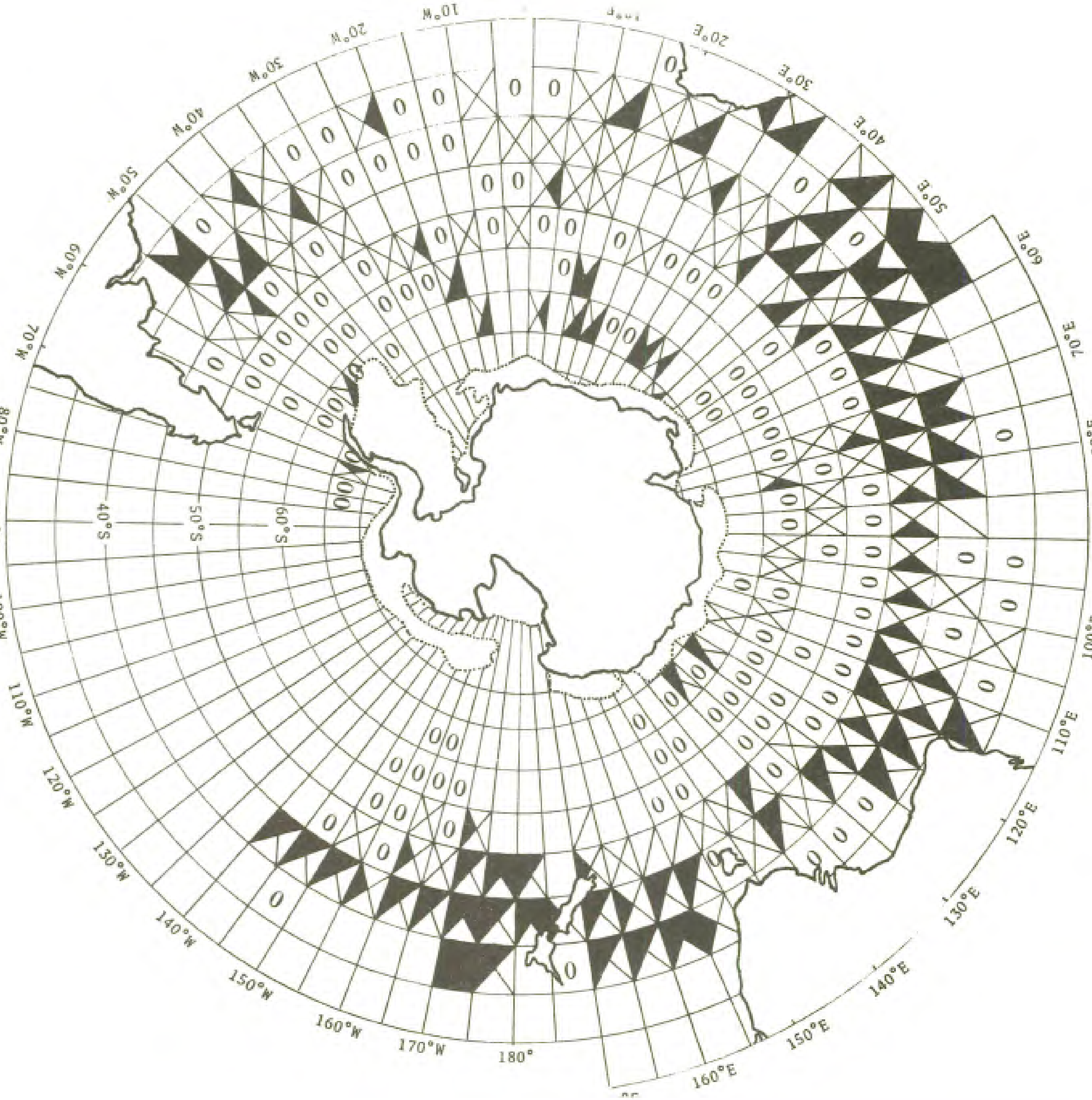
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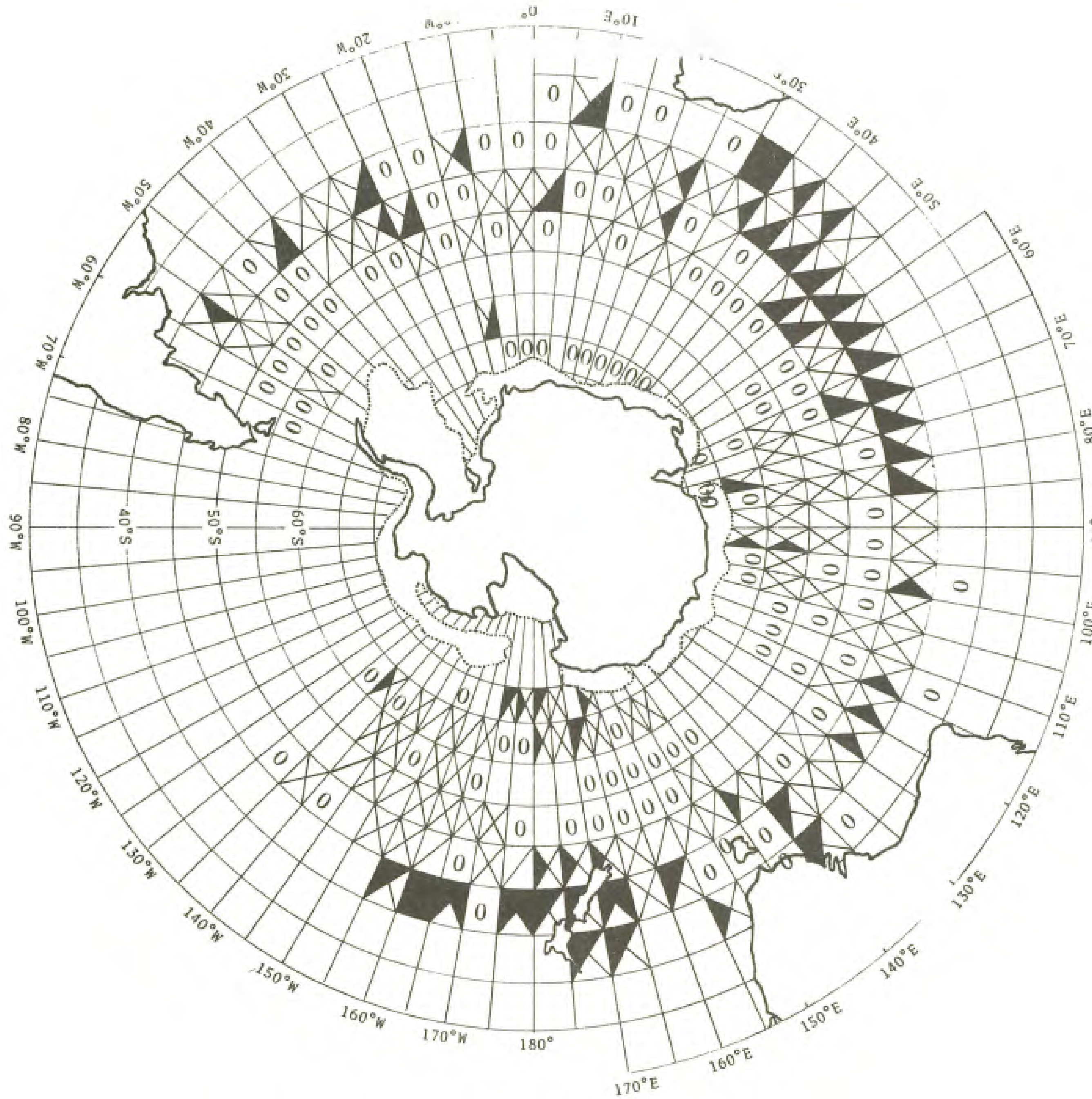
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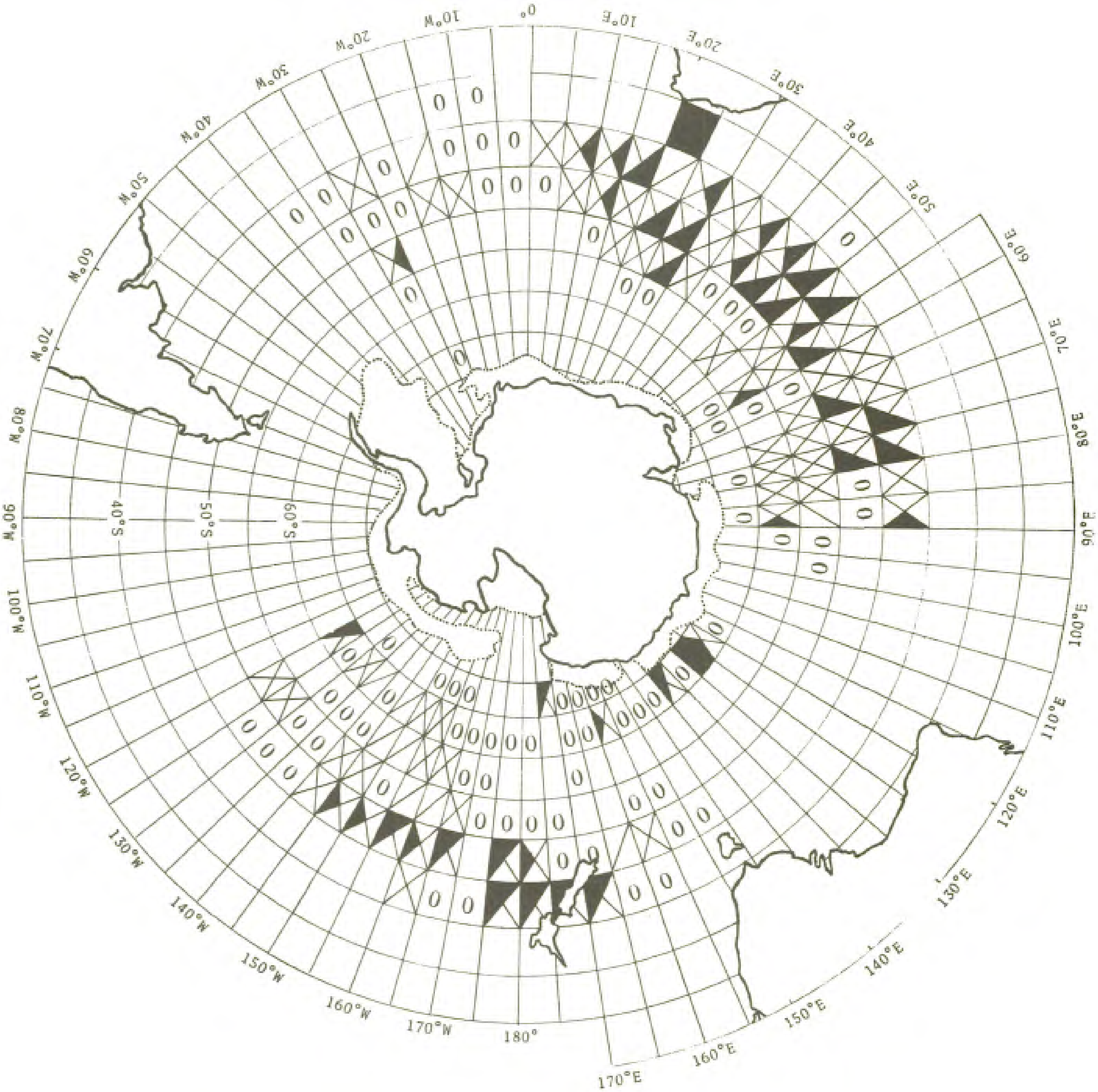

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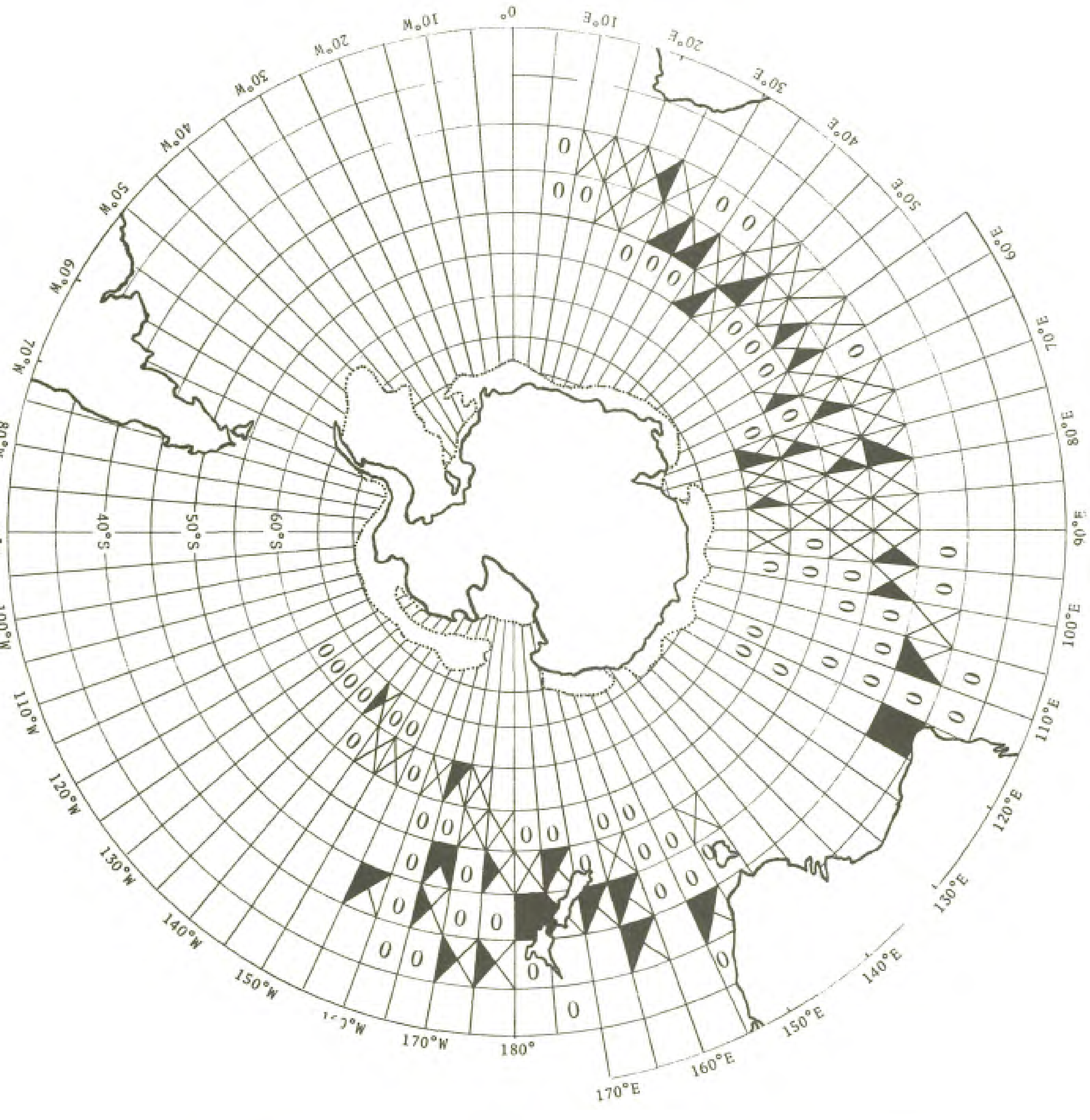

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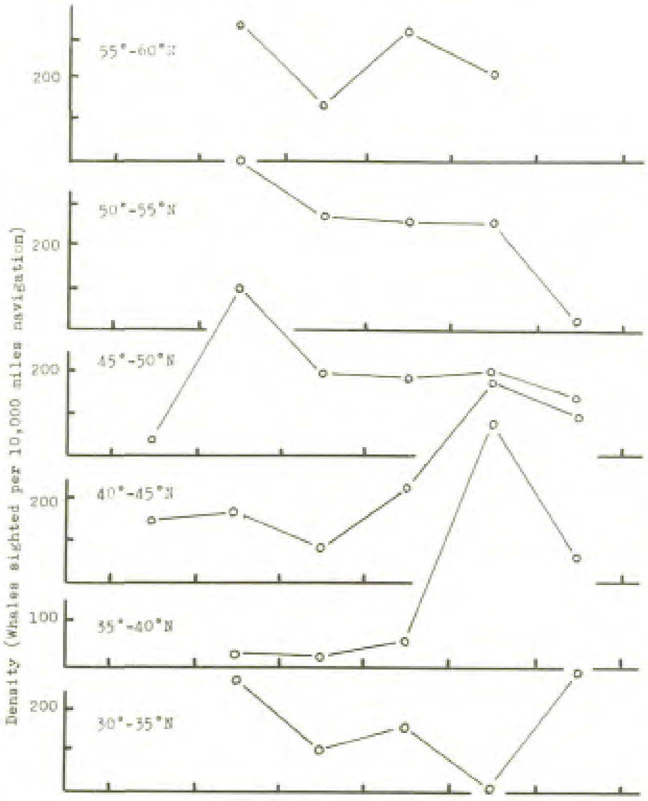

Density (Whales sighted per 10,000 miles navigation)
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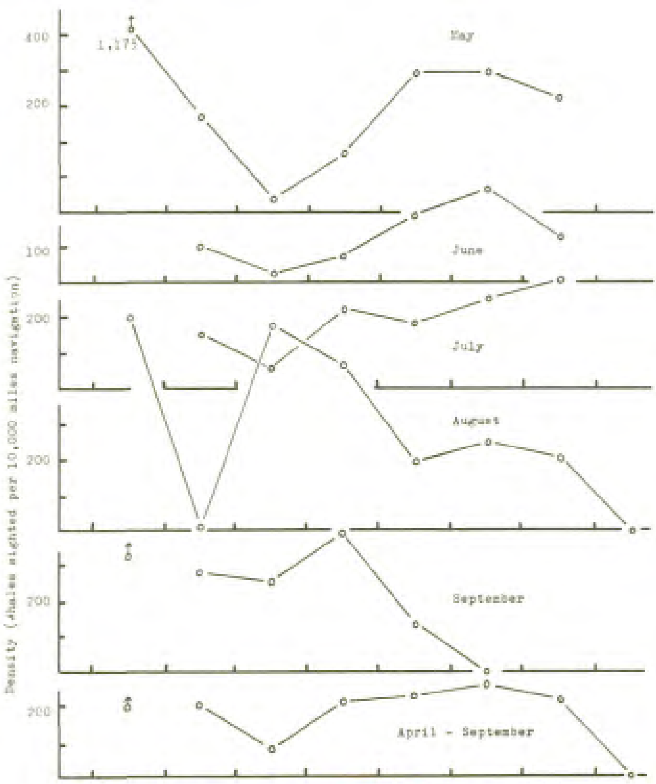
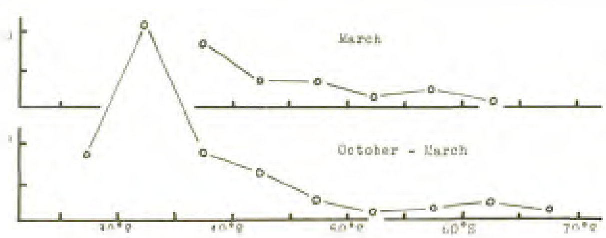
45°-50°N
40°-45°N
35°-40°N
30°-35°N
200
100



Density (Whales sighted per 10,000 miles navigation)
1,175
May
June
July
August
September
April - September
400
200
100



March
October - March
60°S

Appendix Table I

Research distances (miles) of whale scouting boats in the North Pacific, April–September 1965–74.

	25°N–NP	30°N–NP	35°N–NP	40°N–JS	40°N–NP	45°N–JS	45°N–OS	45°N–NP	50°N–NP	50°N–BS	55°N–NP	55°N–BS	60°N–BS	Total
135°E–	–	–	–	510	–	380	–	–	–	–	–	–	–	890
140°E–	–	–	139	–	–	190	–	–	–	–	–	–	–	190
145°E–	–	383	1,429	–	–	–	93	–	–	–	–	–	–	232
150°E–	–	1,319	975	–	716	–	–	333	–	–	–	–	–	2,861
155°E–	–	1,326	2,099	–	3,918	–	–	4,294	1,409	–	–	–	–	11,915
160°E–	–	3,732	18,799	–	6,780	–	–	18,309	6,346	–	225	214	–	35,219
165°E–	490	7,240	17,004	–	22,174	–	–	31,089	9,212	719	–	3,398	128	89,741
170°E–	584	5,156	10,931	–	39,342	–	–	28,829	6,083	7,353	–	1,163	190	107,788
175°E–	177	2,245	5,397	–	18,268	–	–	21,907	10,734	9,874	–	1,664	181	78,892
180°–	–	1,038	3,030	–	13,403	–	–	20,083	9,570	8,954	–	6,545	333	66,530
175°W–	–	336	3,282	–	17,467	–	–	15,879	10,014	11,739	–	8,338	–	67,505
170°W–	–	204	2,252	–	24,196	–	–	15,005	14,294	3,505	–	3,381	–	63,999
165°W–	202	–	1,547	–	22,425	–	–	12,704	10,769	–	–	503	–	49,059
160°W–	202	221	942	–	15,751	–	–	9,514	11,148	–	399	–	–	38,561
155°W–	–	–	405	–	9,687	–	–	10,055	19,410	–	2,189	–	–	42,504
150°W–	–	210	400	–	9,553	–	–	12,287	15,476	–	9,561	–	–	47,282
145°W–	–	–	1,282	–	10,896	–	–	11,505	13,669	–	9,974	–	–	46,654
140°W–	–	–	621	–	4,891	–	–	10,657	8,848	–	2,202	–	–	27,880
135°W–	–	–	37	–	2,922	–	–	8,673	5,208	–	190	–	–	17,614
130°W–	–	–	–	–	1,189	–	–	2,771	–	–	–	–	–	3,997
Total	1,655	23,410	70,571	510	223,578	570	93	233,894	152,190	42,144	24,740	25,206	832	799,493

Remarks: NP: North Pacific, JS: Sea of Japan, OS: Okhotsk Sea, BS: Bering Sea.

Appendix Table II

Number of sperm whales sighted by scouting boats in the North Pacific, April–September 1965–74.

	25°N–NP	30°N–NP	35°N–NP	40°N–JS	40°N–NP	45°N–JS	45°N–OS	45°N–NP	50°N–NP	50°N–BS	55°N–NP	55°N–BS	60°N–BS	Total
135°E–	–	–	–	0	–	0	–	–	–	–	–	–	–	0
140°E–	–	–	0	–	–	0	–	–	–	–	–	–	–	0
145°E–	–	0	0	–	–	–	0	–	–	–	–	–	–	0
150°E–	–	8	4	–	0	–	–	0	–	–	–	–	–	12
155°E–	–	60	0	–	21	–	–	58	38	–	–	–	–	177
160°E–	–	49	0	–	47	–	–	268	146	–	24	20	–	554
165°E–	50	30	24	–	300	–	–	837	203	75	–	159	0	1,678
170°E–	76	262	3	–	764	–	–	767	234	220	–	58	0	2,384
175°E–	90	22	42	–	231	–	–	660	514	303	–	3	0	1,865
180°–	–	21	74	–	73	–	–	379	214	122	–	291	0	1,174
175°W–	–	25	18	–	496	–	–	262	160	362	–	166	–	1,489
170°W–	–	–	2	–	412	–	–	206	174	93	–	–	–	887
165°W–	0	–	35	–	352	–	–	274	209	–	–	–	–	870
160°W–	12	0	135	–	350	–	–	72	270	–	6	–	–	845
155°W–	–	–	19	–	79	–	–	182	418	–	0	–	–	698
150°W–	–	0	0	–	244	–	–	284	217	–	52	–	–	797
145°W–	–	–	0	–	178	–	–	220	592	–	286	–	–	1,276
140°W–	–	–	69	–	112	–	–	359	461	–	32	–	–	1,033
135°W–	–	–	112	–	569	–	–	216	194	–	–	–	–	1,091
130°W–	–	–	–	–	513	–	–	233	–	–	–	–	–	746
Total	228	477	537	0	4,741	0	0	5,277	4,044	1,175	400	697	0	17,576

Appendix Table III

Research distances (miles) of whale scouting boats in the Southern Hemisphere, October–March 1965–66 to 1973–74.

	25°S–	30°S–	35°S–	40°S–	45°S–	50°S–	55°S–	60°S–	65°S–	Total
0°E–	–	595	1,432	5,626	3,209	848	–	217	222	12,149
5°E–	–	213	4,251	11,232	3,801	1,103	186	–	–	20,786
10°E–	–	1,033	3,154	15,492	4,903	2,260	157	198	429	27,626
15°E–	–	80	2,321	13,903	6,285	3,487	349	378	210	27,013
20°E–	–	901	3,024	10,680	11,142	4,650	116	179	404	31,096
25°E–	–	1,703	1,471	13,951	17,658	4,101	183	178	404	39,649
30°E–	–	1,094	2,059	11,255	18,589	3,731	–	378	549	37,655
35°E–	–	1,329	2,180	14,417	14,053	1,171	–	217	354	33,721
40°E–	–	1,478	1,615	17,024	11,027	1,298	–	–	130	32,572
45°E–	–	1,372	2,226	30,011	13,650	1,730	235	–	194	49,418
50°E–	–	1,637	1,636	37,623	19,391	923	243	194	–	61,647
55°E–	173	2,352	1,552	19,033	25,915	1,401	1,061	457	168	52,112
60°E–	1,126	338	783	22,490	22,024	675	1,329	427	–	49,192
65°E–	1,295	182	1,719	22,153	10,804	2,275	2,012	257	236	40,933
70°E–	609	174	3,519	24,703	18,373	16,473	4,325	–	–	68,176
75°E–	–	720	4,270	28,252	11,024	26,879	15,983	692	168	87,988
80°E–	38	1,160	5,206	30,277	8,294	38,613	28,793	821	190	113,392
85°E–	206	1,479	3,632	28,430	5,210	8,930	8,535	2,318	–	58,740
90°E–	605	4,034	5,235	28,569	2,596	2.615	7,711	410	–	51,775
95°E–	–	3,802	6,360	30,820	2,404	1,338	5,102	829	–	50,655
100°E–	–	5,824	7,178	24,616	1,252	1,196	2,850	985	–	43,901
105°E–	296	7,774	11,497	29,401	1,273	433	1,829	–	–	52,503
110°E–	502	8,169	13,366	33,132	1,216	384	1,371	886	–	59,026
115°E–	–	938	11,988	31,901	1,246	396	747	520	–	47,736
120°E–	–	–	6,793	28,332	1,070	170	211	778	–	37,354
125°E–	–	202	6,101	19,227	989	173	214	662	–	27,568
130°E–	–	–	2,840	9,174	589	182	210	615	–	13,610
135°E–	–	–	2,301	4,807	2,319	–	–	616	–	10,043
140°E–	–	–	168	3,754	4,785	–	803	337	–	9,847
145°E–	–	–	–	2,620	8,007	765	387	1,418	–	13,197
150°E–	156	103	5,354	13,809	11,221	598	176	1,507	209	33,136
155°E–	110	170	6,150	23,380	8,931	835	419	1,762	293	42,050
160°E–	–	155	5,978	19,754	11,002	920	203	1,354	560	39,926
165°E–	333	2,110	3,221	7,616	4,355	879	360	1,045	360	20,279
170°E–	–	2,421	1,480	3,783	5,913	525	–	808	413	15,343
175°E–	–	816	190	5,489	5,777	1,269	–	938	237	14,716
180°–	–	–	551	3,422	4,968	1,544	164	784	608	12,041
175°W–	–	–	491	3,643	2,534	2,928	673	541	207	11,017
170°W–	–	–	176	3,268	5,101	7,052	1,820	1,256	–	18,673
165°W–	–	–	203	4,430	4,762	5,117	2,636	2,215	198	19,561
160°W–	–	–	–	2,136	1,433	3,187	4,472	3,348	593	15,169
155°W–	–	–	–	1,149	2,307	3,285	6,660	4,714	219	18,334
150°W–	–	–	293	1,038	475	2,237	10,071	7,009	–	21,123
145°W–	–	–	–	472	647	2,948	4,214	3,158	–	11,439
140°W–	–	–	–	–	547	633	353	1,852	–	3,385
135°W–	–	–	–	–	353	1,050	903	1,801	178	4,285
130°W–	–	–	–	–	152	670	–	300	–	1,122
125°W–	–	–	–	–	–	289	–	678	179	1,146
120°W–	–	–	–	–	–	–	–	–	–	–
115°W–	–	–	–	–	–	–	–	–	–	–
110°W–	–	–	–	–	–	–	–	–	–	–
105°W–	–	–	–	–	–	–	–	–	–	–
100°W–	–	–	–	–	–	–	–	–	–	–
95°W–	–	–	–	–	–	–	–	–	–	–
90°W–	–	–	–	–	–	–	–	–	–	–
85°W–	–	–	–	–	–	–	–	–	237	237
80°W–	–	–	–	–	–	–	–	–	214	214
75°W–	–	–	–	–	–	–	142	–	206	348
70°W–	–	–	–	–	–	–	153	–	357	510
65°W–	–	–	–	–	615	3,065	354	202	–	4,236
60°W–	–	–	–	3,482	4,346	1,282	712	409	–	10,231
55°W–	–	–	377	10,447	9,889	2,523	318	201	–	23,755
50°W–	–	–	784	6,079	4,982	2,550	218	293	–	14,906
45°W–	–	–	188	7,337	6,806	857	210	–	–	15,398
40°W–	–	–	1,108	4,986	4,300	243	431	142	–	11,210
35°W–	–	–	991	5,379	3,250	761	239	–	–	10,620
30°W–	–	–	602	4,083	1,795	1,009	254	–	–	7,743
25°W–	–	–	352	2,597	1,643	1,640	403	–	189	6,824
20°W–	–	–	701	2,722	4,934	835	464	–	–	9,656
15°W–	–	–	1,126	3,771	2,339	1,392	–	298	–	8,926
10°W–	–	–	1,652	3,665	2,542	1,312	–	–	500	9,671
5°W–	–	–	1,637	3,099	2,398	1,139	–	–	215	8,488
Total	5,449	54,358	153,482	753,941	373,415	182,774	121,964	51,582	9,830	1,706,795

Appendix Table IV

Number of sperm whales sighted by scouting boats in the Southern Hemisphere, October–March, 1965–66 to 1973–74.

	25°S–	30°S–	35°S–	40°S–	45°S–	50°S–	55°S–	60°S–	65°S–	Total
0°E–	–	0	9	10	12	0	–	2	0	33
5°E–	–	0	16	60	6	0	0	–	–	82
10°E–	–	22	15	40	31	3	13	6	0	130
15°E–	–	0	21	40	21	1	1	4	0	88
20°E–	–	0	45	73	101	9	0	0	0	228
25°E–	–	7	19	66	208	23	0	0	0	323
30°E–	–	3	20	75	81	4	–	26	0	209
35°E–	–	8	36	165	81	11	–	2	0	303
40°E–	–	42	64	215	171	3	–	–	2	497
45°E–	–	45	1	444	135	0	1	–	0	626
50°E–	–	78	76	595	173	1	0	0	–	923
55°E–	4	205	59	195	209	1	2	0	0	675
60°E–	11	0	6	407	83	1	0	0	–	511
65°E–	27	0	1	631	123	3	2	0	0	787
70°E–	5	15	191	969	58	21	8	–	–	1,267
75°E–	–	22	267	613	51	37	21	11	0	1,022
80°E–	0	105	109	368	19	59	132	0	0	792
85°E–	0	45	1	158	3	9	43	1	–	260
90°E–	0	25	3	117	1	4	38	3	–	191
95°E–	–	106	16	208	0	0	16	0	–	346
100°E–	–	49	134	180	0	2	2	0	–	367
105°E–	31	703	116	305	2	0	1	–	–	1,158
110°E–	0	670	201	414	1	0	0	1	–	1,287
115°E–	–	2	301	291	2	0	0	0	–	596
120°E–	–	–	105	144	0	0	0	7	–	256
125°E–	–	0	24	198	3	0	0	25	–	250
130°E–	–	–	3	10	0	0	0	8	–	21
135°E–	–	–	36	32	15	–	–	5	–	88
140°E–	–	–	0	29	20	–	0	1	–	50
145°E–	–	–	–	20	24	1	0	2	–	47
150°E–	8	0	161	271	10	0	0	1	0	451
155°E–	0	0	318	323	8	0	0	9	0	658
160°E–	–	0	124	137	31	0	0	4	2	298
165°E–	3	264	137	200	14	0	0	12	0	630
170°E–	–	285	30	36	38	0	–	1	5	395
175°E–	–	113	0	353	49	0	–	5	10	530
180°–	–	–	18	72	87	3	0	0	5	185
175°W–	–	–	24	325	31	6	1	0	3	390
170°W–	–	–	0	72	60	16	10	1	–	159
165°W–	–	–	0	195	13	9	6	1	0	224
160°W–	–	–	–	24	17	9	10	13	0	73
155°W–	–	–	–	20	14	2	11	11	0	58
150°W–	–	–	0	12	2	5	14	6	–	39
145°W–	–	–	–	6	1	3	3	1	–	14
140°W–	–	–	–	–	1	0	0	4	–	5
135°W–	–	–	–	–	0	0	0	2	0	2
130°W–	–	–	–	–	0	2	–	0	–	2
125°W–	–	–	–	–	–	1	–	8	0	9
120°W–	–	–	–	–	–	–	–	–	–	–
115°W–	–	–	–	–	–	–	–	–	–	–
110°W–	–	–	–	–	–	–	–	–	–	–
105°W–	–	–	–	–	–	–	–	–	–	–
100°W–	–	–	–	–	–	–	–	–	–	–
95°W–	–	–	–	–	–	–	–	–	–	–
90°W–	–	–	–	–	–	–	–	–	–	–
85°W–	–	–	–	–	–	–	–	–	0	0
80°W–	–	–	–	–	–	–		–	0	0
75°W–	–	–	–	–	–	–	0	–	2	2
70°W–	–	–	–	–	–	–	0	–	0	0
65°W–	–	–	–	–	0	0	0	0	–	0
60°W–	–	–	–	6	12	1	1	0	–	20
55°W–	–	–	19	142	32	0	0	3	–	196
50°W–	–	–	0	44	0	3	0	0	–	47
45°W–	–	–	1	46	10	0	0	–	–	57
40°W–	–	–	2	22	2	0	0	0	–	26
35°W–	–	–	0	27	10	0	0	–	–	37
30°W–	–	–	0	24	2	3	0	–	–	29
25°W–	–	–	2	0	6	9	0	–	0	17
20°W–	–	–	0	1	6	3	9	–	–	19
15°W–	–	–	0	6	2	2	–	6	–	16
10°W–	–	–	3	1	1	0	–	–	0	5
5°W–	–	–	2	2	1	3	–	–	0	8
Total	92	2,814	2,736	9,439	2,094	273	345	192	29	18,014

SP/Doc 16

Provisional Report on Investigation of Sperm Whales off the Coast of Japan Under a Special Permit

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INTRODUCTION

It has become more important to regulate the whale stocks rationally and to utilize them efficiently under the circumstances that catch quotas of the whale stocks have been forced to reduce more and more. Ecological information and knowledge are needed throughout the year for the examination of these matters. However, the whaling season is limited within eight months from May to December in the coastal whaling of Japan, so that it has been impossible to obtain ecological information outside the whaling season.

The Far Seas Fisheries Research Laboratory planned to investigate sperm whales outside the whaling season under a special permit for taking whales for scientific purposes in accordance with the provisions of Article VIII of the International Convention for Regulation of Whaling, 1946. This Laboratory was granted a permit by the Minister of Agriculture and Forestry on 8 January 1976, to take not more than 80 sperm whales in the waters adjacent to Japan from 11 January to 20 February.

This investigation was carried out with the cooperation of the Whales Research Institute and Nittoh Hogei Co. Ltd. by use of two catcher boats and Ohsawa land station. Investigation started on 11 January and ended on 5 February, after taking 80 sperm whales.

The items of investigation comprised investigation at sea by means of catcher boats, measurement and collection of materials on the land station, and economic research on cost and products.

Yoko Satake stayed at the land station from 11 January till 6 February to engage in biological research on the whale carcasses, and Seiji Ohsumi also stayed at the same station from 15–29 January, and engaged in observation of whales on board a catcher boat as well as biological study of whale carcasses at the station.

The present paper is a provisional report of this investigation. Collected materials have not yet been analized, and the report on cost and products has not become available. A detailed report will be presented in future.

INVESTIGATION ON SEA

Research time and distance

Investigation effort data were collected in detail to estimate the density of whales which were distributed in the research area. However, it is rather difficult to compare the result with ordinary whaling, for the present investigation is different from the ordinary operation in some points. Ordinary whaling has no detailed data on the operation time and distance; catcher boats in the present investigation were used for whale sighting as well as whaling operation, and catch was limited to as few as possible, even when many whales were found, to prolong the catching days within the small amount of whales permitted in the present investigation.

Table 1 shows research times by catcher boat during this investigation. Much time was spent in researching the whaling ground and towing the carcasses to the land station (51.2% of total times), because the investigation ground was very far from the land station (140–240 miles), and net operation times were only 19.1%. The average time in each towing was more than 20 hours, and caused the large decline of freshness of carcasses. Abdominal cavity was not cut open in this investigation for measurement and collection of internal organs, and it was another reason for the decline of freshness of carcasses.

Table 2 shows the distance of investigation spent for operation and sighting. Navigation miles from start of operation to end of gathering represent the operation distance, and the sighting distance is represented as miles navigated from start of sighting to end of sighting in a day.

Research area

Operation ground was distributed as a narrow fan-shape ranged within 157°–192° and 240 miles from Shachizaki

Table 1

Research times (hr:min.)

Items	*Ryuho maru* Total	*Ryuho maru* Average	*Ryuho maru No. 5* Total	*Ryuho maru No. 5* Average	Total	Ratio (%)
Anchorage	17:15	2:53	46:35	5:11	63:50	5.2
Departure-arrival	126:25	12:39	105:20	13:10	231:45	18.8
Start-finding	98:55	7:34	72:05	6:01	171:00	13.8
Chasing-end of catch	17:45	1:47	39:10	3:55	65:55	5.3
Gathering of carcase	9:00	1:00				
Towing	193:35	21:31	206:10	20:37	399:45	32.4
Drifting	130:00	26:00	86:55	10:52	216:55	17.6
Whale sighting	31:55	7:39	54:00	9:00	85:55	7.0
Total	624:50	–	610:15	–	1,235:05	–

Table 2

Research distance (miles).

	Ryuho maru		*Ryuho maru No. 5*		
Items	Total	Average	Total	Average	Total
Operation	1,379	135.0	1,030	85.8	2,409
Sighting	419	104.8	745	124.2	1,164

(near land station), and the waters where sperm whales were found were limited within 141°20′E–142°50′E and 35°30′N–37°20′N. The positions of sperm whale schools found are shown in Figs. 1–3.

Whale sighting cruises were carried out by *Ryuho maru* from 21–24 January and on 5 February and by *Ryuho maru No. 5* from 30 January to 2 Febraury and on 5 February. Research area developed eastward to 147°10′E and northward to 40°50′N during the period, but enough research was not made due to bad weather conditions.

Weather condition

Investigation at sea was often difficult as cold waves hit frequently research area and seasonal wind from north-west blew strongly. Tables 3 and 4 show weather conditions at noon of each day on two catcher boats during investigation period. Table 5 shows the composition of average wind force and the investigation hours of each day except the days spent for towing whales. The latter half of the investigation period was worse in weather condition than the earlier half. Wind blew stronger in off-shore waters than in in-shore waters, and this was the main cause of the lack of success of whale sighting cruises during the investigation period.

Sea condition

Figs. 1 and 2 show surface water temperature in the investigation areas by use of data collected by the catcher boats every 2 hours during research times. As shown in Fig. 1, Kuroshio current swept eastward off Boso Peninsula, and dense distribution of isothermal lines was formed in the research area during the earlier half of investigation period, but the current axis of Kuroshio moved southward in the later half. On the other hand, in northern area, Oyashio moved remarkably along the coast of Sanriku in the later half of the period compared with the earlier half. These phenomena show that sea condition changed largely during the investigation period.

Sperm whale schools were found in the waters of 12.0°–16.9°C in the earlier half, but a school was found in the waters of 10.4°C in the later half of the period. It may be that the sperm whale schools had a tendency to swim northward in the period, and also they did not change their distribution position notwithstanding the cold water mass which moved southward. For the examination of the relationship between the distribution of sperm whales and the sea condition, collection of environmental information under the water surface where food organizms are distributed is needed.

Table 3

Outline of investigation by *Ryuho maru*.

	At noon								
Date	Position	Weather	W.D.	W.F.	Vis.	W.T.	Distance	Inv.	Marine mammals found
11 Jan.	36°11′N, 142°27′E	BC	290	3	10	15.8	127	O	P1(20), R1(10).
12 ,,	38°04′N, 141°47′E	SF	310	6	7	11.8	31	O	
13 ,,	36°41′N, 141°47′E	C	360	3	10	12.2	146	O	P1(10).
14 ,,	37°03′N, 143°24′E	O	270	4–5	10	12.4	144	O	
15 ,,	36°11′N, 142°09′E	BC	310	7	10	12.4	99	O	S1(7–8), P2(30).
16 ,,	38°44′N, 141°49′E	B	290	3	10	11.9	–	T	
17 ,,	36°14′N, 142°37′E	M	230	4	7	15.6	117	O	S1(15), B1(20), P1(50), K1(20), R1(20).
18 ,,	38°38′N, 141°54′E	B	290	5	10	11.9	–	T	
19 ,,	35°43′N, 142°28′E	BC	230	1	10	16.8	96	O	T2(10), F1(2), S2(25), P1(20), R1(5–6).
20 ,,	38°28′N, 142°10′E	S	290	4	0	11.0	–	T	
21 ,,	40°43′N, 143°16′E	S	310	7	2–3	7.1	41	S	
22 ,,	39°52′N, 144°17′E	BC	290	6	10	8.1	134	S	T4(25), F7(42).
23 ,,	37°40′N, 146°17′E	BC	310	5	10	15.5	141	S	T1(5), K1(20).
24 ,,	37°03′N, 145°39′E	BC	310	8	10	15.1	–	S	
25 ,,	36°48′N, 142°26′E	BC	250	5	10	12.3	103	O	S1(15), P3(76–77), K1(20), T4(25), F1(3).
26 ,,	39°20′N, 142°02′E	B	310	6	10	8.2	–	T	
27 ,,	36°13′N, 141°44′E	BC	290	7	10	12.4	82	O	S1(10), T1(10).
28 ,,	38°17′N, 141°37′E	BC	290	4	10	8.5	–	T	
29 ,,	36°28′N, 142°00′E	BC	250	5	10	12.8	96	O	S1(30), K1(20), R1(20), F5(12).
30 ,,	39°05′N, 141°58′E	S	290	6–7	8	7.4	–	T	
31 ,,	36°11′N, 141°29′E	B	310	7	10	15.6	103	O	S1(7–8), P2(50), R1(30), F4(9–10).
1 Feb.	39°14′N, 142°00′E	CM	160	1	10	8.7	–	T	
2 ,,	36°09′N, 141°46′E	BC	225	4	10	12.6	113	O	S1(20), T1(10), F1(2).
3 ,,	Ohsawa station							T	
4 ,,	37°27′N, 141°53′E	BC	310	4	10	11.5	122	O	S4(40).
5 ,,	39°09′N, 142°05′E	O	45	3	10	7.7	103	S	

W.D.: Wind direction (°), W.F.: Wind force (Beaufort), Vis.: Visibility (miles), W.T.: Water temperature (°C), Distance: miles,
Inv.: Type of investigation, O: Operating, T: Towing, S: Sighting.
Marine mammals found, P: Pilot whale, R: Right whale dolphin, S: Sperm whale, B: Bottlenosed dolphin, K: Killer whale, T: True's porpoise, F: Norther fur seal, S1(10) means 1 school of 10 sperm whales.

Table 4

Outline of investigation by *Ryuho maru No. 5.*

	At noon								
Date	Position	Weather	W.D.	W.F.	Vis.	W.T.	Distance	Inv.	Marine mammals found
11 Jan.	36°20'N, 141°39'E	B	270	3	9	15.3	106	O	S1(11).
12 ,,	39°14'N, 142°01'E	B	310	3	3	9.8	–	T	
13 ,,	36°51'N, 142°22'E	C	360	3	9	12.2	126	O	S1(18), P1(20).
14 ,,	39°15'N, 142°07'E	R	220	2	4	9.2	–	T	
15 ,,	36°33'N, 143°17'E	BC	340	6–7	9	13.0	129	O	T1(10).
16 ,,	35°34'N, 142°44'E	B	340	4	9	15.2	114	O	S2(12, ?), K1(15).
17 ,,	38°49'N, 142°15'E	BC	200	3	8	9.0	–	T	
18 ,,	35°33'N, 142°19'E	BC	340	7	8	15.1	89	O	S1(12).
19 ,,	39°23'N, 142°05'E	C	250	4	9	8.5	–	T	
20 ,,	36°01'N, 141°29'E	B	270	5	9	13.1	75	O	S1(26), K1(10).
21 ,,	38°54'N, 141°53'E	O	270	6	1–5	8.2	–	T	
22 ,,	36°39'N, 141°34'E	B	340	1	10	12.1	61	O	S1(28), P1(50–60), P+T1(50–60), T1(7–8), F1(1).
23 ,,	Ohsawa station							T	
24 ,,	35°54'N, 141°50'E	BC	310	7	7	15.0	92	O	S4(7, 15, 15, 30).
25 ,,	Ohsawa station							T	
26 ,,	36°39'N, 141°50'E	B	320	7	7	12.2	35	O	S1(10).
27 ,,	38°14'N, 142°26'E	BC	290	6	8	11.6	118	S	T1(7).
28 ,,	37°16'N, 142°09'E	B	310	7	7	11.3	21	O	S1(31).
29 ,,	Ohsawa station							T	
30 ,,	39°38'N, 145°51'E	C	340	7	6–7	7.8	102	S	
31 ,,	38°24'N, 146°55'E	BC	320	6	8	10.1	142	S	S1(10).
1 Feb.	36°19'N, 145°43'E	O	110	4	7	15.6	137	S	T1(8).
2 ,,	36°42'N, 143°38'E	B	250	4	10	14.8	145	S	P1(30).
3 ,,	36°08'N, 141°38'E	B	340	3	10	12.7	114	O	S1(16), T1(8).
4 ,,	Ohsawa station							T	
5 ,,	39°10'N, 142°17'E	O	45	3	7	7.8	101	S	F1(7–8).

Notations are the same as in Table 3.

Topography of sea bottom

Fig. 3 shows the distribution of depth contour lines in the research area. Sperm whale schools were all found in the waters of 1,000–5,000 m in depth, and it is remarkable that several schools were found on a bank (3,600 m deep on the top) at 142°40'E and 35°45'N. This will be also concerned with the behaviour of food organizms of the sperm whale.

Compositions of sperm whale schools

Numbers of schools and individuals of sperm whales found during the investigation period are shown in Table 6.

The maximum number of individuals in a school was 31, and minimum size was 3–4. The average size of school was 14.

Table 7 shows school composition of sperm whales found and caught in the operation times. Two 'harem'

Table 5

Average wind force in research hours.

	Wind force						
Dates	2.0–	3.0–	4.0–	5.0–	6.0–	7.0–	Average
11–23 Jan.	5	2	3	2	5	–	4.50
24 Jan.–5 Feb.	1	4	2	3	6	1	5.21
Total	6	6	5	5	11	1	4.86

Table 6

Sperm whale schools found.

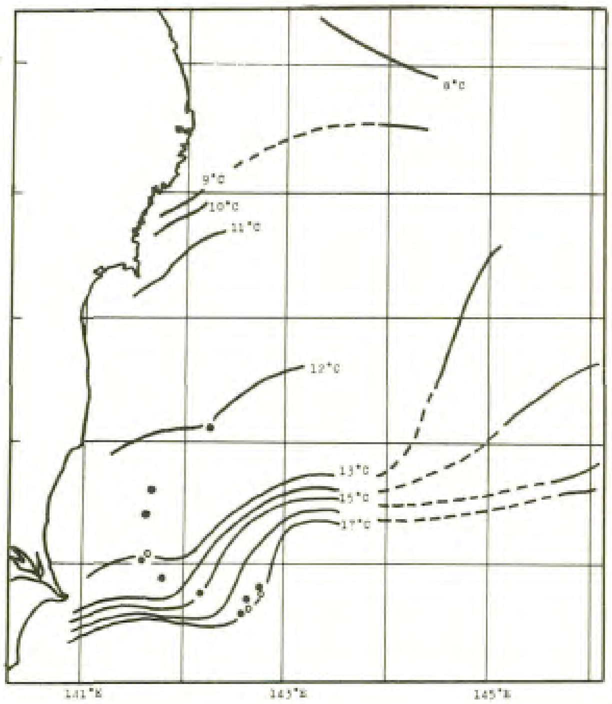
Research		Ryuho maru	Ryuho maru No. 5	Total
Sighting	Schools	–	1	1
	Whales	–	10	10
Operation	Schools	14	14	28
	Whales	174–176	220†	396+
Total	Schools	14	15	29
	Whales	174–176	230+	406+
	Average size	12.5	16.4	14.0

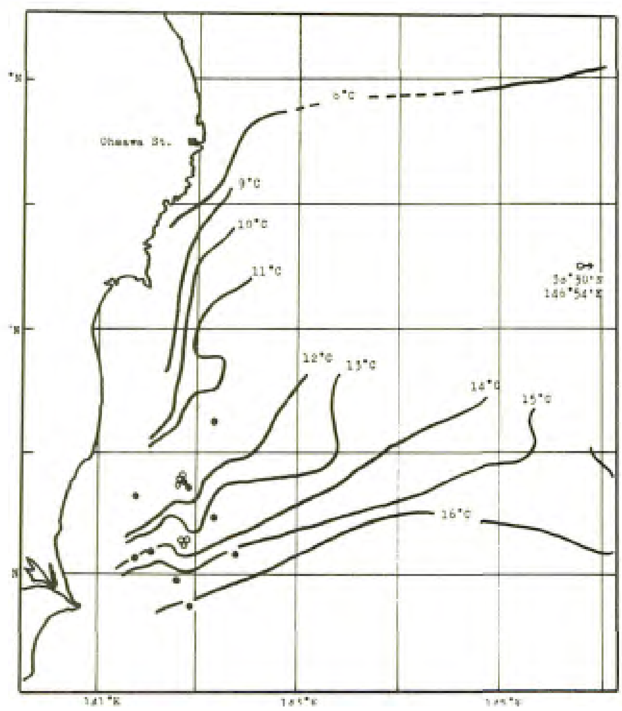
Table 7

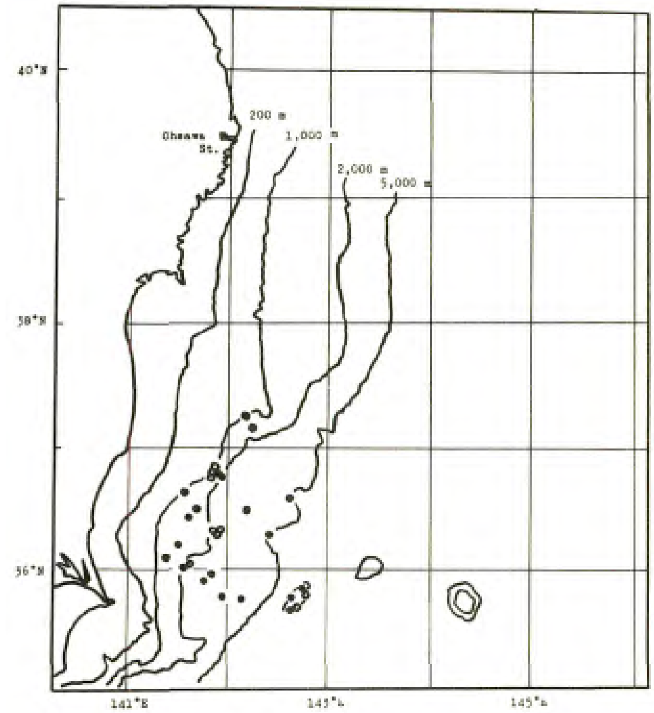
Outlines of sperm whale schools which were found and caught simultaneously.

School	Date	Time	Position found	Direction		School composition							Catch	Relation with others
				Swim.	Escape	50<	40<	35<	30<	25<	Calf	Total		
R1	15 Jan.	14:20	35°52′N, 141°47′E	NNE	SE	–	–	–	5	–	2	7	3	
R2	17 ,,	15:05	35°40′N, 142°39′E	NW	SSW	–	1	–	8	4	3	16	4	With R1(20), K1(20), P1(50), B1(20).
R3	19 ,,	13:50	35°36′N, 142°39′E	Circle	ESE	–	–	–	8	3	4	15	4	S1(10)90°6′, K1(10), P1(20), R1(6).
R4	25 ,,	14:00	35°16′N, 142°26′E	Stop		–	–	–	8	3	4	15	5	With K1(20), P2(70).
R5	27 ,,	13:45	36°09′N, 141°22′E	NW	WSW	–	–	1	4	1	4	10	4	
R6	29 ,,	14:20	36°14′N, 141°32′E	WSW	SE	–	–	3	10	10	7–8	30–31	2	
R7	31 ,,	15:00	35°43′N, 141°58′E	NW	SSW	–	–	1	3	2	2	8	2	
R8	2 Feb.	14:15	36°30′N, 142°10′E	NW	SSE	1	–	4	10	2	3	20	4	
R9	4 ,,	07:35	36°45′N, 141°53′E	NW	SE	–	–	5	5	–	–	10	2	S1(10)45°1′, S1(10)180°0.5′, S1(10)180°1.5′.
5R1	11 Jan.	12:40	36°32′N, 141°41′E	NNE	SE	–	–	–	6–7	5	–	11–12	6	
5R2	13 ,,	16:15	37°07′N, 142°17′E	S	ESE	–	1	11	2	2	2	18	6	P1(20)200°2′.
5R3	16 ,,	14:25	35°48′N, 142°47′E	ESE	SE	–	–	7	3	2	–	12	5	S1(?)45°58′, K1(15)110°3.5′.
5R4	18 ,,	12:45	35°46′N, 142°10′E	SSE	ENE	–	–	2	8	2	–	12	3	
5R5	20 ,,	12:15	36°01′N, 141°33′E	WSW	SSE	–	–	3	10	3	–	16	6	S1(10)200°6′, K1(10)130°2′.
5R6	22 ,,	06:35	36°27′N, 141°37′E	WNW	SE	–	–	2	22	4	–	28	7	
5R7	24 ,,	09:45	35°57′N, 141°49′E	N	SSE	–	–	4	3	–	–	7	4	S2(30)20°19′, S1(30)20°19′.
5R8	26 ,,	08:30	36°43′N, 141°56′E	WSW	SSW	–	–	4	4	2	–	10	5	
5R9	28 ,,	08:20	37°14′N, 142°10′E	E	Circle	1	–	–	10	10	10	31	4	
5R10	3 Feb.	14:35	36°40′N, 141°33′E	ENE	SSE	–	2	10	4	–	–	16	4	

B: Bottle-nosed dolphin, K: Killer whale, P: Pilot whale, R: Right whale dolphin, S: Sperm whale.
S1(10)90°3′ means 1 school of 10 sperm whales found at the position 90° in direction and 3 miles apart from the position where the main sperm whale school was found.


8°C
9°C
10°C
11°C
12°C
13°C
15°C
17°C
141°E
143°E
145°E


Ohmawa St.
9°C
10°C
11°C
12°C
13°C
14°C
15°C
16°C
141°E
143°E
145°E



40°N
38°N
36°N
200 m
Ohsawa
St.
1,000 m
2,000 m
5,000 m
141°E
143°E
145°E

Table 10

Size distribution of sperm whales caught.

Length (m)	Males				Females					
	Imm.	Pub.	Mat.	Total	Imm.	Preg.	Lact.	Rest.	Unkn.	Total
9.2–	–	–	–	–	3	–	–	–	–	3
9.4–	–	–	–	–	3	–	1	–	–	4
9.6–	1	–	–	1	–	–	1	–	–	1
9.8–	–	1	–	1	1	–	–	4	–	5
10.0–	1	–	–	1	–	2*	1	1	–	4
10.2–	–	1	–	1	–	4	2	3	–	9
10.4–	–	–	–	–	–	1	2	1	–	4
10.6–	–	1	–	1	–	1	–	6	1	8
10.8–	–	1	–	1	–	2	2	4	–	8
11.0–	–	–	–	–	–	2*	–	3	–	5
11.2–	–	–	–	–	–	2	–	8	–	10
11.4–	–	2	–	2	–	–	–	2	–	2
11.6–	–	1	–	1	–	1	–	1	–	2
11.8–	–	–	–	–	–	–	–	1	–	1
12.0–	–	–	–	–	–	–	–	2**	–	2
12.2–	–	–	–	–	–	–	–	–	–	–
13.0–13.1	–	1	–	1	–	–	–	–	–	–
16.6–16.7	–	–	2	2	–	–	–	–	–	–
Total	2	8	2	12	7	15	9	36	1	68

* One lost foetus ** Ovaries of one still to be examined.

Foetuses

Two foetuses were considered to be lost, estimating from the size of uterus and ovaries. Among 13 foetuses found, 8 were male and 5 were female. Body lengths of the foetuses ranged between 128 and 246 cm, and the average was 183.8 cm. By use of growth curve of foetus, conception season was estimated to be March – July, 1975, for the group caught in this investigation.

Table 11

Eruption of mandibular tooth row.

Eruption	Males			Females	
	Imm.	Pub.	Mat.	Imm.	Mat.
–	–	–	–	3	–
±	2	–	–	4	–
+	–	6	–	–	11
++	–	2	2	–	48
Total	2	8	2	7	59

–: Not erupted, ±: Just erupted, +: Erupted, but top of tooth row is not erupted, ++: Fully erupted.

Lactation

Milk was found from mammary glands of 9 females, but it was yellow or brown in 7 individuals among them. There were no whales from which much amount of white milk was secreted. They are estimated to be near weaning period. According to the observation by one of us on board a catcher boat, very small calves were not found. Mammary glands were collected for histological examination.

Table 12 shows the frequency of depth of mammary gland by sexual condition. It was found that the measurement of depth of mammary gland was in practice rather difficult. There is a need to standardize internationally the method of measurement of mammary gland of the sperm whale. The depths of lactating mammary gland were 12 cm and over. The definition of lactating females of the sperm whale in the Schedule of the Convention must be re-examined.

Ovarian follicles were very small in most lactating females, but one female had a follicle of 4.5 cm diameter.

Resting females

Resting females were 36, and 60% of the sexually mature females. Almost all of these resting whales had very small ovarian follicles, but one resting female had a follicle of 3.5 cm diameter. It may be concluded that the sperm whales which were distributed in the waters of the research area in this investigation period were not in the breeding season. The resting whales which were caught from two schools with harem bulls had no mature follicles.

Table 12

Depth of mammary gland.

Depth (cm)	Immature	Pregnant	Lactating	Resting
3	1	–	–	–
4	3	–	–	–
5	–	–	–	2
6	1	2	–	3
7	1	2	–	2
8	1	5	–	7
9	–	2	–	7
10	–	1	–	4
11	–	1	–	–
12	–	1	1	2
13	–	–	2	–
14	–	–	2	–
15	–	–	3	–
16	–	–	1	–
Total	7	14	9	27

Stomach contents

Stomach contents were one of the major items of this investigation. Unlike the baleen whales, it is not enough to examine the first stomach chamber only, for much amount of food was found from the second chamber, and sometimes the contents in the second chamber are more fresh than those in the first chamber. Therefore, we regard both the contents in the first and second stomach chambers as stomach contents. It is notable that the contents in the second chamber are often recorded as food in ordinary whaling, for it is hard to examine the first stomach only in busy processing of carcasses. The second chamber is larger than the first one, and easier to be found by workers. It takes much time to open the first chamber after cutting off the diaphragm and liver.

Food species

Almost all food investigated were squids, but fishes belonging to the Lophiida and Gadida were found with squids from two whales. Squids were roughly classified into several groups, and the head number counted as shown in Table 13.

Table 13

Classification of squids in stomach contents.

Family	Males (8 whales) Total heads	Males (8 whales) Per whale	Females (43 whales) Total heads	Females (43 whales) Per whale
Octopoteuthidae	2	0.25	3	0.07
Onychoteuthidae	42	5.25	49	1.14
Gonatidae	19	2.38	3	0.07
Architeuthidae	1	0.13	1	0.02
Histioteuthidae	41	5.13	206	4.79
Ommastrephidae	4	0.50	125	2.91
Thysanoteuthidae	1	0.13	86	2.00
Cranchiidae	–	–	1	0.02

All families belong to the Oegopsida. They were not represented as weight. Body weights are largely different by species and by growth. There may be sexual difference in the food species.

Stomach contents were collected as much as possible, and they are in preparation for species identification in laboratory. Some of the above classification which was made in land station may be changed by the laboratory work.

As foreign bodies, fragments of a plastic bucket and bag were found from the stomachs of two whales.

Weights of stomach contents

It is difficult to measure the food weight in practice, because foods are usually in digestion at the time when the whale is caught.

The stomach contents in the first and second chambers were weighed for each whale. Table 14 shows the frequency distribution of the weights of contents.

The whales with empty stomachs were 6.6% of the whales of which stomach contents were weighed. The maximum weight was 97.8 and 58.1 kg in a male and female, respectively. The ratio of stomach contents to body weight of these whales is 0.47 and 0.56% in male and female, respectively. These values are very small compared with estimated food consumption per day. If the above ratio is actually the amount of food taken at one time, sperm whales must take food several times in a day.

As shown in Table 16, there is no clear relationship between the time of day and the weight of stomach contents, and large amounts of food were found from the whales which were caught in the afternoon. Besides this, the foods were relatively fresh as shown in Table 15. One problem to be solved is the digestion time of squids in the stomach, but it may be not so unnatural to consider that the sperm whale takes food even in the day time from the above examination.

Table 17 shows an example of stomach contents of whales caught from the same school. There are large individual variation of food species, weight and freshness of food. There were many similar cases in other schools. It may be supported from these phenomena that each individual takes food as its manner even in the same school.

Parasites

There was no whale in which diatom film covered clearly, but diatom colonies of 1–2 mm in diameter were scattered on the skin of some whales.

Open pits or un-healed scars were observed on the skins of many whales.

A few whale lice were found on the skin of 8 whales, and a *Conchoderma* and sea-lentil were attached to a mandibular tooth of top of tooth row of a whale.

It may be estimated from above features that most of the sperm whales which were caught during the investigation period had not stayed in the higher latitudinal waters for a long time, but had come from southern waters.

Table 14

Food weights of the sperm whales.

	Weight (kg.)											
Sex	0	0.1–	10–	20–	30–	40–	50–	60–	70–	80–	90–	Total
Males	1	3	2	1	1	1	–	–	–	1	1	11
Females	3	21	11	7	3	3	2	–	–	–	–	50
Total	4	24	13	8	4	4	2	–	–	1	1	61

Table 15

Data on whales from which large amounts of food were found

Sex	Length (m)	Wt. (ton)	Wt. (kg.)	Stomach contents Species	Stomach contents Freshness	Date, time
Male	13.0	20.8	97.8	On. 12, Go. 8, Ar. 1, Hi. 19	fff	F/3/15:00
Male	16.7	46.3	89.3	On. 3, Oc. 1, Hi. 4, Om. 1	ff	F/2/15:00
Female	10.4	10.3	58.1	Oc. 1, On. 2	fff	F/3/16:20
Female	9.5	7.7	51.8	On. 2, Ar. 1, Om. 30, Th. 17, Hi. 3	ff	F/4/08:20

Remarks: Oc.: Octopoteuthidae, On.: Onychoteuthidae, Go.: Gonatidae, Ar.: Architeuthidae, Om.: Ommastrephidae, Hi.: Histioteuthidae; Th.: Thysanoteuthidae.

Table 16

Relation between catch time and food weight.

Time of day	Weights of stomach contents (kg.)						
	0	0.1–	10–	30–	50–	70–	Total
7	1	1	3	–	–	–	5
8	1	4	–	–	1	–	6
9	–	2	1	2	–	–	5
10	1	4	1	1	–	–	7
11	–	–	1	–	–	–	1
12	–	1	–	–	–	–	1
13	–	1	1	–	–	–	2
14	–	3	5	1	–	–	9
15	1	6	8	2	–	–	17
16	–	1	1	1	1	2	6
17	–	1	–	–	–	–	1

Table 17

Stomach contents of whales in School No. 5R10.

Sex	Length (m)	Time caught	Weight (kg.)	Stomach contents	
				Species and number	Freshness
Male	13.0	15:00	97.8	On.12, Go.8, Ar.1, Hi.19	fff
Female	11.9	15:30	7.1	On.1, Th.1, ? 4	f
,,	9.9	15:50	28.0	On.2, Go.11, Om.3, Hi.1, Th.1, ? 2	ff
,,	10.4	16:20	38.1	On.2, Oc.1	fff

Anisakis spp. was found from the stomach of all whales examined, and cysts of parasites were often found in the blubber.

Other items in examination

1. Age: A maxillary tooth was collected from each whale, but the dentinal growth layers have not yet been counted for age determination.
2. Ovaries: All ovaries found were collected and fixed in formaline, and they are in the laboratory to count and measure the corpora lutea, corpora albicantia and ovarian follicles.
3. Testes and mammary gland tissues: Collected for histological examination.
4. Epiphyses: Observed the fusion of epiphyses for study of physical maturity.
5. Tooth scars on skin: Recorded the condition and distribution of tooth scars for the study of behaviour of sperm whales.
6. Stomach contents: Already noted.
7. Frozen liver tissue: Collected for biochemical analysis, but most samples are bad, for it took a long time from kill to collection.
8. Thickness of blubber: Measured on all whales caught.
9. Cost and production: The report from the company not yet received.
10. Whale mark: No whale mark was recovered from the whales caught.

ACKNOWLEDGEMENT

We are indebted to the staff of the Fisheries Agency on the business of issuing the permit for the present investigation.

We express our sincere thanks for the cooperation of Nittoh Hogei Co. Ltd., including staff, whalers and workers.

Our sincere thanks are also due to Dr Hideo Omura, director of the Whales Research Institute, for his kind help to us.

Sperm Whales in the Equatorial Eastern Pacific: Population Size and Social Organization

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ABSTRACT

A calculated population of about 81,000 (±30,000) sperm whales *Physeter macrocephalus* was found in the eastern Pacific within 10 degrees of the equator, from 80°W to 110°W longitude, in February-April 1975. Five breeding aggregations observed each consisted of 40 to 120 individuals (total 415); 13 apparent bachelor groups each consisted of 1 to 40 individuals (total 169). Sperm whale populations in the equatorial Pacific possibly comprise a stock separate from those at higher latitudes.

INTRODUCTION

The major objective of the 1975 Soviet-American Cooperative Cetacean Research Cruise was to determine the distribution, numbers, and movements of the great whales, particularly sperm whales *Physeter macrocephalus*[1], in the equatorial region of the eastern Pacific Ocean.

The vessel was the catcher boat *Vnushitel'nyi*, belonging to Dalmoreproduct Dalriba, Vladivostok. It has a gross tonnage of 844, an overall length of 65 m. (213 ft.), and a 4,000 horsepower diesel-electric power plant. The cruising speed is 10 knots and the top speed 18 knots.

The cetologists aboard were A. Berzin (TINRO, Vladivostok), W. E. Evans (Naval Undersea Center, San Diego; for first half of cruise only), and myself. I. Moroz (cruise leader), A. Volkov, and two technicians (all with TINRO) comprised the remainder of the scientific staff.

We departed from San Pedro, California, on 18 February 1975 and sailed a series of pre-established transects between the equator and 10°S latitude (Fig. 1). From 20 to 24 March we stopped at Balboa, Canal Zone. We then sailed a series of transects between the equator and 17°N latitude. The cruise terminated at Balboa on 26 April.

A total of 89 sperm whales was marked with Discovery-type marks. Particulars are on file at TINRO, Vladivostok.

Physical and biological oceanographic data were regularly recorded at a series of stations (Fig. 1).

The interpretations and conclusions presented in this paper are my own, and do not necessarily represent those of Berzin or Evans.

Michael F. Tillman calculated the confidence intervals.

POPULATION SIZE

The total population in each 10° square of latitude and longitude has been calculated with the formula used by Gambell, Best, and Rice (1975):

where $P = N \times A / (D \times W)$
P = population
N = number of whales observed
A = area of square
D = distance cruised
W = average width of transect

The variance of P and a 95% confidence interval were approximated by using the 'delta method' (Seber, 1973). Since W is an average value calculated from several observations,

where $\mathrm{Var}(P) = (dP/dW)^2 \times \mathrm{Var}(W)$
$dP/dW = -(N \times A/D \times W^2) = -(\hat{P}/W)$
$\mathrm{Var}(W) = \text{Sum of squares } (W)/n \times (n-1)$
n = number of observed values of W

Given these definitions, a 95% confidence limit for P may then be approximated as

$$\hat{P} \pm 2 \times \sqrt{\mathrm{Var}(P)}$$

Sperm whales were encountered on 19 occasions, and the estimated total number of individuals was 614 (Table 1).

The total water area of the ten 10° squares surveyed between 20°N and 10°S latitude was 2,917,000 square miles or 10,003,000 square kilometers (Table 2). The six squares between 10°N and 10°S latitude, from 80°W to 110°W longitude, in which almost all the sightings were made, totalled 2,081,000 square miles, or 7,136,000 square kilometers.

The total distance covered during the cruise was about 13,500 miles (25,000 km.), of which 12,630 miles (23,388 km.) were between 20°N and 10°S latitude (Fig. 1). This does not include excursions from the established course in pursuit of marine mammals. A regular watch for mammals was maintained from sunrise to sunset. This included one man in the crows nest, and two on the bridge in addition to the helmsman. The officer on duty also spent most of his watch on the bridge. I spent about 10 hours a day on watch, and Berzin and Evans were also on watch much of the day. In addition, there were usually several off-duty crew members on the bridge. Throughout the cruise, there were almost exactly twelve hours between sunrise and sunset, so the distance cruised during daylight was half the distance of the total cruise track (Table 3). This totals 6,315 miles (11,694 km.) between 20°N and 10°S latitude, and 4,875 miles (9,028 km.) between 10°N and 10°S latitude from 80°W to 110°W longitude. The amount of time that visibility was significantly impaired by weather was negligible. Where the ship's track coincided with the boundary between two ten-degree squares, I have allotted half the distance to each of the squares (except for the leg along the 110th meridian from 0°30'N to 10°00'N, the western boundary of the study area, which was entirely allotted to the square immediately to the east).

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[1] For nomenclature, see Husson and Holthuis (1974).

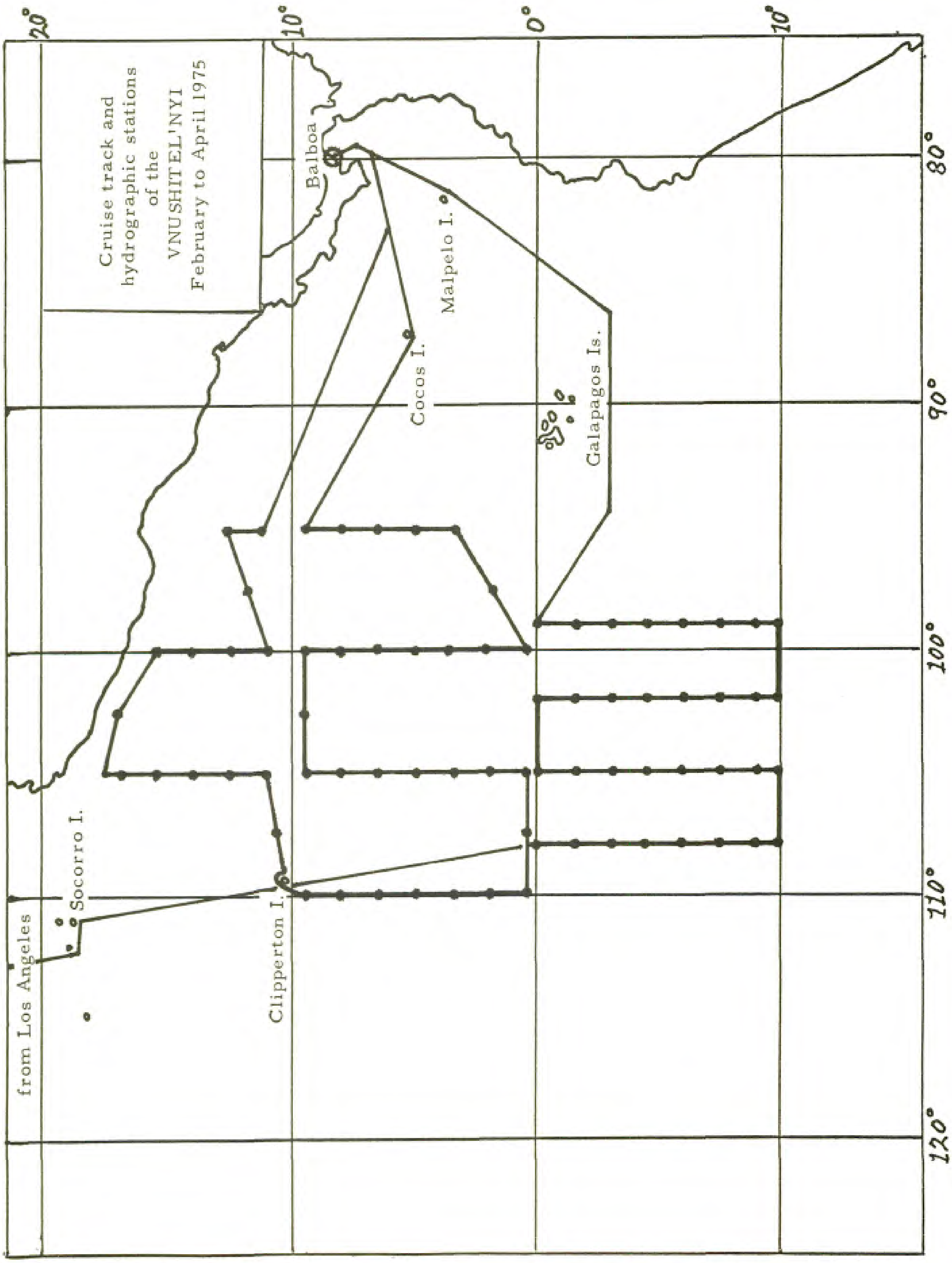
Cruise track and
hydrographic stations
of the
VNUSHITEL'NYI
February to April 1975
Balboa
Malpelo I.
Cocos I.
Galapagos Is.
Clipperton I.
Socorro I.
from Los Angeles
20°
10°
0°
10°
80°
90°
100°
110°
120°

Fig. 1.

Table 1

Sperm whales sighted during the cruise of the *Vnushitel'nyi*

Date	Position	Number	School type*
28 Feb 1975	03°08'S 108°00'W	55	Bs
28 Feb 1975	03°17'S 108°00'W	40	Ms
1 Mar 1975	05°50'S 108°16'W	30	Ms
3 Mar 1975	10°00'S 106°27'W	1	Ms
3 Mar 1975	10°00'S 106°22'W	2	Ms
3 Mar 1975	10°00'S 106°19'W	1	Ms
11 Mar 1975	09°20'S 99°02'W	4	M
14 Mar 1975	00°58'S 98°58'W	40	Bs
16 Mar 1975	02°53'S 92°40'W	16	Ml
17 Mar 1975	02°15'S 86°20'W	120	Bs
29 Mar 1975	09°12'N 94°04'W	100	Bs
2 Apr 1975	00°59'N 99°15'W	30	?
4 Apr 1975	07°34'N 99°55'W	28	Mm
5 Apr 1975	09°20'N 100°00'W	30	Mm
8 Apr 1975	04°30'N 105°10'W	100	Bsm
9 Apr 1975	01°40'N 105°00'W	10	Mm
22 Apr 1975	10°28'N 93°48'W	2	Mm
22 Apr 1975	10°17'N 93°27'W	2	M
24 Apr 1975	05°45'N 84°58'W	3	M

* B = breeding school; M = bachelor school;
s = small (<11 m); m = medium (11–14 m);
l = large (>14 m)

Table 2

Water area of each 10° square surveyed in the eastern Pacific (in thousands of square nautical miles)

	West Longitude				
Latitude	120–110°	110–100°	100–90°	90–80°	80–70°
20–10°N	326	293	163	–	–
10–0°N	–	357	357	321	54
0–10°S	–	357	350	339	–

Table 3

Distance cruised during daylight in each 10° square (in nautical miles)

	West Longitude				
Latitude	120–110°	110–100°	100–90°	90–80°	80–70°
20–10°N	255	652	352	–	–
10–0°N	–	1,335	740	805	180
0–10°S	–	1,095	680	220	–

Only five accurate records were obtained of the distance from the vessel at which sperm whales were first sighted. These were calculated from the time taken at known speed to close with the animals. The measured distances were 2.0 (3 records), 1.5, and 0.5 miles, a mean of 1.6 miles. The effective transect width is therefore taken to be 3.2 miles (5.9 kilometers). This is the same as the transect width calculated for sperm whales in the southern Indian Ocean (Gambell, Best, and Rice, 1975).

The sum of the individual population estimates for each 10° square (Table 4) is 118,000, for which is obtained a 95% confidence interval of ±20% (Table 5) when individual variances are summed. Although this method is more statistically precise (having a smaller confidence interval), it is biased, giving undue weight to the estimates for those squares that were less intensively sampled. In particular, the high estimate for the square 0°–10°S lat, 80°–90°W long, where only 220 miles were covered, is based on only a single encounter with an unusually large aggregation of sperm whales. If the data from all ten squares are combined, they yield a more reliable, although less precise (±36%), estimate of 89,000 whales. It may be more germane to calculate the population for only the area in which nearly all the sightings were made; this yields an estimate of 81,000 (±30,000) sperm whales within 10° of the equator from 80° to 110°W longitude. The calculated population density in this area is 39 whales per thousand square miles (or 26 square miles per whale).

SOCIAL ORGANIZATION

I classified all groups of sperm whales (except one group of 30) as either breeding schools or as bachelor schools (Table 1). Criteria regarded as diagnostic of breeding schools were presence of calves and presence of animals with calluses on their dorsal fin. Schools with no calves or animals shorter than 10 m. (33 ft.), and no animals with calluses on their dorsal fins, were regarded as bachelor schools.

Five groups, totalling 415 individuals, were classified as breeding groups. These varied in size from 40 to 120 animals. The larger of these groups may have been aggregations of several schools (some of which could have been bachelor schools). Only one of these groups included 'medium' sized (11–14 m.) animals – presumably males. No 'large' (>14 m.) males were seen with breeding groups. The smallest calves observed were estimated to be 4 to 5 m. long.

Thirteen groups, totalling 169 individuals, were assumed to be bachelor schools. These ranged in size from 1 to 40 animals. Five schools (74 individuals) consisted of only 'small' (10–11 m.) animals, 4 schools (70 individuals) consisted of mostly 'medium' (11–14 m.) animals, and only one group (16 individuals) consisted of mostly 'large' animals (>14 m.) The animals in the latter group were lolling at the surface during a glassy calm, and were scat-

Table 4

Calculated population of sperm whales in each 10° square

	West Longitude				
Latitude	120–110°	110–100°	100–90°	90–80°	80–70°
20–10°N	0	0	579	–	–
10–0°N	–	10,446	26,082	374	0
0–10°S	–	13,143	9,650	57,784	–

Table 5

Estimated variances and approximate 95% confidence intervals for sperm whale population estimates

Method	Population Estimate	Variance (10^8)	Confidence Interval*
Sum of individual population estimates for each 10° square	118,000	1.4592	94,000–142,000 (± 20%)
Combined data from all 10° squares	89,000	2.6064	57,000–121,000 (± 36%)
Combined data from 10° squares where most sightings obtained	81,000	2.2000	51,000–111,000 (± 37%)

* Values in parentheses express confidence limits in terms of percentage difference about the estimated population size.

tered singly along five miles of the cruise track. Three groups of apparent males (9 individuals) were not classified according to size.

DISCUSSION

The area that we surveyed has historically been renowned for its abundance of sperm whales. It comprises the 'Galapagos Ground' and the 'Off-shore Ground' where American whalers captured many sperm whales during the 19th century (Townsend, 1935). It is essentially contiguous with three other famous sperm whale grounds – 'On the Line' to the west, and the 'Callao Ground' and 'Panama Bay Ground' to the east. In our three quick transits of the latter ground we encountered no sperm whales.

The relationship of the equatorial stocks of sperm whales to those at higher latitudes is unknown. The 19th century whalers took sperm whales near the equator all across the Pacific the year round. This suggests that they represent a stock separate from the breeding stocks at higher latitudes. Another hypothesis (not mutually exclusive with the first) is that the equatorial populations are comprised of Northern Hemisphere animals during the boreal winter, and of Southern Hemisphere animals during the austral winter. Recovery of whales that we marked should help resolve this question.

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A Matrix Model of Sperm Whale Populations

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Allen (1973) and Ohsumi and Fukuda (1972) have described the development and use of a model of the population dynamics of sperm whales. This model is most completely described in Allen (1973). The basic development of this model appears to be based on the basic life table equation:

$$\sum_{x=0}^{\infty} e^{rx} 1_x m_x = 1.0$$

Here different assumptions of how the probability of survival to age 1_x, and the reproductive rate m_x vary with age can be considered. For different levels of complexity in these assumptions somewhat different models are developed. For different assumptions of mortality and reproduction rates values of the parameter r, the 'intrinsic' rate of increase of the populations, can be computed. In particular when $r = o$ the parameter values are such that the population is not changing in size.

The analysis of these models that has been done involves determining values of mortality and reproductive rates for unexploited populations. The mortality rate of immature animals is adjusted to cause the value of r to be zero. Then values of mortality and reproductive rates for exploited populations are used, and the resulting r value suggests allowable rates of exploitation. The age of entry to the harvesting can be varied in these models, and harvesting rates determined which balance the capacity for increase. Depending on the population size associated with changes in mortality and reproductive rates, the yield associated with these harvesting rates can be computed.

The basic limitation of this modeling approach is that it is primarily oriented towards equilibrium states of the population. Thus the behavior of the population in transition, responding to changes in harvesting rates, is not easily described. A second limitation is that the population is divided into a small number of age groupings, such as immature, and mature or exploited and unexploited. This restricts the level of age specific changes which can be examined.

In this paper I describe a specific example of a variable matrix population model, based ultimately on the work of Leslie (1945, 1948). This modeling approach is oriented towards describing the number of animals alive in each age class over time. Thus it is primarily a dynamic description of changes in the population age structure and size. It is very similar to the above model in its description of equilibrium states, but is rather more complex in that it also describes the transition to equilibrium.

The use of this modeling approach allows the consideration of the state of the population as it moves toward a new equilibrium. It also allows one to better determine the effect on age specific changes in reproductive and mortality rates on the equilibrium points.

There are several points which I am interested in exploring with this tool. These include the possible effects of:

(1) gradual onset of reproductive maturity with age.
(2) decrease in reproductive activity with age,
(3) change in mortality rates with age,
(4) gradual recruitment to the fishery over several years,
(5) non-linear changes in mortality and reproductive rates with population size,
(6) time-lags in the density dependent effect of population size changes,
(7) density dependence on total population size or total female population size, versus total mature female population size,
(8) long transition times to new equilibrium and corresponding gradual decreases in catches, and
(9) changing age of recruitment to the fishery on catches both in numbers and in weight.

In this paper the basic model is described, and some preliminary computations of equilibrium yield of females and corresponding numbers of males available are given.

DESCRIPTION OF MODEL

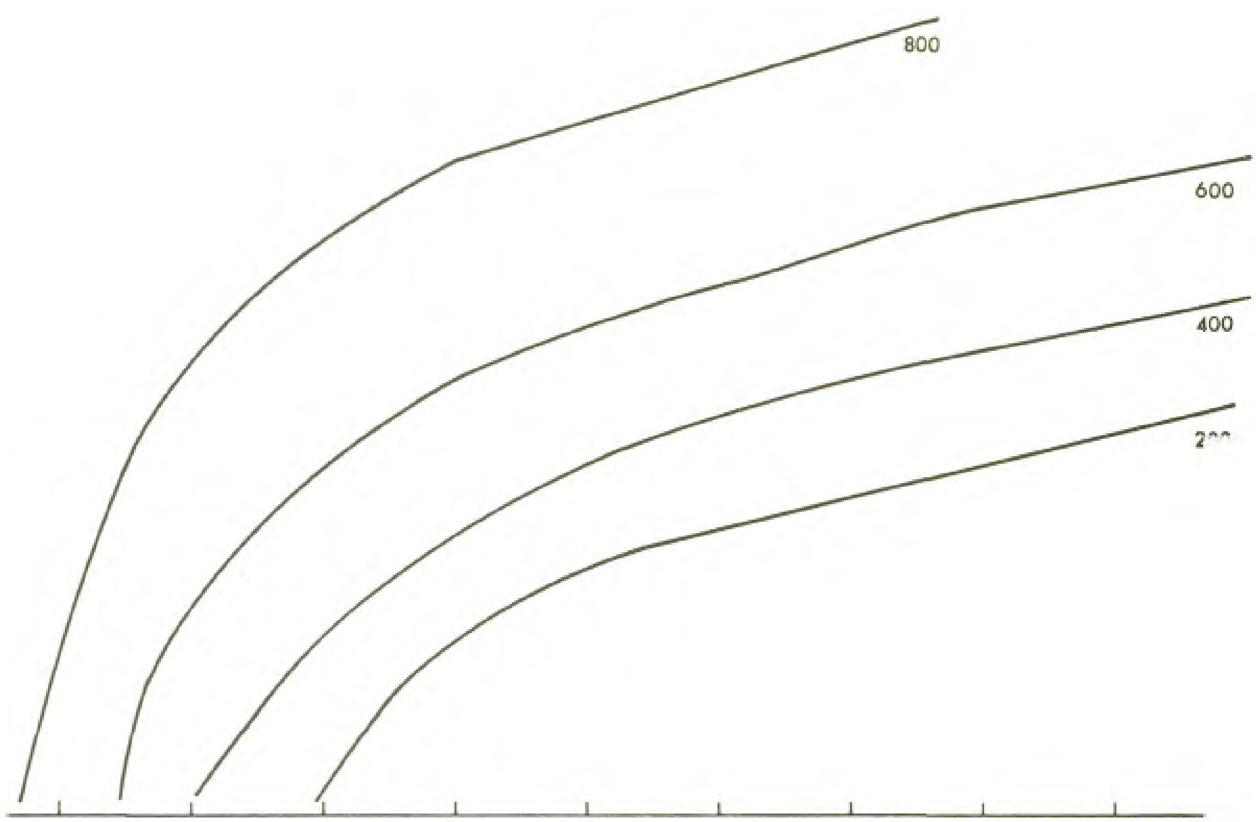
The basic mathematical model used here is a variable Leslie matrix. Its use has been described elsewhere several times (Fowler and Smith, 1973; Smith, 1973; Pennycuick, 1969; Allen, 1973). This basic Leslie matrix model involves a vector denoting the numbers or biomass of females in each age class, and a matrix of reproductive and survival rates describing how the numbers in each age class change each time interval. In the present application the model is 'variable' in the elements of this matrix depending on the size of the female population. Thus the reproductive and/or survival rates are taken to be functions of the population size. The specific functional relationships used are described below. The male population is not necessarily described, although it is added in later.

Denoting the age distribution vector at time t by P_t and the projection matrix as a function of population size P by $M(P_t)$, one has

$$P_{t+1} = M(P_t)*P_t \qquad (1)$$

The number in the i^{th} age class is $P_t(i)$, i=l to k. The elements of the matrix M are denoted M(i,j). The survival rates appear as the M(i+1, i) elements, i = 1 to k − 1. Here k denotes the maximum number of age classes in the population. This is taken to be sixty for sperm whales. The annual reproductive rates multiplied by the survival from birth to age one appear as the $M(1,i)$ elements, i = 1 to k. These elements are defined in the following equations as functions of total population size.

$$M(1,i) = PR * S_o * SR * FM_i/GP \qquad (2)$$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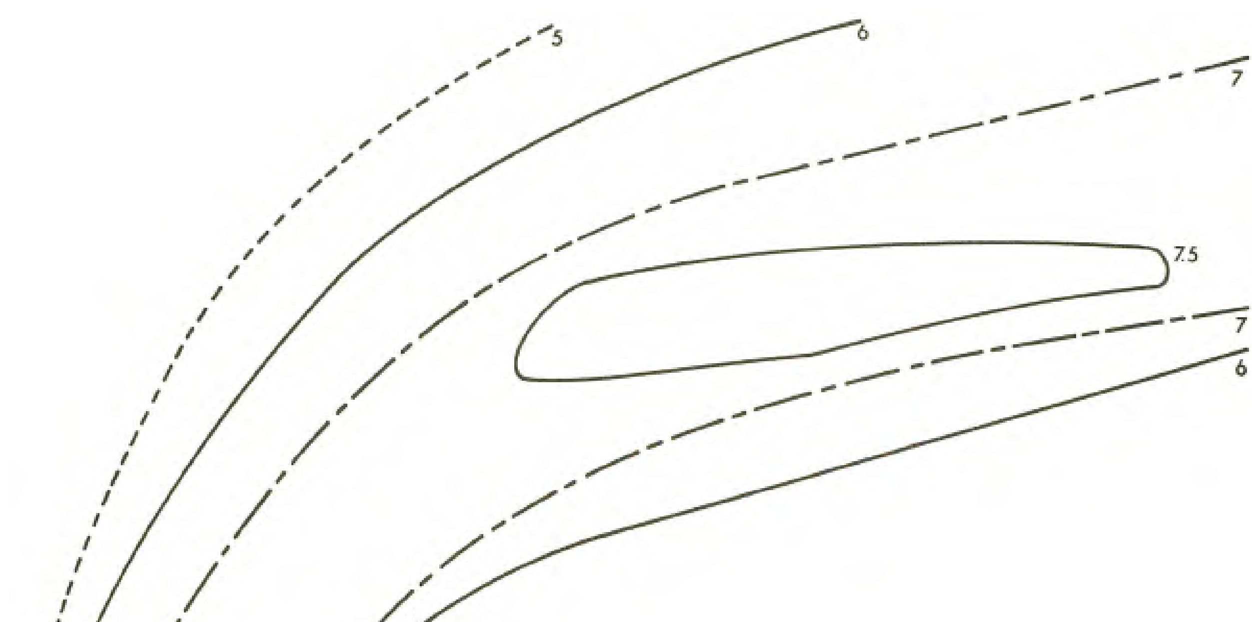
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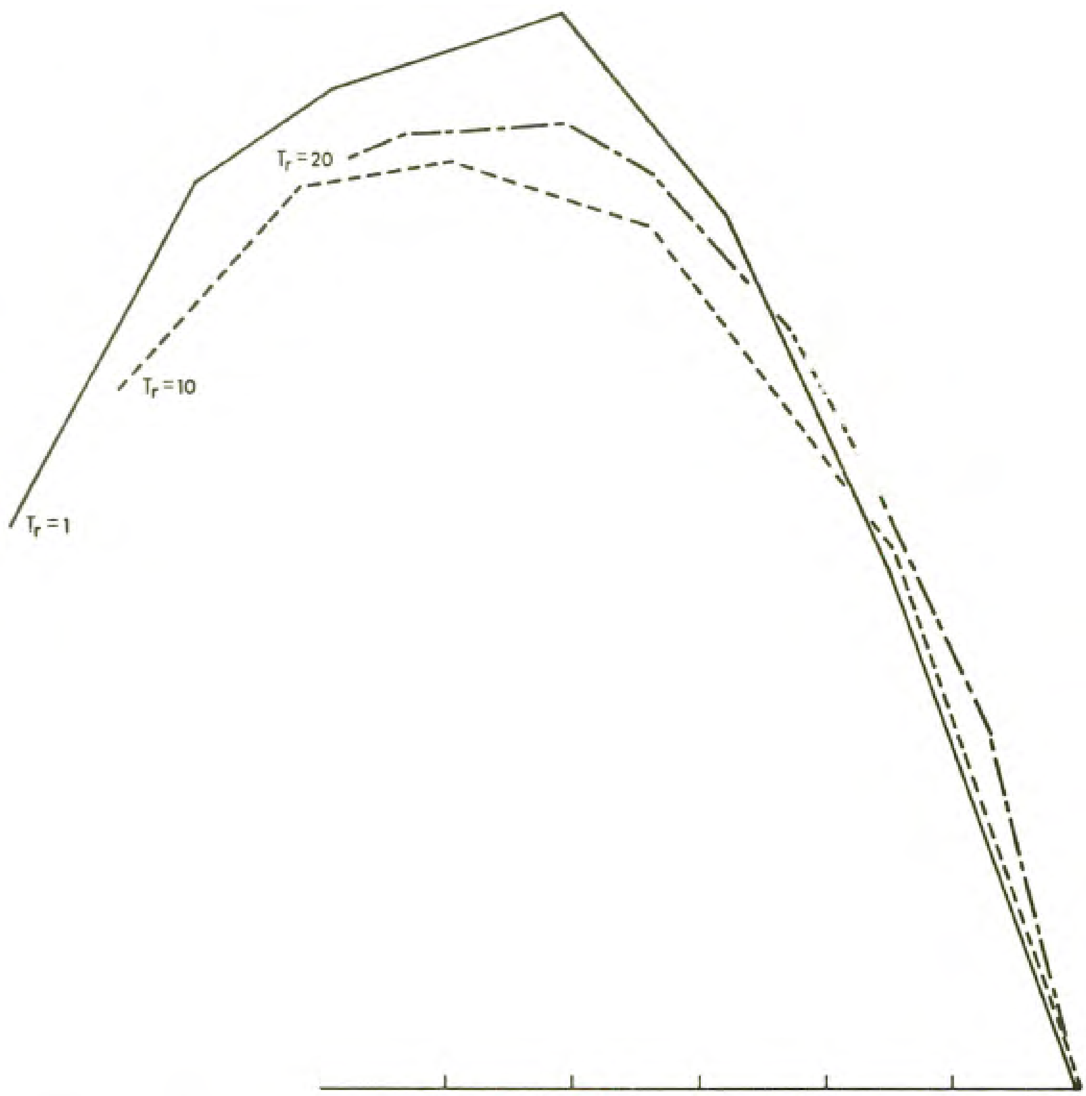
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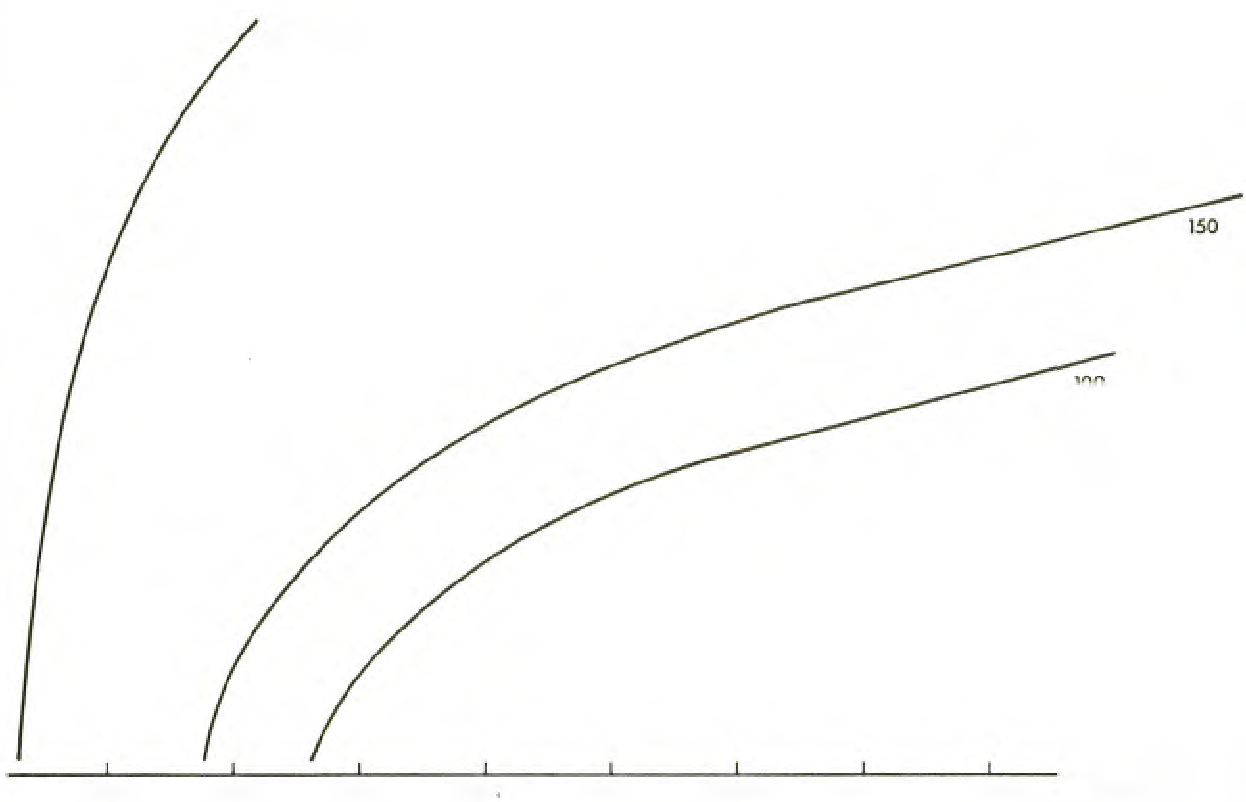
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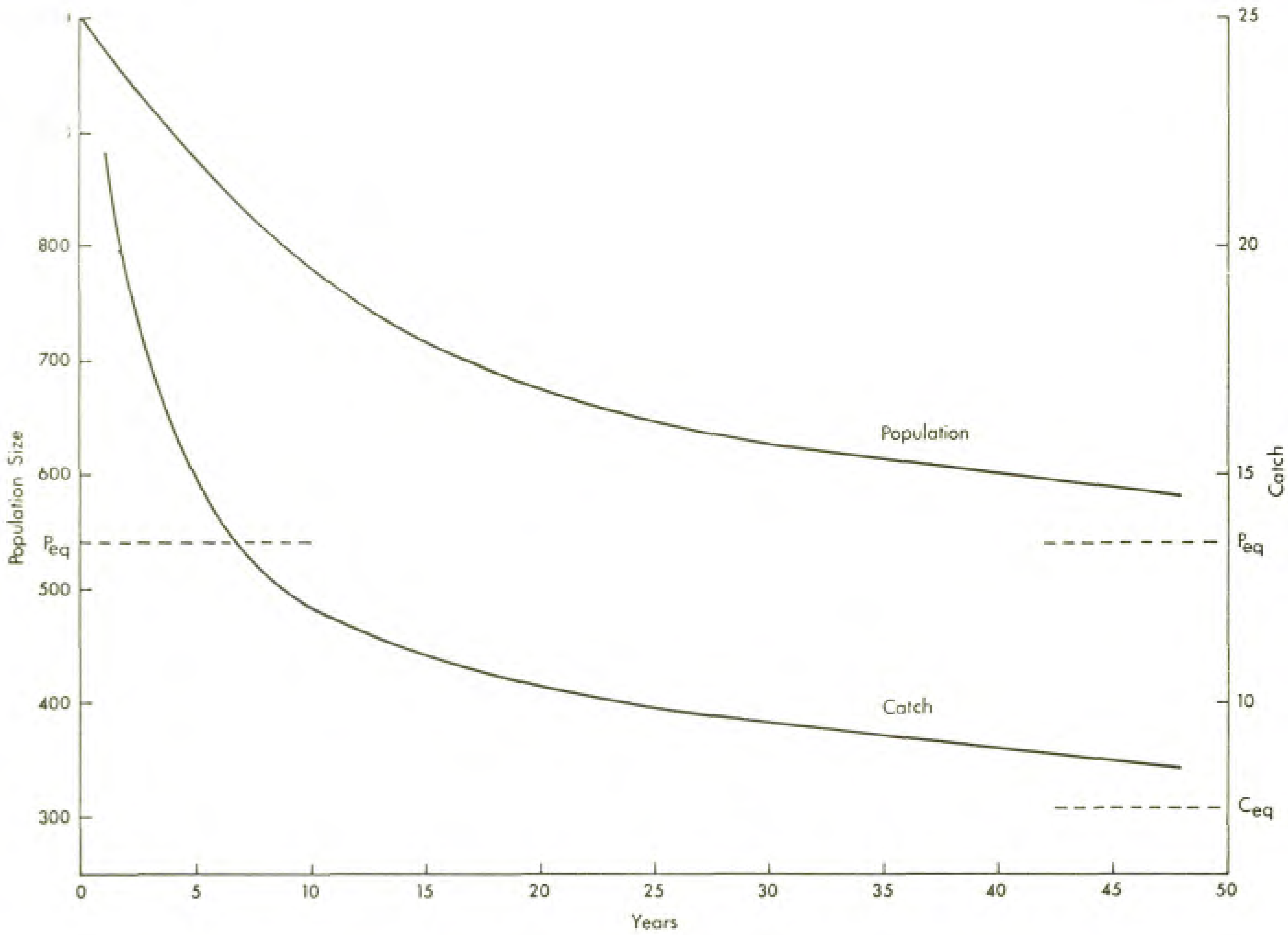
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Trends in Abundance of Sperm Whales in Three Areas of the North Pacific

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INTRODUCTION

Although three breeding stocks were postulated for sperm whales of the North Pacific, the Scientific Committee found it was most appropriate to treat this population as a whole at the Parksville meeting on sperm whale assessment (IWC, 1973). Ohsumi and Fukuda (1974) subsequently determined that exploitable males and females in this population were considerably above their respective MSY levels (expressed as percentages of initial sizes in 1910):

	Males	Females
1973 level	47%	82%
MSY level	27–33%	52%

Based upon these results, the exploitable populations of male and female sperm whales were then classified as Initial Management Stocks in 1975 (IWC, 1976).

Treating population components in aggregate, however, often leads to incorrect conclusions about the status of individual stocks. Fin whales of the Southern Hemisphere provide a noteworthy example (Chapman, 1976): Treating this population as a whole masked the fact that the Area I stock was still at its MSY level and thus could be exploited. Conversely, such aggregation for assessment purposes often indicates an overall healthy condition, even though one or more population components may be in difficulty due to excessive exploitation.

Therefore, the purpose of this paper is to determine the assessment implications of defining stock areas for the North Pacific sperm whale. To that end, three stock areas have been defined, based in part upon Masaki's (1970) evidence for discreteness of stocks in the North Pacific. Also, catch per unit effort statistics have been developed for each area and analyzed for significant trends in abundance.

METHODS

Stock Areas

Based upon an analysis of marking data, blood types, catch distributions, sighting data, and size compositions, Masaki (1970) assumed three discrete stock units for the North Pacific sperm whale:

West of 170°E – including coastal waters of Japan, Kuril Islands, and Kamchatka;
East of 150°W – including the Gulf of Alaska and North American coastal waters;
180°–160°W – including the central North Pacific and Aleutian Islands.

As indicated in Fig. 1, the stock areas defined for this paper were adapted from the above results. The shaded areas of the map indicate the statistical areas of the North Pacific Working Group which were assigned to the Asian (west of 170°E) and American (east of 160°W) stock areas. The boundary of the American stock area in the Gulf of Alaska was moved westward to account for recent recoveries of sperm whales marked in North American coastal waters (Rice, pers. com.). The unshaded portion of Fig. 1 represents the Central stock area.

Even if the above stock areas cannot be wholly justified using biological arguments, they at least might be considered separately because of their different histories of exploitation. That is, land-based whalers have long taken considerable numbers of sperm whales along the Asian coast, while significant exploitation, primarily by pelagic whalers, did not begin until 1954 in the central North Pacific nor until 1962 along the American coast. Tables 1–2, compiled from NP 1 data forms of the North Pacific Working Group, show the annual catches in each area resulting from this geographic expansion of exploitation.

Indices of Abundance

Following Gambell (1976), catches per unit effort (CPUEs) were assumed proportional to the annual densities of sperm whales in each stock area. These indices were calculated using catches and efforts summarized from the NP 1 and NP 2 data forms submitted by countries for each statistical area in which they operate. These data were available as follows:

Country	Operation	Seasons
Japan	Land	1949–75
	Pelagic	1954–75
Soviet Union	Land and Pelagic	1948–59
	Pelagic	1962–75

Effort was initially defined as net catcher-days whaling, i.e., days were excluded for which no sperm whales were taken. Additionally a tonnage correction factor was applied to account for annual changes in catching power (Gambell, 1975); i.e., effective effort = net catcher-days x average tonnage/1,000. Table 3 gives the average tonnages of catcher vessels by country and operation.

Unfortunately, the quality of the effort statistics varies somewhat. The Japanese land-based operation and both Soviet operations are mixed species fisheries. Consequently, their effort may have been influenced by the shift in emphasis among species of North Pacific baleen whales. Although some of this bias may have been reduced by excluding days for which no sperm whales were taken, CPUEs for these operations still may not be entirely satisfactory for measuring changes in sperm whale abundance. On the other hand, effort from Japanese pelagic whaling is allocated by species and thus should provide a more reasonable index of abundance in each stock area.

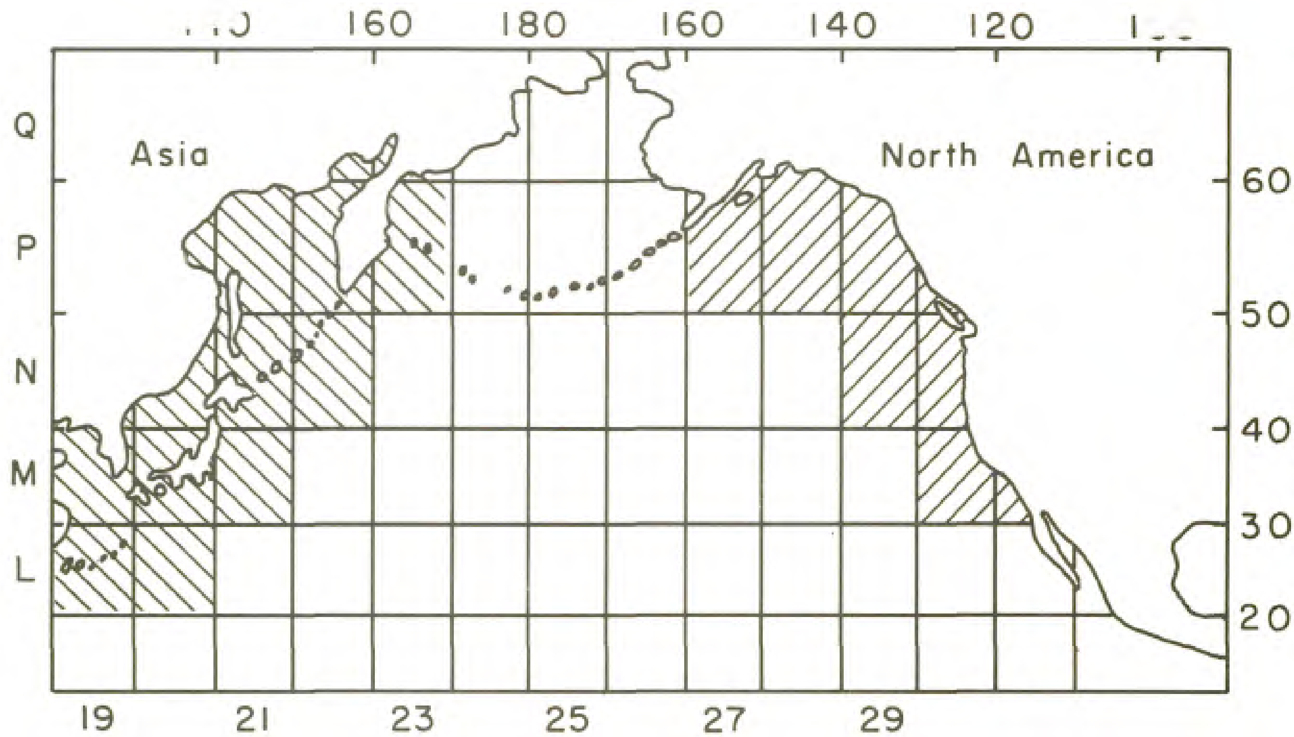
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Table 2

Catch of female sperm whales by area in the north Pacific.

	Area				
Season	Asian	Central	Asian and Central	American	Total
1948	424	82	506	–	506
1949	208	13	221	–	221
1950	740	5	745	–	745
1951	*	*	817	17	834
1952	873	5	878	4	882
1953	*	*	725	6	731
1954	798	–	798	11	809
1955	1,176	–	1,176	16	1,192
1956	1,195	24	1,219	20	1,239
1957	1,706	3	1,709	45	1,754
1958	1,961	–	1,961	36	1,997
1959	*	*	1,516	45	1,561
1960	1,370	29	–	2	1,401
1961	1,335	68	–	42	1,445
1962	1,331	166	–	250	1,747
1963	1,229	90	–	311	1,630
1964	1,334	181	–	446	1,961
1965	873	192	–	382	1,447
1966	1,235	353	–	276	1,864
1967	1,717	284	–	438	2,439
1968	2,656	693	–	269	3,618
1969	2,087	617	–	901	3,605
1970	2,168	911	–	500	3,579
1971	1,748	548	–	165	2,461
1972	1,887	277	–	127	2,291
1973	1,496	1,794	–	672	3,962
1974	1,196	1,943	–	566	3,705
1975	1,190	2,102	–	318	3,610

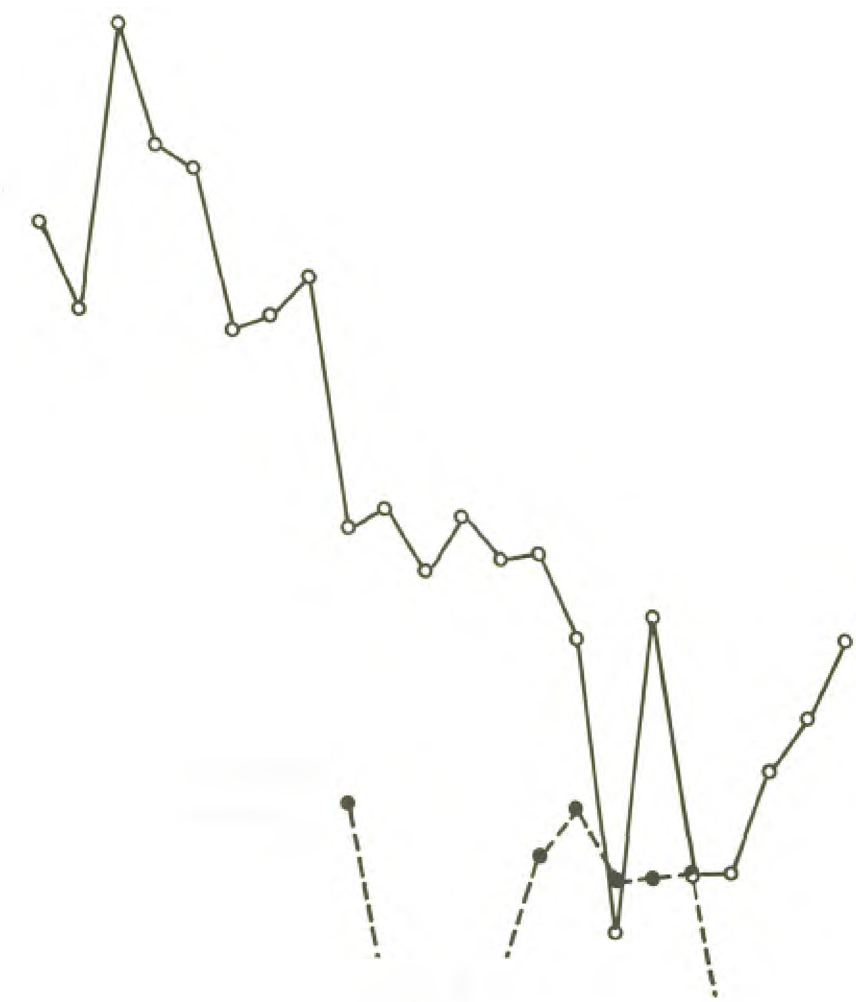
* Data not available.

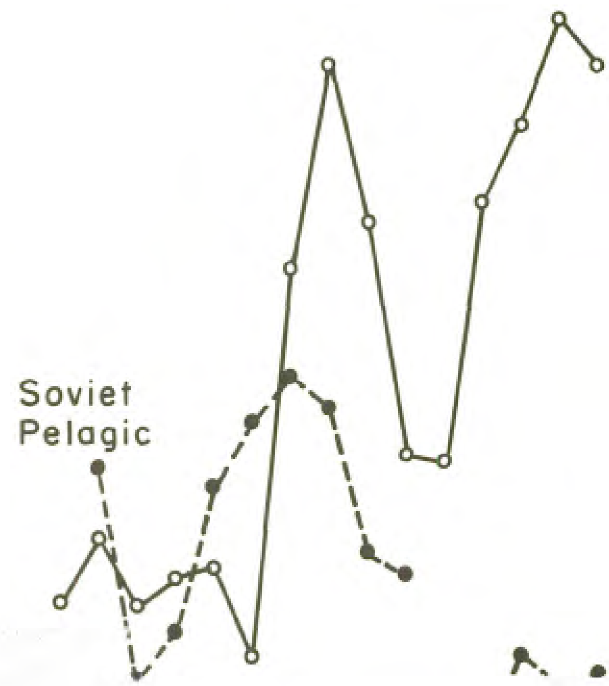
Table 3

Average catcher vessel tonnage by nationality and type of operation

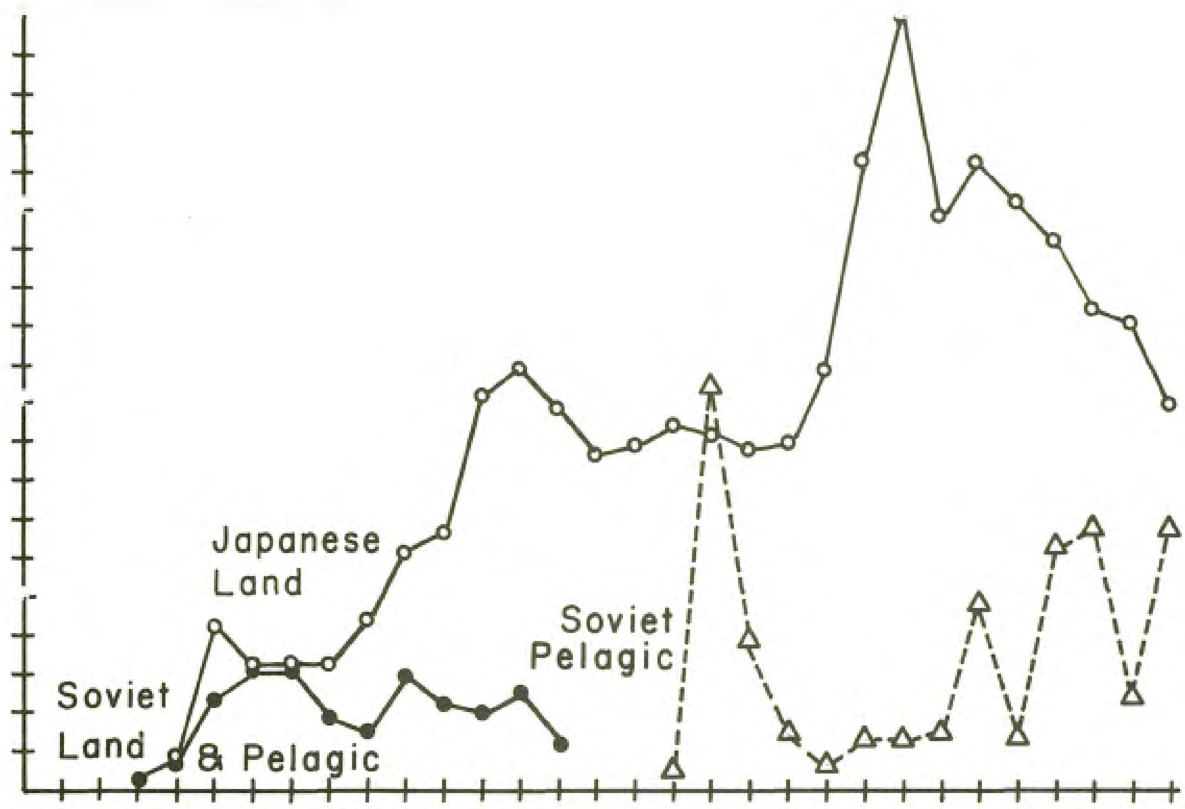
	Japan		USSR[1]	
Season	Land	Pelagic	Land	Pelagic
1948	–	–	720.4	–
1949	239.9	–	740.3	–
1950	298.0	–	719.1	–
1951	309.6	–	717.1	–
1952	320.1	–	707.6	–
1953	335.1	–	719.1	–
1954	355.3	448.4	719.1	–
1955	345.1	458.3	681.9	–
1956	401.2	557.2	638.1	–
1957	383.4	610.5	713.9	–
1958	360.0	649.9	638.7	–
1959	361.8	661.1	819.6	–
1960	356.8	676.1	–	–
1961	357.5	678.8	–	–
1962	370.3	690.2	–	780
1963	408.1	684.4	–	780
1964	372.0	692.7	–	780
1965	368.5	686.2	–	780
1966	370.1	670.8	–	845
1967	400.7	667.5	–	845
1968	487.1	681.9	–	844
1969	486.7	702.8	–	844
1970	568.4	688.1	–	844
1971	566.8	706.0	–	844
1972	586.3	712.0	–	844
1973	568.1	737.1	–	844
1974	554.6	740.8	–	844
1975	547.4	745.4	–	844

[1] Average of Land and Pelagic catchers combined during 1948–59.





Soviet
Pelagic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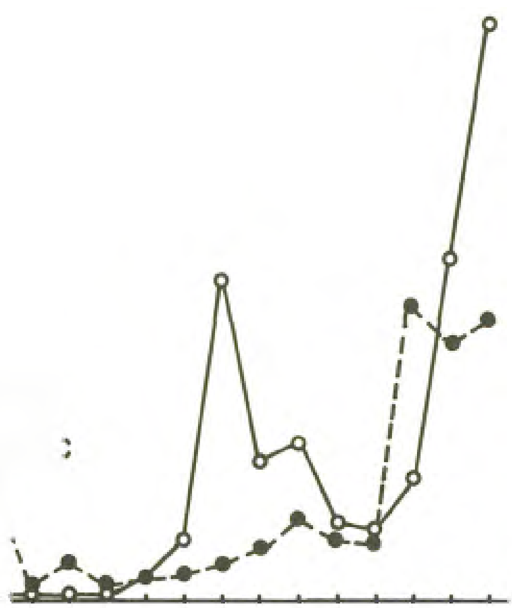


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Short Information on the USSR Investigation of Sperm Whales 1972–75

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Investigations of sperm whale biology and the problem of whaling are conducted by the specialists of different research institutes of the USSR Ministry of Fisheries, namely, by VNIRO, TINRO, AtlantNIRO and Odessa Branch AzCherNIRO. In addition, investigations are partly conducted by some specialists of the USSR Academy of Sciences.

Throughout the commercial season, the factory ships *Vladivostok, Dalny Vostok, Sovetskaya Ukraina, Sovetskaya Rossia* and *Jury Dolgoruky* were operating in the Southern Hemisphere and the North Pacific; it should be noted here that *Jury Dolgoruky* was out of operation since the season 1974–75. The biologists on board those vessels examined the bodies of sperm whales, registered their sex and length, looked through their fetuses, and collected the ovary and testis samples. During the last years, the population morphology of sperm whales is being developed. The annual marking process of sperm whales is conducted in both commercial areas. Further, materials collected in the field conditions are continued to be treated at stationary rooms. Since the last meeting on sperm whales, which took place in Canada, 1972, there were published 25 articles and short informations (see Appendix 1).

APPENDIX I

LIST OF PUBLICATIONS ON SPERM WHALES (PUBLISHED IN RUSSIAN. NAMES OF AUTHORS AND TITLES ARE GIVEN IN ENGLISH)

News of TINRO, No. 81, 1972, Vladivostok.

Blokhin, S. A. Topography of skull bones, spermaceti organ and nostrils on the cut surface of sperm whale embryo head: 253–57.

Trudy of the Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO) 51, 1973, Kaliningrad.

Tormosov, D. D. Maturation of sperm whale male inhabiting the Southern Hemisphere: 83–90.

Tormosov, D. D. Areas of sperm whales reproduction in the Southern Hemisphere: 91–94.

Panfilov, B. G., Pervushin, A. S. Reasons exploiting the sperm whale female migrating to the Antarctic waters: 95–105.

Budylenko, G. A., Pervushin, A. S. Occurrence of fish in stomach of sperm whale *Physeter catodon* L in the main productive zones of the Southern Ocean: 106–14.

First International Theriological Congress, Moscow, 1974, VINITI (Theses of reports, vol. 1 and 2). Published in England. (Reports on sperm whales only). Volume I.

Chuzhakina, E. S. Specific structural features of the ovaries in *Physeter catodon*, L., 1758: 113–14.

Klumov, S. K., Yukhov, V. L. The feeding and trophic relations of sperm whale (*Physeter catodon* L) in the Southern Hemisphere: 273.

Volume II.

Veinger, G. M. The use of peculiarities of coloration in *Physeter macrocephalus* L. (Cetacea) for the determination of its population structure: 269–70.

Morskie mlekopitajushie (marine mammals) Materialy VI Vsesojuznogo Soveshanija (Kiev, 1975) (Theses of papers on sperm whales only).

Berzin, A. A., Lagerov, S. J., Isakov, G. I. Materials on sperm whales population morphology in the Pacific: 28–30.

Mikhalev, Ju. A. The method of quantitative characteristic of laminations in marine mammals teeth and other registration structure of vertebrates: 7–9.

Mikhalev, Ju. A. Experience of profilogram analysis decalcinated surfaces of sperm whales teeth: 10–12.

Tormosov, D. D. Ecological and morphological grounds of structure differences of sperm whales concentration (Southern Hemisphere): 127–29.

Tormosov, D. D. To the character of sperm whales females ovulation: 129–31.

Jukhov, V. L., Vinogradova, E. K., Savusin, V. P. Food itemes of sperm whales in Antarctic and their role in ecosystem of Southern Ocean pelagial: 186–88.

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Ivanov, A. P., 1973. Small sperm whales in the Antarctic. Trudy VNIRO, 90: 182–83.

Klumov, S. K., Yulkov, V. L. 1975. *Mesonychoteuthis hamiltony* Robson, 1975 (Cephalopoda, Oegopsidae) and its significance in the feeding of sperm whale in the antarctic waters. *The Antarctic, the Committee Reports*, No. 14: 159–89.

Kozak, V. A. Videoacoustic system of sperm whale (*Physeter catodon* L. 1758). In *Podvodnye mediko-physiologicheskie issledovaniya*, Kiev, Naukova Dumka: 248–54.

Mrochkov, K. A., Kiselev, V. J., 1972. Weight rations of the carcass parts in Antarctic sperm whales. *Trudy VNIRO*, 88: 194–99.

Osipuk, O. E., 1975. The materials of sperm whale embryo development. *Actualnye problemi teoreticheskoi i klinicheskoi meditsini.* Minsk: 45–145.

Pervushin, A. S., Latogursky, V. J., 1972. On the problem ensueing with food of baleen and toothed whales in the Antarctic. *Trudy AtlantNIRO*, 42: 120–25.

Skryabin, A. S., Muravieva, S. M. 1972. First incidence of cestode *Tetrobothrius curilensis* (Tetraphyllidea) in sperm whales taken in the Antarctic. *Vestnik Zoologii* (Kiev), No. 3: 85–87.

Tinyakov, G. G., Chumakov, V. P., Sevostyanov, B. A. 1975. Microstructure of sperm whale (*Physeter catodon*) milk. *Zoologicheskyi Zhurnal.* 54 (9): 1413–15.

Tormosov, D. D., Sazhinov, E. G. 1974. Nuptial behaviour in sperm whale (*Physeter catodon*). *Zoologichesky Zhurnal*, Vol. 53 (7): 1105–6.

Veinger, G. M. 1972. To the problem of embryonic pigmentation of sperm whales. In *Studies of fish biology and fishing hydrology*, TINRO, No. 7: 184–90.

Veinger, G. M. 1974. Studying of sperm whale population structure on the base of the analysis of the colour. Collection of articles *Investigation in field of fish biology and commercial oceanography*, TINRO, No. 5: 153–65.

Tagging of Sperm Whales in the Southern Hemisphere

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As has been noted before (Ivashin, 1973) Soviet research workers began tagging whales in the Southern Hemisphere in the Antarctic whaling season of 1952–53 when among tagged whales there were 15 sperm whales all tagged north of 40°S latitude. Tagging of sperm whales was made almost every season in the years that followed. In the first period tagging was performed mostly from whale-boats of Antarctic whaling flotillas. Later on in individual years for tagging scout and fishing vessels of the fishing industry and Soviet Antarctic expeditions were also used. Tagging of whales was also made from special expeditional vessels, for instance, during the joint Soviet-American expedition on the whale-boat *Vnushitelny* in the warm zone of the Pacific, in February-July, 1975.

In seasons the number of sperm whales varied from 1 to 241 (Table 1). All in all in the Southern Hemisphere 1,250 sperm whales were marked with Soviet tags (1952–53 to 1974–75). In the seasons of 1967–68, 1969–70, 1971–72, 1973–74 and especially in 1974–75 tagging was most intensive.

Tagged whales spread in the water areas of commercial stocks of sperm whales very unevenly (Tables 1 and 2). It is partly accounted for by the fact that the water area in one case spreads over 30° in latitude and in the other over 70°. Besides, these water spaces considerably differ in area (each spreads south of the Equator up to the ice border). Most of sperm whales were tagged in Division 7 (265 or 21.2% of the total of tagged sperm whales) and in Division 9 (192 or 15.4%), Table 2.

As far as zones of the Southern Hemisphere are concerned the distribution of tagged sperm whales here is also uneven. For instance, of 1,250 whales south of 40°S (i.e. in Antarctic waters proper) there are 355 (28.4%) whales tagged. A small number of sperm whales are tagged in zones adjacent to latitude 40°: in zone E-414 or 33.1% and zone D-269 or 21.5% (Table 2, Fig. 1). The number of sperm whales tagged in the pre-equatorial zone is also relatively large (zone H-251 or 20.1% and zone G-109 or 8.7%), Table 2, Fig. 1.

All in all in the period of 1952–53 to 1974–75 there were returned 42 Soviet tags including 31 tags found when processing whales on Soviet Antarctic whale bases, 3 on Japanese Antarctic flotillas, and 8 on coastal stations (1 in Australia and 7 in the Republic of South Africa).

After the season of 1971–72 (data for this period see Ivashin, 1973) 22 tags were returned (with allowance for the adjusted data of previous years). 12 of these were returned a few hours after tagging and therefore they are not included in Table 3 showing the return of only 10 tags. Thus the percentage of the return (42 tags) in the number of tagged whales is equal to a paltry 3.56%.

As has been said Soviet specialists intensively tagged whales in the zone north of 40°S in particular in zone H (0–10°S) and in zone F (10°–20°S) where whaling was

Table 1

Tagging of sperm whales in whaling areas of the Southern Hemisphere

	Whaling Division									
Seasons	1	2	3	4	5	6	7	8	8	Total
1952–53	–	15	–	–	–	–	–	–	–	15
1954–55	–	1	–	–	–	–	–	–	–	1
1955–56	–	6	–	–	–	–	–	–	–	6
1956–57	1	–	–	–	–	–	–	–	–	1
1957–58	1	15	–	–	2	8	–	–	–	26
1958–59	–	3	–	–	7	1	–	–	–	11
1960–61	–	1	1	–	–	–	–	–	–	2
1961–62	1	6	6	–	–	–	8	–	2	23
1962–63	1	–	4	1	2	–	–	–	7	15
1963–64	–	14	17	13	–	–	–	–	–	44
1964–65	–	23	–	1	8	10	9	2	–	53
1965–66	1	5	40	30	1	2	14	–	–	93
1966–67	22	12	–	16	9	–	15	–	–	74
1967–68	–	1	20	3	8	14	54	–	–	100
1968–69	2	1	16	7	6	6	35	32	4	109
1969–70	–	20	21	4	–	2	5	3	81	136
1970–71	7	3	20	11	–	–	1	6	–	48
1971–72	22	6	13	–	–	4	50	4	–	99
1972–73	21	–	9	3	–	3	1	9	1	47
1973–74	8	5	13	2	–	22	21	27	8	106
1974–75	8	15	–	–	–	3	52	74	89	241
Total	95	152	180	91	43	75	265	157	192	1,250
%	7.6	12.1	14.4	7.3	3.4	6.0	21.2	12.6	15.4	100.0

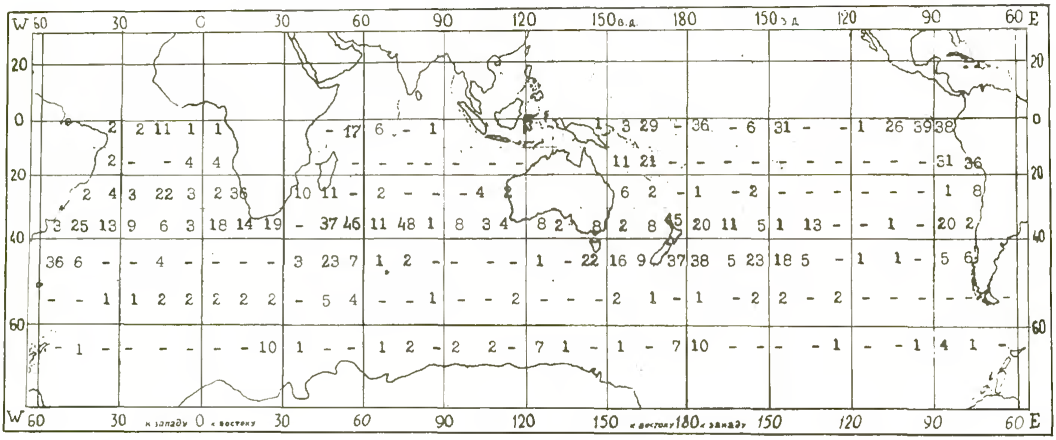


Fig. 1. Distribution of marked sperm whales by squares and zones of the Southern Hemisphere (Soviet data).

limited or was not performed at all. Most intensive tagging in these zones was in progress in recent years.

Low return of whale tags from the pre-equatorial zone shows among other things that they insufficiently shift to adjacent areas or perhaps insufficiently move into southward latitudes (or into northward waters?) – first of all to the respective water area of the Pacific (migration of sperm whales from the warm zone of the Central Atlantic is known – Ivashin, 1967a, 1967b, 1971 and 1973). Therefore the remark of Ohsumi (1975) about the low return of Soviet tags seems to require more attentive consideration which perhaps will be done somewhat later.

Migration of sperm whales according to the return of Soviet tags in the Southern Hemisphere is given in Fig. 2. Well seen are migrations of males moving south-northward and north-southward (tags 563,650203 and 610245). In the first two cases they were males 10.7 m. long marked in the Antarctic waters and caught in the temperate zone. This fact shows that males about 11.0 m. long often leave harem herds and begin to participate (yearly?) in north-southward and south-northward migrations (Ivashin, 1972). Gambell (1967) notes that sperm whales come to this area from the south.

A few sperm whales were caught in Antarctic waters proper not far from the place of tagging (tags 651283, 618,737,760 – Ivashin, 1971, 1973; Fig. 2).

Perhaps only in two cases (tags 650834 and 207) we can speak about considerable migration within the southern part of 30° latitudes and the beginning of the 40° latitudes of the Southern Hemisphere. In both cases migrants were males over 11.0 m. long. In the first case the whale was tagged in early November and caught four years later at the end of the first 10 days of October. It remains unclear whether the whale stayed in this area all this time or migrated southward. In the second case a male 12 m. long in early January 1965 was marked in 36°S. Nine years later (when he undoubtedly became larger) in the middle of March 1974, he was seen in 41°S, perhaps when leaving Antarctic waters.

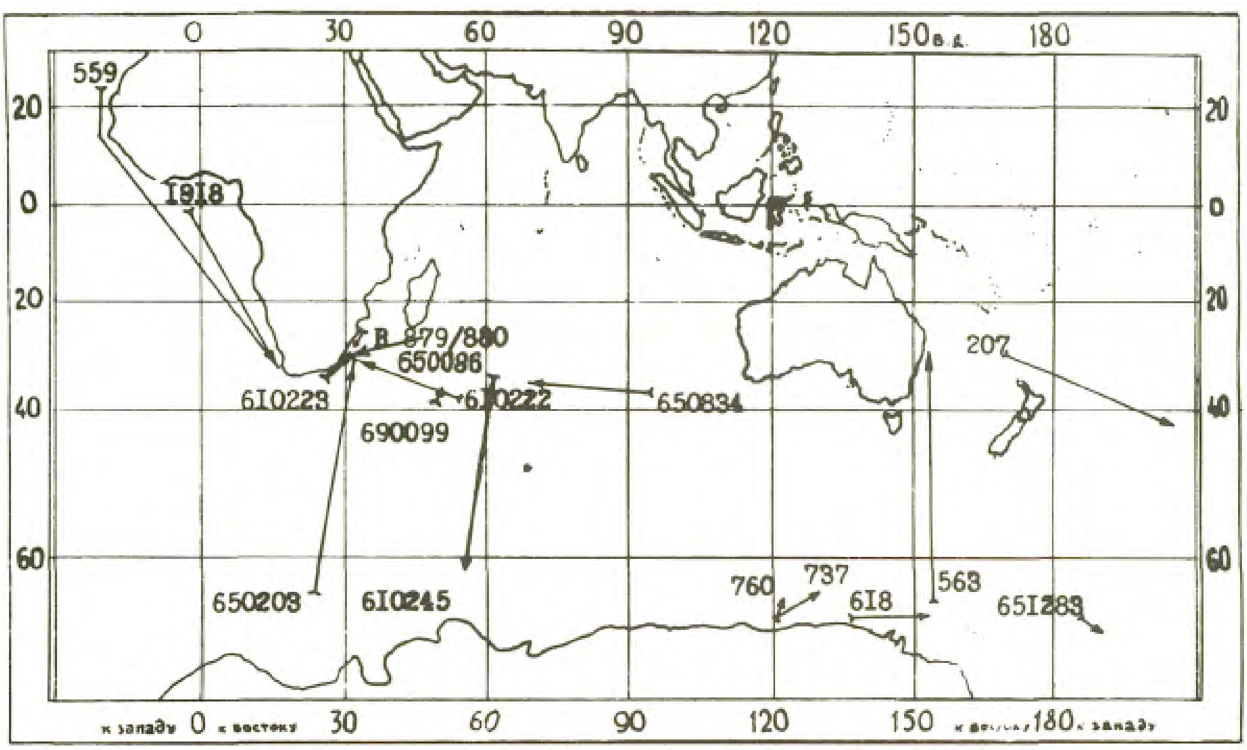
In the area of Durban (The Republic of South Africa) sperm whales were seen coming from the south in the period from November until April (tag 610223) and from the north tentatively from October until February (tags B879, B880). In December sperm whales were seen in the zone 33°–38°S in the area 45°–52°E (tags 610222 and 650086) and at the beginning of the second half of April they were observed in the Durban area (Fig. 2).

The character of migrations of sperm whales up to 11 m. long in the zone of 30° latitudes can be completed with the information obtained with the return of tag 690099 two years later (the end of December 1969 – the end of

Table 2

Tagging of sperm whales in areas and zones of the Southern Hemisphere

		Zone	H	G	F	E	D	A	B		
Division	Boundaries	Zone boundaries lat. S	0°–10°	10°–20°	20°–30°	30°–40°	40°–50°	50°–60°	60°–70°	Total	%%
1.	60°W– 30°W		2	2	6	41	42	1	1	95	7.6
2.	30°W– 20°E		15	8	66	50	4	9	–	152	12.1
3.	20°E– 60°E		17	–	21	87	33	11	11	180	14.4
4.	60°E– 90°E		7	–	2	75	3	1	3	91	7.3
5.	90°E–130°E		–	–	6	23	1	2	11	43	3.4
6.	130°E–160°E		4	11	6	12	38	2	2	75	6.0
7.	160°E–170°E		65	21	3	73	84	2	17	265	21.2
8.	170°W–100°W		64	–	2	31	53	6	1	157	12.6
9.	100°W– 60°W		77	67	9	22	11	–	6	192	15.4
	Total		251	109	121	414	269	34	52	1,250	100.0
	%		20.1	8.7	9.7	33.1	21.5	2.7	4.2	100.0	



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Method for Graphical Record of Surface Relief of Decalcinated Sections of Sperm Whale Teeth with the Aim to Determine their Age

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INTRODUCTION

Determination of age composition of commercial animals is one of the important links which are required for working out the methods for rational catch of these species. Meanwhile it is rather difficult to determine the age of most mammals. In the first place it is necessary to find recording structures in which various cycles of the life of animals are noted (Mina and Klevezal, 1970). However, when such structures are found, the problem of their deciphering appears.

Age of whales and sperm whales in particular is determined with great difficulty. Seasonal whaling and aquatic way of life of these mammals does not give the possibility to carry out detailed observations all the year round. By the same reasons there is no possibility to mark neonatals and to observe them then at least in the period of 2–4 years if not during the whole life. All these circumstances force the researchers while determining the age of whales to resort to indirect methods of logical constructions and to use the analogy with other species of animals.

At present, it is universally recognized that the teeth of the lower jaw are the best recording structure for sperm whales. Cutting of tooth lamellas with the shape of narrow and wider stripes, stipulated by various degrees of their calcination can be discriminated on cement and dentine along the longitudinal axis. Laminations in dentine are usually used for age determination of sperm whales as they can be seen better than on cement.

Papers by Nishiwaki, Hibiya and Ohsumi (1958), Berzin (1961, 1971), Ohsumi, Kasuya and Nishiwaki (1963) and other authors indicate that the number of laminations in teeth of sperm whales is correlated with the length of whale, i.e. that it is connected with the age of animals. However, there is no single opinion in the question what and how many laminations are deposited in teeth during the year. Some researchers (Nishiwaki et al. 1958, Berzin, 1961, 1971, Gambell and Grzegorzewska, 1967) consider it to be more possible that two layers are deposited in dentine for one year; others (Ohsumi *et al.* 1963; Tormosov, 1970) suggest one layer.

Klevezal and Kleinenberg (1967) believe that the discrepancy is caused by the presence of additional quite clear laminations inside the annual layer which is taken into account by some researchers and not by others. Delimination of layers becomes also more complicated due to the fact that there are additional laminations whose number and clearness vary within wide limits.

Judging from the forementioned facts it is presumed that estimation of the meaningfulness of laminations and hence the method of age determination of sperm whales at present have a subjective character. It is quite clear that not only qualitative (narrow, wide, double, additional and so on) but quantitative characteristics of laminations like the layering of some recording structures in baleen whales as estimated by Ruud (1940, 1945), Nishiwaki (1950), Ichihara (1963, 1966) and van Utrecht-Cock (1965) should be used for working out reliable methods. We have done some work in this direction the results of which are stated below.

BACKGROUND

Purpose

Proceeding from the fact that layering of sperm whale teeth is defined by the various extent of tissue calcination, quantitative characteristics of laminations in a sense can be brought to direct determination of calcium content along the tooth beginning from its top to the pulp cavity. The purpose in itself seems rather complicated and the possibility of its being carried out is limited. Therefore a number of attempts were made to find the method of indirect, relative determination of the degree of calcination of laminations in sperm whale teeth.

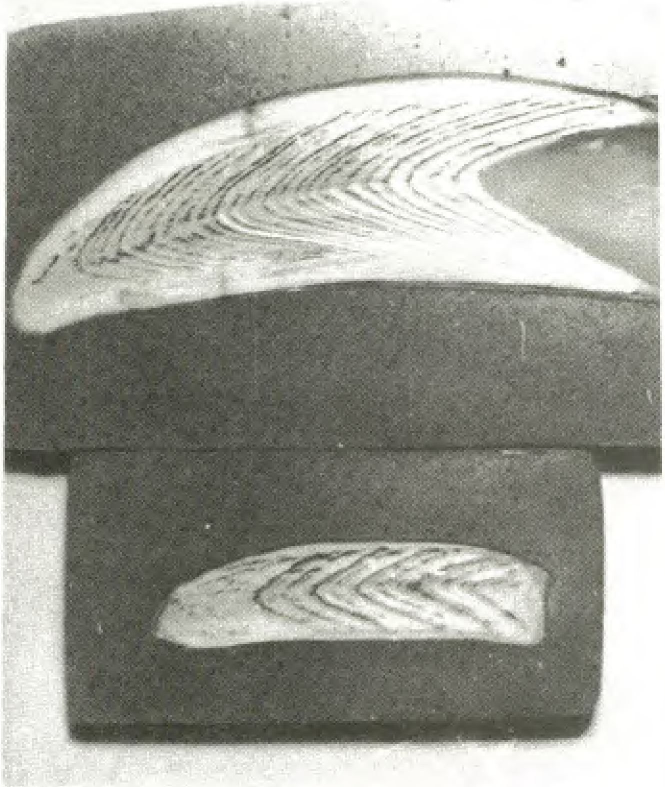
Finally we turn our attention to the method of acid etching of sections (half of tooth which is cut longitudinally) employed for increasing lamination clearness (Bow and Purday, 1966). If the section is cleaned well, acid etching of calcium can probably be distributed evenly and relief obtained with microridges and grooves will reflect the real calcium content in tooth laminations. In addition to the comparison of acid etched and unetched sections from one tooth this fact can be easily proved in the following way. If we draw a line on a decalcinated section by graphite or wax pencil, then more convex ridges at weak pressure will be painted in the first place and ridges with less height will appear at increasing pressure (Fig. 1).

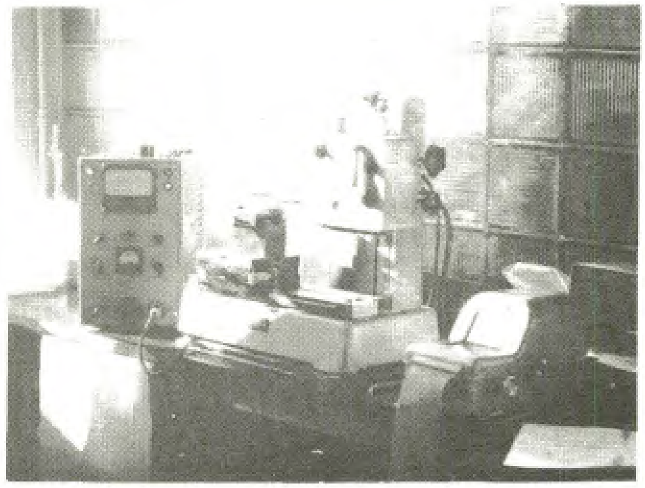
However, it is practically impossible to measure exactly the distance between ridges. It happens not only because the height of ridges is equal to one tenth, one hundredth and sometimes one thousandth of a millimetre but also due to the difficulty to settle the points of measurement.

Judging from this situation we consider it to be more useful to work out the method for relief recording of decalcinated sections of sperm whale teeth on a large scale. Such a profile diagram would be of great value not only because of its graphical clearness but also owing to the fact that it would give the possibility to measure the depth, width and other parameters of microridges and grooves on a section much more exactly, i.e. to judge the relative calcium content in various layers of the tooth.

Design of device

It was suggested that the design of a device for reading a profile diagram would be the same as that worked out by Ruud for relief record of whalebone, i.e. the needle is to slide on the surface of the tooth section which is etched by acid, and the oscillations appearing at passing of surface unevenness and increased with some system, must be recorded on the paper tape. However, the ridges on decal-





nations have the most typical features. Profile diagrams are read in the direction from the top of teeth to the pulp cavity. The scale grid is equal to 10 × 10 mm.

First of all we shall consider the profile diagram which has been recorded on the dentine of a tooth section of a male sperm whale with the length of 12.1 m. (Fig. 3). The time of tooth etching was 8 hours. As we can see the profile diagram represents a rather complicated picture of peak and hollow alternations corresponding to the tooth laminations. Analysing the profile diagram in the direction from the pulp cavity to the top of tooth (from right to left), we can discover that distinct high peaks are replaced by lower and wider ones, the protuberances of which are discriminated with difficulty. Then again the zone of comparatively distinct and high peaks begins. On the full length of the tooth these zones are alternated several times in such a way that a smoothed out curve of the whole profile diagram would have the view of a curve with some waves.

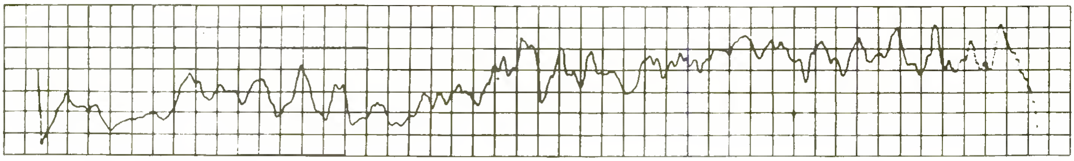


Fig. 3. Profile diagram of decalcinated tooth of sperm whale male recorded on dentine.

Evidently, for still unknown reasons, the degree of tooth calcination is unequal and changes not only by laminations but also by zones. This opinion is also confirmed by the fact that wide zones including several (3–6) layers can be often discriminated even visually on decalcinated and non-decalcinated sections.

It is necessary to note that the layers which seem to be more clear on sections and named 'marks' (Klevezal and Tormosov, 1971), always correspond to peaks on the profile diagram, disposed on the top of the wave, but the proper 'marks' for all such peaks on the section can not be found with the naked eye.

The 'marks' are better seen on section cements. However, the profile diagrams, recorded on cement (Fig. 4) are less successful and it is difficult to compare them with the profile diagrams recorded on the dentine of the same tooth. Firstly, it can be explained by the fact that character of the location of layers on cement does not permit to choose a line of record which would cross all the layers (say, on their middle).

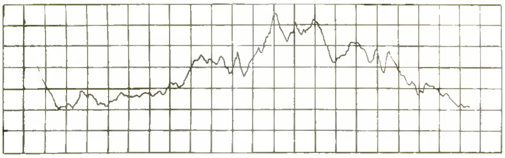


Fig. 4. Profile diagram of decalcinated tooth section of sperm whale male recorded on cement.

Profile diagrams read on dentine along the tooth on various parallel cuts of the same section, show that their pictures do not coincide completely. Fig. 5 gives the possibility to compare the pieces of profile diagram which have been read close to the tooth axis and along the middle of the left side of the dentine.

We can see insignificant differences in the configuration of peaks, though the general tendency of the diagram remains unchanged. It is stipulated not only by the fact that the width of the layers changes from the axis to the periphery, but probably by the degree of calcination. The later suggestion can be confirmed with the following argument: while examining non-decalcinated sections it has been found that the areas along the tooth axis are appreciably darker (in transmitted light – more translucent) than neighbouring areas; that is the index of a greater tissue calcination (Fig. 6).

When attentive examination of the cut is done, we can see optically more transparent nebulous stripes on dentine – which diverge from the edges of the pulp cavity and go perpendicularly or almost perpendicularly to the tooth layers.

Apparently, the top of the pulp and its several outlying parts, when the layers are formed, lay aside relatively greater amount of calcium salts.

Nebulous stripes can be also seen in the direction to the tooth top, but they become here more aged and indistinct. The layers become also illegible. This situation is also expressed on the profile diagram and show that peak configuration in the direction to the tooth top becomes less distinct. We consider it insufficient to explain the change of layer clearness by means of peculiarities of the animals' biology (Berzin, 1971), because analogical character of distribution of layer clearness can be observed on sperm whale teeth which have various lengths. Nevertheless, it is possible that the calcination degree of layers formed earlier undergoes some changes with the tooth growth.

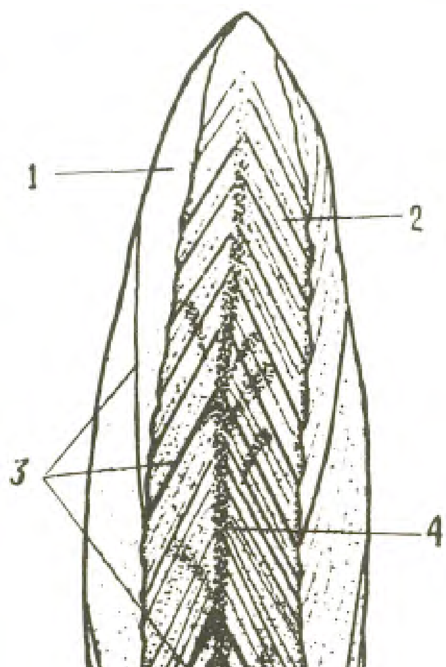
The only profile diagram showing the general regularity does not give a unified characteristic of layers, because the degree of calcination of laminae on dentine changes from the tooth axis to its outlying parts.

It is necessary to make several profile diagrams along section on various cuts (it is better to make it along middle part of one from dentine halves where the calcination is more homogeneous) in order to eliminate unessential peaks or cavities on the diagrams, using the method of their comparison. Such a summarizing profile diagram is more suitable for its further deciphering.

We would like to draw attention to the fact that in the Fig. 5 pieces of profile diagrams are turned over. It is done with the aim to show that it is easier to analyse not the peaks but the cavities. In such a form it is easier to determine and count the layers on the profile diagram.

Now we shall consider the profile diagram of tooth section of sperm whale female (Fig. 7). The time of decalcination is 12 hours.

As is generally known (Klevezal and Tormosov, 1971) that the 'marks' are discovered more often on tooth dentine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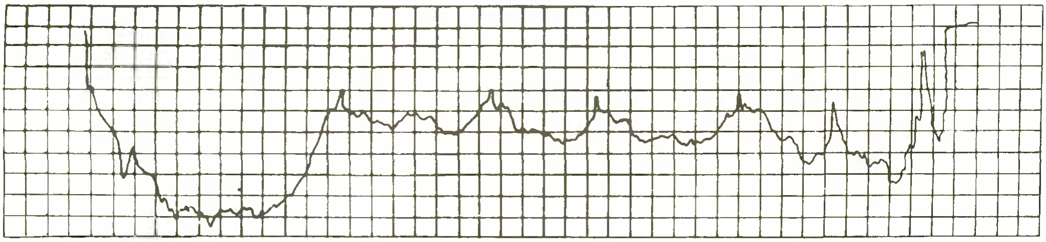

Fig. 7. Profile diagram of decalcinated section of tooth of sperm whale female.

using a device for recording surface microroughness. In its essence such diagrams show relative content of calcium in tooth layers. They permit to determine sizes of ridges and grooves on decalcinated sections and are convenient for analysis. It is better to make the record on dentine but not on cement.

Profile diagrams obtained by such a way illustrate the rather complicated character of deposits of calcium salts in sperm whale teeth. Calcination degree changes periodically not only by laminae but also by zones which include several layers. Calcination is also unequal for different zones in the direction from the tooth axis to its outlying parts. Therefore, it is necessary to record several profile diagrams read for various directions of the section in order to obtain a more reliable picture of tooth layering. It is better to make the record along the middle part of the dentine, where calcination of the layers is more homogeneous.

This method can be also used for writing profile diagrams from recording structures of other animals if microrelief showing their real layers appears after decalcination.

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Ecological Aspects of Differential Distribution of Sperm Whales

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The sperm whale is one of the most widespread species of the cetaceans. Extraordinarily high adaptability of cetaceans including sperm whales to water life allows them to live in various areas of the world ocean. It is difficult to find another marine mammal whose ability to live in the deep sea would be equal to the sperm whale's. In this connection it is of special interest to study the space structure of a sperm whale population as a factor securing the ecological plasticity of the species over vast spaces.

The sperm whale's habitat is wide and includes different geographical and climatic zones, from tropics to the highest latitudes. It is but natural that animals of different age, size, sex and physiological state are affected by the complex of environmental factors differently in different areas. The reaction of the animals to varying outer conditions (change of seasons, migrations, etc.) will be also different. All this in the final analysis directly affects the animals and must determine their behaviour and choice of optimal conditions of life. Difference in distribution of male and female sperm whales furnishes an illustrative example of this.

Specimens of any species differ from each other in plenty of individual properties, specificity of reaction to changing factors of the environment even if the outer effects are quite identical (Shmalgauzen, 1968). However in a population one always can single out groups uniting specimens with similar reaction to factors of the environment (Zavadsky, 1961) which tend to concentrate in one ecological niche (Mettler and Gregg, 1972).

The oceanic environment has a number of properties which substantially distinguish it from the land environment and which give great advantages to its inhabitants. While land conditions differ by a complicated background with very high daily and seasonal variance in numerous abiotic and biotic factors, the ocean is characterized by relatively even daily and seasonal developments. This cannot but affect the seasonal rhythm, behaviour and distribution of many marine animals including cetaceans. Unlike for land animals for them does not exist insuperable obstacles like big rivers, mountain ridges, deserts and so on. Nevertheless, despite the relative stability of living conditions in the ocean, all changes, especially seasonal changes occurring in the ocean and in nature in general exert a certain effect on its inhabitants.

Direct or indirect effect of different factors (temperature, salinity, direction and rate of currents, formation of feeding fields, light regime, intensity of solar radiation, etc.) undoubtedly affect the behaviour and distribution of whales. At present it is well-known that the biological rhythm of animals, functioning of reproductive system and behaviour are greatly affected by photo-periodism (Slonim, 1962; Naumov, 1963; Chernomordikov, 1963; Pegelman, 1966; Agadzhanjan, 1967; Odum, 1968; Willy, 1968 and others). The preliminary results of investigations of magnetism in biology speak about a serious effect of magnetic fields on the organism as a whole, on the functional activity of its system, biological rhythms and behaviour of animals (Holodov, 1970; Presman, 1971). There are grounds to believe that the geomagnetic field, seasonal and cyclical changeability of its tension in different areas of the globe may be an important signal and ecological factor.

The reaction of the animal to a certain factor-signal and first of all to a certain complex of factors proceeds in conformity with the general physiological principle of the structure of behaviour, i.e. forestalling of the reflection of reality which adapts the organism to forthcoming developments (Anohin, 1963).

The behaviour of animals in the final analysis is determined by the necessity to secure equilibrium between the organism and the environment with minimum efforts (Swarts, 1969; Shkorbatov, 1971).

This principle is evidently one of the most important principles determining the formation of sperm whale concentrations and their specific distribution in various areas of the ocean characterized by different ecological conditions. By concentration we mean a group of whales temporarily standing apart in a relatively small water area. We have made an attempt to study the structure of over 200 concentrations of sperm whales. As a basis for the analysis were used data of visual observations and data of biological analysis of some captured sperm whales collected in the Southern Hemisphere for 14 years. Sperm whale concentrations number hundreds of animals. Sperm whales form mixed concentrations which consist of males and females and unmixed concentrations consisting of specimens of one sex. The latter is almost exclusively characteristic of males. The preliminary analysis of data on the structure of sperm whale concentrations allowed six main types – three mixed and three unmixed – to be singled out.

Type I – the number of females several times exceeds the number of males, the percentage of immature females among the female animals is high (in average about 30%).

Type II – the number of females either somewhat exceeds or equals the number of males. The percentage of immature females is relatively low (about 7%).

Type III – the number of females several times exceeds the number of males. The percentage of immature females is low (about 7%).

Type IV – the concentration mostly consists of pubertant males.

Type V – the concentration mostly consists of males that reached maturity shortly before.

Type VI – the concentration mostly consists of males of older age groups.

In Type I, mature males comprise 13% of the total of animals; in Type II – 24%; in Type III – 7%. Pregnant females comprise the highest percentage in Type II and the lowest in Type I. The size of males of Type IV varies within 9.6 and 15.5 m. The bulk of the type ranges between 10.5 and 12.5 m. For Type V the general range is 10.5–16.5 m., the bulk of males varying in the limits of 11.5 and 13.5 m. Males in Type VI in general vary between 12.5–17.0 m., the bulk of males being 13.5–15 m. long.

Of the mixed concentrations, Type I occurs most often in the tropical zone, and less often in the subtropical zone. Types II and III most often occur in the subtropical and less often in the temperate zone. Type IV occurs in the tropical and subtropical zones. Type V in temperate and less often in subtropical waters. Concentrations of Type V sometimes occur in the temperate zone but most often concentrations of this type distribute in higher latitudes of the Antarctic basin. The above characteristics of sperm whale concentrations pertain to the period from November to April.

Unlike mixed concentrations, male concentrations are more distinctly characterized by size-age composition in different latitudinal zones which is in full conformity with different heat emission of animals of different size and hydro-dynamic characteristics related to the length of the body and unequal ability to procure food from the deep sea.

As a result of the first preliminary analysis of the structure of space-and-time groups of sperm whales we have succeeded in singling out most easily distinguished types. In the ocean concentrations of a different structure also occur but they are much rarer.

Further investigations with a more accurate detailing of signs for distinguishing types of concentrations are required. It will allow the regularities of formation and distribution of space-and-time groups of sperm whales to be studied more completely and will help the scientists to read the mosaic of space and time interrelations of this species.

It should be noted that the problem of studying 'local populations' (the interpretation of this term according to Mayer, 1974) is difficult to solve without the knowledge of dynamics of the structure of space-and-time groups of sperm whales and all relations between them. Work in this direction will give a considerable result only if this work is outside the framework of whaling.

SUMMARY

The first preliminary analysis of the composition of space-and-time groups (concentrations) of sperm whales in the Southern Hemisphere allows six main types to be distinguished: 3 mixed and 3 unmixed types. Unmixed concentrations occur as a rule only among males. The types of concentrations differ in sex composition, size-and-age characteristics and distribution in the ocean. It is natural that data obtained cannot be exhaustive and require adjustments and additional information on the basis of profound and detailed investigations.

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Estimation of Sperm Whale Population Sizes from Changes in the Mean Size of Whales in Catches

S. J. Holt

I have earlier drawn the Committee's attention to the fact that the mean lengths of sperm whales in catches – especially of males – has declined over the period of 'modern whaling' and that this may be interpreted as evidence of an effect of whaling on the size of the populations. Indeed it would be surprising if the statistics did not show a decline, considering that male sperm whales can nearly double their weight during that part of their natural life-span falling within the 'exploited phase' of the stock.

If the mortality rate in a part of a population is increased, as by exploitation, the mean age of animals in it is reduced and, to the extent that growth in individual size occurs within that part of the population, so is the mean size. This phenomenon is evident in the catches of male sperm whales in the Antarctic, the mean length of which declined steadily from 53.5 ft. in the early 1930s to about 51 ft. in 1946–47 to 1948–49 to 47 ft. in 1969–70 to 1971–72. The magnitude of the decline shows a decrease in average weight of individual males of the order of 40%, which means that optimal stock number to maximise sustainable catch in weight will be significantly higher than that which will maximise catch in numbers.

However, it was objected that a decline in mean size can be caused by a progressive move of the fleets onto concentrations of smaller whales which are segregated from the larger and presumably older ones. In the Antarctic smaller male sperm whales are found in the northern Series D than in the more southerly Series A and B.

Best (1977) has provided to the present meeting a tabulation, based on BIWS data, of mean lengths of male animals in Antarctic pelagic catches, for the period 1932–33 to 1972–73, by area, and within area, by latitudinal series. This shows that the decline clearly occurred in Series A and Series B, and to the same degree in both series. Series D shows a decline, but less clear and, it appears, to a lesser degree. In series C there are data for only four years in the period 1950–51 to 1966–67 but even there a small decline is apparent. Furthermore the pattern is repeated in every area.

In the Antarctic the whales in Series D were not exploited significantly until the early 1960s, after which time smaller catches were taken from Series A and B (Table 1). If whalers were seeking only sperm whales, such a shift would be expected if whaling reduced the abundance in Series A and B sufficiently that it would give better returns to catch more, though smaller, whales in Series D for the same expenditure of effort. In this case, however, the shift is probably related to changing interest in the various baleen whales and the changes in *their* abundance caused by whaling, although some stimulus to move northward because of a decline in availability in sperm whales further south should not be ruled out; the whalers were presumably seeking to maximise their total returns, and the values of the sperm whales were significant within that total.

Best's tabulation shows a steady decline in mean size in both Series A and Series B catches in the period from 1946–47/1948–49 to 1961–62, after which the mean size remained steady, or perhaps even increased again slightly. The changes in these two Series are closely parallel, so I have considered them together. From the early 1960s the continuing decline in mean size of Antarctic catches as a whole is caused mainly by the progressive shift to Series D but the catches in Series D also show a decline of about one foot (from 44 to 43 ft.) from 1958–59 to 1972–73.

In principle, the examination of degree of decline in mean size, considered together with the magnitude of catches, should provide estimates of population size, relative change in population size and number of recruits provided certain assumptions are made about natural mortality and growth rates. An advantage of attempting this is that such estimates do not depend on the use of effort data and cpue indices of relative abundance which, for sperm whales, are notoriously difficult to interpret.

A computer programme could be established, analogous to that developed by K. R. Allen for the analysis of series of annual changes in catch per unit effort as a function of catches, to extract maximum information from data series of mean sizes and catches. Here, however, I only explore the gross features of the method.

At the beginning of the whaling season the exploitable stock of magnitude P can be regarded as having two components: R recruits of mean length ${}_r\bar{l}$, and (P – R) post recruits ('non-recruits') of mean length ${}_n\bar{l}$. Then the mean length $\bar{l}$ of all whales is given by

$$\bar{l} = \frac{R\,{}_r\bar{l} + (P - R)\,{}_n\bar{l}}{P}$$

To develop a simple model to use this expression we designate by the suffix 1 population numbers and mean sizes at the beginning of a period of x years, and by 2 the numbers and sizes at the end of that period. We assume that:

(a) Just before each whaling season a batch of R recruits enters the stock, each batch having constant average length ${}_r\bar{l}$. In our case we can use a period of $x = 14$ years, and it is reasonable to assume constant R because the age of recruitment is greater than 14 years, and because we deal with males only while recruitment is essentially a function of the number of females, which had not been, and were not being, exploited and were, it is presumed, not changing much in number by natural causes.

(b) A small constant natural mortality M was operating and that this caused a total number of removals from the stock equal to

$$xM\frac{(P_1 + P_2)}{2}$$

Table 1

Antarctic pelagic catches/male sperm whales

Season	Series D	 A	 B	 A+B	$\frac{A+B}{A+B+D}\%$
1946–47	18	573	705	1,278	98.6
1947–48	0	930	1,539	2,469	100
1948–49	0	1,754	2,098	3,852	100
1949–50	0	1,253	1,300	2,553	100
1950–51	0	2,126	2,498	4,624	100
1951–52	0	2,047	3,203	5,250	100
1952–53	0	880	1,292	2,172	100
1953–54	0	1.076	1,610	2,686	100
1954–55	15	2,009	3,634	5,643	99.7
1955–56	31	1,471	5,322	6,793	99.5
1956–57	24	1,424	2,883	4,307	99.4
1957–58	134	1,893	4,269	6,162	97.9
1958–59	55	1,764	3,609	5,373	99.0
1959–60	90	1,523	2,509	4,032	97.8
1960–61	226	2,549	1,868	4,417	95.1
1961–62	521	3,073	1.095	4,168	88.9
1962–63	1,215	1,972	1,466	3,438	73.9
1963–64	3,031	1,833	1,427	3,260	51.8
1964–65	2,541	1,202	379	1,581	38.4
1965–66	1,526	1,012	1,500	2,512	62.2
1966–67	1,828	442	2,387	2,829	60.7
1967–68	1,146	340	1,025	1,365	54.4
1968–69	1,175	701	687	1,388	54.2
1969–70	1,841	235	909	1,144	38.3
1970–71	2,318	295	246	541	18.9
1971–72	1.995	463	737	1,200	37.6
1972–73	1,761	648	1,491	2,139	54.8

(c) A total removal, by capture, of ΣC was spread fairly evenly throughout the period.

(d) The mean sizes of whales in the catches are unbiased estimates of mean sizes in the population. This implies the presumption that although a whaler would prefer to take a larger rather than a smaller one, nevertheless he may not pass up the opportunity to take a smaller one when he sees it. (The consequences of this assumption will be examined later.) We can now write:

$$P_1 \, . \, \bar{l}_1 = R . {}_r\bar{l} + (P_1 - R) . {}_n\bar{l}_1 \qquad (1)$$

$$P_2 \, . \, \bar{l}_2 = R . {}_r\bar{l} + (P_2 - R) . {}_n\bar{l}_2 \qquad (2)$$

$$P_2 = P_1 + xR - \Sigma C - xM \frac{(P_1 + P_2)}{2} \qquad (3)$$

From (1) and (2) we find:

$$\frac{P_2}{P_1} = \frac{({}_n\bar{l}_2 - {}_r\bar{l})\,({}_n\bar{l}_1 - \bar{l}_1)}{({}_n\bar{l}_2 - \bar{l}_2)\,({}_n\bar{l}_1 - {}_r\bar{l})} \qquad (4)$$

and from (3) and (4):

$$P_1 = \frac{\dfrac{R . ({}_n\bar{l}_1 - {}_r\bar{l})\,(1 + xM/2)}{({}_n\bar{l}_2 - \bar{l}_2)} - xR + \Sigma C}{(1 - xM/2)} \qquad (5)$$

Combining (5) and (1) to eliminate P_1 we find:

$$R = \frac{\Sigma C}{\left(\dfrac{{}_n\bar{l}_1 - {}_r\bar{l}}{{}_n\bar{l}_1 - \bar{l}_1}\right) - \dfrac{({}_n\bar{l}_2 - {}_r\bar{l})}{({}_n l_2 - l_2)}(1 - xM/2) + x} \qquad (6)$$

A first step in applying these expressions is to estimate ${}_n\bar{l}_1$, given values for ${}_r\bar{l}$ and $\bar{l}_1$. To this end I rewrite (1) as

$${}_n\bar{l}_1 = \frac{\bar{l}_1 - {}_r\bar{l} \, . \, R/P_1}{1 - R/P_1} \qquad (7)$$

and assume that we start with a balanced population in which $R/P_1 = M$ and that this has been estimated from other data.

One cannot estimate ${}_n\bar{l}_2$ in the same way, except by complex calculations requiring estimates of growth as well as of natural mortality rates and a full cohort analysis which is beyond the scope of this paper. However:

$$\bar{l}_2 < {}_n\bar{l}_2 \leqslant {}_n\bar{l}_1 \text{ and probably} < \bar{l}_1 \qquad (8)$$

By putting ${}_n\bar{l}_2 = \bar{l}_1$ we obtain *minimum* estimates of P_1, of R and of the ratio P_2/P_1.

In the x = 14 years 1947–48 to 1961–62 the mean length of male sperm whales caught in Antarctic Series A and B, all divisions, declined from 51 feet to 47 feet. During that period the total catch was 65,800 whales, averaging 4,700 per year. The results of applying the above model to these values are given in Table 2.

It will be seen that the model gives a fairly narrow range of estimates of P_1 (and the same relative range of R) but that the estimate of stock decline depends very much on the value of ${}_n\bar{l}_2$.

Table 3 shows that estimates of R, and of P_1, are not very sensitive to values either of M ($= R/P_1$) or of $\bar{l}$. Estimates of the ratio P_2/P_1 are however sensitive to values both of ${}_r\bar{l}$, and of M. Although in the results given here a central value of 42 ft. for ${}_r\bar{l}$ has been used, the 'initial' size composition of the Series A and B catches suggests that in these Series, at least at that time, a more reasonable figure might be 44 or even as high as 46 ft.

The usefulness of the method is improved if one can narrow the limits of ${}_n\bar{l}_2$. A first approximation can be obtained from growth curves. At the end of the 14-year period, half of the incoming recruit groups will have been present for more than 7 years, and half of them for less than 7 years. Ohsumi's (1977) summary of growth curves suggests that 42 ft. male sperm whales, recruiting at 22–23

Table 2

Estimates for Series A+B

$\bar{l}_1$ = 51 feet $_r\bar{l}$ = 42 feet

if M = R/P_1 = 0.05, then $_n\bar{l}_1$ = 51.47 feet

Assumed	All divisions			Area III E only		
$_n\bar{l}_2$	P_1	R	P_2/P_1	P_1	R	P_2/P_1
51.47 (min.)	40,160	2.008	.105	10,320	516	.091
51	40,260	2,013	.122	10,340	517	.095
49	41,288	2,064	.174	10,580	529	.123
48	43,510	2,175	.298	10,600	530	.158
47.5	48,740	2,437	.546	10,750	537	.193
47.4	51,860	2,593	.670	10,790	539	.203
47.3	58,060	2,903	.877	10,840	542	.215
$\bar{l}_2$ =	47 feet			46 feet		

Table 3

Sensitivity of estimates to $_r\bar{l}$ and M values

(Example is for $_n\bar{l}_2$ = 49 feet)

	P_1	R	P_2/P_1	$_n\bar{l}_1$
M = 0.05				
$_r\bar{l}$ = 40	42,400	2,120	.225	–
42	41,288	2,064	.174	–
44	40,750	2,037	.126	–
46	39,570	1,979	0.074	–
$_r\bar{l}$ = 42				
M = 0.025	51,360	1,280	0.087	51.23
0.050	41,288	2,064	0.174	51.47
0.075	34,180	2,564	0.263	51.73

years, would, after 7 years (half the 14-year period), average 47 ft. in length. Because of the shape of the growth curve the mean of all 14 groups would be a little less than 47 ft., and also those that have been present for a longer time will have been subjected to mortality – natural and man-caused – for longer. So in the population P_2 the survivors of the last 14 recruitments might average in length 46 ft. The survivors of the initial (P_1 – R) 'non-recruits' will, one may presume, not have grown much, if at all, beyond their mean length of 51.5 ft., say to 52 ft. at most. From this it can be calculated that in P_2 the survivors of the initial 'non-recruits' constitute no more than about 15%, and perhaps as few as 12%. This means that $_n\bar{l}_2$ cannot be much higher than 47 ft., and surely is not more than 48 ft. This analysis therefore favors estimates of 1947–48 stocks of about 50,000 whales, reduced by perhaps 50% over the next 14 years.

Now I consider the direction and possible magnitude of error that might arise if the assumption is incorrect that whaling was not selective for size, even in the early years when male sperm whales in general and larger ones in particular were more abundant. In this case the decline in mean size in the population would be less than is indicated by the catches, especially because the initial mean size, as estimated from catches, would be too high. The effect of this is to cause the figures given in Table 2 to be underestimates of R and P_1 and also, of the ratio P_2/P_1. The effect is not, however, very great. Thus suppose the true $\bar{l}_1$ were 50 instead of the estimated 51 ft. Then $_n\bar{l}_1$ becomes 50.42 instead of 51.47 and we find, for the case $_n\bar{l}_2$ = 49

$$\begin{aligned} P_2/P_1 &= 0.175 \text{ (instead of 0.174)} \\ R &= 2{,}071 \text{ (instead of 2,064)} \\ \text{and } P_1 &= 41{,}420 \text{ (instead of 41,288)} \end{aligned}$$

that is, R, and hence P_1, were underestimated by 0.3%. Assuming a more extreme selective bias, with $\bar{l}_1$ = 49, and again $_n\bar{l}_2$ = 49 we find R and P_1 to be underestimated by 0.7%.

Another approach is to compare the non-selective case, with $_n\bar{l}_1$ = $_n\bar{l}_2$ = 51.47, with a selective case $\bar{l}_1$ = 50 and $_n\bar{l}_1$ = $_n\bar{l}_2$ = 49.37. We now find

$$\begin{aligned} P_2/P_1 &= 0.156 \text{ (instead of 0.105)} \\ R &= 2{,}136 \text{ (instead of 2,008)} \\ \text{and } P_1 &= 42{,}714 \text{ (instead of 40,160)} \end{aligned}$$

i.e. R and P_1 underestimated by 6%.

It appears, therefore, that the effect of initially selecting for the larger males is not very great.

The method described here can be applied equally to longitudinally separated stocks. Thus Table 4 shows the mean size and catch data for Area III E only, Series A and B. The mean size shows much the same trend as in those series as a whole, starting from the same initial level of 51 ft. but declining perhaps rather more, to 46 ft. The average annual catch was 1,190 male whales, that is 25% of the total for the Series. The results of applying the above method are shown in the last three columns of Table 1. They suggest that, whatever might have happened in the Series A and B as a whole, the population in Area III E was considerably reduced over the 14-year period; this, however, illustrates the sensitivity of the calculations to the value of $\bar{l}_2$ taken – in this case as 46 instead of 47 ft. The 'initial' stock-size estimates are remarkably stable at 10–11,000.

In all the above calculations it has been assumed that the sizes of male sperm whales in Series A and B were affected only by catches taken in those series. More likely, however, they were affected by catches at *all* latitudes in the Southern Hemisphere. From expression (6) it will be seen that estimates of R, and hence of P_1, are proportional to ΣC, and it is in that expression only that the cumulative catch is used. Thus corrected R and P_1 values are obtained by multiplying the results given in Tables 2 and 3 by the ratio

$$\frac{\text{Total catch, all latitudes}}{\text{Catch from Series A and B}} = 1.71$$

Table 4

Area III E, Series A+B

	$\bar{l}$	Catch
1946–47	50.6	596
1947–48	51.5	726
1948–49	51.0	1,660
1949–50	49.8	816
1950–51	50.2	1,264
1951–52	49.7	1,457
1952–53	49.8	793
1953–54	48.0	788
1954–55	48.5	2,272
1955–56	47.7	1,687
1956–57	48.2	708
1957–58	47.1	1,737
1958–59	46.6	1,425
1959–60	46.2	958
1960–61	46.1	929

which gives a revised P_1 estimate in the range 69–103,000.

The same calculation can be made by area or division. For Division 3 the Area III E values of P_1 and R are converted approximately by the ratio

$$\frac{\text{Total catch in Division 3}}{\text{Catch in Area III E, Series A + B}} = 1.42$$

thus arriving at a Division 3 estimate of about 15,000.

In order to compare this estimate with those obtained from analysis of changes in catch per unit effort and simulation models developed and used by K. R. Allen, it is necessary to allow for differences in the effective ages (and sizes) at recruitment which are assumed. A value used in the latter case for trial estimation is 15 years, as compared with 22.5 years in the present calculations. Assuming, again, $M = 0.05$ the necessary upward correction of the above figure – 15,000 – is by the factor

$$\text{Exp. } [0.05\,(22.5 - 15)] = 1.45$$

The revised estimate is therefore about 21,000. This is not very far from Allen's estimate of 24,700 for the same population, using Japanese data.

A further comparison can be made for the sum of population numbers in Divisions 3 to 8 inclusive, for which there is sufficient information to apply both methods.

The change in length, Series A and B, in Areas III E to VI (corresponding roughly with Divisions 3 to 8) was from 51.1 ft. in 1947–48 to 46.1 ft. in 1961–62, that is about the same as in Area III E. The mean annual catches over the period were

Division(s)	No.
3	1,577
3 (A+B)	1,190
3–8	3,410
1–9	7,480

The estimate required is

$$1.45 \times 15{,}000 \times 3{,}410/1{,}577 = 49{,}500.$$

A corresponding estimate from catches per unit effort (CHPOP programme) is about 100,000, using Japanese data, effort corrected for tonnage and use of ASDIC, and a single best value of q. When, however, individual q values are used, based on changes in catches per unit effort in the Antarctic (outside the baleen whaling season) the estimate is brought down nearly to 50,000 i.e. about the same as from changes in mean length. I do not suggest that such close correspondence is other than accidental. It does seem, nevertheless, that this method gives results not inconsistent with the estimates obtained by other methods; it gives results in, though at the lower end of, their admittedly wide range.

All methods which assume that at some particular time (in this case just after the second world war) the stock was stabilized, with constant recruitment continuing for some years after intensive exploitation, will of course be biassed if that assumption is not valid. In the six years 1932–33 to 1938–39 the male catch in Series A and B averaged 470 annually, mainly from Areas II E to IV; that is about one tenth of the post-war catch level. The catches in Area III E pre- and post-war were in the same ratio. At this catch rate, for only a few years, one would not expect to see a large change in mean size – the data suggest a possible decline of 0.5 ft. This pre-war catch rate is not, however, entirely negligible in terms of its possible effect on population abundance, especially if the rather substantial post-war depletion suggested by some analyses is credible. Furthermore, the stock in 1945–46 and subsequent years would not necessarily have an equilibrium age/size structure. This can perhaps explain, at least in part, the anomaly pointed out elsewhere that the mean length in immediate post-war catches is less than in immediate pre-war catches. This would be expected if, during the 6 years of very low war-time catches, a somewhat reduced stock was slowly recovering in numbers through the annual increment of new recruits, but did not have time to approach again a stable age/size structure in which eventually the mean size would regain its original higher value.

Thus the indications are that initial unexploited population numbers were somewhat higher than the 1947–48 estimates, especially as we cannot entirely reject the possibility that these populations had been affected by the low intensity, but much extended period, of 19th century whaling, and had not, by 1932–33 fully recovered from this.

There is a further possibility that pre-world war 2 whaling could, by reducing the mature males and perhaps also the females, have affected the subsequent recruitment. The time-lags in the 'recovering' population would ensure however that the average number of recruits in the early post-war years (R_1) would be more than we have supposed, and (*vide* expression (7)) $R_1/P_1 > M$.

To examine the consequences, let us suppose post-war R_1/P_1 was 0.06, i.e. 20% more than the equilibrium value. For all areas this gives ${}_n\bar{l}_1 = 51.57$ instead of 51.47 for ${}_r\bar{l} = 42$. Expression (6) then gives

$$R_1 = 2{,}310 \text{ (instead of } R = 2{,}064)$$

for the case ${}_n\bar{l}_2 = 49$

so $P_1 = 38{,}500$ (instead of 41,290)
also $P_r/P_1 = 0.208$ (instead of 0.174)
and $P_2 = 8{,}000$ (instead of 7,180)

but as noted earlier these values are highly dependent on the uncertain – and, strictly, altered – value of ${}_n\bar{l}_2$.

The true initial stock would have been given by

$$P_o \geqslant R_1/0.05$$
$$\geqslant 46{,}200$$

(and the index of relative state of the present stock $P_2/P_o \leqslant 0.173$).

Thus, if the post-war stock P_1 was in fact a 'recovering' one, the assumption that it was an insignificantly exploited or a fully recovered one would result in it being overestimated, in this case by about 7%, and the relative amount by which the 'present' stock has been reduced to below the unexploited level being underestimated.

This is, of course, only a crude way of assessing the errors, since recruitment would be continuously changing through the period prior to and following the post-war resumption of whaling, but I suppose the errors indicated are correct as to their direction, and roughly as to their degree.

REFERENCES

Best, P. B. 1977. Mean lengths (and no.) of Male Sperm Whales in Antarctic Pelagic Catches. Paper SC/28/Rep 1 (Appendix 3) (published in this volume).

Ohsumi, S. 1977. Age-Length Key of Male Sperm Whale in the North Pacific and Comparison of Growth Curves. Paper SP/Doc 12 (published in this volume).

SP/Doc 22

Estimation of Initial Stock and Catchability Coefficient of Male Sperm Whales in the Southern Hemisphere

R. G. Borodin

The simplified method of Allen (1966) was used for the estimation of male sperm whale stocks.

Relation between the stock size N in the first year and in a year t may be taken as:

$$N_t = N_1 K^{t-1} - (C_1 K^{t-2} + \ldots + C_{t-1})$$

Where: K is constant and equal to 1 + (r − M);
C − catch;
(r − M) − net recruitment.

Expected catch in a year t

$$C_t^{\exp} = (N_t - \frac{C_t}{2})\, qf_t$$

$$\text{or } C_t^{\exp} = \left\{[N_1 K^{t-1} - (C_1 K^{t-2} + \ldots + C_{t-1})] - \frac{C_t}{2}\right\} qf_t,$$

Where f − fishing effort in a year;
q − catchability coefficient.

Stock size N, and catchability coefficient q are estimated by comparison of actual and expected catch:

$$\sum_{t=1}^{\gamma} [C_t^{\exp} - C_t]^2 \longrightarrow \text{min.}$$

Statistical data on annual catch and fishing effort were used for estimation of the Southern Hemisphere sperm whale males taken from the articles of Gambell (1977).

Fishing effort in Antarctic pelagic catches of male sperm whales outside the baleen whale season were extrapolated upon the whole Southern Hemisphere.

Table 1 shows estimation of initial stock N and catchability coefficient q for all Divisions of Southern Hemisphere. It is assumed here that for the first years t = 18, K = 1.00, but then K = 1.01 ÷ 1.03 after 1963.

REFERENCES

Allen, K. R. 1966. Some methods for estimating exploited populations. *J. Fish. Res. Bd. Can.* 23 (10): 1553–74.

Gambell, R. 1977. Southern Hemisphere Sperm Whale Catch and Effort Data. Paper SP/Doc 8 (published in this volume).

Table 1

Population Estimates and Catchability Coefficient for Male Sperm Whales by Divisions of Southern Hemisphere

r − M since 1963	I	II	III	IV	V	VI	VII	VIII*	IX	Total	Whole
Stock size, (N × (1,000), 1946											
0.01	10.0	29.4	42.1	17.8	23.3	10.8	18.9	5.6+	47.8	205.8+	209.8
0.02	11.2	33.5	47.2	19.2	25.2	12.0	20.1	6.3+	53.5	228.0+	220.6
0.03	12.7	38.2	53.8	21.9	28.7	13.7	22.9	7.2+	60.7	259.8+	251.6
Coefficient catchability, q, × 10^{-3}											
0.01	0.1970	0.0834	0.0702	0.7492	0.7314	0.2910	0.1820	0.4681	0.0712	–	0.0149
0.02	0.1740	0.0691	0.0590	0.1287	0.1112	0.2518	0.1638	0.4329	0.0631	–	0.0121
0.03	0.1390	0.0551	0.0471	0.1027	0.0886	0.2008	0.1306	0.3952	0.0539	–	0.0097

* Whaling was not carried out on a large scale.

Report of the Working Group on North Atlantic Whales

Oslo 5–13 April 1976

1. The Scientific Committee of The International Whaling Commission proposed at the June 1975 Meeting that a working group on North Atlantic whales meet during the next year and that Jonsgård convene the meeting. The group met at 10.00 hours on 5 April 1976, and on following days, in the Department of Marine Zoology and Marine Chemistry, Institute of Marine Biology and Limnology, University of Oslo. Mr. F. Beyer, Director of the Institute welcomed the group and Jonsgård outlined arrangements of the meeting.

2. Rørvik was elected Chairman of the meeting and Brown elected as rapporteur.

3. There were present:

M. C. Mercer	Canada
E. D. Mitchell	
F. O. Kapel	Denmark
S. Ohsumi	Japan
I. Christensen	Norway
Å. Jonsgård	
D. Petzel	
C. J. Rørvik	
O. -V. Solvik	
K. I. Ugland	
C. H. Lockyer	UK
S. G. Brown	
G. A. Bertrand	USA
J. G. Mead	
M. F. Tillman	

4. It had been agreed before the meeting that the group should concentrate mainly on fin, minke and bottlenose whales, and the agenda proposed by Ohsumi was adopted (Annex A).

5. EXCHANGE AND REVIEW OF DOCUMENTS

A list of papers and tables prepared for the meeting, and of available relevant published papers is given in Annex B. Jonsgård drew attention to the data available for use during the meeting relating to Norwegian catches from 1938 onwards of all four species of small whales (minke, bottlenose, pilot, killer whales), listing length and sex distribution by seasons, months and areas. Also available were length and sex distribution by seasons and months for fin whale catches from all Norwegian land stations from 1946 onwards.

6. REVIEW OF HISTORY OF WHALING IN THE NORTH ATLANTIC (AGENDA ITEM 3)

Jonsgård drew attention to relevant papers (NA 76/1, 76/3, 76/5, 76/6, 76/22 and a paper by Ruud, J. T. on whaling off the west coast of Norway (*Norsk Hvalfangsttid.* 1946, Nos. 2 and 3)).

7. REVIEW OF HISTORY OF REGULATION OF WHALING IN THE NORTH ATLANTIC (AGENDA ITEM 4)

Jonsgård outlined his paper NA 76/4 on Norwegian and international regulations for minke whales and small whales. He especially drew attention to the potential problems associated with the introduction by the IWC in 1975 of regulation of the minke whale catch by quota (2,550 animals) and to the potentially dangerous situation which could arise for the stocks if Norwegian national regulations were completely removed and replaced by the IWC quota system without adequate inspection.

Kapel briefly reviewed the regulation of minke whaling in Greenland. There are three levels of regulation. First by Danish law, and here the regulations are similar to those of the IWC, e.g., the killing of calves or females accompanying calves, is forbidden; all whales are to be measured; the length of the season is regulated. At the second level there are the regulations of the Greenlandic Council. These include the limit of the season (8 months, 1 April–30 November); only those qualifying as full-time hunters are allowed to catch minke whales; the harpoon gun used must be of 50 mm or more calibre, but this regulation can be relaxed if only small catches are intended. In the case of single whales trapped in the ice other methods of killing may be used, providing that the animals are officially reported. At the third level are the regulations of local district councils. These apply mainly to beluga and narwhal, but in one area these regulations relate also to minke whales.

8. STOCK UNITS (AGENDA ITEM 5)

The group considered various definitions of a stock unit in the relation to present knowledge of different stocks of whales. It is not at present possible to separate stocks on a genetic or a breeding basis. However, the first aim is to distinguish populations or stocks which can be viewed as independent management units. As a basis, the definition given in NA 76/25, p. 2, was adopted as a practical definition of a stock:

> 'a relatively homogeneous and self-contained population whose losses by emigration and accessions by immigration, if any, are negligible in relation to the rates of growth and mortality'. (Anon., 1960, p. 8).*

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* Anon., 1960. Proceedings of joint scientific meeting of ICNAF, ICES and FAO on fishing efforts, the effect of fishing on resources and the selectivity of fishing gear. Vol. 1 – reports. *Spec. Publs. int. Comm., NW Atlantic Fish.* (2): 1–45.

9. FIN WHALE STOCKS

The group considered the following papers relevant to the identification of different stocks (NA 76/2, 5, 9, 16, 19, 25, 34, 35). The Canadian investigations reviewed by Sergeant (NA 76/19), indicate that two stocks occur off the east coast of Canada, with some interchange between them. One stock is found off Nova Scotia, and the other stock off Newfoundland/Labrador.

Whale marking has not demonstrated any interchange between fin whales occurring in the three regions Iceland – East Greenland; West Greenland; and the east coast of Canada (NA 76/16). Only small numbers of whales have been marked in the first two regions and catches in the West Greenland region are also small but, in the absence of positive evidence to the contrary, it was considered appropriate to treat the fin whales occurring off West Greenland as a separate stock.

The results of whale marking, and other evidence (NA 76/9), justify the treatment of fin whales in the waters off East Greenland and off the west coast of Iceland as one stock. Fin whales occurring off North Norway were considered to be a separate stock in the absence of positive evidence that they belong to the same stock as those occurring off west Iceland. Fin whales occurring off the western coast of Norway belong to a separate stock from those off North Norway, but may belong to the same stock as those caught around the Faroe Islands (NA 76/5).

There are indications that fin whales in Scottish waters (Shetland and the Hebrides) and those occurring off Spain and Portugal can be treated as one stock (NA 76/5).

The group concluded that the following areas of the North Atlantic contain concentrations of fin whales which can be treated as independent management units:

1. Nova Scotia
2. Newfoundland-Labrador
3. West Greenland
4. East Greenland – Iceland
5. North Norway
6. West Norway – Faroe Islands
7. British Isles – Spain and Portugal

10. MINKE WHALE STOCKS

The evidence for dividing minke whales in the North Atlantic into different stocks is very scanty. The group considered the well established segregation between the sexes and between length groups in minke whales (NA 76/6, 10, 24, 26, 34) as a means of identifying a stock. They also noted that the distribution of catches (NA 76/10, 12, 17, 18, 20, 28, 34), sightings (NA 76/2) and mark returns (NA 76/16) provide some clues to stock identification. Taking into consideration all the above evidence, the group concluded that the following areas probably contain fairly independent stocks of minke whales:

1. The Canadian east coast
2. The West Greenland area
3. The East Greenland – Iceland – Jan Mayen area
4. The region from Svalbard, the Barents Sea, along the Norwegian coast, including Skagerak, the North Sea and other areas around the British Isles.

There are some suggestions (segregation by length, trends in the percentage of mature animals, and the distribution of first year animals in the catches in the period 1960–72 (NA 76/10) which can be interpreted as indications of a separate stock around the British Isles, independent from those occurring off Norway. However, in the absence of stronger evidence, it was decided not to regard minke whales in British waters as a separate stock. The Svalbard area may also be an area where there is mixing between the stock of minke whales from the East Greenland – Iceland – Jan Mayen area, and the stock occurring off the Norwegian coast.

Petzel gave a brief outline of studies he is developing into biochemical methods, especially cryopreservation of blood, haemoglobin analysis and electrophoresis of red blood cell isozymes, for identifying stock units in fin, sei, minke and sperm whales. It is hoped that these methods, together with the extensive Norwegian marking programme for minke whales, will provide a firmer basis for identifying stocks.

11. BOTTLENOSE WHALE STOCKS

Nothing is known about the occurrence of separate biological populations of bottlenose whales in the North Atlantic. The distribution of the recent catches in the North-east North Atlantic shows four areas of concentration. These are:

1. West of Svalbard,
2. north of Iceland and around Jan Mayen,
3. in the Andenes area,
4. in the Møre area; these last two being off the Norwegian coast (Na 76/1, Fig. 1).

Mitchell pointed out that these were feeding concentrations and suggested that the factors governing distribution in bottlenose and sperm whales may be similar. Mead suggested that these four areas represent real concentrations of this species and that they might represent separate stocks. A concentration of catches in the Labrador Sea – Davis Strait region was also noted, with the possibility that there were two stocks, one on each side of the North Atlantic, which could be separated by a line drawn south from Kap Farvel. However, the group decided that, in the absence of clear evidence to the contrary, the bottlenose whale throughout the North Atlantic should be regarded as one stock.

12. BIOLOGICAL PARAMETERS (AGENDA ITEM 6)

The group developed a table of biological parameters for fin, minke and bottlenose whales in the North Atlantic (Annex C).

13. REPRODUCTION CURVE AND MSY (AGENDA ITEM 7)

The policy of management now adopted by the IWC requires an estimate of MSY, MSY population level, and the present population level, for setting catch limits for each stock. A population model is therefore needed which can provide such an estimate, but the models which can be used depend heavily on knowledge of biological parameters. In order to construct a reproduction curve which can provide an MSY estimate, information is required on natural mortality, ages at sexual maturity and recruitment, pregnancy rate, etc., and the change in these parameters with change in stock level. These parameters are only partially known for some stocks in the North Atlantic, the best information is available for fin whale stocks, especially the East Greenland – Iceland stock (NA 76/15) and the Newfoundland – Labrador stocks (NA 76/34).

Some data are available for minke whale stocks (especially the stock along the Norwegian coast (NA 76/26)). The need for data on the age structure of minke whale catches was stressed by the group. A sub-committee was appointed to report on the problems of sampling and reading ear plugs from minke whales, and possibilities of overcoming them (Annex F). It was agreed that methods of collecting and reading teeth from bottlenose whales were satisfactory (NA 76/14). If annual catches of minke whales can be divided into age-groups, estimates of population size for the different years could be made by virtual population analysis (VPA). This method is independent of effort data which is very difficult to obtain for small whale fisheries.

14. CATCH STATISTICS (AGENDA ITEM 8)

15. CATCH STATISTICS FOR NORTH ATLANTIC MINKE WHALES

Given the stocks defined by the Committee as a whole for the North Atlantic minke whale, catches from the following statistical areas were pooled for each stock (Annex D).

Shetland – Coastal Norway – Barents Sea
Between 1938–59 catches from Norwegian coastal areas I–VIII were pooled with Christensen's areas A, B (NA 76/3, Fig. 3). To separate increased catches off northern waters of East Greenland in the mid-1960s from those off Svalbard between 1960–75, catches from Solvik's areas A–I were pooled together (NA 76/10, Fig. 6).

Denmark Strait – East Greenland
Between 1952–59, Christensen's areas C, D were pooled, and between 1960–75 Solvik's areas J. K. L were pooled. Area L was first revised to end at Kap Farvel, Greenland. Icelandic catch data were available only for 1972–75 (NA 76/40).

West Greenland
Catches from Solvik's area M (revised to Kap Farvel) were pooled with Kapel's West Greenland catch data (NA 76/18).

Labrador – Newfoundland – Nova Scotia
Catches from Solvik's area N were pooled with Canadian catches from NA 76/22, p. 37–38.

It should be noted that differences between Solvik's catch values and those reported by Christensen or BIWS for 1960–75, are caused by the preliminary nature of the latter sources. Moreover, Solvik's data account for fin whales and sei whales suspected to be illegally captured by one vessel in 1971 and 1972, primarily in the West Greenland area, which were reported as minke whales.

16. EFFORT STATISTICS FOR NORTH ATLANTIC MINKE WHALES (TABLES IN ANNEX D)

For the Norwegian coastal stocks, two sources of effort data were available for consideration:

1. From NA 76/10, Solvik's wind corrected, effective boat-days per 10-day period and
2. uncorrected boat-days per month from unpublished Norwegian Annual Reports on Small Whaling. It was determined that a problem existed with Solvik's method of adjusting effort to account for the fact that vessels often operated in several statistical areas during a 10-day period. This problem most often occurred in Solvik's areas A, B, C and G, H, I. It was determined that pooling data from the above adjacent areas would eliminate the problem of how to account for vessel mobility. Thus, three new statistical areas were defined and effective boat-days per 10-day period were pooled for each:

Norwegian Stock Subareas

I – A, B, C (Barents Sea – Svalbard area)
II – D, E, F, (Norwegian coastal area)
III – G, H, I (Shetland – North Sea area)

The group discussed several factors which might affect effort, including wind strength, 'seeking' and migratory behavior, changes in the effectiveness of gear, regulation of the fishery, multi-species harvesting, and difference in day length at different latitudes. 'Seeking' was believed not to be important in high winds (>Beaufort 4), but in such winds minkes sometimes breached, becoming more visible. However, these winds also made the capture process difficult, if not impossible, so that increased visibility would not improve catcher efficiency. Thus wind strength was considered to be important and Solvik's factors to adjust for winds > Beaufort 3 were adopted. Catches decline drastically with winds greater than Beaufort 3. His data for 3 weather stations in areas A, B, C were averaged and used to correct pooled effort for those areas; no such data were available for D, E, F; and data from area I were used to correct pooled effort for G, H, I. It was also noted that considering the three newly-defined subareas would tend to eliminate the problem of different day length as well as that of differential segregation of sizes with latitude. Effort was also tabulated by month to account for different day length and migratory behavior.

Another factor considered was the effect of annual changes in catching vessels. Solvik reported that efficiency did not appear to be related significantly to vessel size (length) or to horsepower. However, the introduction of nylon line may have increased effective shooting range and radios facilitated cooperation among vessels. Measuring the effect of these changes is not possible, however, due to present lack of data.

It was not possible to make similar corrections for the old data from Norwegian Annual Reports on Small Whaling. This data was tabled for Norwegian Stock Subarea I, however, since it extended back to 1952. Solvik's data only covered the period 1960–72. The results for Subarea II are given in Annex D, Figure 4 from data made available by Jonsgård and Øritsland. Considering other stocks of minke whales in the North Atlantic, the group noted a lack of Icelandic data, for both catch and effort applied to the East Greenland – Denmark Strait Stock. The multi-species nature of the West Greenland fishery was discussed, and it was reported that only a few vessels could be considered whalers, other vessels taking shrimp, fish, seals, or whales as the opportunity was presented. Canadian effort data suffered from the same multi-species shortcomings, but were available for the group's use if needed. Thus, in these 3 remaining stocks only Norwegian effort seemed useful at present and have been tabled in terms of effective boat-days per month as given by Solvik. It may be possible to use data from the Greenlanders' catch when this is available.

Finally, the group considered the usefulness of the boat-day measure used. Given the nature of the many problems discussed above, it was decided that boat-days* may not reflect true whaling effort. The group considered alternative measures and decided that actual hours of searching and chasing would be the ideal effort measure. It recommended that all member nations review their collection of effort data with a view toward obtaining actual hours of searching and chasing.

17. STOCK ASSESSMENTS (AGENDA ITEM 9)

18. FIN WHALE STOCK ASSESSMENTS (SEE TABLES IN ANNEX E)

Catch and effort data (NA 76/13) comprise numbers of whales and numbers of boats from 1868 onwards. Unspecified catches occur especially in the earlier years. The difficulties using these statistics before 1915 are discussed in NA 76/25.

(i) North Norway

(a) A DeLury plot of CPUE versus cumulative catch for the period 1896 to 1904 produced a regression without a significant slope (catches for 1883–84 and 1891–95 were estimated from unspecified catches by proportional allocation corresponding to species composition of catches in adjacent years). Chapman's accumulated catch method indicated $N_{1896} = 3{,}095$ or 3,796, with net recruitment of 6% and 4% respectively ($0.05 < P < 0.1$).

(b) Cumulative catch 1896–1904 was 3,205 whales in the 9 year period. This gives a lower limit for 1896 population size, but because of the results in (a) above, no upper limit for the estimate is available.

(c) Catches 1876–1920 showed no trend in CPUE so that the DeLury method could not be applied.

(d) Effort data for periods (i) 1876–1920 and (ii) 1896–1904 were adjusted by dividing by catches of other baleen whales. No trend in CPUE thus adjusted was found in (i) but in (ii) the slope was significant ($P < 0.05$) and indicated $N_{1896} = 3{,}658$. The mean of 4 estimates of N_{1896} above is 3,438. If prior removals are deemed to have reduced the stock to MSY level this implies MSY = 138–206 whales/year for assumed 4 or 6% net recruitment (removals 1885–90 were 2,216).

(e) For the recent period 1948–71, plots of CPUE versus effort, and CPUE versus effort divided by sperm whale catch (the other species exploited at this time) did not produce a regression with a significant slope.

Lack of an estimate of 1948 population size precludes a definitive conclusion on the degree of recovery from the period of earlier extensive over-exploitation. Annual catches 1948–71 ranged from 21 to 138 (mean 61) below the calculated MSY. Rørvik and Jonsgård (NA 76/25) estimated that if the stock can sustain a catch of 61 whales annually, the recruited stock must have been at least 2,034.

(ii) Western Norway and the Faroe Islands

A recent analysis applying the modified DeLury method (SC/26/13)† indicated a 1946 stock size of 2,700 reduced to 430 at the start of the 1963 season. These data were reanalysed resulting in an improved estimate of 1,050 for the 1963 stock level. Assuming that the stock in 1946 was half the accumulated stock size, and a net recruitment rate of 6%, this implies a maximum sustainable yield of 160.

Chapman's accumulated catch method using net recruitment rate of 6%, gives $N_{1946} = 3{,}007$, and $N_{1963} = 1{,}550$. All regressions were significant in this case.

Removals from the depleted 1963 stock were 84 whales in the period 1963–69. The stock is thus in a seriously depressed state.

(iii) Spain, Portugal and British Isles

(a) Cumulative catch 1921–27 for Spain and Portugal was 6,433 and for Shetland, Hebrides and Ireland 1922–27 was 2,071. A minimum estimate of 1921 stock size is thus 8,504.

(b) A DeLury plot catch per Spanish boat versus cumulative catch for all boats 1924–27 produced a significant slope (correlation coefficient = 0.938, P = 0.07) with an estimate of $N_{1924} = 10{,}470$ and N_{1921} by addition = 13,038. From 1924 to 1929 catch per boat decreased from 71.6 to 18.3 fin whales/boat in the Scottish fishery (NA 76/5).

Application of Chapman's accumulated catch method with an assumed net recruitment of 6% for 1924–27 produced a significant regression (correlation coefficient = 0.936, P = 0.07) with an estimate of $N_{1924} = 7{,}389$. By addition $N_{1921} = 9{,}957$. With net recruitment assumed at 4%, then $N_{1921} = 10{,}768$.

There is thus strong evidence of extensive over-exploitation in the 1920s. The mean estimate of N_{1921} is 10,567 and removals prior to that time were extensive (3,209 in 1906–14) so the stock may have been at MSY level in 1921. MSY would then be 423 or 634 with assumptions of net recruitment of 4 or 6% respectively.

Lack of trend in catch/effort data in the period 1950 to the present precludes assessment of current stock size and lack of accurate data on species composition of the catch precludes detailed determination of the level of recent removals. Removals appear to have been in the order of 19–152 in 1950–73, far below MSY level.

(iv) East Greenland – Iceland

The best estimate of stock size from tag-recapture data is 6,900 (NA 76/9). It is evident that there has been no serious reduction in the stock in the period 1948–74. The population appears to be in equilibrium with the continuing catch of about 250 animals per year (NA 76/9). Lack of refinement of effort data could mask persistent removals at levels slightly exceeding MSY over an extended period and reflect a change in stock size only after extensive depletion had occurred. Rørvik is preparing a model simulating such a potential circumstance. The need for extensive collection of ear plug data to facilitate cohort analysis is thus indicated.

(v) West Greenland

Pelagic whaling in the North Atlantic 1929–34 and 1937 resulted in removals of 2,809 whales (annual average 401) from grounds near Svalbard, Bear Island, Jan Mayen, Denmark Strait and West Greenland. The exact number taken at West Greenland is uncertain, but from data given in NA 76/5 the total appears to be about 526 or 75 per year.

The removals by shore-based whaling were 3 to 75 per year 1922–24 and 1931–39 (total for the period 247).

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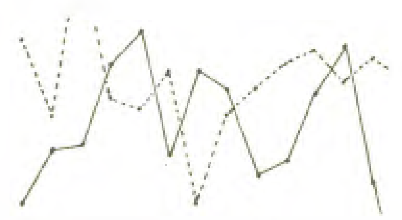
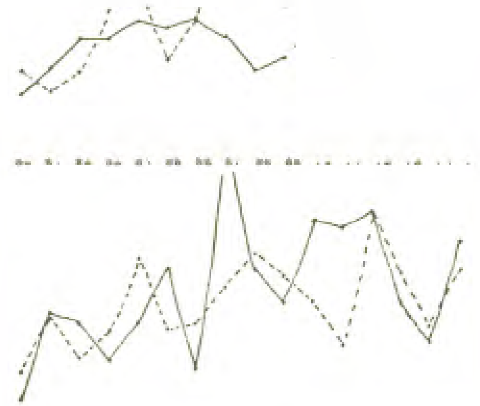
* Boat-days = number of boats with a catch in this area and month in question multiplied by the number of days when at least one whale was caught by any boat in the area.

† Jonsgård, Å. and Rørvik, C. J. 1975. A note on the stock of fin whales, *Balaenoptera Physalus (L)*, off the west coast of Norway and the Faroes. *Rep. int. Whal. Commn.* 25: 166–173.





caution. Other members believe that the evidence from the analyses of CPUE and length distributions by area adequately supported the assumption of an equilibrium state and that the estimates were adequate. However, all agree that in view of the above problems, additional data should be collected with a view to using alternative methods of assessment. The group recommend that programmes for collecting sighting data and ear plugs and other material for age determination be undertaken. Especially important in this connection is the continuation and expansion of the minke whale marking programme. The question of recording information on the occurrence of 'seeking' behavior in individual animals at the time of marking and possibly also for animals from which marks were recovered, was discussed and this possibility will be examined.

No estimates are as yet possible for the other stocks (Canadian, West Greenland, East Greenland) using the methods outlined above. However, given a satisfactory estimate for the Norwegian stock, it may be possible to calculate abundance for the other stocks using relative indices of abundance from future sighting data.

The group draws to the attention of the Scientific Committee the fact that it has recommended that catches of minke whales be regulated by two areas, each and west of Kap Farvel, while the group has defined four stocks of minke whales in the North Atlantic.

20. STOCK ASSESSMENT – BOTTLENOSE WHALES

The status and exploitation of the bottlenose whale was discussed mainly on the basis of documents NA 76/1, 2, 3, 4, 6, 21.

Christensen (NA 76/1) concludes on the basis of the catches after 1912 that it is unlikely that the present stock of bottlenose whales in the eastern north Atlantic is below the 1912 level. It may therefore be higher than 30,000 whales, the MSY is probably between 500 and 1,000 (NA 76/1).

DISCUSSION

Christensen and Rørvik considered catch per boat to be a relatively good measure of stock size because of the fairly regular downward trend, after the few initial years, in the catch per boat shown in the period 1883 to 1915 (NA 76/1, Fig. 5).

Some members of the group believe that catch per boat is not a useful measure in this context because of seeking behaviour and the marked epimeletic behavior of bottlenose whales. However, it was pointed out that if epimeletic behavior was a major factor influencing the catches of bottlenose whales, one would not expect the large proportion of catches of single or few animals taken at intervals during the period 1938–73 (NA 76/1, Table 5).

In NA 76/1 (Fig. 4) Christensen shows the value of minke whales and bottlenose whales during the period 1960 to 1971. The mean value of minke whales has increased both absolutely and relatively to that of bottlenose whales. To reflect local Norwegian prices for meat and blubber Fig. 4 in NA 76/1, should include a correction factor for foreign sale by one boat in 1970 and 1971. Jonsgård provided the annual Norwegian reports from 1938 to the present which include all available data on meat and blubber production and prices.

The meat from bottlenose whales was used by fur farmers. However, the decline of fur farming caused the market for this meat to decline also. At the present time the demand for meat for fur farmers is supplied by slaughter houses which offer a cheaper source of meat. It was also noted that meat from toothed whales cannot be sold for human consumption in Norway.

Jonsgård pointed out that the Norwegian land station at Tromsø, which relied heavily on sperm whale oil and meat which have similar economic values to bottlenose whale oil and meat, stopped whaling after the 1971 season because of low prices.

Christensen described the method of storing meat on small whale boats. Meat from minke whales cannot be mixed with that from bottlenose whales. Only the larger boats have separate holds allowing for the storage of large quantities of meat from both species. The whalers are primarily interested in catching minke whales and they are mainly caught in different areas from bottlenose whales (NA 76/21 – Fig. 1; NA 76/10 – Fig. I–XXVI; NA 76/12).

Jonsgård and Christensen stated that it was because of the economic reasons outlined above that the Norwegian catch of bottlenose whales has declined; only 20 whales having been caught since 1971 compared with annual catches ranging from 87 to 692 animals in the years 1960–70 (NA 76/1, Table 1).

Mitchell, however, pointed out that the mean price of bottlenose meat (NA 76/1, Fig. 4) had not decreased in the period 1960–71 suggesting that bottlenose whaling declined because of depleted numbers rather than for economic reasons. In this connection he stressed the importance of having published information on the prices of bottlenose and minke whale products for as many years as possible in order to provide a basis for evaluating the catches of the two species, to determine whether bottlenose catches are strictly tied to prices. He also pointed out that the westerly expansion of the Norwegian small whale fisheries with decreased catches in the eastern part of the North Atlantic (NA 76/3, Table 3) indicated successive depletion of the different concentrations or stocks.

Christensen (NA 76/2) reported more than 569 bottlenose whales were sighted on a cruise off Labrador in 1971, the last year of Norwegian operations in the area when only 151 were caught (NA 76/3). Table 1 (NA 76/1) shows an increase in catch per bottlenose catcherboat (exclusive of combined catchers) in the period from 1937 onwards.

In view of this doubt about the present status of bottlenose whales, the group agreed that it would be very valuable to:

(1) Obtain relevant economic data for the Norwegian small whale industry for as long a period as possible and for this to be available to the Scientific Committee of the IWC.

(2) To mount a special whale sighting cruise (or cruises) across the old bottlenose whaling grounds in order to check the present density of bottlenose whales on these grounds, since the boats operating now are not whaling on the same grounds.

(3) Further analyse the available data for the transition period from bottlenose whaling to modern minke whaling.

21. ECOSYSTEM (AGENDA ITEM 10)

Possible effects of sequential depletion of stocks of various whale species on interspecific competition were discussed with reference to document NA 76/33. Interaction among trophic levels involving such complexes as capelin – cod – fin and minke whales and harp seals were discussed. The intensive nature of modern fisheries harvesting at several trophic levels was noted. Present fisheries models are generally single species analytical models. The need for a systems approach to study interactive aspects was stressed.

22. FUTURE STUDIES (AGENDA ITEM 11)

The group considers that the IDCR North Atlantic Research Proposals (in press) should be reviewed in the light of the following items which are of high priority in future studies:

(i) Studies in age determination. This involves both studies of reading methods and sampling methods. The importance of age distributions for yearly catches is emphasized because these would enable assessments to be made by virtual population analysis without taking into account effort. Age distribution also allows more sophisticated models to be used for MSY determinations, etc. Reliable and practical methods, and substantial collections, for age determination of minke whales are still lacking (Annex F). A reward system for collections of ear plugs and bulla tympanica for this species should be considered.

(ii) Whale marking. Marking is still one of the best methods for stock identification, age and growth studies and estimation of stock size. In connection with marking, seeking behavior, etc. should be studied, because marking and collecting may be taking place on a biassed sample of the population.

(iii) Sightings data from operations. Based upon the group's review of the new Norwegian form for recording catch data it was suggested that the utility of the form would be improved if it included sighting data for all species observed while whaling. Some members of the group felt that this additional data more properly should be recorded upon a separate form by the whalers, recommending that this second form adopt the format proposed by the Scientific Committee for recording sighting data in its North Atlantic IDCR programme. Other members, citing practical problems for whalers, felt that the proper course of action should merely be to alter the new form if possible and include the additional data desired. Although a consensus was not achieved on how to record the desired data, it was agreed that the following parameters should be recorded to ensure proper analysis of sightings:

    (1) Sightings of all cetacean species encountered.
    (2) Number in each sighting.
    (3) Whether animals approached vessel ('seeking'), or not.
    (4) Position.
    (5) Date and time.
    (6) Check-list of weather parameters (cf. IDCR form).
    (7) Sighting effort, in 'hours on watch', each day.

These data are included in the IDCR sightings form except for 3.

(iv) Studies of effort. The importance of factors which are independent of stock size but have an influence on effort needs to be evaluated. Studies of how these factors can be reduced in order to increase the sensitivity of catch per unit effort as an indicator of stock size should be carried out.

(v) Survey cruises. Sighting cruises to the areas of concentrations of whales should be undertaken in order to obtain independent estimates of stock size; particular emphasis should be given to bottlenose whales in this context.

23. OTHER BUSINESS (AGENDA 12)

Regulation of Icelandic whaling

The group was asked by the chairman of the Scientific Committee to consider an Icelandic proposal that their fishery for large whales be regulated by effort rather than by quota because of the variations in the availability of whales from year to year (see NA 76/9, Table 2). Reference is made to the assessment of fin whale stocks in this report. The group discussed the possible biological effects of this proposed regulation and expressed reservations concerning effort data in relation to stock size.

The group felt however, that the question of which method of regulation should be used for the Icelandic fishery was a matter for the Technical Committee of the IWC.

Inclusion of the bottlenose whale in the Schedule of the IWC

The group noted that the bottlenose whale (*Hyperoodon ampullatus*) does not appear in the Schedule of the IWC and draws this to the attention of the Scientific Committee.

ACKNOWLEDGEMENTS

The group expressed thanks to Mr Beyer for the excellent facilities provided for the meeting and to Jonsgård for the provision of working papers, statistics and other material which had contributed greatly to facilitating the work of the meeting. Members also wished to thank Mr Rye for his valuable assistance in running computer programmes, providing copies of papers, and typing the draft report.

Annex A

WORKING GROUP MEETING ON NORTH ATLANTIC WHALES, THE UNIVERSITY OF OSLO
5–13 APRIL 1976

Agenda
(Proposed by Dr Ohsumi)

1. Introduction
2. Appointment of chairman
3. Review of history of whaling
4. Review of history of regulation
5. Stock units
   - 5.1. Method of identification of stock units
   - 5.2. Distribution
   - 5.3. Segregation
   - 5.4. Identity of stock units
6. Biological parameters
   - 6.1. Natural mortality
   - 6.2. Age and length at recruitment
   - 6.3. Age and length at sexual maturity
   - 6.4. Pregnancy rate
   - 6.5. Sex ratio and others
7. Reproduction curve and MSY
   - 7.1. Population model
   - 7.2. Reproduction curve
   - 7.3. Net recruitment rate
   - 7.4. MSY population level and MSY
8. Catch statistics
   - 8.1. Catch
   - 8.2. Fishing effort
9. Assessment
   - 9.1. Minke whales
   - 9.2. Fin whales
   - 9.3. Bottlenose whales
10. Ecosystem
11. Further study
12. Other business

Annex B

LIST OF MEETING DOCUMENTS

NA 76/1. Christensen, I. The history of exploitation and the initial status of the northern Atlantic bottlenose whale (*Hyperoodon ampullatus*).

NA 76/2. Christensen, I. Observations of whales in the North Atlantic from cruises with small whale catchers in the seasons from 1971 to 1975.

NA 76/3. Christensen, I. 1975. Preliminary report on the Norwegian Fishery for small whales. *J. Fish. Res. Bd. Can.* 32: 1083–94.

NA 76/4. Jonsgård, Å. Norwegian and international regulations in the Norwegian whaling for minke whales, *Balaenoptera acutorostrata*, and small whales.

NA 76/5. Jonsgård, Å. 1966. Biology of the North Atlantic fin whale *Balaenoptera physalus* (L). *Hvalrådets Skrifter*, No. 49: 62 pp.

NA 76/6. Jonsgård, Å. 1955. Development of the modern Norwegian small whale industry. *Norwegian Whaling Gazette* (1955), No. 12: 697–718.

NA 76/7. Jonsgård, Å. 1968. A review of Norwegian biological research on whales in the Northern North Atlantic Ocean after the Second World War. *Norwegian Whaling Gazette*. (1968), No. 6: 164–67.

NA 76/8. Petzel, D. The North Atlantic minke whale, *Balaenoptera acutorostrata* Lacépède: White flipper band analysis.

NA 76/9. Rørvik, C. J., Jónsson, J., Mathisen, O. A. and Jonsgård, Å. 1976. Fin whales, *Balaenoptera physalus* (L) off the west coast of Iceland. Distribution, segregation by length and exploitation. *Rit. Fisk.* 5 (5): 1–30.

NA 76/10. Solvik, O.-V. The minke whale, *Balaenoptera acutorostrata* Lacépède, in the North Atlantic.

NA 76/11. Ugland, K. I. Studies in an equilibrium model for whale stock assessments.

NA 76/12. Norwegian whaling for small whales. Tables for bottlenose, pilot, killer and minke whale catches, with chart showing whaling areas.

NA 76/13. Tables of catch statistics for large whales in the North Atlantic.

NA 76/14. Christensen, I. 1973. Age determination, age distribution and growth of bottlenose whales, *Hyperoodon ampullatus* (Forster), in the Labrador Sea. *Norwegian J. Zool.* 21 (4): 331–40.

NA 76/15. Lockyer, C., Gambell, R. and Brown, S. G. Notes on age data of fin whales taken off Iceland, 1967–74, with age/length keys.

NA 76/16. Whale marking – North Atlantic – Tables 1–10 and 2 charts (fin and minke).

NA 76/17. Kapel, F. O. 1975. Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland. *J. Fish. Res. Bd. Can.* 32: 1079–82.

NA 76/18. Catch statistics for minke whales, West Greenland, 1954–74.

NA 76/19. Sergeant, D. E. Stocks of fin whales *Balaenoptera physalus* (L) in the North Atlantic Ocean.

NA 76/20. Four charts of distribution of concentrations or stocks of fin, minke, blue and bottlenose whales. (From Annex E4, SC/SP 74/Rep. 2).

NA 76/21. Benjaminsen, T. 1972. On the biology of the bottlenose whale, *Hyperoodon ampullatus* (Forster). *Norwegian J. Zool.* 20 (3): 233–41.

NA 76/22. Mitchell, E. 1975. Porpoise, dolphin and small whale fisheries of the world. Status and problems. *IUCN Monograph* No. 3: 129 pp.

NA 76/23. Christensen, I. 1972. Minke whale investigations in the area Spitsbergen-Barents Sea in May–June 1972. *Fiskets Gang*, No. 48: 961–65.

NA 76/24. Christensen, I. 1974. Minke whale investigations in the Barents Sea and off East and West Greenland in 1973. *Fiskets Gang*, No. 14: 278–86.

NA 76/25. Rørvik, C. J. and Jonsgård, Å. Review of Balaenopterids in the North Atlantic Ocean. (ACMRR Group I document).

NA 76/26. Jonsgård, Å. 1951. Studies on the little piked whale or minke whale: *Norsk Hvalfangsttid.* (1951) No. 5: 209–32.

NA 76/27. Mitchell, E. D. 1973. The status of the world's whales. *Nature Canada* 2 (4): 9–25.

NA 76/28. Mitchell, E. and Kozicki, V. M. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. *J. Fish. Res. Bd. Can.* 32: 985–94.

NA 76/29. Mitchell, E. and Kozicki, V. M. 1975. Autumn stranding of a northern bottlenose whale (*Hyperoodon ampullatus*) in the Bay of Fundy Nova Scotia. *J. Fish. Res. Bd. Can.* 32: 1019–40.

NA 76/30. Foote, D. C. 1975. Investigation of small whale hunting in Northern Norway, 1964. *J. Fish. Res. Bd. Can.* 32: 1163–89.

NA 76/31. Mitchell, E. 1972. Whale pigmentation and feeding behavior. *American Zoologist* 12 (4): 60.

NA 76/32. Mitchell, E. D. 1968. North Atlantic whale research. *Annual Review Fish. Council Canada* 1968: 45, 47/8.

NA 76/33. Mitchell, E. 1974. Trophic relationships and competition for food in northwest Atlantic whales. *Proc. Canadian Soc. Zool.* (Annual meeting 1974): 123–33.

NA 76/34. Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. *In* Schevill (Editor). *The Whale Problem: a Status Report:* 110–68.

NA 76/35. Mitchell, E. 1972. Assessments of northwest Atlantic fin whale stocks. *Rep. int. Whal. Commn* 22: 111–18.

NA 76/36. Mitchell, E. 1974. Preliminary report on Newfoundland fishery for minke whales (*Balaenoptera acutorostrata*), *Rep. int. Whal. Commn* 24: 159–76.

NA 76/37. Mitchell, E. 1974. Progress report on whale research, Canada, May 1972 to May 1973. *Rep. int. Whal. Commn* 24: 196–213.

NA 76/38. Mitchell, E. 1975. Progress report on whale research, Canada, May 1973–May 1974. *Rep. int. Whal. Commn* 25: 270–282.

NA 76/39. Jonsgård, Å. 1974. Whaling in Eastern North Atlantic. Section on small whales. *In* Schevill (Editor). *The Whale Problem: a Status Report:* 102–7.

NA 76/40. Note on minke whale catches in Iceland 1973–75, provided by the Icelandic Ministry of Fisheries.

ANNEX C

BIOLOGICAL PARAMETERS

PARAMETER	FIN		MINKE		BOTTLENOSE	
Instantaneous Natural Mortality Coefficient, M	0.04–interpolated from Z = 0.07/9		0.09 N.E. Atlantic/11, p. 54		0.03–0.08/1, p. 11	
RECRUITMENT:						
Initial age	1–3 yr. Iceland/15		0 yr./26, pp 26–43		1–2 yr./14	
Initial length	50 ft. Iceland, elsewhere/15		15–17 ft. N.E. Atlantic/10, p. 52		16 ft./21, p. 238	
SEXUAL MATURITY:	♀	♂	♀	♂	♀	♂
Mean Age (50% level)	Iceland 7 yr/15 E. Canada 11–12 yr./34	E. Canada 10–13 yr./34	N.E. Atlantic 5–6 yr./10, pp. 78, 83. N.W. Atlantic 7 yr./28.	N.E. Atlantic 3–4 yr./10, p. 83	9 yr. (7–18 yr.)/14	9–11 yr./21
	♀	♂				
Mean length (50% level)	62.7 ft. N. Norway 60.6 ft. W. Norway/15 60 ft. Iceland/15 E. Canada 58–60.5 ft./34	E. Canada 55.5–57.5 ft./34	N.W. Atlantic 24 ft./28	N.W. Atlantic ca. 22 ft./28	22–23 ft. /14, 21	24 ft./21
OVULATORY PERIOD in yrs. (from ovulation rate)	1.3–1.4 yr. Iceland/15		1.7 yr. Newfoundland/28		2.0 yr./14	
PREGNANCY RATE:	0.358–0.418	Newfoundland and Nova Scotia/34	0.96 Newfoundland/28 0.90–0.97 Barents Sea/24		2 yr. cycle/14	

N.B. /n refers to Document NA 76/number

ANNEX D

Table 1.

Minke catches. Barents Sea – Coastal Norway – Shetlands stock. All catches done by Norway.

Season	♂	♀	Unknown	Total
1938	661	531	198	1,390
1939	441	391	85	917
1940	233	218	92	543
1941	1,047	890	176	2,113
1942	1,043	834	254	2,131
1943	663	568	380	1,611
1944	657	591	125	1,373
1945	943	741	94	1,778
1946	895	738	257	1,890
1947	1,235	998	339	2,572
1948	1,791	1,496	274	3,561
1949	1,814	1,878	233	3,925
1950	862	972	155	1,989
1951	1,311	1,289	150	2,750
1952	1,458	1,826	81	3,365
1953	1,181	1,162	90	2,433
1954	1,696	1,720	37	3,453
1955	2,020	2,246	48	4,314
1956	1,775	1,802	81	3,658
1957	1,587	1,903	150	3,640
1958	1,853	2,268	220	4,341
1959	1,616	1,413	61	3,090
1960	1,521	1,715		3,236
1961	1,427	1,689		3,116
1962	1,539	1,655		3,194
1963	1,435	1,580		3,015
1964	1,183	1,280		2,463
1965	1,013	1,091		2,104
1966	548	1,056		1,904
1967	884	879		1,763
1968	1,165	813		1,978
1969	1,004	1,012		2,016
1970	880	1,008		1,888
1971	851	946		1,797
1972	791	1,385		2,176
1973	677	917		1,594
1974	527	884		1,411
1975	593	781		1,374
				91,866

Table 2.

Minke catches. Denmark Strait – East Greenland stock

	Norway			Iceland	
Season	♂	♀	Total	Total	Total
1952			2		2
1955			16		16
1957			2		2
1960	22	18	40		40
1961	101	38	139		139
1962	141	113	254		254
1963	88	81	169		169
1964	180	91	271		271
1965	170	179	349		349
1966	126	124	250		250
1967	284	124	408		408
1968	385	342	727		727
1969	128	80	208		208
1970	163	123	286		286
1971	78	56	134		134
1972	132	104	236	35	271[1]
1973	188	76	264	122	386
1974	97	65	162	86	248
1975	82	129	211	171	382
					4,542

[1] Earlier Iceland data not available

Table 3.

Minke catches. West Greenland stock.

	Norway			Greenland	
Season	♂	♀	Total	Total	Total
1954				25	25
1955				21	21
1956				26	26
1957				24	24
1958				14	14
1959				35	35
1960				52	52
1961				34	34
1962				71	71
1963				164	164
1964				165	165
1965				195	195
1966				254	254
1967				237	237
1968	20	7	27	312	339
1969	121	47	168	263	431
1970	76	48	123	196	319
1971	84	176	260	189	449
1972	34	93	127	145	272
1973	67	154	221	268	489
1974	43	207	250	204	454
1975	11	92	103	–	103[1]
					4,173

[1] Greenland data not available

Table 4

Minke catches. Labrador – Newfoundland – Nova Scotia stock.

Season	Norway ♂	Norway ♀	Norway Total	Canada Total	Total
1947				16	16
1948				41	41
1950				–	–
1951				55	55
1952				17	17
1953				20	20
1954				32	32
1955				13	13
1956				57	57
1957				37	37
1958				42	42
1959				18	18
1960				11	11
1961				22	22
1962				50	50
1963				18	18
1964				54	54
1965				41	41
1966				28	28
1967				40	40
1968				–	–
1969	2	4	6	50	56
1970	1	4	5	86	91
1971	7	7	14	73	87
1972	62	51	113	97	210
1973	–	–	–	–	–[1]
1974	–	–	–	–	–
1975	–	–	–	–	–
					1,056

[1] Whaling ended

Table 5

Catch per Unit Effort for Norwegian stock of minke whales, Subarea I (A,B,C, in NA 76/10) based upon data from Norwegian annual reports.

Season	Catch May	Catch June	Effort (Boat-days) May	Effort (Boat-days) June	CPUE May	CPUE June	Combined
1952	427	1,033	1,257	2,164	.35	.48	.43
1953	381	685	1,139	1,569	.33	.44	.39
1954	341	768	1,223	1,846	.28	.42	.36
1955	423	1,262	1,630	2,133	.26	.59	.45
1956	702	868	2,334	2,473	.30	.35	.33
1957	702	874	2,323	2,446	.30	.36	.33
1958	595	1,299	2,185	2,952	.27	.44	.37
1959	436	903	1,597	3,153	.27	.29	.28
1960	439	979	2,101	2,876	.21	.34	.28
1961	456	978	1,571	2,930	.29	.33	.32
1962	314	1,007	1,401	2,472	.22	.41	.34
1963	656	974	2,282	2,545	.29	.38	.35
1964	400	629	1,143	1,815	.35	.35	.35
1965	236	749	799	1,601	.30	.47	.41
1966	321	631	871	1,346	.37	.47	.43
1967	378	449	1,208	1,683	.31	.27	.29
1968	374	656	1,520	1,774	.25	.37	.31
1969	400	930	1,331	1,865	.30	.50	.42
1970	535	658	1,710	1,771	.31	.37	.34
1971	365	718	848	1,619	.43	.44	.44
1972	552	1,170	1,527	1,758	.36	.67	.52
1973	224	929	800	2,240	.28	.41	.38
1974	263	749	962	1,174	.27	.64	.47
1975	179	829	511	1,295	.35	.64	.56

Table 6

Minke whales

Norwegian stock Subarea 1 (A + B + C in NA 76/10).

			Boat-days						Wind corrected			
	Catch		May			June			Effort		CPUE	
Year	May	June	1	2	3	1	2	3	May	June	May	June
1960	393	951	370	440	410	260	550	570	619.1	785.1	.64	1.21
1961	459	957	270	410	460	570	520	580	549.4	1003.2	.84	.95
1962	312	982	210	300	310	310	480	490	361.0	646.4	.86	1.52
1963	655	967	240	380	430	400	520	510	573.1	953.3	1.14	1.01
1964	399	645	100	300	350	420	450	440	317.3	659.7	1.26	.98
1965	238	682	130	190	240	350	410	430	288.7	612.3	.82	1.11
1966	323	328	120	190	250	310	380	300	288.8	494.8	1.12	.66
1967	372	447	140	250	290	410	260	380	350.4	463.9	1.06	.96
1968	358	643	230	330	400	350	360	420	423.6	602.6	.76	1.06
1969	401	962	300	150	300	460	460	310	496.8	820.5	.81	1.13
1970	525	563	250	340	390	400	240	440	492.1	503.6	1.07	1.19
1971	362	706	90	250	280	240	420	290	299.8	655.7	1.21	1.08
1972	545	1,162	220	360	310	450	480	360	742.8	1010.0	.73	1.15
1973	216	921	170	300	350	420	490	600	559.3	835.3	.39	1.10

Table 7

Minke whales

Norwegian stock, Subarea II (D,E,F, in NA 76/10).

			Boat-days							
	Catch		May			June			CPUE	
Season	May	June	1	2	3	1	2	3	May	June
1960	113	306	270	360	290	470	570	820	0.12	0.16
1961	284	315	360	490	490	740	530	650	0.21	0.16
1962	171	277	400	480	410	320	640	590	0.13	0.18
1963	90	138	230	240	300	310	190	430	0.12	0.15
1964	132	145	180	330	430	260	290	400	0.14	0.15
1965	154	180	180	270	350	360	280	330	0.16	0.19
1966	43	142	170	100	160	240	240	280	0.10	0.19
1967	110	122	220	210	220	160	260	210	0.17	0.16
1968	163	92	260	90	450	260	170	290	0.20	0.13
1969	60	66	150	60	120	120	190	90	0.18	0.17
1970	76	148	190	120	130	230	180	290	0.17	0.21
1971	81	118	200	150	170	200	200	300	0.16	0.17
1972	61	33	110	180	100	70	110	60	0.09	0.14
1973	115	48	90	180	220	60	140	150	0.23	0.14
1974	62	69	120	100	190	70	150	160	0.15	0.18
1975	35	65	70	100	100	130	120	70	0.13	0.20

Table 8

Minke whales

Norwegian stock, Subarea III (G,H,I, in NA 76/10).

			Effort (Boat-days)						Wind corrected			
	Catch		May			June			Effort		CPUE	
Season	May	June	1	2	3	1	2	3	May	June	May	June
1960	124	151	230	190	170	180	180	240	513.0	475.5	0.24	0.32
1961	126	125	160	210	160	210	160	170	387.1	489.5	0.33	0.25
1962	166	77	210	150	110	210	60	20	387.8	237.3	0.43	0.32
1963	87	155	70	140	170	150	170	130	198.5	272.5	0.44	0.57
1964	109	134	90	140	170	160	140	130	217.9	218.0	0.50	0.61
1965	86	71	160	160	80	180	50	30	180.0	191.8	0.48	0.37
1966	77	112	120	70	90	120	130	110	153.0	221.5	0.50	0.51
1967	50	49	90	60	70	40	70	30	110.1	49.8	0.45	0.98
1968	39	162	20	20	100	80	200	70	119.5	267.5	0.33	0.61
1969	82	190	140	50	150	200	220	160	220.5	336.5	0.37	0.56
1970	79	174	40	140	110	210	180	80	166.0	277.2	0.48	0.63
1971	59	127	110	90	60	150	60	170	166.2	217.7	0.35	0.58
1972	102	62	130	120	110	120	120	70	307.5	215.5	0.33	0.29

Table 9

Minke whales

East Greenland stock (J,K,L, in NA 76/10).

	Catch		Boat-days		CPUE	
Season	July	August	July	August	July	August
1960	4	26	20	90	.20	.29
1961	40	78	80	160	.50	.49
1962	108	127	230	380	.47	.33
1963	43	107	130	250	.33	.43
1964	71	165	150	240	.47	.69
1965	119	100	180	230	.66	.43
1966	21	102	70	220	.30	.46
1967	174	166	160	280	1.09	.59
1968	89	260	140	370	.64	.70
1969	16	99	30	160	.53	.62
1970	113	140	140	260	.81	.54
1971	64	51	80	130	.80	.39
1972	59	116	70	140	.84	.83
1973	59	176	110	280	.54	.63
1974	16	112	40	250	.40	.45
1975	87	127	120	200	.73	.64

Table 10

Minke whales West Greenland stock (M) Canada stock (N)

	West Greenland Stock (M) Catch					Boats					Boat-days					CPUE				
Season	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
1968				20					6					60					.33	
1969		1	1	166			1	1	16			10	10	160			.10	.10	1.04	
1970		2	6	92	24		1	2	11	3		10	20	110	30		.20	.30	.84	.80
1971	9	87	2	138		3	8	1	12		30	80	10	120		.30	1.09	.20	1.15	
1972	12	45	9	60	1	3	8	1	6	1	30	80	10	60	10	.40	.56	.90	1.00	.10
1973		47	29	145			2	2	11			20	20	110			2.35	1.45	1.32	
1974		24	73	151			2	5	13			20	50	130			1.20	1.46	1.16	
1975		41	11	51			2	2	6			20	20	60			2.05	.55	.85	

	Canada stock (N)																			
Season	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
1969			1	8				1	3				10	30				.10	.27	
1970		2		1			1		1			10		10			.20		.10	
1971		13	2	11			2	1	2			20	10	20			.65	.20	.55	
1972				4					1					10					.40	

Table 11

Wind adjustment factors for subarea I. Average for A,B,C, (NA 76/10).

		Period		
Season	Month	1	2	3
1960	May	.538	.538	.447
	June	.475	.521	.658
1961	May	.592	.508	.394
	June	.679	.567	.554
1962	May	.487	.475	.371
	June	.412	.613	.458
1963	May	.463	.625	.522
	June	.600	.742	.642
1964	May	.229	.483	.428
	June	.538	.475	.500
1965	May	.583	.546	.455
	June	.425	.667	.442
1966	May	.425	.504	.568
	June	.350	.467	.696
1967	May	.475	.529	.523
	June	.525	.458	.341
1968	May	.413	.592	.458
	June	.550	.404	.642
1969	May	.733	.596	.625
	June	.629	.683	.700
1970	May	.496	.587	.432
	June	.467	.396	.504
1971	May	.375	.925	.950
	June	.650	.625	.818
1972	May	.775	.750	.975
	June	.700	.800	.864
1973	May	.650	.475	.875
	June	.425	.700	.523

Table 12

Wind adjustment factors for subarea III (For G,H,I, in NA 76/10).

		Period		
Season	Month	1	2	3
1960	May	1.000	.900	.659
	June	.975	.800	.575
	July	1.000	1.000	.900
1961	May	.700	.650	.886
	June	.975	.850	.875
	July	1.000	1.000	.750
1962	May	.900	.775	.750
	June	.850	.775	.675
	July	1.000	1.000	.275
1963	May	.300	.400	.591
	June	.775	.325	.775
	July	1.000	1.000	.600
1964	May	.350	.475	.705
	June	.500	.475	.550
	July	1.000	1.000	.400
1965	May	.350	.525	.500
	June	.850	.625	.250
	July	1.000	1.000	.475
1966	May	.725	.475	.364
	June	.550	.625	.675
	July	1.000	1.000	.700
1967	May	.450	.550	.523
	June	.200	.425	.400
	July	1.000	1.000	.525
1968	May	.500	.700	.955
	June	.725	.925	.350
	July	1.000	1.000	.650
1969	May	.825	.525	.841
	June	.400	.675	.675
	July	1.000	1.000	.500
1970	May	.200	.700	.455
	June	.875	.275	.550
1971	May	.550	.675	.750
	June	.550	.625	.575
1972	May	.900	.900	.750
	June	.800	.675	.550

ANNEX E

Table 13

Fin whales

Area: British Isles, Spain and Portugal. Fin catch and catch per boat.

	British Isles		Spain and Portugal		Total	
Year	Fin catch	Nos. of Fin/boat	Fin catch	Nos. of Fin/boat	Fin catch	Nos. of Fin/boat
1904	263	26.3				
1905	450	40.9				
1906	317	26.4				
1907	396	30.5				
1908	379	29.1				
1909	432	33.2				
1910	381	23.8				
1911	344	21.5				
1912	292	18.2				
1913	346	20.4				
1914	322	21.5				
1920	407	37.0				
1921	–	–	323	161.5		
1922	282	47.0	571	285.5		
1923	312	44.6	1,080	540.0		
1924	501	71.6	1.218	121.8	1.719	
1925	315	45.0	1.498	107.0	1.813	
1926	400	57.1	1.374	98.2	1.774	
1927	261	37.3	369	52.7	630	
1928	139	19.9				
1929	73	18.3				

Table 13B

Area: British Isles, Spain and Portugal. Fin catch and catch per boat.

	Spain and Portugal		British Isles	
Year	Fin catch	Nos. fin per boat	Fin catch	Nos. fin per boat
1950	19	9.5	33	33.0
1951	27	13.5	13	13.0
1952	74 (+ 49)*	20.5		
1953	18 (+ 17)	7.0		
1954	30 (+ 82)	22.4		
1955	36 (+ 98)	22.3		
1956	5 (+ 13)	3.6		
1957	(+ 30)	6.0		
1958	4 (+ 16)	4.0		
1959	(+ 55)	11.0		
1960	(+ 75)	25.0		
1961	(+ 94)	31.3		
1962	(+ 31)	10.3		
1963	(+ 13)	4.3		
1964	(+ 37)	12.3		
1965	(+ 116)	38.7		
1966	(+ 80)	26.7?		
1967	(+ 80)	26.7?		
1968	(+ 92)	30.7		
1969	(+ 122)	40.7		
1970	152	50.7		
1971	83	– No information		
1972	90	–		
1973	73	–		

*Figures in parentheses are nos. fin whales taken apportioned from unspecified catch of balaenopterid whales.

Table 14
Fin whales
Area: North Norway

Year	Fin catch	Nos. of fins/boat
1876	3	1.00
1877	8	2.00
1878	40	10.00
1879	40	10.00
1880	50	12.50
1881	52	4.73
1882	250	16.67
1883	(250)	
1884	(250)	
1885	437	13.24
1886	609	17.91
1887	268	7.88
1888	346	10.81
1889	188	6.48
1890	368	13.14
1891		(16.36)
1892		(24.41)
1893		(26.56)
1894		(22.25)
1895		(17.0)
1896	733	27.15
1897	400	16.00
1898	448	17.92
1899	256	10.24
1900	263	10.52
1901	347	15.09
1902	457	25.39
1903	140	8.24
1904	161	10.73
1918	305	–
1919	194	–
1920	44	14.67
1948	41	13.67
1949	138	46.00
1950	90	30.00
1951	70	23.33
1952	83	27.67
1953	60	20.00
1954	58	19.33
1955	95	31.67
1956	63	21.00
1957	47	15.67
1958	70	23.33
1959	82	27.33
1960	51	17.00
1961	43	14.33
1962	76	25.33
1963	21	7.00
1964	32	10.67
1965	101	33.67
1966	54	18.00
1967	28	9.33
1968	68	22.67
1969	14	4.67
1970	44	22.00
1971	37	12.33

Table 15
Fin whales
Iceland

1890 to 1915 & 1935 to 1939

Figures for these periods are available in document NA 76/9 Table 1. In years for which unspecified catches plus blue/fin catches were available, these were prorated by the blue/fin catches.

Year	Nos. of fins	Nos. of fins/boat
1948	195	48.8
1949	249	62.3
1950	226	56.5
1951	312	78.0
1952	224	56.0
1953	207	51.8
1954	177	44.3
1955	236	59.0
1956	265	66.3
1957	348	87.0
1958	289	72.3
1959	178	44.5
1960	160	40.0
1961	142	35.5
1962	303	75.8
1963	283	70.8
1964	217	54.3
1965	288	72.0
1966	310	77.5
1967	239	59.8
1968	202	50.5
1969	251	62.8
1970	272	68.0
1971	208	52.0
1972	238	59.5
1973	267	66.8
1974	285	71.3
1975	245	61.3

ANNEX F

MINKE WHALE EARPLUG SUB-COMMITTEE

Mead, Mercer, Ohsumi, Christensen, Kapel, Lockyer.

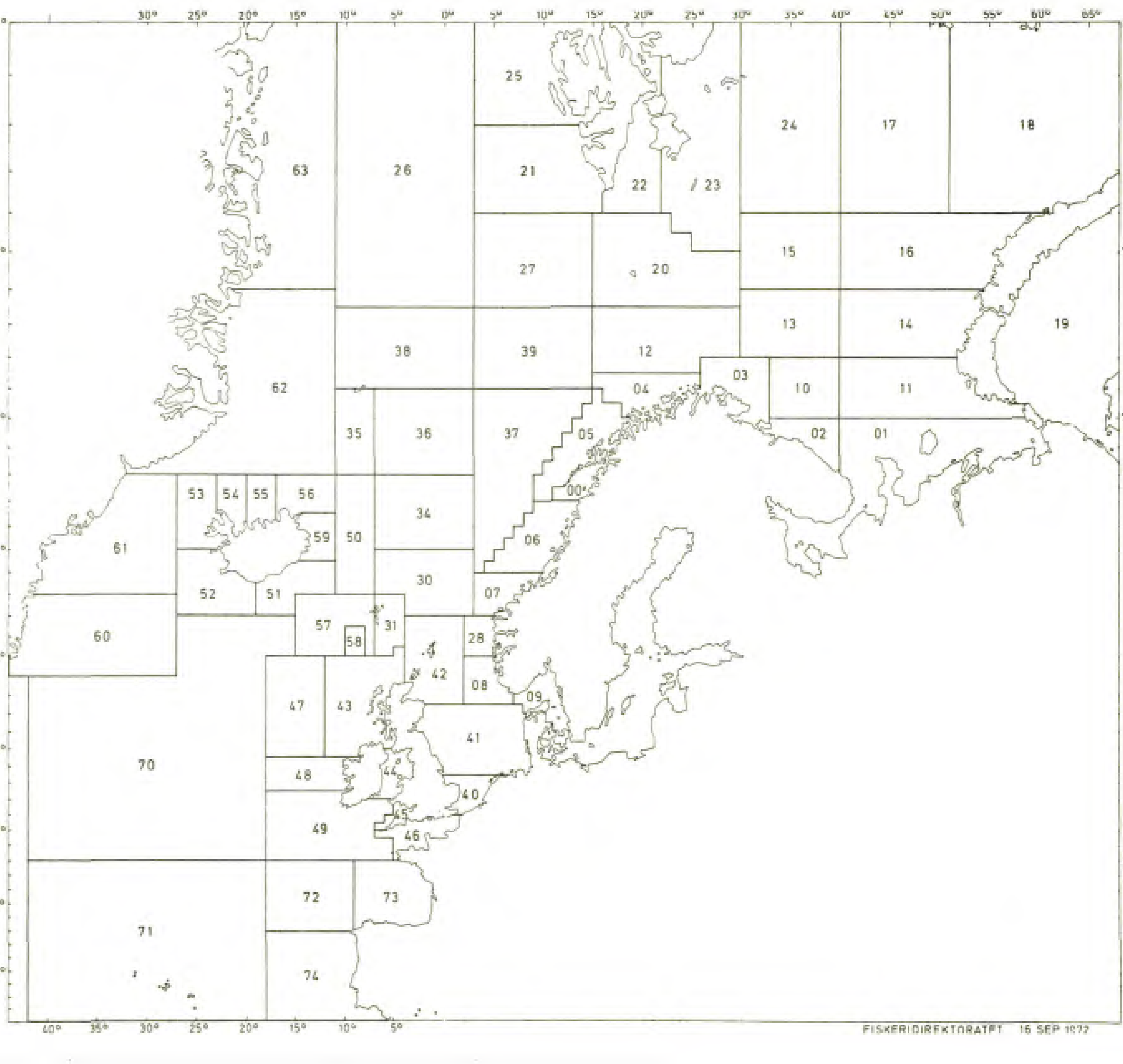
It was agreed that attempts should be made to collect earplugs from minke whales wherever possible in the North Atlantic fisheries. In all areas the data are necessary for the derivation of age related biological parameters, such as reproductive rates.

There are two general problem areas involving (a) the logistic difficulties of collecting earplugs, and (b) deriving age estimates from the earplugs once they have been collected. In the Norwegian fisheries the logistic problems centre around the difficulty of dealing with carcasses flensed on board the small whaling vessels. It was suggested that experimentation be undertaken by experienced technicians in the coming season to determine (1) the best physical technique for handling the head and extracting the earplugs, and (2) the effect of cooling and post-mortem time on the condition of the earplugs, and (3) the feasibility of obtaining earplugs from the whalers themselves through a reward system.

In view of the problems already encountered in reading minke earplugs from the Norwegian fisheries, it is important that as much data as possible be collected for factors which may influence plug readability. These should include such things as length of time from killing to flensing, from flensing to earplug removal, some measure of cooling rate (such as air temperature, whether the head was iced, etc.), presentation and handling of earplugs subsequent to collecting, plus the usual data on locality, length, sex, etc. Given that there is a problem in reading these plugs, it will be most important to try to determine what the causes of the problem are. The IOS whale group has indicated a willingness to assist in the problems of reading the earplugs.

Kapel has indicated that it may be possible to obtain small samples of earplugs from the West Greenland fishery, but that there are problems of (1) non-localization of the fishery, with relatively small catches coming into any particular port, and (2) lack of manpower and money to field an extensive collecting program. While it may not be possible to obtain an extensive sample from this fishery, even small samples will be valuable, particularly in terms of possible difference in earplug readability and age related biological parameters between different stocks.

Most of this proposed work is of a preliminary nature, necessary to plan the feasibility of a large program. It will also be very useful to collect as much other biological data as possible from the whales from which the earplugs are taken, such as baleen, gonads, and bullae. The possibility of making useful age determinations from other tissues, such as bullae, premaxillae, and auditory ossicles, should be investigated, but no specific proposals were developed.



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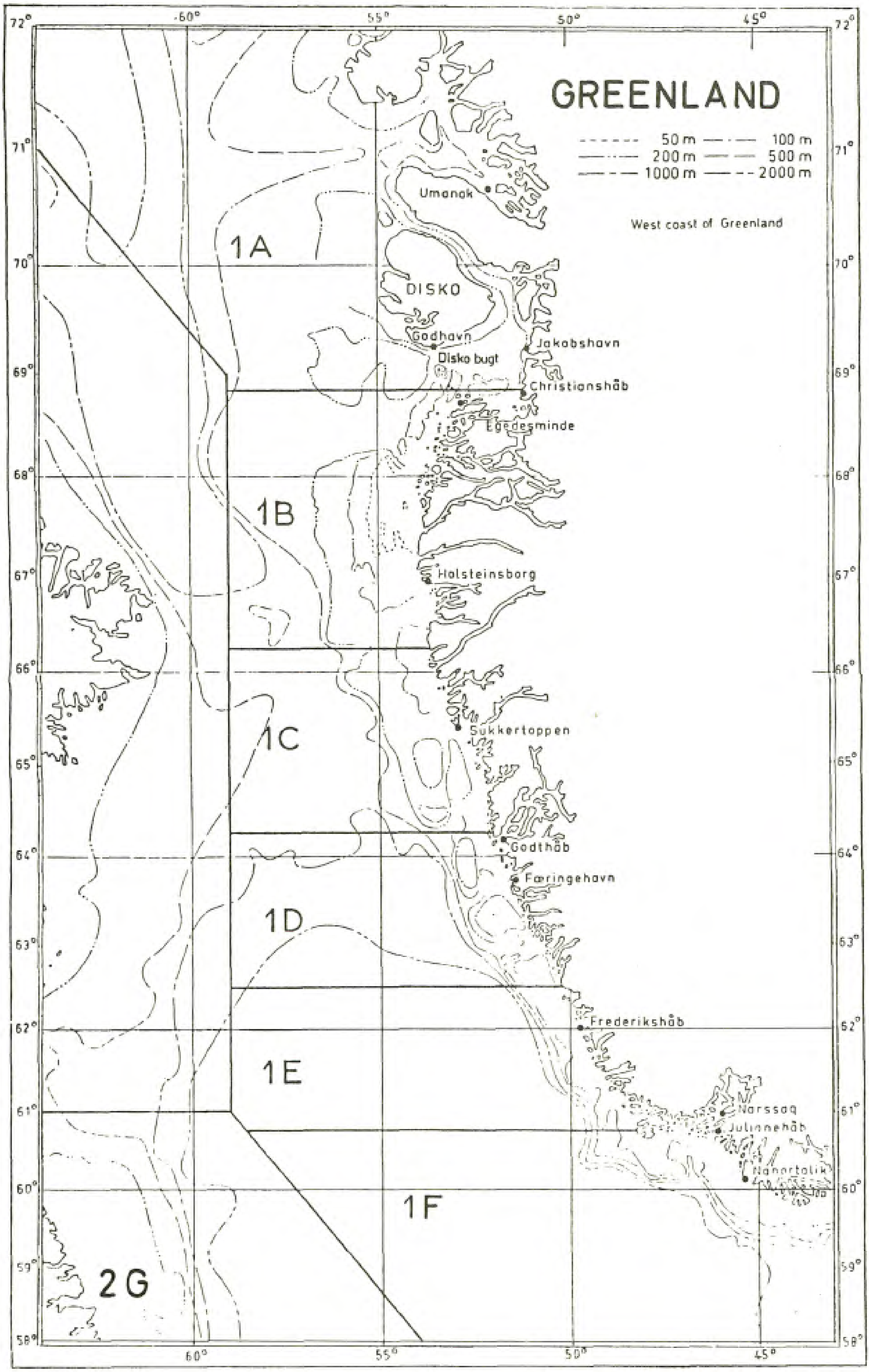
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100 m
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500 m
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West coast of Greenland
Umanak
DISKO
Godhavn
Disko bugt
Jakobshavn
Christianshåb
Egedesminde
Holsteinsborg
Sukkertoppen
Godthåb
Færingehavn
Frederikshåb
Narssaq
Julianehåb
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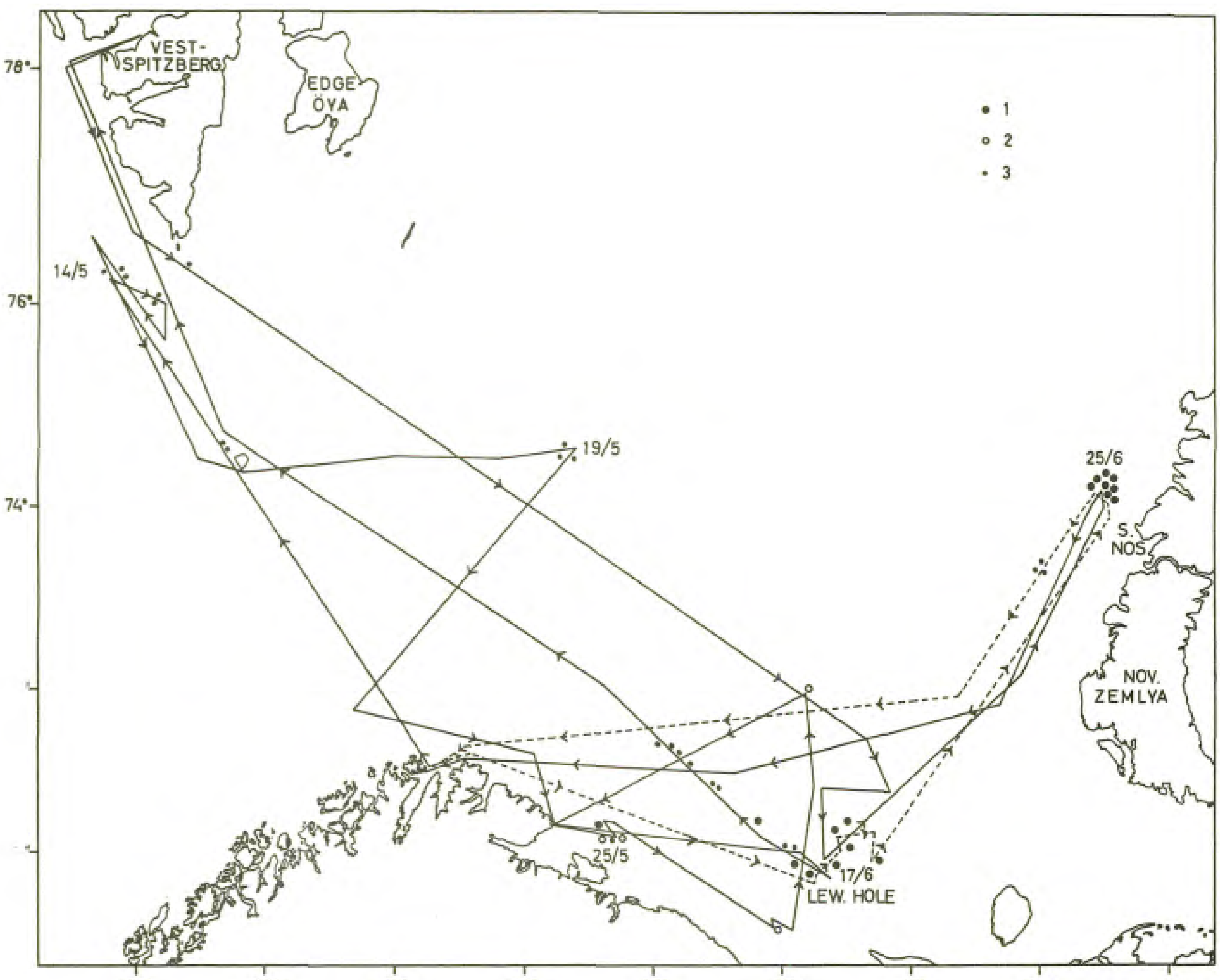

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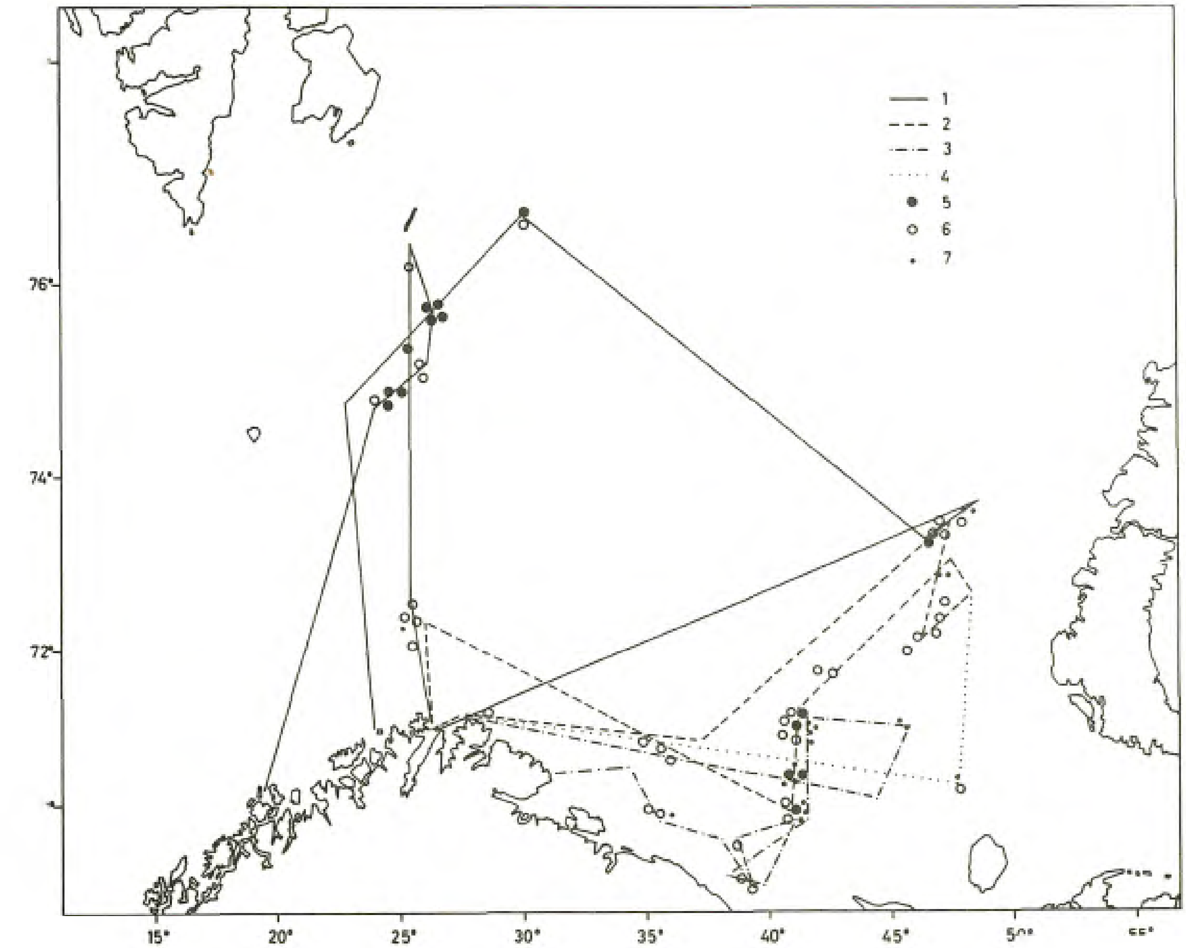

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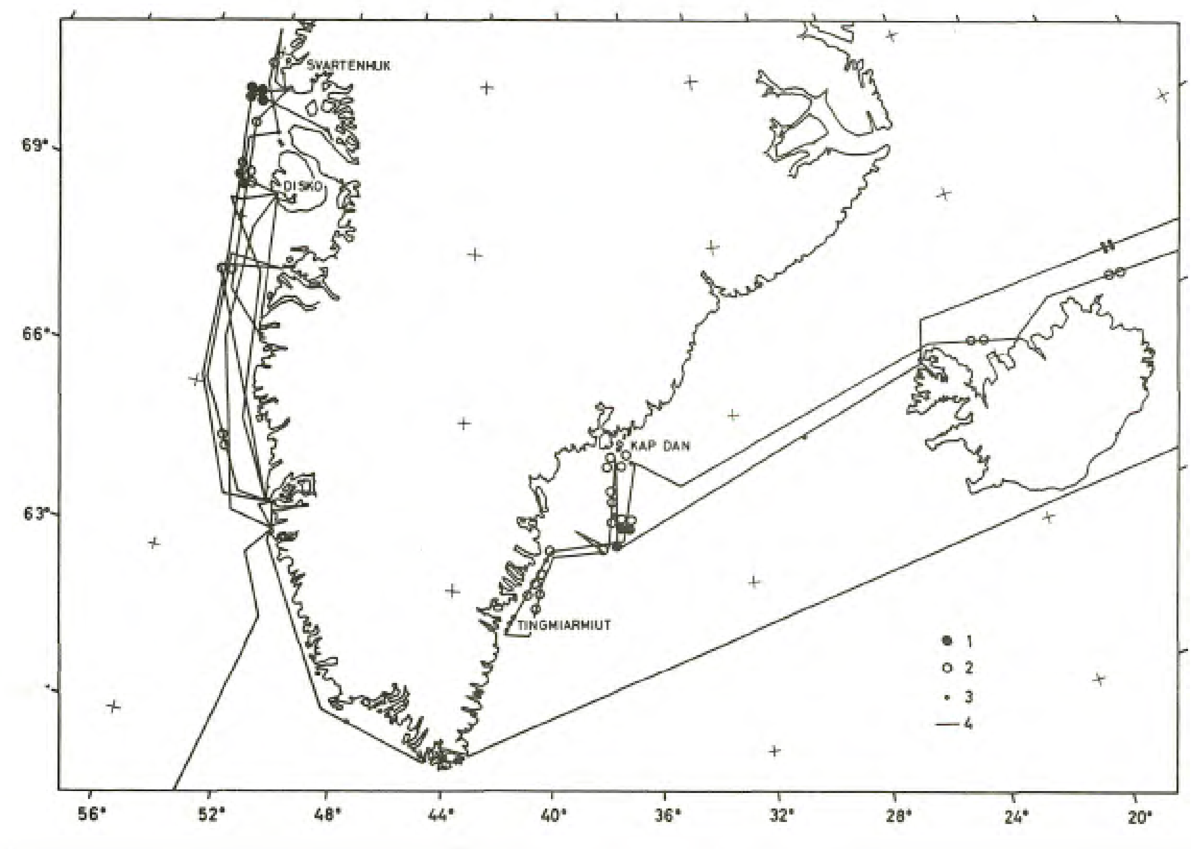

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TINGMIARMIUT
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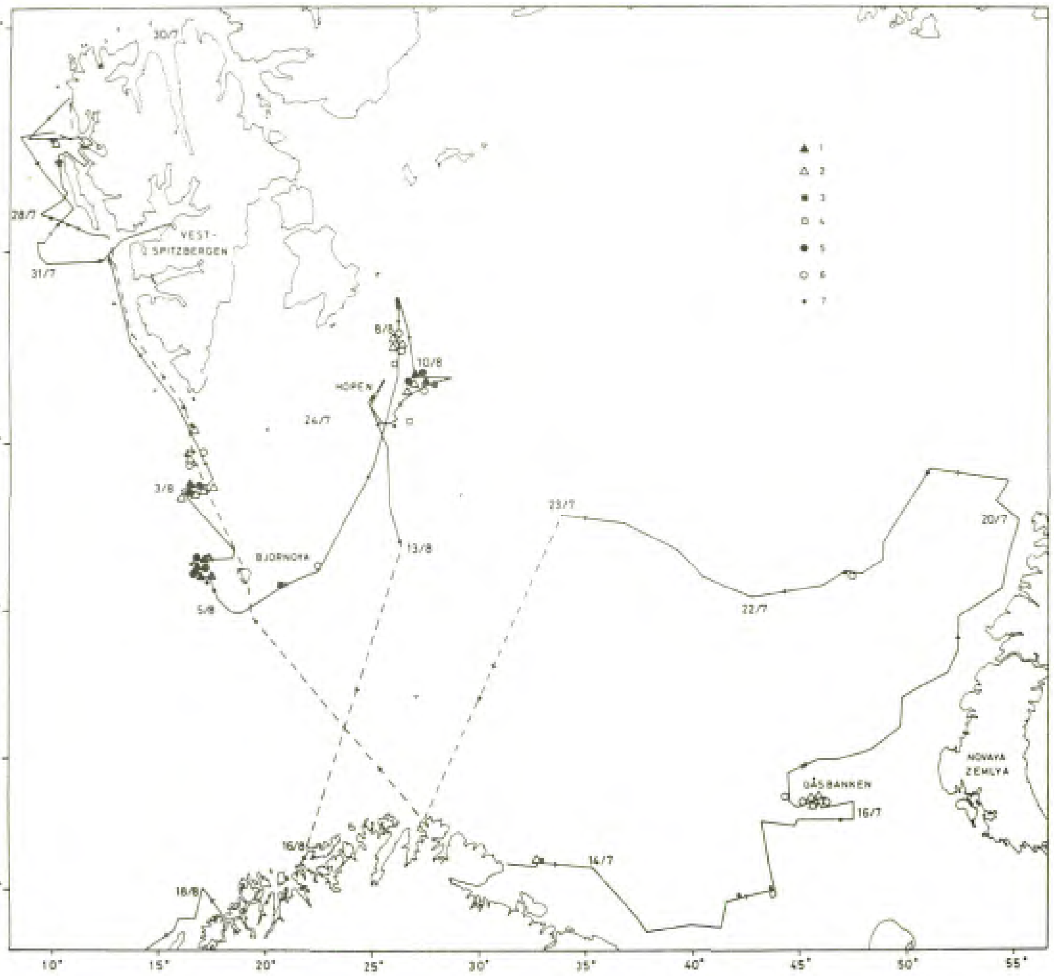
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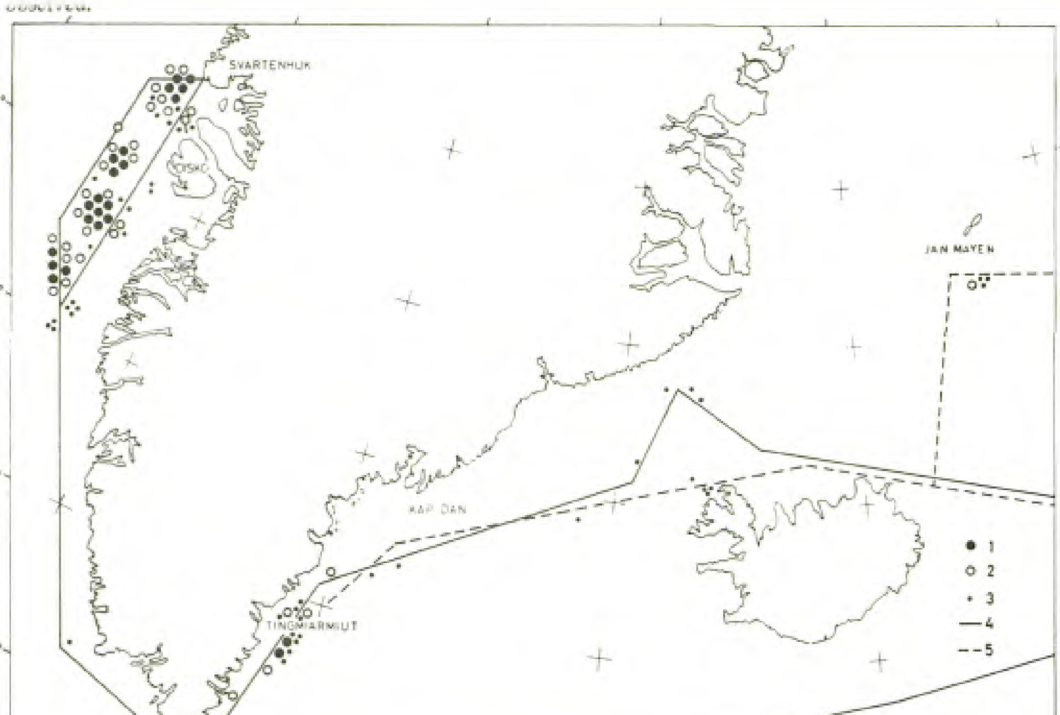
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JAN MAYEN
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TINGMIARMIUT
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Table 1
Summary of whale observations by areas and seasons 1971–1975.

Year	Locality	Minke whale	Fin whale	Hump-back	Sei whale	Sperm whale	Bottle nose	Killer whale	Pilot whale	Dolphins	Porpoise	Various
1971	Labrador-Norway	22	69+	3	1	72+	569+	20	340+	262+	–	
1972	Barents Sea	570+	4	–	–	–	–	9	–	130+	2	
1973	Barents Sea	544+	–	19+	–	–	–	60–70+	–	500+	23+	
1973	E. Greenland	192+	69	–	2	10	–	72+	60	200+	2	
1973	W. Greenland	279	115	26	12	5	1	7	1,100	210+	–	2 Blue whales 1 Narwhale
1974	E. Atlantic	277	1	21+	15	–	–	400–500	–	1,770	26	8–10 *M. bidens*
1974	E. Greenland	117+	109+	1	–	40	2	10+	307	315+	–	
1974	W. Greenland	583+	138+	3	–	33	1	2	70	50	–	
1975	Barents Sea	1,339	1	10	–	1	–	26+	4	128	22+	10 White whales 2 Large whales
1975	North Sea	74	–	–	–	–	–	1	–	1,000+	–	
1975	E. Greenland	277+	135+	3	–	64	1	23	–	155	–	
	Total	4,274+	641+	86+	30	225	574+	700–800	2,500+	5,000+	75+	

Table 2

Summary of whale observations in the Labrador Sea and between Norway and Labrador in the spring 1971. The observations are grouped according to the Norwegian fisheries statistics (Fiskeridirektoratet, 1972) and ICNAF subareas and divisions (ICNAF, 1968).

			Number of whales observed								
Area	Locality	Date	Minke	Fin	Hump-back	Sperm	Bottle nose	Killer	Pilot	Dolphin	Sei
30	North of Faroe Island	14/5	–	–	–	1	–	–	–	–	–
30	N62°50′ E01°00′	13/5	–	–	–	–	–	1	–	–	–
30	N62°50′ W03°20′	19/6	–	–	–	–	–	7	–	–	–
31	N62°50′ W06°00′	14/5	–	–	–	2	–	–	–	–	–
57	N62°45′ W14°50′	15/5	–	1	–	–	–	–	–	–	–
51	N63°16′ W17°20′	17/5	1	–	–	–	–	–	–	6	–
52	N63°–64° W19°–25°	15–18/5	2	6	1	2	–	–	–	100	–
52	N63°–64° W19°–25°		8	1	2	–	2	4	36+	120	–
56	N66°35′ W13°30′	24/5	–	–	–	–	–	–	–	some	–
54	N66°40′ W21°10′	25/5	–	–	–	–	–	8	–	–	–
59	N66° W13°	1/7	1	–	–	–	–	–	–	10	–
61	N63°30′ W28°30′	18/5	–	–	–	2	–	–	–	–	–
61	N64°–65° W29°–36°	27–28/5	–	–	–	6	9	–	–	18	–
61	N63°30′ W37°00′	29/5	1	–	–	7	–	–	–	–	–
61	N63°25′ W36°40′	25/6	1	15	–	–	2	–	–	–	–
61	N65°10′ W30°10′	26/6	–	1	–	–	–	–	–	–	–
61	N63°45′ W38°58′	25/6	2	–	–	–	–	–	–	–	–
61	N65° W33°	26–27/6	2	20	–	30	3	–	–	2	1
60	N62°–60° W39°–41°	29–30/5	–	9	–	2	–	–	–	6	–
60	N62°30′ W31°30′	14/6	–	5	–	–	–	–	–	–	–
60	N61°05′ W42°05′	24/6	3	–	–	–	–	–	–	–	–
60	N62°15′ W39°10′	25/6	–	11	–	–	–	–	–	–	–
1F	N59°30′ W55°30′	23/5	–	–	–	–	–	–	3	–	–
1F	N60°00′ W55°00′	10/6	–	–	–	–	–	–	1	–	–
1F	N60°22′ W50°23′	21/6	–	–	–	–	–	–	300	–	–
2G	N60°–61° W60°–61°	24–25/5	–	–	–	6	60	–	–	–	–
2G	N61°00′ W60°50′	8/6	–	–	–	–	12	–	–	–	–
2G	N61°00′ W60°15′	19/6	–	–	–	–	3	–	–	–	–
2G	N61°10′ W59°20′	3/6	–	–	–	–	4	–	–	–	–
2G	N60°50′ W60°50′	9–11/6	–	–	–	–	26+	–	–	–	–
–	N61°–63° W59°–61°30′	26/5–2/6	–	–	–	3	30	–	–	–	–
–	N60°45′–62°10′ W60°–61°	4–9/6	–	–	–	–	53	–	–	–	–
–	N63°–61°50′ W60°–60°30′	4–18/6	–	–	–	2	128+	–	–	–	–
–	N61°30′–62°20′ W60°28′–60°30′	11–19/6	–	–	–	1	141	–	–	–	–
–	N61°05′–62°40′ W59°–61′	26/5–10/6	1	–	–	5	94	–	–	–	–
1D	N62°40′ W59°00′	3/6	–	–	–	3	2	–	–	–	–
	Total		22	69+	3	72+	569+	20	340+	262+	1

Table 3

Summary of whale observations in the Barents Sea in 1972. The observations are grouped according to statistical areas used in Norwegian fisheries statistics. (Fiskeridirektoratet, 1972).

			Number of whales observed				
Area	Locality	Date	Minke	Fin	Killer	Dolphin	Porpoise
01	Lewis Hole	6–8/6	20+	–	–	–	–
01	Lewis Hole	18–21/6	80+	–	–	–	–
02	Cherny grunnen	27/5	5	–	–	–	–
03	Ostbanken	23–25/5	41+	–	–	many	1
03	Nordbanken	17/6	1	–	–	20–30	–
04	Ingøydjupet	20/5	–	–	–	100+	–
11	Prestneset	30–31/5	5	–	–	some	–
11	Norddjupet	4–5/6	6	–	7	–	1
11	Norddjupt-Lewis Hole	9–10/6	45+	2	–	–	–
14	North of Gåsbanken	23/6	1	–	–	–	–
14	South of Suchoj Nos	24/6	150	–	–	–	–
14	Gåsbanken	29/6	5	–	–	–	–
15	Centralbanken	19/5	3	–	–	–	–
16	North of Suchoj Nos	25–28/6	200+	–	–	–	–
20	North of Bjørnøya	12/5	1	–	–	–	–
20	N74°30′ E29°00′	18/5	1	–	2	–	–
20	Storfjordrenna	16/6	1	–	–	–	–
21	South of Sørkapp, Svalbard	13–14/5	2	–	–	–	–
21	Hornsund, Svalbard	15/5	3	–	–	–	–
21	Hornsundbanken, Svalbard	13/6	–	2	–	–	–
	Total		570+	4	9	130+	2

Table 4

Summary of whale observations in the Barents Sea in 1973. The observations are grouped according to statistical areas used in Norwegian fisheries statistics (Fiskeridirektoratet 1972).

			Number of whales observed				
Area	Locality	Date	Minke	Hump-back	Killer	Dolphins	Porpoise
01	Nortongrunnen	10–11/6	4	–	–	20	–
01	Northern Lewis Hole	15–16/6	9	–	–	–	–
01	Northern Lewis Hole	19–21/6	29	–	–	–	–
02	Kildinbanken	8–9/6	11	–	–	–	–
02	Cherny grunnen	13–14/6	10	–	–	–	–
03	Porsangerfjorden	5/6	–	–	60–70+	–	–
03	Coast of Finnmark	17/6	–	–	–	5	1
03	Coast of Finnmark	1–2/7	1	–	–	200–300	–
10	Skolpenbanken	6/6	1	–	–	–	–
10	Skolpenbanken	18–20/6	8	–	–	some	–
10	Skolpenbanken	2/7	5	–	–	–	–
11	North of Lewis Hole	17–18/6	43	–	–	–	2
11	Drinkalls grunn	22/6–1/7	59	–	–	–	some
11	South of Prestness	22/6	10	–	–	–	–
11	South of Gåsbanken	26/6	2	–	–	–	–
11	Kolguevgrunnen	27–28/6	6+	–	–	–	–
11	Kolguev-Prestness	29–30/6	2+	–	–	–	–
11	Gåsbanken	26–1/7	71	–	–	–	–
12	Nordkappbanken	14–21/5	21	–	–	20–30	20–30
12	Nordkappbanken	25/7	–	–	–	60	–
20	South of Hopen	8–9/6	100	2	–	–	–
20	South of Hopen	16–17/6	1	–	–	100	–
22	Southeast of Sørkapp	14–21/7	1	6	–	–	–
23	Southeast of Hopen	24/5–7/6	120+	1	–	30–40	–
23	Southeast of Hopen	24/7	–	2	–	–	–
23	Northeast of Hopen	15/8	–	7–8	–	–	–
23	Hopen-Ryke Yseøyane	1–7/9	–	–	–	by hundreds	–
23	Northeast of Ryke Yseøyane	8/9	–	many	–	–	–
24	East of Hopen	18–26/6	30	–	–	–	–
	Total		544+	19+	60–70+	500+	20–30+

Table 5

Summary of whale observations off East Greenland and between western Norway and Greenland in 1973. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics (Fiskeridirektoratet 1972).

			Number of whales observed						
Area	Locality	Date	Minke	Fin	Sperm	Killer	Pilot	Dolphin	Other
07	Møre	17/7	–	–	1	–	–	some	–
42	Nordsjøen	17/5 & 2/7	3	–	–	–	–	–	2 porpoise
43	North of Flannan Island	19/5	1	–	–	2	–	–	–
50	East of Langanes	20/7	–	–	–	–	–	some	–
52	Southwest of Iceland	9–10/9	–	9	–	–	–	200	–
53	Strømnes	25/8	1	–	–	–	–	–	–
54	Strandagrunnen	22/7	9+	–	–	–	–	–	–
56	Langanes	26/8	4	–	–	–	–	–	–
56/59	North and east of Langanes	21/7	10	–	–	–	–	–	–
60	Fylkirbanken	28–29/7	10+	15	–	–	–	–	–
60	Skjoldungen	30/7	9	–	–	–	–	–	–
60	Skjoldungen-Kap Dan	1–2/8	11	–	–	–	–	–	–
60	K. Farvel-Iceland	6–7/9	–	6	–	–	–	–	–
61	Stredebukten	23/7	–	–	6	–	–	–	–
61	Kap Dan	24–25/7	3+	–	–	–	–	–	–
61	Kap Dan	4–6/8	21	20	–	–	–	–	–
61	Sermilikdypet-Heimlandsryggen	7–22/8	106+	–	2	–	–	many	2 Sei Whales
61	Kap Møsting grunn	26–27/7	4+	11	–	–	–	–	–
70	Route Iceland-Newfoundland	22–24/5	–	8	1	70+	60	–	–
	Total		192+	69	10	72+	60	200++	–

Table 6

Summary of whale observations at Newfoundland and West Greenland in the summer 1973. The observations are grouped according to the ICNAF subareas and divisions (ICNAF 1968).

			Number of whales observed								
Area	Locality	Date	Minke	Fin	Hump-back	Blue	Sperm	Killer	Pilot	Dolphin	Other
1A	SW. border of Disko Bank	22–23/7	42	8	–	–	–	–	–	–	–
1A	SW. border of Disko Bank	8–9/8	16	4	–	–	–	–	–	–	–
1A	NW. border of Disko Bank	21/7	5	50	–	–	–	–	–	–	–
1A	NW. of Hareøen-Disko Bank	26/8	1	–	–	–	–	–	–	–	–
1A	NW. of Svartenhuk	16–18/7	4	–	–	–	–	4	–	–	–
1A	North of Svartenhuk	10–16/8	93	1	–	–	–	–	–	–	–
1A	South of Svartenhuk	18/8	1	–	–	–	–	–	–	–	–
1A	South of Svartenhuk	23–24/8	5	–	–	–	–	–	–	–	–
1A	Umanakfjord	18 & 20/8	1	6	–	2	–	–	–	–	1 Narwhale
1B	N. Border of St Hellefiskebank	21–30/6	41	5	–	–	1	3	600	–	–
1B	N. Border of St Hellefiskebank	3–7/8	38	4	–	–	–	–	–	–	–
1B	N. Border of St Hellefiskebank	28–29/8	9	2	–	–	–	–	–	–	–
1B	S. Border of Disko Bank	1/7	3	–	–	–	–	–	–	–	–
1B	S. Border of Disko Bank	24/7	3	–	–	–	–	–	–	–	–
1C	Lille Hellefiskebank	1–2/8	8	–	–	–	–	–	–	–	–
1F	Juliane Bugt	4/9	1	–	–	–	–	–	–	–	–
2J	S. Border of Hamilton Inlet Bank	14–15/6	3	–	–	–	3	–	400	–	12 Sei whales
3L-3Ps	Grand Bank-St Pierre Bank	26–27/5	–	22	16	–	–	–	–	110	
4Vs	Southeast of Sable Island	9/6	–	2	–	–	–	–	–	100	1 bottlenose
4W	Sable Island Bank	5–7/6	5	11	–	–	1	–	100	–	–
4	St Pierre-Halifax	30/5	–	–	10	–	–	–	–	–	–
	Total		279	115	26	2	5	7	1,100	210	–

Table 7

Summary of whale observations in the Barents Sea and from the coast of Norway in 1974. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics. (Fiskeridirektoratet 1972).

			Number of whales observed					
Area	Locality	Date	Minke	Hump-back	Killer	Dolphins	Porpoise	Other
01	Kap Kanin	4/5	–	–	4	–	–	–
01	Lewis Hole	14–15/7	8	–	–	22	2	–
03	Østbanken	13/7	1	–	–	200+	–	–
04	Sørøy	12/7	–	–	–	–	1	–
05	SW. of Lofoten	21/6	–	–	–	–	5	–
05	SW. of Lofoten	27–28/6	3	–	200–300	–	–	–
05	Vesterålen	18–19/8	–	–	–	–	13	–
06	Helgeland	7/6	–	–	2	–	–	–
06–07	SW. of Lofoten	14–15/6	1	–	110+	–	3	–
07	Møre	19/5	1	–	–	–	–	–
11	Gåsbanken	16–17/7	18	–	–	20	–	–
13–12	Nordkappbanken	23–25/7	1	–	–	1,000+	–	–
14–16	NE. part of Barents Sea	19–21/7	7	–	–	20	–	–
20	Storfjordrenna S	27/7	8	–	–	–	–	–
20	Sørkapp-Bjørnøya	2–7/8	140	7	–	500++	–	–
21	Minkebakken	1–2/8	2	–	–	–	–	–
22	Sørkapp	25/7	1	–	–	6	–	–
23	SE. of Hopen	24/7	1	1	–	–	–	1 fin whale
23	Hopen-Edgeøya	7–12/8	68	13+	8	–	1	–
25	Forlandet up to 80°N	28–31/7	6	–	–	–	–	–
28	Vestlandet	16/5	–	–	14	–	–	–
30	NE. of Shetland	19–28/5	7	–	8	–	1	8–10 *M. bidens*
37	W. of Lofoten	15–16/6	3	–	50	–	–	–
	Total		277	21+	400–500	1,770++	26	–

Table 8

Summary of whale observations off East Greenland and between Norway and Greenland in 1974. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics. (Fiskeridirektoratet, 1972).

			Number of whales observed							
Area	Locality	Date	Minke	Fin	Sperm	Pilot	Killer	Dolphins	Sei	Other
07	Møre	16/7	–	–	–	–	6–7	–	–	–
31	Faroe Island	13/7	–	–	–	many	–	–	–	–
35	Jan Mayen	12–20/6	19	–	–	–	–	–	–	–
50	East of Iceland	22/5 + 15/7	2	–	–	–	–	–	–	2 bottlenose
52	Northwest of Iceland	5/6	–	2	–	–	–	–	–	–
52	Northwest of Iceland	29/8	–	–	–	–	–	many	–	–
53	West of Iceland	17–20/7 + 26/8	8	–	–	–	–	–	2	–
56	Langanes	17/6	–	–	–	10	–	1	–	–
59	East of Iceland	23/5 + 10/6	4	–	–	–	–	5	–	–
60	Iceland-Greenland	3/6 + 1/9	–	–	–	–	–	–	3	–
60	East of Greenland	30/5–1/6	2	7	4	20+	1	25+	–	–
60	East of Greenland	22/7 + 20–21/8	61	21	–	–	–	21	–	–
60	East of Greenland	23/–27/8	8+	6	–	12	–	some	8	–
61	East of Greenland	27/5–4/6	2	–	18	32+	2	240+	–	–
61	East of Greenland	18–29/6	2	10	–	–	1	–	–	–
61	East of Greenland	21/7	5	38	17	–	–	22	–	1 humpback
61	East of Greenland	19–22/7 + 22/8	3	25+	–	133+	–	many	–	3 large whales
61	East of Greenland	1/9	–	–	–	100+	–	1	–	–
62	West of Jan Mayen	12/6	–	–	1	–	–	–	–	–
70	Southeast of Greenland	23/7	1	–	–	–	–	–	–	–
	Total		117+	109+	40	307+	10+	315+	13	–

Table 9

Summary of whale observations at West Greenland in 1974. The observations are grouped according to the ICNAF subareas and divisions (ICNAF 1968).

		Number of whales observed								
Area	Locality	Date	Minke	Fin	Hump-back	Sperm	Pilot	Killer	Dolphin	Other
1F	Julianebukt	24/7	–	–	–	1	–	–	–	–
1F	Julianebukt	18–19 + 25/8	1	–	–	1	–	–	50	–
1E	N. of Fredrikshåb	24/8	1	–	–	–	–	–	–	–
1D	W. of Fiskenaes Banke	10–11/6	–	3	2	20	–	–	–	–
1D	W. of Fiskenaes Banke	2/7 + 25/7	–	–	–	2	50	–	–	1 bottlenose
1C	S. of Lille Hellefiske Banke	26/7 + 16/8	–	2	1	–	–	–	–	–
1C	W. of Lille Hellefiske Banke	1/7 + 25/7	–	2	–	3	–	–	–	–
1C	NW. of Lille Hellefiske Banke	30/6	3	1	–	1	–	–	–	–
1B	S. of Store Hellefiske Banke	13/6 + 30/6	6	2	–	–	–	–	–	–
1B	S. of Store Hellefiske Banke	27–29/7	17+	–	–	–	–	–	–	–
1B	S. of Store Hellefiske Banke	21/8	4	–	–	–	–	–	–	–
1B	W. of Store Hellefiske Banke	13–14/6	5	–	–	–	–	–	–	–
1B	W. of Store Hellefiske Banke	28–31/7	69+	9	–	–	20++	–	–	–
1B	W. of Store Hellefiske Banke	27/7	15	–	–	–	–	–	–	–
1B	N. of Store Hellefiske Banke	14–15/6	6	–	–	–	–	–	–	–
1B	N. of Store Hellefiske Banke	18–22/6	20+	6	–	–	–	–	–	–
1B	N. of Store Hellefiske Banke	28–29/7	6	28+	–	–	–	–	–	–
1B	N. of Store Hellefiske Banke	29/7–3/8	67++	20	–	–	–	–	–	–
1B	N. of Store Hellefiske Banke	20 + 26/8	5	10	–	1	–	–	–	–
1B	South of Disko Banke	17/6	1	–	–	–	–	–	–	–
1B	South of Disko Banke	28–29/7	16	–	–	–	–	–	–	–
1B	South of Disko Banke	2–4/8	57+	7	–	–	–	–	–	–
1B	South of Disko Banke	15/8	16	4	–	–	–	–	–	–
1A	North of Disko Banke	17/6	–	–	–	4	–	–	–	–
1A	North of Disko Banke	22–23/6	30+	–	–	–	–	–	–	–
1A	North of Disko Banke	29/6	35	–	–	–	–	–	–	–
1A	North of Disko Banke	21/7	–	1	–	–	–	–	–	–
1A	North of Disko Banke	23–24/7	6	6	–	–	–	–	–	–
1A	West of Disko Banke	5/8 + 8/8	20	12	–	–	–	–	–	–
1A	West of Disko Banke	13/8	–	2	–	–	–	–	–	–
1A	NW. of Disko Banke	21–22/7	20+	–	–	–	–	–	–	–
1A	NW. of Disko Banke	8–25/8	3	3	–	–	–	–	–	–
1A	Hareøen	26/7	–	–	–	–	–	2	–	–
1A	Umanak fjord	13 + 16/8	–	4	–	–	–	–	–	–
1A	S. and SW. of Svartenhuk	10–12/8	51+	–	–	–	–	–	–	–
1A	S. and SW. of Svartenhuk	16–19/8	41+	16+	–	–	–	–	–	–
1A	S. and SW. of Svartenhuk	21–25/8	31	–	–	–	–	–	–	–
	Total		583+	138++	3	33	70++	2	50	1 bottlenose

Table 10

Summary of whale observations in the Barents Sea in 1975. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics. (Fiskeridirektoratet, 1972).

			Number of whales observed					
Area	Locality	Date	Minke	Hump-back	Killer	Dolphin	Porpoise	Other
00	Vadholmen	10/7	–	2	–	–	–	–
01	Lewis Hole	21–29/5	30	–	5	6	–	1 fin whale
01	Lewis Hole	5–17/6	60	–	1	22	–	–
01	Lewis Hole	17/7	2	–	–	–	1	–
02	Skolpenbanken	4/6	3	–	–	–	–	–
02	Syddjupet	16/7	–	–	–	many	many	–
03	Hellnes fyr	13/7	1	–	–	–	–	–
03	Nordbanken	15/7	–	–	–	19	–	–
03	Østbanken	16/7	–	–	–	many	–	–
04	Fugløybanken	12–14/5	5	–	5	–	–	4 pilot whales
04	Nordkappbanken	19–20/5	2	–	15	–	–	–
04	Nysleppen	13/7	–	–	–	31	–	–
05	North of Andenes	18/8	–	–	–	–	–	1 sperm whale
10	Østbanken	16/7	1	–	–	many	–	–
11	Gåsbanken	15–27/6	6	–	–	7	–	–
11	Drinkall's ground	15–28/6	167	–	–	2	4	–
11	Drinkall's ground	17–18/7	12	–	–	8	12+	–
11	South of Gåsbanken	19/7	–	–	–	–	1	–
11	East of Gåsbanken	19/7	–	–	–	–	2	–
12	Bjørnøya – Coast of Norway	17/8	–	–	–	31	–	–
15	Sentralbanken	8/6	2	–	–	–	–	–
14–16–18	Coast of Novaya Zemlya	10–22/7	4	–	–	–	1	–
20	Sørbakke	25–27/6	11	–	–	–	–	–
20	Leirdjupet	23–27/6	210	4	–	–	–	–
20	Fingerdjupet	25/6	25	–	–	–	–	–
20	Thompsongrunnen		–	–	–	3	–	–
20	Mc. Gregorgrunnen	28/7	1	–	–	–	–	–
20	Kveitehola	29/7	3	–	–	–	–	–
20	North of Kveitehola	2/8	28	–	–	–	–	–
20	Kveitehola	3/8	32	–	–	–	–	–
20	South of Kveitehola	4/8	25	–	–	–	–	–
20	Northwest of Bjørnøya	5/8	145	1+	–	–	1	–
20	West and Southwest of Bjørnøya	9–16/8	507	1	–	5	–	1 large whale
21	Sørkappbanken	12/6	4	–	–	–	–	–
21	Hornsundbanken	13/6	2	–	–	–	–	–
21	Bellsundbanken	13/6	2	–	–	–	–	–
21	Southwest coast of Svalbard	1/8	2	–	–	–	–	–
23	Iversengrunnen	9–10/6	2	–	–	–	–	–
23	Northeast of Hopen	25/7	2	–	–	–	–	–
23	East of Hopen	26/7	8	–	–	–	–	–
24	Storbanken	22–24/7	19	2	–	–	–	1 large whale
25	Minkebakken	14–18/6	14	–	–	–	–	–
25	Forlandsbanken	19/6	2	–	–	–	–	–
25	Sjubrebanken	19/6	–	–	–	–	–	10 white whales
	Total		1,339	10+	26+	128+	22+	–

Table 11

Summary of whale observations in the North Sea in 1975. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics. (Fiskeridirektoratet, 1972).

			Number of whales observed		
Area	Locality	Date	Minke	Killer	Dolphins
08	Middle Bank	5/6	4	–	–
08	East Bank	8/6	2	–	–
08	Great Fisher Bank	12/6	4	–	–
08	West Bank	27/5	1	–	–
08	Klondyke	25/5	2	–	–
08	Ling Bank	17/6	5	1	–
08	Koral Bank	4/6	1	–	4
08	Patch Bank	11/6	4	–	–
08	East Bank	15/6	6	–	–
08	Outer Shoal	18/6	12	–	–
08	NW-Flat	17/6	5	–	–
08	Broad Weed	21/6	4	–	–
28	Bressay East Ground	9/6	10	–	–
28	Old Viking Bank	3/6	2	–	–
28	Bressays Ground	5–8/6	12	–	1.000+
	Total		74	1	1,000+

Table 12

Summary of whale observations at East-Greenland in 1975. The observations are grouped according to statistical areas used in the Norwegian fisheries statistics. (Fiskeridirektoratet, 1972).

			Number of whales observed						
Area	Locality	Date	Minke	Fin	Humpback	Sperm	Bottlenose	Killer	Dolphins
36	Lofoten/Langenes	16–17/7	4	1	–	2	1	1	–
56	Langenes Flak	18–19/7	3	2	–	–	–	15	32
54	Djuphall	18–20/7	10	–	–	–	–	–	4
61	Vikurall	18–19/8	20	4	–	–	–	–	–
61	Dohrn Bank	25/7	2	3	2	50	–	–	55
61	Cap Dan Bank	7–16/8	44	24	–	2	–	1	17
61	Sermilik Djupet	26/7–14/8	57	5	1	9	–	4	27
61/60	Heimland Ryggen	27/7–6/8	42	11	–	–	–	2	20
60	Kap Møsting Ground	31/7–5/8	18	58	–	–	–	–	–
60	Skjoldungen Bank	1–4/8	27	14	–	1	–	–	–
60	Fylkir banken	3–4/8	47	13	–	–	–	–	–
	Total		274	135	3	64	1	23	155

NA 76/4

Norwegian and International Regulations in the Norwegian Whaling for Minke Whales, *Balaenoptera acutorostrata*, and Small Whales

Åge Jonsgård

INTRODUCTION

Modern whaling for small whales started in Norway about 1930. The whaling operations in prewar seasons were undertaken in Norwegian coastal and adjacent waters, the Lofoten area being the main whaling grounds in the late 1930s. During postwar seasons an expansion took place in the northern North Atlantic. Coastal whaling, however, has been maintained throughout this period by smaller vessels, but they are today reduced in numbers as compared to those operating before and just after the war.

The minke whales, meat of which is used for human consumption, has by far been the main species caught. Other species, which have been taken mainly when prices for animal food were good, are bottlenose whales, killer whales and pilot whales.

The first regulation of this whaling was put into force in 1938, when the participation in the whaling was licenced by the Norwegian Government. Detailed requirements were also made on the whaling equipment, and several other aspects concerning the whaling operations and the preparing of the products. The whaling was controlled by a sailing inspector representing the Norwegian Government.

Since 1938 different kinds of regulations have been put into force, mainly with the aim in mind to give protection to minke whales in the waters where whaling operations for this species seemed to be too intensive. The Norwegian and International (IWC) regulations for Norwegian whaling of small whales are shown separately in Table 1.

DISCUSSION

Norwegian regulations

As seen from Table 1, the regulations put into force by the Norwegian Government include three kinds of effort limitation:

1. REGULATION BY LICENCES

During the 1930s the whaling for minke whales expanded along the coast of Norway and the number of vessels participating in whaling operations increased considerably from one season to another. At that time little was known concerning the biology of the minke whale, and no regulations based upon such knowledge could be introduced. However, in 1937 the Norwegian Government was aware of the fact that in spite of lack of basic scientific data for introducing effort limitation, a conservative attitude pointed to the fact that something had to be done. As a consequence, the whaling was made dependent upon licences from 1938 onwards. At the same time collection of catch and effort data was organized, resulting in the Norwegian small whale statistics. These statistics are completely based upon information from the licencees.

At the end of the 1940s up to 378 licences were issued each season. At this time the whaling had expanded also to waters outside the coast of Norway, mainly to the Spitsbergen and Barents Sea areas. Scientific data available at that time and the increasing number of whales being

Table 1

Norwegian and International regulations in the Norwegian whaling for minke whales and small whales

	Norwegian regulations
1930–37	No regulations
1938	Regulation by licences issued by the Norwegian Government. *This regulation has been maintained for all later seasons.*
1950	All whaling forbidden in a period of three weeks lasting from July 1 to July 21. *This regulation has been maintained for all later seasons, except for 1972.*
1952	Whaling only permitted in a period of six months lasting from March 15 to September 14.
1955	Whaling north of 70° N and east of 0° only permitted in the period March 15 to June 30. In other waters as for 1952
1961	No whaling permitted south of 70° N and east of 25° E (South-eastern Barents Sea). In other waters as for 1955.
1972	In the waters north of 65° N and east of 15° W whaling only permitted from March 15 to July 15. In other waters as for 1952.
1973	In the waters north of 70° N (South-eastern Barents Sea included), whaling limited to the period April 1 to June 30. In other waters whaling limited to the period April 1 to August 31. A maximum quota per season for minke whale meat set at 70 tons per vessel.
1974	In the waters north of 70° N and east of 20° W whaling limited to the period May 1 to June 30. For other waters east of 44° W (Cape Farewell) whaling permitted from April 15 to August 31, and for waters west of Cape Farewell from May 15 to August 31. The maximum quota set in 1973 maintained.
	International regulations
1952	The season should include no more than six consecutive months (IWC.)
1975	A catch quota set at 2,000 and 550 minke whales east and west of Cape Farewell respectively. (IWC)

taken pointed to the fact that the number of licences had to be reduced. Since then the Norwegian Government has gradually reduced the number of licences and as a result of this reduction, only 91 licences were issued in 1975.

2. REGULATION BY TIME AND AREA

As early as 1950 a three weeks halt in whaling operations was imposed from 1 July to 21 July. Since then this regulation has been left in force, except for 1972, when whaling was permitted until 15 July in the waters north of 65°N and east of 15°W. When introducing the three weeks catch stop in July, it was anticipated that the total number of minke whales in the catches would be reduced, because in relation to other months, the catches were very high in July. Since a considerable number of calves are inhabiting Norwegian coastal waters (especially the Lofoten area) in July, it was also anticipated that a part of those calves would be spared. From a commercial point of view this regulation no doubt was also useful since the reduced quantities of minke whale meat being brought ashore at the peak of the holiday season, when most people were away from home, had a stabilizing affect on the prices for whale meat being sent to the market.

Both time and area limitations were put into effect in the season 1955, when whaling was permitted only from 15 March to 30 June in the waters north of 70°N and east of 0°. This regulation was based upon the biological knowledge that, because of segregation, a relatively large number of mature female whales inhabited this area. In North Atlantic minke whales, almost all mature females are pregnant during the whaling season. A reduced catch of such females would therefore positively affect the recruitment of the minke whale stocks.

Because of the relatively large number of minke whales being caught in 1972, further time and area restrictions were put into effect in 1973 and in 1974. In 1973 the whaling in the Barents Sea was limited to the period 1 April to 30 June, and in 1974 only from 1 May to 30 June. For the same reason, further time restrictions have been made for all other North Atlantic areas of Norwegian whaling for small whales. Up to and including 1972 whaling was permitted in these waters from 15 March to 14 September. In 1973 whaling was limited to the period 1 April to 31 August, and in 1974 the whaling season was further restricted to the period 15 April to 31 August in the waters east of Greenland (Cape Farewell), and to the period 15 May to 31 August west of Greenland. The regulations put into effect in 1974 were not changed in 1975.

3. REGULATION BY A MAXIMUM QUOTA

In order to try and reduce the rather large number of minke whales taken by the 4 or 5 largest vessels, equipped with refrigerators for freezing the meat at sea, a maximum quota per season for minke whale meat was set at 70 tons per vessel in 1973. This regulation has not been changed since then. In special circumstances the Norwegian Government may dispense from this restriction.

International regulations

In 1952 the International Whaling Commission made the first step to regulate the whaling for minke whales in the North Atlantic, deciding that the season should include no more than six consecutive months. Since a six month season almost exactly included the period of time in which minke whales inhabit northern North Atlantic waters, the practical meaning of this decision has not at all restricted the whaling operations. On the other hand, the decision prevented trials to be made to catch minke whales during the breeding seasons.

Far more important is the regulation by quota carried through in 1975, which is in accordance with all other regulations of whaling being made by IWC. A quota regulation by number for minke whales has been discussed at several occasions in Norway, but it has been generally agreed that such a way of regulating would be too hazardous and therefore could not be recommended. The main reasons are the following. Introducing a quota by number, an effective control system also had to be put into force. The only way of making effective control would be to send an inspector on board every vessel. Since so very many vessels are participating in the whaling operations, both practical and economic problems would make such a regulation unreasonable and in fact impossible. If no effective control is put into force, there can be no doubt that at least a part of the whalers would use a quota by number regulation to catch more whales than permitted. Almost all the whalers have long experience in filling out forms for each whale caught, and they may very easily convert two or three smaller whales into one large one; and even experienced scientists will not be doubting the data presented. As a consequence, not only the small whale statistics would be 'killed', but in all probability also an over-exploitation of the stocks of minke whales would take place. Such problems are avoided or almost avoided by using the different kinds of effort limitation now in force.

According to the decisions of the International Whaling Commission, the Norwegian whaling for minke whales can now be lawfully carried out within six consecutive months and within an overall quota for 1976 set at 2,000 and 550 east and west of Cape Farewell, respectively. The Norwegian Government must consider the desirability of keeping to this regulation only or, in addition, to have further regulations. For the 1976 season at least, it has already been decided that the Norwegian effort limitations being in force in the season 1975 shall also be kept in 1976, in spite of the additional quota by number limitation.

CONCLUDING REMARKS

The decision of the IWC to introduce a quota by number limitation for the catch of North Atlantic minke whales is disagreed by the Norwegian specialists in this field, for reasons explained in this paper. The regulation by effort limitations has apparently worked well during four decades, and a quota limitation may only be preferred if an effective control is introduced at the same time. To avoid collapse in future whaling for North Atlantic minke whales this problem has to be solved immediately, and, in fact, should have been solved before a quota was set.

NA 76/11

Studies in an Equilibrium Model for Whale Stock Assessments

Karl Inne Ugland

Preface

This work has been conducted at the Institute of Marine Biology and Limnology, Department of Marine Zoology and Marine Chemistry, University of Oslo.

A hearty thanks to Professor Ole A. Mathison who encouraged me to study population dynamics.

I am greatly indebted to Dr Åge Jonsgård. I had numerous discussions with him on problems concerning the biology and exploitation of the minke whales off Norway, out of which this work grew.

I also want to thank the UK Whale Research Unit who sent me their earplug readings of the fin whales off Iceland

CONTENTS

Section

INTRODUCTION

Much of the current work on whale stock assessments is based on a few parameters which are believed to be the most important of the many parameters affecting the size of the whale stock. Almost every list of the selected parameters includes

Pregnancy rate
Age at sexual maturity for females
Age at recruitment
Natural mortality coefficient.

Because of the complexity of the population dynamics of whales firm estimates of recruitment rates and hence of sustainable yields, are seldom found.

Different models according to various hypotheses have been suggested. Often the result is gaps between the estimates of the important population parameters.

In a model a hypothesis is essentially an equation describing something that is unknown, i.e. lack of biological knowledge is replaced by an equation. Common to many general models is a set of equations with too many unknowns. The catch statistics are therefore used to estimate some of the parameters in order to get a set of n equations with n unknowns. A model constructed in this way is of course consistent with the catch statistics; but if too many parameters are estimated, this procedure may leave open the question about the model's validity.

Ideally, from the point of view of judging validity, a good model should contain at least one prediction that may be tested with the catch statistics.

The model developed in this work is a generalisation of Ottestad's model in "The Optimum Catch" (Hjort *et al.*, 1933) and will be referred to as "the equilibrium model" because only virgin stocks or stocks being in equilibrium with the catching are described. The main differences from most of the current methods are

1. Let N♀ = Number of females and a_0 N♀, a_1 N♀, a_2 N♀ be the number of female calves, immature females at least one year old and mature females.

   a_0, a_1, a_2 are regarded as three fundamental parameters and not simply as a consequence of survival rates.
2. The common procedure of putting age at maturity equal the age where 50% of the whales are mature is abandoned. Thus the gradual transition from the immature group to the mature group is taken into consideration.

Only elementary arithmetic is used in the text. The complex solutions of the model's equations are found in Appendix I and II. Those places where special attention is called for are marked with the sign Z.

THE UNEXPLOITED STOCK

Consider an unexploited stock. Divide the population into three groups:

0–Group – the calves
1–Group – Immature whales one year old or more
2–Group – The mature whales.

Suppose all the births take place at a particular time of the year and that no animal dies in this birth season. At the end of the birth season the following parameters are defined.

N = Population size
N♀ = Number of females
a_0 = The part of N♀ belonging to the 0–Group
a_1 = the part of N♀ belonging to the 1–Group
a_2 = The part of N♀ belonging to the 2–Group

Consequently the number of females in the three groups at the end of the birth season are a_0 N♀, a_1 N♀, and a_2 N♀.

In the period between two birth seasons two important events occur.

First a certain part of the whales will die. Let

M = Natural mortality

M is supposed to have the same value in all groups, i.e. each year 100M per cent of a_0 N♀, a_1 N♀, and a_2 N♀ die.

Next a certain part of the immature females mature. Let

p = The part of a_1 N♀ that each year mature.

i.e. each year 100p per cent of the immature females in the 1–Group mature.

The composition prior to the next birth season will therefore be

$(1 - M)a_0 N_♀$ = Females in the 0-Group
$(1 - p)(1 - M)a_1 N_♀$ = Immature females in the 1-Group
$(1 - M)a_2 N_♀ + p(1 - M)a_1 N_♀$ = Mature females.

Let θ = The part of $(1 - M)a_2 N_♀$ giving birth to a female calf

Z In most of the studied whale species the $P(1-M)a_1$ N♀ females will have their first calf earliest in the second birth season of which they are mature.

If half the number of all calves are females, θ may be calculated this way:

(i) Minke whales have a one year reproduction cycle which gives

$$\theta = \frac{1}{1} \cdot \frac{1}{2} = 0.50$$

(ii) Fin whales and bottlenose whales have a two year reproduction cycle which gives

$$\theta = \frac{1}{2} \cdot \frac{1}{2} = 0.25$$

The composition at the end of the next birth season is

$\theta(1 - M)a_2 N_♀$ = Female calves.
$(1 - p)(1 - M)a_1 N_♀ + (1 - M)a_0 N_♀$ = Immature females in the 1–Group
$(1 - M)a_2 N_♀ + p(1 - M)a_1 N_♀$ = Mature females.

If the age composition is stable, the number of females in each of the three groups is the same in the two years. Consequently

$a_0 N_♀ = \theta(1 - M)a_2 N_♀$
$a_1 N_♀ = (1 - p)(1 - M)a_1 N_♀ + (1 - M)a_0 N_♀$
$a_2 N_♀ = (1 - M)a_2 N_♀ + p(1 - M)a_1 N_♀$ and per definition
$a_0 N_♀ + a_1 N_♀ + a_2 N_♀ = N_♀$

Division by $N_♀$ gives the following set of equations for stable populations

$$a_0 = \theta(1 - M)a_2 \tag{1}$$

$$a_1 = (1 - p)(1 - M)a_1 + (1 - M)a_0 \tag{2}$$

$$a_2 = (1 - M)a_2 + p(1 - M)a_1 \tag{3}$$

$$1 = a_0 + a_1 + a_2 \tag{4}$$

(1)–(4) are a set of four equations with five unknowns: a_0, a_1, a_2, m, p.

Let

n = The average age among the $p(1-M)a_1 N_♀$ females

i.e. n is the average age at maturity.

Per definition the number of females being n years is $(1-M)^n a_0 N_♀$

Z This expression is correct for all real numbers, for example n = 6.75.

Thus, if the average age among the $(1-M)pa_1 N_♀$ females is n years the following equation is reasonable.

$$(1 - M)p\,a_1 N_♀ = (1 - M)^n a_0 N_♀$$

or

$$(1 - M)pa_1 = (1 - M)^n a_0 \tag{5}$$

The common procedure is now to put n equal to the age where 50% of the females are mature. (1)–(5) are thus a set of five equations with five unknowns and all the parameters may be estimated.

Z With the definition of n given in the text there is no mathematical theorem that states (5) is correct and there is no *a priori* reason to choose n as the 50% limit.

This is the reason for using (5) as the definition of n and regard (1) – (5) as a set of five equations with six unknowns: a_0, a_1, a_2, M, p, n.

The sixth equation may be derived from the curve giving the proportion of mature females at different ages.

Let

fkj = First year some females mature

For i = fkj, fkj + 1, fkj + 2, . . . let

r_i = The proportion of mature females at age i

Let

skj = First year such that $r_{skj} = r_{skj+1}$

The numbers r_i (i = fkj, . . . , skj) gives a new relation between p and the survival rate S = 1–M. To see this assume that the number of females being one year old is 1.

The number of females being x years old is consequently S^{x-1}.

A natural assumption is that the females being mature fkj years old were immature fkj–1 years old.

Therefore $r_{fkj-1} = 0$ and the number of females which mature fkj years old is

$$r_{fkj} S^{fkj-1}$$

These females will of course also be mature fkj + 1 years old. The number of females mature fkj + 1 years old is

$$r_{fkj+1} S^{fkj}$$

but

$$S\, r_{fkj} S^{fkj-1} = r_{fkj} S^{fkj}$$

of these matured the year before.

This means that

$$(r_{fkj+1} - r_{fkj}) S^{fkj}$$

matured fkj + 1 years old.

Quite generally let $i \in$ fkj, ... , skj .

The number of females mature i years old is

$$r_i S^{i-1}$$

The number of females mature i – 1 years old is

$$r_{i-1} S^{i-2}$$

and these females constitute

$$S\, r_{i-1} S^{i-2} = r_{i-1} S^{i-1}$$

of $r_i S^{i-1}$

The number of females which mature i years old is therefore

$$(r_i - r_{i-1}) S^{i-1} \quad \ldots.\ i = \text{fkj}, \ldots., \text{skj}.$$

Consequently the number of females which each year mature is

$$r_{fkj}\, S^{fkj-1} + \sum_{i=fkj+1}^{skj} (r_i - r_{i-1})\, S^{i-1}$$

$$= \frac{1-S}{S} \sum_{i=fkj}^{skj-1} r_i\, S^i + r_{skj}\, S^{skj-1}$$

The number of i years old females which were mature i–1 years old is

$$S\, r_{i-1}\, S^{i-2} = r_{i-1}\, S^{i-1}$$

A natural assumption is that those females which matured i years old come from $(1 - r_{i-1})\, S^{i-1}$ females.

An estimate of the immature females in the 1–Group is therefore

$$\sum_{i=1}^{fkj} S^{i-1} + \sum_{i=fkj+1}^{skj} (1 - r_{i-1})\, S^{i-1}$$

$$= \sum_{i=1}^{skj} S^{i-1} - \sum_{i=fkj+1}^{skj} r_{i-1}\, S^{i-1}$$

$$= \frac{1 - S^{skj}}{1 - S} - \sum_{i=fkj}^{skj-1} r_i S^i$$

The definition of p now gives a new relation between p and s.

$$p = \frac{\dfrac{1-S}{S} \displaystyle\sum_{i=fkj}^{skj-1} r_i\, S^i + r_{skj}\, S^{skj-1}}{\dfrac{1 - S^{skj}}{1 - S} - \displaystyle\sum_{i=fkj}^{skj-1} r_i\, S^i} \tag{6}$$

Z Because of the division in (6) the assumption of only one whale being one year old is no loss of generality.

(1) – (6) is a set of six equations with six unknowns and therefore determines a unique point in the six dimensional Euclidian space.

Z The danger in putting n equal the 50% value is now clearly visible:

A small pertubation of n could remove the estimated point far from the true point.

(1) – (6) represent the equilibrium model for unexploited stocks of whales.

Antarctic minke whales, *Balaenoptera acutorastrata*

Ohsumi and Masaki (1975) pooled all the catch statistics from Japanese catches in the Antarctic seasons 1971–72 and 1972–73. They thus risk to pool different stocks and this is, of course, also a weakness in the application of the equilibrium model. With a classical method they arrive at the following estimates:

age at maturity = 6 years

Instantaneous natural mortality for

(i)	immature females	0.213
(ii)	mature females	0.127

These values imply the following equations:

$$a_1 = a_0\, (e^{-0.213} + e^{-2x0.213} + \ldots . + e^{-5x0.213})$$

$$a_2 = a_0\, e^{-6x0.213} \frac{1}{1 - e^{-0.127}}$$

From $a_0 + a_1 + a_2 = 1$ the following age composition is derived:

$$(a_0, a_1, a_2) = (0.164, 0.453, 0.383)$$

Of these parameters age at maturity and instantaneous natural mortality for mature females have been estimated from the catch statistics with the 50%–rule and linear regression. The instantaneous natural mortality for immature females is calculated from equation (4) in their model. This makes the model consistent with the catch statistics but test of validity is lost.

Ohsumi and Masaki (1975) also give estimates of reproduction parameters:

Pregnancy rate = 0.85
Litter size = 1.007
Sex ratio at birth = 1 : 1

This means that

$$\theta = 0.85 \times 1.007 \times 0.5 = 0.427975$$

Their Fig. 3 gives the following information:

fkj = 3 years
skj = 12 years

$r_3 = 0.035$
$r_4 = 0.125$
$r_5 = 0.252$
$r_6 = 0.448$
$r_7 = 0.643$
$r_8 = 0.797$
$r_9 = 0.888$
$r_{10} = 0.937$
$r_{11} = 0.965$
$r_{12} = 0.979$

The equilibrium model now gives the following estimates for the females:

n = 7.66 years
$m = 0.129143$
$p = 0.097994$
$a_0 = 0.129143$
$a_1 = 0.524356$
$a_2 = 0.346501$

First note that the age at maturity estimated to be 7.66 years and the proportion of mature females at this age is approximately 0.75. This means that 75% of the females are mature at the age at maturity.

Next observe that the equilibrium model predicts a survival rate equal

$1 - M \approx 0.871$ (predicted value)

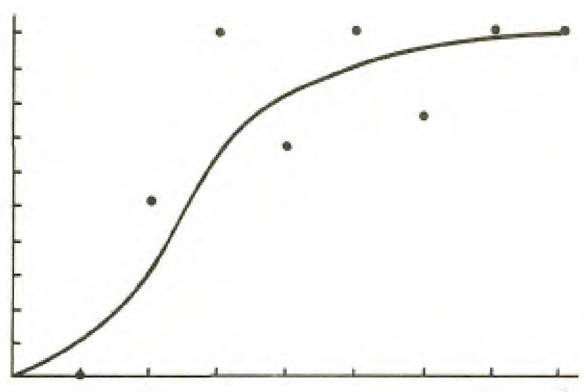
The observed survival rates for mature females are (Ohsumi *et al* 1975)

1. The survival rate based on age composition is $e^{-0.129} = 0.879$.
2. The survival rate based on ovulation rate and corpora composition is $e^{-0.124} = 0.883$.
3. The survival rate based on the average of these methods is $e^{-0.127} = 0.881$.

The differences between the predicted and observed values are about $\frac{1}{100}$ and indicate validity.

Bottlenose whales, *Hyperoodon ampullatus* (Forster), in the Labrador Sea

Christensen (1973, 1975) has investigated this stock which may be considered as virginal before 1969. He found a reproduction cycle of two years and age at maturity equal



This may serve as an intuitive explanation of the fact that n (which is density dependent) is almost independent of S_1 in the algorithm suggested in this section.

Fin whales, *Balaenoptera physalus* (L), off the west coast of Iceland.

Gambell *et al* (1973) and Røorvik *et al* (1975) have studied this whaling. These papers conclude:

The stock estimates based on both earplug readings and markings indicate a population large enough to sustain the present annual catch. The study of the percentage of mature animals in the catches indicate a stable population. Catch per unit effort has decreased, but not significantly different from zero. This indicates that the stock has decreased.

Thus, there is no conclusive evidence that the stock is in equilibrium with the harvesting.

However, since the study of the percentage of mature animals in the catches indicate a stable stock it may be interesting to apply the equilibrium model.

C_0, C_1, C_2, are estimated as the average catches of females in each group in the period 1951 – 1973. Rørvik (1974) gives

$$C_0 = 0 \qquad C_1 = 47 \quad , \; C_2 = 78$$

Dr Gambell has sent me the following results of the earplug readings:

Table 1

Iceland fin whales 1967, 1969, 1973.

Age	♀♀ No. sampled	No. mature
3	9	1
4	4	0
5	7	1
6	7	4
7	7	3
8	4	3
9	5	5
10	7	5
11	7	6
12	2	2
13	2	2

From these data the curve in Fig. 2 has been drawn freehand.

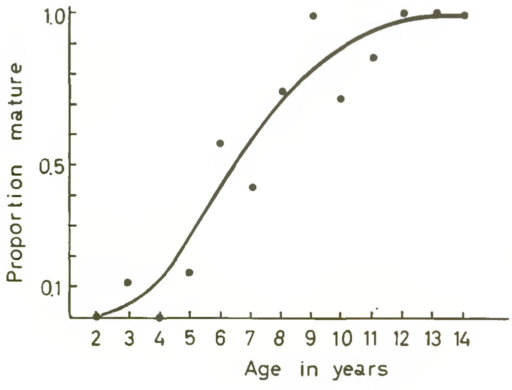


Fig. 2.

The following estimates are obtained:

fkj = 3 years
skj = 13 years

$r_3 = 0.04$ $r_9 = 0.805$
$r_4 = 0.125$ $r_{10} = 0.89$
$r_5 = 0.25$ $r_{11} = 0.95$
$r_6 = 0.41$ $r_{12} = 0.99$
$r_7 = 0.57$ $r_{13} = 1.00$
r $r_8 = 0.695$

With $\theta = 0.25$ the study of n (age at maturity) as a function of S_1 (survival rate for immature females) gives the results shown in Table 2.

Table 2

S_1	n	S_1	n	S_1	n
.75	7.53	.82	7.74	.89	7.95
.76	7.56	.83	7.78	.90	7.99
.77	7.59	.84	7.81	.91	8.02
.78	7.62	.85	7.84	.92	8.04
.79	7.65	.86	7.87	.93	8.07
.80	7.68	.87	7.90	.94	8.10
.81	7.71	.88	7.93	.95	8.13

The estimate of the age at maturity is the mean of all these n-values:

$$n = 7.83 \text{ years}$$

The equilibrium model now gives the estimates for different values of M shown in Table 3.

Z The same phenomenon is observed in the application of the equilibrium model to the minke whaling off Norway These small variations are thus probably due to some inner properties of the model. It is difficult to grasp the point because m runs over a wide range of values among which only one is the true number.

Table 3

M	p	a_0	a_1	a_2
.01	.117095	.89933	.496318	.413749
.02	.115602	.091040	.492133	.416827
.03	.114162	.092134	.487962	.419904
.04	.112778	.093213	.483810	.422977
.05	.111449	.094278	.479680	.426042
.06	.110176	.095327	.475576	.429097
.07	.108960	.096360	.471500	.432139
.08	.107801	.097377	.467457	.435166

M	S_0	S_1	S_2	Stock size
.01	.99	.929444	.869448	3,128
.02	.98	.925724	.873651	3,519
.03	.97	.922123	.877666	4,024
.04	.96	.918645	.881497	4,698
.05	.95	.915293	.885149	5,646
.06	.94	.912070	.888627	7,077
.07	.93	.908979	.891936	9,484
.08	.92	.906022	.895082	14,387

Note the small variations in the estimates of p, a_0, a_1, a_2, S_1, S_2

Taking the mean of all the alternative values the following estimates are obtained:

$$p = 0.112253$$
$$(a_0, a_1, a_2) = (0.094, 0.482, 0.424)$$
$$S_1 = 0.917$$
$$S_2 = 0.883$$


22
23

provided the age at maturity has been constant during the period 1960 – 1972.

The study of CPUE and size composition thus indicates that the equilibrium model may be applied to the period 1960 – 1972.

Solvik (1976) suggests the following age-length key:

Age	Length	Age	Length
4	22.63	7	25.32
5	23.72	8	25.93
6	24.59	9	26.42

The following estimates are obtained from this age-length key and Fig. 3.

$$fkj = 4 \text{ years}$$
$$skj = 9 \text{ years}$$

$r_4 = 0.055$ $r_7 = 0.87$
$r_5 = 0.30$ $r_8 = 0.97$
$r_6 = 0.62$ $r_9 = 1.00$

The study of n (age at maturity) as a function of S_1 (survival rate for immature females) gives the values shown in Table 5.

Table 5

S_1	n	S_1	n	S_1	n
.75	7.00	.82	7.05	.89	7.11
.76	7.01	.83	7.06	.90	7.11
.77	7.01	.84	7.07	.91	7.12
.78	7.02	.85	7.08	.92	7.13
.79	7.03	.86	7.08	.93	7.14
.80	7.04	.87	7.09	.94	7.14
.81	7.05	.88	7.10	.95	7.15

The estimate of the age at maturity is the mean of all these n-values:

$$n = 7.08 \text{ years}$$

The proportion of mature females at the age at maturity is approximately 0.878.

Ugland (1976) gives the following estimates of the composition of the equilibrium catch:

$$C_0 = 129 \quad , \quad , \quad C_1 = 649 \quad , \quad C_2 = 302$$

With $\theta = 0.50$ the estimates of the equilibrium model are given in Table 6.

The estimates based on the mean of all the values are:

$$S_0 = 0.869$$
$$S_1 = 0.842$$
$$S_2 = 0.868$$

Based on markings the best estimate of the stock size is 40,700 (Ugland, 1976). This corresponds to $M \approx 0.09$ in the equilibrium model. These values have an interesting implication.

51 minke whales were marked in 1974. The total catch of the eastern stock of minke whales was 1,290 in 1975.

The expected number of recoveries is

$$\frac{1,290}{40,700} \times 51 \times 0.91 \approx 1.47 \text{ (predicted value)}$$

The actual number recovered was 1. This indicates a stock size of approximately 40,000.

However, since no method for age determination of this stock is known, it is very difficult to test the predictions of age distribution and survival rates. Therefore this stock estimate should only be taken as indication of the stock size.

Table 6

M	p	a_0	a_1	a_2
.01	.097400	.147294	.516362	.336343
.02	.098173	.146982	.516821	.336196
.03	.098939	.146673	.517276	.336052
.04	.099698	.146365	.517725	.335909
.05	.100451	.146060	.518171	.335769
.06	.101196	.145756	.518613	.335631
.07	.101936	.145455	.519051	.335494
.08	.102668	.145155	.519485	.335359
.09	.103395	.144858	.519917	.335226
.10	.104115	.144562	.520345	.335093
.11	.104828	.144267	.520771	.334962
.12	.105536	.143974	.521194	.334832

The estimates based on the mean of all the values are:

$$p = 0.101528$$

$$(a_0, a_1, a_2) = (0.146, 0.519, 0.336)$$

M	S_0	S_1	S_2	Stock size
.01	.878665	.830221	.875856	15,733
.02	.876808	.832353	.874383	17,010
.03	.874986	.834460	.872916	18,513
.04	.873198	.836542	.871456	20,307
.05	.871444	.838599	.870001	22,486
.06	.869724	.840632	.868552	25,188
.07	.868038	.842643	.867109	28,626
.08	.866385	.844630	.865672	33,151
.09	.864766	.846595	.864240	39,375
.10	.863181	.848538	.862814	48,472
.11	.861629	.850459	.861394	63,034
.12	.860111	.852358	.859978	90,097

Z There is a discrepancy between the estimates of p (and hence the age at maturity) in this work and Ugland (1976). The reason for this difference is that Ugland (1976) assumes $S_1 = S_2$ as an extra equation to the set (7) – (14). This demonstrates that the equilibrium model is very sensitive to small errors in *a priori* assumptions giving new relations that involve only the model's fundamental parameters.

CONCLUSIONS

The equilibrium model suggests that the current method of estimating age at maturity at the 50% level should be abandoned.

The equilibrium model for unexploited stocks gives predictions that may be tested from the catch statistics. This is an advantage because such a test is an indication of validity.

The equilibrium model for exploited stocks produces a table of estimates. In both applications studied in this work the age composition and survival rates for the groups being exploited could be estimated. This indicates that the statement

'The stock has a stable age composition'

is equivalent to many other statements (i.e. the predicted age composition and survival rates) regarding the population dynamics of the stock.

Finally, it seems that no *a priori* assumptions (for example $S_1 = S_2$) involving only the fundamental parameters (a_0, a_1, a_2, p, M, n, N♀, S_0, S_1 S_2) should be applied in order to find the true alternative.

SUMMARY

An equilibrium model for whale stock assessments has been developed.

For unexploited stocks the model gives estimates that may be tested from the catch statistics. The differences between the observed and predicted values are thus indications of validity.

For exploited stocks the model gives an array of estimates corresponding to different alternative values of natural mortality. The estimates of the population size vary a great deal with different values of natural mortality. Estimates based on markings will provide indications for the best alternative.

In both examples studied in this work the estimates of all the other population parameters showed only a small variation with different values of natural mortality.

APPENDIX I

The solution of the equilibrium model's equations for unexploited stocks.

Put $S = 1 - M$

S is called the survival rate.

(2) gives

$$a_1 = \frac{S}{1-(1-p)S}\, a_0 \tag{16}$$

Substitute (1) in (16)

$$a_1 = \frac{\theta S^2}{1-(1-p)S}\, a_2 \tag{17}$$

(3) gives

$$a_1 = \frac{1-S}{pS}\, a_2 \tag{18}$$

(17) and (18) imply

$$1 - \frac{\theta S^2}{(1-p)S} = \frac{1-S}{pS}$$

hence

$$p = \frac{(1-S)^2}{\theta S^3 + S^2 - S} \tag{19}$$

(4), (1) and (16) give

$$1 = a_0 + \frac{S}{1-(1-p)S}\, a_0 + \frac{1}{\theta S}\, a_0$$

hence

$$a_0 = \frac{1}{1 + \dfrac{S}{1-(1-p)S} + \dfrac{1}{\theta S}} \tag{20}$$

If (19), (20), (16), (1), (5) are applied in sequence the following algorithm will give all the estimates when S is known:

Algorithm 1

$$p = \frac{(1-S)^2}{\theta S^3 + S^2 - S}$$

$$a_0 = \frac{1}{1 + \dfrac{S}{1-(1-p)S} + \dfrac{1}{\theta S}}$$

$$a_1 = \frac{S}{1-(1-p)S}\, a_0$$

$$a_2 = \frac{1}{\theta S}\, a_0$$

$$n = \frac{\ln \dfrac{Spa_1}{a_0}}{\ln S}$$

It remains to estimate S.

Write (19) on the form

$$(1-\theta pS)\,S^2 - (2+pS)\,S + (1+pS) = 0$$

Put

$$T = pS$$

$$a = \frac{2+T}{1-\theta T} \tag{21}$$

$$b = \frac{1+T}{1-\theta T} \tag{22}$$

Then

$$S^2 - aS + b = 0 \tag{23}$$

The definitions of p, s, and θ imply

$$T = pS > 0 \text{ and } 0 < \theta T < 1$$

Therefore

$$a > 2 \text{ and } b > 0$$

Consequently the sum of the roots in (23) is greater than 2 and the product is positive. The only possibility is that both roots are positive and because the sum is greater than 2 the estimate of S must be the smallest root

$$S = \frac{a - \sqrt{a^2 - 4b}}{2} \tag{24}$$

(6) gives (remember $T = pS$)

$$T = \frac{(1-S)\sum\limits_{i=fkj}^{skj-1} r_i S^i + r_{skj} S^{skj}}{\dfrac{1-S^{skj}}{1-S} - \sum\limits_{i=fkj}^{skj-1} r_i S^i}$$

Let eps be the desired degree of accuracy in the estimate of S (for example eps = 10^{-6}).

The following algorithm will estimate S.

Algorithm 2

1. Guess a S-value : $S = S_{Guess}$.
2. Estimate T from (25) with $S = S_{Guess}$ and find a and b from (21) and (22).
3. Estimate a new S-value : $S = S_{old}$ from (24).
4. Estimate T from (25) with $S = S_{old}$ and find a new estimate $S = S'$ from (24).
5. Estimate T from (25) with $S = S'$ and find a new estimate $S = S_{new}$ from (24).
6. If $|\, S_{new} - S_{old} \,| <$ eps then $S = S_{new}$ is the desired estimate of S, else the process 3, 4, 5 must be repeated with $S_{old} = S_{new}$ (i.e. the new ≪old≫ – value of S is S_{new}).

$$k_4 = -\left(1 + \frac{\frac{1}{\theta} + \frac{C_2}{C}}{1 - M}\right)$$

(9), (7) and (31) give

$$S_1\ pa_1 = \left(\frac{\frac{1}{\theta} + \frac{C_2}{C}}{1 - M} - \frac{1}{\theta}\right) a_0.$$

$$= \left(1 + \frac{\frac{1}{\theta} + \frac{C_2}{C}}{1 - M}\right)(1$$

The following algorithm will thus estimate all the parameters when n and M are known:

Algorithm 3

1. Put $S_1 = S_{Guess} = \left(\frac{C_2}{C - C_0}\right)^{\frac{1}{n-1}}$
2. Apply Newton's method to equation (36) with $S_1 = S_{Guess}$ as initial value.
3. Estimate p from (37).
4. Estimate a_0 from (33).
5. Estimate a_1 from (32).
6. Estimate a_2 from (31).
7. Estimate S_2 from (7)

$$S_2 = \frac{a_0}{\theta a_2}$$

8. Estimate S_0 from (8):

$$S_0 = \frac{a_1}{a_0}(1 - (1-p)S_1)$$

9. Estimate N♀ from (29).
10. Estimate N from N = 2N♀.

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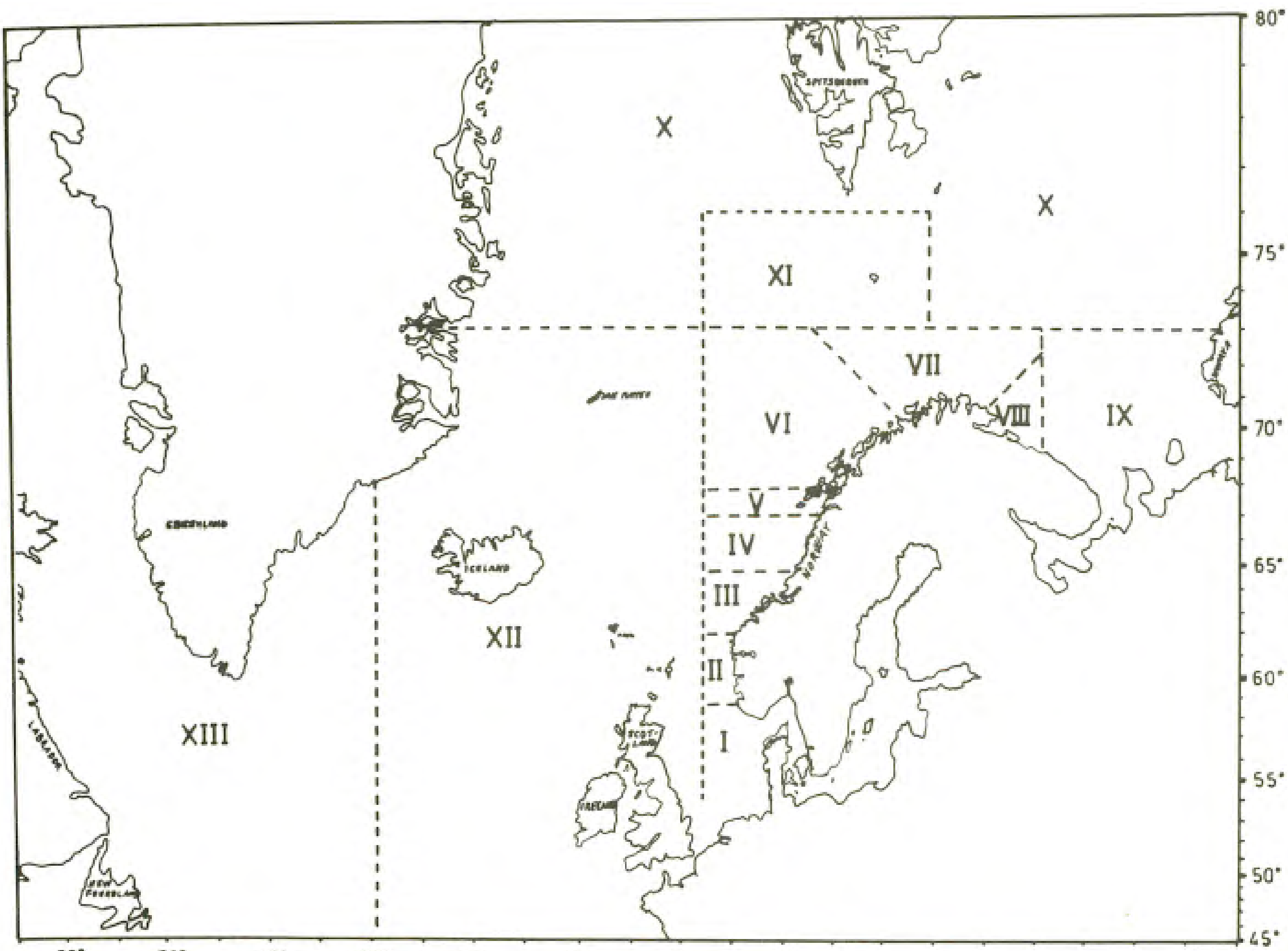

X
X
XI
VII
VI
VIII
IX
V
IV
III
II
I
XII
XIII
80°
75°
70°
65°
60°
55°
50°
45°

Table 1

Norwegian whaling for small whales

Number of minke whales caught in different areas and seasons.

	I	II	III	IV	V	VI	VII	VIII	IX–XI	XII	Total
1942	34	126	356	35	1,316	241	23	0	0	0	2,131
1943	45	115	273	50	760	359	9	0	0	0	1,611
1944	37	62	230	32	896	116	0	0	0	0	1,373
1945	31	136	207	76	1,236	76	8	8	0	0	1,778
1946	35	116	149	74	850	232	43	88	146	157	1,890
1947	42	129	201	162	1,100	287	68	211	140	232	2,572
1948	19	110	205	43	1,451	231	172	311	679	340	3,561

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1949	25	167	45	70	802	202	139	339	937	1,009	0	192	3,928
1950	10	91	236	45	695	135	156	64	161	212	169	15	1,989
1951	2	36	395	38	1,249	132	34	44	171	503	85	61	2,750
1952	3	16	229	44	942	64	78	107	1,135	562	79	107	3,366
1953	2	8	252	28	853	76	41	91	698	325	8	51	2,433
1954	4	315	442	14	1,005	42	79	43	415	1,055	28	54	3,496
1955	10	296	431	108	1,550	41	29	66	610	957	46	184	4,328
1956	4	263	561	47	921	61	49	327	386	685	167	187	3,658
1957	21	284	397	37	830	134	40	222	346	876	155	300	3,642
1958	17	218	368	99	962	187	85	162	1,238	403	189	410	4,338
1959	21	114	209	80	524	31	122	169	752	497	106	465	3,090
1960	41	149	226	28	732	72	80	100	585	741	179	498	3,431
1961	20	60	70	69	776	285	130	10	643	609	132	434	3,238
1962	11	93	158	122	863	144	30	89	494	717	37	537	3,295
1963	18	44	272	66	449	244	40	487	727	414	22	445	3,228
1964	10	72	77	121	722	91	486	210	110	191	56	580	2,726
1965	15	75	70	73	670	81	173	62	169	213	338	526	2,465
1966	10	132	73	15	429	84	36	67	583	218	72	433	2,152
1967	16	67	48	107	516	106	200	5	30	497	134	465	2,191

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
1968	34	38	188	16	306	50	298	61	32	198	589	923	0	2,733
1969	30	80	29	6	154	3	548	14	378	270	164	715	0	2,391
1970	43	22	52	14	359	22	209	22	239	254	391	393	287	2,307
1971	48	94	20	0	285	4	80	2	475	285	241	390	406	2,330
1972	110	10	2	0	118	0	132	25	1,170	252	154	288	389	2,650
1973	54	13	6	1	198	6	82	32	736	229	77	187	434	2,055
1974	51	14	6	20	195	1	132	30	820	16	14	169	352	1,820
1975	43	6	3	5	220	0	70	8	588	58	289	180	318	1,788

Table 2

Norwegian whaling for small whales

Number of bottlenose whales caught in different areas and seasons.

	I	II	III	IV	V	VI	VII	VIII	IX–XI	XII	Total
1941	0	0	7	0	0	14	0	0	0	0	21
1942	0	0	1	0	0	8	0	0	0	0	9
1943	0	1	24	0	0	9	0	0	0	0	34
1944	0	0	28	0	0	12	0	0	0	0	40
1945	0	0	19	0	0	3	0	0	0	0	22
1946	0	0	11	1	0	1	0	0	7	0	20
1947	0	0	81	0	0	4	0	0	23	0	108
1948	0	0	41	0	1	4	0	0	15	0	61
1949	0	0	34	0	0	0	0	0	185	2	221
1950	0	0	29	0	0	2	0	0	16	1	48
1951	0	0	23	0	0	9	0	0	43	2	77
1952	0	0	13	0	0	4	0	0	0	0	17
1953	0	0	30	0	0	2	0	0	17	0	49
1954	0	0	41	0	1	0	0	0	19	9	70

Continued

Table 2 – *continued*

Norwegian whaling for small whales

Number of bottlenose whales caught in different areas and seasons.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
1955	0	0	40	0	0	1	0	0	0	80	2	1	0	124
1956	0	0	49	0	0	0	0	0	0	210	7	1	0	267
1957	0	0	47	0	0	0	0	0	0	91	1	24	0	163
1958	0	0	35	0	0	1	0	0	0	91	6	12	0	145
1959	0	0	20	0	2	2	0	0	0	69	0	1	0	94
1960	0	0	41	0	0	2	0	0	0	150	0	0	0	193
1961	0	0	13	0	0	15	0	0	0	47	2	10	0	87
1962	0	0	3	0	0	2	0	0	0	129	2	185	0	321
1963	0	0	34	0	0	2	0	0	0	82	1	148	0	267
1964	0	0	11	0	0	3	0	0	0	64	0	229	0	307
1965	0	0	3	0	0	0	0	0	0	3	0	689	0	695
1966	0	0	1	0	0	4	0	0	0	0	4	331	0	340
1967	0	0	0	0	0	2	0	0	0	11	1	250	0	264
1968	0	0	0	0	0	2	0	0	0	159	25	198	0	384
1969	0	0	0	0	0	6	2	0	0	135	15	327	0	485
1970	0	1	1	0	0	4	0	0	0	81	0	8	440	535
1971	0	0	0	0	0	0	0	0	0	0	0	62	151	213
1972	0	0	0	0	0	0	0	0	0	0	0	0	17	17
1973	0	0	0	0	0	0	0	0	0	3	0	0	0	3
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3

Norwegian whaling for small whales

Numbers of killer whales caught in different areas and seasons.

	I	II	III	IV	V	VI	VII	VIII	IX–XI	XII	Total
1941	0	4	6	0	4	0	0	0	0	0	14
1942	1	16	11	0	28	1	0	0	0	0	57
1943	0	3	2	0	5	2	0	0	0	0	12
1944	1	8	14	3	1	2	0	0	0	0	29
1945	0	3	4	0	4	1	0	0	0	0	12
1946	1	0	6	1	10	3	0	2	4	5	32
1947	0	5	3	1	5	5	2	1	1	6	29
1948	0	6	10	0	12	2	0	0	4	4	38
1949	1	4	3	2	6	6	0	0	12	0	34
1950	2	4	3	0	2	0	0	0	0	1	12
1951	1	2	0	13	2	2	0	2	2	0	24
1952	0	2	2	0	3	2	4	0	0	0	13
1953	0	0	2	1	5	0	0	0	1	0	9
1954	0	0	6	0	4	0	0	3	0	0	13

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
1955	0	0	14	0	3	0	0	0	0	1	1	7	0	26
1956	1	0	9	0	8	0	0	0	7	2	0	13	0	40
1957	0	1	17	0	15	0	0	0	2	0	0	13	0	48
1958	0	0	11	2	9	1	1	4	10	1	0	0	0	39
1959	0	0	9	0	1	0	0	3	2	17	5	32	0	69
1960	1	0	19	4	11	2	3	0	0	9	5	28	0	82
1961	9	0	44	0	3	0	1	0	9	2	0	43	0	111
1962	1	3	32	3	3	0	3	1	3	6	2	67	0	124
1963	1	0	25	6	0	3	3	9	3	12	0	28	0	90
1964	2	3	11	0	7	1	0	1	5	0	0	47	0	77
1965	0	1	20	0	1	0	4	0	0	6	0	72	0	104
1966	0	1	4	0	48	2	4	4	1	0	4	94	0	162
1967	0	0	3	0	7	0	0	0	0	0	0	26	0	36
1968	0	0	38	3	4	1	0	0	0	0	2	38	0	86
1969	0	3	178	0	7	0	1	0	0	3	0	39	0	231
1970	2	5	207	0	17	0	1	0	0	0	2	9	3	246
1971	2	4	9	0	3	0	0	0	0	1	0	4	34	57
1972	0	0	0	0	7	0	0	0	0	0	0	4	17	28
1973	0	0	0	0	1	0	0	0	0	0	0	0	0	1
1974	0	1	0	0	5	0	0	0	0	0	0	0	0	6
1975	0	0	0	1	1	0	0	0	0	0	0	0	0	2

Table 4

Norwegian whaling for small whales

Numbers of pilot whales caught in different areas and seasons.

	I	II	III	IV	V	VI	VII	VIII	IX–XI	XII	Total
1942	0	1	2	0	0	5	0	0	0	0	8
1943	0	0	8	0	0	0	0	0	0	0	8
1944	0	0	5	0	0	0	0	0	0	0	5
1945	0	0	1	0	0	11	0	0	0	0	12
1946	0	0	0	0	0	1	0	0	0	0	1
1947	0	0	4	0	0	0	0	0	0	3	7
1948	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	4	0	0	0	0	4
1950	0	0	1	0	0	9	0	0	0	0	10
1951	0	0	4	0	0	2	0	0	0	2	8
1952	0	0	1	0	0	1	0	0	0	0	2
1953	0	0	0	0	0	1	0	0	0	0	1
1954	0	0	0	0	0	0	0	0	0	0	0

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	Total
1955	0	0	0	0	7	0	0	0	0	0	0	6	0	13
1956	0	0	1	0	0	0	0	0	0	0	0	0	0	1
1957	0	0	12	0	6	20	0	0	0	0	0	42	0	80
1958	0	0	14	0	1	19	0	0	0	0	0	182	0	216
1959	0	0	9	0	0	47	0	0	0	0	0	168	0	224
1960	0	0	37	0	9	6	0	0	0	0	0	279	0	331
1961	0	1	8	0	0	143	0	0	0	0	0	142	0	294
1962	0	0	1	10	0	10	0	0	0	0	0	22	0	43
1963	0	0	18	0	0	5	0	0	0	0	0	48	0	71
1964	0	0	4	0	0	0	0	0	0	0	0	50	0	54
1965	0	0	2	0	0	30	0	0	0	0	0	0	0	32
1966	0	0	0	0	9	1	0	0	0	0	0	329	0	339
1967	0	0	0	0	0	3	0	0	0	0	0	114	0	117
1968	0	0	2	0	0	0	0	0	0	0	0	29	0	31
1969	0	0	0	0	0	3	0	0	0	0	0	24	0	27
1970	0	0	41	0	0	1	0	0	0	0	0	0	1	43
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	1	0	0	0	0	0	0	0	0	0	0	1
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5

Area: North Norway

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspecified catch	No. of shore stations	No. of boats
1868	30	–	–	–	–	–	–	–	1	1
1869	17	–	–	–	–	–	–	–	1	2
1870	36	–	–	–	–	–	–	–	1	2
1871	20	–	–	–	–	–	–	–	1	2
1872	40	–	–	–	–	–	–	–	1	2
1873	36	–	–	–	–	–	–	–	1	2
1874	–	–	–	–	–	–	–	51	1	2
1875	–	–	–	–	–	–	–	39	1	2
1876	42	3	–	–	–	–	–	–	2	3
1877	28	8	–	–	–	–	–	–	2	4
1878	76	40	–	–	–	–	–	–	2	4
1879	90	40	–	–	–	–	–	–	2	4
1880	113	50	–	–	–	–	–	–	2	4
1881	221	52	–	9	–	–	–	–	6	11
1882	101	250	–	–	–	–	–	–	7	15
1883	–	–	–	–	–	–	–	561	16	27
1884	–	–	–	–	–	–	–	465	18	31
1885	34	437	724	92	–	–	–	–	18	33
1886	114	609	61	88	–	–	–	–	19	34
1887	66	268	202	22	–	–	–	–	19	34
1888	68	346	144	69	–	–	–	–	19	32
1889	14	188	22	5	–	–	–	–	17	29
1890	22	368	213	24	–	–	–	–	16	28
1891	–	–	–	–	–	–	–	704	16	28
1892	–	–	–	–	–	–	–	1,014	15	27
1893	–	–	–	–	–	–	–	1,102	15	27
1894	–	–	–	–	–	–	–	959	15	28
1895	–	–	–	–	–	–	–	732	15	28
1896	58	733	106	174	–	–	–	–	15	27
1897	94	400	513	56	–	–	–	–	14	25
1898	24	448	547	53	–	–	–	–	14	25
1899	47	256	117	54	–	–	–	–	14	25
1900	12	263	39	68	–	–	–	–	14	25
1901	11	347	22	118	–	–	–	–	12	23
1902	58	457	33	155	–	–	–	–	10	18
1903	126	140	59	58	–	–	–	–	10	17
1904	235	161	24	39	–	–	–	–	9	15
1918	2	305	8	1	–	–	–	–	–	–
1919	–	194	6	3	–	–	–	–	–	–
1920	–	44	24	–	–	–	–	–	–	3
1948	–	41	1	–	–	36	–	–	1	3
1949	–	138	–	1	–	–	–	–	1	3
1950	–	90	–	7	–	54	–	–	1	3
1951	1	70	–	5	–	63	–	–	1	3
1952	1	83	–	2	–	31	–	–	1	3
1953	1	60	–	4	–	34	–	–	1	3
1954	–	58	–	6	–	73	–	–	1	3
1955	–	95	–	1	–	24	–	–	1	3
1956	–	63	–	–	–	38	–	–	1	3
1957	–	47	–	–	–	20	–	–	1	3
1958	–	70	–	–	–	81	–	–	1	3
1959	–	82	–	–	–	29	–	–	1	3
1960	–	51	–	–	–	60	–	–	1	3
1961	–	43	–	–	–	77	–	–	1	3
1962	–	76	–	–	–	57	–	–	1	3
1963	–	21	–	–	–	68	–	–	1	3
1964	–	32	–	–	–	42	–	–	1	3
1965	–	101	–	–	–	23	–	–	1	3
1966	–	54	1	–	–	36	–	–	1	3
1967	–	28	–	–	–	22	–	–	1	3
1968	–	68	–	–	–	1	–	–	1	3
1969	–	14	–	–	–	106	–	–	1	3
1970	–	44	–	–	–	51	–	–	1	2
1971	–	37	–	–	–	62	–	–	1	3

Table 6

Area: West Norway

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1912	–	–	–	–	–	–	–	30	1	1
1913	–	32	13	–	–	–	–	–	1	1
1918	3	605	154	1	–	–	–	–	6	18
1919	–	477	305	3	–	–	–	–	5	17
1920	1	150	173	–	–	–	–	–	3	8
1921	1	37	85	–	–	–	–	–	1	2
1922	–	117	99	–	–	–	–	–	2	6
1923	2	147	237	–	–	–	–	–	2	6
1924	8	272	131	–	–	–	–	–	2	6
1925	2	326	248	–	–	4	–	–	4	11
1926	–	376	188	3	1	2	6[1]	–	4	12
1927	1	359	121	–	–	1	–	–	4	12
1928	2	427	140	2	–	1	–	–	4	12
1929	2	148	121	–	–	3	–	–	4	12
1930	4	101	60	1	–	4	–	–	3	9
1931	2	69	52	–	–	5	–	–	2	6
1932	23	190	59	1	–	6	–	–	3	9
1933	7	197	22	1	–	9	–	–	2	6
1934	–	132	172	–	–	4	–	–	2	6
1935	1	106	108	–	–	4	–	–	3	10
1936	4	147	154	–	–	17	–	–	4	12
1937	9	223	55	–	–	20	–	–	4	12
1938	4	261	94	–	–	9	–	–	4	12
1939	4	282	46	1	–	14	1[1]	–	3	9
1941	–	6	149	–	–	–	–	–	–	26[2]
1942	–	58	48	–	–	–	–	–	–	56[2]
1943	–	111	45	–	–	–	–	–	–	86[3]
1944	–	112	31	–	–	–	–	–	–	72[3]
1945	–	135	28	–	–	–	–	–	–	80[3]
	3	158	27	–	–	4	–	–	1	3
1946	17	392	11	–	–	21	–	–	3	9
1947	11	285	12	–	–	16	–	–	3	9
1948	2	219	34	–	–	11	–	–	3	8
1949	4	204	6	–	–	20	1	–	3	9
1950	3	252	–	1	–	6	–	–	3	10
1951	3	251	11	–	–	13	–	–	3	9
1952	–	291	24	–	–	20	–	–	3	8
1953	6	215	48	–	–	10	2	–	3	8
1954	2	212	20	–	–	21	–	–	3	8
1955	1	115	10	–	–	20	–	–	2	5
1956	–	69	16	–	–	20	–	–	2	5
1957	–	92	1	–	–	10	–	–	1	3
1958	–	53	6	–	–	11	–	–	1	3
1959	–	98	4	–	–	2	–	–	1	3
1960	–	23	–	–	–	–	–	–	1	3
1961	–	119	6	–	–	11	–	–	1	3
1962	1	10	–	–	–	–	–	–	1	2
1963	–	21	–	–	–	39	–	–	1	3
1964	1	6	–	–	–	7	–	–	1	3
1965	–	5	–	–	–	4	–	–	1	1
1967	–	6	–	–	–	–	–	–	1	1
1968	–	8	–	–	–	–	–	–	1	1
1969	–	2	1	–	–	5	–	–	1	1

[1] Bottlenose

[2] 1941 – 1945, Fishing vessels equipped with harpoon guns and licensed for taking large whales.

[3] Fishing vessels equipped with harpoon guns and licensed for taking large whales.

Table 7

Area: Faroe Islands

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspecified catch	No. of shore stations	No. of boats
1894	–	–	–	–	–	–	–	46	–	1
1895	–	–	–	–	–	–	–	26	–	1
1896	–	–	–	–	–	–	–	62	–	1
1897	–	–	–	–	–	–	–	78	–	2
1898	–	–	–	–	–	–	–	118	–	3
1899	–	–	–	–	–	–	–	144	–	3
1900	–	–	–	–	–	–	–	197	–	3
1901	–	–	–	–	–	–	–	235	–	5
1902	–	–	–	–	–	–	–	309	–	7
1903	–	–	–	–	–	–	–	455	–	9
1904	–	–	–	–	–	–	–	414	–	9
1905	–	–	–	–	–	–	–	467	–	11
1906	–	–	–	–	–	–	–	394	–	13
1907	–	–	–	–	–	–	–	640	–	13
1908	–	–	–	–	–	–	–	614	–	17
1909	–	–	–	–	–	–	–	773	–	17
1910	–	202	103	7	3	6	–	64	6	14
1911	–	–	–	–	–	–	–	336	6	15
1912	–	–	–	–	–	–	–	175	5	12
1913	–	112	21	–	–	2	8[1]	–	2	5
1914	6	117	40	–	–	–	8[1]	–	3	9
1915	–	150	–	–	–	–	–	152	2	5
1916	3	77	6	–	–	1	–	103	2	6
1920	6	273	75	3	–	–	8[1]	–	4	12
1921	6	174	6	1	–	–	–	–	1	4
1922	2	155	16	1	1	1	–	–	1	4
1923	3	193	8	2	–	3	8[1]	–	2	7
1924	2	246	28	1	1	3	4[1]	–	2	7
1925	1	227	–	5	–	–	–	–	2	8
1926	1	156	9	3	–	2	–	–	2	6
1927	2	170	16	1	–	6	–	–	1	5
1928	3	276	9	3	–	4	–	–	2	7
1929	–	160	14	1	–	3	–	–	2	8
1930	3	231	10	3	–	11	–	–	2	8
1931	–	–	–	–	–	–	–	–	–	–
1932	–	–	–	–	–	–	–	–	–	–
1933	6	91	7	–	–	3	–	–	1	2
1934	2	74	13	–	–	7	–	–	1	2
1935	3	75	3	2	–	5	–	–	1	2
1936	2	82	1	–	–	9	–	–	2	5
1937	7	142	11	4	–	11	–	–	2	5
1938	2	184	6	1	–	7	–	–	2	6
1939	2	153	8	1	–	9	–	–	2	6
1946	5	94	1	1	–	14	–	–	2	3
1947	3	196	2	–	–	15	–	–	2	4
1948	3	223	15	–	–	30	–	–	2	5
1949	10	222	21	1	–	53	–	–	2	7
1950	6	377	2	1	–	46	–	–	2	6
1951	9	156	126	–	–	70	–	–	2	6
1952	–	20	2	–	–	1	–	–	1	2
1953	2	87	27	1	–	52	–	–	2	5
1954	–	17	3	–	–	11	–	–	1	2
1955	1	80	11	–	–	69	–	–	1	5
1956	–	43	3	3	–	97	–	–	1	5
1957	–	141	–	1	–	57	–	–	1	5
1958	–	16	1	–	–	40	–	–	1	4
1959	–	–	–	–	–	–	–	–	–	–
1960	–	–	–	–	–	–	22[2]	–	–	–
1962	–	6	–	–	–	7	–	–	1	1
1963	–	3	–	–	–	8	–	–	1	1
1964	–	13	–	1	–	5	–	–	1	1
1965	1	10	–	–	–	6	–	–	1	1
1966	–	4	–	–	–	1	19[2]	–	1	1
1967	–	–	–	–	–	–	21[2]	–	–	–
1968	–	6	–	–	–	6	32[2]	–	1	1
1969	–	–	–	–	–	–	–	–	–	–
1970	–	–	–	–	–	–	–	–	–	–
1971	–	–	–	–	–	–	3[2]	–	–	–

[1] Bottlenose

[2] Minke

Table 8

Area: Coast of Spain and Portugal

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of shore stations	No. of boats
1921	–	323	–	–	–	33	–	–	1	2
1922	–	571	–	–	–	29	–	–	1	2
1923	–	1,080	–	–	–	36	–	–	1	2
1924	–	1,218	–	–	–	149	–	–	1	10
1925	2	1,498	20	–	–	128	–	–	3	14
1926	–	1,374	45	–	–	61	–	–	3	14
1927	–	369	1	–	–	53	–	–	2	7

Table 9

Area: Portugal

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of shore stations	No. of boats
1944	–	38	–	–	–	20	–	–	1	–
1945	–	36	–	–	–	11	–	–	1	–
1946	–	42	–	–	–	31	–	–	1	–
1947	–	111	–	–	–	50	–	–	1	3
1948	–	106	–	–	–	35	–	–	1	3
1949	–	14	–	–	–	23	–	–	1	3
1950	–	34	–	–	–	10	–	–	1	3
1951	1	9	–	–	–	11	1[1]	–	1	3

[1] Minke

Table 10

Area: Spain

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of shore stations	No. of boats
1950	–	19	8	–	–	3	–	–	1	2
1951	–	27	34	–	–	35	–	–	1	2
1952	–	74	–	–	–	94	–	49	2	6
1953	–	18	12	–	–	38	–	29	2	5
1954	–	30	–	–	–	105	–	82	2	5
1955	–	36	–	–	–	158	–	98	2	6
1956	–	5	6	–	–	234	–	28	3	5
1957	–	–	–	–	–	241	–	60	3	5
1958	–	4	3	–	–	149	–	25	3	5
1959	–	–	–	–	–	182	–	55	3	5
1960	–	–	–	–	–	122	–	75	2	3
1961	–	–	–	–	–	98	–	94	2	3
1962	–	–	–	–	–	167	–	31	2	3
1963	–	–	–	–	–	113	–	13	2	3
1964	–	–	–	–	–	182	–	37	2	3
1965	–	–	–	–	–	164	–	116	2	3
1966	–	–	–	–	–	203	–	80	3	3?
1967	–	–	–	–	–	207	–	80	3	3?
1968	–	–	–	–	–	267	–	92	3	3
1969	–	–	–	–	–	193	–	122	3	3
1970	–	–	–	–	–	261	–	–	3	3
1971	–	–	–	–	–	273	–	–	3	?
1972	–	–	–	–	–	181	–	–	3	?
1973	–	–	–	–	–	178	–	–	1	?
1974	–	–	–	–	–	167	–	–	?	?

Table 11

Area: Azores

	Specified catch									
Year	Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspecified catch	No. of shore stations	No. of boats
1933	–	–	–	–	–	77	–	176	–	–
1934	–	–	–	–	–	82	–	158	–	–
1935	–	–	–	–	–	136	–	140	–	–
1936	–	–	–	–	–	172	–	308	–	–
1937	–	–	–	–	–	80	–	208	–	–
1938	–	–	–	–	–	417	–	388	–	–
1939	–	–	–	–	–	400	–	–	–	–
1942	–	–	–	–	–	525	–	–	–	–
1943	–	–	–	–	–	663	–	–	–	–
1944	–	–	–	–	–	591	–	–	–	–
1945	–	–	–	–	–	443	–	–	–	–
1946	–	–	–	–	–	592	–	–	–	–
1947	–	–	–	–	–	565	–	–	–	–
1948	–	–	–	–	–	698	–	–	–	–
1949	–	–	–	–	–	484	–	–	–	–
1950	–	–	–	–	–	390	–	–	–	–
1951	–	–	–	–	–	724	–	–	–	–
1952	–	–	–	–	–	618	–	–	–	–
1953	–	–	–	–	–	528	–	–	–	–
1954	–	–	–	–	–	683	–	–	–	–
1955	–	–	–	–	–	664	–	–	–	–
1956	–	–	–	–	–	536	–	–	–	–
1957	–	–	–	–	–	671	–	–	–	–
1958	–	–	–	–	–	527	–	–	–	–
1959	–	–	–	–	–	485	–	–	–	–
1960	–	–	–	–	–	438	–	–	–	–
1961	–	–	–	–	–	374	–	–	–	–
1962	–	–	–	–	–	412	–	–	–	–
1963	–	–	–	–	–	472	–	–	–	–
1964	–	–	–	–	–	478	–	–	–	–
1965	–	–	–	–	–	379	–	–	–	–
1966	–	–	–	–	–	297	–	–	–	–
1967	–	–	–	–	–	310	–	–	–	–
1968	–	–	–	–	–	71	–	–	–	–
1969	–	–	–	–	–	145	–	–	–	–
1970	–	–	–	–	–	205	–	–	–	–
1971	–	–	–	–	–	286	–	–	–	–
1972	–	–	–	–	–	327	–	–	–	–
1973	–	–	–	–	–	311	–	–	–	–
1974	–	–	–	–	–	146	–	–	–	–
1975	–	–	–	–	–	150	–	–	–	–

Table 12

Area: Madeira

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1941	–	–	–	–	–	76	–	–	–	–
1942	–	–	–	–	–	23	–	–	–	–
1943	–	–	–	–	–	133	–	–	–	–
1944	–	–	–	–	–	75	–	–	–	–
1945	–	–	–	–	–	91	–	–	–	–
1946	–	–	–	–	–	166	–	–	–	–
1947	–	–	–	–	–	109	–	–	–	–
1948	–	–	–	–	–	162	–	–	–	–
1949	–	–	–	–	–	135	–	–	–	–
1950	–	–	–	–	–	14	–	–	–	–
1951	–	–	–	–	–	182	–	–	–	–
1952	–	6	–	–	–	160	–	–	–	–
1953	–	2	–	–	–	107	–	–	–	–
1954	–	2	–	–	–	122	–	–	–	–
1955	–	–	–	–	–	175	–	–	–	–
1956	–	1	–	–	–	168	–	–	–	–
1957	–	2	–	1	–	168	–	–	–	–
1958	–	–	–	–	–	174	–	–	–	–
1959	–	–	–	–	1	86	–	–	–	–
1960	–	–	–	–	–	168	–	–	–	–
1961	–	–	–	4	–	129	–	–	–	–
1962	–	–	–	–	–	171	–	–	–	–
1963	–	–	–	–	–	186	–	–	–	–
1964	–	–	–	–	–	133	–	–	–	–
1965	–	–	–	–	–	151	–	–	–	–
1966	–	–	–	–	–	113	–	–	–	–
1967	–	–	–	–	–	85	–	–	–	–
1968	–	–	–	–	–	78	–	–	–	–
1969	–	–	–	–	–	83	–	–	–	–
1970	–	–	–	–	–	44	–	–	–	–
1971	–	–	–	–	–	67	–	–	–	–
1972	–	–	–	–	–	63	–	–	–	–
1973	–	–	–	–	–	77	–	–	–	–

Table 13

Area: Shetlands, Hebrides and Ireland

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1904	42	263	7	10	–	5	–	–	–	10
1905	37	450	34	6	–	5	–	–	–	11
1906	54	317	326	5	6	1	–	–	–	12
1907	12	396	151	5	24	10	–	–	–	13
1908	17	379	232	2	20	1	–	–	–	13
1909	33	432	223	12	21	7	–	–	–	13
1910	21	381	190	11	9	6	1[1]	115		16
1911	5	344	130	4	–	18	2[1]	131	7	16
1912	12	292	108	–	11	8	8[1]	59	7	16
1913	12	346	159	3	1	21	7[1]	–	7	17
1914	19	322	248	2	5	–	–	89	6	15
1920	65	407	262	1	2	–	–	–	4	11
1922	29	282	44	–	–	–	–	–	2	6
1923	23	312	10	–	2	–	–	–	2	7
1924	59	501	57	1	–	–	–	–	2	7
1925	37	315	18	–	–	–	–	–	2	7
1926	36	400	21	–	–	–	–	–	2	7
1927	3	261	33	–	–	–	–	–	2	7
1928	8	139	28	–	–	–	–	–	2	7
1929	4	73	4	2	–	–	–	–	1	4
1950	2	33	–	–	–	–	–	–	1	1
1951	4	13	3	–	–	1	–	–	1	1

[1] Bottlenose.

Table 14

Area: Newfoundland and St Lawrence Gulf

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1910	–	–	–	–	–	–	–	384	–	5
1911	–	–	–	–	–	–	–	390	–	6
1912	60	202	–	22	–	5	–	85	–	12
1913	12	165	1	8	–	9	–	117	–	10
1914	5	142	–	13	–	1	–	90	–	9
1915	28	171	–	5	–	19	–	78	–	5
1918	–	–	–	–	–	–	–	101	–	2
1919	–	–	–	–	–	–	–	?	–	?
1923	–	66	–	3	–	1	–	–	–	2
1924	12	144	–	16	–	8	–	–	–	2
1925	12	270	4	35	–	10	–	–	–	3
1926	10	329	3	18	–	–	–	–	–	3
1927	15	243	9	88	–	8	–	–	–	5
1928	58	358	23	21	–	48	–	–	–	7
1929	23	334	3	11	–	11	–	–	–	3
1930	23	282	1	7	–	8	–	–	–	5
1935	4	156	13	9	–	16	–	–	–	3
1936	20	146	2	10	–	14	–	–	–	3
1937	8	439	7	9	1	19	–	–	–	5
1938	–	–	–	–	–	–	–	–	–	–
1939	7	118	2	4	–	13	–	–	–	2

Area: Newfoundland

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1940	1	64	–	7	–	6	–	–	1	1
1941	2	65	2	3	–	–	–	–	1	1
1942	4	62	4	1	–	–	–	–	1	1
1943	1	141	–	6	–	4	–	–	2	2
1944	5	231	1	10	–	17	–	–	2	4
1945	11	346	5	9	–	22	–	–	2	6
1946	11	502	–	5	–	11	–	–	2	6
1947	14	413	4	6	–	18	–	–	2	7
1948	57	669	4	15	–	14	–	–	3	9
1949	30	425	23	11	–	53	–	–	2	6
1950	15	409	16	16	–	29	–	–	2	7
1951	24	483	39	29	–	12	–	–	2	8
1952	–	1	–	1	–	–	–	–	–	–
1953	–	1	–	–	–	–	–	–	–	–
1954	–	–	–	–	–	–	–	–	–	–
1955	–	2	–	–	–	–	–	–	–	–
1956	–	7	2	–	–	13	–	–	1	1

Area: Newfoundland and Labrador

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1957	–	23	5	–	–	14	–	–	1	1
1958	–	55	–	4	–	7	–	–	1	1
1959	–	14	5	–	–	1	18[1]	–	1	1
1960	–	1	–	–	–	1	11[1]	–	–	–
1961	–	–	1	–	–	–	22[1]	–	–	–
1962	–	–	–	–	–	–	45[1]	–	–	–
1963	–	–	–	–	–	1	18[1]	–	–	–
1964	–	1	1	–	–	–	–	–	–	–
1965	–	6	2	1	–	–	29[1]	–	–	–
1966	–	164	–	–	–	2	28[1]	–	1	1
1967	–	436	7	–	–	–	25[1]	–	2	2
1968	–	438	4	–	–	–	–	–	2	3
1969	–	376	3	5	–	5	50[1]	–	2	3
1970	–	406	1	14	–	2	86[1]	–	–	–
1971	–	301	–	16	–	–	73[1]	–	–	–
1972	–	265	–	–	–	2	97[1]	–	–	–

[1] Minke

Table 15

Area: Nova Scotia

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1962	–	–	–	–	–	–	5[1]	–	–	–
1963	–	–	–	–	–	–	–	–	–	–
1964	–	56	–	–	–	4	–	–	1	2
1965	–	135	–	–	–	–	12[1]	–	2	4
1966	1	263	8	–	–	–	–	–	1	3
1967	–	309	55	–	–	2	15[1]	–	1	3
1968	–	262	100	–	–	–	–	–	1	3
1969	–	157	149	–	–	–	–	–	1	2
1970	–	170	93	1	–	25	–	–	1	2
1971	–	117	235	4	–	37	–	–	1	1
1972	–	95	183	–	–	41	–	–	1	1

[1] Minke

Table 16

Area: Svalbard

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1903	42	7	–	8	–	–	–	–	–	2
1904	134	48	–	15	–	–	–	–	–	3
1905	337	253	–	9	–	–	–	–	–	16
1906	127	63	–	5	–	–	–	120	–	14
1907	134	87	–	–	–	–	–	112	–	15
1908	86	36	–	–	–	–	–	76	–	9
1909	50	32	–	–	–	–	–	32	–	6
1910	20	70	6	3	–	–	4[1]	63	1	6
1911	43	100	–	–	–	–	1[2]	–	1	6
1912	–	–	–	–	–	–	–	58	1	6
1920	5	13	–	–	–	–	–	–	1	2
1926	–	24	–	2	–	–	–	–	–	1
1927	7	44	–	–	–	–	–	–	–	2

[1] Bottlenose

[2] Bowhead

Table 17

Area: Murman Coast

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1883	–	–	–	–	–	–	–	?	–	1
1884	–	–	–	–	–	–	–	?	–	2
1885	26	38	47	4	–	–	–	–	–	5
1886	35	41	–	13	–	–	–	–	–	4
1887	24	52	4	8	–	–	–	–	–	4
1889	–	–	–	–	–	–	–	20	–	4

Table 18

Area: Davis Strait and West Greenland

Year	Specified catch Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of shore stations	No. of boats
1922	14	14	–	140	–	–	–	–	–	3
1923	20	20	–	150	–	–	–	–	–	3
1924	48	75	2	37	–	2	–	–	–	4
1931	–	16	–	4	–	–	–	–	–	1
1932	1	25	–	4	–	–	–	–	–	1
1933	3	17	–	1	–	–	–	–	–	1
1934	2	23	–	2	–	–	–	–	–	1
1935	–	23	–	6	–	–	–	–	–	?
1936	–	15	–	5	–	–	–	–	–	?
1937	4	9	–	4	–	–	–	–	–	1
1938	–	7	–	1	–	–	–	–	–	1
1939	–	3	–	2	–	–	–	–	–	1
1946	3	47	–	4	–	6	–	–	–	1
1947	4	51	2	5	–	6	–	–	–	1
1948	2	21	1	1	–	6	–	–	–	1
1949	2	21	–	2	–	3	–	–	–	1
1950	–	35	–	4	–	5	2[1]	–	–	1

[1] Bottlenose

Table 19

Area: Pelagic Whaling in the North Atlantic

Year	Specified catch Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of floating factories	No. of boats
1929	29	192	–	3	–	1	–	–	–	4
1930	60	580	1	53	–	1	–	–	–	11
1931	52	456	8	39	–	–	–	–	2	7
1932	38	443	24	9	–	–	4[1]	–	2	7
1933	43	549	–	7	–	41	–	–	3	10
1934	21	128	–	3	–	–	–	–	1	4
1937	28	461	100	7	–	218	–	–	2	11

[1] Bowhead

Table 20

Area: Iceland

(Source IWS, Risting (1922), Tønnessen (1967), Ingebrigtsen (1929))

Year	Specified catch Blue	Fin	Sei	Hump-back	Right	Sperm	Others	Unspeci-fied catch	No. of shore stations	No. of boats
1883	8	–	–	–	–	–	–	0	–	1
1884	–	–	–	–	–	–	–	25	–	1
1885	–	–	–	–	–	–	–	32	–	1
1886	–	–	–	–	–	–	–	25	–	1
1887	–	–	–	–	–	–	–	48	–	2
1888	–	–	–	–	–	–	–	82	–	2
1889	–	–	–	–	–	–	–	128	–	4
1890	79	23	–	1	–	–	–	96	–	7
1891	67	43	–	1	10	–	–	84	–	8
1892	122	47	–	1	–	–	–	132	–	11
1893	116	113	3	2	–	3	–	258	–	13
1894	196	79	2	8	–	2	–	236	–	15
1895	309	112	4	8	–	4	–	331	–	16
1896	327	45	1	6	–	1	–	412	–	18
1897	190	36	2	6	–	2	–	560	–	21
1898	216	57	3	66	–	6	–	302	–	21
1899	247	82	2	40	–	6	–	491	–	23
1900	234	95	20	26	–	1	–	447	–	23
1901	38	13	–	12	–	6	–	1,123	–	27
1902	21	18	–	14	–	3	–	1,249	–	30
1903	16	21	–	7	–	6	–	1,207	–	30
1904	19	40	–	7	2	4	–	911	–	27

Continued

Table 20 – *continued*
Area: Iceland

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1905	–	–	–	–	–	–	–	1,041	–	25
1906	–	–	–	–	–	–	–	650	–	25
1907	–	–	–	–	–	–	–	843	–	25
1908	–	–	–	–	–	–	–	761	–	29
1909	–	–	–	–	–	–	–	947	–	30
1910	–	–	–	–	–	–	–	649	–	32
1911	20	193	4	1	–	1	–	209	–	22
1912	–	–	–	–	–	–	–	152	–	20
1913	23	84	9	5	1	1	2[1]	0	–	13
1914	15	20	–	–	–	–	–	0	–	3
1915	9	45	–	–	–	–	–	0	–	4
1935	2	25	1	0	–	0	–	–	1	2
1936	5	72	1	0	–	7	–	–	1	2
1937	1	56	0	1	–	21	–	–	1	2
1938	9	113	5	0	–	20	–	–	1	3
1939	13	109	3	1	–	4	–	–	1	3
1948	24	195	5	0	–	15	–	–	1	4
1949	33	249	12	2	–	28	–	–	1	4
1950	28	226	0	0	–	11	–	–	1	4
1951	11	312	2	1	–	13	–	–	1	4
1952	14	224	25	0	–	2	–	–	1	4
1953	5	207	70	2	–	48	–	–	1	4
1954	9	177	93	–	–	54	–	–	1	4
1955	10	236	134	–	–	20	–	–	1	4
1956	8	265	72	–	–	95	–	–	1	4
1957	10	348	78	–	–	81	–	–	1	4
1958	5	289	91	–	–	123	–	–	1	4
1959	6	178	67	–	–	120	–	–	1	4
1960	–	160	42	–	–	177	–	–	1	4
1961	–	142	58	–	–	150	–	–	1	4
1962	–	303	44	–	–	136	–	–	1	4
1963	–	283	20	–	–	136	–	–	1	4
1964	–	217	89	–	–	138	–	–	1	4
1965	–	288	74	–	–	70	–	–	1	4
1966	–	310	41	–	–	86	–	–	1	4
1967	–	239	48	–	–	119	–	–	1	4
1968	–	202	3	–	–	75	–	–	1	4
1969	–	251	69	–	–	103	–	–	1	4
1970	–	272	44	–	–	61	–	–	1	4
1971	–	208	240	–	–	106	–	–	1	4
1972	–	238	132	–	–	76	35[2]	–	1	4
1973	–	267	139	–	–	47	122[2]	–	1	4
1974	–	285	9	–	–	71	90[2]	–	1	4
1975	–	245	138	–	–	37	181[2]	–	1	4

[1] Bottlenose.
[2] Minke.

Note: In the seasons 1900 – 1913 whaling took place off East Iceland. The catches in this area are not separable from the catches off West Iceland, which may have been from different stocks.

Table 21
Area: Greenland

Year	Specified catch							Unspecified catch	No. of shore stations	No. of boats
	Blue	Fin	Sei	Humpback	Right	Sperm	Others			
1959	–	–	–	–	–	–	19[1]	–	–	–
1960	–	–	–	–	–	–	21[1]	–	–	–
1961	–	–	–	–	–	–	26[1]	–	–	–
1962	–	–	–	–	–	–	58[1]	–	–	–
1969	–	–	–	3	–	–	263[1]	–	–	–
1970	–	–	1	–	–	–	197[1]	–	–	–
1971	–	–	1	4	–	–	186[1]	–	–	–
1972	–	1	–	3	–	1	145[1]	–	–	–
1973	–	2	–	9	–	–	268[1]	1	–	–
1974	–	4	–	9	–	–	204[1]	–	–	–
1975	–	1	3	9	–	–	171[1]	–	–	–

[1] Minke

Notes on Age Data of Fin Whales Taken off Iceland, 1967–74

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MATERIAL USED FOR AGE DETERMINATION

Ear plug collections were made during the seasons 1967, 1969, 1972, 1973 and 1974. Collections were also made in 1975, but the material is not yet available for analysis. The numbers of plugs taken, which include pairs from some animals, are shown in Table 1. These plugs were cut down along the longitudinal axis to the mid-line as in usual practice, for examination of the layering structure of the core. All seasons' collections of plugs were examined at least on two occasions by three persons each time. The extent of agreement of layer counts is shown in Table 1. The overall agreement was never good, indicating much difficulty in counting the layers. In Fig. 1, all seasons have been combined, and the percentage agreement according to body length of the whale has been plotted out for males and females separately. It appears that for both sexes, readability of the plug tends to fall off with the largest sizes of animals. This is mainly because the layering structures in the plugs of very old animals become too compressed at the core base for exact counting. The male sample includes more smaller sized whales than the female one, and there is an indication that here too difficulties are present in counting the layers. Between body lengths 55–65 ft the agreement on counts is generally over 60%, although the females fall below 60% at the end of this size range. The implications are that there is some biass introduced into analyses using age data, especially where young animals are involved, because here a difference of even one layer from the true count can affect results where exact age is critical. One can reckon that of any collection at Iceland of ear plugs, roughly 40–50% will not always give usable data. A chi-square test on the agreement and non-agreement of counts for males and females indicates that comparing the total samples from all seasons, $\chi^2 = 2.8232$ with one degree of freedom, which means that the readability of plugs from both males and females is not significantly different.

During 1973, a small collection of 9 pairs of baleen plates were collected from fin whales under 60 ft in body length. These were in addition to the ear plugs collected. Dr Jonsgård kindly made surface ridge traces of these plates for us, and interpreted the age readings. In Table 2 the ear plug age (where agreed) is compared with the baleen age group. In addition, the total numbers of minor laminae seen in the plugs are also given. The correlation is not exact between the two methods of age determination. However, the two methods show clearly that these whales are very young. The total number of minor laminae counted indicate that considerable scope for confusion on actual age as determined from ear plugs is present. The possibility of using baleen plates as well as or instead of ear plugs for age determination could perhaps be explored in order to reduce the comparatively low agreements on age for these small animals.

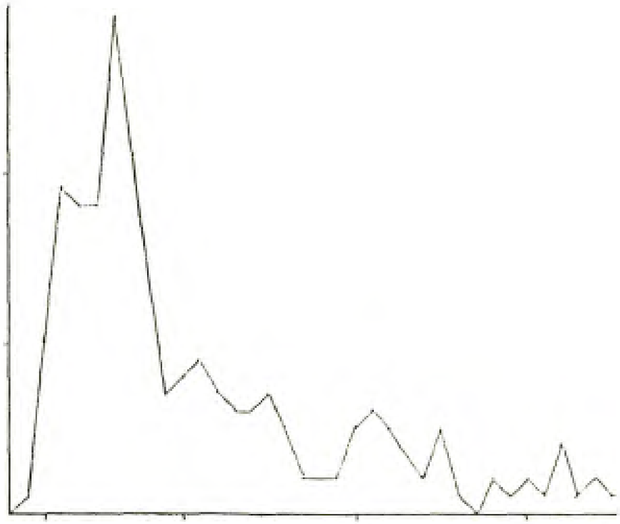
Table 1

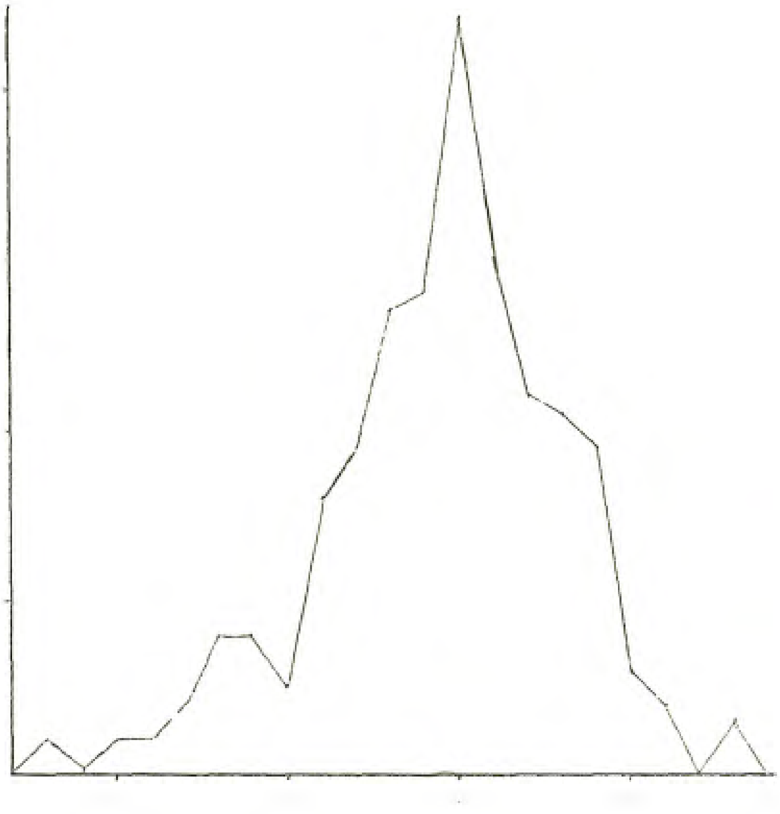
Numbers of ear plugs collected each season at Iceland, and the percentage of agreement on age readings from the plugs.

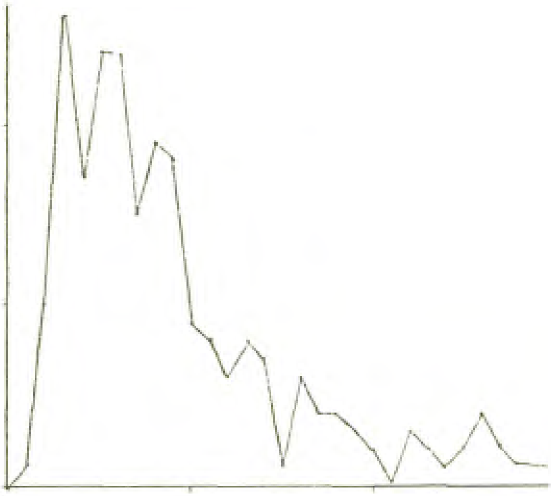
	Seasons					
	1967	1969	1972	1973	1974	Total
Males Number of plugs collected (pairs treated as two plugs)	50	59	126	134	117	486
Agreed layer counts	39	34	86	67	73	299
% agreement	78	58	68	50	62	62
Females Number of plugs collected (pairs treated as two plugs)	50	78	119	129	127	503
Agreed layer counts	30	50	65	64	74	283
% agreement	60	64	55	50	58	56

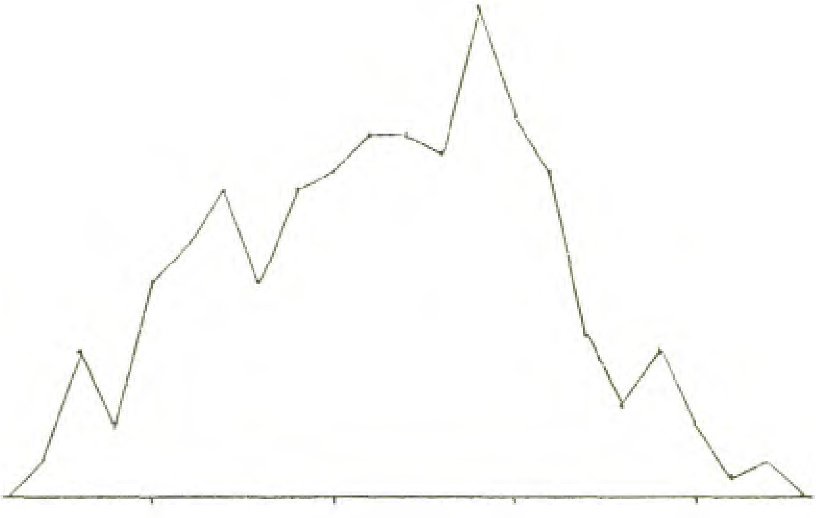
AGE DATA FROM EAR PLUG LAYER COUNTS AND INFORMATION ON SEXUAL MATURITY

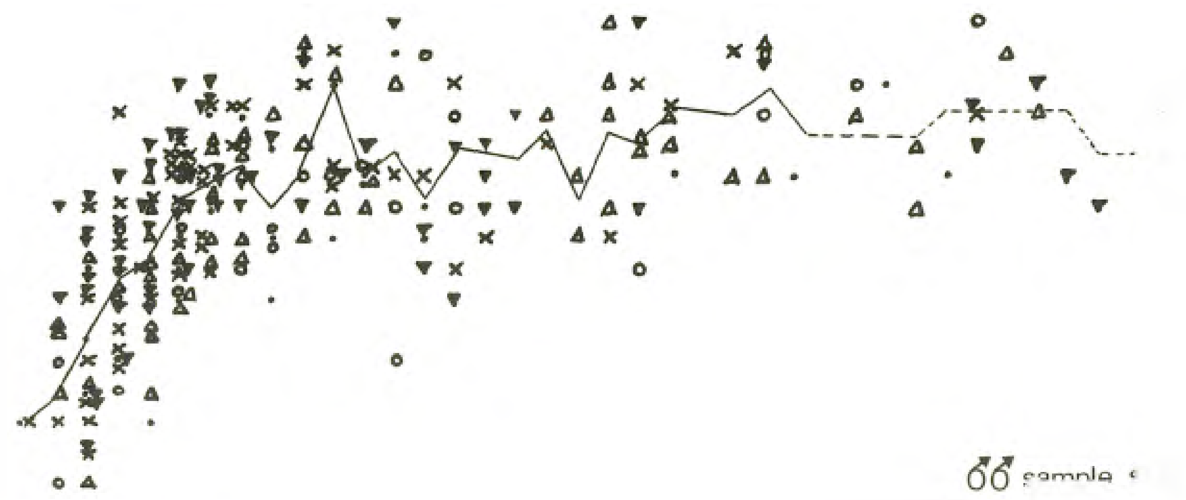
Age/length keys for fin whales taken off Iceland are given in Appendix Table 1. The seasons are given separately, and males are separate from females. Distribution of numbers at each age, and also at each length, for all the seasons' catches are given for males and females separately in Figs. 2 and 3. The modes of the age frequency distributions are 6 and 3 ear plug growth layers for males and females respectively.







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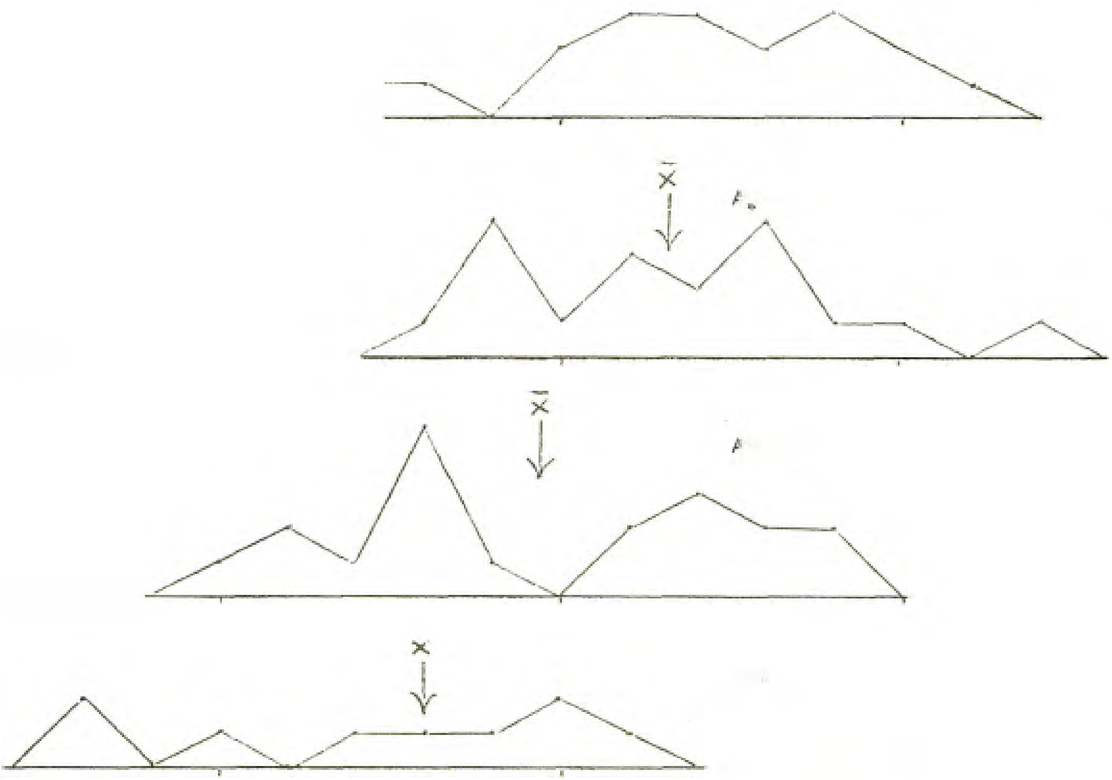

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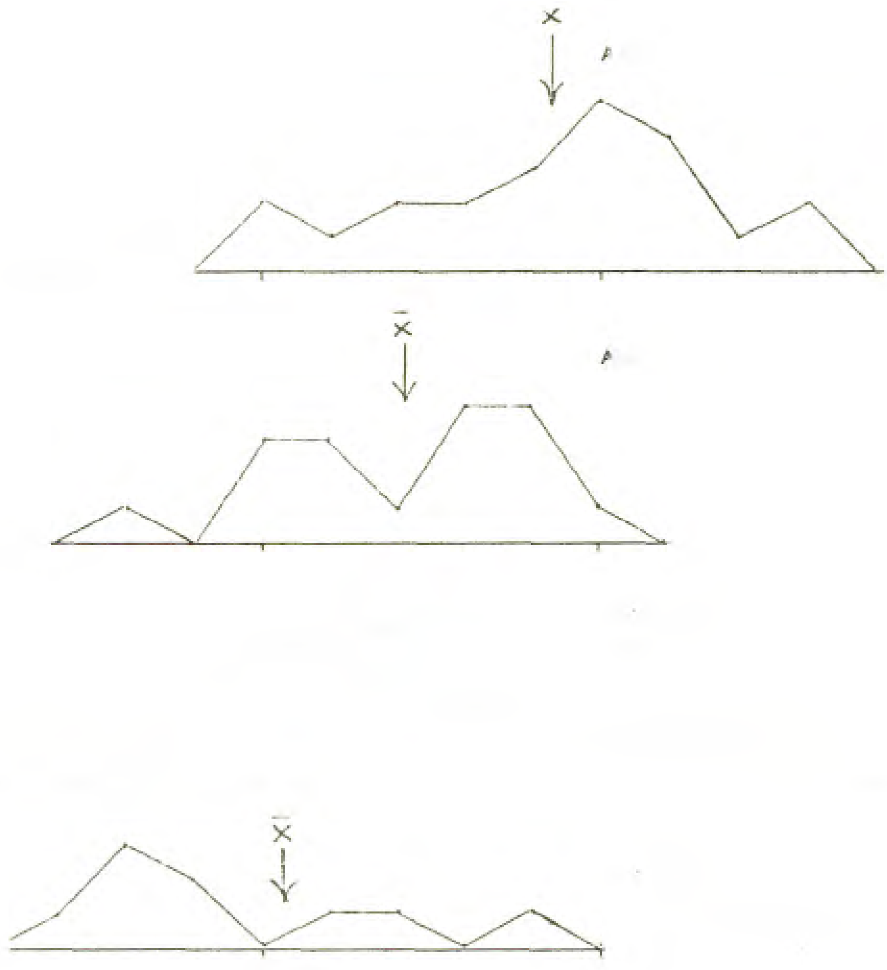


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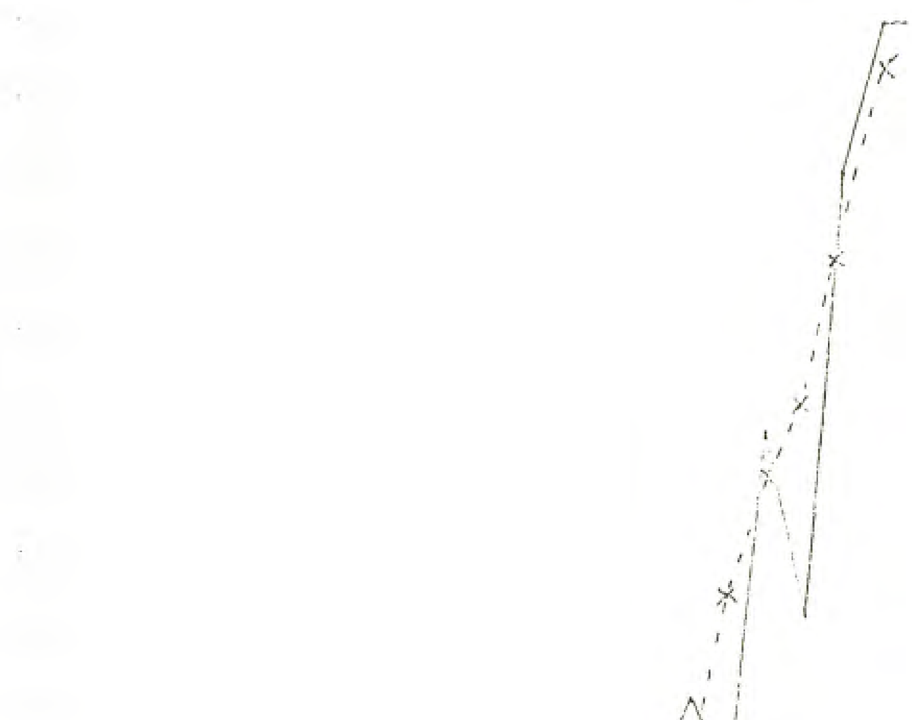

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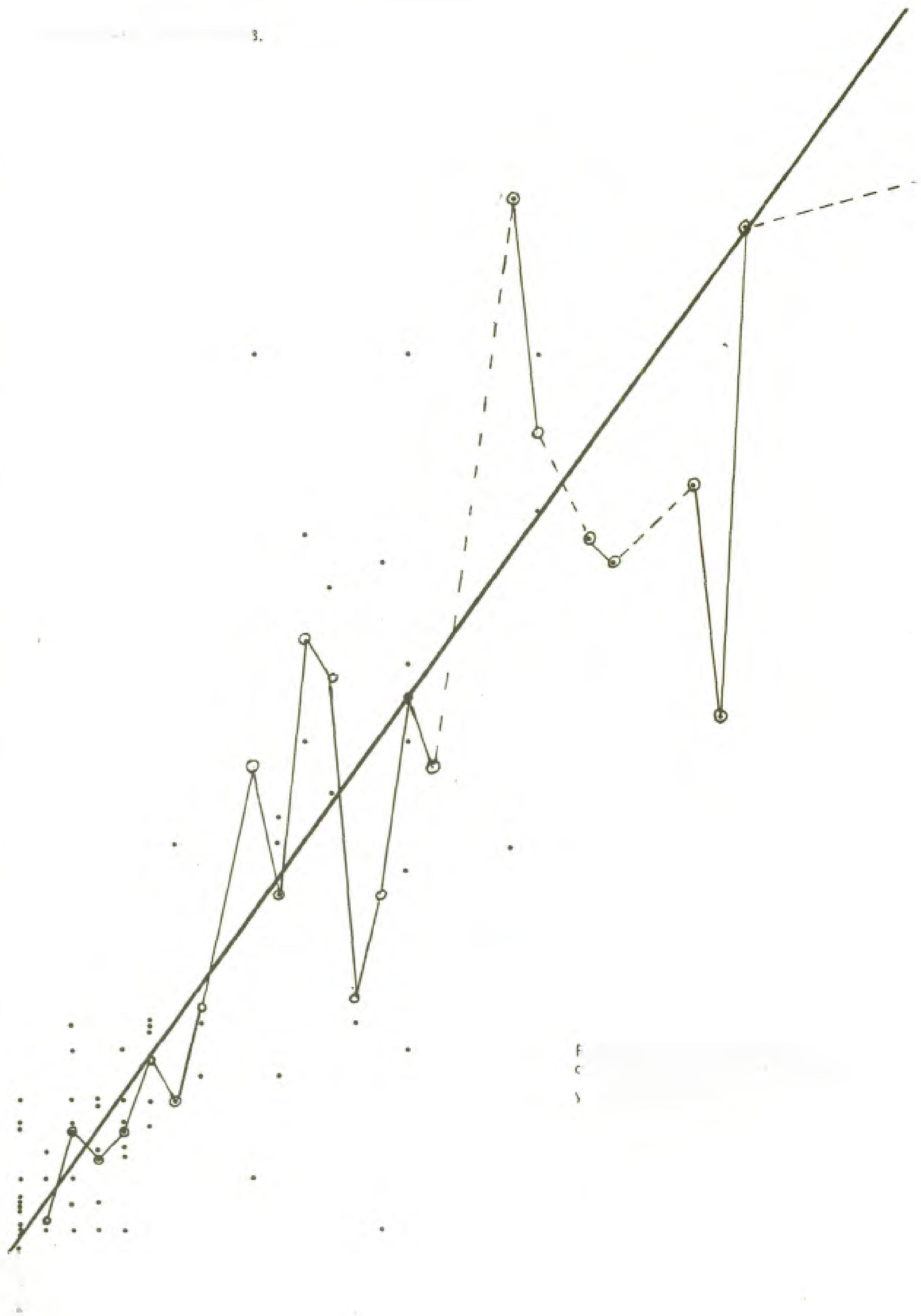


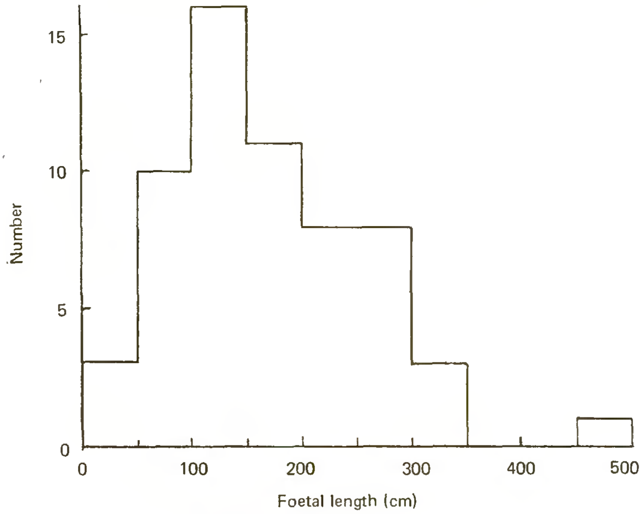


Fig. 11. Foetal size frequency distribution.

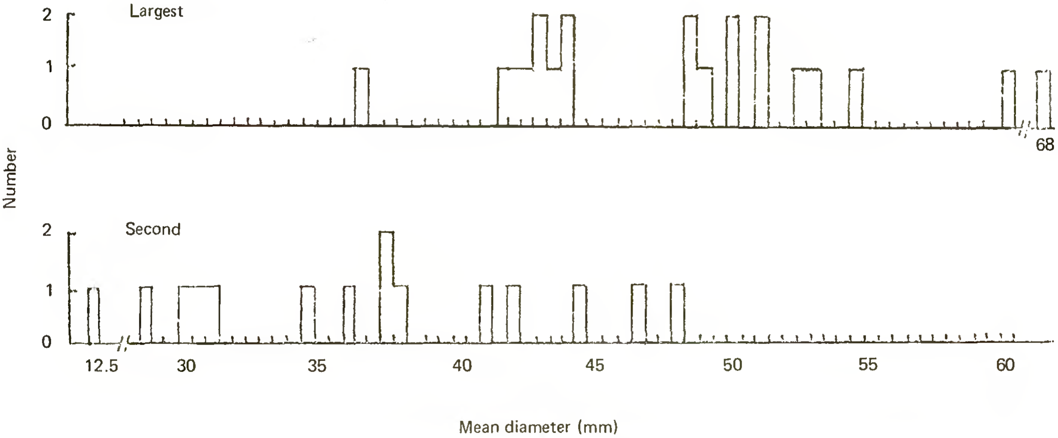


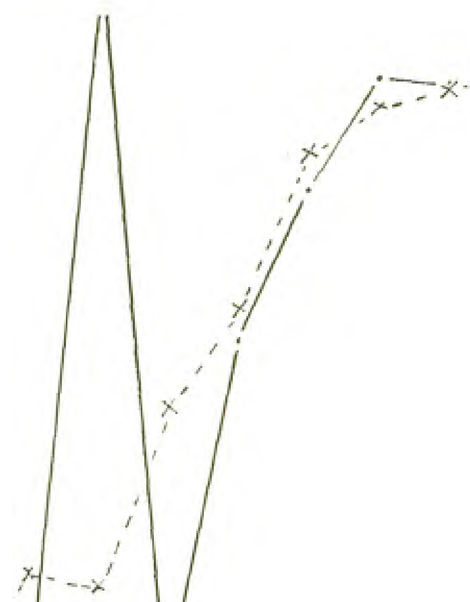
Fig. 12. Size frequency distributions of the first and second largest corpora albicantia in 'resting' fin whales.

were present in the ovaries of the non-pregnant whales which might point to any further ovulations at this time. The conception success is 1/3 = 33%, neglecting the two whales caught at ovulation and whose potential future cannot be known.

(d) Main winter oestrus

The whales which ovulate at the main winter oestrus are represented in the Icelandic samples by pregnant females and the 'resting' animals discussed above, depending on whether conception took place or not.

The size frequency distributions of the three largest corpora albicantia in the pregnant females are shown in Fig. 13. It is clear that there are a number of exceptionally large corpora represented in the two largest categories. These are taken as evidence of unfertilized ovulations during the oestrous cycle which gave rise to the current pregnancy. The corpus luteum of pregnancy was shown to regress to a corpus albicans of no more than 60 mm mean diameter during a similar period in the lactating whales. The mean diameter of the corpus luteum of ovulation is smaller than that of pregnancy in southern fin whales (Laws, 1961). In the Iceland samples, two corpora lutea of ovulation measured 71 and 95 mm in mean diameter, while the average diameter of 62 corpora lutea of pregnancy was 107 mm. A corpus albicans from an unfertilized winter ovulation might be expected to regress to a little less than 60 mm by the following summer.



There is some sign of a prolongation in the frequency distribution of the first largest corpus albicans in the pregnant females above 55 mm (Fig. 13). There are 8 whales with a largest corpus greater than this size, and 1 whale has a second largest corpus of comparable size, indicating a second unfertilized ovulation at the preceeding oestrus. Thus, the 63 pregnant females sampled experienced 63 + 8 + 1 = 72 ovulations at this oestrous period, or an average of 72/63 = 1.14 per whale.

Calculation of ovulation rate .

Starting from the assumption that all the mature females ovulate and conceive at the main winter oestrus, the average annual ovulation rate of fin whales off Iceland can be calculated as shown in Table 3.

After pregnancy and the succeeding lactation period, which is presumed to last for approximately six months as in the southern hemisphere fin whales (Laws, 1961), 21% of the females ovulate at a summer oestrous period. There is evidence of only a single cycle at this time, and 33% of the whales conceive.

The remaining whales, that is, the 79% which did not experience a summer oestrus and the unfertilized 67% of those which did, ovulate on average 1.14 times at the main winter oestrous period. The total number of ovulations in the two year breeding cycle is therefore 1.27, equivalent to an average rate of 0.64 ovulations per annum.

This should be regarded as a minimum estimate, as winter samples from the same population of fin whales might give evidence of additional ovulations which cannot be detected by the summer material alone.

Table 3

Calculation of ovulation frequency in Icelandic fin whales.

Oestrous period	Proportion of population not pregnant (A)	Proportion of A ovulating (B)	Proportion of B conceiving (C)	Proportion of population conceiving (A x B x C)	Frequency of ovulation (D)	Net ovulation rate (A x B x D)
Summer	1.00	0.21	0.33	0.07	1.00	0.21
Winter	0.93	1.00	1.00	0.93	1.14	1.06
Total	–	–	–	–	–	1.27

5. Comments related to a comparison of calculated ovulation rates

The result using follicular and corpora dimensions indicates an ovulation rate of one corpus every 1.27 years. The result dependent upon age-related ear plug layer counts is one corpus every 1.39 growth layers.

The two results are now compared in order to test whether they are numerically significantly different. The variances, $S^2_x{}^2$, $S^2_y{}^2$, S^2_{xy}, have been calculated for the ear plug with ovary sample, according to the method of Bartlett (1949): these are 21.17, 24.06 and 43.54, respectively.

In order to test whether the age-independent estimate of ovulation rate, one corpus per 1.27 years falls within the confidence limits of one corpus per 1.39 growth layers, a calculation of Student's 't' was made. The value of 't' was 1.49, with 58 degrees of freedom. This falls well within the 90% probability range, so that it can be assumed that 1.27 and 1.39 are only different because of small sample size.

In conclusion it can be estimated that ovulation occurs at least every 1½ years, probably less. Also, the age-independent estimate of ovulation rate suggests that ear plug growth layers form annually.

6. Age and body length at sexual maturity in males

Small collections of testes have been made during 1967, 1969, 1973 and 1975 seasons at Iceland. The testes taken in 1967 and 1969 have been sampled and sectioned at 10μ thickness, stained in Ehrlich's haemotoxylin and eosin stains, and the mean testis tubule diameter measured in order to ascertain maturity. Results are summarised in Figs. 14 and 15.

In Fig. 14, the mean body length at 50% level of maturation is about 55 ft. In Fig. 15, the mean age at 50% level of maturity is between 3 and 6 growth layers. The age is clearly quite low, but the data are so scanty that it would probably be safer to assume a similar age of maturity for males as females (that is 7 years), and certainly not less without further evidence. The mean body length at maturity estimated here is also likely to be too low, and probably a length somewhere between 55 ft and 59 ft would be more reasonable with reference to Fig. 4. These results for males should therefore only be regarded as preliminary.

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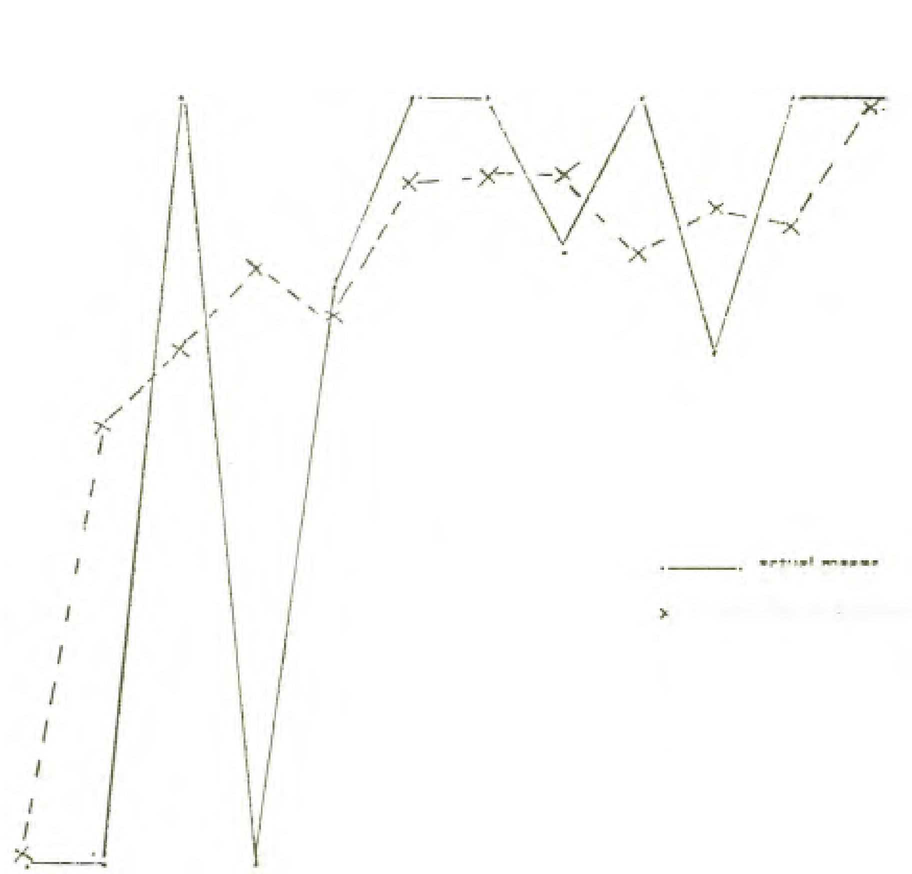
actual means

APPENDIX TABLE 1

SPECIES: FIN SEX: ♀ YEAR: 1967 EXPEDITION: ICELAND LAND STATIONS METHOD: EAR PLUGS

AGE IN GROWTH LAYERS

Body Length (feet)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50				Total
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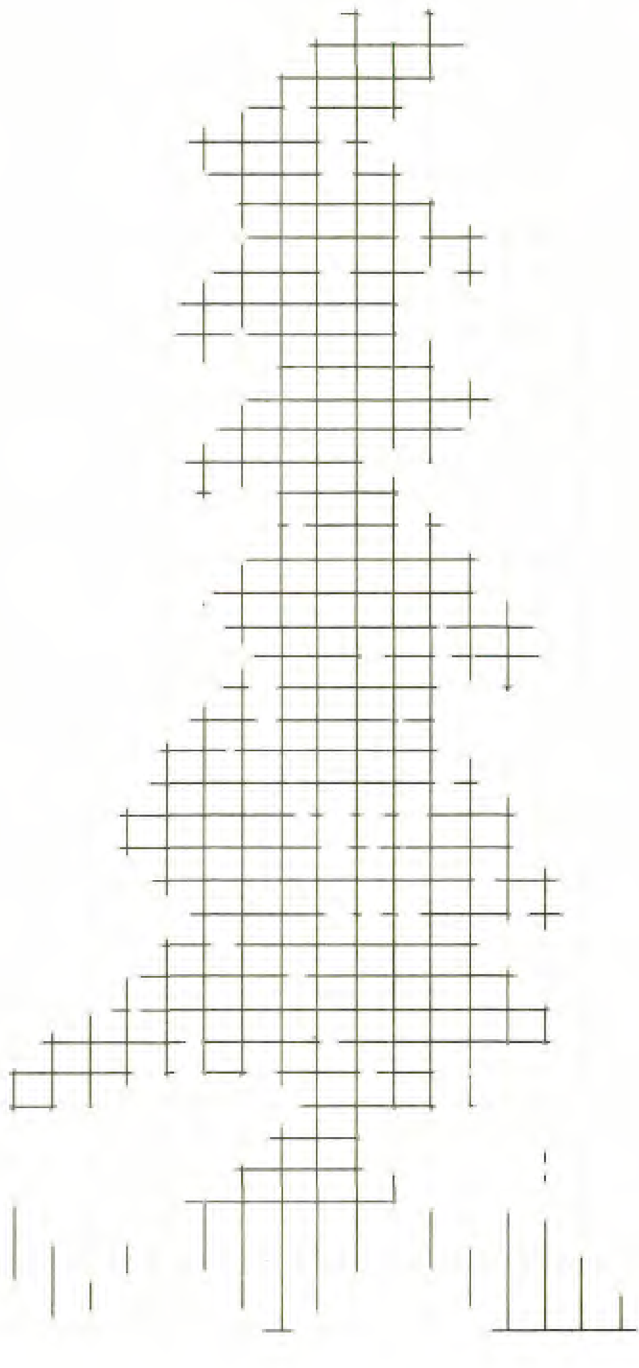

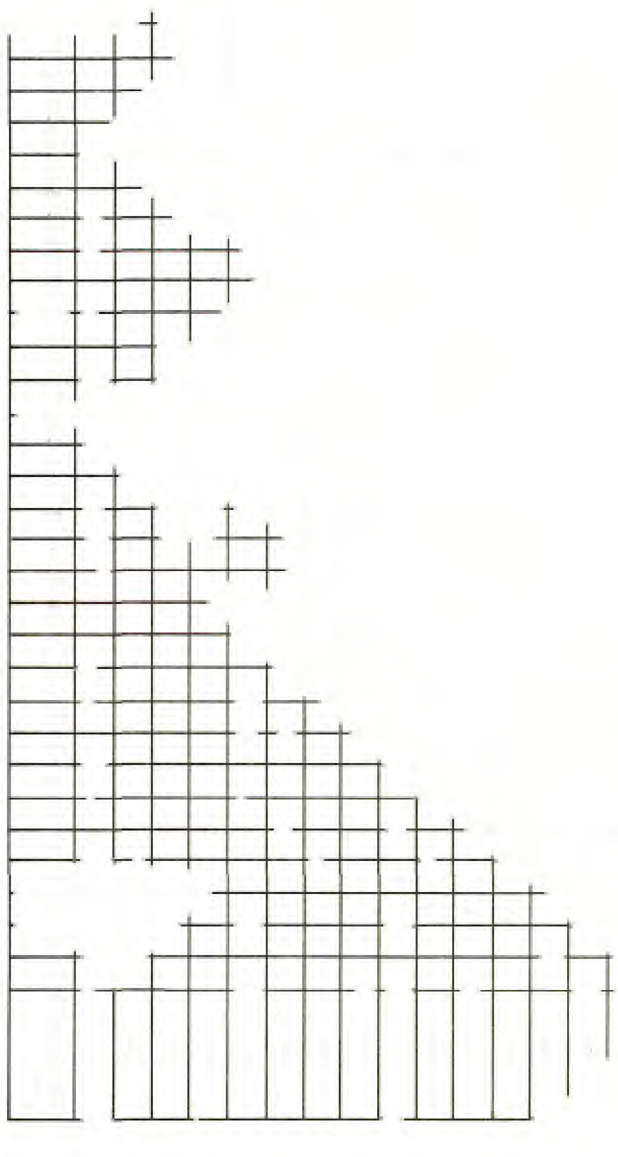

APPENDIX TABLE I

SPECIES: FIN SEX: ♀ YEAR: 1973 EXPEDITION: ICELAND LAND STATION METHOD: EAR PLUGS

AGE IN GROWTH LAYERS

Body Length (feet)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	65		Total
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58				2	1																																																	3
59			1	1		1	2				1																																											6
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61					1		1							1																																								3
62		1	1					1																																														3
63					1			1				2		1									1																															6
64						1				2		1				1											1													1						1								8
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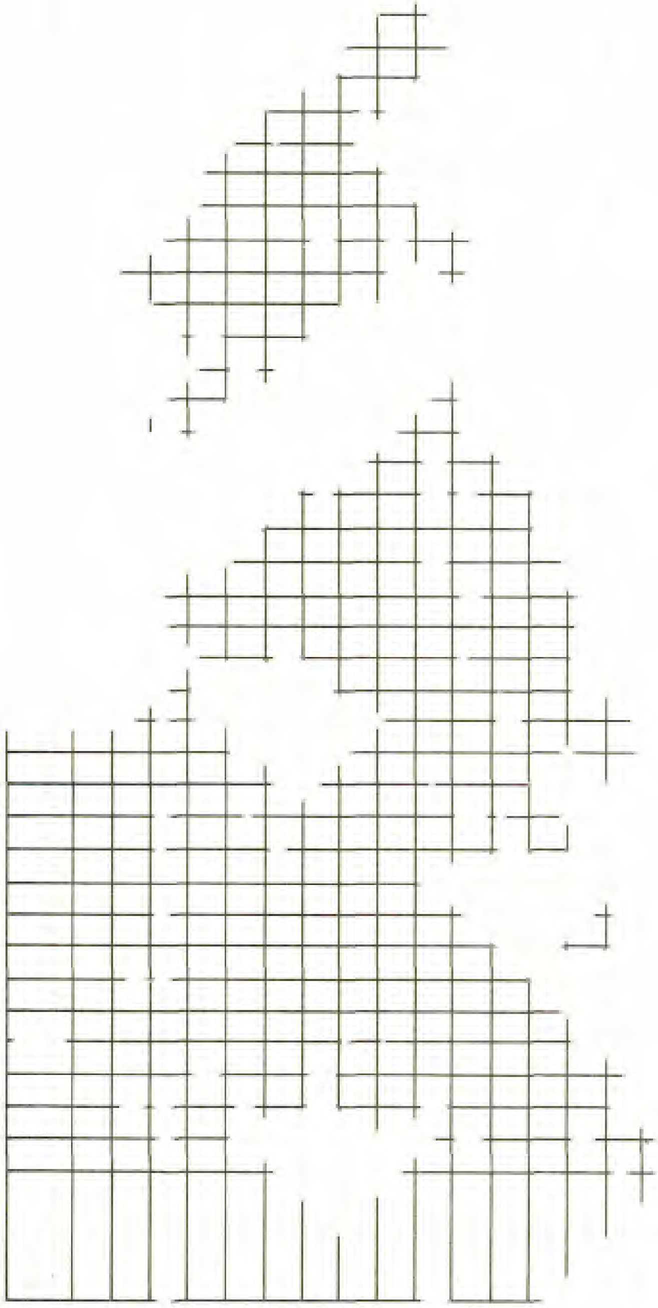
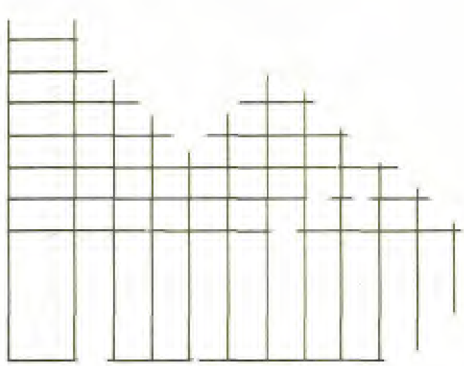
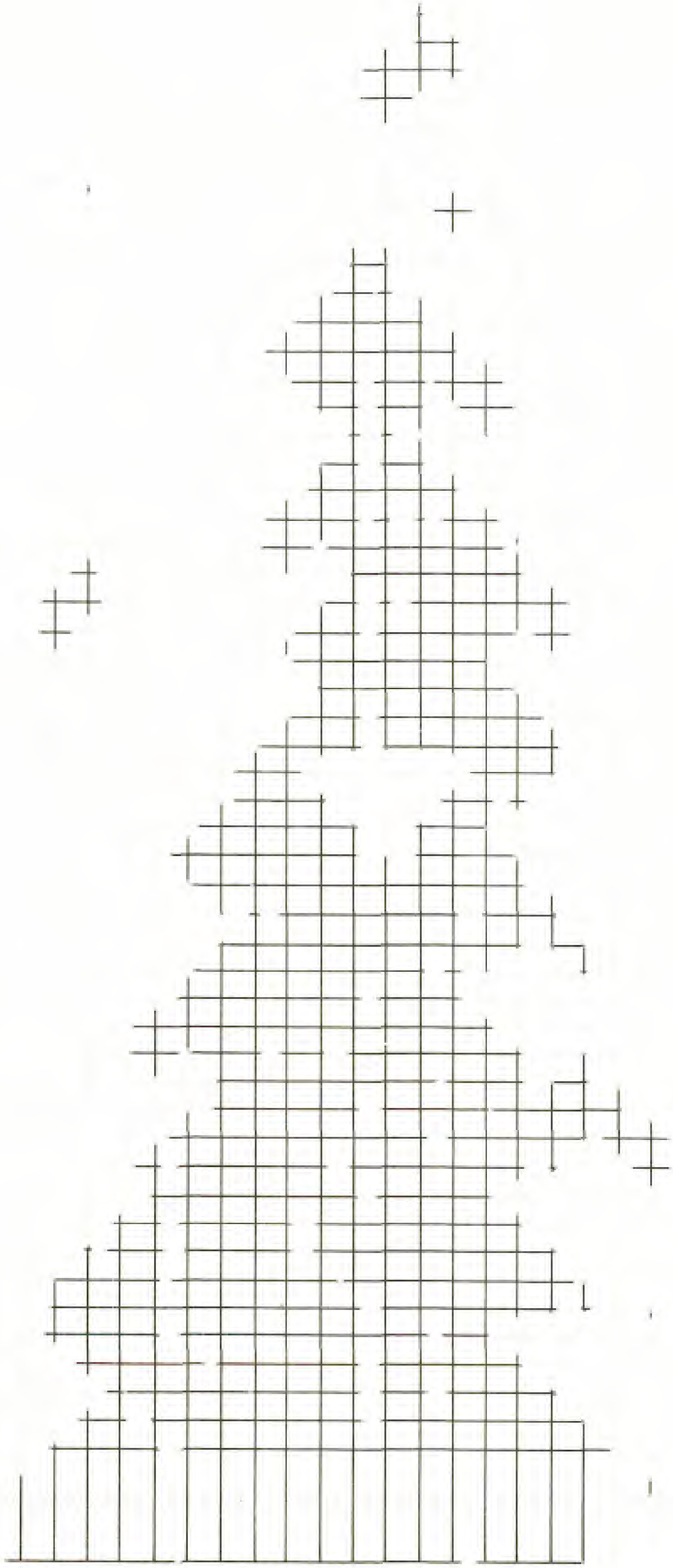
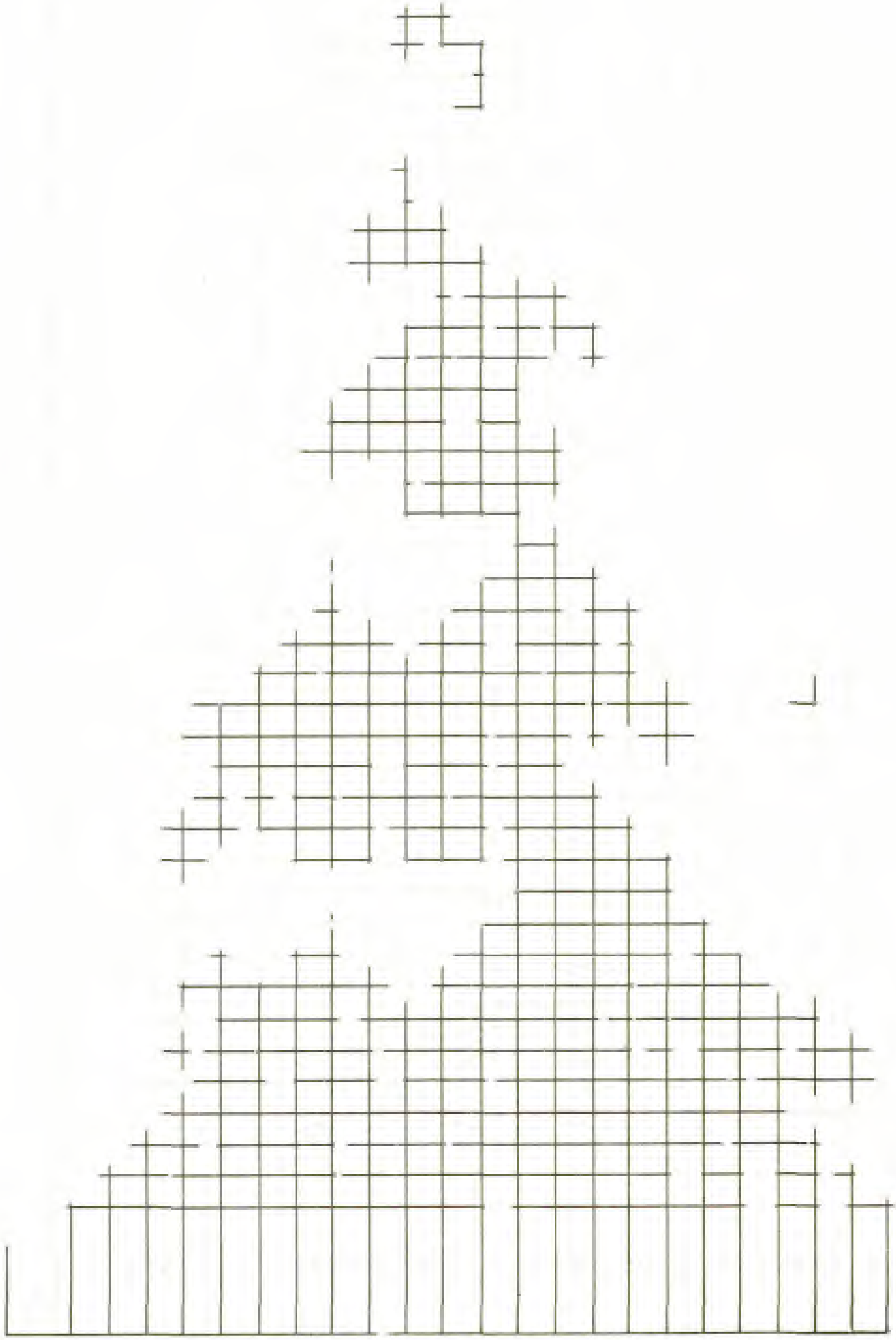
Total	1	4	5	4	4	5	3	6	3	2	1	3	1	2		2		2					1			1	1		1			1			1					1			1			1			1		1	1		60









APPENDIX TABLE 1

SPECIES: FIN SEX: ♂ YEAR: 1973 EXPEDITION: ICELAND LAND STATION METHOD: EAR PLUGS

AGE IN GROWTH LAYERS

Body Length (feet)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	65	70		Total
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56			1		1																																																	2
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59			1	1	1																																																	3
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Total	1	2	6	7	3	9	6	3		1	3	1	1	1	3	1		1		1	1	1		1								1						1		1			1		1	1				1		2		62

APPENDIX TABLE 1

SPECIES: FIN SEX: ♂ YEAR: 1974 EXPEDITION: ICELAND LAND STATION METHOD: EAR PLUGS

AGE IN GROWTH LAYERS

Body Length (feet)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	65	80		Total
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56		1	1	1	2										1							1																																7
57			1	2		1								1																																								5
58			2		1									1																										1														5
59		1	1		1	2	1	1		1						1	1				1															1																		12
60				1	1	1	2	2			1					1																			1														1					11
61					1	3			1			1			1	1																1																						9
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Whale Marking in the North Atlantic

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Whale Research Unit, Institute of Oceanographic Sciences, UK.

Table 1

Numbers of whales effectively marked in the North Atlantic 1950–75

Country	Year	Blue	Fin	Hump-back	Sei*	Right	Minke	Sperm	Bottle-nose	Pilot	Killer	Total
Canada	1960	–	1	1	–	–	–	–	–	–	–	2
	1965	–	3	–	–	–	3	–	–	–	–	6
	1966	2	79	8	14	2	2	61	–	1	2	171
	1967	3	67	38	3	–	1	26	–	–	–	138
	1968	4	1	–	–	4	–	1	–	–	–	10
	1969	3	45	87	11	–	5	11	2	6	–	170
	1970	–	3	29	–	–	–	–	–	–	–	32
	1971	–	19	1	2	2	–	7	–	–	–	31
	1972	5	59	26	–	–	1	3	–	–	4	98
	1973	3	10	–	–	–	–	–	–	–	–	13
	Total	20	287	190	30	8	12	109	2	7	6	671
France	1965	–	–	–	–	–	–	4	–	–	–	4
	1966	–	–	–	–	–	–	–	–	2	–	2
	1969	–	2†	–	–	–	–	–	–	–	–	2†
	Total	–	2	–	–	–	–	4	–	2	–	8
Iceland	1965	–	13	–	–	–	–	6	–	–	–	19
	1970	–	1	–	–	–	–	–	–	–	–	1
	1972	–	3	–	–	–	–	–	–	–	–	3
	Total	–	17	–	–	–	–	6	–	–	–	23
Norway	1954	–	–	–	–	–	1	–	–	–	–	1
	1964	–	–	–	–	–	7	–	–	–	–	7
	1965	–	–	–	–	–	9	–	–	–	–	9
	1967	–	–	2	–	–	–	–	–	–	–	2
	1968	–	17	–	–	–	1	1	–	–	–	19
	1971	–	2	–	–	–	–	1	–	–	–	3
	1973	–	8	4	–	–	–	–	–	–	–	12
	1974	–	–	12	–	–	53	–	–	–	–	65
	1975	–	–	2	–	–	136	–	–	–	–	138
	Total	–	27	20	–	–	207	2	–	–	–	256
United Kingdom	1950	–	9	–	–	–	–	10	–	–	–	19
	1954	–	–	–	–	–	–	3	–	–	–	3
	1955	–	–	–	–	–	–	1	–	–	–	1
	Total	–	9	–	–	–	–	14	–	–	–	23
All countries	Total	20	342	210	30	8	219	135	2	9	6	981

* Includes Bryde's whales.
† 2 fin whales marked in the Mediterranean Sea.

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France – Records of whale marking provided by Dr P. Budker.
Iceland – Copies of whale marking records at Whale Research Unit, IOS.
Norway – Copies of whale marking records at Whale Research Unit, IOS and information from Dr Å. Jonsgård.
United Kingdom – Whale marking records at Whale Research Unit, IOS.

Table 2

Fin whales – numbers effectively marked in the North Atlantic 1950–75.

	1950	1960	1965	1966	1967	1968	1969	1970	1971	1972	1973	Total
Canada	–	1	3	79	67	1	45	3	19	59	10	287
France	–	–	–	–	–	–	2*	–	–	–	–	2*
Iceland	–	–	13	–	–	–	–	1	–	3	–	17
Norway	–	–	–	–	–	17	–	–	2	–	8	27
United Kingdom	9	–	–	–	–	–	–	–	–	–	–	9
Total	9	1	16	79	67	18	47	4	21	62	18	342

* 2 whales marked in the Mediterranean Sea.

Table 3

Minke whales – numbers effectively marked in the North Atlantic 1954–75.

	1954	1964	1965	1966	1967	1968	1969	1972	1974	1975	Total
Canada	–	–	3	2	1	–	5	1	–	–	12
Norway	1	7	9	–	–	1	–	–	53	136	207
Total	1	7	12	2	1	1	5	1	53	136	219

Table 4

Distribution of marked fin whales in the North Atlantic.

	Year	Total number marked	Nova Scotia	Labrador	Gulf of St Lawrence	Other Areas
Canada	1960	1	1	–	–	–
	1965	3	–	–	1	Labrador Sea–2
	1966	79	65	14	–	–
	1967	67	21	28	–	Labrador Sea–2, West Greenland–5, American–1, Gulf Stream–2, East Greenland–8
	1968	1	–	–	–	American–1
	1969	45	20	2	22	Labrador Sea–1
	1970	3	1	1	1	–
	1971	19	16	–	–	American–3
	1972	59	5	44	10	–
	1973	10	–	–	10	–
	Total	287	129	89	44	Labrador Sea–5, West Greenland–5, American–5, Gulf Stream–2, East Greenland–8
France	1969	2				Square N7 (Mediterranean)–2
Iceland	1965	13				Square Q4–13
	1970	1				Square Q4–1
	1972	3				Square Q4–3
	Total	17				Square Q4–17
Norway	1968	17				Square Q3–14, Q4–3
	1971	2				Square Q2–2?
	1973	8				Square Q1–3, Q2–3, N1–2
	Total	27				Square Q1–3, Q2–5, Q3–14, Q4–3, N1–2
United Kingdom	1950	9				Square J6–8, K5–1

Table 5

Distribution of marked minke whales in the North Atlantic.

	Year	Total number marked	Nova Scotia	Labrador	Gulf of St Lawrence	Other Areas
Canada	1965	3	–	–	3	–
	1966	2	–	–	–	Baffin–2
	1967	1	1	–	–	–
	1969	5	1	–	2	Southern Sargasso Sea–2
	1972	1	–	1	–	–
	Total	12	2	1	5	Baffin–2, Southern Sargasso Sea–2
Norway	1954	1				Square Q6–1
	1964	7				Square Q6–1, Q8–6
	1965	9				Square Q8–9
	1968	1				Square Q4–1
	1974	53				Square Q7–2, R8–32, R9–15, R10–1, R11–3
	1975	136				Square R8–132, R10–4
	Total	207				Square Q4–1, Q6–2, Q7–2, Q8–15, R8–164, R9–15, R10–5, R11–3

Table 6

Fin whales – numbers of marked whales killed in each year-group for each year of marking.

	Year	Number marked	Same year 0-Group	1-Group	2-Group	3-Group	4-Group	5-Group	6-Group	7-Group	8-Group	Returns to 1975
Canadian marking	1960	1	–	–	–	–	–	–	–	–	–	–
	1965	3	–	–	–	–	–	–	–	–	–	–
	1966	79	4	6	10	4	3	1	–	–	–	28
	1967	67	2	1	–	–	1	1	–	–	–	5
	1968	1	–	–	–	–	–	–	–	–		–
	1969	45	–	–	1	–	–	–	–			1
	1970	3	1	–	–	–	–	–				1
	1971	19	–	1	–	–	–					1
	1972	59	2	–	–	–						2
	1973	10	–	–	–							–
	Total	287	9	8	11	4	4	2	–	–	–	38
Icelandic marking	1965	13	–	3	–	–	–	–	–	1	1	5
	1970	1	–	–	–	–	–	–				–
	1972	3	1	–	–	–						1
	Total	17	1	3	–	–	–	–	–	1	1	6
Norwegian marking	1968	17	1	1	–	–	–	–	–	–		2
	1971	2	–	–	–	–	–					–
	1973	8	–	–	–							–
	Total	27	1	1	–	–	–	–	–	–		2

Table 7

Minke whales – numbers of marked whales killed in each year-group for each year of marking.

	Year	Number marked	Same year 0-Group	1-Group	2-Group	3-Group	4-Group	Returns to 1975
Norwegian marking	1954	1	–	–	–	–	1	1
	1964	7	1	–	–	–	–	1
	1965	9	–	–	–	–	–	–
	1968	1	–	–	–	–	–	–
	1974	53	–	1				1
	1975	136	–					–
	Total	207	1	1	–	–	1	3

Table 8

Fin whales – marks returned. Canadian marking.*

Mark no.	Sex	Length (ft.)	Date fired	Date recovered	Months elapsed	Position fired	Position recovered	Distance (miles)
Nova Scotia/Newfoundland Area†								
				0-Group				
5 (410)	♂	59	21.vii.66	9.xi.66	3½	43°01′N, 64°16′W	43°30′N, 65°01′W	30
34	♀	59	24.vii.66	28.viii.66	1	42°50′N, 65°34′W	43°40′N, 62°45′W	130
67	♂	55	24.vii.66	23.ix.66	2	42°30′N, 65°36′W	48°29′N, 52°36′W	652
16 (410)	♂	54	24.vii.66	28.ix.66	2	42°24′N, 65°35′W	43°35′N, 62°10′W	155
15481	♀	50	28.vii.67	29.vii.67	–	43°30′N, 63°10′W	43°23′N, 63°07′W	8
926	♀	60	18.vi.70	22.vi.70	–	49°47′N, 52°36′W	51°28′N, 54°15′W	130
1291/3	♂	56	10.vii.72	14.viii.72	1	48°37′N, 50°52′W	51°28′N, 53°57′W	215
1296	♂	61	10.vii.72	14.viii.72	1	48°37′N, 50°52′W	51°28′N, 53°57′W	215
				1-Group				
3 (410)	♂	53	23.vii.66	16.viii.67	12¾	41°53′N, 65°31′W	42°54′N, 64°07′W	86
63	♂	59	24.vii.66	24.viii.67	13	42°25′N, 65°32′W	43°30′N, 63°08′W	120
94	♂	44	28.vii.66	6.viii.67	12¼	43°52′N, 62°42′W	43°45′N, 62°35′W	8
86	–	–	27.vii.66	Before vi.68	Ca.11	43°14′N, 65°35′W	Nova Scotia	–
1756	♀	53	4.x.71	30.vii.72	10	43°13′N, 65°56′W	43°04′N, 63°32′W	60
				2-Group				
56	–	–	24.vii.66	Before 10.viii.68	24/26	42°25′N, 65°32′W	Nova Scotia	–
70	♀	58	24.vii.66	28.x.68	27	42°30′N, 65°36′W	43°20′N, 65°00′W	57
72	♀	62	24.vii.66	30.vi.68	24	42°30′N, 65°36′W	43°20′N, 63°10′W	118
73	–	–	24.vii.66	Before 11.ix.68	23/26	42°30′N, 65°36′W	Nova Scotia	–
10 (410)	–	–	24.vii.66	Before 3.vii.69	Ca.23	42°22′N, 65°33′W	Nova Scotia	–
89	♂	54	27.vii.66	11.viii.68	24½	43°14′N, 64°35′W	42°21′N, 63°03′W	86
C154	–	–	3.viii.66	Before 10.viii.68	22/24	43°30′N, 62°25′W	Nova Scotia	–
C164	♂	59	4.viii.66	4.ix.68	25	44°23′N, 59°06′W	50°22′N, 53°25′W	452
15456	♀	64	15.x.66	8.viii.68	21¾	44°13′N, 61°22′W	43°27′N, 63°00′W	86
15466	♂	49	15.x.66	5.ix.68	22⅔	44°22′N, 61°20′W	43°50′N, 62°35′W	65
1083	♀	62	24.v.69	12.vii.71	25⅔	44°42′N, 59°44′W	44°11′N, 63°50′W	177
				3-Group				
3	♂	51	21.vii.66	16.vii.69	35¾	43°10′N, 63°56′W	43°07′N, 63°17′W	28
55 and 11 (410)	♂	53	24.vii.66	21.ix.69	38	42°25′N, 65°32′W	43°07′N, 64°54′W	50
85	♀	56	27.vii.66	10.vii.69	35½	43°12′N, 64°30′W	42°54′N, 63°12′W	60
97 and 912 ('67)	♂	57	3.viii.66	10.vii.69	35¼	43°15′N, 62°10′W	42°54′N, 63°12′W	46/56
				4-Group				
48	♀	56	24.vii.66	14.vi.70	46⅔	42°23′N, 65°33′W	43°18′N, 63° W	115
58	♀	56	24.vii.66	30.vi.70	47¼	42°25′N, 65°32′W	43°25′N, 63°14′W	120
Labrador Area								
				0-Group				
809	♀	64	3.viii.67	19.viii.67	½	53°34′N, 55°30′W	50°27′N, 55°20′W	180
				1-Group				
C177	♀	57	12.viii.66	2.vii.67	10¾	50°30′N, 53°36′W	48°20′N, 52°53′W	136
C319	♂	58	31.viii.66	17.vii.67	10½	54°38′N, 56°06′W	48°55′N, 52°33′W	350
816	♀	56	6.viii.67	30.vi.68	10¾	57°37′N, 60°36′W	50°37′N, 55°32′W	450
				4-Group				
C318	♂	56	31.viii.66	27.vii.70	47	54°38′N, 56°06′W	50°35′N, 53°45′W	255
753	♂	63	29.vii.67	9.v.71	45⅓	51°39′N, 54°15′W	44°07′N, 59°13′W	495
				5-Group				
C183	♂	57	14.viii.66	1.vi.71	57½	53°28′N, 55°06′W	48°50′N, 52°40′W	275
807	♀	63	3.viii.67	30.viii.72	61	53°20′N, 55°26′W	51°24′N, 53°47′W	130

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* Compiled from Mitchell, E. (1974) Progress report on whale research, Canada, May, 1972 to May, 1973. *Rep. int. Whal. Commn,* 24: 196–213.

† Northern boundary of Nova Scotia/Newfoundland area taken as 50°00′N latitude.

Table 9

Fin whales – marks returned. Norwegian and Icelandic marking.*

Mark no.	Sex	Length (ft.)	Date fired	Date recovered	Years/ months elapsed	Position fired	Position recovered
Norwegian marking							
				0-Group			
16150	?	63	13.vii.68	21.vii.68	0.0	63°27′N, 38°15′W	Ca. 65°25′N, 28°30′W (Sq. 81AB)
				1-Group			
16144	♂	64	13.vii.68	24.vii.69	1.0	63°27′N, 38°15′W	Ca. 64°38′N, 28°00′W (Sq. 102C/101D)
Icelandic marking							
				0-Group			
15815	♂	62	25.v.72	15.vii.72	0.2	62°58′N, 25°25′W (Sq. 184B)	Ca. 65°23′N, 28°15′W (Sq. 81B)
				1-Group			
16110/11	♂	62	19.v.65	30.vii.66	1.2	65°35′N, 29°00′W (Sq. 60D/61C)	Ca. 65°23′N, 27°45′W (Sq. 82A)
16131	♂	60	19.v.65	24.v.66	1.0	65°38′N, 29°05′W (Sq. 60D)	Ca. 65°23′N, 29°15′W (Sq. 80B)
16133	♂	60	19.v.65	23.ix.66	1.4	65°38′N, 29°05′W (Sq. 60D)	Ca. 65°08′N, 28°15′W (Sq. 81D)
				7-Group			
16135	♂	59	19.v.65	27.vi.72	7.1	65°38′N, 29°05′W (Sq. 60D)	Ca. 65°38′N, 28°45′W (Sq. 61C)
				8-Group			
16132	♂	59	19.v.65	28.vi.73	8.1	65°38′N, 29°05′W (Sq. 60D)	Ca. 63°53′N, 26°45′W (Sq. 143A)

* Compiled from information provided by Å. Jonsgård & J. Jónsson and from copies of marking records at Whale Research Unit, IOS.

Table 10

Minke whales – marks returned. Norwegian marking.*

Mark no.	Sex	Length (ft.)	Date fired	Date recovered	Years/ months elapsed	Position fired	Position recovered
				0-Group			
26128	–	–	11.vii.64	29.vii.64	0.0	Lofoten Islands, 10 n.m. SE Vaerøy	Lofoten Islands, 3 n.m. NW Vaerøy
				1-Group			
30497	♀	24	5.viii.74	4.vi.75	0.10	74°26′N, 17°10′E	71°33′N, 25°41′E
				4-Group			
N91	–	27	22.vi.54	29.viii.58	4.2	66°00′N, 02°00′W	Vesteralen, 25 n.m. NNW Anda Light

* Compiled from information provided by Å. Jonsgård and from copies of marking records at Whale Research Unit, IOS.

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Catch Statistics for Minke Whales, West Greenland, 1954–74

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The following Tables and Figures give a preliminary presentation of the development of the catch of minke whales in West Greenland.

The catch of minke whales is a relatively new feature in the pattern of hunting activity of the Greenlanders, whereas there was an old tradition for hunting bowheads and humpback whales. Between 1924 and 1939, and again in 1946–1958 whaling was carried out by the Danish authorities, but minke whales were not taken in those operations.

The Greenlanders' catch of minke whales started around 1950. In the period 1954–58 (the first period for which data have been published) one or two vessels in Central West Greenland equipped with harpoon cannons were taking around 25 minke whales annually. During the following 4-year period the number of participating vessels increased to around ten, and the total catches were of the order of 50 minke whales per year. In this initial period of exploitation at least a couple of vessels seem to have been engaged in minke whaling during the whole season, taking 15–20 whales per year.

In the beginning of the 1960s the pattern seems to have changed considerably as far as the number of participating vessels is concerned. The available data have not yet been finally examined, but from that time and up to date the number of vessels participating in each particular season seems to have been in the order of 50.

None of these vessels have been in the fishery during the entire period 1954–1975, and most vessels are basically fishing vessels engaged in cod, shrimp, or salmon-fishery, taking minke whales only occasionally. Therefore, measures of effort will probably be impossible to get, even if the landings of other products were known, because the time spent whaling has not been recorded.

On the other hand, catching of minke whales seems to be so economically important compared with other fisheries, that one would expect the boats equipped with harpoon cannons to be whaling whenever possible, if the whales were abundant. As mentioned above, a few boats may have been occupied full-time in minke whaling at least for some seasons, and if this is true, some indication of catch per effort could be arrived at. The maximum catch per boat per season seems to be around 25, but the data need further examination.

However, the number of participating vessels does not seem to have changed much during the last ten years, and the total catches might therefore be taken as a crude estimate of the availability of whales during that period.

If so, it should be noticed that the largest catches taken by the Greenlanders occurred in the years 1966–1969 (average 267 per year), whereas the mean catches for the following six years have been 25% lower. The reasons for this decline are not clear. One could be the development of other fisheries; the Greenlanders' salmon-fishery developed rapidly after 1960 and shifted ten years later from an exclusively gill net fishery to a high proportion using drift nets; at the same time the importance of the cod-fishery decreased, whereas the shrimp-fishery increased rapidly. The effect of these changes on the catch of minke whales, in which the same vessels were involved, could be considerable – and complex.

However, it is also worth noting that the decline in the Greenlanders' catch of minke whales occurred at the same time as the Norwegian pelagic fleet began catching minke whales off West Greenland, and that the decline is most pronounced in the areas (SW) and in the months (June-August) where the Norwegians started their operations in the Davis Strait. In the last few years the fleet seems to have moved further north.

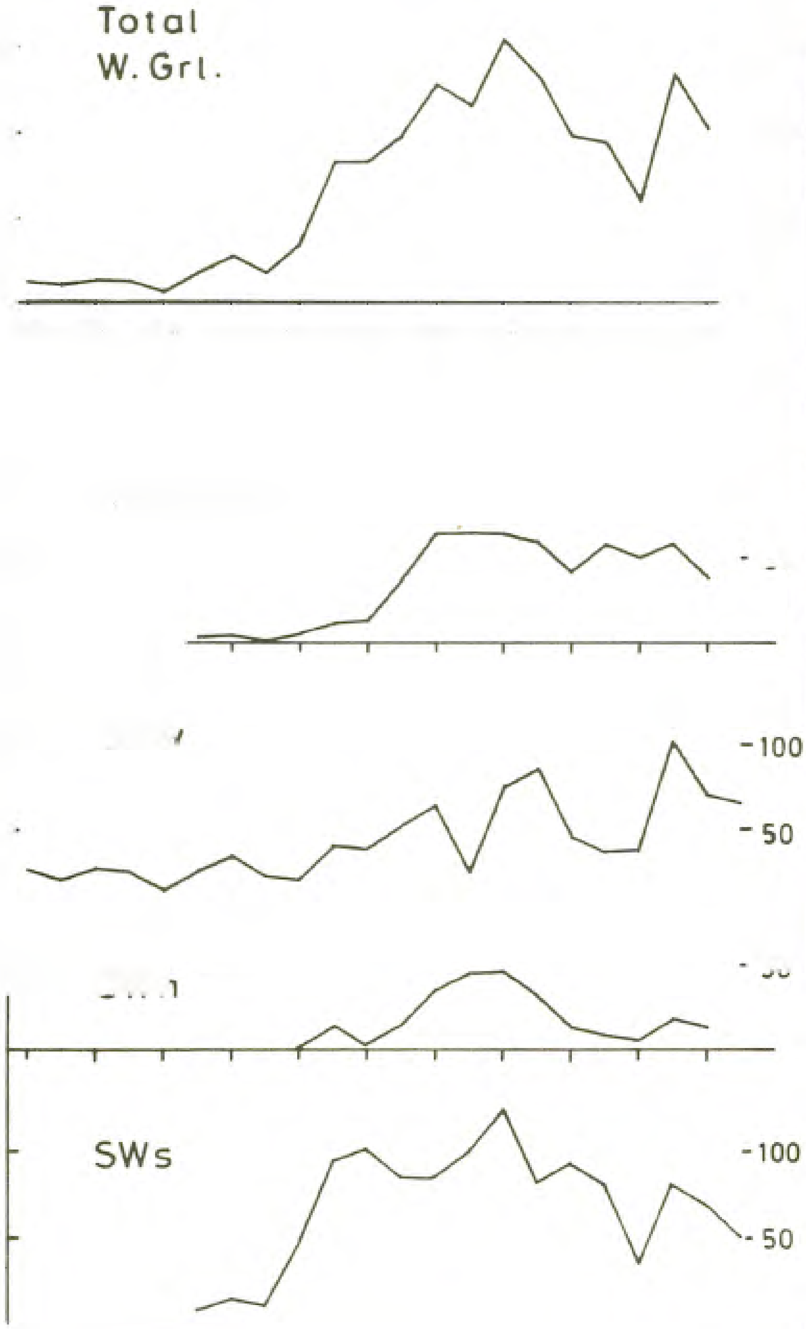
The evidence for a relation between the onset of the Norwegian catch of minke whales in the Davis Strait and the decline in the Greenlanders' catch is circumstantial and needs further examination, but the fact that this stock of minke whales has been exposed to a rapidly expanding exploitation during the last twenty years should be considered, not least when its importance as a future source of meat supply for the Greenlanders is taken into account.

Table 1

Catch of minke whales in West Greenland, 1954–74, by regions and districts.

Region	District	1954	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
	Upernavik	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	9	10
	Umanak	–	–	–	–	–	–	–	–	–	–	7	17	17	25	23	20	19	28	33	36	9	19
	Jakobshavn	–	1	–	–	–	–	–	–	–	5	2	14	47	39	34	35	21	31	18	22	20	.
	Christianshåb	–	–	–	–	–	3	3	1	4	5	3	5	–	2	4	3	1	–	–	–	1	3
NW + CWe		–	1	–	–	–	3	3	1	4	10	12	36	64	66	64	58	41	59	51	58	39	.
	Godhavn	–	–	–	–	7	4	31	10	5	21	19	37	55	21	63	81	34	21	31	89	43	31
	Egedesminde	23	20	26	24	7	19	–	13	15	19	19	15	9	4	11	6	3	3	7	14	27	35
	Kangatsiaq	2	–	–	–	–	1	3	–	–	–	1	–	–	–	1	–	10	12	–	–	–	–
CWw		25	20	26	24	14	24	34	23	20	40	39	52	64	25	75	87	47	36	38	103	70	66
SWn	Holsteinsborg	–	–	–	–	–	–	–	–	1	13	4	15	35	44	47	32	14	9	6	18	13	.
	Sukkertoppen	–	–	–	–	–	–	–	–	3	26	38	51	51	53	83	37	37	20	21	41	36	29
	Godthåb	–	–	–	–	–	7	14	10	30	39	36	27	15	13	15	20	34	33	7	19	16	16
	Frederikshåb	–	–	–	–	–	1	–	–	13	30	28	9	20	34	27	26	23	28	8	21	17	5
SWs		–	–	–	–	–	8	14	10	46	95	102	87	86	100	125	83	94	81	36	81	69	50
	Narssaq	–	–	–	–	–	–	1	–	–	3	4	2	3	–	1	–	–	–	8	–	–	.
	Julianehåb	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2	–	8	5	13
	Nanortalik	–	–	–	–	–	–	–	–	–	3	3	3	2	2	–	3	–	2	6	–	8	9
S		–	–	–	–	–	–	1	–	–	6	8	5	5	2	1	3	–	4	14	8	13	.
Total	West Greenland	25	21	26	24	14	35	52	34	71	164	165	195	254	237	312	263	196	189	145	268	204	171+

Note: Figures for 1975 provisional, and for some districts lacking (.).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SWs
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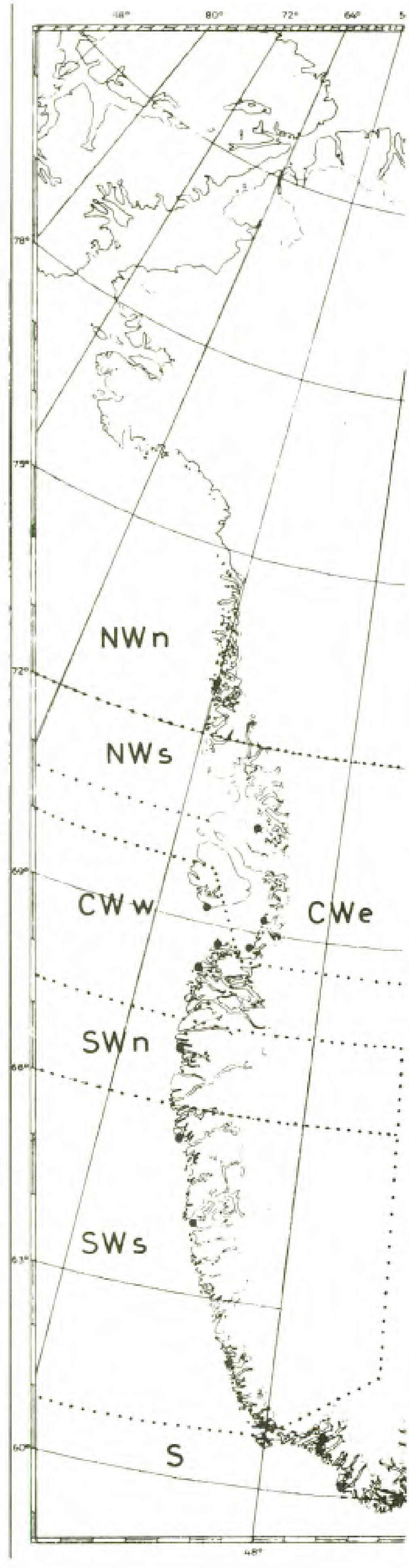
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Stocks of Fin Whales *Balaenoptera physalus* L. in the North Atlantic Ocean

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Abstract

Fin whales exist over a wide part of the North Atlantic Ocean in all areas of high biological productivity, between the ice edge and a surface sea temperature of about 15°C. Those occurring in the colder waters (north Norway, Labrador) reach larger maximal sizes and larger sizes at sexual maturity than those from warmer waters (Nova Scotia, west Norway). The impression is given of a continuum rather than distinct stocks, since fin whales from one catching area mix with those from another area to an appreciable degree, as told by a significant mix of recoveries from marking and by simultaneous depletion, at distances of at least 500 km but less than 1000 km. Movements of individuals as shown by marking can be as great as 1250 km, nevertheless stocks separated by this distance can be depleted at considerably different rates, as shown by a comparison of Nova Scotia and Newfoundland, or western Norway and northern Norway. Thus the rate of mixing of stocks at this distance is small as compared with rates of depletion of the same stocks subjected to heavy whaling. Measurable 'stocks' as so distinguished have been estimated to number from 2,000 to 10,000 in several examples: Newfoundland, Iceland, west Norway-Faeroes and Spain-with-Portugal. Probably the size of such 'stocks' depends on the precise sea area considered. The total primeval fin whale population of the North Atlantic exceeded 30,000 but was probably less than 50,000. All European stocks are now depleted, those in northern European seas being almost or totally eliminated, while those in Iceland remain in good condition, and those on the eastern North American seaboard remain numerous, or are rapidly recovering after cessation of brief overexploitation. Pollution by heavy metal ions may be a source of mortality in the western Mediterranean Sea.

GENERAL DISTRIBUTION

1. Southern Limits

Fin whales are found commonly in the western North Atlantic south to Capes Hatteras and Lookout, North Carolina at about 35°N, mainly in February and March (Caldwell and Golley, 1965). Surface temperatures at this time at the coast are about 15°C (Walford and Wicklund, 1968). Rarely the species reaches south to the Atlantic coast of peninsular Florida at 29°N (Moore, 1953), and perhaps beyond (Mitchell, 1974).

In the eastern North Atlantic Jonsgård (1966a) showed that catching was formerly common south to the Straits of Gibraltar. Viale *et al.* (1973), Viale (1974), and Duguy and Cyrus (1973) show that fin whales are moderately common in the western Mediterranean basin in summer. Museo de Zoologico, Barcelona (MS 1974) cite several more records off the Spanish Mediterranean coast, and together these records show that the season of occurrence there extends from at least April to November. Murdoch and Onuf (1974) give the annual surface temperature range in the western Mediterranean basin as from 12 to 16°C. It is the coldest, and also most productive of the three Mediterranean basins. Kirpichnokov (1950) sighted three fin whales on May 12, 1948 at 20°50'N, 18°10'W (southwest of Cabo Blanco, Rio de Oro), and saw a number of fin whales on May 16, 1948, north of the Canary Is. at about 30°N, 15°W. It seems likely that the trade winds in this area of the northwest African coast are constant enough in spring to produce some mixing and cooling. Note that mixing will produce both cooling and increased productivity, attracting cool water whales which feed on schooling fish and Euphausiidae. Khromov (1962 Fig. 1) indeed shows high productivity in the Canary Is. – northwest Africa area.

2. Northern Limits

Jonsgård (1966b) gives the northern limits of fin whales as the limits of the pack ice, and cites catch records north to 80°42′N, 11°E off northwest Spitsbergen. (See Fig. 1[1] in Jonsgård, 1966a). In cold waters this limit may be much further south than the above record. Thus, fin whales close to the Labrador coast in the core of the Labrador current do not seem to be common north of about 57°N (Sergeant, MS 1966). However, in the warmer waters of the Labrador Sea and along the west coast of Greenland limits are further north. Thus, Jonsgård (1966a, Fig. 1). shows catches of fin whales in the 1930s off west Greenland north to 72°N.

FEEDING

While the northern limits are set by ice, and the southern limits possibly by a maximum tolerance of about 15°C water temperature, in the vast sea area between these limits, distribution and abundance of fin whales is determined largely by that of their prey. As is well known, fin whales eat a wide spectrum of food organisms ranging from copepods through euphausiids to schooling fish such as capelin *Mallotus villosus,* and herring *Clupea harengus,* (Jonsgård, 1966b; Mitchell, 1975) as well as probably sardines *Sardina pilchardus* and perhaps *Sardinella* spp. Schooling fishes are frequently taken in the spawning phase. when they are easier to catch, as for example herring at Møre, Norway in winter-spring, the Magdalen Islands in the Gulf of St. Lawrence in spring, and northern Georges Bank in autumn; spawning capelin at Finmark and the Murman coast in late winter, and the southeast shoal of the Grand Bank in early summer. Close inshore, depths may be too shallow for this large whale species to take spawning capelin, and the post-spawning shoals may be more accessible to the fin whales than the spawners. Many immature fish are also taken; the immature capelin at Newfoundland are, confusingly, called whitefish.

Hjort and Ruud (1929) related fin whale movements to those of Euphausiidae at west Norway. It becomes clear from this work and that of Jonsgård (1966a) on the same stock that plankton-feeding whales change their distribution annually in latitude and longitude according to food distribution. Catches from land stations change accordingly with a large annual variance. By contrast, fin whales taking schooling fishes such as capelin close to land will change little annually, or only in one plane (e.g. east-west along the Finmark-Murman coast) and may therefore be more predictable in their movements and hence catchable. It was probably no accident that Svend Føyn started catching in north Norway, where both fin whales and humpbacks *Megaptera novaeangliae* feed on these capelin.

DETAILED DISTRIBUTION AND STOCK DISTINCTIONS

1. Western North Atlantic Ocean

(a) Newfoundland and Nova Scotia

Mitchell (1974) gives vital statistics for fin whales captured from three land stations situated in eastern Canada in the most recent period of whaling there from 1965 to 1971.

These data show that fin whales killed off Nova Scotia in summer at latitudes 42° to 45°N are smaller than those killed at Newfoundland in summer at latitudes 48° to 55°N. Differences were greater for mean lengths than for modal or median lengths, and were about 2.5 to 3 ft (0.7 to 0.9 m), or about 5% of body length (Table 1). Within Newfoundland catches, fin whales killed from South Dildo at 48° to 51°N were smaller than those killed from Williamsport at 51° to 55°N by a small amount, less than 1 ft. (0.3 m) of mean body length.

The distance between southern Nova Scotia and eastern Newfoundland is much larger than the distance between catching fields at eastern Newfoundland, which overlapped each other. Therefore, these differences in length could argue either for separate stocks at Nova Scotia and Newfoundland, perhaps divided by the Laurentian Channel, or for a gradient or cline of size.

Table 1

Lengths in feet of fin whales landed at eastern Canadian land stations in 1965–71. Condensed from Mitchell, 1974, Table 5-1, a to c.

Station		Williamsport	South Dildo	Blandford
Province		Newfoundland	Newfoundland	Nova Scotia
Latitude of station		51°N	48°N	44°25′N
Latitude of main catches		51°–55°N	48°–51°N	42°–45°N
Years		1967–71	1966–71	1965–71
Number (N)	males	425	469	589
	females	652	462	752
	Total	1,077	931	1,341
Mean ($\bar{L}$) length	males	57.56	57.55	54.72
	females	60.53	60.08	57.33
	Total	59.50 (59.64)[1]	58.77 (58.96)[1]	56.20 (57.15)[1]
Median	males	58	56	55
	females	61	61	59
	Total	60	59	57
Mode	males	58	59	56
	females	61	60	61
	Total	61	60	58

[1] Corrected figure when undersized whales, less than 50 ft. in length, omitted.

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[1] Jonsgård, 1966a has a frontispiece and end plate both labelled Fig. 1. I refer here throughout to the end plate chart.

Table 2 shows that full sexual maturity occurred at a smaller mean length for male fin whales at Nova Scotia than at the two Newfoundland stations, for higher mean ages at Nova Scotia (Mitchell, 1974, p. 126). Samples of first-maturing female fin whales were too small to show significant differences in length at onset of sexual maturity between Nova Scotia and Newfoundland, but the mean length was higher at the same age at northeast Newfoundland than at southeast Newfoundland and Nova Scotia combined, for similar mean ages. These data at least argue for a cline in sizes of stocks, and not in degree of maturity of animals, from northeast to southwest.

Marking: Mitchell (1974, p. 120, Figs. 5-2 to 5-4) from mark returns showed a movement between Nova Scotian and Newfoundland waters of the order of 2 out of 22, or 10% of fin whales taken in summer over a 3 to 4 year period, with marking also mainly in summer. Therefore the potential existed for mixing between stocks of the two areas. The two stocks could have moved northeast to southwest in parallel, seasonally, or could have mixed.

Studies by K. R. Allen (1971) cited by Mitchell (1974, p. 150, Tables 5-10 and 5-11), showed a relative distinctness of stocks in that catch declined more rapidly at Nova Scotia than at Newfoundland when both stocks were being exploited simultaneously. Between 1968 and 1969, CPE fell by 0.62 at Nova Scotia as compared with 0.92 at both Newfoundland stations within the same year. From catch-effort data and from change in abundance, Allen calculated stock size at Nova Scotia from 1966 to 1970, and estimated a mean decrease in stock size within this time period of 0.24 per annum. The rate of decline at Newfoundland was less. Thus the stocks could not have been fully mixed.

Moreover, if mixing did occur to the extent of 10%, which would be the maximum possible mixing possible from mark returns, then this mixing was not sufficient to offset heavy catching; that is, the stocks under this regime were relatively distinct.

Furthermore, a small stock in the Gulf of St Lawrence (p. 463) remained relatively unaffected by this hunting. This stock leaves the Gulf in winter, and must reach the Laurentian Channel and probably northern Nova Scotia in winter. Mitchell (1974, p. 149) estimated its size in 1966–1969 as approximately 340 whales. The existence of this population too was not enough to prevent whales off southern Nova Scotia from being depleted to a number estimated by Allen (1971) as 569 in 1969; therefore these fin whales too seem to be relatively separated from those off southern Nova Scotia. Therefore, migrations of these sets of populations off eastern Canada are not of a large magnitude. The four maximal displacements found by Mitchell from summer to summer, based on tag recoveries, were about 1250 km, 750, 650 and 650 km. The majority showed constancy of return to summering areas (Mitchell, 1974, Fig. 5-2).

(b) Wintering

The above data tend to suggest relatively small shifts, perhaps to slightly warmer waters either seaward or along the coast in winter, by northwest Atlantic fin whales. Little is known about wintering areas of northwest Atlantic whales because of stormy weather in winter which prevents frequent accurate observations at sea. Slijper *et al.* (1964) in their sightings of rorquals (chart 1) in the western North Atlantic show few sightings of rorquals on the continental shelf in November to May but the majority of these were still north of 40°N. As stated earlier, fin whales winter regularly along the North American seaboard south to 35°N. Mitchell (1974, p. 120) gives the southern limit of concentration in summer in the western north Atlantic as 41°20′N, i.e. about Cape Cod. With coastal migration, this difference would argue for a mean seasonal displacement of the southernmost fin whales of about 6°20′, or about 600 km.

Whether fin whales move coastally or out to sea in winter would depend on their need for food in winter. Brodie (1975, p. 157) observed fin whales in eastern Nova Scotian waters in December to May, feeding close to shore on what he believed, from the observed abundances of the organisms, to be herring (*Clupea harengus*) in winter, and euphausiids (chiefly *Meganyctiphanes norwegica*) in spring. Since these are the summer foods of the Nova Scotian-caught whales (Mitchell, 1975), Brodie believed that these were the Nova Scotian whales, resident. They could equally probably be animals displaced from the Gulf of St Lawrence by pack ice, moving to the nearest open waters.

The chief food of the eastern Newfoundland stock of fin whales is capelin *Mallotus villosus* with small quantities of euphausiids, mostly *Thysanoessa raschi* and *Th. inermis*, as secondary foods (Mitchell, 1975). While nothing is known of the variability of foods of fin whales through the seasons, specific groups of fin whales could well develop 'specific search images' for certain prey species. More

Table 2

Lengths in feet of sexually mature male fin whales and at maturity of female fin whales landed at eastern Canadian land stations in 1965–71. Data from Mitchell 1974, Tables 5-2 and 5-3. N, number; $\bar{L}$, mean length.

Station	Williamsport	South Dildo	Blandford
Latitude of catching fields	51°–55°N	48°–51°N	42°–45°N
Years	1967–68	1966–68	1965–68
N for mature males	57	61	47
$\bar{L}$ for mature males	59.5	59.0	57.0
Mean age of mature males (yrs)	20.4	24.2	34.4
N for length, females	23	11	12
$\bar{L}$ for females with first corpus luteum	60.5[1]	58.0	58.0
N for age, females	18	9	8
Mean age for females with first c.l.	10.8	11.7	11.8

[1] Data from Williamsport, Newfoundland and Hawke's Harbour, Labrador whaling stations in 1945–51, compiled by fishery inspectors, confirm the accuracy of this figure, when analysed as the mean minimum length at which 50% of females were pregnant.

certainly, with the development of offshore fisheries for capelin on the northeast Newfoundland shelf, fin whales have been seen in almost all months feeding around the capelin seining vessels, and it seems likely that the fin whales summering in this area do not all move out of it until forced south or east (to the outer Grand Bank or Flemish Cap) by pack ice at its maximum in March and April.

Brodie (1975) noted that the Newfoundland and Nova Scotian fin whales differed considerably in mean and maximum size and speculated that they developed different strategies, the more northern whales feeding heavily for the summer months (much as the Antarctic fin whales are believed to do) and starving in the winter, while the smaller Nova Scotian ones feed steadily through the year to a greater degree. In a less extreme form, as suggested above, this is quite an attractive hypothesis but measurements are needed on relative blubber thicknesses of both populations through the summer catching season to its ending in November, data which must exist and could be analysed. It should then be possible to determine whether the observed differences in bulk and blubber thickness can be explained solely in terms of differences in mean ambient water temperatures, or require the additional hypothesis of longer seasonal food supplies in more southern localities.

(c) The Gulf of St Lawrence

A small number of fin whales summer in the Gulf of St Lawrence. They are seen or stranded in areas of intensive summer production such as the tip of the Gaspe Peninsula, where they have been seen feeding, perhaps on herring, with the typical side-rolling behaviour, in summer; on the North Shore of Quebec at Tadoussac, where a small whale-watching tourist industry has developed since 1971; and at Sept Iles, where they were captured in small numbers from 1910 to 1917. Mitchell (1974, Table 5-7 p. 137) gives statistics of catch, which were incomplete by species.

In the Gulf of St Lawrence, abundant herring, capelin and Euphausiidae are all available as food, although the nature of foods eaten has to be determined from observation.

These animals are driven out of the Gulf of St Lawrence by pack ice formation between December and April or May. If they remain late, or arrive unusually early in the eastern side of the Gulf, where there is usually a channel along the western coast of Newfoundland, they can become stranded and killed by wind-driven ice (Sergeant, Mansfield and Beck, 1970 pp. 1905–1906). That is, selection works against their early arrival by increasing the risk of stranding. However, since abundant herring are usually available in winter in western Newfoundland, selection also exists in favour of late lingering or early arrival, and a balance must exist between the two tendencies.

Fin whales penetrate upstream to the confluence of the Saguenay River at Tadoussac (48°N, 70°W) where the 200 m contour of the deep Laurentian Channel abruptly ends. This makes likely the hypothesis that fin whales tend to follow steep slope contours, either because they detect them readily, or because biological productivity is high along steep contours due to tidal mixing and perhaps current mixing. (See Drobysheva, 1964 for variations of Euphausiid biomass along the slopes of the Grand Bank, for example).

(d) Northern Limit of Fin Whales on the Labrador Coast

Catching from a land station on the southern Labrador coast in the period 1945–1951 extended north to Hamilton Inlet Bank at 56°N. Unpublished sightings by the Arctic Biological Station cited in Sergeant MS 1966, Table 7, also show numerous fin whales on this bank in the summer months with few sightings near the coast north of 57°N.

Although capelin spawn along the coast north to Cape Chidley, northernmost Labrador (Templeman, 1947), there are no shallow offshore banks of any size north of Hamilton Inlet Bank, and it is possible that the capelin north of this area are rather coastal in their occurrence and not so available to fin whales as on extensive banks.

2. Iceland

(a) Catch Data

Jónsson (1965a) studied catches of fin whales in Icelandic waters. From the factory at Hvalfjorfur (ca 65°N, 24°W) all whales were caught off the west coast of Iceland between 63° and 67°N, and 24° and 30°W, by 4 catchers, from 1961 to 1964. Catches of fin whales oscillated about a mean of 236 fin whales from 1948 to 1964, with no discernible trend. Oscillations were attributed partly to weather conditions since bad weather reduced catching. Distribution of fin whales varied also from year to year in latitude and longitude due to spatial variations in abundance of zooplankton.

(b) Dispersal

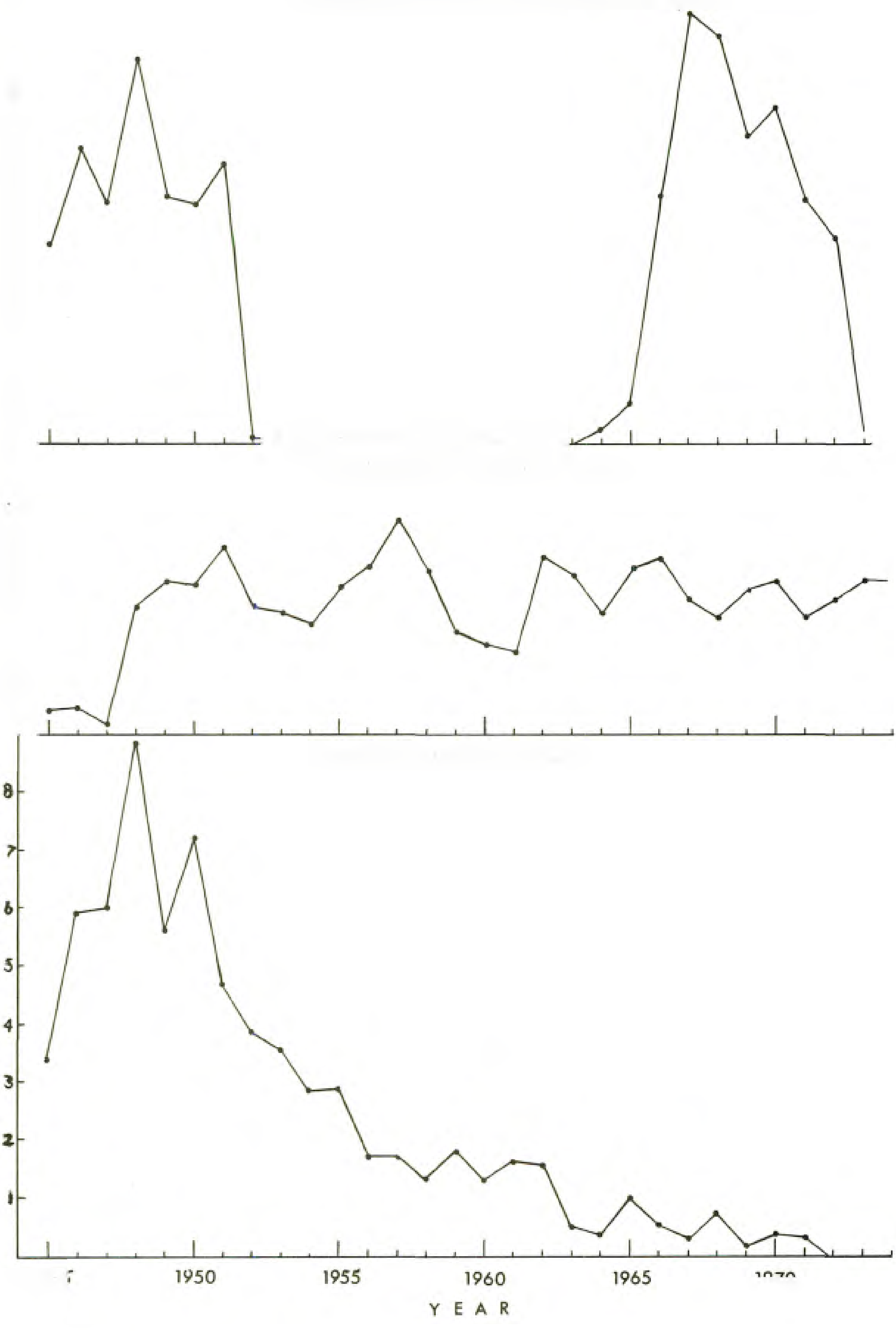
Jónsson (1965b) reported on 13 fin whales marked at Iceland in spring 1965. There had been no recoveries up to November 1965. Rørvik *et al.* (1974) reported 4 recoveries at Iceland from 17 marked in 1965, 1970 and 1972 at Iceland. From sixteen additional fin whales marked off east Greenland by Norwegian scientists in 1968 and 1970, two had been recovered at Iceland. Apparently no marks put on in the Iceland-east Greenland areas had been recovered at other catching fields.

3. East and West Greenland

Jonsgård (1966a, Fig. 1) showed that during the 1930s considerable pelagic catching of fin whales took place both at east and west Greenland. Further details of catching for a slightly earlier period, the late 1920s, are shown by Hjort and Ruud (1929) for West Greenland, although they did not distinguish species of baleen whale caught.

At west Greenland catching took place by one catcher from 1946 to 1958. Catch statistics for 1946 to 1958 given in International Whaling Statistics showed that fin whales were caught in July to October (one in November) with highest catches from July to September. No fin whales were taken in west Greenland in May and June although a number of sperm whales *Physeter catodon* were taken. Thus, fin whales were slow to arrive at the west Greenland coast in spring. Krill (Euphausiidae) were reported in 75% of the stomachs of fin whales at west Greenland, capelin in 17%, and sand launce *Ammodytes* sp. in 8%. The low percentage of capelin in stomachs of fin whales from west Greenland, as compared with Newfoundland for example (Mitchell, 1975) may be due to a more coastal distribution here of capelin, suggested by Hansen and Hermann (1953). This capelin is taken abundantly by harp seals in May and June (Sergeant, 1973), moving close into the coasts.

Jonsgård and Christensen (1968) reported a greater concentration of fin whales in July-August, 1968 at southeast than at southwest Greenland, with considerable numbers at the edge of the shelf of southeast Greenland



8
7
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4
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1
1950
1955
1960
1965
YEAR

especially at 63°27′N, 38°15′W. The fin whales were believed to be feeding on capelin.

In 1963 ICNAF carried out a multi-ship survey of hydrography and fisheries biology around the coasts of east and west Greenland and to some extent, Labrador (Operation NORWESTLANT). Results were reported by various authors in 1968. Sergeant (1968) reported the collected whale sightings. Unfortunately critical groups like the rorquals could not accurately be identified as to species. J. Corlett on board M/V *Ernest Holt* reported good numbers of *Balaenoptera* whales in the region of Anton Dohrn Bank at 65°–66°N, 28°–32°W. These were in areas of zooplankton abundance. Corlett tentatively identified the whales as sei whales. There were higher Icelandic catches of fin whales than of sei whales just east of this area at 65°–66°N, 27°–29°W. in summer 1963 (Jónsson, 1965a, Figs. 3 and 7), with sei whales scarce and not taken till August in 1963 (Jónsson, 1965a, Fig. 7). Therefore, Corlett's sightings were more likely of fin whales than of sei whales.

In summary, fin whales exist in a continuum between west Iceland and east Greenland and are rather common on the east Greenland shelf in summer in the region of water mixing and high productivity which lies near the shelf or near the ice edge. The ICNAF 1963 surveys show that this is an area of high plankton production. Magnusson (1968, p. 164, Table 244) from the ICNAF 1963 surveys showed that while most capelin production took place at Iceland, there were considerable abundances of capelin eggs, larvae and young fish along the east Greenland current systems. Hørsted (1968) in studies based on the same, as well as later, surveys showed that the 1963 year-class of cod at west Greenland resulted mainly from Iceland. Fin whales pursuing food fish drifted by the current could follow the same path. Catch per effort of fin whales at west Greenland in 1945–1958 was only 22 fin whales per catcher-year, as compared with 70.9 at Iceland, and 61.0 at Newfoundland and Labrador, for years within the same time period when large or intensive catching took place here. The lower catch results at west Greenland could result either from a lower abundance of fin whales, or a lower intensity of catching effort, or both. There appear to be no mark returns between either Newfoundland and west Greenland on the one hand, nor Iceland and west Greenland on the other. To achieve results, marking would have been necessary at west Greenland, since catching there preceded marking at Iceland and at Newfoundland and Nova Scotia.

It is clear from all this information that fin whales are more abundant at east than at west Greenland. Fin whales at east Greenland are continuous with those at west Iceland and must represent a reserve for catching at Iceland. The fin whales at west Greenland may possibly be related to those at east Greenland, like some of the pelagic fish stocks, or may be a relatively independent population.

4. North European Coasts

For North Norway Risting (1922) wrote and I translate (pp. 13–16) 'While the real plankton-eating whales only come to the Finmark coast in the beginning of June, the fin whales arrive as soon as April. At this time there usually occurs a big swarming of capelin, and fin whales are often seen to follow them. At this time fin whales are often shot close to land. Later in summer one has to go further out after them and they are caught northward towards Bear Island and further north. The summer months of June-August were the best catching period for this species, and from the journals that I have had access to, three quarters of all fin whales brought in were caught in these months. From the Finmark coast a quantity of fin whales migrate west into the open sea to give birth.'

For west Norway Risting (1922, p. 13) writes:

> 'While blue whales hardly ever occur along our southern coast, fin whales here are rather common and occur nearly the whole year round. When the herring shoals move in toward land, the fin whales are its closest followers. They are met with at the big herring fishery close to the Romsdal coast, and at the spring and winter herring fishery in the Bergen and Skagerrak coasts. During the State whale fishery in 1918 and 1919 there were shot from the three stations south of Trondhjemsfjord in all 575 fin whales or 32 per boat per year. This indicates a rather high abundance. After 1 September in these catching years, no more whales arrived on the coast, but in general, the species occurs throughout the whole year'.

For the Skagerrak he wrote:

> 'In the years when an exceptionally big winter herring fishery took place on the east coast of the Skagerrak fin whales appeared in such big numbers that they gave a good basis for a whale hunt. Later, one rarely took them in these waters. During the State catch here in 1918–19 only five whales were brought in in spite of intensive effort. Their occurrence is on the whole irregular, depending completely on the abundance of fish shoals which they follow. They come and go with these'.

And in general:

> 'The same is confirmed also in the other catching fields in the northeast Atlantic Sea[1]. Although the fin whale in the broad view is the whale species whose catch has been most constant over the whole catch period, its abundance at the catching fields in the northeast Atlantic has varied greatly from year to year. It is specially at Shetland and Faeroes that one has good occasion to observe these conditions'.
>
> 'How this whale depends on the food is most clearly seen on the Icelandic coast. Here one met with it in spring and early summer together with blue whales north of Iceland right up to the ice edge. It ate plankton, and the stomachs of caught individuals were full of copepods (aate). Later in the year, when the herring concentrated one met with fin whales closer to land, and it showed itself to be a herring feeder par excellence. The greatest catches took place at this time'.
>
> 'It is to be found nearly everywhere and in northern waters has a much more even distribution than any of the other big whale species. This state of affairs apparently relates to the fact that it doesn't undertake long migrations as do the plankton-feeding whales. It roams around only on quite short voyages'.
>
> 'The stock of this whale species is still quite large in the northeast Atlantic and has only in the last 10–15 years supported an intensive fishery. The stock must have been much bigger at the start of whale catching in northern waters, since after many years of heavy catching it still exists in good numbers'.
>
> 'In 1913 from combined stations in the northeast Atlantic there were taken 862 whales of which 574 were fin whales. In 1914, 870 whales were shot. Of these, 539

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[1] Nordhavet. This word could also be translated as 'Norwegian Sea' but seems a little broader in Risting's usage.

were fin whales. At individual stations it contributed up to three quarters of the catch. In the last few years at certain catching fields it has apparently become more numerous than for some years back. During the State catch in 1918–19, 1,084 fin whales were caught at the Norwegian coast, so the stock of this species must still be reckoned as pretty good. In summer, 1920, fin whales were observed in very good numbers north of the 80th parallel of latitude at Spitsbergen, where A/S *Spitsbergen Hval* whaled'.

Jonsgård (1966a) takes up the story from here, recording (his Fig. 1) catches in 1930–1934 in these northern waters at Spitsbergen, Bjørnøya, Jan Mayen, Iceland to east Greenland, and west Greenland by Norwegian pelagic expeditions. All areas showed good catches except Jan Mayen, where they were small.

(a) *West and North Norwegian and Faeroish coasts*

Jonsgård (1958) showed a catch of 2,793 fin whales on the Norwegian west coast from 1946 to 1957, or 232.7 per annum. In addition in the same years, 1,869 fin whales or 155.7 per annum were taken from the Faeroe Is. Thus 4,662 or 388.5 per annum were taken from both areas combined. Jonsgård (1966a, Fig. 6) showed that catches at west Norway declined markedly between 1946 and 1964, as did those at the Faeroes. Whaling ceased at the Faeroes after 1968, and at west Norway after 1969, after negligible catches (less than 10 a year) had been reached. From 3 stations in 1945, only one remained at west Norway by 1957. There was a lesser decline at North Norway, where whaling continued until 1971, but by then, catches were only 30–40 fin whales per annum. There was no coincidental decline in west Iceland. Therefore, there is much intermittent mixing between stocks of fin whales at west Norway and the Faeroes, little mixing between North Norway and west Norway, and none between west Norway–Faeroes and West Iceland. Jonsgård (1966a, Fig. 4) shows a gap of about 1,000 km between median catching areas of west and north Norway. The distance between the Faeroes and west Iceland is about 850 km.

Jonsgård (1958) studied in detail the relations between catches from west Norwegian and Faeroese land stations. There was no close correlation between catch or catch per effort in earlier years, but a close approximation in the later years of analysis, in 1956 and 1957. This suggests that local stocks of fin whales were hunted soon after resumption of whaling in 1945 or 1946, but then as these stocks became depleted, the catchers moved further out and – insofar as Faeroese catchers worked to the eastward – worked on the same stock of fin whales. This analysis is supported by an early high catch per effort (CPE) at Faeroes, and a rapid drop there after 1950 to below the level of CPE at west Norway, though this could have been coincidental.

(b) *The Barents Sea*

Christensen (1974 and MS 1975) shows the relative abundance of whales from extensive sightings in the North Atlantic in summers of 1973 and 1974 (Table 3).

This table shows a general abundance of minke whales (*B. acutorostrata*) in the North Atlantic but a complete absence of fin whales in the northeastern sector as compared with northerly central and western sectors. For the northeastern sector, this was true for both summers, 1973 and 1974. After viewing the catch data for fin whales in the Barents Sea as shown by Jonsgård (1966a, Fig. 1) one can believe that a decline has occurred in fin whales in the Barents Sea since the early 1930s, when heavy pelagic catching was taking place off Bjørnøya and off Spitsbergen in the summer months. From the remarks of Risting (1922) quoted above, an absence of fin whales in the Barents Sea in summer does not seem to have been true in the past.[1]

Table 3

Sightings of Cetacea in the northern North Atlantic. From Christensen, 1974 and MS 1975.

Area	Barents Sea		East Greenland and Norway to Greenland	Newfoundland and West Greenland
Date	1973	1974	1973	1973
Season	May–June	July–Aug.	July–Aug.	May–Sept.
Species				
Minke	545+	800	183+	279
Fin	–	–	103	115
Sei	–	–	2	12
Hump	19+	6	–	26
Blue	–	–	–	2
Sperm	–	1	10	5
Killer	60–70+	10–15	72+	7
Pilot	–	–	60	1,100
Dolphins	500+	100's	many	200
C. Porpoise	23+	20+	2	–
Bottlenose	–	–	–	1
Narwhal	–	–	–	1

Moreover, in 1948 the author made a voyage between Tromsø and Bjørnøya in mid July returning in late August. He saw several minke whales and two humpbacks (*Megaptera novaeangliae*), but no fin whales, except for a single dead whale in Sørhamna, Bjørnøya. This sampling although small agrees with that of Christensen and suggests that a depletion of fin whales in the Barents Sea occurred before 1948. We may therefore, probably, locate it as some time in the 1930s at the end of the phase of pelagic whaling in the arctic Atlantic. If this is true, then the fin whales taken north of the Tromsø region from the 1940s to the 1960s must have been replenished from the westward. The absence of mark recoveries, in spite of the few marks put on at west Iceland and east Greenland, suggests that the distance of movement of these whales toward north Norway could not however have been very great.

(c) *British Seas*

In the Hebrides, Scotland, CPE declined from a maximum of 71.6 fin whales per boat in 1924 to a minimum of 18.6 per boat in 1929, when whaling ended (Jonsgård, 1966a, Fig. 7). The total catch was 2,229 in 8 years, or a mean of 278.6 per annum. During this period catches at west Norway and the Faeroes also declined, following the same general pattern, but to a lesser degree. Whaling however continued here through the 1930s. At the Faeroes 2,789 fin whales were taken in 17 out of the 19 years 1921 to 1939, for a mean of 164 per annum, while at west Norway 3,917 were taken in the same 19 years, for a mean of 206 per annum. Together, catches at west Norway and the Faeroes were 370 per annum. These catches and the decline suggest some excess over sustainable yield from the west

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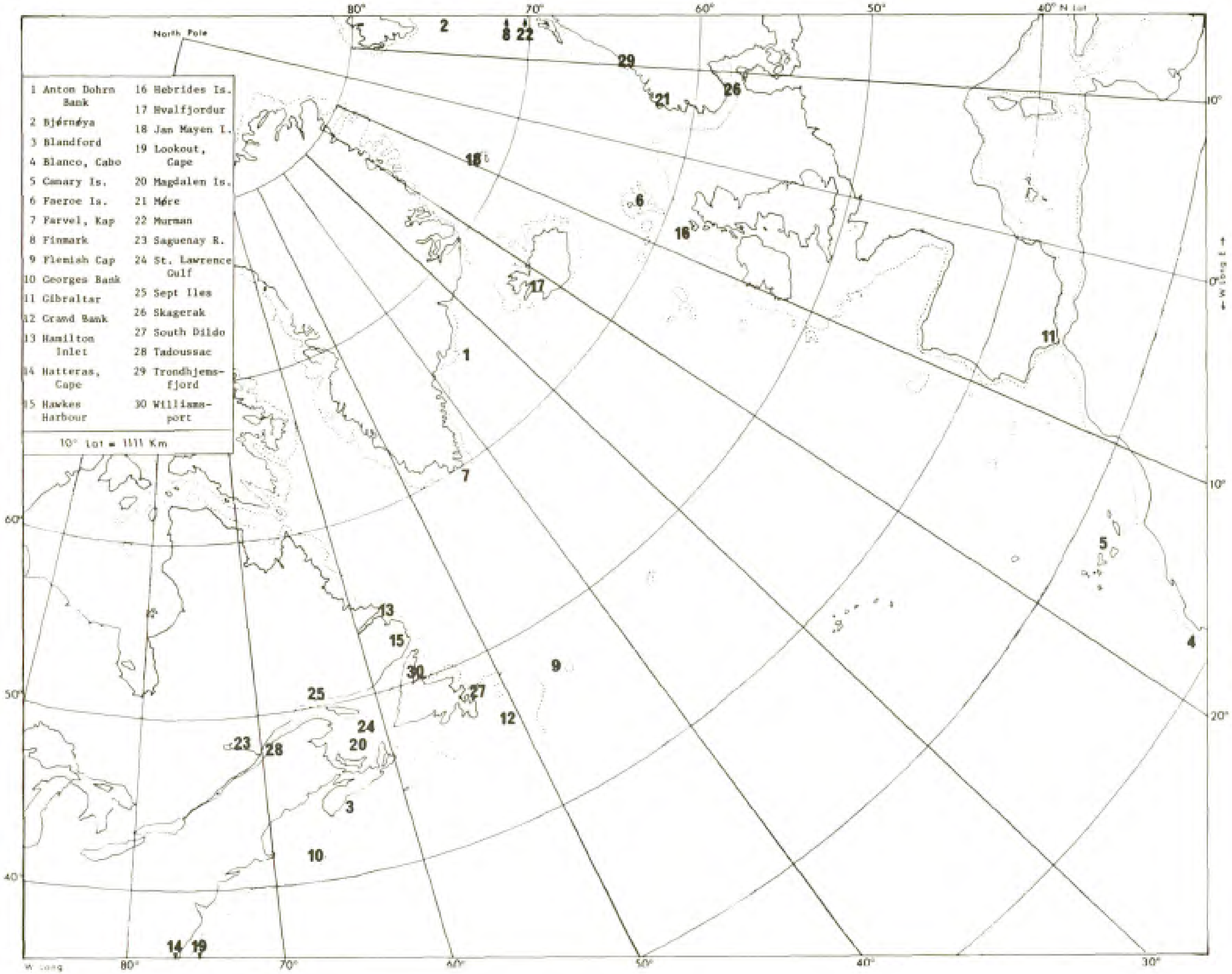
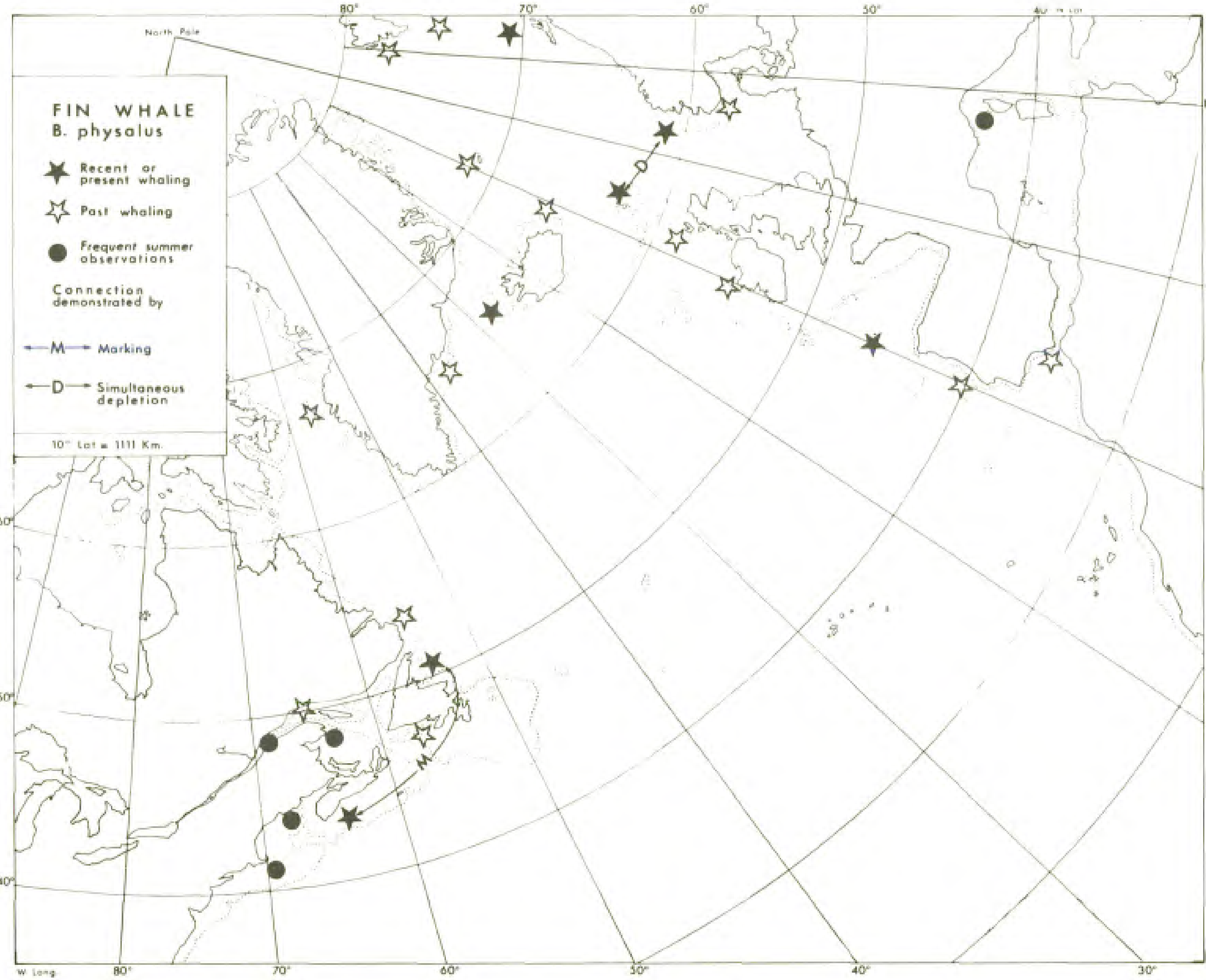
[1] Christensen (in litt. 16 III 76) states that 9 fin whales were seen in the Barents Sea in May–June, 1975 and that there were further reports from fishermen of many fin and humpback whales in areas of capelin abundance in the northern Barents Sea in August–September 1975.



North Pole
1 Anton Dohrn Bank
2 Bjørnøya
3 Blandford
4 Blanco, Cabo
5 Canary Is.
6 Faeroe Is.
7 Farvel, Kap
8 Finmark
9 Flemish Cap
10 Georges Bank
11 Gibraltar
12 Grand Bank
13 Hamilton Inlet
14 Hatteras, Cape
15 Hawkes Harbour
16 Hebrides Is.
17 Hvalfjordur
18 Jan Mayen I.
19 Lookout, Cape
20 Magdalen Is.
21 Møre
22 Murman
23 Saguenay R.
24 St. Lawrence Gulf
25 Sept Iles
26 Skagerak
27 South Dildo
28 Tadoussac
29 Trondhjemsfjord
30 Williamsport
10° Lat = 1111 Km
40° N Lat
W Long
W Long E


FIN WHALE
B. physalus
Recent or present whaling
Past whaling
Frequent summer observations
Connection demonstrated by
M Marking
D Simultaneous depletion
10° Lat = 1111 Km.
North Pole
W Long.
W Long E

Norwegian-Faeroes area. The similarity of the declines suggest that there is some connexion between the Hebrides and the Faeroes, separated by only some 400 km. Like the Faeroe Is., the Hebrides probably also have a component which is resident. The total fin whale stock accessible from The Hebrides seems about as large as that accessible from the Faeroe Is. alone but smaller than that from West Norway and the Faeroe Is. together.

Whaling has not taken place on the British coasts since 1929 except for a small amount in the Hebrides in 1950 and 1951 (International Whaling Statistics). Something, however, can be learnt from strandings on the coasts about the status of species, because of the long period of well-recorded strandings (Harmer, 1927; Fraser, 1934, 1946, 1953 and 1974; Purves, MS 1974). Table 4 shows the strandings of all Cetacea and of fin whales in Britain for periods of roughly equal reporting effort between 1913 and 1966, as well as in 1973. Fin whale strandings are shown as a percentage of the total, and also by order of rank as for example first in abundance, fifth, etc.

Table 4 shows that the fin whale dropped from sixth to thirteenth most abundant species in stranding, and from 5.1 to 1.1%, between 1913–1926 and 1927–1932. During the second war years approximately, from 1938 to 1947, it had risen again to 10th in rank and 2.2%, but fell quite soon to fourteenth and 0.6%. These trends appear to parallel catches, which took place from the Hebrides (also earlier at Ireland and Shetland) up to 1929 and again at the Hebrides in 1950 and 1951. Some of the strandings in 1913–1926 were actually of wounded whales near the Hebrides.

Table 4

Strandings of all Cetacea and of fin whales at Britain, 1913 to 1966 by time periods and in 1973. Data from Harmer (1927) and Fraser (1934, 1946, 1953 and 1974) and Purves (MS 1974).

Years	1913–26	1927–32	1933–37	1938–47	1948–66	1973	1913–47
Number of years	14	6	5	9	9	1	35
Total, all species	407	186	216	220	507	33	1,043
Fin whales:							
percent total	5.1	1.1	–	2.2	0.6	–	2.9
rank order	6	13	–	10	14	–	8

Fraser (1934, p. 14) thought that the earlier decrease in strandings might have been due either to the decrease in number of wounded whales, or to a decrease in total population. I would favour a natural source of strandings as more important, since a decrease occurred again after 1945 when whaling at Scotland was negligible. Also, many strandings occur in areas such as the eastern seaboard of the USA where no catching takes place.

Strandings in fact will increase in two situations; where mortality increases due to human causes (whaling, pollution), and where mortality increases due to natural population increase. The strandings on the US eastern seaboard are probably an example of the latter trend at present. However, when populations are moderate in size, as a result of human hunting in the general area, but where there is no nearby hunting, or where hunting is efficient with few wounded animals, strandings are probably a good index of population size. This seems to hold true for the British stranding records.

We can deduce therefore, that (a) accumulated stocks off Britain were high in about 1914 and were markedly reduced by the late 1920s; (b) stocks built up again but to a low degree in the 1940s; (c) stocks were reduced again to very low levels by the 1950s or 1960s and are now very low around Britain.

Fraser (1934) showed that the majority of strandings at Britain occurred around north Scotland. Faeroe-west Norwegian catches reached a peak in 1950 (Fig. 1) and went down subsequently. Although the first decline at Britain in the late 1920s can be associated with catching at north Britain, catching in the 1940s–1950s at north Britain was negligible, and it is hard not to relate the second decline in fin whale strandings (and therefore, of abundance) at Britain to heavy catching at the Faeroe Is. and west Norway.

I deduce therefore that fin whales occurring around north British coasts are quite closely connected to those occurring to the northward. This conclusion is reinforced from the conclusion reached below that fin whales in the Bay of Biscay area were not reduced, in recent times, until the early 1970s. However, surely fin whales stranded in south and southwest Britain must be related to fin whales occurring in the Bay of Biscay.

5. The more southern stocks in the North Atlantic

According to Jonsgård (1966a, p. 41), off Spain and Portugal, fin whale catch per ship decreased from 540 in 1923 to 54.7 in 1927. The total catch in the years 1921–1927 was 6,433, almost a total population estimate, with a mean catch of 919 per annum. The area is not well described. According to Jonsgård, west Norwegian and Faeroese catches were high immediately at the end of this period, so the two stocks could not have been related.

(a) Bay of Biscay

Viale and Riddell (MS 1975) were able to obtain statistics of catch from one captain, evidently landing whales in Vigo, northwest Spain, though this is not stated. Table 5 shows his catches of fin whales. Since this captain stated that the fleet was of 5 ships, the catches are multiplied by 5 to give total catch of the fleet. This figure is compared with catches of fin whales given in International Whaling Statistics, or computed from them where the catch of baleen whales is not identified to species. Agreement is fairly good. Although accuracy of data for 1974 is crucial, there is a strong suggestion of a fall in catches which may have become catastrophic by 1974. The Bay of Biscay stock must therefore now be very low.

Duguy and Aloncle (MS 1974) show 1.6% of observations of fin whales out of all sightings of Cetacea in the Bay of Biscay during observations made principally in 1972 to 1974. However, if unidentified whales of the genus *Balaenoptera* are increased proportionally to the identified species of the genus, the percentage of fin whales in total sightings rises to 4.1%.

Budker (1968), Duguy (1972, 1973, 1974), Duguy and

Table 5

Catches of fin whales in the Bay of Biscay. Data from Viale and Riddell, MS 1975, and from International Whaling Statistics.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974
Catch/Ship	20	19	32	31	34	17	25	11	1
Calculated catch of 5 ships	100	95	160	155	170	85	100	55	5
Actual catch (IWS)[1]	(80)	(80)	(92)	(122)	151	88	90	73	?

[1] If species not given in IWS, number bracketed, and believed to be all fin whales.

Budker (1971), Duguy and Cazaux (1974) and Duguy and van Bree (1968) cite strandings of whales along the French Atlantic coast from historic times up to 1974. Only one calf fin whale stranded during this time out of 100 recorded strandings, although strandings were recorded of other species of *Balaenoptera*. Probably the species is not so rare as this survey indicates since Fischer (1881) cites some unidentified whales probably fin whales stranded on the Atlantic coast of France. However, Duguy and Robineau (1973) state that the fin whale is rare close to shore on the Channel and Atlantic coasts of France. Duguy and Aloncle (MS 1974) mention several sightings far west towards the Azores islands.

(b) Mediterranean Sea

Duguy (1972, 1974) and Duguy and Cyrus (1973) cite 5 strandings of fin whales on the Mediterranean coasts of France, including Corsica, in 1971–1974, out of 57 recorded Cetacean strandings. This very high stranding rate of nearly 9% of all Cetacea appears to relate principally to the circumstance described by Viale (1974) and Viale *et al.* (1973). Fin whales entering an area of euphausiid abundance north of Corsica are affected by heavy metal ions dumped by barge from an industrial plant on the Italian coast. They either die, or being incapacitated, are hit by ferry boats and other craft. This circumstance argues for a marked concentration of fin whales in what is one of the richer parts of the Mediterranean (Murdoch and Onuf, 1974). French sightings and strandings of fin whales in the Mediterranean were 34 in number up to 1973 (Duguy and Cyrus, 1973), and recent Spanish records four (Museo de Zoologia, Barcelona, 1973). Eight dated records of the above between 1971 and 1974 extend in time between April and November, so that the species may very well be resident in the western Mediterranean basin. However the catches at Getares, Strait of Gibraltar, mentioned by Jonsgård (1966a, p. 30), may indicate that migrations occur into and out of the Mediterranean Sea. (See addendum).

COMPARISONS

1. Length frequencies east and west

Jonsgård (1966a, p. 45) showed that the mean lengths of fin whales taken in 1951–1964 were 57.7 ft. for western Norway, 59.6 ft. for north Norway. Females were respectively 59.9 ft. and 61.9 ft. in mean length. Thus the animals were larger at north Norway than at west Norway.

As discussed above, Mitchell found the same difference for animals at Nova Scotia and at Newfoundland. The minimal legal length of capture was the same, 50 ft., in both sets of observations, at Norway and at Canada. With the same distance between catching fields, the difference in mean size was the same between the northern and southern catching fields; about 2 ft. (0.6 m). Nevertheless the absolute lengths were greater at Norway than at Canada (Table 6) by about 4% of body length. This interesting difference needs careful checking by ensuring that measurements were carried out in the same way. A similar difference has also been found in pilot whales *Globicephala melaena*. Unpublished data by the author show fractionally larger sizes of pilot whales at Faeroe Is. over those at Newfoundland, of the order of 5% of body length. The difference would be considerably greater in bulk. The explanation for this difference is not clear, but it may well be due to a longer season of good feeding conditions in the eastern North Atlantic with its mild North Atlantic Drift, compared with the western North Atlantic, where the cold Labrador Current forces many Cetacea offshore in winter. One recalls Jonsgård's (1952) study which showed that Antarctic fin whales are larger than both those in the North Pacific and in the North Atlantic oceans.

2. Estimates of stock size

(a) Newfoundland and Nova Scotia

Mitchell (1974, p. 147) gives results of a number of estimates, shown in Table 7. The mean figure is 8,330 for Newfoundland and Nova Scotia combined which would

Table 6

Mean lengths of fin whales from the North Atlantic Ocean, and differences in mean length between fin whales from different areas. Lengths in feet. Sources: Jonsgård (1966a) and Mitchell (1974).

Location		Males	Difference	Females	Difference	Mean Difference
North Norway West Norway	Mean	59.6 57.6	2.0	61.9 59.9	2.0	2.0
Newfoundland Nova Scotia	Mean	57.6 54.7	2.9	60.3 57.3	3.0	3.0
Norway Canada	Mean Mean	58.6 56.2	2.4	60.9 58.8	2.1	2.3 (3.8%)

Table 7

Estimates of stock size of North Atlantic fin whales.

Region	Method	Result	Reference
Newfoundland and Nova Scotia	Marking analysis	11,610	Mitchell, 1974, p. 147
Newfoundland and Nova Scotia	Strip census 1966–68	7,130	Mitchell, 1974, p. 147
Newfoundland and Nova Scotia	Catch/effort analysis	6,250	Mitchell, 1974, p. 147
Nova Scotia	Strip census	2,800	Mitchell, 1974, p. 147
Iceland	Marking analysis	4,358	Gambell, Jónsson and Jonsgård, 1973
Iceland	Total mortality rate	8,333	Gambell, Jónsson and Jonsgård,.1973
Iceland	Marking analysis	9,000	Rørvik, Jónsson, Jonsgård and Mathisen, 1976
Iceland with East and West Greenland	Marking analysis	11,000	Rørvik, Jónsson, Jonsgård and Mathisen, 1976
Norway and Faeroes	Cumulative catch 1945–73	7,234	International Whaling Statistics, analysed by author
Spain and Portugal	Cumulative catch 1921–27	6,433	International Whaling Statistics, analysed by Jonsgård, 1966a, p. 41.

include the Labrador coast. The population off Nova Scotia alone, shown by K. R. Allen to have been relatively distinct, was estimated to number about 2,000. The southern limits of this population are not clear, because no catching has taken place along the US eastern seaboard.

(b) Iceland

Jónsson (1965a) from an unchanging though variable catch per effort believed the stock of fin whales at Iceland to be in balance with catching. Rørvik, Jónsson, Mathisen and Jonsgård (1976) extended Jónsson's (1965a) study in time. They continued to find no significant change in catch per effort, nor any decline in percentage of mature animals, indeed this percentage had increased slightly. Mean annual catch during 1948 to 1973 had remained at 242. As shown in Fig. 1, catches of fin whales at Iceland and west Greenland from 1945 to 1973 remained steady with a cumulative catch of 6,633. The population must be larger than this figure, since it still exists in good condition. Gambell, Jónsson and Jonsgård (MS 1973) from the total mortality rate, as obtained from an age frequency using ear plug counts, calculated the stock to number 8,333 animals.

Rørvik *et al.* (1976) calculated a stock of 9,000 animals from mark recaptures, or a higher stock (some 11,000 animals) if west Greenland animals were to be included in a more comprehensive west Iceland-west Greenland stock.

(c) Norway–Faeroes

Considering this as one stock, crude addition of catches from 1945 to complete depletion in 1969–1971 gives a figure of 7,234 animals.

(d) Spain and Portugal

For 1921–1927, Jonsgård (1966a, p. 39) added catches in the same way and obtained a total, fully depleted population of 6,433.

Taking mean figures of estimates and assuming all the populations above, one finds a total of about 31,000 fin whales as follows:

Newfoundland and Nova Scotia	8,333
Iceland	7,230
West Greenland	2,000
Norway and Faeroes	7,234
Spain and Portugal	6,433
Total	31,230

Significant areas omitted would be: the present north American stocks south of Nova Scotia in summer, and past stocks in north Norway–Barents Sea. It is not clear from the data cited by Jonsgård (1966a) what area was comprised by the 'Spain and Portugal' stocks. Probably the fringe to the north, around Britain, was omitted, as well as that in the western Mediterranean Sea. So one might estimate primeval fin whale stocks in the North Atlantic Ocean as in excess of 30,000 but probably less than 50,000.

DISCUSSION

Absence of clear cut isolation of stocks, together with absence of clear cut migrations, implies that fin whales in the North Atlantic exist in a patchy continuum, with relatively small movements necessitated mainly by the search for food. Let us suppose that zooplankton, chiefly euphausiids, consititutes the basic food and that pelagic fish represent a richer, additional food supply, available when sufficiently accessible and concentrated, particularly in the pre-spawning, spawning and post-spawning adult stages on the Continental Shelf and in coastal waters. The concentrations of the fish are well-known because all are sought by man, and it is now more and more frequently reported that pelagic concentrations of capelin over the Continental Shelf are sought out simultaneously by purse-seining vessels and by whales, including fin whales. More detailed documentation of these correspondences is needed.

As to plankton, Kanaeva (1962) shows clearly (her Fig. 3) that moderate to high concentrations (50 to 200 or more mg/m^3) of food zooplankton, evidently mainly copepods but also prominently Euphausiacea in the depths 0–200 m., occur in a broad zone from the Carolinas past Newfoundland towards Iceland and the British Isles, as well as in the Bay of Biscay and (mainly outside the range of the fin whale) in the upwelling area of the northwest African coast. According to Klumov (1963), fin whales feed at 100–0 m. According to the data of Kanaeva, more than half the copepods and nearly half the Euphausiacea would be available at those depths, and it seems probable that at night the percentage available would increase due to upward migration of the zooplankton. As discussed by Nemoto (1959; see also Sergeant, 1969), whalebone whales apparently rarely find sufficient concentrations of zooplankton for adequate nourishment in the North Pacific. The same must hold true to much the same degree in the North Atlantic. However, if fin whales can survive the lean periods on such fare, the schooling pelagic fishes taken as the main foods during their spawning periods will give the whales the extra food needed for good nourishment. On such a regime, only small migrations will be necessary and these will be mainly between the plankton and fish feeding zones. The blue whale by contrast is a Euphausiid specialist, and as Jonsgård (1955) and others have shown, the balance of the evidence suggests that in the North Atlantic, this species makes extensive migrations.

FUTURE WORK NEEDED

Tagging would have been ideal during the 1950s but can now be contemplated only where whaling takes place, or can be foreseen. External tags would be useful if one can be devised which does not injure the animal and does not work out. Extension of Lund's work in the 1920s on iodine values of the oil (cited by Jonsgård, 1966a) appears profitable in order to separate stocks and might be extended to other biochemical methods, using either stranded or captured animals according to area. Maps of seasonal distribution with maps of abundance of food organisms (euphausiids and fish) as overlays would be useful, as done with the ICNAF Norwestlant surveys of 1963. Some work of this kind might be done on past data. Strandings are now well monitored on the US eastern seaboard and more analysis of seasonality of strandings would tell us more about southern displacement in winter on this and other coasts. Continued monitoring of strandings on European coasts will, among other things, tell in the long run at what rate depleted stocks of fin whales recover.

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ADDENDUM

Casinos, A. and Vericad, J.-R. (in press). The cetaceans of the Spanish Coasts; a survey. *Mammalia* (According to Dr A. Casinos, in litt., 16-III-76 this paper will analyse, inter al., past occurrences and strandings of fin whales on the Spanish coasts.)

Annex L
SC/28/Rep. 3

Report of the Sub-Committee on Small Cetaceans – London 7–9 June 1976

1. INTRODUCTORY REMARKS

The 27th Annual Meeting of the International Whaling Commission, held in June 1975, endorsed the recommendation of its Scientific Committee that the Sub-Committee on Small Cetaceans be retained as a standing sub-committee of the Scientific Committee. The Group met at 1030 hours on 7 June, and on the following days, in the Ministry of Agriculture, Fisheries and Food, under the Chairmanship of R. L. Brownell, Jr.

2. AGENDA AND DOCUMENTATION

The Agenda adopted for the meeting is attached as Appendix A. A list of working documents submitted is given in Appendix B.

3. PARTICIPANTS

Members (M) of the Sub-Committee or the Scientific Committee of IWC, invited experts (E), and observers (O) attended the meeting as listed below:

Aguayo, A. L.	(E)
Asper, E. D.	(E)
Bertrand, G. A.	(M)
Best, P. B.	(M)
Bree, P. J. H. van	(E)
Brown, S. G.	(M)
Brownell, R. L., Jr.	(M)
Christensen, I.	(M)
Duguy, R.	(E)
Gambell, R.	(Secretary, IWC)
Gaskin, D. E.	(E)
Holt, S. J.	(O, FAO)
Kapel, F. O.	(M)
Lockyer, C.	(M)
Mercer, M. C.	(M)
Mitchell, E. D.	(M)
Ohsumi, S.	(M)
Perrin, W. F.	(M)
Purves, P. E.	(E)
Sheldrick, M. C.	(E)
Tillman, M. F.	(M)

4. UPDATE OF SPECIES INFORMATION IN IWC, IUCN, FAO REPORTS

The following is a list of nominal species recognised in the three reports, in the same taxonomic order. New data are summarised below for each species.

Minke whale (*Balaenoptera acutorostrata*)
Jonsgård (Paper L.22) provides information on the value, market situation and prices in postwar Norway.

Pigmy right whale (*Caperea marginata*)
Best reported one additional record (photos available). Van Bree drew attention to an overlooked specimen from New Zealand collected in the second half of the last century and present in the Vienna Natural History Museum.

Shepherd's beaked whale (*Tasmacetus shepherdi*)
One new sighting record was reported from New Zealand (Watkins, 1976, *J. Mammal.* 57: 415).

Arnoux's beaked whale (*Berardius arnuxii*)
One old stranding reported, south east Atlantic. Ohsumi has mapped sightings of beaked whales by the Antarctic pelagic fishery. These will include this species.

Baird's beaked whale (*Berardius bairdii*)
Balcomb and Goebel (Paper L.8) summarised information from specimens taken in the Japanese coastal fishery. Ohsumi *et al.* (Paper L.20) records North Pacific pelagic sightings.

Beaked whales (*Mesoplodon spp*)
The Smithsonian Institution (James Mead) has lately collected a number of specimens (of several species) from east and west coasts of USA and from Alaska. Van Bree reported two strandings of *M. densirostris* on Mauritius (see C. Michel and P. J. H. van Bree, 1976. *Z. Säugetierkunde*, 41: 194–96). Recent strandings in South Africa covering several species will be treated by Ross and Best.

Cuvier's beaked whale (*Ziphius cavirostris*)
Aguayo (Paper L.12) noted that this species has been reported before from the Baltic Sea, but no confirmed specimen has yet been found.

Northern bottlenose whale (*Hyperoodon ampullatus*)
Jonsgård (Paper L.22), Christensen (Paper L.23) provide information on the fishing history and biology of this species.

Southern bottlenose whale (*Hyperoodon planifrons*)
Best reported on a specimen taken on a marking cruise.

Pygmy and dwarf sperm whales (*Kogia breviceps and K. simus*)
Odell and Asper (Paper L.10) summarise new records of these species in Florida. Mead continues to find these species to be the most common in single strandings on the east coast of the USA. Ohsumi (IWC/SC/25/10) refers to winter sightings in western Pacific tropical waters. Ross has in press a detailed study of specimens from South African waters.

Narwhal (*Monodon monoceros*)
Catch statistics for Canadian Arctic were presented (Paper L.26). Kapel has 1954–76 catch data available (Paper L.27) for Greenland.

White whale (*Delphinapterus leucas*)
Catch statistics for the Canadian Arctic were presented (Paper L.26). Mead observed a live specimen in Boston Harbour, Mass, May 1976. Kapel has 1954–76 data available (Paper L.27) for Greenland.

Rough-Toothed Dolphin (*Steno bredanensis*)
Perrin noted that his paper from Montreal (Paper M.40) referring to *Tursiops* sightings in the eastern tropical Pacific may include misidentified observations of this species.

Tucuxi (*Sotalia fluviatilis*)
No new data.

Indo-Pacific hump-backed dolphin (*Sousa chinensis*)
No new data.

Atlantic hump-backed dolphin (*Sousa teuszii*)
No new data.

Irrawaddy dolphin (*Orcaella brevirostris*)
Several live specimens are in good health in Jaya Ancol Oceanarium, Jakarta, Indonesia.

Melon-headed whale (*Peponocephala electra*)
Miyazaki and Wada (SC/28/Prog Rep 6) report sightings and one specimen was collected from the western tropical Pacific. Pilleri (*Invest. on Cetaceans*, Vol. 5) includes new information. Purves reported a series of skulls from Aldabra Island. Gaskin reported the possible occurrence off St Lucia, West Indies.

Pygmy killer whale (*Feresa attenuata*)
Sightings records are reported by Miyazaki and Wada (SC/28/Prog Rep 6) from the Western Pacific.

False killer whale (*Pseudorca crassidens*)
Ohsumi reported damage to Japanese long line tuna fishery by this species.

Killer whale (*Orcinus orca*)
Best reported that killer whales take tuna off hooks in the South African sports fishery. Ohsumi *et al.* has sightings data for North Pacific (Paper L.20) and Southern Hemisphere. Details of seven specimens netted off British Columbia appear in Mitchell (Paper L.23). MacAskie and Bigg have studied the discreteness of schools in British Columbian waters (Paper L.16) and Balcomb is doing a similar survey in Puget Sound (Washington). Erickson (University, Washington) radio tagged and tracked two animals for nine days during his survey. Perrin has a paper in preparation summarising sighting records in the eastern tropical Pacific.

Long-finned pilot whale (*Globicephala melaena*)
Mitchell (Paper L.23) records a mass stranding of about 300 animals in Newfoundland. Sheldrick (*Mammal Rev.* 1976, 6 (1): 15–23) indicated that strandings in the British Isles have increased during the period 1913–72. This may be associated with changes in sea temperature and Kapel reported catches of 80 in 1975 in Greenland, where the species had not been caught for a number of years. It seems that recently in the Faroe Islands large numbers of pilot whales have been taken.

Short-finned pilot whale (*Globicephala macrorhynchus*)
Perrin reported several taken in one net set in 1975 in the tuna fishery in the eastern tropical pacific and one was tagged and released. He also noted an association between skipjack tuna and pilot whales. Gaskin (Paper L.15) records the fishery for this species from St Lucia, WI. Van Bree reported a possible native fishery for this species in the south western Pacific but data from this fishery are not available at this time.

White-beaked dolphin (*Lagenorhynchus albirostris*)
No new data.

Atlantic white-sided dolphin (*Lagenorhynchus acutus*)
Van Bree noted that this species has moved southwards in the North Sea in the last 10–15 years. Increased numbers of strandings in 1975–76 on the east coast of North America are reported.

Dusky dolphin (*Lagenorhynchus obscurus*)
Social behaviour and local movements of radio tagged specimens are being studied off the Valdez Peninsula (Argentina) by Wuersig (University of New York). Brownell reported that probably hundreds of animals are taken annually in incidental fisheries along the coast of Peru. Goodall (Paper L.24) reports stranded specimens from Tierra del Fuego. Best reported that one specimen was in captivity in South Africa and that two live specimens had been sent to an aquarium in Switzerland.

Hourglass dolphin (*Lagenorhynchus cruciger*)
McIntyre has sightings records from the Antarctic 1975–76 season.

Peale's dolphin (*Lagenorhynchus australis*)
Goodall (Paper L.24) reports stranded specimens from Tierra del Fuego.

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
Perrin reported that five animals from a school were captured in a purse-seine off southern California and the carcases have been sent to the Smithsonian Institution. Ohsumi noted that there were several in captivity in Japan and Asper noted captive specimens in North America. There may be differences in northern and southern stocks of this species.

Fraser's dolphin (*Lagenodelphis hosei*)
Perrin reported many new records for this species and that colour differences suggest there may be northern and southern stocks. One or two specimens were captured in the western tropical Pacific (Miyazaki and Wada, SC/28/Prog Rep 6).

Bottlenose dolphin (*Tursiops truncatus*)
A workshop was held in December 1975 on breeding this species in captivity and the proceedings are being edited for publication by Ridgway and Benirschke. Anatomical observations on South Australian specimens by Harrison and Fanning are published in Pilleri, *Invest. on Cetaceans*, 5.

Risso's dolphin (*Grampus griseus*)
Hubbs and Leatherwood have a paper in press on a mass stranding in the Gulf of California. They and Perrin have a paper in preparation on all eastern Pacific stranding records. Miyazaki and Wada (SC/28/Prog Rep 6) sighted this species in the Western tropical Pacific. The species has been reported from the tuna fishery in the western tropical Pacific this year; two specimens were collected for the Smithsonian Institution.

Ocean Dolphins (*Stenella spp*)
New information is available in Papers L.1, L.2, L.3, L.4 and L.7. Miyazaki and Wada collected specimens in the western tropical Pacific of three species of *Stenella* including *S. longirostris.* Nishiwaki suggests there may be two forms of this species in that area. A possibly new larger form, similar to forms occurring in the Central and South Pacific has been discovered in waters south west of the Galapagos Islands and 'fished' (for tuna) this year for the first time by the international yellow fin tuna fleet. Perrin has material of *S. coeruleoalba* for a comparison with Japanese material. Van Bree reported a late 19th century mass stranding of about 60 animals, the first such record for this species. Sheldrick and Duguy reported recent strandings on the British and French coasts. There are two papers in Japanese by Kasuya on this species in the western Pacific. Perrin is making a behaviour study of these species in relation to the history of the tuna fishery. Kasuya has a paper in press (*Sci. Rep. Whales Res. Inst., Tokyo*) in which he reconsiders the life history parameters of spotted and striped dolphins based on cemental layers.

Common dolphin (*Delphinus delphis*)
Evans and Perrin have papers in preparation on biology, distribution, and abundance. Christensen reported a recent specimen from 68°N off the Norwegian coast. Asper noted that a few specimens are being maintained in captivity in the USA.

Southern right whale dolphin (*Lissodelphis peronii*)
Brownell noted that McIntyre has sightings records from the Antarctic 1975–76. Goodall (Paper L.24) reports stranded specimens for Tierra del Fuego.

Northern right whale dolphin (*Lissodelphis borealis*)
Leatherwood and Walker have a comprehensive manuscript available (Paper L.9) on the biology of this species.

Heaviside's dolphin (*Cephalorhynchus heavisidii*)
Best noted a sound recording of captive animals.

Black dolphin (*Cephalorhynchus eutropia*)
Aguayo and Mitchell (in preparation) are studying two skulls of this species and two of *C. commersonii* found in the collection of the Naturhistoriska Riksmuseet, Stockholm.

Hector's dolphin (*Cephalorhynchus hectori*)
Webb in New Zealand reports that this species is now confined to the Marlborough Sounds region. Gaskin compared this distribution with earlier records. The reduction in range may be a result of pollution by pesticides.

Commerson's dolphin (*Cephalorhynchus commersonii*)
Goodall reports stranded specimens (Paper L.24) from Tierra del Fuego.

Harbour porpoise (*Phocoena phocoena*)
Van Bree reported a very sharp decline in strandings on the Dutch coast, and Duguy noted a similar decline on the French coast. There has been no decline in British strandings. Differential pollution on the West European coasts and British coasts may be involved. Gaskin reported a possible change in age structure in the Eastern Canadian population; distribution is very local. Kapel noted that there had been a decline in Greenland catches since 1970. The reason for this decline is not clear. It may be only a periodic fluctuation. The pelagic gill-net fishery for salmon has ceased and the only fishery at Greenland is now Greenlandic and this fishery is severely restricted as to quota. Aguayo reported that M. Olsson from the Naturhistoriska Riksmuseet, Stockholm, is studying DDT and PCBs in several specimens from Baltic waters.

Cochito (*Phocoena sinus*)
Brownell stated that mortality in a former gill-net fishery in the Gulf of California was high but this fishery has now ceased. A joint US-Mexican scientific meeting in February 1976 recommended that additional research be undertaken to determine its current status.

Burmeister's porpoise (*Phocoena spinipinnis*)
Brownell and Mead recently found (January and February 1976) that this species is taken in large numbers along the Peru coast as an incidental catch. Goodall reports specimens (Paper L.24) from Tierra del Fuego.

Spectacled porpoise (*Phocoena dioptrica*)
Goodall (Paper L.24) reports many stranded specimens from Tierra del Fuego.

Dall's porpoise (*Phocoenoides dalli*)
Kasuya has a paper in preparation on specimens from the harpoon fishery in coastal Japanese waters. Leatherwood is working on eastern Pacific records.

Finless porpoise (*Neophocaena phocaenoides*)
Ohsumi reported the live birth of a calf, conceived in captivity, in October 1975 (*Japanese Journal of Zoo and Aquarium*). Van Bree noted that there are at least three different stocks. Kasuya is studying the species in the Seto Inland Sea. Best noted that there are no modern records for South African waters.

Ganges Susu (*Platanista gangetica*)
There is much new information in Pilleri, *Invest. on Cetaceans*, 6.

Indus Susu (*Platanista minor*)
No new data, but Van Bree (Paper L.30) reported that the specific name *minor* had priority over *indi*.

Boutu (*Inia geoffrensis*)
No new data.

White flag dolphin (*Lipotes vexillifer*)
New specimens are reported in a recent paper (Chen I-yu and Chen Wei, 1975. *Acta Hydrobiologica Sinica*, 5 (3): 360–71).

Franciscana (*Pontoporia blainvillei*)
Praderi has recent fishery statistics on the incidental catch of this species from Uruguay (Paper L.28).

Additional comments
The Sub-Committee was informed that a Working Group of the IWC Scientific Committee met in Oslo in April to discuss fin, minke and bottlenose whales in the North Atlantic. Stock units, biological parameters and catch statistics for these species were studied. The Group examined recent published stock assessments and made some new ones. A report on the meeting, including some recommendations for future studies, will be presented to the Scientific Committee (SC/28/Rep 2).

5. REGIONAL FISHERIES ACCOUNTS AND CATCH STATISTICS

Arctic

Mitchell (L.26) summarised the Arctic catch of the two species. White whales in Cumberland Sound, Baffin Island, were identified as low in number by Sergeant and Brodie (*J. Fish. Res. Board Can.* 1975, 32 (7): 1047–54), and warrant continuous monitoring. The Gulf of St Lawrence population, estimated as initially 5,000 or less (Mitchell, 1974. In *The Whale Problem*), is now estimated at 500 (Sergeant and Brodie, 1975, Table 1). Other populations appear to be stable. The only exploitation of whales in the Canadian Arctic is by Aboriginals.

Gaskin stated that the Gulf of St Lawrence population may be further reduced by proposed local development which might interfere with movements. The Saguenay River region seems to be the major remaining stronghold of the species in the southeast St Lawrence. Gaskin agrees with Sergeant and Brodie (1975: 1052) that the damming of the Manicouagan and Outardes rivers for hydroelectric power has eliminated calving in these river estuaries. Proposals for establishment of a National Park in the Saguenay region leading to increased human activity causes concern. Studies on the social structure and movements of the white whale in the Saguenay by Jean Laurin are being completed at the University of Guelph, Canada.

Canadian narwhal loss rates may be in the order of 100% of catch and white whale loss rates may be in the order of 75% of catch (L.26). Narwhal biology and loss rates are being investigated by Keith Hay (McGill University) working in conjunction with the Arctic Biological Station, at Pond Inlet, Baffin Island.

In Canada, new narwhal regulations by quota per village rather than per hunter are being considered. Present regulations are five narwhal per hunter. The narwhal was listed by Canada in Appendix 3 of the International Convention on Trade in Endangered Species of Wild Fauna and Flora, thus an export permit is required for tusks.

Tillman reported that the State of Alaska has requested that management of some marine mammals be returned to the State. The State management plan includes a white whale quota for total take, including aboriginal, of 360 animals. There is no narwhal hunting in Alaska, as only stragglers appear along the northern coast.

Greenland catch statistics presented by Kapel (Paper L.27) record the 1975 catch of white whales as 400, but additional information is expected to raise the total to 700. Catches fluctuate greatly with the incidence and extent of ice entrapment. The 1975 total recorded catch for narwhals is 120; but with additional data from Thule may be found to be nearer to 250. Kapel pointed out as did Mitchell that loss rates in the spring are high in ice-edge hunting but decline as the season progresses. Local regulations for narwhal hunting in North Greenland (Thule) require harpooning before shooting, reducing the loss rate significantly.

Temperate North Atlantic

Gaskin reported that *Phocoena phocoena* is caught as a by-catch in trawling in Bay of Fundy but numbers are probably low. Fixed herring weirs catch an estimated 60 animals in south-western New Brunswick alone. The total weir catch including Grand Manan Island is probably over 100 per year. Trapped porpoises are often released alive. Up to 10 animals per season are trapped in gill-nets on Grand Manan Island, also with some released alive.

The Passamaquoddy Indians on Moose Island in Maine kill an estimated 30 *P. phocoena* per year. Gaskin has verified reports of over several dozen *P. phocoena* killed on the Gaspé Peninsula each year for meat.

Kapel noted that the non-Greenlandic salmon driftnet fishery has recently stopped. This fishery in 1972 was responsible for an estimated by-catch of approximately 1,500 porpoise. However, Kapel also stated that the local Greenlandic salmon driftnet may still be taking a by-catch of this species and the incidental take by this fishery and by shooting from other vessels has declined from approximately 1,000 individuals per year to about 700 to 800.

Phocoena phocoena has been decreasing in the Baltic Sea as pollution and over-fishing have increased. No data are available for the Iceland incidental and direct kill of this species. The Secretary was asked to gather information on this problem.

Van Bree asked about British herring fishery by-catches of *Phocoena*. The Secretary was asked to gather information since none was available to this Committee.

Duguy (Paper L.21) reported two netted specimens in coastal France and felt that fishermen and increased pollution have seriously affected this species. Strandings are less than one per year where formerly common and live sightings have ceased in many areas.

Van Bree indicated two significant drops in harbour porpoise stranding on the coast of the Netherlands in 1950 and 1958. Sheldrick (1976) noted a drop in British strandings in 1938 and 1970.

Mercer noted that the Newfoundland pilot whale fishery declined due to a depletion of the population. The fishery ceased with the imposition of a total ban on commercial whaling in Canada on 22 December 1972.

Jonsgård (Paper L.22) reported that the 1975 bottlenose and pilot whale catches were zero and the killer whale catch was two animals. Christensen said killer whales appear to be increasing in coastal Norway and fishermen are complaining of interference with the herring fishing. No data on actual numbers are available.

No data are available on the *D. delphis* catch in the Azores but evidence of a marketable catch exists in photographs. Data may be available from a mainland fisheries officer stationed on the islands to gather fisheries information.

Mediterranean

Duguy reported a kill of *Stenella, Delphinus* and *Ziphius* on the southern French coast by shooters in speedboats. Stranded animals have bullet holes. There is a small incidental catch in a net fishery. French law currently prohibits the marketing of small cetaceans.

The bottlenose dolphin live capture operation is no longer active. Greek fishermen's complaints of *D. delphis* damage to the fishery were noted but no information was available.

Black Sea

No new information.

Tropical Atlantic

Although purse-seining for tuna associated with dolphins is known from the Atlantic North African coast there is very little data on incidental kills. Van Bree reported that museum data include specimens and information that indicate French, Spanish, Russian, Japanese and South Korean vessels may be involved in this fishery. More precise information is needed and IWC member countries are urged to collect these data and make them available.

The Mauritania mullet fishery does not appear to involve any *Tursiops* or *Sousa* mortality.

Gaskin (Paper L.15) discussed the primitive St Lucia fishery for cetaceans. There are 12 vessels but only 4 are significant for the catch. Increased gasoline prices may eliminate the fishery. No data are available on catches for St Lucia or St Vincent for 1974. Gaskin indicated that 100–200 short finned pilot whales and a similar number of *Stenella spp* and *S. longirostris* were taken in 1972. There are no loss rate estimates but the loss may be high.

Temperate South Atlantic

A small number of dolphins (probably mostly *D. delphis* and *L. obscurus*) are taken incidentally in a purse-seine fishery for pelagic fish and deliberately by hand-harpooning from a variety of fish boats off Southern Africa.

The South Africa live capture fishery for cetaceans is now regulated.

Brazil has an incidental fishery but no data are available. Praderi (Paper L.28) reported that the Uruguay fishery for *Pontoporia blainvillei* has declined in 1974 and 1975 to approximately 150 and 100 respectively.

Goodall (Paper L.24) mentions a small incidental take of *C. commersoni* and *L. australis* in a crab net fishery in Tierra del Fuego. The change from crab nets to crab pots will eliminate this kill, but Goodall pointed out that direct catches might occur and that the dolphins could be used to bait the crab pots.

North Pacific

Ohsumi (Paper L.20) discussed the coastal small cetacean fishery in Japan. In 1974 approximately 20,000 animals were taken but the species composition of the catch is unknown. There is an apparent increasing efficiency in this kill with more species being taken. Less than five killer whales per year were taken from 1972 to 1975, but many were sighted.

Balcomb and Goebel (Paper L.8) summarised the Japanese catch of 25–30 *Berardius bairdii* each year in Chiba Prefecture, Japan. Only one station is active. *Ziphius cavirostris* and a few *B. bairdii* are taken in the pelagic fishery.

Nishiwaki and Uchida (Paper L.29) reported catch records of small cetaceans from the Ryukyu Islands between 1960 and 1976. The species involved in this drive fishery are: *Tursiops*, *Steno*, *Pseudorca* and *Globicephala macrorhynchus.*

Asper summarised Goldsberry *et al.* (Paper L.11) on killer whales caught live from 1961 to 1976. To date 303 animals have been caught in California, Oregon, Washington and British Columbia. Ten died, 56 were kept and 237 were released. Capture mortality was 0.22% per year and post-capture mortality was 4.5% per year. This was discussed and the mortality may have declined in recent years. Asper was asked to collect and circulate current information. The population estimate of 300–600 individuals was estimated in the four areas examined. This is higher than other estimates.

A review of the status of the population of killer whales in British Columbia was recently finished and management implications are under review.

The US Marine Mammal Act of 1972 allows an inspection officer to be present at the live capture of marine mammals and this usually occurs. In Canada individual permits are required from the government for the live capture of cetaceans.

The estimated take of porpoise (all species) in the US yellow-fin tuna industry for 1975 was 134,224; the total for all nations was 159,093 (Powers, Paper L.6). A judicial decision interpreting the US Marine Mammal Act would have stopped setting on porpoise as of 1 June 1976, but there is a stay of the order while the decision is on appeal. Fox, Powers and Lenary (Paper L.7) indicate that the estimated kill for the first 3½ months of 1976 was 67% lower than in the same period for 1975. This was due in part to excellent skipjack tuna fishing which does not involve porpoise sets, to improved gear and to adherence to regulations on fishing methods.

Mitchell (Paper L.26) indicated that Canadian boats (5) use the Medina panel. There are no public statistics on porpoise kill in the Canadian fishery in the eastern tropical Pacific.

Omura (Paper L.20) reported eight sets on porpoise in the equatorial area 120°–130°W during experimental tuna cruises. No information on mortality is given.

No information on French, Mexican, or Panamanian porpoise sets is available.

There are now 11 species involved in the purse-seine porpoise mortality in the eastern tropical Pacific. The newly reported species are: *Globicephala macrorhynchus, Grampus griseus* and *Peponocephala electra.*

Central, Southern and Western Tropical Pacific and East Indian Ocean

Bannister (Paper L.25) reported that a survey of Australian State Fishery Departments and other workers showed a small take of cetaceans, probably *Tursiops* and *Delphinus*, for bait and a small incidental take in fishing operations. Shark nets set to protect swimming beaches kill large numbers, 20% on one beach. Genera involved are *Orcaella, Sousa, Tursiops* and possibly *Pseudorca.*

Gaskin and Van Bree have some information to suspect a take of small cetaceans in the tropical islands of Samoa (short finned pilot whales) Gilbert, Ellice and Papua New Guinea.

Temperate South Pacific

Brownell reported that he and Mead recently visited Peru to collect information on marine mammals being exploited by man, or killed incidental to other fisheries. They made short trips to Chimbote and Pisco. In Chimbote they found that the following small cetaceans were taken incidental to fishing operations: *Phocoena spinipinnis, Lagenorhynchus obscurus, Tursiops truncatus, Delphinus delphis.* In Pisco they visited the fishmarket at San Andres where they found the remains of the following species that were probably taken incidental to commercial fishing operations: *P. spinipinnis*, *T. truncatus*, and *Mesoplodon* sp. They also found remains of the following species on the beaches in Caleta Lagunillas and Bahia de Paracas that may either have been taken incidental to fishing operations, or may have washed ashore dead of natural causes: *P. spinipinnis, L. obscurus, T. truncatus, Grampus griseus,* and *Globicephala* sp.

West Indian Ocean

Best (Paper L.17) summarised the shark net fishery on 39 beaches in South East Africa. The minimum kill was 17 *T. truncatus* (*aduncus*), 104 *D. delphis* and 1 *S. chinensis (plumbea).*

Antarctic

No new data, but Ohsumi noted that the Japanese Antarctic fleets do not take small cetaceans.

6. SPECIES ACCOUNTS

Stenella spp

Perrin summarised the three papers L.1, L.2 and L.3 on *Stenella.*

The first (L.1) on growth and reproduction in *S. attenuata* in the offshore eastern tropical Pacific is based on data from several thousand specimens. Gestation is 11.5 months. Direct calibration of dentinal layers after the first year is not possible. Breeding is diffusely seasonal. Sexual maturity is on average attained at about 12 dentinal layers in males and 9 layers in females. Corpora albicantia persist indefinitely and ovulation rate declines with age. The average calving interval is 26 months and the gross annual production of calves is 14.4% of the population per year. There was no evidence of age or sex segregation in schools. The estimated parameters differ consistently from those for a population in the Western Pacific, possibly reflecting the exploitation in the Eastern Pacific.

The second paper (L.2) on growth and reproductive parameters of the whitebelly spinner dolphin, a geographical form of *S. longirostris* in the eastern tropical Pacific, is based on 985 specimens. Various parameters are compared with those for the eastern form of the species. Both sexes of the whitebelly form are on average longer than the eastern form. Sex ratios do not differ in the two populations. A significantly greater proportion of whitebelly females are simultaneously lactating and pregnant than of the eastern form females. Differences in the proportions of females of reproductive age in the two populations may be inherent or it may reflect a change in age structure of one of the populations resulting from exploitation in the tuna fishery.

The third paper (L.3) on growth and reproduction of the eastern spinner dolphin, a geographical form of *S. longirostris* in the eastern tropical Pacific, is based on some 2,600 specimens. Gestation is 10.6 months and average length at birth 77.0 cm. Direct calibration of dentinal growth zones is not possible. Males attain sexual maturity on average at 9 to 12 zones and females at 5.5 zones. Corpora albicantia persist indefinitely and ovulation rate declines with age. Estimates of annual pregnancy rate range from 0.243 to 0.444 and of calving interval from 4.12 years to 2.25 years. The gross annual reproductive rates are estimated at 5–10%, compared with 14% in *S. attenuata.*

Kasuya (1976a, 1976b *Geiken Tsushin* Nos 295, 296) continued his studies of *S. coeruleoalba* and believes MSY to be approximately 5,000 per year. The current catch is 10,000 per year. Uncertainties in the population estimate result from the estimates of natural mortality rate, estimation of the annual change of mean calving intervals, lack of past statistics, and the lack of an independent method of checking the recent trend of population decrease. However, a decrease in population size is suggested by the decrease in the number of dolphin fishing groups on the Izu coast, extension of the fishing grounds offshore and use of improved equipment associated with a decline in catch. If the population is nearly at the level producing the MSY, continuation of the present annual catch for 20 years will reduce the population to half the present level. If the catch is reduced to about 5,000 annually, fishing can be continued indefinitely.

Ohsumi feels that this is an underestimate of potential yield due to the possibly larger stock size, wider distribution, and method of estimating fishing mortality.

Miyazaki (Paper L.18) analysed school structure by age, sex and movements between schools. The number of schools of immature, mature and mixed animals were 9, 21 and 10 respectively. Size of immature, mature and mixed schools were 36–903 ($\bar{x}$ = 277) 25–2,327 ($\bar{x}$ = 470) and 225–912 ($\bar{x}$ = 375) dolphins respectively for *S. coeruleoalba.*

Phocoena phocoena

Gaskin reported on the harbour porpoise in the Bay of Fundy approaches (Papers L.13, L.14). This population has been under study by personnel at the University of Guelph since 1969. Study of sightings per unit effort during the period 1969–75 indicate no particular trend in changes of abundance other than the effect of variation in oceanographic conditions and productivity in the region.

Seasonal movements can be closely correlated with those of the main food species, herring and mackerel. The greater part of the population leaves the region at the end of summer or in the early autumn. The main population disappears in the region when surface temperatures of 8°C are recorded. A very few animals over-winter in temperatures of 1.9°C to 3.8°C. The main migratory movement appears to be onshore-offshore. Based on the sighting data, a preliminary estimate of the minimum summer population is about 4,000 animals in the Bay of Fundy, northern Gulf of Maine and Atlantic coast of Nova Scotia. The maximum may not be much more than 8,000 animals.

Pygmy and dwarf sperm whales ***Kogia spp***

Odell and Asper (Paper L.10) found 5 *Kogia simus* and 11 *K. breviceps* stranded in central and south Florida. Up to 17,000 ppb DDT was found in the fatty tissues of stranded animals. Copper, zinc and lead were high, particularly in the liver.

Northern right whale dolphin ***Lissodelphis borealis***

Brownell summarised the Leatherwood and Walker paper (L.9) on the strandings, sightings, schooling and biology of *L. borealis.* There are 10 past stranding records and 24 new records are added. 175 new at-sea sightings are added to the previously recorded 16.

Killer whale ***Orcinus orca***

Bigg (Paper L.16) summarised the identification work on the Puget Sound population of *O. orca.* The method of identification used includes black and white photography of dorsal fins, and scar and saddle markings. Dorsal fin injuries, scars and cuts appeared to change little during the 1972–76 study period. The recommendation was made that fin changes and growth be examined in captive animals.

7. RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

7.1. Recognised list of small cetaceans

The Small Cetacean Sub-Committee recommends to the Scientific Committee of the IWC that the list of smaller cetaceans of the world (Report of the Meeting on Smaller Cetaceans, Montreal, *J. Fish. Res. Board Can.* 1975, 32 (7): 966–68) be recognised and accepted, for administrative and reference purposes, as the working list of smaller cetaceans of the world and that the Scientific Committee recommend the list to the Commission of the IWC for similar recognition and acceptance. This list is attached as Appendix C.

7.2. Management of small cetaceans

The Sub-Committee points out to the Scientific Committee that there is an urgent need for an international body to effectively manage stock of all cetaceans not covered by the present IWC Schedule. This body should concern itself with all types of exploitation of cetaceans, both incidental and deliberate. All nations involved in such exploitation of small, as well as large cetaceans, should be included in such a body, but the Sub-Committee recognises the political problems this creates and points out that many of the small cetacean 'fisheries' are carried out by member nations of the IWC.

The Sub-Committee therefore recommends that the present Convention for the regulation of whaling should be revised so that the Convention covers all cetaceans and all forms of exploitation, and that further efforts should be made to enlarge membership of the IWC to include other nations that are involved in cetacean exploitation. The Sub-Committee recognises however, that this approach will be time-consuming and may not be immediately acceptable to all members.

In the meantime, the Sub-Committee recommends that all cetaceans taken deliberately for their own value should be subject to consideration by the Scientific Committee for future management and, in particular, points to the following species in the following areas for immediate action:

Northern Bottlenose Whale – *Hyperoodon ampullatus* – North Atlantic.
Striped Dolphin – *Stenella coeruleoalba* – North West Pacific.
Dall's Porpoise – *Phocoenoides dalli* – North West Pacific
Harbour Porpoise – *Phocoena phocoena* – North Atlantic.

7.3. Definition of new stock category

In considering the status and possible management of small cetacean stocks, the Sub-Committee recognised that it would be unlikely to be in the possession (either now or in the immediate future) of sufficient basic data to be able to classify the stocks in the way that large whale stocks are now classified under the New Management Procedure, i.e. in relation to the MSY level. On the other hand there could be occasions when circumstantial evidence indicted that a population had been severely affected by exploitation and some management action seemed imperative. The Sub-Committee therefore felt that new management categories might be created. It therefore suggested the addition of the following classification to the Schedule:

(a) *Vulnerable Stocks* – those that circumstantial evidence suggests have been heavily fished in the past or are being heavily fished now and for which there is urgent need of population assessment.

Management action that should be taken would be:

1. Catch may be permitted up to present levels for NOT MORE THAN five years.
2. Within the five year period national bodies fishing the stock should produce appropriate scientific evidence (e.g. present population size, present level of take, biological evidence on the response of that population to exploitation) on the basis of which the Commission could take whatever management action is needed.
3. If the national bodies are unable to provide such evidence, there should be no further catch until evidence becomes available.

7.4. Collection of statistics

(a) Statistics and data should be collected by the IWC on a mandatory or optional basis for the various small cetaceans as indicated below:

(i) Biological data: the already existing form employed by IWS should be adopted for IWC use and made mandatory for reporting data on small cetaceans taken during pelagic and land-based large whale operations as well as in pelagic and land-based operations relying entirely on small whales. The same form should be used as practical to collect biological data on animals examined or sub-sampled in local small harpoon fisheries for small cetaceans, in direct drive and net fisheries, in purse-seining operations and other situations causing incidental kills.

(ii) Catch effort data:

(a) For small whales taken in the course of large-whale operations the same data should be required as for large whales.

(b) For pelagic and land-based small-whale operations, the following should be collected on a daily basis:

*Time to grounds, *time searching, *time chasing *time towing, *time lost, *time in port.
*Position of sighting
*Numbers sighted by species
Direction of travel of animals
Water temperature
*Numbers killed by species
*Length
*Sex
*Time killed
Average whale sighting distance

Weather observations for morning and afternoon as follows:
  *Sea state
  Wind speed
  *Visibility
  Wind direction
  Wave height
  Atmosphere
*Time landed

* = Essential information

Items included in (b) are included in a form reproduced on pages 173–74 of 'Report and Papers of the Scientific Committee of the Commission 1975'.

- (c) For local, sporadic harpoon fisheries, and
- (d) For drive and net direct fisheries, and
- (e) for deliberate incidental fisheries (e.g. tuna purse seining), and
- (f) For inadvertent incidental captures.

The following data should be collected for each operation: (ref. Mitchell, E. 1975 'Porpoise, Dolphin and Small Whale Fisheries of the World', IUCN Monograph No. 3).

The catch and effort statistics should include as a minimum:

- (a) The species name and the local vernacular name where available.
- (b) The numbers caught, and the gross weight of the accompanying catch where available.
- (c) The numbers killed or wounded and not recovered.
- (d) The date of capture.
- (e) An appropriate indication of the intensity of the catching effort such as:
  - (i) Catcher vessel days spent hunting and capturing.
  - (ii) The number of cetaceans captured, and killed, in each net set.
  - (iii) The number of net sets per month.
  - (iv) The number caught in each drive ashore and the number of boats used in the drive.
  - (v) The number of hunter days expended in harpooning cetaceans.
  - (vi) Any modifications of these measures or data from other suitable indicators of hunting effort.

(b) The Small Cetacean Sub-Committee recommends that the Scientific Committee consider the appropriate way to contact Regional Fishery Management Bodies, requesting them to provide catch and effort data for incidental captures by the fisheries with which they are concerned.

7.5. Research

It is recommended that the Secretariat and governments of member nations be urged to initiate or augment research on species involved in direct fisheries. Priority problem species and recommended research are:

1. Northern bottlenose whale (Hyperoodon ampullatus) North Atlantic

As pointed out by the Working Group on North Atlantic Whales (SC/28/Rep 2), sighting cruises should be undertaken in the North Atlantic to obtain independent estimates of stock size, giving particular emphasis to bottlenose whales across the former bottlenose whaling grounds, since Norwegian whaling boats are now operating in different areas.

2. Striped dolphin (Stenella coeruleoalba) North West Pacific

Although extensive biological and population studies have been carried out, several specific research needs remain. Collection of catch and effort statistics with more complete species identification is needed for fisheries in which other species are also taken; species are now lumped in many of the available statistics. Tagging and census studies are needed in order to obtain information on school structure, migration and definition of stocks. Life history parameters need to be monitored, as the status of the population has changed and may continue to change.

3. Dall's porpoise (Phocoenoides dalli) North West Pacific

This species is involved in both direct and incidental fisheries. The identity and discreteness of three putative stocks in the North Pacific need to be tested through comparative systematic studies of pigmentation, biochemical blood analysis, external morphometrics, osteology and through analysis of catch/effort data by area. Basic life history parameters need to be calculated, through study of materials and data collected in the field, so that the status of the stocks can be assessed. Such materials must be collected over at least a 3-year period, in connection with the collection of incidental kill statistics in the salmon gill-net fisheries recommended elsewhere in this report.

4. Harbour porpoise (Phocoena phocoena) North Atlantic

This species is involved in both direct and incidental fisheries along the west coast of Greenland. In recent years up to 2,500 porpoises have been taken each year. This is a coastal species and this catch must certainly be considered substantial for such a restricted area. These fisheries should be examined and sampled over at least a 3-year period, along with the collection of catch statistics. Additional problems for the species may exist in the Baltic and the North Sea.

7.6. Studies of effort

The Sub-Committee noted the comments of the Working Group on North Atlantic Whales (SC/28/Rep 2) concerning the importance of factors which have an influence on effort, e.g. the opportunistic and/or multispecies nature of small cetacean fisheries and the complex behaviour of small cetaceans themselves. Consequently, the Sub-Committee concurred with the recommendation of the North Atlantic Working Group that studies of these factors be undertaken in order to develop better effort statistics which increase the sensitivity of catch per unit effort as an indicator of stock size for small cetaceans.

7.7. Recommendation on age determination

Extensive collection of material for age determination is required to facilitate stock assessment independent of effort statistics; virtual population analysis would provide a means of checking on population estimates from catch per unit data in some instances and provide a valid methodology in instances where catch per unit effort data can be demonstrated to provide inadequate indices of stock size. The Sub-Committee recommends that efforts be made to collect information and materials wherever possible.

7.8. Need to convene workshops

The Sub-Committee noted the proposals initiated by the FAO/ACMRR Group II (small cetaceans) to convene two international workshops. One will be concerned with age determination, and the other with female reproduction in odontocetes. Preliminary suggestions are to convene these meetings in April and December 1978 respectively. The Sub-Committee supports these proposals, and asks the Scientific Committee to request the Commission to join in sponsoring the meetings.

7.9. Research on captive cetaceans

The Sub-Committee feels that more information should be derived from captive cetaceans that would be useful as control data for wild cetaceans. Such information is particularly needed for studies on age and growth, feeding rates and changes in pigmentation, scars and surface lesions. It is recommended that special effort should be made to co-ordinate a programme of dosing captive animals with tetracycline shortly after arrival at the facility and freeze-branding or otherwise identifying the animal with a code when it is dosed designating it as a dosed animal. Teeth should be collected at death or prior to release alive. The Sub-Committee felt that an approach should be made to the IWC Secretary to initiate such a programme through negotiations with appropriate groups.

7.10. Consideration of the current status of the northern bottlenose whale (*Hyperoodon ampullatus*)

The document by Christensen (Paper L.23) was discussed and questions were raised about the validity of the estimate. The Sub-Committee asked Holt (SC/28/Doc 12); Tillman and Bertrand (SC/28/Doc 24); and Mitchell (SC/28/Doc 30) to prepare papers setting out their criticism for discussion by the Scientific Committee.

Appendix A

SUB-COMMITTEE ON SMALL CETACEANS

Agenda

1. Introductory remarks.
2. Agenda and documentation.
3. Participants.
4. Update of species information in IWC, IUCN and FAO Reports.
5. Regional Fisheries Accounts and Catch Statistics.
6. Species Accounts.
7. Recommendations to the Scientific Committee.

Appendix B

WORKING DOCUMENTS SUBMITTED TO MEETING OF SUB-COMMITTEE ON SMALL CETACEANS

L.1 PERRIN, W. F., *et al.* Growth and Reproduction of the Spotted Porpoise, *Stenella attenuata*, in the Offshore Eastern Tropical Pacific. *Fish. Bull.* 74 (2), 1976.

L.2 PERRIN, W. F., *et al.* Preliminary Estimates of Some Parameters of Growth and Reproduction of the Whitebelly Spinner Dolphin, A Geographical Form of *Stenella longirostris*, in the Eastern Tropical Pacific. *Southwest Fisheries Center Administrative Report* No. LJ-76-12.

L.3 PERRIN, W. F., *et al.* Growth and Reproduction of the Eastern Spinner Dolphin, A Geographical Form of *S. longirostris* in the Eastern Tropical Pacific. *Southwest Fisheries Center Administrative Report* No. LJ-76-13.

L.4 KIMURA, M. and PERRIN W. F. Progress Report on Studies of the Biology, of the Striped Dolphin, *Stenella coeruleoalba*, in the Eastern Tropical Pacific. *Southwest Fisheries Center Administrative Report* No. LJ-76-11.

L.5 EVERETT, J. T. Co-operative Tuna Industry/Government Porpoise Mortality Reduction Experiment – A Brief Overview, for use of Vessel Captains & Owners.

L.6 POWERS, J. E. Estimated Incidental Porpoise Mortality in the Eastern Pacific Tuna Fishery for 1975. *Southwest Fisheries Center Administrative Report* No. LJ-76-4.

L.7 FOX, W. W., Jr, *et al.* Incidental Porpoise Mortality by US Purse Seine Vessels, 1 January through 14 April 1976. *Southwest Fisheries Center Administrative Report* No. LJ-76-7.

L.8 BALCOMB, K. C. III and GOEBEL, C. A. Some Information on a *Berardius bairdii* Fishery in Japan.

L.9 LEATHERWOOD, S. and WALKER, W. A. 1977 (in press). The Northern Right Whale Dolphin *Lissodelphis borealis* Peale, in the Eastern North Pacific. *In* Winn, H. E. and Olla M. C. *Behaviour of Marine Animals. Vol. III. Natural History of Cetaceans.* N.Y. Plennum Press.

L.10 ODELL, D. K. and ASPER, E. D. Studies on the Biology of *Kogia* (Cetacea; Physeteridae) in Florida: Preliminary Report.

L.11 GOLDSBERRY, D. G., *et al.* Live Capture Techniques for the Killer Whale (*Orcinus orca*) and Live Capture Fishery Statistics 1961–76.

L.12 AGUAYO, A. L. Smaller Cetaceans in the Baltic Sea.

L.13 GASKIN, D. E. and BLAIR, B. A. Age Determination of Harbour Porpoise *Phocoena phocoena* (L.) in the western North Atlantic. *Can. J. Zool.* 55 (1), 1977.

L.14 GASKIN, D. E. Harbour porpoise *Phocoena phocoena* (L.) in the Western Approaches to the Bay of Fundy 1969–75.

L.15 GASKIN, D. E. and SMITH, D. J. The Small Whale Fishery of St Lucia, WI.

L.16 BIGG, M. A. Photographic Identification of Individual Killer Whales.

L.17 BEST, P. B. and ROSS, G. J. B. Exploitation of Small Cetacea off South Africa.

L.18 MIYAZAKI, N. School structure of *Stenella coeruleoalba.*

L.19 OMURA, H. A Brief Report on Experimental Tuna Fishing in the Eastern Tropical Pacific by Nippon Maru in 1975.

L.20 OHSUMI, S., MASAKI, Y. and WADA, S. A Note on Distribution of Some Smaller Cetaceans in the North Pacific.

L.21 DUGUY, R. Note sur les petits cétacés des côtes de France.

L.22 JONSGÅRD, Å. A Note on the Value of Bottlenose Whales in Relation to Minke Whales in Postwar Seasons, and the influence of the market situation and the prices on Norwegian whaling activity.

L.23 CHRISTENSEN, I. The history of exploitation and the Initial Status of the Northeast Atlantic Bottlenose whale (*Hyperoodon ampullatus*). IWC/NA/76/1.

L.24 GOODALL, R. N. P. Preliminary Report on the Small Cetaceans Stranded on the Coasts of Tierra del Fuego.

L.25 BANNISTER, J. L. Incidental Catches of Small Cetacea off Australia.

L.26 MITCHELL, E. D. Canadian Progress Report on Whale Research, June 1975–May 1976. IWC/SC/28/Prog Rep 3.

L.27 KAPEL, F. O. Catch of Belugas, Narwhals and Harbour Porpoises in Greenland, 1954–75, by year, month and regions.

L.28*PRADERI, R. Incidental Catch of Franciscanas, *Pontoporia blainvillei*, in shark gill-nets off Uruguay, 1975.

L.29*NISHIWAKI, M. and UCHIDA, S. Dolphin Fishing in the Ryukyus.

L.30*VAN BREE, P. J. H. On the Correct Latin Name of the Indus Susu (*Cetacea, Platanistoidea*). *Bull. Zool. Mus. Univ. Amsterdam*, 5 (17), 1976.

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* Paper arrived at end of meeting.

APPENDIX C

LIST OF SMALLER CETACEANS RECOGNISED

Scientific Name	*Recommended Common Name*
Balaenoptera acutorostrata Lacepede, 1804	Minke whale
Caperea marginata (Gray, 1846)	Pygmy right whale
Tasmacetus shepherdi Oliver, 1937	Shepherd's beaked whale
Berardius arnuxii Duvernoy, 1851	Arnoux's beaked whale
Berardius bairdii Stejneger, 1883	Baird's beaked whale
Mesoplodon pacificus (Longman, 1926)	Longman's beaked whale
Mesoplodon bidens (Sowerby, 1804)	Sowerby's beaked whale
Mesoplodon densirostris (de Blainville, 1817)	Blainville's beaked whale
Mesoplodon europaeus (Gervais, 1855)	Gervais' beaked whale
Mesoplodon layardii (Gray, 1865)	Strap-toothed whale
Mesoplodon hectori (Gray, 1871)	Hector's beaked whale
Mesoplodon grayi von Haast, 1876	Gray's beaked whale
Mesoplodon stejnegeri True, 1885	Stejneger's beaked whale
Mesoplodon bowdoini Andrews, 1908	Andrew's beaked whale
Mesoplodon mirus True, 1913	True's beaked whale
Mesoplodon ginkgodens Nishiwaki & Kamiya, 1958	Ginkgo-toothed beaked whale
Mesoplodon carlhubbsi Moore, 1963	Hubb's beaked whale
Ziphius cavirostris G. Cuvier, 1823	Cuvier's beaked whale
Hyperoodon ampullatus (Forster, 1770)	Northern bottlenose whale
Hyperoodon planifrons Flower, 1882	Southern bottlenose whale
Kogia breviceps (de Blainville, 1838)	Pygmy sperm whale
Kogia simus Owen, 1866	Dwarf sperm whale
Monodon monoceros Linnaeus, 1758	Narwhal
Delphinapterus leucas (Pallas, 1776)	White whale

Appendix C (Cont.)

Scientific Name	*Recommended Common Name*
Steno bredanensis (Lesson, 1828)	Rough-toothed dolphin
Sotalia fluviatilis (Gervais, 1853)	Tucuxi
Sousa chinensis (Osbeck, 1765)	Indo–Pacific hump-backed dolphin
Sousa teuszii (Kukenthal, 1892)	Atlantic hump-backed dolphin
Orcaella brevirostris (Gray, 1866)	Irrawaddy dolphin
Peponocephala electra (Gray, 1846)	Melon-headed whale
Feresa attenuata Gray, 1875	Pygmy killer whale
Pseudorca crassidens (Owen, 1846)	False killer whale
Orcinus orca (Linnaeus, 1758)	Killer whale
Globicephala melaena (Traill, 1809)	Long-finned pilot whale
Globicephala macrorhynchus Gray, 1846	Short-finned pilot whale
Lagenorhynchus albirostris (Gray, 1846)	White-beaked dolphin
Lagenorhynchus acutus (Gray, 1828)	Atlantic white-sided dolphin
Lagenorhynchus obscurus (Gray, 1828)	Dusky dolphin
Lagenorhynchus cruciger (Quoy & Gaimard, 1824)	Hourglass dolphin
Lagenorhynchus australis (Peale, 1848)	Peale's dolphin
Lagenorhynchus obliquidens Gill, 1865	Pacific white-sided dolphin
Lagenodelphis hosei Fraser, 1956	Fraser's dolphin
Tursiops truncatus (Montagu, 1821)	Bottlenose dolphin
Grampus griseus (G. Cuvier, 1812)	Risso's dolphin
Stenella longirostris (Gray, 1828)	Spinner dolphin
Stenella coeruleoalba (Meyen, 1833)	Striped dolphin
Stenella attenuata (Gray, 1846)	Spotted dolphin (two species)
Stenella dubia (G. Cuvier, 1812)	
Stenella frontalis (G. Cuvier, 1829)	
Stenella plagiodon (Cope, 1866)	
Delphinus delphis Linnaeus, 1758	Common dolphin
Lissodelphis peronii (Lacepede, 1804)	Southern right whale dolphin
Lissodelphis borealis (Peale, 1848)	Northern right whale dolphin
Cephalorhynchus heavisidii (Gray, 1828)	Heaviside's dolphin
Cephalorhynchus eutropia (Gray, 1846)	Black dolphin
Cephalorhynchus hectori (van Beneden, 1881)	Hector's dolphin
Cephalorhynchus commersonii (Lacepede, 1804)	Commerson's dolphin
Phocoena phocoena (Linnaeus, 1758)	Harbour porpoise
Phocoena sinus Norris & McFarland, 1958	Cochito
Phocoena spinipinnis Burmeister, 1865	Burmeister's porpoise
Phocoena dioptrica Lahille, 1912	Spectacled porpoise
Phocoenoides dalli (True, 1885)	Dall's porpoise
Neophocaena phocaenoides (G. Cuvier, 1829)	Finless porpoise
Platanista gangetica (Roxburgh, 1801)	Ganges susu
Platanista minor Owen, (1854)	Indus susu
Inia geoffrensis (de Blainville, 1817)	Boutu
Lipotes vexillifer Miller, 1918	White flag dolphin
Pontoporia blainvillei (Gervais and d'Orbigny, 1844)	Franciscana

Some Information on a *Berardius bairdii* Fishery in Japan

Kenneth C. Balcomb, III and Camille A. Goebel

(Moclips Cetological Society)

Through a kind introduction by Dr Hideo Omura we were permitted to document and collect specimens from Gaibo Hogei, a small whaling company operating from Wadaura, Chiba Prefecture, Japan, during the summer whaling seasons of 1974 and 1975. The primary species taken in this fishery is *Berardius bairdii*, commonly known as tsuchi-kujira (Japanese), plevun (Russian), or Baird's beaked whale.

HISTORY OF CATCH

Since at least 1612, tsuchi-kujira has been the object of catch by Chiba whalers, at first equipped only with small boats and hand harpoon, but since 1908 equipped with a harpoon gun mounted on a small catcher boat (Omura *et al.* 1955). The average catch per year in early years was said to be only four or five whales, all used for human consumption. More recently, Matsuura (1942) graphed the catch of this species off Chiba from 1932 to 1942, during which time 382 whales were caught at a rate of 23 to 50 ($\bar{X} = 35$) in the months of June through September, when tsuchi-kujira migrate to the Chiba coast. Omura *et al.* (1955) state that, according to the Japan Association of Whalers, 24 *Berardius bairdii* were taken in 1943, while 45 were taken during the years 1941–43 inclusive. It is likely, however, that there was some error in reporting, as Matsuura gives measurements for 36 tsuchi-kujira taken off Chiba in 1942. Omura *et al.* (1955) go on to list the catch during the years 1948–52, showing totals for the area off Chiba (393, ave. 79/year), and for all waters off Japan (929, ave. 185/year). Sixteen years later, Nishiwaki and Oguro (1971) summarized the catch of *Berardius bairdii* for all waters off Japan from 1948 to 1962, during which time they indicate 4,123 whales were caught for an average of 187 per year. Their data for 1965 through 1969 indicate that the average catch per year for all waters off Japan was 140, and the average catch per year off Chiba Prefecture was 76 whales. Ohsumi (1975) reviewed Japanese small type whaling from 1948 through 1972, during which time he indicates 4,384 whales were caught for an average of 175 per year in all waters off Japan.

At present, *Berardius bairdii* figures in a minor way in the small whaling catch in waters off Japan, other than off Chiba Prefecture. The people of that region have acquired a taste for the dried meat of tsuchi-kujira over generations, and the price of that species has risen, whereas it dropped, relatively, in other areas where other species are preferred. Hiroji Shoji, the owner of Gaibo Hogei, kindly provided us with data on catches by his company off Chiba Prefecture from 1965 to 1975, during which time they caught 273 whales for an average of 25 per year. He thinks that the published records of catch for *Berardius bairdii* are too high, and that the discrepancy may be due to the inclusion of other species in the records. Because his is the only company in Chiba Prefecture that is catching tsuchi-kujira in recent years, he has good knowledge of the numbers caught.

Even considering the discrepancy in numbers reported, it is apparent that the catch has risen from a very few per year in past centuries to several hundred per year in the middle of this century. At present, the catch seems limited by economic factors to a regional harvest of about 25 to 30 whales per year, mostly taken off Chiba Prefecture. Considering the Chiba stock of *Berardius bairdii* was harvested at about that level for many years in the 1930s and 1940s without apparent adverse effect, it seems reasonable that it can endure the current level of harvest. It should be emphasized, however, that information on the life history and biology of this species is very scanty, so any harvest should be accompanied by collection and examination of specimen materials to shed light on those areas. Until more is known about tsuchi-kujira it would be folly to try to increase the catch.

OFFER

We examined 26 of the 30 *Berardius bairdii* caught by Gaibo Hogei in 1975. As with most previous years, the catch was preponderantly of males, usually ten meters in length and sexually mature. Only seven of the whales that we examined were female, and only three of those had mature ovaries. External measurements were taken on all whales, as were teeth, stomach contents, gonad samples, parasites, and selected histological tissues. We will be happy to share these materials with specialists that are interested in probing the life secrets of these curious whales.

We are indebted to Mr Hiroji Shoji, his wife Misao, Dr Hideo Omura, and the many other people who made our field studies possible.

Japanese statistics on *Berardius bairdii*

	Matsuura, 1942 Chiba only	Omura *et al.*, 1955 Chiba only	Omura *et al.*, 1955 All Japan	Nishiwaki and Oguro, 1971 Chiba only	Nishiwaki and Oguro, 1971 All Japan	Ohsumi, 1975 All Japan	Shoji-San, pers. comm. Chiba only
1932	31	–	–	–	–	–	–
1933	31	–	–	–	–	–	–
1934	34	–	–	–	–	–	–
1935	35	–	–	–	–	–	–
1936	33	–	–	–	–	–	–
1937	50	–	–	–	–	–	–
1938	34	–	–	–	–	–	–
1939	50	–	–	–	–	–	–
1940	25	–	–	–	–	–	–
1941	23	–	45	–	–	–	–
1942	36	–	for 3 yrs	–	–	–	–
1943	–	–	24	–	–	–	–
1944	–	–	–	–	–	–	–
1945	–	–	–	–	–	–	–
1946	–	–	–	–	–	–	–
1947	–	–	–	–	–	–	–
1948	–	43	73	–	76	76	–
1949	–	48	92	–	95	95	–
1950	–	122	186	–	197	197	–
1951	–	108	252	–	242	242	–
1952	–	72	321	–	382	322	–
1953	–	–	–	–	270	270	–
1954	–	–	–	–	230	230	–
1955	–	–	–	–	258	258	–
1956	–	–	–	–	297	297	–
1957	–	–	–	–	186	186	–
1958	–	–	–	–	229	229	–
1959	–	–	–	–	186	186	–
1960	–	–	–	–	147	147	–
1961	–	–	–	–	133	133	–
1962	–	–	–	–	145	145	–
1963	–	–	–	–	160	160	–
1964	–	–	–	–	189	189	–
1965	–	–	–	68	172	172	24
1966	–	–	–	85	171	171	39
1967	–	–	–	58	107	107	21
1968	–	–	–	80	117	117	26
1969	–	–	–	91	134	138	30
1970	–	–	–	–	–	113	28
1971	–	–	–	–	–	118	25
1972	–	–	–	–	–	86	20
1973	–	–	–	–	–	–	13
1974	–	–	–	–	–	–	26
1975	–	–	–	–	–	–	30

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Harbour Porpoise *Phocoena phocoena* (L.) in the Western Approaches to the Bay of Fundy 1969–75

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INTRODUCTION

There is little significant literature relevant to the ecology and life cycle of the harbour porpoise in eastern North American waters other than the preliminary study of the male and female reproductive cycle by Fisher and Harrison (1970), the analysis of sightings by ferry operators, conducted by Neave and Wright (1968), and the more recent studies by researchers at the University of Guelph (Gaskin *et al.* 1971; Arnold 1972; Smith 1972; Gaskin *et al.* 1972; Smith and Gaskin 1974; Gaskin *et al.* 1974; Arnold and Gaskin 1975; Rowlatt and Gaskin 1975; Gaskin *et al.* 1975; Smith *et al.* 1976). Phonation of a specimen held temporarily in the vicinity of Pendleton's Passage was described by Schevill *et al.* (1969), and there are some useful allusions to the species in regional Canadian papers by Gilpin (1875); Sergeant and Fisher (1957); and Sergeant *et al.* (1970).

Studies on the biology and ecology of the species by the University of Guelph, largely sponsored by the National Research Council of Canada, were begun in the western Bay of Fundy approaches in 1969. We plan to continue this programme at least until 1979, under a renewal of funding granted for the period 1976–79 by NRC and other agencies. Since this will be one of the longest periods for which a population of a small cetacean will have been kept under continual observation and study we hope that our findings will have much general application.

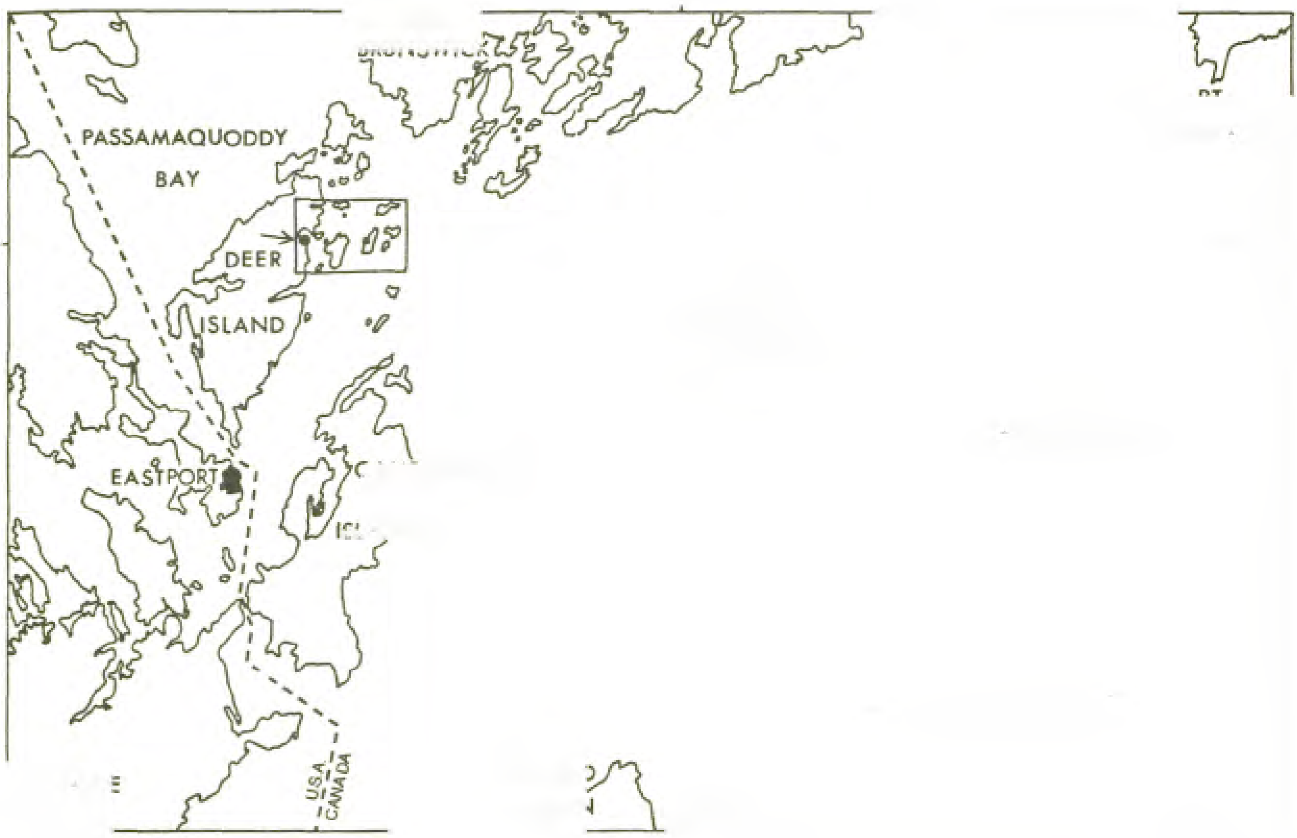
This submission is more in the nature of a general summary of findings from 1969 to 1975, and some of the data presented are of a preliminary nature and may be subject to modification when analyses are completed. Distributional and behavioural ecology of the harbour porpoise is the subject of several MSc and PhD theses at Guelph at the time of writing, and hopefully all the results from these studies will have been published in the primary literature by the end of 1979. Manuscripts in an advanced state of preparation include work on seasonal and daily movements and behaviour of marked individuals (Watson and Gaskin), male reproductive cycle (Smith, Gaskin and Yurick), morphometrics of North Pacific, western and eastern North Atlantic, North Sea, and Baltic populations based on 462 specimens (Yurick), structure and function of the coronary system (Halina), morphology and histology of the liver vascular system (Hilton and Gaskin), morphology and microanatomy of the kidney (Hedges and Gaskin), histology and histochemistry of the adrenal gland (Louisy), histology of the parathyroid glands (Mertens), and age determination based on dentinal layering (Gaskin and Blair). A detailed manuscript on the latter aspect has been submitted for the present meeting (Paper L.13). The amount of information on distribution and movements is so large now that it seems unlikely that final papers on this aspect will be ready for at least two more years. Restrictions on funding have limited the number of computing hours which can be expended on this material in each fiscal year, and made it very difficult to pay staff for all the necessary tasks, resulting in some switches in priorities.

METHODS, AND THE MAIN STUDY REGION

The western approaches to the Bay of Fundy, comprising the main study region, are shown in Fig. 1 on a scale of approximately 6.3 km to the inch. The inset in that figure delineates the inner study area where animals were kept under intensive observation during the summer months between 1973 and 1975 (Fig. 2). The closed circle in each figure, arrowed in Fig. 1, indicates the position of our small field station.

In this programme we endeavoured to pay special attention to the problems of census of these mammals, which are difficult to see at the best of times. Showing little or no curiosity where boats are concerned, in fact making avoidance reactions when craft are moving under power, the harbour porpoise is a difficult study animal. We have been fortunate in keeping the same experienced observers for the total duration of the programme to date, and these people have trained all subsequent observers. After examining results for the same area covered by different vessels with differing numbers of observers during the same period we concluded that it is possible to graph approximate observer efficiency and to use this when making rough population/area counts (see Fig. 3).

Since the harbour porpoise is such an unobtrusive animal at sea unless actively pursuing fast-swimming prey such as mackerel, when individuals may jump virtually clear of the surface during fast swimming, we subdivided working conditions by sea surface/wind strength up to Beaufort force 3 only. Only under exceptional circumstances was observation worthwhile once the wind speed was above force 2. While visibility largely dictated the actual area open to search we concluded that light conditions were equally, if not more important. Broken, fast-moving cloud made small dark objects, including harbour porpoises, very difficult to see even when the wind speed reached force 2. Each period of observation was rated in the records according to the sighting condition category system shown in Fig. 4. Nevertheless when sighting conditions were optimal (sea state 0 or 1, visibility unlimited and lighting direct or diffuse but uniform), we concluded that three observers using both naked eye and binoculars were able to locate an estimated 85–90% of all harbour porpoises in a given area. Under such circumstances the frequent schooling habit, the relatively short dive times of individuals and our tactic of working and re-working the area in question before moving on made us confident that sighting estimates per unit time were reliable.



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DEER
ISLAND
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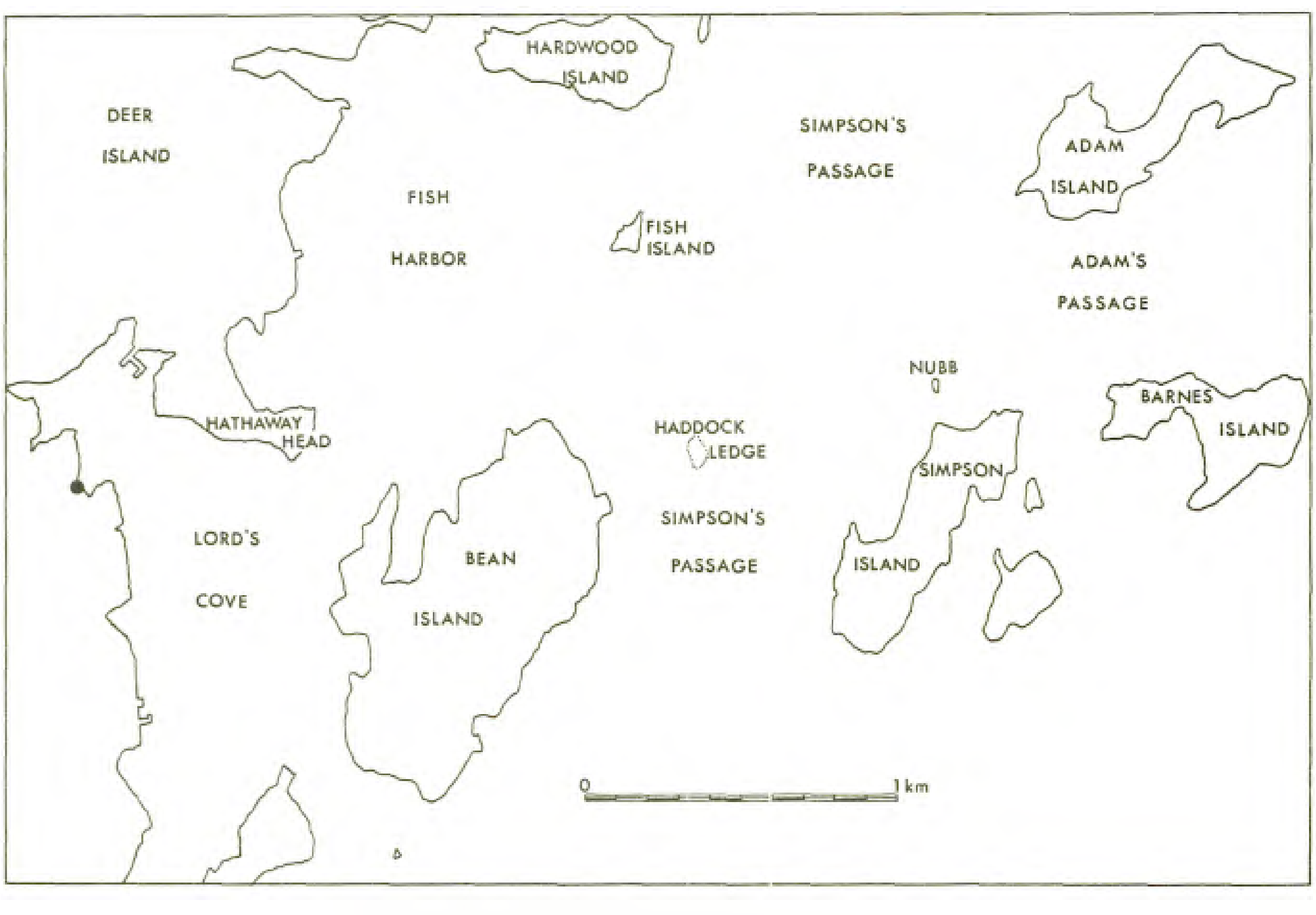

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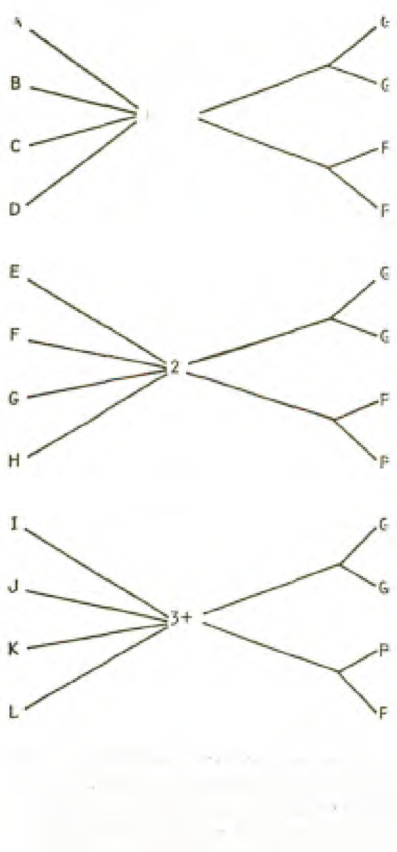
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Table 1

Total numbers of harbour porpoises seen in main study region of western Bay of Fundy approaches by month and year, 1969–75.*

Month	1969	1970	1971	1972	1973	1974	1975	
April		23						
May		42	6		23			
June		48	32		16			
July	124	171	66	133	69	25	46	
August	154	334	278	350	513	216	292	
September			61		23	97		
Total	278	618	443	483	644	338	338	(3,142)

*In good observation conditions only.

Table 2

Numbers of harbour porpoises seen in western Bay of Fundy region converted to sightings per unit effort (per hr) for 1969–75.

Month	1969	1970	1971	1972	1973	1974	1975
April		0.82					
May		1.07	0.92		1.99		
June		1.30	1.38		2.61		
July	2.53	2.25	1.53	3.70	2.43	6.12	2.53
August	4.27	3.79	2.86	5.30	4.41	6.49	5.73
September			3.21		4.76	8.08	
July to September mean value	3.40	3.02	2.53	4.50	3.86	6.89	4.13

While we are not yet in a position to draw specific conclusions about these results, since analysis of oceanograph records are not yet complete for the period, the relatively narrow range of variation gives us considerable confidence in the accuracy of our search methods. The lowest value (1971) was also noted during the only season in which right whales were found in the study area, with unusually large numbers of fin whales. In 1974, when harbour porpoise were consistently more abundant than usual, no large baleen whales were recorded in the area.

Table 3

Sighting per unit effort values (per hr) of harbour porpoises seen in the inner study area of Simpson's Passage and Fish Harbour, 1970–75.

Month	1970	1971	1972	1973	1974	1975	Mean
Simpsons Passage							
May	–	0	–	–	–	–	0
June	–	1.3	0.3	–	–	–	0.80
July	6.1	1.5	2.5	4.0	2.0	1.6	2.95
August	3.8	6.3	6.6	4.0	6.8	1.4	4.80
September	–	5.0	8.0	–	–	–	6.50
Fish Harbour							
May	–	0	–	0	–	–	0
June	–	0	0	1.0	–	–	0.3
July	–	0.4	3.3	0.2	0.5	0.3	0.94
August	–	1.0	5.5	3.9	2.9	1.2	2.90
September	–	4.0	0	8.0	4.0	–	4.00

A high percentage of the animals recorded in these two areas are mothers with calves, although these form a higher percentage of the total in Fish harbour than in the outer Passage. The variability of sightings seems to be tied in with occurrence of fish schools in the inner area. But in all seasons there is virtually no penetration of these close inshore waters until July, and depending on the weather giving an advanced or retarded season, the inshore population peaks either in mid-August or early September. We have been unable to work extensively in October ourselves, but auxiliary observers report that numbers decline through the month, and that by the beginning of November the last individuals have left the inner study area.

suggesting an offshore to onshore movement throughout the region.

At the present time we are in a position to provide some very approximate census results; the quality of these data will hopefully be much improved by the time Mr D. Yurick has completed his analyses. While most effort has been concentrated in the main study region, we have worked quite a number of representative localities south of the northern Gulf of St Lawrence, and a summary of the results is briefly presented, for what it is worth.

Since early 1970 groups of experienced observers have worked from four localities each season; Lord's Cove, Deer Is., NB; St Andrews, NB; North Head, Grand Manan, NB; and Digby, NS. Observations have been made also at St. Mary's Bay, La Have estuary, and Mahone Bay, NS; Boothbay Harbour, Me.; Georgetown and Souris, PEI; and Tadoussac, Rimouski, Fox River and Les Escoumains, Q., but not on a continuing basis. Where convenient and useful, shore spotting points have been established; at Cumming's Cove, Deer Island Point, Green Point, and Lepreau Head, NB, Prim Point, NS, and Dogfish Head, Southport Island, Me. Using the relatively primitive method of expressing observations comparatively as 'high', 'moderate' or 'low', we arrived at the following summarized conclusions:

Quoddy/Grand Manan region	High
Central Bay of Fundy banks	Moderate
Digby approaches	High
Black's Harbour–Lepreau	Moderate
Lepreau-St John northwards	Low
Annapolis coast northwards	Very low
N. Maine coast	Moderate
S. Maine coast	Moderate
New Hampshire-Mass. coasts	Low
St Mary's Bay	Low
Lockport region (from Yarmouth)	Not investigated
La Have region	Low
Mahone-St Margaret's Bay	Low
Halifax northwards	Not investigated
Atlantic Cape Breton	Usually low
Eastern PEI	Very low
Northern PEI	Very low

Until reproductive data are fully analysed, and perhaps even then, we have to depend largely on a strip census approach, and unless the effort is tightly standardized this has considerable limitations. However since the writer is reasonably convinced that the sighting effort data are reliable, some solid figures can be quoted. The level of accuracy can be established after more work on confidence limits.

Based on the best available August density estimates, with no correction factors added, it is possible to arrive at a series of values which appear to represent reasonable population sizes area by area. They can be considered minima since there are no correction factors for animals missed during searching. They are centred on mid-August, when the concentration of the total population into coastal waters is at its greatest.

The La Have to St Margaret's Bay coast has been worked a number of times by this research group between 1970 and 1972. Our experience suggests that the population density on the Scotian shelf is much lower than in the Fundy approaches; possibly there are as few as 700 harbour porpoises between Yarmouth and Canso, and probably certainly not more than about 2,000 in coastal waters. The Gulf Stream influences this coast in summer, and the field teams have noted that *Lagenorhynchus* is far more common than the harbour porpoise away from shore, and may in fact largely replace it in this region in summer.

Little or no information is available on the occurrence of harbour porpoises away from coastal waters. Based on a single stranding record it can be inferred that Sable Island may have a local coastal population. Various long-range cetacean cruises in offshore Scotian shelf waters do not support any theory of a large offshore harbour porpoise population.

On present evidence it seems that the edge of the Gulf of Maine and the approaches to the Bay of Fundy may support as much as 80% of the total summer population of the species in Canadian waters south of the St. Lawrence. Almost a quarter of that total feeds within a radius of about 20 miles from the mouth of Head Harbour Passage. It must also be pointed out that that quarter actually represents *half* of the *proven* population, since the grand total of 4,000 is largely an extrapolated quantity.

In conclusion, while the data presented here are to be considered no more than preliminary, all currently point to a relatively low population size estimate. The species seems to be short-lived; 13 years is the present maximum, with 6–9 years a more reasonable average maximum. The pulp cavity of the tooth does not close, so upper age classes can be analysed in this species. The short life span was anticipated in view of what is known of the metabolism. Only one calf is produced at a time, we have no records of twinning though it undoubtedly occurs. All foetuses recorded have been very small, at the end of summer; all were normal and single. The pregnancy rate is not likely to

Sub-Area	Estimate	Comments
Passamaquoddy Bay	40	The Bay is not an area of intensive concentration.
Western Passage to St Croix	50	
'The River' and Island Channels	50	Mother with small calves frequent.
Outer Quoddy (outside Deer and Campobello to Gt Duck I and Lepreau Hd)	450	Many schools of submatures in August.
Grand Manan Channel	50	Lack of subsurface topographic relief probably limits feeding areas
Lepreau to St John across to Nova Scotia	650	Counts based on observations from *Princess of Acadia.*
Digby approaches and Annapolis Basin	480	
Outer Grand Manan Basin ridges	600	May be high estimate
N. Maine shelf to Bar Harbour	400	May be low estimate
Whole inner Bay of Fundy north of St John	200	May be high estimate
St Mary's Bay	50	
Edge of Jordan Basin	500	May be high estimate
Grand Manan Banks	500	

Total Fundy approaches c. 4,000 animals.

be much above about 0.35; there is evidence (Fisher and Harrison, 1970) that females have resting years between pregnancies. Consequently the short life span is not apparently countered by a rapid turnover in the reproductive rate, and the species is not likely to be more flexible in response to exploitation or other causes of excessive mortality than any other odontocete. The writer is moderately alarmed by persistent reports from responsible sources that the species appears to be steadily disappearing from the Baltic and the Dutch coast. There is no corresponding indication that this is merely a redistribution. While the population north of the southern St Lawrence, around Newfoundland and into Davis Strait is probably far larger than that found in the northern Gulf of Maine and the Bay of Fundy, the magnitude of incidental and direct catches of the species reported by Lear and Christensen (1975) is cause for considerable concern.

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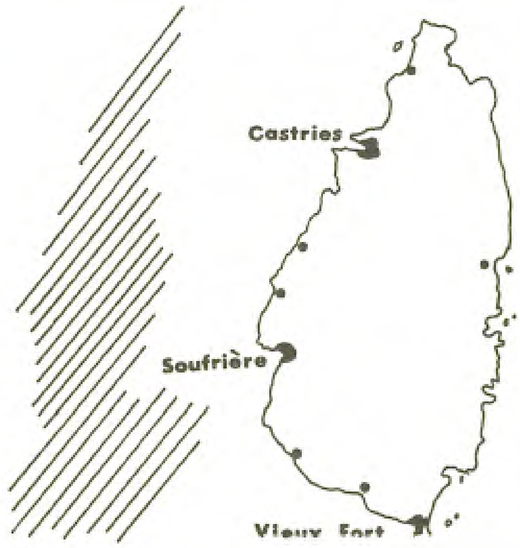
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Paper L.17

Exploitation of Small Cetaceans off Southern Africa

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INTRODUCTION

The intention in this paper is to describe the forms of exploitation of small cetaceans that occur (or have occurred in the immediate past) off Southern Africa, and the methods of control of this exploitation. Small cetaceans are defined as all odontocetes (apart from the sperm whale) and one mysticete, the pygmy right whale. Where catch figures exist these are given, and what is known of the composition of the catch is included. Other potential or real hazards to stocks of small cetaceans, such as pollution of their environment or the intensive exploitation by man of some of their food species, are not discussed here, though their potential population impact may be far greater than any of the more direct forms of exploitation mentioned in this paper.

LEGAL POSITION

At present the legislative protection afforded to small cetaceans varies considerably. Regulations governing the exploitation of large whales off South Africa (i.e. all mysticetes and the sperm whale) are included in the Sea Fisheries Act of 1973, in which the pygmy right whale is protected from commercial whaling. Under the same Act (regulation 59), 'no person shall without the written authority of the director kill, catch, attempt to kill or catch or disturb any dolphin, known also as porpoise. Dolphins include all species of the superfamily *Delphinoidea*'. No specific regulations exist at present concerning the exploitation of members of the family *Ziphiidae* (beaked and bottlenose whales) or of the family *Physeteridae* apart from the sperm whale. Management of all small cetacean stocks off Southern Africa, however, would seem to be the responsibility of the Department of Industries (Minister of Economic Affairs), while conditions governing the transport and confinement of small cetaceans within Southern Africa above the high water mark are the responsibility of the Department of Nature Conservation of the province concerned.

Enforcement of regulations under the Sea Fisheries Act is possible through the 43 Sea Fisheries Inspectors of the Department of Industries distributed along most of the populated coastline of the Cape Province and South West Africa, with some representation in Natal. In addition each provincial Department of Nature Conservation has its own inspectorate.

SIDE CATCHES BY WHALING INDUSTRY

Between 1968 and 1975 the only commercial whaling enterprise in South Africa was a land station based on the Bluff in Durban, whose catching fleet took mostly sperm, fin, sei and minke whales (Best and Surmon, 1974). Starting in 1971, however, the fleet began to take killer whales (*Orcinus orca*) in a somewhat desultory fashion, depending on the availability of other species and the idiosyncrasies of the gunners. These animals were processed into meal, oil and extract. Monthly catches of killer whales are shown in Table 1, and the size and sex composition of the catch in Table 2.

Table 1

Killer whale catches at Durban, 1971–75.

Month	1971	1972	1973	1974	1975	Total
March	0	0	0	0	0	0
April	0	2	0	0	2	4
May	0	10	0	0	0	10
June	1	0	0	2	0	3
July	1	0	6	0	2	9
August	0	0	2	0	0	2
September	3	5	0	0	0	8
Total	5	17	8	2	4	36

Table 2

Size and sex composition of killer whales landed at Durban, 1971–75

Length (feet)	Males	Females
19	1	1
20	–	1
21	2	3
22	2	2
23	4	2
24	1	1
25	8	1
26	5	1
29	1	–
Total	24	12

Two-thirds of the total catch of 36 killer whales was male. This probably arises from the sexual dimorphism in size and fin shape of the species, so that adult males were easily recognised and chosen for their known larger bulk.

As the whaling company ceased operations in 1976, this exploitation of killer whales has been discontinued.

The industry also took one goose-beaked whale (*Ziphius cavirostris*) in March 1973, in answer to a request from the authors for an example of the 'bottlenose' whales that the catcher crews frequently reported.

SMALL CETACEANS TAKEN ACCIDENTALLY IN SHARK NETS OFF NATAL

Since 1952 bathers at several of the beaches along the Natal coast have been protected from shark attacks by nets set parallel to the shore and about 500 m offshore. Each net is a panel 106.8 m. x 6.4 m deep (though off Durban panels 304 m. x 7.3 m. deep are used) with a mesh size of 25 cm., and the nets are set in an overlapping but staggered fashion so that gaps exist between individual panels. Each panel hangs vertically, usually in a mid-water position (depending on the water depth) and is secured by anchors at the bottom and floats at the top. At present there are 253 such nets set at a total of 39 bathing beaches along 250 km. of the Natal coast, from Zinkwazi in the north to Port Edward in the south.

The nets are intended to act principally as a barrier to shark movements shorewards but also to catch sharks through enmeshment. They are inspected daily when weather conditions permit. Besides sharks the nets also catch a number of dolphins which become entangled and die, presumably of shock or drowning. The annual reported catch of dolphins in these nets is listed in Table 3.

Table 3

Monthly catch of dolphins in shark nets off Natal, 1972–75.

						Area[1]		
Month	1972	1973	1974	1975	Total	A	B	C
January	0	0	0	0	0	0	0	0
February	0	0	0	2	2	1	1	0
March	0	0	0	0	0	0	0	0
April	1	1	0	0	2	0	1	1
May	2	0	3	0	5	3	0	2
June	0	43	0	1	44	0	2	42
July	11	2	24	16	53	6	4	43
August	7	8	11	19	45	10	11	24
September	4	0	0	0	4	0	0	4
October	2	5	1	0	8	1	0	7
November	1	0	0	0	1	0	0	1
December	4	2	0	1	7	1	0	6
Total	32	61	39	39	171	22	19	130

[1] A = Zinkwazi to Durban
B = Amanzimtoti to Mtwalumi
C = Hibberdene to Port Edward

It is immediately clear that the mortality is very seasonal. Of the 171 animals reported since 1972, 83% have died in the period June to August. This corresponds in time with the annual 'sardine run', in which shoals of pilchard (*Sardinops ocellata*) move northwards (possibly from Cape waters) in a cold inshore current and may become trapped against the shore by the combined effects of near-shore circulation, wind conditions and predators (Baird, 1971). It is therefore possible that enmeshments of the dolphins at this time of year are correlated with seasonal movements in response to the same environmental conditions as the fish, or are more directly related to the pursuit of the pilchards themselves or predatory fish associated with the pilchards.

Most of the mortality (76%) occurs in Area C or the most southerly region covered by shark nets. Catches here have averaged 1.8 animals per beach installation per year as opposed to 0.5 in Areas A and B. Reasons for this difference are not yet clear, but may reflect the distribution of the dolphins, movements of the fish or the fact that the density of installations per km of coast is much higher in Area C than in the other two Areas.

Three species of dolphins are known to be involved in this 'fishery' – the bottlenosed dolphin (*Tursiops aduncus*), the common dolphin (*Delphinus delphis*) and the humpback dolphin (*Sousa plumbea*). Accurate figures of the species composition of the catch are not available, but some specimens have been preserved from the catch since 1964 and examined by members of the staff of the Oceanographic Research Institute, Durban, the Port Elizabeth Museum and the Sea Fisheries Branch, Cape Town (Table 4).

Table 4

Dolphin species and numbers caught in shark nets off Natal.

Species	1964	1969–75	Total
Delphinus delphis	93	11	104
Tursiops aduncus	1	16	17
Sousa plumbea	1	–	1
Total	95	27	122

The species most frequently involved appears to be the common dolphin, although this sample composition is highly affected by the large number of animals enmeshed and examined in October 1964 (Anon, 1965). On the other hand, the ratio of *Delphinus* to *Tursiops* identified from shark nets between 1969 and 1975 probably does not give a true reflection of the numbers of *Delphinus* killed, for whereas bottlenosed dolphins are most often netted singly or in pairs, on several occasions groups of common dolphins have been recorded in the nets, from which only one or two animals would be brought ashore and identified.

Although the sample size is small, seasonality of occurrence seems more marked in the common dolphin, as specimens were recorded only from the months July, August and October, whereas bottlenosed dolphins were identified from May, July, August, September and October. Stomach contents examined to date have revealed that the common dolphins caught in October 1964 had been feeding on 'sardines' (Anon, 1965), and more recently caught animals have been feeding on pilchards or mackerel, while bottlenosed dolphins from the shark nets examined since 1969 have had no pilchard remains in their stomachs.

Efforts are being made to reduce the extent of this mortality. The Natal Anti-shark Measures Board (N.A.M.B.), which is responsible for the control and maintenance of these nets, has obtained the co-operation of all local authorities so that on notification of the beginning of the sardine run all but two monitor nets at each end of each installation are rolled up and bathing is banned at those beaches for as long as is necessary (Mrs B. Davis, in litt. 12 May 1976). When the monitor nets indicate no catches for a week the entire installation is re-established. Further investigation of this problem will be undertaken by the N.A.M.B. in conjunction with the Sea Fisheries Branch in the near future.

LIVE CAPTURE OF DOLPHINS FOR PUBLIC DISPLAY

The first oceanarium to house dolphins in South Africa was built at Port Elizabeth in 1961, where dolphins (mostly *Tursiops*) have been maintained almost continuously since. From 1969 to 1973 the Tygerberg Zoopark near Cape Town also maintained a small number of dolphins (*L. obscurus*). The Safari Park, Hennopsrivier, near Pretoria, began to keep dolphins (*Tursiops*) in 1975. It is anticipated that the Oceanographic Research Institute, Durban will receive the first animals for its newly-built dolphin complex in 1976. A list of all dolphins taken since 1961 (Table 5) does not include stranded animals that have from time to

Table 5

Animals captured off Southern Africa for live display.

	Species		
Year	*T. truncatus* or *aduncus*	*L. obscurus*	*S. plumbea*
1961	–	4	–
1962	2	–	–
1963	6	–	3
1967	2	–	–
1968	–	–	–
1969	–	10	–
1971	4	–	–
1975	6	–	–
1976	(1)	(5)	–
Total	21	19	3 = 43

time been maintained briefly in oceanaria, nor animals that have been released immediately or shortly after capture because they were unsuitable or (in two cases) illegally caught. Since 1974 the capture of dolphins has been controlled by permit under the Sea Fisheries Act of 1973, and a number of animals has subsequently been caught both for local and overseas institutions.

The survival rate of the four species caught is given in Table 6. Peri-capture mortality (i.e. mortality during capture, transport to holding tanks, or introduction to holding tanks or permanent facility) is highest in the bottlenosed dolphin. Similar high mortality at capture (estimated to be as high as 40%) has been found for bottlenosed dolphins elsewhere (Walker, 1975). Once peri-capture mortality is completed, however, the survival rates of these species are higher than that of the dusky dolphin (*Lagenorhynchus obscurus*), with the humpback dolphin's the least. Walker (1975) also found that the bottlenosed dolphin was the most adaptable to captivity of all the cetaceans taken off southern California, once the animal was in captivity.

Table 6

Survival rate of dolphins captured off Southern Africa.

	Species		
Fate[1]	*T. truncatus* or *T. aduncus*	*L. obscurus*	*S. plumbea*
Number captured	21	19	3
S_0	0.67	0.79	1.00
$S_{0.25}$	0.42	0.25	0
S_1	0.22	0.19	–
S_2	0.22	0.19	–
S_3	0.22	0.06	–
S_4	0.22	0.06	–
S_5	0.17	0	–
S_6	0.17	–	–
S_7	0.17	–	–
S_8	0.17	–	–
S_9	0.06	–	–
S_{10}	0.06	–	–
S_{11}	0.06	–	–
S_{12}	0.06	–	–

[1] S_0 = proportion surviving peri-capture activities.
$S_{0.25}$ = ,, ,, 3 months in captivity.
S_1 = ,, ,, 1 year in captivity.
S_2 = ,, ,, 2 years in captivity
etc. etc.

For these reasons, the Department of Industries is at present confining permits to the capture of *Tursiops* and *Lagenorhynchus*. All permit applications are submitted to a panel consisting of representatives from the University of Cape Town, South African Museum, Department of Nature and Environmental Conservation of the Cape Province, and the Department of Industries. The panel reviews the numbers, species and methods of capture of the dolphins and the facilities of the institutions for which the animals are destined. After April 1976 permits for live capture of dolphins will be issued only to recognised oceanaria and not to private individuals.

ANIMALS TAKEN INCIDENTALLY OR DELIBERATELY DURING FISHING OPERATIONS

An extensive purse-seine fishery for pelagic fish (pilchards, anchovies (*Engraulis capensis*) and maasbankers (*Trachurus trachurus*)) employing about 200 boats exists off the west and southwest coasts of South Africa and off South West Africa, landing about 1 million tons annually. Reports of mortality resulting from the accidental entrapment of dolphins in nets of these boats have been confirmed by the occasional landing of such animals in fishing harbours, where they are cut up for local human consumption. Four common dolphins and one dusky dolphin caught in this manner have been examined. These are considered (from their distribution and feeding habits) to be the species most likely to be involved in this 'fishery'. Other species that could be involved are Heaviside's dolphins (*Cephalorhynchus heavisidii*) and bottlenosed dolphins. Reliable estimates of the number of animals killed in this way are not available. Informal discussions with fishermen and others involved in the industry indicate that the entrapment of dolphins is not a regular occurrence and large numbers of animals are not involved. We see no reason to change the estimate of a total catch of 100 animals a year made previously (Best, in Mitchell, 1975), though a more accurate figure is urgently needed and requires the placement of observers on one or more fishing boats for extended periods.

A more deliberate and traditional form of dolphin exploitation by fishermen is the hand-harpooning of individual animals from the bows of a variety of fishing vessels including line-fishing boats, purse-seiners and trawlers. Although illegal (and probably reduced in extent since the passing of the Sea Fisheries Act of 1973 regulations and the development of public sentiment concerning dolphins), this practice apparently still persists, particularly amongst Cape fishermen who are partial to the meat. There is little information on the species taken: common dolphins and bottlenosed dolphins have definitely been taken in the Port Elizabeth area, while it is suspected that common dolphins and dusky dolphins are caught on the west coast. No estimate of the probable size of the catch exists, though it might be put no higher than that from entrapment in the purse-seine fishery, i.e. at about 100 a year.

The scarcity of data on catch levels and species composition for these two forms of exploitation probably results largely from the introduction of legislation protecting dolphins. Instead of landing at least part of their catch for butchering ashore (as previously), it is believed that the fishermen now cut up any animals that are taken at sea and only bring the meat ashore.

A further traditional form of small cetacean exploitation, the deliberate catching of animals with beach-seines or 'trek' nets, now seems to be rare, at least in the Cape Peninsula. This appears to be a direct result of public concern over the practice. In the past dusky dolphins are known to have been caught in this manner for human consumption. On at least three occasions (in 1957, ca. 1963 and in 1965) pygmy right whales (*Caperea marginata*) have been caught, though on the last occasion the animal was released after an altercation between the public and fishermen. Other species that might be involved in such a fishery are bottlenosed and Heaviside's dolphins. If this practice still continues the total catch must be very small, probably less than 50 animals annually.

CONCLUSIONS

There appears to be no major 'fishery' for small cetaceans off Southern Africa, though more details of the rate of incidental and deliberate exploitation from fishing vessels are required. It is unlikely that any of the practices described in this paper can be having a major impact on overall population levels of the species concerned, though the effect might be greatest on certain stocks that are likely to have restricted home ranges (such as bottlenosed dolphins off Natal). As mentioned at the outset, the effects of pollution and the exploitation of food species such as pelagic fish by man may be potentially far more significant in affecting population levels. It is hoped that more research will be directed in future towards determining the status of small cetacean stocks off South Africa and the relative importance of these factors to their maintenance at healthy levels.

ACKNOWLEDGEMENTS

The Director of the Natal Anti-shark Measures Board, Mrs B. Davis, kindly supplied details of the shark nets off Natal and the date, locality, and number of dolphins entrapped in them. We are also grateful to the Directors of the Port Elizabeth Museum and Tygerberg Zoopark, Cape Town, for releasing information on the number of animals caught for their institutions and the degree of mortality involved.

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Paper L.18

School Structure of *Stenella coeruleoalba*

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INTRODUCTION

The striped dolphin, *Stenella coeruleoalba*, is distributed widely in tropical and subtropical waters of the Pacific Ocean. In Japanese coastal waters the species is common (Nishiwaki and Yagi, 1953; Kasuya, 1972; Miyazaki *et al.*, 1974). On the east coast of Izu Peninsula many striped dolphins are caught annually from October to January by the driving method for dolphins.

Although the biology of striped dolphin has been studied by many Japanese biologists, very little of school structure of the species is known: Striped dolphin is the most adequate species to study school structure of the dolphin on the coast of Japan, because it is the most avilable for examination of many specimens in the unit of school.

In order to resolve the mechanism of maintenance of the species, and to make reasonable management of the resource, it is one of the very important factors to know the school structure.

Based on the examination of age, body length, and sexual condition of the members composing the school, this study intends to analyse the school structure from aspects of reproduction and growth.

MATERIALS AND METHODS

A total of 4,415 dolphins from 40 schools caught by the driving method were examined on the east coast of Izu Peninsula in 7 years from 1963 to 1973. Also 271 dolphins caught by harpoon were examined on the Kii Peninsula from January to February in 1973.

Fishing effort and catching data on the east coast of Izu Peninsula, and catching data on its west coast were also used.

As an opaque layer in the dentine is laid down in a year, age determination was made by means of the number of opaque layers.

Sexual conditions of the males were decided by the histological observations in the centre of the cross section at the midlength of the left testis. When spermatozoa, only spermatogonia and spermatocytes, and only spermatogonia were observed in this part, the testis were considered to be in maturity, puberty and immaturity respectively. As the increase of testis weight corresponds to its development and there is no significant difference between the weight of left and right testis, when many specimens were examined, sexual conditions of males were decided by the left testis weight. In the mature males the males which were considered to copulate with oesterous females were classified as in social maturity.

Sexual conditions of the females were decided by presence of corpora lutea and corpora albicantia, the weight of ovary, condition of mammary gland, and foetus size. The females with corpora lutea in the ovary, only corpora albicantia in it, and lactation in the mammary gland were considered to be pregnant, resting, and lactating females. The immature female with the left ovary more than 2.0 g was classified as in puberty. In the mature females, early pregnant (with foetus less than 34 cm), lactating, and resting females were defined as mating females because these females are before and after conception. On the other hand, middle pregnant (with foetus from 34 to 66 cm) and late pregnant females (with foetus more than 67 cm) were defined as non-mating females.

GROWTH AND REPRODUCTION

Mean body length at birth is 100 cm. Some dolphins start to feed on solid food at the age of 0.5 years (Body length: 158 cm). The weaning of the dolphin occurs, in the average, at the age of 1.5 years (174 cm). Mean left testis weight of the dolphin attained at puberty, sexual maturity, and social maturity was 6.8 g, 15.5 g, and 68.9 g respectively. Mean seminiferous tubule size of the dolphin attained at puberty, sexual maturity, and social maturity was 54.6 μ, 130.8 μ, and 150.0 μ respectively. Mean ages of females and males attained at puberty were 8.3 years (214 cm) and 7.0 years (212 cm) respectively. Mean age of females and males attained at sexual maturity was 9.0 years (217 cm) and 8.7 years (219 cm) respectively. Mean age of females and males attained at physical maturity was 11.5 years (225 cm) and 13.5 years (238 cm) respectively. Mean age of males attained at social maturity was 13.5 years.

There are three mating seasons in the year, January to February, May to June, and September to October. During the mating season the female was considered to ovulate once a month. Gestation lasts for about 12 months and lactation for about 18 months. The mean length of one reproductive cycle is approximately 3 years. As mean annual accumulation rate of ovarian corpora is 0.59, the number of ovulations in one reproductive cycle may be 1.8.

SCHOOL STRUCTURE

School size

Based on my observations at sea, the large school was often composed of numerous small schools. Size of small schools ranged approximately from 20 to 200 dolphins. In such a small school several females with a calf, or several pairs of dolphins were observed. The smallest school caught on Izu Peninsula was composed of 25 dolphins, and the largest 2,327 dolphins. The mean school size was 415 dolphins. Most schools were composed of less than 500 dolphins (85.8%). Very few schools were composed of more than 1,000 dolphins (4.2%). Southbound schools were caught on the west coast of Izu Peninsula, and on the east coast from autumn to winter. In these seasons there was no difference of school size between the east and the west coast of Izu Peninsula. Average size of school caught in these seasons was about 300 dolphins. Northbound schools were caught on the west coast of Izu Peninsula from spring to summer. Their average size was about 150 dolphins, and they were half the average school size of those with southbound movement. Several schools of more than 1,000 dolphins were caught in the main fishing periods both from autumn to winter and from spring to summer (Southbound: November to January; Northbound: April to May).

Classification of the school and its characters

The schools were classified on the ratio of the number of the mature dolphins to the total number excluding the calves. The ratio of the immature, the mature, and the mixed schools were less than 0.3, more than 0.6, and between 0.3 and 0.6 respectively. The immature schools were composed of mainly immature and pubertal dolphins. The mature schools were composed of mainly mature dolphins. The mixed school has the combined characters of the immature and the mature schools. The number of schools of the immature, the mature, and the mixed schools were 9, 21, and 10 schools respectively. The school size of the immature, the mature, and the mixed schools were 36–903 (average 277), 25–2,327 (470), and 225–912 (375) dolphins respectively.

School composition of the mixed school was analogous to the combined composition of the immature and the mature schools. Many of the mixed schools were caught in the years when the Kuroshio current was situated close to the main fishing ground and the density of schools seemed to be high. Based on this information it is considered that the mixed school is made as the result of mixing the immature with the mature schools.

The mature schools were classified on the ratio of the number of social mature males to that of mating females. The ratios of the mating and non-mating mature schools were more than 1.0 and less than 0.6 respectively.

The mating mature schools were composed of many mating females and many social mature males. The non-mating mature schools were composed of many non-mating females and few social mature males. The school size of the mating and non-mating mature schools were 31–535 (average 225) and 200–1,832 (764) dolphins respectively.

Dolphin movement between schools

Striped dolphins remain in the mature school for 1 or 2 years after weaning (average 1.5 years), and then most of the dolphins move into the immature school. However, some of the dolphins stay in the mature school. Especially females remain in the mature school longer than males. The females in the immature school move into the mature school three years before attainment of sexual maturity (9.0 years). Then, most of the females in the immature school move into the non-mating mature school, and some of them into the mating mature school. The females which move into the non-mating mature school move into the mating mature school after about one reproductive cycle (approximately 3 years). On the other hand, the males in the immature school almost equally move into both mating and non-mating mature schools about 1.5 years after attainment of sexual maturity (8.7 years). The males which remain in the non-mating mature school move into the mating school after attainment of social maturity.

The pubertal males sometimes come together with each other to make their own groups. However, their groups were always found together with the groups of immature dolphins or mature dolphins. The former is considered to be the immature school, and the latter the mixed school.

As soon as the oesterous females in the schools come together with each other, the socially mature males also join, and then they make a unit of the mating mature school. The mature school consists of one or several of these units.

Relation between school structure, school size, and the Kuroshio current

The catch of striped dolphins in the Sagami Bay has a negative correlation with the distance between the main fishing ground and the Kuroshio current. In the years when the Kuroshio current was situated close to the fishing ground, the number of catch was greater, the intervals of fishing dates became shorter, and the density of schools on the fishing ground seemed to be higher compared with the years when the Kuroshio current was far from the fishing ground. In the former years many bigger mature schools (average 440 dolphins) and a few smaller immature schools (average 105) were caught, and in the latter many bigger immature schools (average 644) and a few smaller mature schools (average 89) were caught.

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Paper L.21

Notes on the Small Cetaceans off the Coasts of France

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Strandings of cetaceans on the coasts of France have been the object of systematic study, published in the form of annual reports, only since 1971. From that date until 1 June 1976, 167 records have been reported, for small cetaceans only.

The total records are presented in Table 1, expressed by species and localities of strandings for the three major areas of the French coastline – the Channel, Atlantic and Mediterranean.

Table 1

Strandings of small cetaceans on the coasts of France (1.1.1971 to 1.6.1976)

Species	Channel	Atlantic	Mediterranean	Total	%
Stenella coeruleoalba	0	2	32	34	20.35
Delphinus delphis	1	34	8	43	25.74
Tursiops truncatus	3	7	14	24	14.37
Orcinus orca	0	1	1	2	1.20
Grampus griseus	0	1	6	7	4.20
Globicephala melaena	1	12	3	16	9.58
Phocoena phocoena	3	1	0	4	2.40
Kogia breviceps	0	1	0	1	0.60
Mesoplodon bidens	1	1	0	2	1.20
Ziphius cavirostris	0	9	6	15	8.98
Hyperoodon ampullatus	1	0	0	1	0.60
Unidentified	2	6	10	18	10.78
Total	12	75	80	167	100.00%

Some remarks may be made on the present status of the 11 species concerned, based on the frequency and locality of strandings, as well as observations made at sea during the same period.

Stenella coeruleoalba

This dolphin may be considered the commonest species in the Mediterranean. Even so, its frequency along these coasts is irregular; it is clearly commonest in the East (notably in Var) than in the mid-West (between Marseille and Sète). In the Atlantic, it was generally considered that the principal populations barely extended beyond the latitude of the Azores but in 1975 two successive strandings, as well as repeated sightings, (47°N/17°W) showed that their distribution might extend over almost all the Gulf of Gascony.

Delphinus delphis

Rare in the Channel and much less frequent in the Mediterranean than *S. coeruleoalba*, the common dolphin is quite clearly the most frequent species on the Atlantic coast. The movements of schools between the deep sea and the coastal waters (rarely inside the 50 m. depth contour) are related to a feeding factor and ultimately a seasonal factor; the frequency of sightings in the open sea and the rarity of strandings in June supports this hypothesis.

Tursiops truncatus

This species is probably the most evenly distributed around all the coasts without ever becoming very common. It is characterised by its remarkable adaptation to very varied ecological conditions. It is found, in fact, in waters as different as the Mediterranean and the Channel, in deep water as well as in water a few metres deep. Its behaviour also is variable according to the zones frequented; near the coast *Tursiops* is usually seen in small groups (three to five individuals) whereas in the open sea it is nearly always associated with groups of *Globicephala melaena*, at least in the NE Atlantic.

Orcinus orca

Strandings of killer whales are fairly rare but sightings in the NE Atlantic show that this species regularly frequents this area, where it has been sometimes observed very near the coast.

Grampus griseus

Risso's dolphin may be considered, according to strandings and sightings at sea, quite common in the eastern zone of the French Mediterranean coast. It is, however, much rarer off the Atlantic coast where strandings are very unusual.

Globicephala melaena

This species may be found on all the French coasts but its appearance in the Channel is only occasional, although it is regularly seen in the Mediterranean, notably in the eastern sector of the coast. In the Atlantic, however, it is one of the commonest species and, according to the sightings and the dates of strandings, it can be proposed that there is a wintering zone in the Gulf of Gascony. Strandings have not occurred in great numbers during the period of study but several have been reported in the past, at various points on the coasts.

Phocoena phocoena

The porpoise was formerly very common near the coasts; it is at present one of the least frequent species. On the Mediterranean coast there has not been a single report since the end of the nineteenth century (*Pyrénées-Orientales*). Along the Atlantic coast, according to sightings at sea and strandings, it is becoming increasingly rare; only one stranding is known since 1971. It is still present on the French Channel coast but strandings are rare: less than one a year, on average, since 1971.

Kogia breviceps

Its presence in the NE Atlantic is known by a very small number of strandings: it may be considered a very unusual species on the French coasts of the Atlantic and the mouth of the Channel.

Mesoplodon bidens

This species also appears among those which are found occasionally on the Atlantic and Channel coasts.

Ziphius cavirostris

The feeding specialisation (squid) of this species localises it in areas of deep water. Strandings, not uncommon, usually happen on the coast of the Gulf of Gascony and in the eastern zone of the French Mediterranean coast.

Hyperoodon ampullatus

This species frequents only the coldest waters of the coasts, such as those of the Channel, where strandings occur regularly but without being frequent.

The factors concerned in the mortality of small cetaceans found on the coasts form the object of current research. The observations given in Table 2 are limited to those which show the action, deliberate or incidental, of man.

There is a tradition of harpooning the small Delphinidae (*S. coeruleoalba* and *D. delphis*) on board certain trawlers and tunny-fishing boats; but these catches are intended solely to improve the crew's diet. No valid estimate can be given for these mortalities, which remain occasional.

A remark may be added concerning the quantitative value of the observations. It must not be forgotten that they do not reflect the exact state of strandings but only those which are known. Biases are also present because of the greater number of observers in some coastal areas, e.g. the Côte d'Azur. Therefore the data supplied do not claim to have any statistical value but only give general ideas on the present status of small cetaceans on the coasts of France.

Table 2

Destruction, deliberate and incidental, of small cetaceans on the coasts of France (1.1.1971 to 1.6.1976)

Species	Total strandings	Nets	Trawls	Shot	Harpoon
Stenella coeruleoalba	34	1	1	2	–
Delphinus delphis	43	1	1	1	1
Tursiops truncatus	24	–	2	2	–
Grampus griseus	7	1	–	–	–
Globicephala melaena	16	–	1	–	–
Phocoena phocoena	4	2	–	–	–
Ziphius cavirostris	15	–	–	3	–

Paper L.22

A Note on the Value of Bottlenose Whales in Relation to Minke Whales and the Influence of the Market Situation and the Prices on Norwegian Whaling Activity

Åge Jonsgård

At the meeting of the Working Group on North Atlantic whales held in Oslo, 5–13 April 1976 (IWC, 1977) a discussion took place whether or not the prices and the market in general, for products from bottlenose whales may explain the fact that very few bottlenose whales have been caught in recent seasons.

Table 1 shows the number of vessels participating in Norwegian whaling and the number and percentage of different species caught in each of the seasons 1938–75. As seen from Table 1, the catch of all three species of toothwhales decreased very considerably in the 1972 season, and in the following three seasons there were almost no catches of bottlenose, killer and pilot whales. It has been argued that for bottlenose whales the drop in catch may be due to the stocks of bottlenose whales being depleted. *Based upon the catch data only, the same argument may very well be used for killer and pilot whales, since the catch data for all three species show an almost identical feature for the last four seasons.*

Norwegian experts on small whales do not agree with the above assumption for bottlenose whales (see IWC, 1977). According to them the changed market situation and the increased value of minke whales as compared to toothed whales completely explain the extremely reduced catches of toothed whales. This explanation is in full agreement with information from the whalers and their organizations and from dealers of whale meat.

For further discussion on this matter it is necessary to

Table 1

Number of participating vessels; and number and percentage of different species caught in each of the seasons 1938–1975

Season	Number of vessels	Minke		Bottlenose		Killer		Pilot		Total
		Number	%	Number	%	Number	%	Number	%	
1938	252	1,342	90.4	70	4.7	46	3.1	26	1.8	1,484
1939	161	917	90.5	45	4.4	23	2.3	28	2.8	1,013
1940	82	543	97.3	8	1.4	7	1.3	0	0.0	558
1941	259	2,113	98.2	21	0.9	14	0.7	4	0.2	2,152
1942	314	2,131	96.6	9	0.4	57	2.6	8	0.4	2,205
1943	292	1,611	96.8	34	2.0	12	0.7	8	0.5	1,665
1944	309	1,373	94.9	40	2.8	29	2.0	5	0.3	1,447
1945	240	1,778	97.5	22	1.2	12	0.7	12	0.7	1,824
1946	251	1,890	97.3	20	1.0	32	1.6	1	0.1	1,943
1947	234	2,572	94.7	108	4.0	29	1.1	7	0.3	2,716
1948	294	3,561	97.3	61	1.7	38	1.0	0	–	3,660
1949	340	3,928	93.8	221	5.3	34	0.8	4	0.1	4,187
1950	199	1,989	96.6	48	2.3	12	0.6	10	0.5	2,059
1951	230	2,750	96.2	77	2.7	24	0.8	8	0.3	2,859
1952	226	3,366	99.1	17	0.5	13	0.4	2	–	3,398
1953	169	2,433	97.6	49	2.0	9	0.4	1	–	2,492
1954	186	3,496	97.7	70	2.0	13	0.4	0	–	3,579
1955	193	4,328	96.4	124	2.8	26	0.6	13	0.2	4,491
1956	198	3,658	92.2	267	6.7	40	1.0	1	–	3,966
1957	197	3,642	92.6	163	4.1	48	1.2	80	2.0	3,933
1958	192	4,338	91.6	145	3.1	39	0.8	216	4.6	4,738
1959	185	3,090	88.9	94	2.7	69	2.0	224	6.4	3,477
1960	183	3,431	85.0	193	4.8	82	2.0	331	8.2	4,037
1961	177	3,238	86.8	87	2.3	111	3.0	294	7.9	3,730
1962	168	3,295	87.1	321	8.5	124	3.3	43	1.1	3,783
1963	156	3,228	88.3	267	7.3	90	2.5	71	1.9	3,656
1964	144	2,726	86.2	307	9.7	77	2.4	54	1.7	3,164
1965	139	2,465	74.8	695	21.1	104	3.2	32	1.0	3,296
1966	115	2,152	71.9	340	11.5	162	5.4	339	11.3	2,993
1967	119	2,191	83.9	264	10.2	36	1.4	117	4.5	2,598
1968	126	2,733	84.5	384	11.9	86	2.7	31	0.9	3,234
1969	115	2,391	76.3	485	15.5	231	7.4	27	0.9	3,134
1970	119	2,307	73.7	535	17.1	246	7.8	43	1.4	3,131
1971	105	2,330	89.6	213	8.2	57	2.2	0	0.0	2,600
1972	99	2,650	98.3	17	0.6	28	1.1	0	0.0	2,695
1973	99	2,055	99.8	3	0.2	1	0.0	0	0.0	2,059
1974	84	1,820	99.6	0	0.0	6	0.4	1	0.0	1,827
1975	80	1,788	99.9	0	0.0	2	0.1	0	0.0	1,790

Preliminary Report on the Small Cetaceans Stranded on the Coasts of Tierra del Fuego

R. N. P. Goodall

ABSTRACT

Little is known of the small cetaceans of the Southern Ocean. In view of the enormous amounts of water and little land in this area, records from Tierra del Fuego become very important. Strandings are much more common than formerly believed. A total of 158 new stranding records for the eastern part of Tierra del Fuego are reported, comprising the following species: *Baleanoptera acutorostrata* (4), *Berardius arnuxii* (1), *Mesoplodon layardii* (4), *M. grayi* (2), *M. hectori* (1), *Ziphius cavirostris* (5), *Hyperoodon planifrons* (1), *Orcinus orca* (19+), *Globiocephala melaena* (12+), *Lagenorhynchus australis* (5), *Lissodelphis peronii* (10), *Delphinus delphis* (1?), *Cephalorhynchus eutropia* (1?), *C. commersonii* (44), *Phocoena spinipinnis* (3), and *P. dioptrica* (46). Nine of these species are reported for the first time from Tierra del Fuego. These stranding records greatly increase the number of known specimens of certain species, more than doubling them in some cases. Stranding locality maps and photographs of skulls are presented. New sight records for *Cephalorhynchus commersonii* and *Lagenorhynchus australis* are given and the accidental exploitation of cetaceans is discussed.

CONCLUSIONS

In a very few days of searching very limited stretches of beach, we have found a very large quantity of material. Less than ten specimens of the smaller cetaceans were formerly known from Tierra del Fuego. We have increased that number by 158 skulls (or parts of skulls) and about an equal number of other bones. Nine species, of the 16 species found to strand on Tierra del Fuego, had never been found here before. Of those three species (*P. spinipinnis, C. eutropia* and *D. delphis*) were not even supposed to be in the area.

The number of specimens in the museums of the world of the dolphins and porpoises of the southern part of the Southern Hemisphere is very small. Six specimens of *Lagenorhynchus australis* were known, to which we now add five more. The ten specimens of *Lissodelphis peronii* are doubled with these ten new specimens. The 25 known specimens of *Cephalorhynchus commersonii* are increased by 44, and we now have 46 new specimens of *Phocoena dioptrica* to add to the eight formerly known.

Of the sixteen species found, I have seen only two alive. Eight sightings for *Lagenorhynchus australis* and seven for *Cephalorhynchus commersonii* are reported.

The specimens that are the most numerous on the beach, both skulls and vertebrae, are those of *Phocoena dioptrica*, which was thought to be one of the rarest porpoises. Although it has never been seen, it must be pretty common off this coast. More study in the area is definitely needed.

The area where most specimens were found was Bahia San Sebastián, but all beaches sampled offered a few specimens. There is a need for periodic revision of the areas of greatest abundance, and all the beaches, of the northeast coast especially, should be checked. The Chilean part of Tierra del Fuego, the north coast of the Strait of Magellan and the southern Patagonian coast should also be looked over for material. I plan to continue a systematic checking of the more accessible beaches, as much as is possible.

Paper L.25

Incidental Catches of Small Cetacea off Australia

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Information has been sought from 13 workers known to me in various States, as well as from all State Fisheries Departments and the Australian Commonwealth Fisheries Division. Replies were received from 9 persons, covering all States, and from 5 of the 7 State Fisheries Departments circulated.

While almost all reports agree that incidental kills may occur, most state that they are likely to involve few or very few individual animals. Most such kills seem to occur, generally illegally, as a result of fishermen shooting dolphins because of their presumed or real interference with fishing operations; some are occasionally trapped in fishing nets, but there are records of such animals being released. A few, particularly *Tursiops* and *Delphinus*, may occasionally be taken for bait. One example was given of 30 dolphins (not positively identified) being shot from one boat in a 'control' operation, but by comparison with all other reports received this seems to be an extreme case.

An exception to the above occurs in shark nets set off eastern coastal beaches. It was reported that off New South Wales the occasional dolphin does get caught, but that they can usually be freed, with on average one being killed every two years. Off Queensland, however, the average number of small cetaceans killed in such nets is rather higher; 13 have been recorded from one area in one year. Genera involved include *Orcaella, Sousa, Tursiops,* and possibly *Pseudorca.*

Not included above are small cetaceans taken under licence in each year for public display in aquaria. The number was reported to be relatively small and the genera involved are mostly *Tursiops* and *Pseudorca.*

Previous references to incidental kills off Australia have been in *J. Fish. Res. Bd. Can.* 32 (7), p. 950 – reference to accidental catch in shark nets off northern Queensland, and in IUCN Monograph 3, p. 65 – possible inadvertent killing of *Orcaella* in fish traps or protected embayments off North Western Australia.

It should be noted that unlike the U.S.A. situation, Australian purse-seining activities are not associated with the location of dolphin/fish groups so consequential dolphin kills do not occur.

Catch of Belugas, Narwhals and Harbour Porpoises in Greenland, 1954–75, by Year, Month and Region

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Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland were presented in a previous paper (Kapel, 1975). In the present paper a more detailed presentation of the statistics showing the catches of the three more important odontocetes during the period 1954 to 1975, and their seasonal and regional distribution, is given.

The districts and the regions used in this paper are shown on Fig. 7, and in Tables 1, 3 and 5.

BELUGA, OR WHITE WHALE

(Delphinapterus leucas)

Previously beluga and narwhal were lumped together in the catch statistics (their Greenlandic names are very similar). Since 1954, however, figures for both species have been published separately.

From Table 1 and Fig. 1 it appears that the main hunting regions are the Disko Bay and adjacent areas (CWe and CWw), where belugas are taken in the winter and especially in the early spring (April–May), see Table 2 and Fig. 2. The catch figures are unusually high for some years (e.g. 1954, 1968 and 1970), where so called 'savssat's (i.e. large groups of animals locked by sudden ice formation) have occurred, most often in January or February (Porsild, 1918).

In Fig. 2 occurrence of 'savssat' is indicated by an asterisk, and two means are given: one including 'savssat's (open circles), and one which is calculated on the basis of 'normal' catches (dots); the upper and lower limits of the columns indicate maximum and minimum monthly catches within the 4-year-period in question. It is obvious, that catches are fluctuating much from year to year, and that the 'most reliable' hunting period is April and May.

In the regions of Southwest Greenland (SWn and SWs south to approx. 63°N in Godthåb district) belugas are taken especially in the winter (February and March), and there is an indication of slightly increased catches during the last decade, although the level of high catches prevailing prior to the 1920s (200–1,000 animals per year) is far from reached.

In Northwest Greenland belugas are taken in low numbers at ice edge in late spring (June) and especially in the autumn (September to November). A tendency of increased catches in the last decade may be due in part to a change in the hunting pattern.

In North Greenland (Thule district) belugas are taken in the summer months, especially July and August, but the level of the catches is not known exactly.

The data from the catch statistics thus support the opinion generally expressed by the Greenlandic hunters, that belugas in Greenland waters are wintering in an area immediately south of the Polar circle (or occasionally in the Disko Bay area), are migrating northward in the spring, summering in the Thule district, and migrating southward in the autumn.

The beluga is only taken in very low numbers in East Greenland, and its occurrence and migrations in that area are not known precisely.

NARWHAL

(Monodon monoceros)

The catches of narwhal show a pattern similar to that described for beluga, but the numbers taken are much smaller, the main hunting area is the Thule district and the species is rarely seen south of Sukkertoppen (approx. 65°N). The distribution and variation in catches appear from Tables 3–4, and Figs. 3–4.

In Southwest Greenland the species was rarely caught prior to 1965, but during the last decade small catches have regularly been taken in late winter (February to May). The explanation for this change may be that some fishing vessels from Southwest Greenland have been catching narwhals farther north, but according to the rules have reported the catch in their native district.

In the outer part of the Disko Bay area (CWw) narwhals are regularly caught from January to May, and also in this region catches have been slightly higher during the last 5–10 years than previously.

The same seems to be true for the inner part of the Disko Bay (CWe) and for the Umanak district (NWs), but the catches in these areas are highly fluctuating, partly due to the occurrence of 'savssat's in the winter (e.g. Umanak 1956, 1960 and 1968, and CWe 1968 and 1970. Small catches are also taken in the spring, and in late autumn (November and December).

In the Upernavik district (NWn) 'savssat's also occur in some years (1955, 1968 and 1969), but narwhals are more regularly taken on their migration in late spring or early autumn.

Statistics for the Thule district are incomplete, but an annual catch of approx. 125–250 narwhals are taken in summer (July and August), especially in the Inglefield Bredning (approx. 77½°N).

The catch of narwhals in East Greenland is insufficiently known. Apparently it is on the same level as the catch in Upernavik district, but the hunting season falls in the summer (June–September).

It should be stressed, that for both beluga and narwhal hunting losses may be considerable, especially during the spring hunt and at the 'savssat's, so that the number of animals killed is higher than it appears from the catch statistics. In the Thule district, and in many other areas, local rules command the use of harpoons in order to limit the losses. In all districts not only the skin ('mátak') and the narwhal tusk are secured, but all the meat and part of the blubber are still used for human consumption or for feeding the dogs.

Table 1

Catch of belugas (or white whales) in Greenland, 1954--1975, by regions and districts.

Region	District	[1]1954/55	55	56	57	58	59	60	61	62/63	63	64	65	66	67	68	69	70	71	72	73	74	75[2]
North Grl. = Thule[3]		·	·	·	·	·	·	·	(32)	(85)	(75)	125	150	·	·	·	·	(17)	(2)	·	·	(21)	·
	Upernavik	16	10	9	6	3	12	13	15	9	18	4	20	25	34	97	111	334	238	293	262	195	150
	Umanak	61	3	8	11	4	12	6	6	7	12	6	53	88	66	65	36	6	3	25	33	13	18
NW		77	13	17	17	7	24	19	21	16	30	10	73	113	100	162	147	342	241	318	295	208	168
	Jakobshavn	1,326	39	89	191	50	48	52	11	52	25	57	102	76	90	490	357	656	82	116	205	290	·
	Christianshåb	69	13	2	8	5	5	17	3	12	5	4	44	34	72	105	119	127	25	39	35	65	·
CWe		1,395	52	91	199	55	53	69	14	64	30	61	146	110	162	595	476	783	107	155	240	355	56
	Godhavn	241	75	75	66	8	46	37	75	42	22	38	28	132	37	160	89	212	97	78	81	22	92
	Egedesminde	88	107	155	96	90	112	55	125	57	36	55	27	135	140	160	83	113	96	107	217	116	53
	Kangatsiaq	50	41	52	30	29	32	18	5	23	5	12	13	21	30	98	13	25	28	22	43	13	18
CWw		379	223	282	192	127	190	110	205	122	63	105	68	288	207	418	185	350	221	207	341	151	163
SWn	Holsteinsborg	23	11	29	95	35	42	17	47	23	8	8	24	24	76	46	100	10	123	135	121	135	·
	Sukkertoppen	–	1	5	–	1	–	–	1	8	12	4	18	13	47	38	40	24	4	11	–	8	–
	Godthåb	–	–	–	–	–	–	1	11	11	11	18	9	12	4	–	30	–	41	14	70	25	13
	Frederikshåb	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–	1	–	2	–
SWms		–	1	5	–	1	–	1	13	19	23	22	27	26	51	38	70	24	45	26	70	35	13
S		–	–	–	–	–	–	–	13	–	–	–	–	–	–	–	–	–	–	–	–	–	·
Total	West Greenland	1,874	300	424	503	225	309	216	313	244	154	206	338	561	596	1,259	978	1,509	737	841	1,067	884	400^{+}
Total	East Greenland[4]	(–)	(5)	(6)	(–)	(3)	(3)	(3)	(1)	(1)	(–)	(5)	(1)	(–)	(–)	(–)	(–)	(1)	(1)	(–)	(2)	(2)	(–)

[1] For 1954–55 to 1962–63 is given data for the period 1.4.–31.3., for 1963 onwards for the calendar year.

[2] Figures for 1975 provisional and for some districts lacking (.).

[3] Figures for Thule district incomplete, 1964 and 1965 probably indicate the level of annual catch.

[4] Figures for East Greenland incomplete.

Fig. 1. Catch of belugas or white whales in West Greenland, 1954–75, by regions.

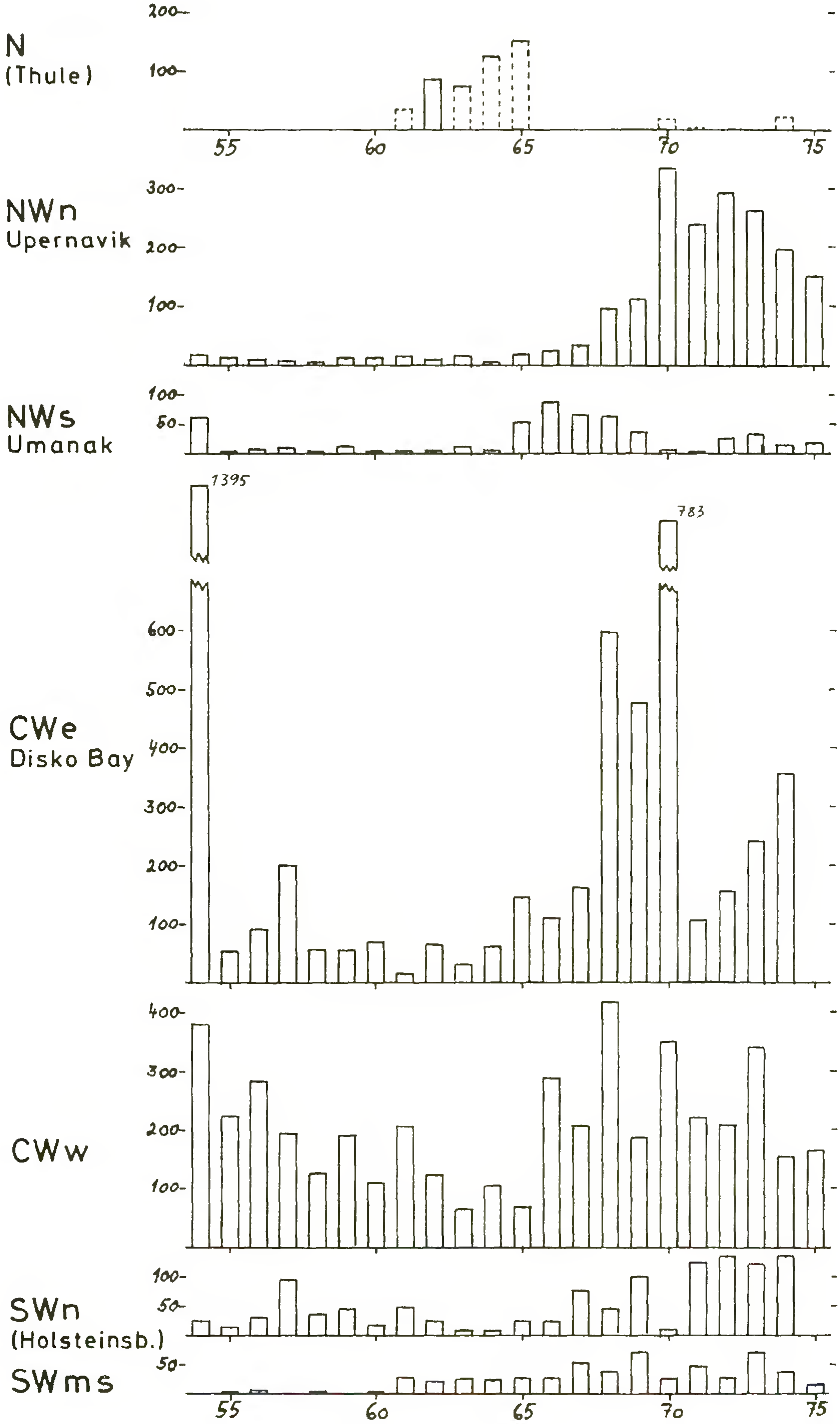

Table 2

Mean catch of belugas in Greenland, by months and regions (4-years periods).

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1963–66													
N. Grl. = Thule[1]	–	–	–	–	–	+	++	++	+	+	–	–	50–150
NW, Upernavik	0.3	0.3	1.3	0.8	0.3	4.0	0.3	0	0.8	5.0	2.3	1.8	16.8
NW, Umanak	0.5	0.3	0	0	1.5	3.5	0.3	0	0	7.0	20.8	6.0	39.8
CWe	3.0	7.5	4.0	27.3	40.5	0.8	0	0.3	0	0	0.5	2.3	86.0
CWw	12.8	7.8	8.5	42.3	40.8	0.5	0	0	0	0	0	0.5	118.3
SW	1.0	6.3	13.8	10.3	5.8	0.3	0	0	0.3	0	0	0	39.5
1967–70													
NW, Upernavik	0.3	0	0	0.3	3.3	5.5	0.3	0.8	17.5	108.0	4.0	0.3	144.0
NW, Umanak	1.8	0.3	0.5	0.8	3.8	2.3	0	0.5	0	13.0	15.5	4.0	43.8
CWe	38.0	45.5	4.8	75.5	127.0	12.3	0.8	0	2.5	1.5	13.3	7.3	374.0
	[2](113.0)	(100.5)	–	–	–	–	–	–	–	–	–	–	(504.0)
CWw	29.3	27.0	36.0	80.8	105.0	3.0	0	3.0	0	0.3	3.0	0.5	290.0
SW	0	37.8	48.5	8.3	4.8	2.0	0	0	0	0	0	0	103.8
1971–74													
NW, Upernavik	0	0	0	0	1.5	3.5	0.5	0.3	0	184.8	56.5	0	247.0
NW, Umanak	0.3	0	0	0	1.0	0.3	0	0.3	0.5	5.5	6.8	4.0	18.5
CWe	15.5	3.8	1.8	34.5	100.5	8.3	0.3	0	0.3	2.8	40.0	6.8	214.3
CWw	24.0	32.8	27.8	74.5	56.3	1.5	0.3	0.5	0	0.8	5.5	5.5	230.0
SW	31.3	65.5	44.0	21.8	5.8	3.3	0	0	0	0.5	0	0.5	172.5

[1] For Thule district the data are incomplete, but the peak season is in July–August.

[2] Figures in brackets indicate the values when exceptional high catches taken in 'savssat' are included (Feb. 1968 and Jan. 1970).

HARBOUR OR COMMON PORPOISE

(Phocoena phocoena)

Contrary to the above mentioned two species the harbour porpoise is not common in the northern part of West Greenland, and is only taken in small numbers north of, and in the inner part of the Disko Bay, especially in late summer. A slight increase in the catches in these areas is indicated by the catch statistics for the last decade (Table 5, Fig. 5).

The same seems to be valid also for the outer part of Central West Greenland, where the catches are somewhat larger, and peak in early summer (July), see Table 6 and Fig. 6.

The main catching region is South West Greenland, where, according to the catch statistics, the catches have been slightly increasing from a level of 400–500 per year in the beginning of this century to 800–900 in the 1960s, probably reflecting the increasing number and activity of fishing vessels during that period. The porpoise is caught in the summer and the autumn (May to November) by shooting or harpooning from all kinds of dinghies and small fishing vessels, but since the late 1960s some of the larger ones adopted the use of salmon drift nets, in which a significant number of porpoises were caught. This is probably the explanation of the sudden increase in the catches at Sukkertoppen (SWn) 1967–71.

At the same time (in fact a couple of years before) foreign (i.e. non-Greenlandic) salmon driftnetters began operating in the Davis Strait, and they also took a considerable number of porpoises, a by-catch which was only partly used and of course not reported in the Greenland hunting statistics. The level of this by-catch has been estimated by Lear and Christensen (1975) to be of the order of 1,500, or slightly higher than the total reported catch by the Greenlanders. The non-Greenlandic drift net fishery peaked in 1971, was phased out during the following four years, and in 1976 only the Greenlanders have been fishing salmon in the Davis Strait.

It is not quite correct, as has been maintained, that the catch of harbour porpoise by the Greenlandic driftnetters is not reported. According to the rules all catches of marine mammals should be reported in the hunting statistics irrespectively of the method used for capture (harpooning, shooting or netting), and the figures for Sukkertoppen indicate that this at least to some extent is the case in that area. On the other hand, it is known that the system for gathering information on the catch is operating better in the true hunting districts than in the fishery regions of South West Greenland.

It is likely that the total catch of harbour porpoises by the Greenlanders is somewhat higher than appear from the catch statistics, maybe of the order of 1,000–1,200 for South West Greenland in the beginning of the 1960s, significantly higher during a five years period around 1970, and evidently a bit lower during the last few years, possibly as a result of the intermezzo of extremely high drift net by-catches in the period 1965–75.

In Southeast Greenland the harbour porpoise is only caught occasionally and in very low numbers.

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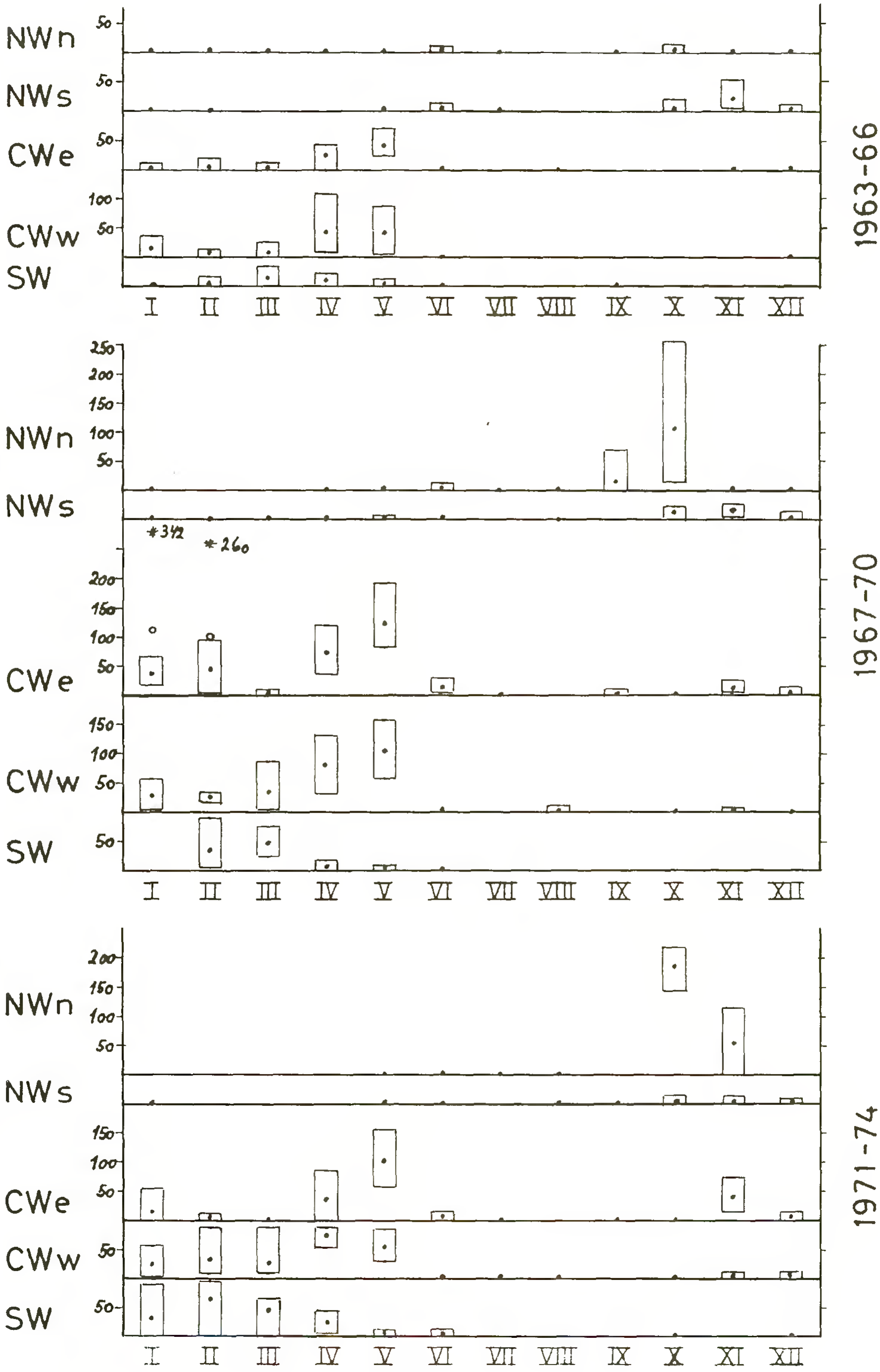
Porsild, M. P. 1918. On 'savssats': A crowding of Arctic animals at holes in the sea ice. *Geogr. Rev.* 6: 215–28.

Fig. 2. Mean catch of belugas or white whales in West Greenland, by month and region (4-year-periods).



For interpretation of symbols, see explanation in the text, page 507.

Table 3

Catch of narwhals in Greenland, 1954–1975, by regions and districts.

Region	District	[1]1954/55	55	56	57	58	59	60	61	62/63	63	64	65	66	67	68	69	70	71	72	73	74	75[2]
North Grl · = Thule[3]		·	·	·	·	·	·	·	134	182	275	275	·	·	·	(48)	(12)	(53)	(43)	·	·	(3)	(1)
	Upernavik	31	179	15	55	24	32	25	25	17	10	17	33	39	48	120	128	46	25	23	28	25	54
	Umanak	2	2	282	11	3	8	296	5	1	3	11	37	23	21	110	26	26	10	30	35	39	11
NW		33	181	297	66	27	40	321	30	18	13	28	70	62	69	230	154	72	35	53	63	64	65
	Jakobshavn	–	2	1	10	9	8	2	1	1	–	2	13	3	36	170	2	135	36	3	5	7	·
	Christianshåb	–	–	–	–	–	2	1	–	–	–	–	–	1	1	11	9	3	2	–	–	1	–
CWe		–	2	1	10	9	10	3	1	1	–	2	13	4	37	181	11	138	38	3	5	8	·
	Godhavn	7	11	11	4	6	1	1	28	1	18	1	3	23	2	15	4	84	55	14	105	40	23
	Egedesminde	1	–	5	1	29	2	–	7	10	8	8	17	14	21	28	5	16	17	14	17	22	20
	Kangatsiaq	4	1	4	–	1	3	3	2	–	3	–	–	2	2	2	–	3	1	–	1	2	1
CWw		12	12	20	5	36	6	4	37	11	29	9	20	39	25	45	9	103	73	28	123	64	44
	Holsteinsborg	1	–	–	–	–	–	1	–	–	–	–	1	–	5	–	–	–	–	2	–	–	·
	Sukkertoppen	–	–	–	–	1	–	1	–	–	–	–	1	3	–	16	30	9	24	19	8	3	6
	Godthåb	–	–	–	–	–	–	1	–	–	–	–	–	2	4	–	–	–	15	–	–	–	–
	Frederikshåb	1	–	–	–	–	1	–	–	1	–	–	–	–	–	1	–	–	–	1	–	–	–
	Nanortalik	–	–	–	–	–	–	1	1	–	–	–	–	–	–	1	–	–	1	1	–	–	1
SW + S		2	–	–	–	1	1	4	1	1	–	–	2	5	9	18	30	9	40	23	8	3	·
Total	West Greenland	47	195	318	81	73	57	332	69	31	42	39	105	110	140	474	204	322	186	107	199	139	116+
Total	East Greenland[4]	24	6	12	29	27	6	65	11	29	8	8	2	43	20	30	17	42	11	13	6	27	4

[1] For 1954–55 to 1962–63 is given data for the period 1.4.–31.3.; for 1963 onwards for the calendar year.

[2] Figures for 1975 provisional and for some districts lacking (·).

[3] Figures for Thule district incomplete; 1961 to 1964 probably indicate the level of annual catch.

[4] Figures for East Greenland incomplete.

Fig. 3. Catch of narwhals in Greenland 1954–75, by regions.

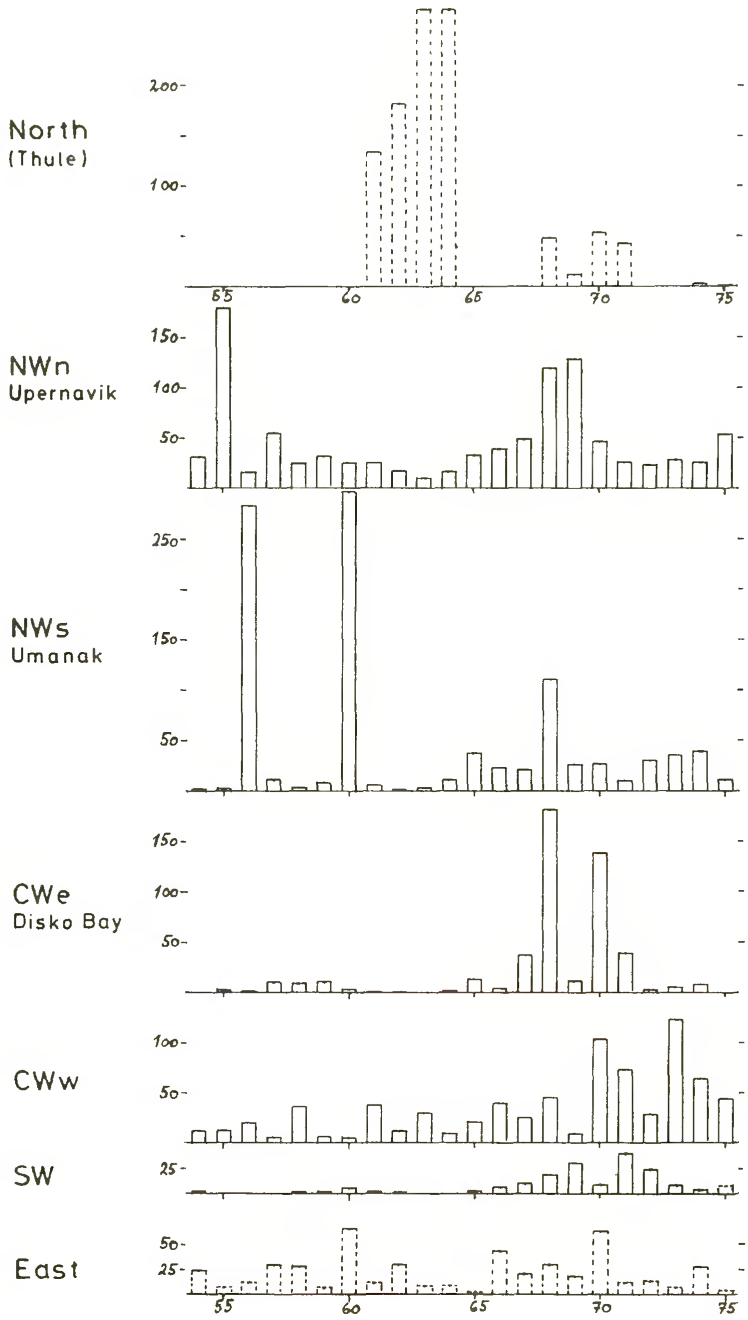


Table 4

Mean catch of narwhals in Greenland, by months and regions (4-year periods).

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1963–66													
N. Grl. = Thule[1]	–	–	–	–	–	+	++	++	+	–	–	–	200–300
NW, Upernavik	0	1.5	0	1.0	4.8	4.5	0.8	6.0	4.0	1.5	0.8	0	24.8
NW, Umanak	0.5	0	0.3	0	0.3	1.0	0	0	0	0	9.0	7.3	18.3
CWe	0.3	0.3	0.3	2.0	0.5	0.3	0	0	0	0	0.8	0.5	4.5
CWw	0.8	2.3	4.0	6.3	3.3	0	0	0	0	0	0	0	22.3
SW (+S)	0	0.5	1.0	0	0.3	0	0	0	0	0	0	0	1.8
1967–70													
NW, Upernavik	20.8	3.0	3.8	2.3	9.3	9.0	8.0	10.5	3.3	1.3	1.3	0	73.0
	[2](33.3)	–	–	–	–	–	–	–	–	–	–	–	(85.5)
NW, Umanak	2.3	2.8	2.3	1.0	1.8	0.3	0	0	0	0.3	11.8	1.8	22.5
	[2]–	(23.8)	–	–	–	–	–	–	–	–	–	–	(45.8)
CWe	2.0	1.3	0	4.3	2.0	0.5	0	0	0	0	2.5	0.5	7.0
	[2](30.5)	(42.5)	(9.0)	–	–	–	–	–	–	–	–	–	(85.8)
CWw	5.5	4.3	19.3	9.0	7.0	0.3	0.3	0	0	0	0	0	45.5
SW (+S)	0.3	1.3	4.3	8.5	1.3	0	0	0.8	0.3	0	0	0	16.5
1971–74													
NW, Upernavik	0	0	0	0.5	7.8	2.5	1.3	5.5	1.3	5.0	1.5	0.3	25.3
NW, Umanak	1.0	0	0.3	1.8	2.8	0	0	0	0	1.5	18.0	3.3	28.5
CWe	0.3	0.3	0.3	0.3	0.3	0	0	0	0	0	3.0	0.3	4.5
	[2](9.3)	–	–	–	–	–	–	–	–	–	–	–	(13.4)
CWw	22.8	14.0	11.5	13.0	8.8	1.0	0	0	0	0	0	1.0	72.0
SW (+S)	0.5	3.8	6.0	4.5	3.0	0	0	0.3	0.3	0	0	0	18.5

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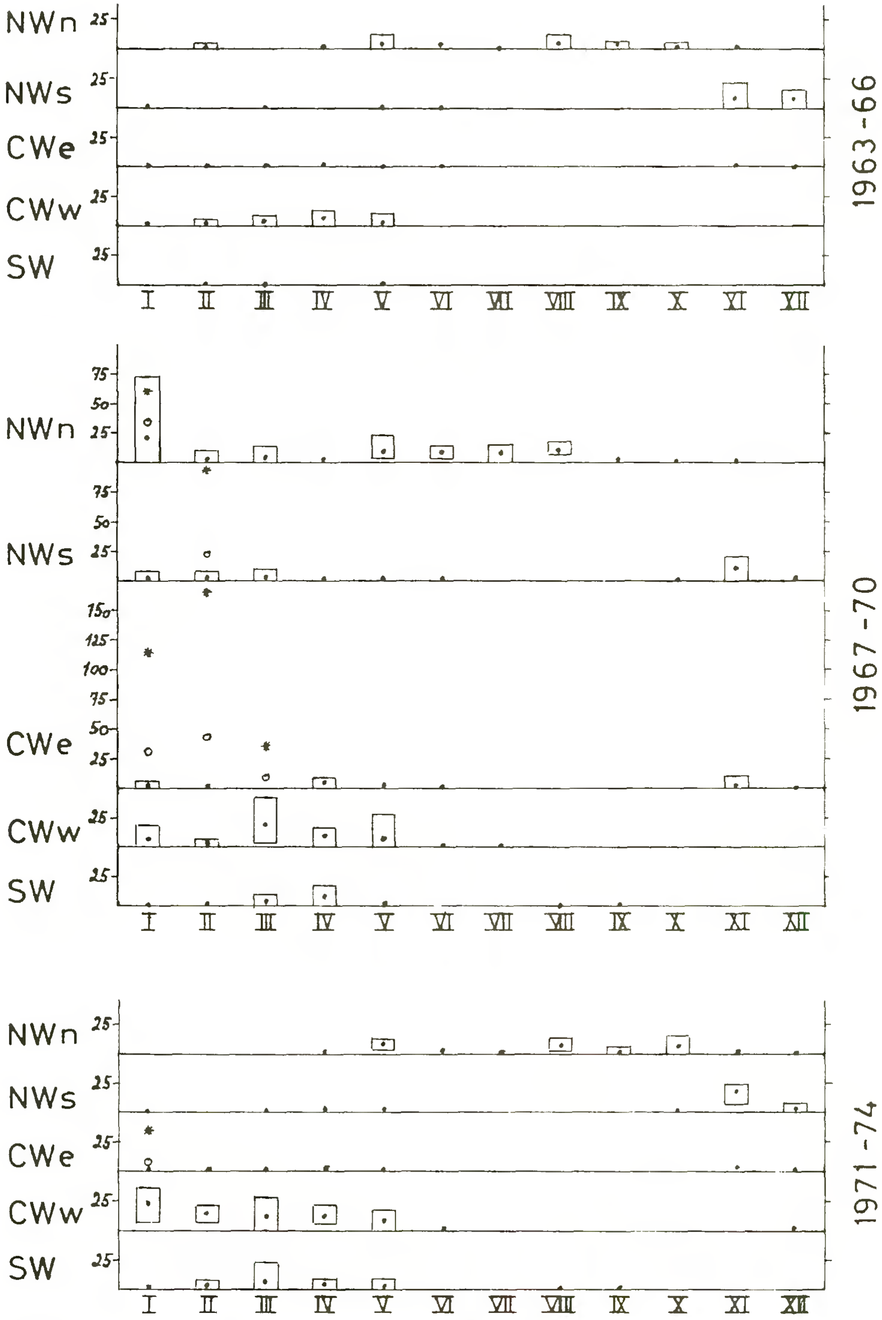
[1] For Thule district the data are incomplete, but the peak season is in July–August.

[2] Figures in brackets indicate the values when the high catches taken occasionally in 'savssat' are included. (Upernavik Jan. 1968, Umanak Feb. 1968, Disko Bay (CWe) Mar. 1967, Feb. 1968, Jan. 1970 and 1971 (?)).

[3] Incomplete data for the catch in East Greenland – probably at the level of 50 annually – indicate that the main period is from June to August.

Fig. 4. Mean catch of narwhals in Greenland, by month and regions (4-year- periods).



For interpretation of symbols, see explanation in the text, page 507.

Table 5

Catch of harbour porpoises in Greenland, 1954–1975, by regions and districts.

Region	District	[1]1954/55	55	56	57	58	59	60	61	62/63	63	64	65	66	67	68	69	70	71	72	73	74	75[2]
	Upernavik	2	–	9	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–
	Umanak	–	–	–	1	–	–	1	–	1	–	–	2	1	–	1	1	–	1	1	–	–	–
NW		2	–	9	1	–	–	1	–	2	–	–	2	1	–	1	1	–	1	2	–	–	–
	Jakobshavn	9	33	28	4	–	4	7	3	3	5	7	14	7	10	18	12	25	22	29	18	27	·
	Christianshåb	4	5	3	4	4	5	3	1	1	6	6	9	7	7	36	6	28	18	28	33	1	31
CWe		13	38	31	8	4	9	10	4	4	11	13	23	14	17	54	18	53	40	57	51	28	·
	Godhavn	36	29	39	16	13	8	7	11	1	8	29	27	12	30	18	72	95	56	61	62	26	47
	Egedesminde	29	13	38	23	14	23	43	36	51	132	47	93	50	44	161	59	81	103	147	108	59	90
	Kangatsiaq	19	22	16	15	16	3	17	8	9	10	26	23	24	5	11	22	18	4	7	13	10	4
CWw		84	64	93	54	43	34	67	55	61	150	102	143	86	79	190	153	194	163	215	183	95	141
	Holsteinsborg	96	156	229	137	52	78	102	55	74	91	176	69	64	81	100	34	162	69	6	5	38	·
	Sukkertoppen	351	395	230	342	186	386	394	354	269	371	369	291	372	521	863	896	729	553	199	245	175	193
SWnm		447	551	459	479	238	464	496	409	343	462	545	360	436	602	963	930	891	622	205	250	213	·
	Godthåb	212	329	174	362	141	111	332	201	344	183	154	257	228	367	266	210	185	379	393	193	184	141
	Frederikshåb	152	227	130	135	122	157	238	101	90	104	212	133	167	64	57	50	37	105	154	91	63	80
SWs		364	556	304	497	263	268	570	302	434	287	366	390	395	431	323	260	222	484	547	284	247	221
S	Narssaq Julianehåb Nanortalik	11	4	19	2	21	4	1	28	22	3	41	1	15	6	7	–	–	10	21	10	13	·
Total	West Greenland	921	1,213	915	1,041	569	779	1,145	798	866	913	1,067	919	947	1,135	1,538	1,362	1,360	1,320	1,047	778	596	586$^+$

[1] For 1954–55 to 1962–63 is given data for the period 1.4.–31.3.; for 1963 onwards for the calendar year

[2] Figures for 1975 are provisional and for some districts lacking (·).

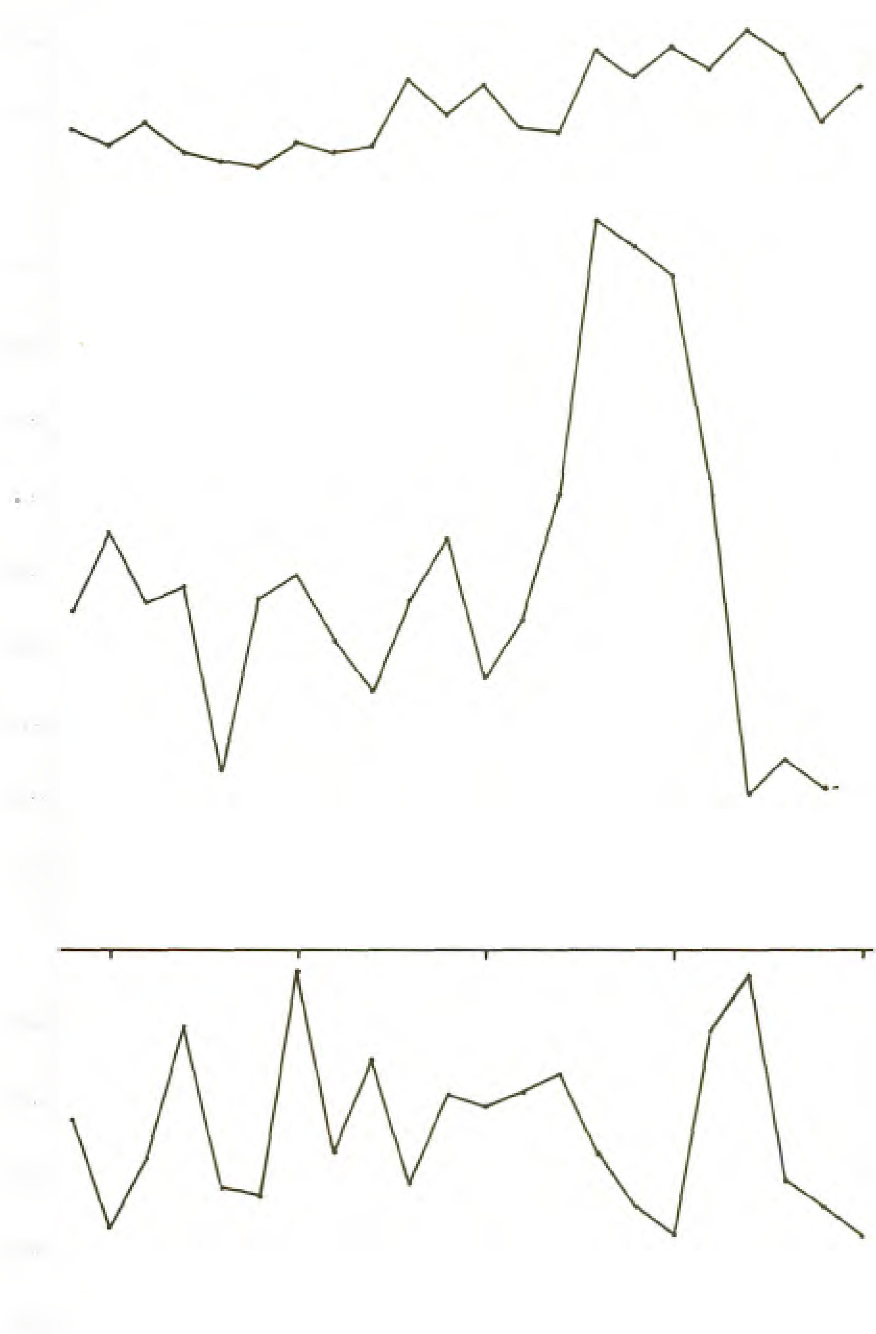
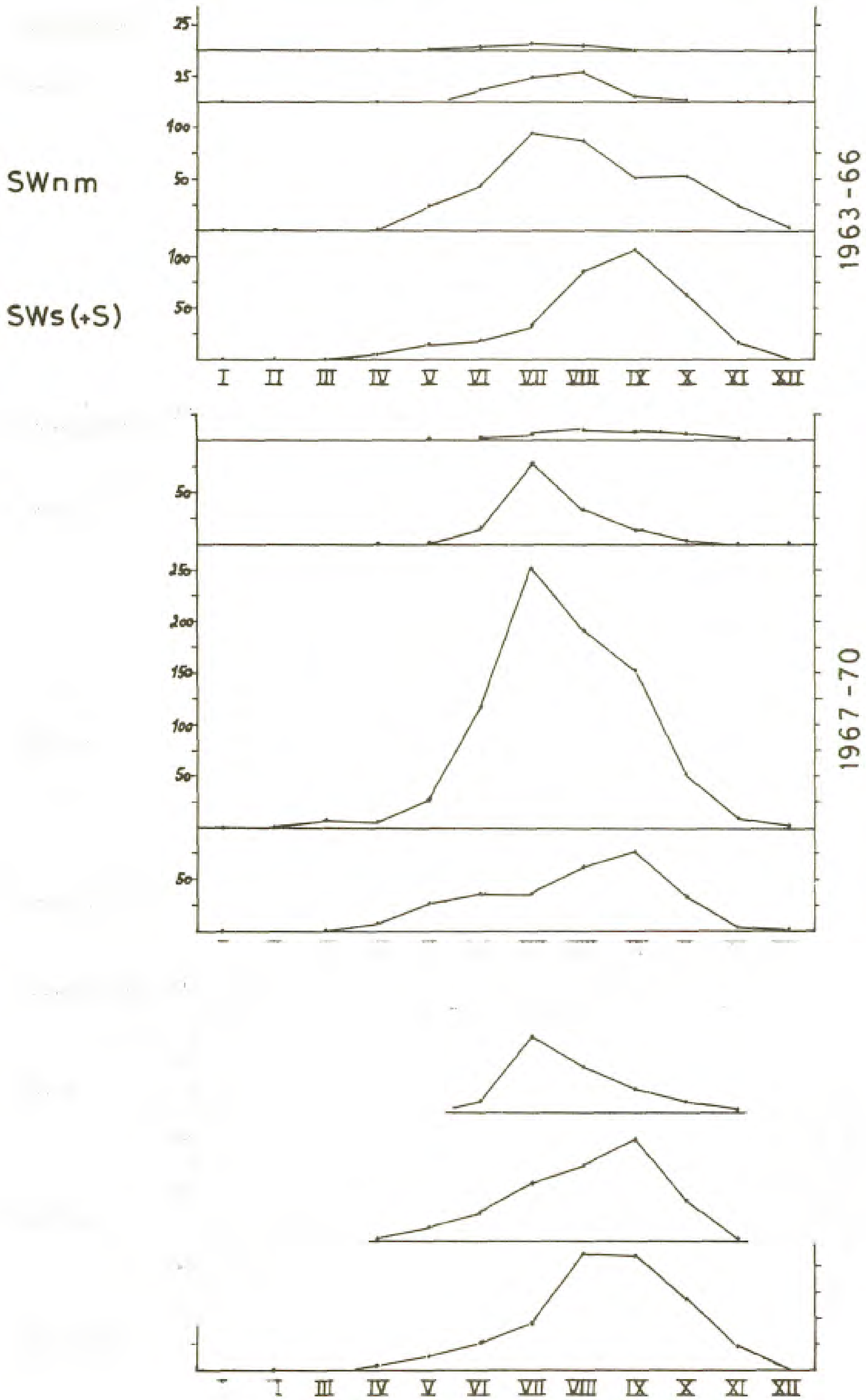


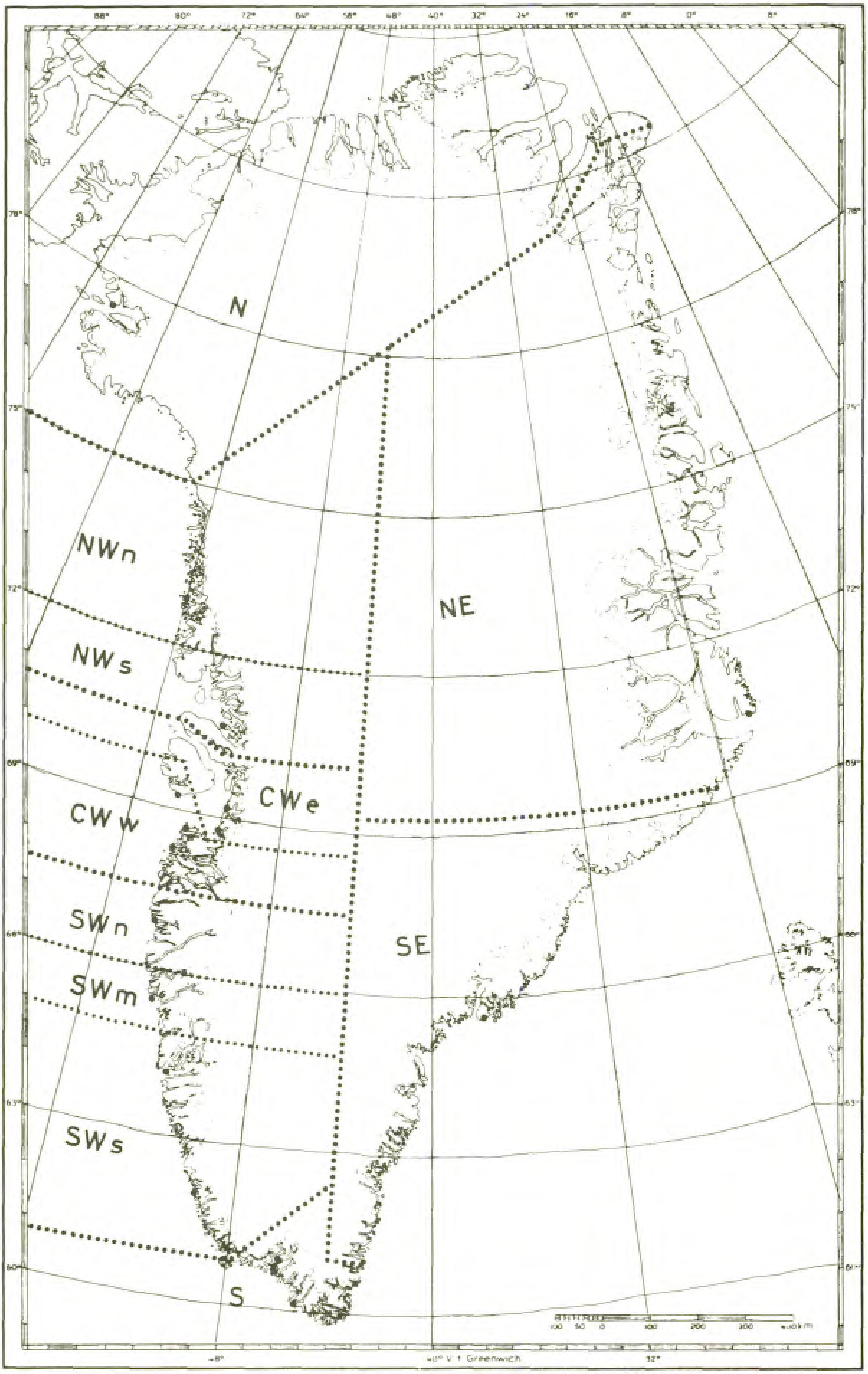
Table 6

Mean catch of harbour porpoises in Greenland, by months and regions (4-year-periods).

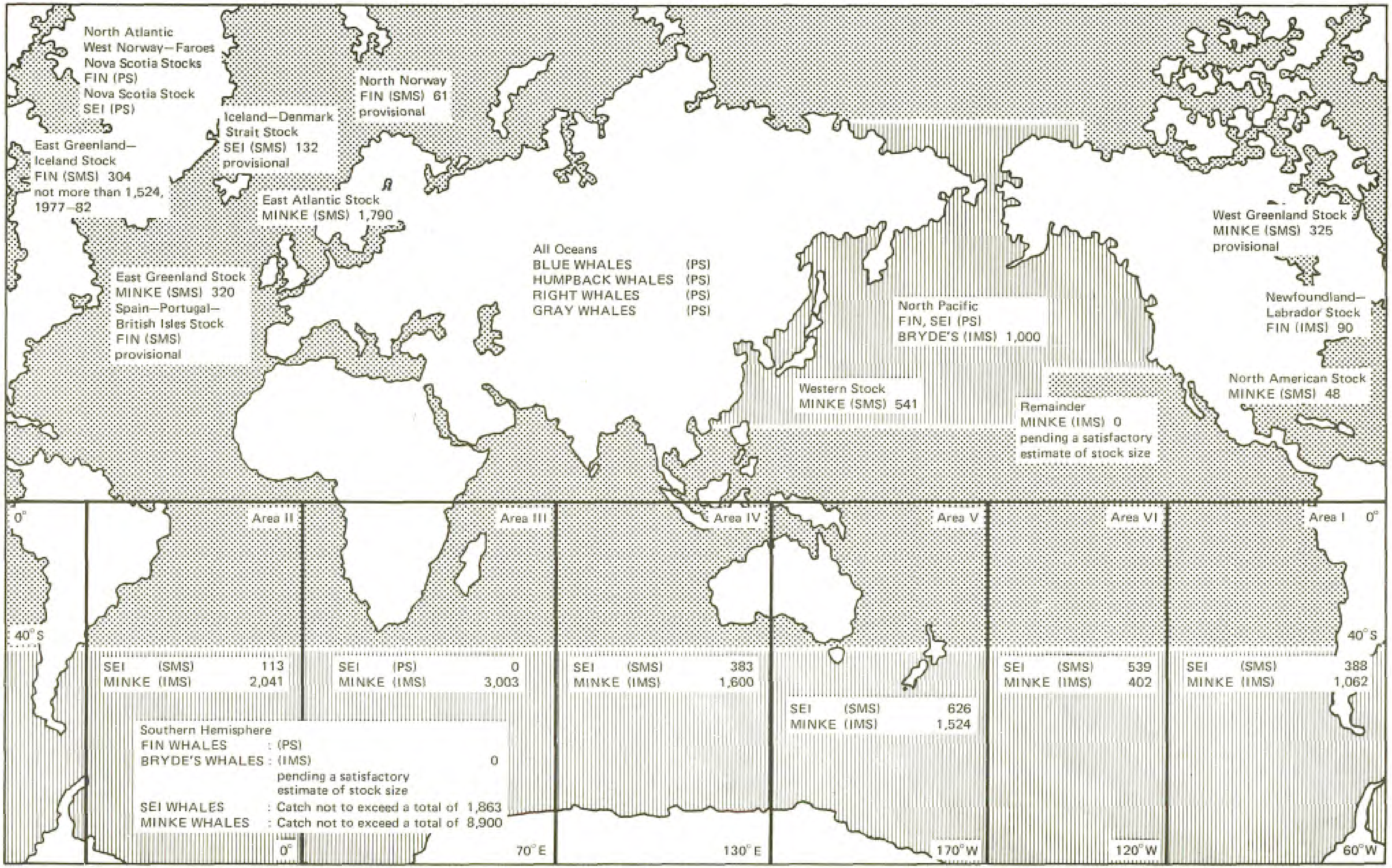
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
1963–66													
(NW+) CWe	–	–	–	0.3	1.0	3.8	6.8	5.0	0.8	–	–	0.3	17.8
CWw	0.3	–	–	0.3	–	11.5	23.3	29.8	5.8	2.0	0.8	0.3	73.8
SWn	0.3	1.0	–	1.8	24.5	43.8	95.3	87.3	51.0	53.5	25.0	2.8	386.0
SWs (+S)	1.0	1.3	1.0	6.3	15.5	19.0	33.0	86.5	107.8	64.5	16.5	1.3	353.5
1967–70													
(NW+) CWe	–	–	–	–	1.3	2.5	5.8	10.3	8.3	5.8	1.8	0.8	36.3
CWw	–	–	–	0.5	0.8	15.8	78.5	34.0	14.3	3.3	0.5	2.3	150.8
SWn	0.5	1.0	3.5	2.5	27.0	118.0	252.3	192.3	153.3	51.8	10.0	2.5	814.5
SWs (+S)	0.3	–	0.5	8.0	27.5	35.8	35.8	62.3	76.8	33.8	4.3	2.5	287.3
1971–75													
(NW+) CWe	–	–	–	–	1.3	4.0	5.5	5.8	17.5	9.3	0.5	–	43.8
CWw	0.3	0.3	1.0	–	–	10.8	73.5	43.5	22.3	10.0	2.5	–	164.0
SWn	1.0	0.8	0.3	2.8	13.3	28.0	56.0	73.5	97.8	39.0	2.5	–	314.8
SWs (+S)	–	0.5	–	5.0	14.0	26.5	45.3	112.5	109.8	68.3	22.0	0.3	404.0

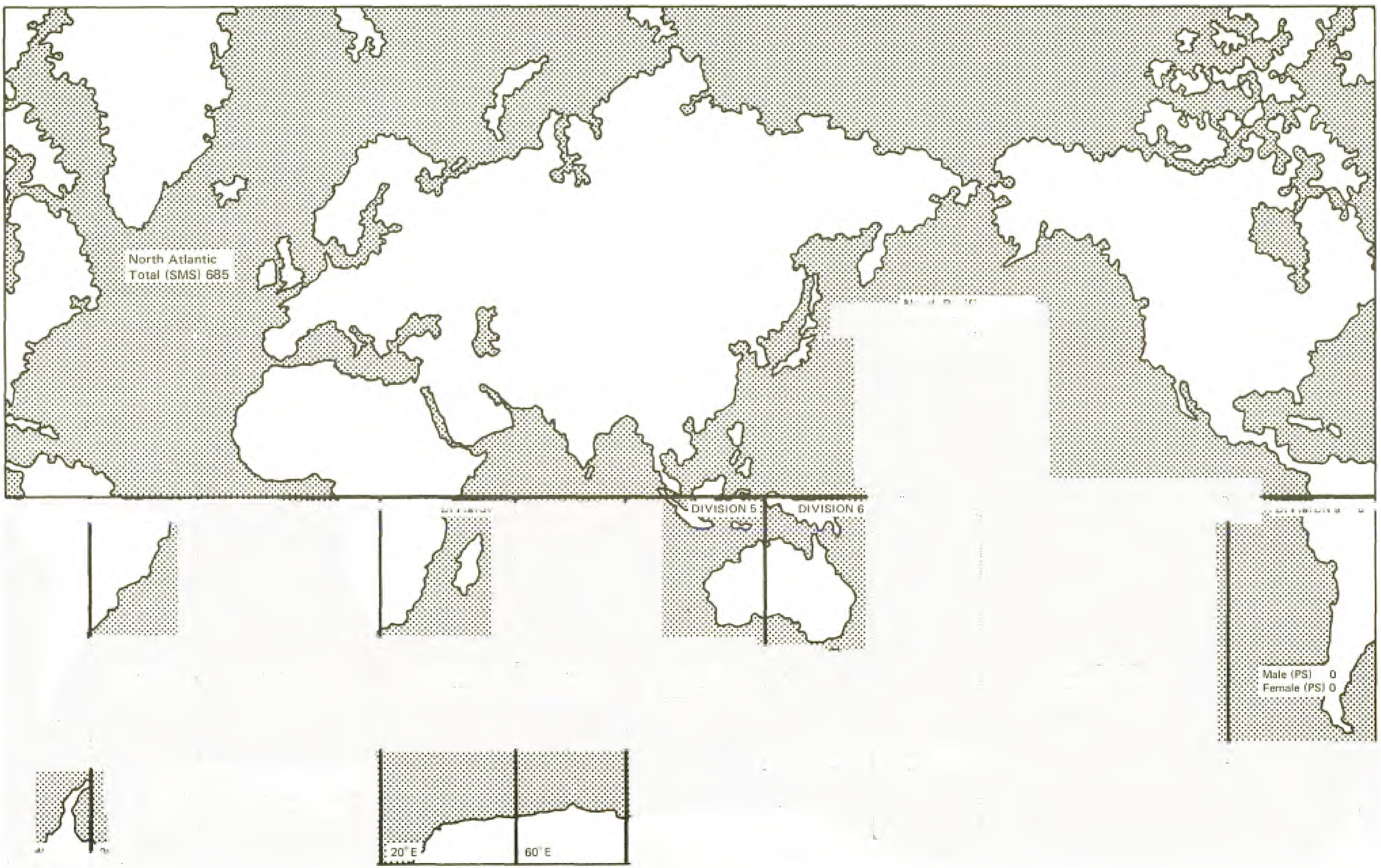


SWnm
SWs (+S)
1963-66
1967-70
I II III IV V VI VII VIII IX X XI XII



N
NE
NWn
NWs
CWe
CWw
SWn
SE
SWm
SWs
S
40° V. f. Greenwich


North Atlantic
West Norway—Faroes
Nova Scotia Stocks
FIN (PS)
Nova Scotia Stock
SEI (PS)
East Greenland—
Iceland Stock
FIN (SMS) 304
not more than 1,524,
1977–82
Iceland—Denmark
Strait Stock
SEI (SMS) 132
provisional
North Norway
FIN (SMS) 61
provisional
East Atlantic Stock
MINKE (SMS) 1,790
East Greenland Stock
MINKE (SMS) 320
Spain—Portugal—
British Isles Stock
FIN (SMS)
provisional
All Oceans
BLUE WHALES (PS)
HUMPBACK WHALES (PS)
RIGHT WHALES (PS)
GRAY WHALES (PS)
North Pacific
FIN, SEI (PS)
BRYDE'S (IMS) 1,000
Western Stock
MINKE (SMS) 541
Remainder
MINKE (IMS) 0
pending a satisfactory
estimate of stock size
West Greenland Stock
MINKE (SMS) 325
provisional
Newfoundland—
Labrador Stock
FIN (IMS) 90
North American Stock
MINKE (SMS) 48
0°
40° S
Area II
SEI (SMS) 113
MINKE (IMS) 2,041
Area III
SEI (PS) 0
MINKE (IMS) 3,003
Area IV
SEI (SMS) 383
MINKE (IMS) 1,600
Area V
SEI (SMS) 626
MINKE (IMS) 1,524
Area VI
SEI (SMS) 539
MINKE (IMS) 402
Area I
0°
40° S
SEI (SMS) 388
MINKE (IMS) 1,062
Southern Hemisphere
FIN WHALES : (PS)
BRYDE'S WHALES : (IMS) 0
pending a satisfactory
estimate of stock size
SEI WHALES : Catch not to exceed a total of 1,863
MINKE WHALES : Catch not to exceed a total of 8,900
0°
70° E
130° E
170° W
120° W
60° W


North Atlantic
Total (SMS) 685
DIVISION 5
DIVISION 6
Male (PS) 0
Female (PS) 0
20° E
60° E