Report of the Scientific Committee

The Committee met at 09.00 on 20 May 1989 and following days at the Hyatt Islandia Hotel, San Diego, California under the Chairmanship of R.L. Brownell Jr. A list of participants is given in Annex A.

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

The Chairman welcomed participants to San Diego.

2. ADOPTION OF AGENDA

The adopted Agenda is given in Annex B. Statements concerning the Agenda are given in Annex T.

3. ARRANGEMENTS FOR MEETING

3.1 Appointment of rapporteurs

Donovan was appointed rapporteur with the assistance of various members of the Committee as appropriate. Chairmen of sub-committees appointed rapporteurs for their meetings.

3.2 Meeting procedures and time schedule

As last year, the Commission decided that the Committee should address the Comprehensive Assessment as well as its normal business. An extra day had again been allocated to facilitate completion of the Committee's report.

The meeting agreed to a work schedule similar to previous years. This took into account comments, suggestions and procedures agreed to at earlier meetings (*Rep. int. Whal. Commn* 33:36; *Rep. int. Whal. Commn* 38:59).

3.3 Establishment of sub-committees

The Chairman stressed that the main business at this year's meeting was to be discussion of methodology in preparation for the Comprehensive Assessment, as agreed last year (*Rep. int. Whal. Commn* 39:64). Four methodological sub–committees were established: stock identity; management procedures; biological parameters and MSY rates; and stock estimation. Their reports are given as Annexes D-G respectively. A sub-committee on small cetaceans was established and its report is given in Annex H. Three *ad hoc* sub-committees were established to examine specific questions: West Greenland stocks; gray whales; and the Indian Ocean sanctuary. Their reports are given as Annexes or incorporated under the relevant Agenda Items.

3.4 Computing arrangements

Allison outlined the computing facilities eventually installed after some initial problems. A digital link had been installed to the University of Cambridge computer, via the Tymnet network and the international packet switching system (IPSS). This was connected to five video terminals. In addition, four personal computers running MS-DOS were provided for the use of Committee members, both for word processing and running of programs.

4. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

4.1 Documents submitted

A list of documents is given in Annex C.

4.2 National progress reports on research

National progress reports received this year had been prepared according to the revised guidelines developed last year (*Rep. int. Whal. Commn* 39:130). The question was raised whether a summary of natural markings data could be included in national progress reports, as data were for 'Discovery' marks, rather than merely noting species and organisations concerned with such studies. This had been raised last year (*Rep. int. Whal. Commn* 39:34) and was referred to Item 4.4.

The Committee reaffirmed its view of the importance of progress reports to its work and again **recommends** that the Commission urges member nations to provide them following the approved guidelines.

4.3 Data collection, storage and manipulation

4.3.1 Catches and other statistical material from the previous season(s)

Individual catch data for the 1988/89 season had been received from Iceland, Norway and Japan and coded by the Secretariat. During the past year the Secretariat had also received a computer disc from Norway containing details of their 1987 catch, and Korea had submitted individual minke whale catch data, covering the period 1982–86, as part of the data inventory (Item 7.7).

4.3.2 Progress on data coding projects

Allison reported that good progress continued to be made with the data coding projects. The backlog of validation reported previously had now been completed and a fully validated data set containing all available individual records of non-Antarctic catches since 1949 (approximately 600,000 records) would be available shortly.

The post-war Antarctic land station catches were currently being coded together with the 1946–48 non-Antarctic catches. On completion of this work the IWC data base would include all available post-war catch data.

In addition, the coding of all information submitted for data inventory had been completed (Item 7.7), and all data from the 1988/89 IWC/IDCR Southern Hemisphere minke whale assessment cruise had been encoded.

No biological data have been received for the West Greenland catch of fin whales. This has implications for the Committee's discussion on the relevance of the minimum size limit currently in force for this stock, in response to a question from the Commissioner for Denmark (*Rep. int. Whal. Commn* 39:21). This was referred to Item 6.5.

4.3.3 Progress on computing projects

Allison reported that the sensitivity tests on the use of the HITTER program to fit data from the bowhead whale stock, as recommended by the Committee last year, had been performed. The results are given in SC/41/PS13. A new version of the program, which calculates confidence intervals and plots the residuals surface, had been received from de la Mare. Since this was received immediately prior to the meeting it has not been possible to validate it yet. Another version of the program, which calculates confidence intervals using a different method, was received from Punt and Butterworth.

Development of a common control program for use in screening of management procedures is nearly complete. The Comprehensive Assessment Workshop on Management Procedures (SC/41/Rep 1) had also requested that the Secretariat carry out first stage screening trials for a management procedure based on the new management procedure (NMP) using a program written by de la Mare. However, the program was not received in time for this task to be completed.

Preparation of data files of Antarctic baleen whale catches by species, month and 1° square for the Workshop on the Feeding Ecology of Southern Baleen whales (see Item 5.1.3) has begun. These should be available within the next few months.

The background task of documentation of programs held by the Secretariat has progressed well, with assistance from Charles Free. The Secretariat hoped to prepare a document summarising the holdings shortly.

Borchers reported that data validation, routine abundance estimation and analyses of experiments from the 1987/88 Southern Hemisphere minke whale assessment cruise have been completed. Data from the 1988/9 cruise have been partially validated and preliminary analyses of two experiments conducted on the cruise have been carried out.

In September 1988, Haw was appointed as data analyst to replace Borchers, whose contract expires in mid-1989.

4.4 Whale marking

No new 'Discovery' marks were placed in the 1988 or 1988/89 seasons. Four marks were recovered from fin whales off Iceland (SC/41/ProgRep Iceland).

A considerable body of natural markings data now exists for many species from many geographical regions (SC/40/Rep 1; *Rep. int. Whal. Commn* 39:36–7). The question was raised as to whether the summary of numbers of animals marked and details of recaptured animals could be included in an Annex to the Report, as information on 'Discovery' marks had been in the past. This would require the data to be available in some form at the meeting; currently, the guidelines for national progress reports state that while information on species and relevant organisations carrying out studies should be provided, the data themselves should not (*Rep. int. Whal. Commn* 39:130).

As a first step, it was agreed that a list of organisations involved in natural marking studies (from SC/40/Rep 1) should be made available at the meeting.

Best suggested that national progress reports should contain the following (by species).

(1) The total number of identified individuals held in photocatalogues for each IWC management area/stock.
(2) A statement of the number of individuals photographed (but not necessarily re-identified) during the preceeding year for each IWC management area/stock.
(3) Incidental information on 'recoveries' of interest (e.g. matches over significant distances or periods).

5. CO-OPERATION WITH OTHER ORGANISATIONS

5.1 Observers' reports

The Secretariat holds copies of meeting documents for all meetings for two years, after which they are discarded; the published proceedings of meetings are retained. It was agreed that observers' reports should include lists of meeting documents.

5.1.1 ICES

The report of the IWC observer at the 76th meeting of ICES held in Bergen, October 1988 was available as IWC/41/10A. The IWC observer attended the meetings of the Marine Mammals Committee (MMC).

Of particular interest to the Scientific Committee was the new information presented on the long-finned pilot whales off the Faroe Islands. A paper on stock identification based on morphological data and a paper on the diet of pilot whales were presented. A list of all papers submitted to the MMC is appended to the observer's report.

ICES is increasing its emphasis on multispecies assessment and multispecies management advice. At its next annual meeting there will be a symposium on Multispecies Models relevant to Management of Living Resources (to be held in the Hague, Netherlands, 2–4 October 1989).

The meeting thanked Bjørge for attending the ICES meetings on its behalf. He agreed to act as IWC observer at the next meeting. Sigurjónsson agreed to act as IWC observer at the forthcoming ICES Multispecies Symposium.

5.1.2 CMS

The report of the IWC observer at the 1988 meeting of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), held in Geneva, 11–14 October 1988, was available as IWC/41/10B.

Johnson explained her position as Secretary to the CMS and introduced SC/41/O 12 which outlined aspects of interest to the Commission. This is discussed further in Annex H.

The next meeting will be held in October 1991.

5.1.3 CCAMLR

The report of the IWC observer at the 7th meeting of the Scientific Committee and Commission of CCAMLR, held in Hobart, 24 October – 4 November 1988, was available as

IWC/41/10C. The item of primary interest to the Committee was the joint IWC/CCAMLR Workshop on the Feeding Ecology of Southern Baleen Whales. This is discussed further below. CCAMLR is now moving towards the development of management procedures and has established a permanent working group on krill which will be involved in assessment. These matters are clearly of interest to the Commission.

Last year the Committee had agreed to the proposed objectives, terms of reference topics and pre-workshop tasks developed by a joint IWC/CCAMLR Scientific Committee steering group (*Rep. int. Whal. Commn* 39:135–6) for a Workshop on the Feeding Ecology of Southern Baleen Whales. CCAMLR had subsequently proposed that the Workshop be held from 7–14 September 1989. Harwood, the co-convenor of the Workshop, informed the Committee that most IWC contributors would be unable to prepare a definitive analysis in time for the proposed dates of the workshop in the first week of September 1989.

The IWC Scientific Committee's highest priority at present is the completion of the 1990 Comprehensive Assessment; this has had to take priority over all other activities. It therefore **recommends** that, for this reason and because of the potential lack of adequate analysis, the workshop should be deferred until the middle of 1991 when it might be held in conjunction with another IWC or CCAMLR meeting. It further **recommends** that the Steering Committee for the workshop should continue to encourage potential contributors to complete the analyses which will be required for the workshop and that it should inform the Scientific Committee when these are sufficiently advanced such that the workshop can be rescheduled.

A recommendation for closer cooperation with CCAMLR with respect to multispecies management is discussed under Item 7.6.

The Committee also **recommends** that the Secretary of CCAMLR and the Chairman of CCAMLR's Scientific Committee should be informed of this proposal as soon as possible.

5.1.4 IATTC

The Commission was not represented at the last meeting of the IATTC, held in Paris in May, 1989. Hall gave a brief report on the progress of research on dolphins at the IATTC. A special meeting on tuna-dolphin associations was held this year in Costa Rica and background documents from this meeting were available on request from the IATTC. Relevant matters are discussed further under Item 12 (Annex H).

The meeting agreed to ask the USA to select an appropriate observer to represent the Commission at next year's meeting of the IATTC to be held in Washington DC.

5.2 UNEP

5.2.1 Meeting on small cetaceans

Holt reported that UNEP hopes to hold the meeting on small cetaceans (discussed in *Rep. int. Whal. Commn* 39:35, 127) early in 1990 in the Soviet Union. Discussions are still underway and more information may become available at the Commission meeting.

5.2.2 Global Plan of Action

Following an internal evaluation of the Global Plan of Action for the Convention, Management and Utilization of Marine Mammals, UNEP has put forward a more structured strategy for the implementation of the Action Plan. It has invited the IWC to join in this activity and requested IWC participation in a new Planning and Programme Committee, as well as an associated Scientific Advisory Committee. The Committee noted that the matter of the Commission's response to the invitation will be discussed at the forthcoming Commission meeting.

The Scientific Committee noted that its members had spent considerable time and effort in the past in developing and contributing to the cetacean component of the Action Plan, which had been endorsed by the Commission in 1984 (*Rep. int. Whal. Commn* 36:19–20). The Committee takes the view that the IWC should continue to be involved in the Action Plan to the fullest extent possible, and **recommends** to the Commission that it takes the necessary steps to achieve this cooperation and participation at all appropriate levels. In particular, members of the Scientific Committee are ready to assist in the work of the proposed Scientific Advisory Committee as requested.

The Committee proposes that if nominations for the Scientific Advisory Committee are requested, these should be determined by the Chairman of the Scientific Committee in consultation with the convenors and the Secretary.

6. COMPREHENSIVE ASSESSMENT – PRIORITY STOCKS

6.1 Southern Hemisphere minke whales

New estimates of the abundance of minke whales in Antarctic Area III from the results of the 1987/88 IWC/IDCR assessment cruise were available in SC/41/SHMi4. These had been calculated using the 'standard methodology' for the analysis of results from these cruises adopted by the Scientific Committee in 1988, *Rep. int. Whal. Commn* 39:71–4, although it had been necessary to pool samples from some strata to obtain a satisfactory fit to the hazard-rate model and to estimate mean school size. The results of this analysis, together with values for the other Antarctic Areas previously accepted by the Scientific Committee, are given in Table 1. These represent the best available estimates of the abundance of minke whales in the Antarctic south of 60°S.

Table 1

Estimates of Southern Hemisphere minke whale population sizes. 'Pooled' survey mode = pooled (closing + passing without IO) Sources: *Rep. int. Whal. Commun* 39:30 and SC/40/Mi14. * = 70°-100°E.

			Population size			
Area	Year	Survey mode	Total	CV	Exploitable	CV
I	1982/83	Closing	55,050	0.203	36,223	0.206
II	1981/82	Closing	37,306	0.213	24,547	0.216
	1986/87	Passing	121,549	0.285	79,979	0.288
	1986/87	Closing	69,558	0.257	45,769	0.260
III	1979/80	Closing	61,272	0.188	40,317	0.191
	1987/88	Closing	51,820	0.521	34,097	0.522
	1987/88	Passing	102,984	0.309	67,763	0.311
IV	1978/79	Closing	72,357	0.156	47,611	0.160
IVW*	1984/85	Pooled	19,980	0.181	13,147	0.185
V	1980/81	Closing	133,382	0.216	87,765	0.219
	1985/86	Closing	211,150	0.174	138,909	0.178
	1985/86	Passing	303,284	0.172	199,520	0.176
VI	1983/84	Closing	80,283	0.232	52,826	0.235

The Committee welcomed the preliminary report of the 1988/89 IWC/IDCR assessment cruise in Area IV (SC/41/SHMi7) and looked forward to receiving estimates of abundance from this cruise in 1990. Estimates made in both Closing and Passing Mode are presented in Table 1; Item 7.5.1 contains a detailed discussion of the relative merits of these two methods. For Areas II and V there are results from two surveys both conducted, at least in part, in the same mode. However, these pairs of results cannot be compared directly because of differences in the extent of the area surveyed.

The same problem exists for the estimates of abundance for Area III in 1979/80 and 1987/88 shown in Table 1. A correction for the differences, along the lines used previously by the Committee (e.g. *Rep. int. Whal. Commn* 39:73–4) had been made in SC/41/SHMi4. The comparable values are shown in Table 2. The 1987/88 estimate for Area III was not significantly different from that for 1979/80. A discussion of the problems encountered in comparing surveys made in different years can be found under Item 7.5.4.

Table 2

Comparison of total population estimates (closing mode only) for Area III (p is the probability associated with the z-statistic under H_0).
H_0: 1979/80 population = 1987/8 population;
H_1: 1979/89 population =/ 1987/8 population

Sub area	1979/80 Est.	(CV)	1987/8 (adjusted) Est.	(CV)	z	p	Signif? (5%)
East	30,998	(0.288)	9,099	(0.875)	1.74	0.082	No
West	30,274	(0.242)	42,596	(0.567)	0.49	0.624	No
Total	61,272	(0.188)	51,695	(0.529)	0.323	0.749	No

6.2 Northeast Atlantic minke whales

An estimate of 23,381 (CV 0.155) for the number of minke whales in that part of the Northeastern stock covered by a Norwegian survey in 1988 was available in SC/41/O 4. This estimate is substantially higher than the estimate of 12,459 obtained for approximately the same portion of the stock in 1987 from a survey which covered a wider area but with a lower survey intensity. SC/41/O 4 suggested that this difference was because the 1987 survey was not designed according to the IWC stock boundaries and a restratification of the data had been required to provide the estimates. As the 1988 survey had been conducted in a different year to the surveys of the remainder of this stock area, the sub-committee did not attempt to provide a new estimate for this stock. The Committee therefore agreed to accept the provisional estimate of 19,112 (CV 0.163) [or 17,014 (CV 0.179) if one poorly surveyed block is excluded] calculated for this stock at the 1988 meeting (*Rep. int. Whal. Commn* 39:45). Discussion of this stock with respect to scientific permit catches is given under Item 9.

The Committee discussed the experiments carried out off Norway last year (SC/41/NHMi10) and the proposed work for the coming year (SC/41/NHMi11) concerning the chemical immobilisation and marking of minke whales with a view to the surgical implantation of satellite transmitters. The Committee had discussed the proposed work for 1988 last year (*Rep. int. Whal. Commn* 39:58).

SC/41/NHMi10 presented the results for 1988. The trials showed that darting the animals and subsequent observation was possible from a helicopter. The immobilising drug tried was etorphine hydrochloride (M99) at a concentration of 0.98%. Five animals were hit with darts ranging from 2–5mg of the drug (corresponding to dose rates of 0.7–1.0 micrograms/kg) with no noticeable effect. One injection at 5 micrograms/kg was also tried on one animal. The unusually long dive time of this whale was initially interpreted to be a result of the injection but subsequent discovery of a broken needle made this uncertain. No other unusual reactions were observed for this whale. The correct dose range for the minke whale thus remains unknown.

SC/41/NHMi11 presented the work plan for 1990. The work will follow the same methodology, but the identification markers will be supplemented with VHF transmitters. The project is divided into two simultaneous projects: chemical immobilisation and application of transmitters. The trials will continue from where they finished in 1988, beginning at 2.5 micrograms/kg of etorphine hydrochloride. The incremental increase in dosages will if necessary be greater than in 1988 to try to establish the ideal dose for minke whales. Although the techniques will be examined, satellite tags will not be implanted in 1989.

A number of questions were raised during the discussion of these papers concerning: what will be the criterion for judging death of the animal should this occur; will the experiments continue if an animal dies; have problems in administering the antidote due to depressed circulation as a result of the drug been considered; how is the weight of the animal (and hence the quantity of drug required) estimated; have experiments been first tried on captive animals; how will the surgery proceed after successful immobilisation?

Øen responded that after administration of the drug the animals are observed from the helicopter. If an animal dives and is not resighted after 20–30 minutes then it will be assumed to have died. The visual and radio tags will help to ensure that the whale will be detected if it surfaces. Observations will continue for at least 24 hours in the area in an attempt to recover the carcass. In the event of the death of an animal the experiment will be stopped and re-evaluated. Logistical problems preclude combining the operations with the special permit catches. He noted that in experiments with other animals the antidote had been shown to work well. He agreed that estimating the weight of whales at sea was a problem; the weight was estimated based on the length-weight relationship obtained from the scientific permit catch and the experimental animals were carefully chosen. Experiments have been carried out using related drugs on captive small cetaceans and these drugs were not found to give any noticeable depression of respiration. He believed that it was important for the trials to be carried out on free-swimming animals. He reported that the implantation surgery will be carried out, with the animal supported by floats in the water, from a small rubber boat at the side of the helper ship.

In response to concerns expressed by several Committee members last year, who cited Schevill *et al.* (1967, *Science* 157:630–1) with respect to cetaceans having a voluntary respiratory system, Blix commented that it was not proven nor biologically likely that this was the case.

Perrin stated the opinion that, because the narcotic drug proposed to be used to sedate a minke whale has not previously been used for a cetacean, a prudent course of action would be to test the drug first on a smaller cetacean, for example a pilot whale at the Faroe Islands, so that

(1) its effects can be monitored in a controlled situation;
(2) the animal can be resuscitated (this has often proved necessary in previous anaesthetisations of small cetaceans) if necessary, and
(3) the precise experimental dosage per weight can be determined.

Øen responded that since even closely related species respond very differently to the same drug, this approach would be of little value (SC/41/NHMi10).

6.3 Central North Atlantic minke whales

SC/40/O 30-revised provided new estimates of the size of the Central North Atlantic stock of minke whales from surveys conducted in 1987 which took account of the results of experiments conducted in 1988 (SC/41/NHMi14). These results had been used to provide new estimates of the proportion of whales missed on the trackline (see Item 7.5.1) and the effect of wind speed and sea condition. The Committee recognised the importance of incorporating the effects of these environmental features and of varying observer efficiency into the underlying statistical model, but some members held that the structure of the model used in SC/41/NHMi14 was inappropriate.

6.4 West Greenland minke whales

Last year the Commission had set catch limits for one year only for the West Greenland stock of minke whales (60) and would therefore be expecting further advice on the status of the stock (*Rep. int. Whal. Commn* 39:21). Many delegations had stressed the need for increased research on West Greenland stocks, particularly with respect to stock identity and stock estimation (this also applied to the fin whale stock, see Item 6.5).

6.4.1 Review of stock boundaries

The Committee again reiterated its concern that there was substantial evidence that West Greenland minke whales did not constitute a separate stock. It recalled that the current stock boundaries imposed in 1976 were based on differences in the sex and length composition of the catches around Greenland and the distribution of these catches, and that a subsequent reanalysis (*Rep. int. Whal. Commn* 38:251–5) did not support the original decision. The Committee noted that a continuous distribution of minke whales around Kap Farvel had been observed on the 1988 aerial survey (SC/41/O 27) and that, in the past, catches in Southern Greenland waters had been taken in a small area to either side of the stock boundary (*Rep. int. Whal. Commn* 35:162–6). It believed that if asked to consider stock boundaries today it would not make the same decision as in 1976. However, there was still insufficient evidence to determine where, if anywhere, stock boundaries should be drawn.

SC/41/NHMi1 described an analysis of morphometric data from minke whales caught throughout the North Atlantic. Results from principal component analyses suggested that the data could not be regarded as a random sample from a uniform distribution. However, the overlap in characteristics among whales from four different areas (West Greenland, East Greenland, Norwegian and Barents Seas, and around the UK) was too great to infer that North Atlantic minke whales comprise several discrete stocks.

At last year's meeting it had been recommended that genetic studies be continued to try to resolve the question of stock identity (*Rep. int. Whal. Commn* 39:84). Larsen reported that development of analytical methodologies had continued, but that samples from outside the West Greenland stock area were still not available. Problems with biopsy equipment had been encountered on the 1988 Norwegian survey and only one sample from Jan Mayen (Central stock) has been taken. The Committee noted that samples from two minke whales stranded in Iceland would be made available. Attempts to obtain samples from the earlier Canadian catch and from incidental catches and strandings throughout the North Atlantic were continuing.

6.4.2 Sightings estimates

This year, the Committee received a revised cue counting estimate for minke whales from the 1987 aerial survey (SC/41/O 21). The revision had been necessary because an error had been made in the calculation of the size of some of the survey blocks. The revised estimate was 1,493. The coefficient of variation (CV) of this estimate, calculated at the meeting, was 0.43.

The Committee also had a cue counting estimate from the 1988 aerial survey of 4,602 (SC/41/O 17). The CV of this estimate, 0.40, was also calculated at the meeting. The Committee noted that the revised 1987 and 1988 estimates were significantly different, assuming that the estimator follows a log-normal distribution, and that the difference was due largely to a difference in effective search area (ESA). Last year, the ESA had been calculated without using the available duplicate sightings data because the duplicate effort was low. The Committee now believed, however, that even though there was so little duplicate effort, it should be included in the analysis. The 1987 estimate was therefore recalculated using the ESA from the duplicate analysis presented in SC/40/O 12 to give an estimate of 1,930 (CV 0.44). This revised 1987 estimate was not significantly different from the 1988 estimate.

SC/41/Mi3 presented data on surfacing rates of minke whales from the 1988 Norwegian shipboard surveys. From the seven experiments conducted in which no problems were identified, a rate of 43.9 surfacings per hour was calculated. The Committee recognised that visual observations of dive times were likely to underestimate mean surfacing rate because some surfacings may be missed. It believed that the estimate used last year of 53 surfacings per hour was unlikely to be too low. SC/41/Mi13 presented a daytime rate of 60.4 surfacings per hour obtained from a radio-tagged minke whale off Iceland. This estimate was higher but from one animal only. The Committee decided, therefore, to use the same mean surfacing rate as last year.

The Committee discussed whether or not combining the 1987 and 1988 data was valid given that the ESAs (2.08km^2 for 1987 and 1.19km^2 for 1988) were so different in the two years, and concluded that it was not able to assess this. In the light of this, the Committee agreed that the best estimate of the number of minke whales off West Greenland was the simple mean of 3,266 (CV=0.31). Approximate 95% confidence intervals were 1,702–5,718.

The Committee discussed ways of reducing the CVs of the individual estimates of abundance, which were at least 0.4. This was of paramount importance if they were to be used in a management scheme which required series of such estimates. These discussions also apply to fin whales (Item 6.5.2). The CV of the cue counting estimate is

comprised of a CV of ESA and a CV of the number of cues seen. ESA CVs could be reduced substantially by estimating ESAs from data pooled over years *if* observers were the same from survey to survey. This is because in the estimation procedure, duplicate sightings data could be used to calculate ESAs on an observer by observer basis. The Committee recognised the difficulty in ensuring that observers remained the same year after year.

The contribution to the overall CV from variability in the number of cues seen is more difficult to reduce. This variability is a function of the number of cues seen and their distribution among survey tracks. Increasing the amount of survey effort (and therefore the number of cues seen) would reduce the CV. The proportion of time spent searching is typically low in West Greenland surveys because of inherent logistical difficulties and the unpredictable weather.

Another problem is that West Greenland aerial surveys are targetted on both minke and fin whales; species with different characteristics with respect to such surveys. Minke whales tend to occur in loose aggregations in relatively small areas and are typically seen close to the aircraft. Fin whales are spread out more homogeneously over a wider area and can be detected at greater distances. A combined survey has to cover this wider area and cannot exploit the aggregated distribution of the minke whale, with the result that between-track variability is higher than it would be for a single species survey. The effect with respect to sighting distances is that an observer's searching strategy to maximise the number of minke whales seen is different to that for fin whales. The result of this is that the number of sightings obtained of each species is less than if the survey had been directed towards a single species.

6.4.3 Stock assessment

The Committee agreed that an assessment could not be attempted this year for reasons which it had discussed last year and which included the unresolved problems with CPUE series, the lack of an agreed basis for choosing a range of MSY rates and the considerable doubts concerning stock identity.

6.4.4 Management advice

The Committee agreed that it was not possible to recommend a classification for this stock because it did not believe that the animals found off West Greenland constituted a separate stock. Even if they did, the Committee had no information upon which to determine the status of the stock in relation to MSY level. Given the best estimate of the number of animals in the area of 3,266 whales and its approximate lower bound of 1,702, the Committee believed that such a stock was above a minimum level below which aboriginal subsistence catches could not be taken. The Committee could offer no advice on the size of catches which would allow the stock to move towards MSY level.

The Committee felt, however, that because aboriginal subsistence whaling is likely to continue on West Greenland minke whales, it should try to provide advice on the length of time it would be necessary to monitor the stock in order to detect a given rate of change in population size, given a regime of surveys with specified CVs.

De la Mare presented an analysis which calculated the annual rate and absolute decline in stock size which would be statistically significant at the 0.05 level, with statistical power of 0.95, for surveys conducted at one or two year intervals, with specified CVs. He stressed that these calculations assumed a constant rate of decline and were based on log-normal statistics with known variance. The results were therefore approximate and should be used only to identify general features.

The results highlighted several important points. They showed clearly the long-term nature of monitoring. For example, to detect a decline of about 2-3% per year, monitoring would have to continue for at least 20 years even with CVs as low as 0.2. By this time the stock may be quite depleted. The Committee noted that the significance level and statistical power used in the analysis were quite restrictive. The length of time to respond to such a decline would be considerably reduced if the decision to respond were made on the existence of a downward trend, regardless of statistical significance. The Committee was encouraged that the time required to detect a specified level of decline was only approximately 20% greater for biennial surveys than for annual surveys. This was of relevance to the problems with conducting combined surveys for both minke and fin whales (Item 6.4.2). However, because it was important to resolve any remaining problems in survey methodology, the Committee did not feel it was appropriate to recommend biennial surveys at this time. A different regime of surveys may be more efficient; this had not been addressed. The Committee concluded that it was important to stress that even with survey estimates with low CVs, monitoring the number of minke whales off West Greenland was a long-term commitment. The same conclusion applied to fin whales (Item 6.5.4).

6.4.5 Priorities for future research

The Committee once again agreed that resolving the question of stock identity was the highest priority for future research. It **recommends** that genetic studies continue and that every attempt be made to make available to relevant research groups existing samples (from Canada, Denmark, Iceland, Norway, USA) and to collect and make available new samples from all areas of the North Atlantic.

The Committee again stressed the importance of continuing to monitor the number of animals off West Greenland, and was pleased to note that a further aerial survey would take place this year as part of the 1989 North Atlantic Sightings Survey. It noted that similar surveys were likely to form the basis for future management of West Greenland minke whales. The Committee **recommends** that aerial surveys continue off West Greenland and that attempts be made to reduce the CV of the estimates of abundance, as discussed under Item 6.4.2.

Annex J presented a request that the Commission provide funds for the purchase of a Global Positioning System to be made available to countries conducting aerial surveys of whales in remote areas where other navigation systems are inadequate. The Committee noted the importance of obtaining accurate position data and **recommends** that this proposal be accepted.

6.5 West Greenland fin whales

The Committee noted that last year the Commission had set a catch limit for one year only for the West Greenland stock of fin whales (23) and would therefore be expecting further advice on the status of the stock (*Rep. int. Whal. Commn* 39:20–1).

In addition, Denmark had requested that this year the Scientific Committee discuss the relevance of the minimum size limit currently in force for West Greenland fin whales.

6.5.1 Review of stock boundaries

There was no available information for the Committee to use to review boundaries for this stock. The continuous distribution of fin whales observed around southern Greenland (SC/41/O 27) was noted.

A photo-identification study of fin whales had been initiated off West Greenland as recommended last year (*Rep. int. Whal. Commn* 39:108). Few photographs had been obtained but it was noted that fin whales off West Greenland do not have such well-defined markings as those found off the northeast coast of the USA or off Iceland (SC/41/ProgRep Denmark). More photographs will be taken this year in order to address this point further. A pilot study had resulted in skin biopsies from six whales, and sampling will continue this year. The Committee welcomed the initiation of these studies. It noted that it was difficult to obtain photographs from animals in the catch but that attempts would be made this year to obtain tissue samples.

6.5.2 Sightings estimates

The Committee received a revised cue counting estimate for fin whales from the 1987 aerial survey (SC/41/O 21). A revision was necessary to correct errors in the calculation of the size of some of the survey blocks. The revised estimate was 1,985 with a CV, calculated at the meeting, of 0.46.

A new cue counting estimate of 961 (CV = 0.45, calculated at the meeting) from the 1988 survey was also available (SC/41/O 17). The Committee had no evidence to suggest that the difference between these estimates was a result of anything other than sampling variation.

No new data were available on surfacing rates. The mean surfacing rate used in the estimates was based upon very limited data with no estimate of variability. The Committee agreed that the question of variability and potential bias in surfacing rates was best addressed by results from telemetry studies. It noted that VHF radio transmitters would be deployed on fin whales off West Greenland this year, welcomed the initiation of this study, and looked forward to seeing the results.

The Committee agreed that an estimate based on the combined 1987 and 1988 data (see Annex K) of 1,589 whales (CV=0.35) was the best estimate of the number of fin whales off West Greenland. Approximate 95% confidence limits were calculated as 763–2,950 whales (Annex K).

Potential ways of reducing the CVs of the cue counting estimates were discussed under Item 6.4.2.

6.5.3 Stock assessment

There were insufficient data available to attempt an assessment of this stock.

6.5.4 Management advice

The Committee was unable to provide advice on classification of this stock because (i) there was no information to allow determination of whether or not it constituted a separate stock and (ii) if it was a separate stock there was no information with which to determine its status in relation to MSY level, initial level or replacement yield.

If it is a separate stock, the small estimate of stock size and its approximate lower bound of 763 are a cause for concern. In particular, the Committee is unable to conclude whether or not the stock is above the minimum level below which aboriginal catches should not be taken. The Committee felt, however, that because aboriginal subsistence whaling is likely to continue, it was important to try to provide advice on the length of time it would be necessary to monitor the stock in order to detect a given rate of change in population size, given a regime of surveys with given CV.

Calculations to investigate this were presented by de la Mare and were discussed under Item 6.4.4.

Minimum size limits

The Committee discussed the minimum size limits currently in force for this stock in response to the Danish Commissioner's request last year (*Rep. int. Whal. Commn* 39:21). The Committee believed that there was insufficient information available at this meeting on the original management goals of the Commission in setting these size limits and that it was thus unable to assess their relevance. It **recommends** that the effects of imposing size limits be explored within the framework of developing new methods of management.

6.5.5 Priorities for future research

The Committee stressed the need for information on the stock identity of West Greenland fin whales. It **recommends** that genetics studies continue to address this question and that new or existing samples from areas adjacent to West Greenland (i.e. Canada, Iceland, USA) be made available to relevant research groups.

The Committee noted that another aerial survey would take place this year and **recommends** that such surveys continue to monitor the number of fin whales off West Greenland. Given the limited information on surfacing rates of fin whales, the Committee **recommends** that such data should be collected as a matter of urgency during the forthcoming 1989 North Atlantic Sightings Survey.

6.6 East Greenland-Iceland fin whales

In 1988, the Scientific Committee had found it necessary to adopt an *ad hoc* procedure to estimate the size of the East Greenland-Iceland stock of fin whales, because the analysis of results from the Norwegian shipboard survey in 1987 was incomplete (*Rep. int. Whal. Commn* 39:95). This analysis had been completed and a revised estimate for the stock of 11,563 (CV 0.261) was calculated (Annex G, Appendix 3). The Committee agreed that this was the best available estimate for this stock. Of the total, 5,806 whales (CV 0.502) were from the area covered by the Norwegian survey. The Committee noted that a survey in 1988 (SC/41/O 4) of 60% of the area covered by the 1987 Norwegian survey gave an estimate of 1,265 (CV 0.459).

The Committee noted with pleasure that a second survey of North Atlantic whale stocks (NASS-89) was planned for the summer of 1989 (SC/41/O 2) and looked forward to receiving the results of those surveys at the 1990 meeting.

An extension of a previous analysis of this stock (*Rep. int. Whal. Commn* 39: 48) using the HITTER/FITTER procedure (SC/41/Ba4) is discussed under Item 7.4. Information on biological parameters is discussed under Item 7.3. Discussion of the stock with respect to scientific permit catches is given under Item 9.

6.7 Iceland – Denmark Strait sei whales

Discussion of this stock with respect to scientific permit catches is given under Item 9. The Committee noted that this was a priority stock for the NASS-89 survey.

6.8 Eastern North Pacific gray whales (see also Annex I)

6.8.1 Planning for a Comprehensive Assessment

Last year the Scientific Committee agreed that the Eastern North Pacific stock of gray whales should be the subject of assessment 'in greater breadth and depth than is usually possible at an annual meeting' (*Rep. int. Whal. Commn* 39:41). The Committee believed that this assessment should be undertaken prior to the next annual meeting in 1990, so that it might serve as a model for the process of undertaking the comprehensive assessment of other priority stocks/groups of whales. Therefore, the Committee **recommends** that a Special Meeting as outlined in Annex I should be undertaken prior to the next annual meeting.

The US National Marine Mammal Laboratory in Seattle, Washington, kindly agreed to host the Special Meeting. The Committee approved the nomination of H.W. Braham as convenor of the meeting and established a steering committee (Braham, Demaster, Swartz and Zeh plus a scientist from each of Canada, Mexico and the USSR) to help complete arrangements. The implications of undertaking this Special Meeting for the planning of the Comprehensive Assessment are discussed under Item 8.2 and the budgetary implications under Item 14.2.

The Scientific Committee noted that entanglement in fishing gear and subsequent loss of gray whales may be a significant source of mortality to consider in the assessment. It therefore **recommends** that the governments of Canada, Mexico and the USA be requested to collect and provide past and current information on gray whale entanglements in fishing gear in time for the Special Meeting.

The Committee observed that a major uncertainty for undertaking an assessment of this stock (which includes estimates of pre-exploitation abundance) lies in the lack of information on pre-1846 catches of gray whales by aboriginals. Therefore the Committee **recommends** that the contract study outlined in Annex I be undertaken prior to the Special Meeting to examine the potential magnitude of this problem. The undertaking of the contract study is included in the budget for the Special Meeting.

The Committee was pleased to note that US scientists undertook to reconcile recent population estimates along the lines of Appendix 3 of Annex I before the Special Meeting.

The possibility was raised that there may be some exchange between the western Pacific stock and the eastern Pacific stock of gray whales. The Committee therefore **recommends** that the Secretary write to appropriate authorities of the Republic of Korea, the People's Republic of China and the USSR, seeking historical and current sightings data on the western Pacific stock for use at the Special Meeting.

The Committee expressed its regrets that Soviet scientists had not been present to discuss the planning for the Special Meeting or to present the results of their research on this species. The Committee urges the USSR to participate in the Special Meeting.

6.8.2 Review of 1988 harvest

A total of 150 gray whales was reported taken from the stock off Chutkotka in 1988 (SC/41/ProgRep USSR). This catch is below the catch limit of 179 set by the Commission for this stock. Tillman reported that Alaskan Eskimos had also struck and lost one gray whale during the 1988 hunt.

Noting the discussion in Annex I about the discrepancies in the Soviet Progress Report regarding the reporting of the sexes of gray whales taken in 1988, the Scientific Committee **recommends** that the Secretariat correspond with appropriate Soviet authorities to resolve this difficulty.

The Committee expressed its concern that a larger proportion of the Soviet catch had not been sampled in 1988, especially for earplugs and reproductive materials. Stressing the scientific importance of collecting and analyzing such samples to the understanding of the biology and population dynamics of the species, the Committee **recommends** that this information be made available to the Special Meeting on the Comprehensive Assessment of Gray Whales.

6.9 Bering-Chukchi-Beaufort Seas bowhead whales

A total of 29 whales was struck of the allowed strike quota of 44 in 1988. By 20 May 1989, 6 whales had been struck and 4 landed of the 47 (44 plus 3 carried over from 1988) allowed strikes for 1989 (Annex L).

Of the 23 whales landed in 1988, 44% were 13m in length or greater, presumed adults. The mean length of the catch was 11.3m and adult females comprised 26% of the catch. Both percentages were lower than 1987 but essentially equal to previous years (*Rep. int. Whal. Commn* 39:49). Two foetuses were collected in 1988, one 4.3m in length from a 15.7m whale taken on 16 April and a second 1.5m in length from a 14.9m whale taken on 24 September.

The 1988 struck and lost rate (23 landed, 6 lost) of 21% was slightly lower than in 1987 and 1986, continuing the downward trend in the struck and lost rate recommended by the Committee.

Since the last meeting of the Committee, additional information on the swimming behaviour of bowhead whales and the acoustic location process (SC/41/PS6) had been used to calculate revised estimates of the size of Bering-Chukchi-Beaufort Sea stock using the Bayes empirical Bayes method (SC/41/PS8). Additional acoustic tracking information and new location data had been used to calculate revised estimates of the same stock using the mark–recapture method (SC/41/PS9). However, the Committee concluded that the results were such that it was not necessary to change the estimate of 7,800 with a confidence interval of 5,700 to 10,600 calculated for this stock in 1988 (*Rep. int. Whal. Commn* 39:106).

The Committee agreed that the possibility of using uncertainty methods such as the Bayes empirical Bayes method for other whale stocks should be investigated (see Item 7.5).

Information on activities related to the bowhead whale census during spring 1989 is given in Annex L.

6.10 Southern Hemisphere right whales

Trends in the populations of right whales off South Africa and Argentina (SC/41/PS3 and PS17 respectively) were discussed under Items 7.3 and 7.4

SC/41/PS4 reported on the results of a photogrammetric study of right whales off South Africa, funded by the Commission in 1988. A total of 46 cow-calf pairs was measured photogrammetrically in monthly flights between August and November, 23 on more than one flight. The lengths of 46 calves ranged from 4.81 to 9.24m, with those from primiparous females generally being smaller. All 21 calves photographed on more than one occasion showed positive growth, estimated as 2.88cm per day. A

comparison of photogrammetrically measured calves, stranded calves and foetuses suggested that calves from primiparous females may suffer a higher natural mortality than those of multiparous females.

The listing of 17 right whales in the International Whaling Statistics as part of the 1925 catch for 'the coast of Angola' were investigated and found to be a probable tabulation error for 17 Bryde's whales (SC/41/PS1).

The maximum number of right whales seen in five aerial surveys off South Australia in 1988 was 27 adults and 14 calves, and the minimum size of the population was estimated to be 75–104 whales (SC/41/ProgRep Australia). Two flights were undertaken off Western Australia in 1988; the highest number of animals (56) and cow-calf pairs (13) since surveys started in 1977 were seen between Cape Leeuwin and Cape Arid. From photographs obtained on the flights, 42 individuals were identified, 10 of which were resightings from earlier years. The photographic catalogue now contains more than 300 identified animals.

Off Brazil, 20 right whales (including 4 calves) were seen in four flights in August and September 1988. Five adults were photographed for inclusion in the Brazilian photographic catalogue. The first link between right whales in Patagonia and Southern Brazil was also established through photoidentification (SC/41/ProgRep Brazil).

In the Antarctic, one right whale was seen at 64°22'S, 108°09'E during the IWC/IDCR Southern Hemisphere minke whale assessment cruise (SC/41/SHMi7).

The New Zealand photographic catalogue of right whales now contained 162 individuals. A match between a female photographed at Campbell Island in May and at Port Ross (Auckland Islands) one and a half months later was noted. Between April 1988 and March 1989, 222 right whales were recorded in the New Zealand sightings area including Campbell Island (SC/41/ProgRep New Zealand).

6.11 Northern Hemisphere humpback whales

Hester informed the Committee that no humpback whales were taken off St. Vincent and the Grenadines in the 1988/89 season.

6.12 Other Antarctic whale stocks

SC/41/O 20 provided estimates of the abundance of Southern Hemisphere (south of 60°S, see below) blue, fin, sei, humpback and sperm whales based on sightings made during the 1978/79 to 1985/86 IWC/IDCR Southern Hemisphere minke whale assessment cruises. The estimates were based on sightings made in Closing Mode and were calculated using essentially the same procedure as that used for minke whales. The number of whales of these species which were sighted was very much less than the number of minke whales which had been seen and it had not been possible to calculate stock estimates for each Area, or to stratify the data in the same detail as had been possible with minke whale sightings. The estimates were for the abundance of each species in the area covered by the surveys (64% of that south of latitude 60°S). All estimates require adjustment for the unsurveyed area and for whales missed on the trackline.

For fin and sei whales the estimates were 2,096 (CV 0.47) and 1,498 (CV 0.46), respectively. The Committee noted that a large proportion of the catches of sei whales and of sightings from scouting boats of sei and fin whales (Masaki, Y. 1979, *Rep. int. Whal. Commun* 29:225–51; Horwood, J. 1987, *Population Biology, Ecology and Management of the Sei Whale*, Croom Helm) were made north of 60°S. As a result, these values probably underestimated the abundance of the species.

The values for blue, humpback and sperm whales were: blue 453 (CV 0.84); humpback 4,047 (CV 0.28); sperm 3,059 (CV 0.56). For sperm whales the surveyed area excludes much of the species' range, particularly for females.

The Committee noted that the authors of SC/41/O 20 had not been able to estimate the size of individual stocks. However, the estimates of abundance are very much less than the total catches known to have been taken from the stocks (Annex G, Appendix 2). The Committee therefore concluded that blue and fin whale stocks, at least, are only a very small fraction of their unexploited levels[1,2].

7. COMPREHENSIVE ASSESSMENT – METHODOLOGY

7.1 Stock identity (see also Annex D)

Before dealing with methodologies in detail, the Committee agreed it was important to attempt to define a 'stock' for the purposes of assessment. After considerable discussion it was agreed that the problem is not so much how to define a stock, but how to delineate it.

For management purposes, a 'stock' is a group of animals treated as a single unit. The species' biology and the management objectives will affect the grouping. In the early days of the Commission, the lack of correspondence between biological and management groupings, under the system of the Blue Whale Unit, resulted in disastrous depletion of several Antarctic baleen whale species (see Item 6.13). As a consequence, the IWC management objective of properly conserving the whale stocks was not achieved.

In practice, biological systems present a continuum from populations, through family units, to individuals. Limited interchange will occur between the various levels. In addition, populations may often overlap, both geographically and seasonally. Delineation of stocks within the continuum cannot be immutable. As biological and ecological knowledge accumulates and/or management objectives change, delineations themselves will change.

Use of geographic areas to define stocks, the option most commonly applied by the Commission, may not always be the most appropriate. For example, where two populations are exploited on a common feeding ground (but have separate breeding grounds), and where one population is severely depleted and the other is not, it is difficult to ensure recovery of the depleted population where the 'stock' is defined purely according to the area inhabited.

The Committee agreed that the Commission should be prepared to expect changes in the use of the term 'stock'. Achievement of management objectives will require a

[1] Best, Butterworth, Cawthorn, Kasuya, Kato and Ohsumi, after the conclusion of the debate on the Committee's report, expressed their reservations concerning the logic of the statement that fin whale stocks were still only a very small fraction of their unexploited levels.
[2] Horwood considered that the analysis on the status of the stocks, conducted in SC/41/O 20, was a retrograde step from techniques that had been developed over the past half century. Notwithstanding the severe problems caused by incomplete coverage of the areas of distribution of the whales, corrections for whales missed and incomplete catch records, the assessments are seriously flawed by not taking into account the existence of stocks and different history of exploitation of those stocks.

more flexible and sophisticated approach to the question of 'stocks' than in the past. Stock delineations should be evaluated regularly, as new techniques (for example in the fields of genetics, individual identification and satellite tagging) provide new information on the uniqueness of populations and rates of interchange between them.

Evaluation of stock delineations will require monitoring and research not only on their whaling grounds but in other areas where the subject whales occur, with account being taken not only of depletion of whale numbers but also of changes in the proportions present of particular morphological and genetic groups identified.

The Committee recognises that it has not provided a generalised definition of stock but is unable to resolve the matter further at this time.

For the purposes of the 1990 Comprehensive Assessment, stock divisions will necessarily be based on little information; it seems appropriate for the time being to retain most of the current stock boundaries. However, redefinition is required as soon as possible of stock boundaries in the North Atlantic, for example of minke whales, possibly by removing the boundary between the West Greenland and Central stocks (see Items 6.4 and 6.5).

7.1.1 Biochemical genetics

The results of the two-year contract study (*Rep. int. Whal. Commn* 38:130–1) as detailed in SC/41/O 26, are so far very encouraging. A variety of molecular probes (two using nuclear DNA, one using mitochondrial DNA) was used to distinguish successfully between certain minke whale groups, and to unravel the social organisation of pilot whales. Further work is being undertaken using a different nuclear DNA sequence.

The significance of the findings to date will be discussed fully at the workshop on the Genetic Analysis of Cetacean Populations to be held in La Jolla, 27–29 September 1989 (*Rep. int. Whal. Commn* 39:133). The Committee agreed that the Workshop should also be asked to address the following questions:

(i) what quantitative information can molecular genetics techniques provide on past and present interchange between IWC stocks?
(ii) what sample sizes are needed to answer (i)?

Other ongoing investigations, involving mitochondrial DNA and protein enzyme studies from Southern Hemisphere minke whales (SC/40/SHMi19), fin, sei, sperm and other species off Iceland and fin whales off Spain (SC/40/O 32) were reviewed. It was agreed that exchange of material should be expedited between the research groups involved in such studies.

In particular the Committee **recommends** that samples (for both DNA and protein analysis) should be obtained from baleen whales in their breeding areas (for example from minke whales in the Southern Hemisphere and North Atlantic) and from fin whales in the North Atlantic, particularly in Canadian waters. The Committee views biopsy sampling as one of the most effective means of collecting such material. Stranded large cetaceans and museum specimens might supply additional material.

The Committee also **recommends** that existing samples from minke whales from the North Atlantic (Canada, Denmark, Iceland and the USA) and fin whales from the North Atlantic (Canada, Iceland and the USA) as well as new samples from all areas of the North Atlantic should be made available to relevant research groups (see Items 6.4 and 6.5). Analysis of this material should be continued as a matter of urgency so that is possible the results can be considered at the 1990 meeting.

To facilitate exchange of material in countries where difficulties are being experienced in export of samples, the Committee again urges action through the relevant CITES channels. In particular it **recommends** that the Commission should request CITES authorities, particularly in Denmark and Japan, to facilitate international exchange of samples.

The Committee also briefly discussed the question of the effect of biopsy sampling on individual animals (Annex N). It **recommends** that the topic be placed on the Agenda for the 1990 meeting and that national groups be asked to obtain and analyse relevant data for discussion at that time.

7.1.2 Photo-identification

The Committee noted that this topic had been discussed at the Workshop on Individual Identification held last year (SC/40/Rep 1). The Committee agreed that for practical purposes there is little that can be done to recommend specific studies to be undertaken prior to 1990 to help in stock identification. However, it stresses the requirement for continued compilation of catalogues and comparison of photographs within oceanic areas, as well as for computerisation to speed up the matching process.

In this regard the Committee recommends that photographic catalogues should continue to be compiled for comparison within oceanic areas. In addition, computer-based methods should be developed for speeding up the matching process without loss of accuracy and for archiving and accessing photographs (see also Item 7.5.2).

Throughout its discussions of this and other techniques, the Committee was continually reminded of the need to regard no technique as providing, when employed in isolation, a unique solution to stock identity problems. Wherever possible, photo-identification should be combined with other available techniques. In combination, such techniques constitute a powerful tool for delineating stocks.

7.1.3 Whale marking

The Committee agreed that whale mark data can provide some information on current stock boundary validity, but the small sample sizes and the fact that marking and recovery usually took place in the same area limit the value of the results.

The results of the most recent Antarctic minke whale marking experiments show that while movement across the present stock boundaries was not uncommon, and that most movements were within 60° of longitude, they did not provide information on where the boundaries should be, if indeed fixed boundaries are appropriate. Nevertheless, it seems that the size of the current management areas is reasonable.

As in the case of other techniques, marking results should not be seen in isolation, but combined with information obtained from other available techniques, particularly molecular genetics and photo-identification.

7.1.4 Other techniques

(A) Radio telemetry

The major benefit of radio telemetry, both conventional and satellite-based, is to provide information on animals' distribution rather than rates of interchange between stocks.

The technique holds considerable promise and considerable advances have been made recently. But as with other available techniques, it would be most valuable when used in combination with them.

(B) Morphometrics

Two papers, SC/41/NHMi1 and SC/41/SHMi21, describe recent studies on North Atlantic and Antarctic minke whales respectively. The Committee agreed that such methods are useful supplements to others.

(C) Acoustics

Acoustic methods have been applied most successfully so far in relation to population estimation studies rather than stock identity, e.g. in bowhead whales.

While some large baleen whales, e.g. bowhead, right and humpback whales, produce complex sounds suitable for stock identity studies, mysticetes in general, particularly blue, fin, gray and minke whales, produce sounds that are relatively simple, and possibly unsuitable. Even where individual differences between sounds can be identified, complementary information, e.g. from photo-identification, should also be obtained where possible.

(D) Contaminants

Studies of chemical contaminants have already proved useful in distinguishing groups within species such as harbour porpoises (off the United States west coast) and Dall's porpoises. Blubber obtained by biopsy sampling can also be used for contaminant studies if appropriately preserved, e.g. by freezing.

(E) Fatty acid profiles

Investigation of fatty acid profiles using gas chromotography may also contribute to stock delineation of some species and the Committee agreed that such studies should be continued.

7.2 Management procedures (see also Annex E)

The screening process

To facilitate its work towards developing an improved management procedure as part of the Comprehensive Assessment (*Rep. int. Whal. Commn* 39:38–9), the Committee has adopted a process in which proposed management procedures are subjected to an extensive series of screening trials. In these trials, simulated whale stocks are managed according to the rules specified in the management procedure for a period of 100 years, and statistics allowing evaluation of the performance of the procedure in meeting management objectives are gathered. The trials are designed to examine the robustness of the procedures to a variety of problems arising from failures in assumptions about stock dynamics and data. The primary data available to the procedures, on which decisions on catch limits are based, are series of estimates of absolute abundance (e.g. from sightings surveys) and relative abundance indices (e.g. CPUE data) for those years in which catches are taken.

The screening process has two stages. The first stage comprised a series of relatively mild tests of the performance of the procedures and was designed to aid in their development and to eliminate any that performed poorly. Procedures that performed satisfactorily on this first stage screening were then to pass to a second stage, which comprises of a set of much more severe and wide-ranging tests. However, on consideration of the range of trials that should be included in the second stage screening at the 1989 Workshop on Management Procedures (SC/41/Rep 1), it was recognised that a further round of development and modification of procedures would be necessary in light of their performance on some of the more severe second stage screening trials. Accordingly, the second stage screening has been divided into two phases. The first phase, which is now seen as still being at least partly developmental, consists of tests of the robustness of the procedures to a series of specific departures from standard conditions. Once the procedures have been modified as necessary to rectify any weaknesses identified, the second (last) phase would commence. In these trials, the dynamics of the simulated populations, and the relationships between data collected and true whale abundance, are to be much more complex than in the earlier trials, with the aim of examining robustness of procedures in as realistic a setting as possible.

On completion of the two stages of screening, the performance of the various procedures is to be compared and the computer programs implementing them validated, following which recommendations on a procedure suitable for adoption by the Commission will be made by the Committee.

Management objectives

Performance of the management procedures can only be evaluated in terms of how well they meet management objectives. The objectives currently being used for evaluation are those proposed by the Committee and accepted as appropriate by the Commission in 1987 (*Rep. int. Whal. Commn* 38:36):

(1) stability of catch limits, which would be desirable for the orderly development of the whaling industry;
(2) acceptable risk that a stock not be depleted (at a certain level of probability) below some chosen level (e.g. a fraction of its carrying capacity), so that the risk of extinction of the stock is not seriously increased by exploitation;
(3) making possible the highest possible continuing yield from the stock.

While the general intent of these objectives is clear and appropriate measures for evaluating the performance of individual procedures in meeting them have been developed, there remain problems in quantitatively comparing performance between procedures.

As they are stated, the three objectives cannot be fully met simultaneously, especially in the case of objectives (2) and (3). Tradeoffs between them are inevitable, but so far the Commission has not advised the Committee as to the relative weightings that should be attached to each of the objectives, nor has it specified appropriate definitions for the qualitative terms in the objectives (e.g. 'stability', 'acceptable risk', 'seriously increased'). In the absence of such Commission interpretations, developers of different procedures have had to make their own interpretations. Inevitably, these have differed, and thus the performance of the procedures on screening trials is not strictly comparable. The implications of this are discussed further under Item 7.2.2.

Five management procedures are being investigated by the Committee. They have been proposed by Cooke (SC/41/O 35), Magnusson and Stefansson (SC/41/O 23), de la Mare (Annex E, Appendix 2), Punt and Butterworth (SC/41/O 19), and Sakuramoto and Tanaka (SC/41/O 13). Descriptions of the essential elements of the procedures are given in Annex E, Section 4.

7.2.1 Report of Workshop

A Comprehensive Assessment Workshop on Management Procedures was held in February 1989 in Lowestoft, UK. The report of the Workshop is SC/41/Rep 1. Its primary aim was to review results of the first stage screening of the five proposed management procedures, and to specify the trials to be carried out under the second stage of screening.

While results of first stage screening had been presented for each procedure, the Workshop found that a lack of sufficient precision in specifying these trials had led to differences in the ways in which the trials had been carried out. A revised set of first stage trials was developed by the Workshop, for completion by the 1989 Annual Meeting. Testing by the Secretariat of an additional management procedure based on the 'new management procedure' (NMP) as defined in the Schedule was recommended, in order that the performance of alternative procedures could be compared against the NMP-based one. The Secretariat was also to develop a common control computer program to facilitate further screening of procedures, for circulation to developers as soon as it had been completed.

The Workshop identified a range of questions to be addressed in second stage screening (SC/41/Rep 1, Annex G) and developed specifications for a subset of these to be carried out where possible for presentation at the 1989 Annual meeting. Quantitative methods for comparing the performance of procedures were discussed.

7.2.2 Further development of management procedures

Revised First Stage Screening Trials

Results of the revised first stage screening trials recommended by the Workshop were presented for the five proposed procedures in (SC/41/O 13, 19, 23, 31 and Annex E, Appendix 2). Due to the late arrival of a computer program implementing the NMP-based procedure, Allison had been unable to complete the recommended trials for this procedure, but a partial set of trials for an alternative version of a procedure based on the NMP carried out by Punt and Butterworth were presented in SC/41/O 19.

Statistics detailing the performance of the procedures on the first stage trials are given in Annex E, Appendix 3. Comparison of the performance of each of the proposed procedures with that of the NMP-based procedure led the Committee to agree that substantially better performance would be achieved than that shown by the NMP-based procedure. In interpreting this comparison, the Committee noted that this NMP-based procedure effectively just substitutes the catch limit rules of the NMP for those proposed in the Punt and Butterworth procedure. As a consequence, it incorporates many of the improvements included in the Punt and Butterworth procedure, and as such will perform considerably better than would a procedure that more faithfully mirrored the way in which the Scientific Committee has actually formulated its advice under the NMP. It is this fact that leads this version of an NMP-based procedure to perform as well as it does relative to the other procedures. To improve the basis for future comparisons, the Committee agreed that any further trials of an NMP-based procedure should be carried out using the version recommended in SC/41/Rep 1. The Committee agreed that further development of the five procedures was definitely warranted.

No attempt was made to rank the alternative procedures on the basis of their performance at this stage, largely because of their different interpretations of the management objectives. The Committee agreed that all procedures had performed satisfactorily on the first stage trials, and that they should all pass to the second stage.

The Committee agreed that any alternative management procedure that may be proposed in the future should be demonstrated to have successfully passed first stage screening before moving to second stage screening. The same should apply to any of the five presently proposed procedures, should they be substantially modified.

Second Stage Screening

Results of the preliminary second stage trials identified in SC/41/Rep 1 that had been carried out so far (SC/41/O 14, 20, 35; Annex E, Appendix 2) were discussed by the Committee. While satisfactory performance was achieved on some of these trials, unrecognised trends in catchability and mistakes in stock identity had the potential to lead to a reduced ability to meet management objectives.

The Committee developed a full specification of trials to be carried out in the first phase of second stage screening (Annex E, Appendix 6). A total of 152 individual trials is required. This represents approximately a tenfold increase in computing. While recognising the magnitude of this task, the Committee agreed that reduction in the scope and number of trials would compromise the screening process.

Specification of the trials that will constitute the second phase of second stage screening will be carried out by the Committee once results from the first phase have been evaluated. Validation of the computer programs implementing the five alternative procedures should not commence until final modifications of the procedures has been completed by the developers.

Role of ancillary information in management procedures

In the screening trials developed by the Committee, it has been assumed that only the minimum essential information is available to the procedures (absolute abundance estimates and/or catch-based relative abundance indices). The Committee agreed that this assumption should be continued for the remaining screening trials. In reality, however, there will often be other information available for particular stocks. In some cases, this additional information can be readily incorporated into a management procedure (e.g. annual series of relative abundance indices from surveys), but in other cases this would be much more difficult (e.g. series of pregnancy rate estimates for stocks being assessed using a simple production model).

The Committee does not believe it appropriate to develop a management procedure that can handle internally all relevant types of data. Rather, the Committee envisages a process in which a stock assessment obtained using a robust management procedure is considered by the Committee along with other relevant data. However, it believes that advice on catch limits for a particular year or period derived from the management procedure should only be varied in response to very strong contrary evidence from ancillary data.

Best queried whether new information on stock identity would be considered ancillary in this context. In response, it was suggested that this would depend on the strength of the information. If it were sufficiently conclusive that the Committee agreed that a change in stock boundaries was appropriate, then this should be done and the management procedure should then be applied to the re-defined stock. However, if the information were such that it simply cast

doubt on the existing stock definition, the extent to which this would be acted upon immediately would depend largely on the demonstrated robustness of the management procedure to uncertainties of this type.

Work plan for 1989/90

The Committee reviewed the tasks that need to be carried out before final presentation of a recommended management procedure and developed a tentative schedule for their completion. This is given in Table 3.

Table 3

Tentative schedule for presentation of final management procedure

Tentative schedule	Tasks
1989 SC	(1) Specify 1st phase of 2nd stage screening
1989 SC	(2) Specify experimental design for interaction trials
1989 IWC	(3) Get advice from Commission on relative weightings for management aims
Jun 89-Feb 90	(4) Tune procedures to take account of Commission advice
Jun 89-Feb 90	(5) Run 1st phase 2nd stage screening single and interaction trials
1990 Wkshop	(6) Review results
1990 Wkshop	(7) Review and analyse interaction experimental design
1990 Wkshop	(8) Specify 2nd phase 2nd stage screening trials
1990 Wkshop	(9) Develop comparison techniques Feb-May 1990
	(10) Complete interaction experiment trials (if not already done)
Feb-May 1990	(11) Run 2nd phase 2nd stage screening trials
1990 SC	(12) Review and compare results
1990 SC	(13) Produce progress report for Commission
1990 IWC	(14) Get further advice if necessary from Commission on management objectives and their weightings
Post 1990 IWC	(15) Final modification/combination of procedures in light of Commission advice (if necessary)
Post 1990 IWC	(16) Program validation by Secretariat
Post 1990 IWC	(17) Rerun 1st stage screening and full 2nd stage screening on modified procedures (Secretariat)
1991	(18) Apply comparison methods to select best procedure (SC)
1991	(19) Recommend best management procedure to Commission (SC)

The Committee **recommends** that the first phase of second stage trials be carried out before February 1990 by the developers of the alternative procedures, and by the Secretariat in the case of the NMP-based procedure identified in SC/41/Rep 1. The common control program being developed by Allison, soon due for completion, should be circulated to developers as soon as possible.

In order to review results of the first phase of second stage screening, to specify the second phase trials, and to further develop quantitative methods for comparisons of performance, the Committee **recommends** that a Workshop be held over an 8-day period in early February 1990. Arrangements should be made to ensure the attendance of Allison and five invited participants (the convenor and developers of the procedures). Walløe advised that the University of Oslo would be pleased to host the Workshop. Budgetary implications of the Workshop and the increased computing costs that will be incurred by developers of procedures and the Secretariat during 1989/90 are discussed under Item 14.2.

To facilitate the work to be carried out in this coming year, the Committee **recommends** that it be coordinated through a Steering Committee convened by Kirkwood. It also urges that if at all possible, Kirkwood should continue to chair future management meetings and attend the 1990 Annual Meetings.

Horwood and Kirkwood commented on the large amount of work that is proposed in the tentative schedule to be done by the Committee at its 1990 Annual Meeting. They believed that this should be borne in mind in discussions under Item 15, particularly in terms of the relative amounts of time that could be devoted to work on management procedures and on the Comprehensive Assessment of priority stocks and regions.

Discussion of the tentative schedule focussed mainly on what could be achieved by the time of the 1990 Commission meeting. Despite the large volume of computing work required, the schedule envisages completion of all second stage screening of each of the proposed procedures and of the NMP-based procedure before the 1990 Scientific Committee meeting. At that meeting, a review and comparison of the performance of the procedures would be carried out, and a report detailing this would be prepared for consideration by the Commission at its 1990 meeting. However, that does not complete the development process. Before the Committee would be in a position to recommend any particular procedure, it is essential that the Secretariat validate the programs and confirm the full first and second stage screening trials for these validated programs (tasks 16 and 17). These tasks can only be started after the 1990 meetings.

In addition, task (15) allows for final modification of procedures to take account of advice from the Commission on operational definitions of its management objectives and the weightings, preferably quantitative, that it assigns to them. The Committee envisaged that this advice would not be given until the 1990 Commission meeting. However, if such advice could be given earlier, for example at the 1989 Commission meeting, then task (15) could be completed earlier. In this context, the Committee noted that the Scientific Committee had first drawn the Technical Committee and Commission's attention to the management aims and the need for clarification of them at the 1987 meetings of the Joint Technical Committee/ Scientific Committee Working Group and the Commission.

The Committee **strongly recommends** that the Commission provides this advice at the earliest possible opportunity.

The Committee wished to emphasise that it believed outstanding progress had been made towards developing an improved management procedure, given the difficulty of that task. It further believed that if short-cuts are taken at this stage in an attempt to complete a foreshortened development process by the 1990 Commission meeting, this would seriously compromise the development of a satisfactory management procedure.

The Committee did recognise, however, that the Commission may feel it necessary to be in a position to adopt a management procedure for use in 1990/91, should a decision be taken in 1990 to allow some commercial whaling from that time. If so, the Commission may require the Committee to recommend an appropriate management procedure. The Committee noted that, in the event of such a request being received, any interim procedure so

developed might be considerably inferior to the one envisaged at the end of the development process outlined in Table 3, in part since effort would have to be diverted to allow time for the interim procedure to be validated before the 1990 meeting. This would significantly delay the finalisation of the preferred development process.

Some members suggested that, if one of the five unvalidated procedures discussed above was adopted as an interim procedure, the potential loss of time may not be as great as suggested above nor would the loss of performance relative to management objectives.

Other matters

The question was raised of whether current versions of programs implementing the five management procedures were available to interested Scientific Committee members so that they could, if desired, carry out additional trials to further investigate their properties. The Committee agreed that, once programs had been formally submitted to the Secretariat for validation, then these would definitely be available to other interested members. However, prior to that time, the management procedures and programs would be in a constant state of development and modification. The Committee agreed that until that time, any requests should be referred directly to the developer of the procedure, in whose discretion should lie the decision of whether or not to accede to the request.

Copies of any requests should be sent to the IWC Secretariat.

The Committee recognised that developers of procedures would probably only be in a position to make available the parts of their programs they had written themselves. Some may have used third-party library routines for standard numerical operations. Other users may have to replace these with the corresponding routines from their local program libraries.

7.3 Biological parameters (see also Annex F)

7.3.1 Background

At the 1987 meeting the Scientific Committee established a postal working group to 'review biological parameters and their changes over time'. No work was undertaken, and the question was carried over to this meeting. No specific objectives had been identified, and in light of the priorities of this meeting it was agreed that the objectives were to 'review information on biological parameters and their changes, and where appropriate to refer to particular priority stocks and regions, and to suggest additional work essential for the 1990 Comprehensive Assessment'. A sub-committee was established to consider this subject, and its report is given in Annex F. The Committee noted that the discussion had only considered baleen whales.

7.3.2 Significance of data on biological parameters for a 1990 Comprehensive Assessment

A large literature on biological parameters exists, but specific details from a study of the East Greenland-Iceland stock of fin whales were presented (SC/41/Ba3) to illustrate the importance of monitoring biological parameters. Several points arose in discussion.

In particular it was recognised that the models used for management did not attempt to capture more than the essentials of whale stock dynamics. In practice, mistakes could occur in the form of the model and its parameter estimates, as well as other mistakes in management arising from abundance estimation and stock misidentification. Consequently, it was agreed that prudent management would be responsive to warnings given by unexpected changes in estimates of various biological parameters. However, within the Committee there was a spectrum of opinion as to how strong and in what direction management should respond to such changes.

Magnusson pointed out that information on values of biological parameters might be useful in tuning management procedures, that is in narrowing the range of feasible values for the control parameters used in the procedures.

It was noted that a knowledge of biological parameters, their magnitude and variations, led ultimately to a greater understanding of the dynamics of whale stocks, and hence to an improved management. However some members considered that inferences about the effects on rates of yield of whale stocks, obtained from observations of one or more vital rates, would inevitably remain ambiguous unless all relevant vital rates were measured.

Specific attention was given to the general significance of age-specific mortality rates. It was recognised that the Japanese research programme was directed towards the estimation of such rates, for Antarctic minke whales, and that this would be considered under Item 9.2.1. It was agreed that the significance of age-dependent rates depended upon two aspects. The first aspect is the use made of the dynamic model. Some uses of the model are robust to a wide range of parameter values; an example would be the estimation of relative depletion of stocks. Other uses are more sensitive, such as the back calculation of recruitment rates. The second aspect is the magnitude of any change in the age-specific parameter.

The Committee recorded that in some past assessments of fin, minke and sei whales, time series of certain biological parameters had been used directly in the biological model, with changes in the rates of other unmeasured parameters assumed.

7.3.3 Additional data or analyses required, or recommendations for a 1990 Comprehensive Assessment

It was agreed that useful information could be obtained from the estimation and monitoring of demographic parameters of stocks depleted to low levels, (such as the right whales) and of the gray whale, for which it is anticipated that a reduction in population growth rate will soon occur. Identified parameters were calving interval, age at first parturition, and adult and juvenile survival rates. Because of the time involved for such studies, they will not be of assistance for a 1990 Comprehensive Assessment, but will be of use in the near future.

The importance was discussed of acquiring data suitable for the estimation of age-specific mortality rates. It was agreed that details of the proposed Japanese programme (Item 9) should not be addressed under this item, and so generalities were focussed upon. Some considered that acquisition and analysis of these data were of importance to a Comprehensive Assessment. Others noted the above discussions, and that the importance of such data depended upon the specific use of the models in which they are used, the magnitude of any age-specific changes and the precision of the estimates; they concluded that in general one could not recognise such collections as of importance to the Comprehensive Assessment.

Sigurjónsson argued that consideration be given to a previous proposal to predict and estimate the mortality schedule of fin whales from parasite burden and other

parameters measured in pathological examinations. It was agreed that before this is considered again a presentation should be made of further examinations of the theoretical basis of such studies.

7.4 MSY rates (and see Annex F)

The Committee was reminded that MSY rate is the ratio of MSY to MSYL expressed as a percentage (*Rep. int. Whal. Commn* 38:165).

7.4.1 Background

At the 1988 meeting the Scientific Committee agreed, in relation to MSY rates, that existing data sets should be examined and reanalysed, consideration be given to design of data collection and analysis, and justification for inter-specific or inter-stock comparisons be examined. The Committee noted that its discussions this year were limited to baleen whales.

7.4.2 Rates estimated from observations of depleted populations

New rates of population increase were reported from several stocks. South African right whales were estimated to have increased at 7.1% p.a. from 1971–87 (SC/41/PS3), Argentinian right whales at 7.6% p.a. from 1971–86 (SC/41/PS17), and blue and humpback whales off western Iceland at 4.9% and 11.6% respectively, from 1970–88 (SC/41/O 22). In the last case, the authors considered the rate of increase of the humpback whales not to represent that of the population. Other estimated rates of increase, of stocks of whales that have been protected from commercial whaling for at least 20 years, are documented in Annex F (Appendix 6).

A series of theoretical studies addressed the question of estimating MSY rates from observations of rates of increase of populations at low levels.

SC/41/O 30 described the statistical characteristics of such estimation, assuming that the underlying population model is correct. The author reported that the study showed that estimates of absolute abundance are essential to estimate the pre-exploitation stock size and extent of stock recovery. For estimating MSY% and MSY the reliability of estimates obtained from absolute abundance data are considerably superior to those obtained from relative abundance data. For estimating MSY and MSY rate the state of the stock being monitored needs to balance the various factors which could bias the results. Reducing the effects of any bias in absolute abundance estimates can be achieved by monitoring very depleted stocks. This however leads to estimates which have to be extrapolated far from the part of the stock recovery trajectory which has been monitored. This problem could be reduced by monitoring the stock in the region of MSYL, but this is a poor region for estimation because: (1) there is a tendency for the estimates of initial population size (and therefore current depletion) and MSY rate to become jointly under-determined; and (2) bias in absolute abundance estimates leads to bias in parameter estimates. Accordingly, the author suggested that to balance the two factors, the best stocks to choose would be ones in which recovery can be monitored from a low point in the range of 20%-30% of unexploited stock size.

In discussion some argued that, based on the above results, rates of increase of depleted populations could not be reliably extrapolated to provide estimates of MSY rates at stock sizes possibly far from these observed. Other members disagreed, considering that the range of the estimates would still be of use in management, but nevertheless they agreed that the results indicated that management procedures should be robust with respect to uncertainty in MSY rates.

In this context, the importance of the monitoring of depleted stocks was briefly discussed. The above results indicated a limited contribution of such monitoring to the calculation of precise MSY rates. However, monitoring such stocks will contribute to a description of the rates of recovery of depleted stocks, provide information on the absolute values of demographic parameters and possibly give some information on the extent of the density dependent response at low stock sizes; the latter warrants a statistical investigation.

SC/41/O 8 reported results from the deterministic calculation of MSY rates, given a particular value of population increase close to zero stock size, and a range of production models that have been used in whale assessments. Since it is not possible to judge which of these models are more 'plausible' or 'realistic', and since the calculated MSY rates span a large range, the author concluded that such calculations were of limited use and could be misleading. The problem is further complicated by the fact that increase of depleted stocks can only be measured over a range of stock size and that calculation of the actual level of depletion using catch histories involves a circularity since an MSY rate and a production function must be assumed.

SC/41/O 8 also demonstrated that if the recruitment function (r(N)) declined continuously with increasing stock size, but while generally convex is not necessarily convex throughout the range of population size, then if MSYL > 0.5 MSY rate/r(0), (where r(0) is the initial rate of increase), is in the range approx. 1.0 to [1-MSYL]. For definitions of convexity see Annex F. SC/41/PS15 further showed that if r(N) was strictly convex everywhere then MSYL > 0.5, and MSY rate > r(0)/2.

SC/41/O 29 reported on the construction of yield curves from a range of postulated density dependent functions of fecundity and mortality. Examples were given of models with high initial growth rates but very low values at higher stock sizes. The author concluded that, rather than attempt to calculate MSY rates from models of uncertain veracity, it was better to develop management procedures that are robust in the face of uncertain population dynamics.

Some of the models considered above had substantial density dependent response at low stock levels. The plausibility of such relationships were discussed and reported on below.

Inferences about the values of MSY rates and other parameters were made in two studies. From data from South African right whales, assuming strict convexity, SC/41/PS15 estimated the lower bound of the MSY rate as 4.5% p.a., and a lower 95% confidence bound on the population rate of increase gave a lower bound to the MSY rate of 2.8% p.a.

SC/41/O 34 demonstrated that demographic parameters and the observed rate of increase of Argentinian right whales together implied an average mortality rate of 0.6% p.a., and the author argued that this may indicate a density–dependent mortality. A density-dependent schedule for birth and deaths was found, which was consistent with observations, but which did not generate a 'supercompensation' effect in recruitment. An earlier study, based on the results of the monitoring of South

African right whales, had indicated that such an effect was necessary to account for the observed rate of increase in the absence of age-dependent mortality (SC/38/O 8).

Discussion within the sub-committee focussed upon the validity of the assumption that r(N) was convex everywhere. It was pointed out that Fowler's arguments (Fowler, G.N. 1981 *Ecology* 62(3):602–10) did not establish such a precise relationship, and would, for instance be equally supportive of the monotonic decreasing functions that changed curvature, as described in SC/41/O 8. It was also argued that Fowler had presented a series of measures of specific parameters, and not of net recruitment rates, and that the shape of the latter was still open to much speculation. Rates near to zero population sizes had also been rarely measured. Further it was pointed out that net recruitment curves could have the expected shape for animals living in a uniform environment, but that spatial variation in the environment could lead to net recruitment functions for an entire population having substantially different shapes. Consequently several members considered that no conclusions could be drawn as to the specific shape of the recruitment functions and that therefore MSY rates lower than the lower bound postulated above could not be excluded.

Butterworth argued that although Fowler had not presented trends with population size for net recruitment rates, the trends of the variety of contributory parameters presented nearly all indicated convex shapes, so that it was highly likely that the resultant net recruitment rate trends would also be convex. He further pointed out that, although data near to zero population size were generally absent from the figures shown in Fowler's study, these figures nowhere revealed indications of the substantial extent of density dependence at low population levels which is necessary to reconcile high whale population growth rates at such levels with low MSY rates.

Ohsumi considered that the continued rate of increase of gray whales, at 2.5% with about an additional 1% catch p.a. (*Rep. int. Whal. Commn* 37:347–9), which are approaching their carrying capacity (Gerrodette and DeMaster, in press, *Mar. Mammal Sci.*) was a confirmation of the convexity of recruitment functions.

In response, de la Mare, Holt, Chapman and Cooke noted that simulation studies by the developers of the dynamic response analyses used by Gerrodette and DeMaster (cited above) showed that reliable determination of whether a stock was above or below MSYL depended on the second order term of a polynomial regression being significantly negative. Appendix 7 of Annex I indicates that this condition is violated in the analysis of Gerrodette and DeMaster and therefore it does not provide unambiguous evidence for the stock relative to MSYL. DeMaster noted that the dynamic response analysis casts no light on whether the recruitment curve is convex or not.

In response, Butterworth drew attention to the comments of DeMaster (Annex I, Appendix 7) regarding the dynamic response analysis of the gray whale count data. DeMaster stated only that *most* (not *all*) of the pertinent coefficients were not significantly different from zero, and also that 'the pattern formed by using 6–11 census periods over the 13 year period was consistent with a population in its OSP range' (i.e. near to or above MSY level).

In conclusion some argued that strict convexity of the net recruitment function was to be expected and hence lower bounds could be placed on the MSY rate. For example, in the case of the South African right whales they estimated the MSY rate to be 4.5% with a lower 95% confidence bound of 2.8%. Others considered that such convexity was not established and therefore that no lower bound could be given.

Some members suggested that the rates of increase of populations at low levels (Annex F, Appendix 6), could be of use in the development of management procedures in narrowing the range of net recruitment rates at low population levels over which they require proposed management procedures to be robust.

7.4.3 Rates inferred from changes in biological parameters

SC/41/O 11 presented results on a study of the sensitivity of calculated net recruitment rates from demographic analyses to error in the biological parameters used. In general a high sensitivity was found, which implies that a relatively high precision in measured parameters is required to obtain a useful degree of precision in estimated net recruitment rates.

It was noted that the Committee had until a few years ago regularly used models which had utilised changes in measured demographic parameters, whilst other unmeasured rates were assumed constant. In such models the yield rate was determined entirely by the input parameters and was not estimated from any observed trends in abundance.

It was recognised that little further could be developed under this item of relevance to a 1990 Comprehensive Assessment.

7.4.4 Rates from analysis of catch-at-age data

There has been extensive past discussion on the information content of catch-at-age data, and the possible estimation of recruitment rates from such data. A brief review is given in Annex F, which shows that there are unresolved differences of opinion on this subject. New material is considered under Item 9.2.1.

7.4.5 Rates from fits of population models (to other than depleted populations)

SC/41/Ba4 reported on population model trajectory fits to CPUE series whilst 'hitting' sighting abundance estimates available for the East Greenland-Iceland fin whale stock. The study took account of covariance in overlapping CPUE series. The data used were those specified last year (*Rep. int. Whal. Commn* 39:100–2) and in particular the 1987 sighting survey estimate of total abundance of 6,436. The resultant MSY rate estimate for 'hits' to this total abundance level were all about 12%, irrespective of the use of non-linearity factors and inclusion or omission of an early CPUE series. However, the estimates were very sensitive to the sighting population estimate used, decreasing as this estimate was increased.

During the meeting (Item 6.5) the sighting abundance estimate for this stock was revised to 11,563 (CV 0.261). The calculations of SC/41/Ba4 were repeated for the revised estimate for the case where non-linearity factors are applied for the CPUE series and all five CPUE series available are taken into account. The revised estimate of MSY rate for this new abundance estimate was 4.3%, with a range of [2.5%, 19.6%] corresponding respectively to the 95% upper and lower confidence limits on this abundance estimate.

In discussion of SC/41/Ba4 various points arose. In particular it was argued that the fitting procedure had

resulted in a low weighting being given to the early CPUE series which might account for the fact that the inclusion or exclusion of this series had little effect on the estimates. It was agreed that further work might resolve this.

Some argued that the results were of limited use since the confidence interval of the calculated MSY rate was large, a feature that was to be expected given the results of simulation studies (*Rep. int. Whal. Commn* 36:399–418; 37:383–6). Others, while recognising that the intervals were large, argued that the study provided useful information, particularly regarding the lower bound, for some of the new management procedures and their control parameters, and that the interval might be reduced with time.

It was further argued that results could be biassed because of an incorrect assumption of the relationship between CPUE (particularly the early series from a multi-species fishery) and abundance, and because of possibly incorrect stock boundaries. Others considered that such errors were likely to be small and hence that the above results could be used.

A list of possible extensions to this study is given in Annex F.

Estimation of MSY rates had not been attempted for the eastern Pacific stock of gray whale, however Ohsumi, Best and Butterworth offered the following arguments. They noted that current estimates of this stock were about 21,000 and that the stock is likely to be approaching to the carrying capacity. When last measured (1967/68–1979/80), it was increasing at about 2.5% p.a., with an aboriginal catch of about 1.2% and further incidental catches (*Rep. int. Whal. Commn* 37:347–9). Assuming the stock was near the MSYL in that period as indicated by Gerrodette and DeMaster (in press, *Mar. Mammal Sci.*) the MSY rate is likely to be close to measured rate of net recruitment and hence is likely to be about 4% p.a. They noted that this was consistent with rates inferred by some members from South African (SC/41/PS15) and Argentinian (SC/41/O 34) right whales.

Chapman, de la Mare and Holt reiterated their concerns about the ambiguity of the results of the dynamic response analysis cited above. They also responded that it was not possible at this time to infer any MSY rates based on information from the gray whale, since the Scientific Committee is still in the process of developing a plan for the Comprehensive Assessment of the gray whale, and that Comprehensive Assessment may lead to a significant re-evaluation of its status and population dynamics.

In concluded its discussion of Item 7.4.5, the Committee made or reiterated the following points.

(1) It was noted that several estimates of MSY rates had been calculated during past assessments. Concerns have been expressed with all of these, and no review has been provided here.

(2) Some considered that problems with interpretation of CPUE and stock identity, and of sensitivity to target stock sizes and lack of robustness of MSY rates, led to the conclusion that no useful quantitative information about MSY rates was provided by the above studies. Others considered that sources of bias were unestablished, and that the results were valid. Although the range of estimated MSY rate from the East Greenland-Iceland stock of fin whales was large, it did provide a useful lower bound (2.5%) for testing of management procedures and in setting values of parameters.

(3) Some members questioned the general usefulness of the approach, given that they considered that most data sets would result in wide confidence intervals, and hence that the results were likely to be of little practical use.

7.4.6 Validity of inter-stock and inter-specific analogy

The Scientific Committee has occasionally used information from particular stocks and species to infer production rates for other stocks and species.

Best tabulated data (Annex F, Appendix 6) on estimated rates of increase of mainly depleted stocks. He noted that the actual relative depletion of all these stocks is not known, but considered that the right whales were at relatively low levels, and humpbacks perhaps less depleted. He noted that the data were variable, but that in considering right and humpback whale stocks, there may be more consistency in rates within the stocks than between them. However, others considered that inspection of the rates did not justify such a conclusion.

The Committee noted that during critical periods of the reproductive cycle, gray, right and humpback whales were of a more coastal distribution than most balaenopterids, and that this was one reason to treat with caution a more general usage of the documented rates.

Arguments for and against the possibility and plausibility of such data sets being self-selecting, by the exclusion of rates from stocks whose abundance trends are unknown, are presented in Annex F.

Butterworth commented that the tabulation of such data at least facilitated a quantitative evaluation of the validity of inter-stock and inter-specific analogies.

7.4.7 Future research requirements

It was suggested that discrimination amongst different hypotheses about the extent of density dependence in net recruitment rates at low population levels may be possible through the analysis of rates of population increase at low levels. In relation to this, it was considered that the statistical problems deserved examination in theory and in relation to specific data sets.

The Committee **recommends** that current monitoring of depleted stocks of right and humpback whales should continue. It also **recommends** that currently unmonitored stocks of these species, as well as stocks of blue, fin and sei whales that are at relatively low levels and for which there are few current data, also be monitored where this is practical.

7.4.8 Recommendations as to appropriate rates for use in any Comprehensive Assessment or in setting quotas

The implications of the discussions for the furtherance of a Comprehensive Assessment were considered.

Attention focussed upon whether the above deliberations had managed to narrow the range of plausible values of MSY rates, particularly in the context of providing a range for use in testing of the proposed new management procedures. Considerable differences of opinion were expressed as to whether this narrowing had been achieved.

Notwithstanding the significant advances made at this meeting in the level of understanding of estimation of MSY rates, some considered that the analyses had shown that, even in ideal circumstances, the estimated MSY rates were subject to very wide confidence intervals, and that the applied studies were subject to additional problems

detailed above. Consequently they argued that the committee was in no better position than in previous years, to advise on ranges of MSY rates.

Based on the material from depleted and other stocks discussed above, others considered that useful quantitative information had been obtained. In particular they argued that values of MSY rates as low as 1% were inconsistent with estimated rates and observed trends in stock size, and that values nearer 4% were more appropriate.

The Committee agreed that, given its inconclusive discussions on this question over recent years, it is particularly important that management procedures should be robust to a range of MSY levels and MSY rates.

7.5 Stock estimates

The Committee recognised that there were two distinct classes of stock estimates that were likely to be required for the Comprehensive Assessment: 'best possible' estimates of absolute abundance; and precise indices of abundance. Even if a stock was to be managed using a procedure that required only an index of abundance, at least one estimate of absolute abundance would be required to determine initial levels of abundance and to calibrate the index.

The estimates of absolute abundance based on sightings which the Committee has been able to provide have often been described as 'minimum estimates' because they contained an unquantified downward bias. The two principal sources of bias are failure to detect every whale on the trackline (i.e. $g(0)<1$ – see Item 7.5.1.1) and failure to survey the entire area known to be used by the stock. The Committee recognised that the Comprehensive Assessment would require the quantification and attempted correction of these biasses, even though this process might not be accurate and would increase the estimated variance. It therefore **recommmends** further work on these problems. The biasses in estimates of absolute abundance derived from other techniques, particularly those based on mark-recapture analysis, are less well understood. However, it was suspected that heterogeneity in susceptibility to marking and recapture was an important factor. The sub-committee **recommended** further work on this problem (see Annex M).

For indices of abundance, bias is a lesser problem provided it is constant from year to year. The precision of the estimates could be improved by applying a consistent procedure in every year so that the various correction factors that were often necessary in the analysis of survey data could be ignored for the purposes of comparison. However, the Committee noted that it has in general experienced great difficulty in interpreting apparent differences in survey results from two years, even when a consistent methodology had been used in both surveys. If a significant difference was found, it was usually possible to identify procedural or environmental factors which could account for it. If there was no difference, it was possible to conclude that a real change had been obscured by the same sorts of factors. A further difficulty in interpreting such comparisons is that the estimates of variance are biassed downwards. The Committee therefore **recommends** that more work be undertaken to identify the extrinsic factors which can affect survey results and to develop a consistent procedure for interpreting differences in these results.

The Committee then reviewed the techniques which were available for estimating the abundance of large whales paying particular attention to the difficulties which had been encountered in their application and the research which might be necessary to overcome these difficulties.

7.5.1 Sightings

Techniques considered under this heading included all those which relied on the detection and enumeration of cues (such as blows, surfacings or vocalisations) produced by whales.

7.5.1.1 Shipboard and aerial surveys

Shipboard and aerial surveys have been the primary techniques used to estimate the abundance of whales in the Southern Ocean and North Atlantic in recent years. Results from these surveys have been analysed using modified line-transect theory (Burnham, K. *et al.* 1980. *Wildl. Monographs* 72:1–202) or cue counting (Hiby, A.R. 1985. IMA *J. Math App. Med. and Biol.* 2:201–20). The Committee noted major areas where problems had been encountered: (i) the choice between Passing and Closing Mode surveys; (ii) estimation of the proportion of whales on the trackline which are detected; (iii) estimation of school size; (iv) error and bias in the estimation of angle and distance to sightings; and (v) whale reaction to the survey platform. Most of the Committee's experience with this problem related to shipboard surveys.

Closing and Passing Mode surveys

Until 1984/85 the Southern Hemisphere IWC/IDCR minke whale assessment cruises were conducted in Closing Mode. However, from that cruise onwards, both Passing and Closing Mode were used. In recent years Passing Mode estimates have been considered to be less biassed than those from Closing Mode. The Committee had available data which permitted a comparison of the density estimates provided by both modes on three surveys. It was thought these might be used to transform the estimates made in Closing Mode on earlier surveys to a common base. However, the difference between density estimates made in the two modes was greater than many members of the Committee expected on the basis of the known biasses of the techniques. The Committee therefore **recommends** that in the coming year, estimates from Passing Mode corrected for the effects of extra observers and the effects of high density areas should be calculated and the comparison of the two modes repeated. The Committee concluded that until this problem was resolved, estimates made in both modes should be presented and that no attempt should be made to transform the earlier Closing Mode estimates.

Estimation of g(0)

Conventional line transect theory assumes that a whale which is on the trackline is certain to be seen. Because whales spend a large proportion of their time beneath the surface, this may not be true – particularly during aerial surveys. A number of attempts had therefore been made on recent IDCR and NASS surveys to estimate the probability ($g(0)$) that a whale on the trackline would be seen by placing a second, independent observer on the survey vessel. The Committee has experienced problems in interpreting the results of similar analyses, *Rep. int. Whal. Commn* 39:72–3, and has recommended further studies to attempt to resolve this problem. However, the results of experiments carried out on recent IWC/IDCR cruises were inconclusive (SC/41/SHMi9, 12).

SC/41/NHMi5 considered the theoretical basis of estimating $g(0)$ from the independent observer experiments and concluded that the assumption of unconditional independence between the observers could

not be justified and that, as a consequence, estimates of g(0) from these experiments would be biased upwards. During discussion, the Committee recognised an additional source of bias in the opposite direction. The author of SC/41/NHMi5 recommended a parallel ship experiment aimed at estimating the sighting hazard probability. Experiments along these lines would be carried out by Norwegian vessels during the NASS-89 surveys. The Committee welcomed this new approach.

The Committee concluded that there were still problems in the estimation of g(0) and **recommends** further work on these.

Estimation of school size

Standard line transect techniques provide an estimate of the density of schools. In order to estimate whale density it is necessary to estimate the mean size of the schools that were seen. Over the past decade, the Committee has attempted to estimate the mean size of schools seen on IWC/IDCR cruises by a variety of means, none of which have been very satisfactory.

As an alternative approach, sightings made in Closing Mode during surveys as part of the Japanese Feasibility Study in the Antarctic in 1987/88 had been stratified by school size. Density estimates were then made for each separate school size category (SC/41/SHMi1 and 3). This took account of the fact that large schools were easier to see than small ones and thus the distribution of sightings with distance from the trackline varied with school size. The Committee welcomed this approach as a good way of overcoming the problems of school size estimation in Closing Mode.

Estimates of school size in Passing Mode were problematic since delayed closing experiments (*Rep. int. Whal. Commn* 37:70) had indicated that estimates of school size made in passing mode were about one third lower than those which were obtained if the survey vessel closed with the school. The Committee noted that in this case, it might be more appropriate to base stock estimates directly on sightings of whales because of possible differences in the way schools were perceived in Passing and Closing Mode. It **recommends** further analysis to determine if this is a more appropriate approach.

Errors in the estimation of angle and distance

For both shipboard and aerial surveys, it is necessary to estimate the perpendicular distance of each sighting from the trackline. For shipboard surveys this is usually done by estimating the bearing and radial distance of the sighting. However, the tendency of observers to assign sightings preferentially to particular distance and angle classes has caused problems in analysis. These problems had been overcome to some extent by the use of sightings boards and graticule binoculars, and by 'smearing' data before analysis to account for misallocation. However, the Committee recognises that there are still problems with these estimates and **recommends** that the suitability of equipment which had been developed for the improved estimation of these variables on dolphin surveys in the Eastern Tropical Pacific be evaluated.

Whale response to the survey platform and dive time

If whales move away from or are attracted to the survey platform, or if they change their behaviour in response to it, this may seriously effect stock estimates from sightings surveys. Attempts to determine the response of whales to vessels on the Southern Hemisphere IWC/IDCR cruises have so far produced inconclusive results. The Committee **recommend** further work to design better experiments to address this problem.

The Committee noted that a knowledge of the proportion of time which whales spend on the surface is important for the interpretation of survey results. It was therefore pleased to receive the report of the successful use of a VHF radio tag to monitor the surfacing behaviour of a minke whale in Icelandic coastal waters (SC/41/NHMi13). It **recommends** that additional data on dive times for other large cetaceans should be collected in well-designed experiments; in particular these could be collected on future Southern Hemisphere IWC/IDCR minke whale assessment cruises and for fin whales on future NASS surveys (see Item 6.5).

The choice between line transect and cue counting techniques

The cue counting technique has been designed to overcome some of the problems encountered with the use of standard line transect techniques for surveying large whales. It has proved particularly useful for aerial surveys. SC/41/SHMi20 reported on further analysis of results obtained using this technique during Southern Hemisphere IWC/IDCR minke whale assessment cruises. Many of the problems encountered earlier have now been resolved and the Committee **recommends** that where possible, data suitable for analysis by both cue counting and line transect techniques should be collected on whale sightings surveys.

The choice between aerial surveys and shipboard surveys

The Committee noted that the choice of a suitable platform for whale survey work depends on a variety of logistic constraints. However, where it is practical to use an aircraft, this does offer some advantages. In particular, it is possible to carry out replicate surveys of the same area in one season and thus avoid many of the problems encountered in comparing shipboard survey results between years. The aircraft used in such surveys should have good downward visibility and this can be achieved by fitting bubble windows. The use of these has been approved by most civil aviation authorities.

7.5.1.2 Land-based and acoustic surveys

Land-based sightings counts have proved particularly useful for estimating the abundance of large whales which migrate close to the coast, including bowhead, right, humpback and gray whales. The Committee noted that in general, more confidence can be attached to estimates of abundance based on such counts than to the results of shipboard or aerial surveys, because a high proportion of the total population is counted (e.g. about one quarter to one third of the Bering-Chukchi-Beaufort Sea bowhead stock was counted during the 1988 census – SC/41/PS7).

The Committee noted that shore-based surveys are affected by a number of factors which have their exact counterparts in shipboard and aerial surveys:

(1) whales may pass the survey point without producing any detectable cue;
(2) whales may produce a cue but this is not detected by the observers;
(3) heterogeneity in individual behaviour (such as swimming speed) may affect (1) and (2);
(4) there is a danger that the same individual may be counted on more than one occasion;

(5) cues from two different individuals may wrongly be assumed to come from the same individual, resulting in under-counting;
(6) environmental conditions may affect all of the previous probabilities;
(7) it is not possible to monitor continuously the whales passing the observation point; if whale behaviour is different in the monitored and unmonitored periods (e.g. between night and day) then the situation is analagous to the problem of unsurveyed areas in sightings surveys.

The standard field methodology for the shore-based bowhead surveys is described in SC/41/PS6; analytical techniques are presented in SC/41/PS6, 8 and 9. Two separate methods, visual and acoustic, are used to provide information equivalent to that generated by having independent observers on shipboard and aerial surveys. A tracking algorithm is used to link sightings and acoustic locations of whales. The data are analysed using a unified probability model which takes account of all the known sources of error in the counting process and of prior information on the size of the stock. The Committee recognised that the bowhead studies have made a very substantial contribution to the methodology of stock estimation.

The Committee also noted that the analysis of the bowhead data had been facilitated because the precise time at which each cue had been detected was recorded. It was now possible to record this kind of information automatically during most types of surveys and the Committee **recommends** that this should be done where practical.

The gray whale migration along the California coast has been monitored for many years by shore based observers. Gray whales produce few acoustic cues so acoustic monitoring could not be used to track individuals between surfacings. Aerial surveys indicated that a very high proportion of the gray whale population migrated close to shore. In 1987/88, two independent observer points, positioned close together, were used to obtain estimates of the probability of detecting individual whales.

Shore-based counts are now being used to monitor the abundance of humpback whales in South Africa and on the east coast of Australia.

Sperm whales produce regularly spaced, distinctive 'clicks' which provide a suitable cue for use in surveys. The Committee recognises that this approach could be valuable and **recommends** a coordinated and cooperative international approach to the development of methods for the acoustic surveying of whales.

7.5.2 Mark-recapture techniques

Mark-recapture analysis requires the presence in the population of a number of individuals which carry a unique identification. A number of techniques have been developed for 'marking' individuals. These include firing an individually-coded Discovery mark into the muscle of the whale, using photographs to identify individual whales, and the determination of individual DNA fingerprints from skin samples collected with a biopsy dart. The Committee discussed the relative merits of these methods.

At the 1988 meeting, concern had been expressed about the sensitivity of stock estimates from Discovery marking results to mark shedding and marking related mortality (*Rep. int. Whal. Commn* 39:43–4). On the basis of an analysis of where test marks fired into marked minke whale carcasses had been found (SC/41/SHMi10), the Committee concluded that mark shedding is unlikely to affect a large proportion of marked minke whales. The Committee noted that heterogeneity in marking and recapture probabilities could be a major problem with all mark-recapture studies. For photo-identification and biopsy darting the marking and recapture processes are identical and this could amplify any effect of heterogeneity. With Discovery marking the recapture process is slightly different from the marking and some members believed that this offered a substantial advantage. The Committee noted that further analysis of Discovery marking experiments should only be carried out where there is reliable information on the efficiency of mark recoveries on factory ships or at land stations.

Mark-recapture estimates based on photo-identification have been used by the Committee to estimate the abundance of humpback whales in the western North Atlantic. Blue, right, bowhead, minke, fin and sperm whales are also known to show variation in a number of characteristics which are useful for individual recognition. SC/41/SHMi11 reported the results of an experiment to obtain photographs of Southern Hemisphere minke whales during the 1988/89 IWC/IDCR minke whale assessment cruise. This indicated that Southern Hemisphere minke whales show the same kinds of variation which have been used to recognise individual minke whales elsewhere. Kasamatsu reported that observers on the research vessel had indicated that the time taken to obtain an adequate photograph was broadly similar to that required to apply a Discovery mark successfully.

The Committee noted that the matching of photographs from the same individual will become increasingly difficult as the number of catalogued individuals increases and **recommends** further work on computer-assisted matching of such photographs.

The DNA fingerprint which can be obtained from a skin sample collected with a biopsy dart provides a unique characterisation of each individual, so collecting such a sample is akin to marking an animal with a Discovery mark but with the additional possibility of multiple recaptures. Recaptures can be identified by subsequent biopsy sampling or if the whale is killed in commercial whaling. A number of members of the Committee reported success in obtaining skin biopsies from humpback, blue, right and sperm whales.

The studies described above indicate that photo-identification and biopsy darting are feasible alternatives to Discovery marking as a basis for mark-recapture assessments of some large whale stocks.

Biopsy darting has potential advantages over photo-identification and Discovery marking because (i) the identification of previously tagged animals should be unequivocal; (ii) there is no danger of unreported double marking; and (iii) there is no danger of mark loss. With biopsy darting and photo-identification there is also no real danger of marking related mortality. However, it is generally easier to photograph animals than to take biopsy samples.

7.5.3 CPUE and other indices of abundance

SC/41/Ba1 described a revised CPUE statistic and its use to estimate trends in fin whale abundance in the Antarctic. The Committee noted that the decline in the CPUE index of abundance was substantially less than the decline in numbers indicated by the survey results and HITTER runs

described in SC/41/O 20. This coincided with what was already known about the tendency of CPUE to underestimate the strength of trends in abundance. The Committee noted that the subject of CPUE had already been covered extensively by an IWC workshop convened as part of the Comprehensive Assessment (*Rep. int. Whal. Commn* 38:157–62).

7.5.4 Incomplete surveys

The Committee recognised that incomplete assessment of either the area known to be occupied by a whale stock or of the time during which whales were known to be moving past a land survey station could cause problems both for the estimation of absolute abundance and for monitoring the effects of management. In addition, the declaration of 200 mile national EEZs could make it difficult to survey entire stock areas in some regions, unless surveys are carried out by international programmes such as NASS-87 and NASS-89.

Because of the known heterogeneity in the distribution of whales, it is most efficient to concentrate survey effort in areas of high density and to devote little, and sometimes no, effort to areas where density is believed to be low. However, it is necessary to estimate the number of whales in these areas for an absolute abundance estimate. If no surveys are conducted in the low density area, any values used will be merely speculative. A different problem occurs if an index of abundance is monitored only in high density areas. In this case it would always be possible to cast doubt on the inferences from changes in the high density area.

There appears to be a number of solutions to this problem. One is to estimate the number of whales in previously unsurveyed areas directly, as is being done in the Japanese Feasibility Study. A second solution is to use some other index of abundance, provided that this is adequately calibrated against conventional survey results and coverage is appropriate in that time and space. This latter approach could be used to provide data for a model of variation in whale density in space and time as a stochastic process, which could then be used to draw management inferences whose reliability could be quantified.

7.5.6 Recommendations

The Committee **recommends** that the following topics listed below should be addressed as a matter of priority in time for the 1990 Comprehensive Assessment.

(1) Theoretical considerations of how to compare the results of surveys which differ in their area coverage, and in the environmental conditions experienced during the surveys.
(2) Development of a general computer program for the implementation of the variable coverage probability analysis (*Rep. int. Whal. Commn* 37:273–6) by the Secretariat computing staff with advice from Cooke.
(3) A study of the effects of heterogeneity in whale distribution and whale marking on estimates of abundance and survival from mark-recapture analysis. (See Annex M.)
(4) Development of improved experiments for the estimation of g(0) and whale reaction to survey platforms, and implementation of these experiments to obtain reliable results.
(5) A study of the effect of possible differences in the way schools are identified in Passing and Closing Mode (Hiby agreed to do this in collaboration with the IWC Secretariat computing staff).
(6) An investigation of the possible basis for the observed difference between density estimates from Closing and Passing Mode surveys on the Southern Hemisphere IWC/IDCR cruises (to be carried out by the IWC Secretariat computing staff in collaboration with Butterworth).
(7) The preparation of a paper on equipment developed for the accurate determination of the position of dolphin schools observed during surveys in the Eastern Tropical Pacific (US scientists agreed to prepare this).
(8) A study of the potential usefulness of data collected by Japanese scouting boats in the lower latitudes of the Southern Ocean for providing some indication of whale density in the area north of 60°S (Butterworth and Kasamatsu agreed to work on this).

The Committee also concluded that there was a need for improved estimates of the abundance of minke and Bryde's whales in the northwest Pacific and of sei whales in the North Atlantic. It therefore stressed the importance of carrying out the following recommendations which had been made by the Scientific Committee in 1988 but which have yet to be acted upon:

(1) A reanalysis of all sightings data for the Western North Pacific Stock of Bryde's whales by 5° square, *Rep. int. Whal. Commn* 39:47 (Japanese scientists agreed to carry out this work).
(2) A re-examination of the mark-recapture data for the above stock with the view of obtaining an alternative estimate of abundance (*Rep. int. Whal. Commn* 39:47). Japanese scientists indicated that they would do this analysis if a solution could be found to the problem caused by the large annual variations in the number of marks recovered.
(3) Analysis of sightings data for the Okhotsk Sea-West Pacific Stock of minke whales from cruises between 1976 and 1986 to include analysis by 5° square, investigation of the results of seasonal trends in distribution, and examination of stratification boundaries (Japanese scientists agreed to carry out this analysis).
(4) An extension of surveys in the North Atlantic to cover as much as possible of the summer distribution of the Iceland-Denmark Strait stock of sei whales. The Committee noted with pleasure that NASS-89 will cover this stock area at least as far south as 52°N (SC/41/O 2).

In the longer term, the Committee also **recommends** a coordinated and collaborative international effort to develop acoustic survey techniques (e.g. for sperm whales) and the extension to other large whale species of the computer-assisted matching techniques now being developed under an IWC contract for the photoidentification of right and blue whales.

These recommendations were drawn up on the assumption that on-going projects relating to stock estimation (such as the analysis of data from the Southern Hemisphere IWC/IDCR minke whale assessment cruises) described during the meeting would continue.

7.6 Implications for whale management of interspecific interactions

Last year the Committee agreed to include this item on its agenda (*Rep. int. Whal. Commn* 39:64).

Sigurjónsson and Magnusson summarised some aspects of this subject. They noted that considerable interest in multi-species management was being shown in other fisheries organisations, particularly ICES, which is holding a multi–species management workshop in October 1989. They recognised that working models of complex ecosystems which are suitable for management are a long way from being developed but noted that in some cases, the predator-prey relationships may be more simple. In particular they drew attention to the capelin/cod relationship in Icelandic waters (Magnusson and Palsson, 1989, *Rapp-P.-v. CIEM*, 188: 206–24). It is estimated that capelin may represent half the yearly food of the fishable cod stock, and large variations in the strength of year classes of that species are reflected in the total yield of the cod stock. Humpback whales also feed on capelin and it appears that its migration pattern may be influenced to some extent by the availability of capelin; concurrently with the drop in capelin, the sightings rate of humpback whales off Iceland reached a minimum in 1983 (SC/41/O 22). They suggested that there may be a need to consider its role in this system for management purposes. A similar relationship was postulated for baleen whales off Newfoundland (1985, Whitehead and Carscadden, *Can. J. Fish. Aquat. Sci.* 42: 976–81).

They considered that a multi-species approach in management of whales and other living marine resources would aim at (1) maximising the long-term yield of the ecosystem, taking into consideration biological and possibly socio-economic factors and (2) minimising the risk of endangering any parts of the ecosystem, including whales, by human activities. Such an approach would take into account potential competition between fisheries and any other components of the system within the framework of the above two overall aims.

However they noted it is quite clear that at present our state of knowledge is far from being sufficient to resolve problems of multi-species management of whales and other marine resources. In order to begin to address such problems, certain basic biological information on whales is required as well as a detailed theoretical examination of the issues involved. They noted that the following might be viewed as basic research needs for any long-term programme to address these problems:

(1) theoretical studies within the framework of whale management schemes currently under development;
(2) modelling of known and postulated interactions of whales and other species;
(3) modelling of the effects of various levels of harvesting of one component of the system on other components;
(4) quantification of energy needs and food preferences of whales and other species;
(5) quantification of the degree of interactions between whales and other species;
(6) quantification of the effect of environmental fluctuations on whales and other species.

In discussion of the above presentation by Sigurjónsson and Magnusson, the Committee recognised the importance in the long term of this topic and agreed that it should consider scientific developments in this field. However it recognised that at present its work on the Comprehensive Assessment and the development of new management procedures precluded any detailed consideration of the topic.

It noted that two of the organisations with which it exchanged observers, CCAMLR and ICES, had a particular interest in such studies. It agreed that IWC observer reports from meetings of those organisations should include a report on aspects of multi-species management discussed. It also recognised that much of the work on this topic in those organisations occurred in workshops where no IWC observer attends. It therefore **recommends** that the IWC Secretariat corresponds with the ICES and CCAMLR Secretariats, pointing out the interest of the IWC Scientific Committee in multi-species management and requesting any relevant documentation they may have as it becomes available. Titles of these documents should be available at Annual Meetings for interested members to consult.

The Committee also agreed that this subject should be included on the agenda of its annual meetings, but noted that it was intended that only discussion of specific matters should take place, where these were supported by documentation.

7.7 Data inventories and coding

Donovan reported that all data inventories submitted prior to the Annual Meeting had been coded. Last year the Committee had recommended that four countries (Chile, Peru, New Zealand and the Netherlands) who had not yet returned data inventories be urged to do so (*Rep. int. Whal. Commn* 39:41–2). Only the Netherlands had responded. The Committee, noting the potentially useful data that exists in these countries, **recommends** that the Commission urges Chile, Peru and New Zealand to return data inventories as soon as possible.

8. COMPREHENSIVE ASSESSMENT – FUTURE WORK

8.1 Priority stocks

Last year, the Committee had agreed that, from a scientific point of view, priority should be assigned to stocks under the following categories:

(a) those for which substantial work is underway i.e. Southern Hemisphere minke whales; North Atlantic minke, fin and sei whales; North Pacific Bryde's and minke whales;
(b) those which have been protected from commercial whaling for some period and which are now showing varying degrees of recovery i.e. eastern North Pacific stock of gray whales and the Bering-Chukchi-Beaufort Seas stock of bowhead whales;
(c) those other fully protected stocks for which considerable data bases exist, the study of which will help to resolve general methodological problems and improve our knowledge of whale population dynamics, e.g. some stocks of right and humpback whales.

This year, the Committee recognised that, in order to progress towards a Comprehensive Assessment, it would need to assign higher priority to certain stocks or stock groups for which assessments in greater depth and breadth than are usually possible at annual meetings could be attempted in 1990. The Committee agreed that, because of the limited time available at annual meetings, it would not be practicable to conduct assessments for more than two stocks or stock groups at the 1990 annual meeting. This was in addition to the assessment proposed for eastern North Pacific gray whales to be undertaken at a Special Meeting (Item 6.8 and Annex I).

The Committee discussed criteria for selecting such stocks in addition to those it had used to assign priorities last year. It agreed that a critical consideration was the amount and quality of relevant information available for assessments. Furthermore, noting that one of the major problems it faced in conducting assessments was the question of stock identity, the Committee agreed that, at this time, assessments of stock groups would be more appropriate than of single stocks.

The Commission had endorsed this view (*Rep. int. Whal. Commn* 39:14).

The Committee discussed possible candidates for assessment at its 1990 annual meeting that might satisfy the criteria identified above. These included minke whales in the Southern Hemisphere, the North Atlantic and the Northwest Pacific, and fin whales in the North Atlantic. Sigurjónsson believed that the East Greenland – Iceland stock of fin whales was a suitable candidate because research in Iceland had been increased in recent years specifically to address a Comprehensive Assessment in 1990. He stated that this stock comprised the majority of fin whales in the North Atlantic, had detailed and reliable catch and effort data, an extensive data base on biological parameters including age and reproductive data, a new abundance estimate and results of extensive biogenetics research. Horwood and Holt considered that because of previously identified problems of stock identity and indices of abundance, the East Greenland-Iceland stock of fin whales should not be a candidate for assessment in 1990. Ohsumi believed that Okhotsk Sea – West Pacific minke whales should be assessed in 1990 for reasons of socio-economic needs. Holt considered that while the Okhotsk Sea – West Pacific stock of minke whales met certain criteria, such as substantial whaling activity before the moratorium (*Rep. int. Whal. Commn* 38:16), it did not meet others, such as the availability of information (*Rep. int. Whal. Commn* 39:47) and the agreed preference for assessing stock groups.

Following this discussion, the Committee agreed that, based on the criteria and for the reasons identified above, assessments of the stock groups of Southern Hemisphere minke whales and North Atlantic minke whales would be attempted at its 1990 meeting as part of the Comprehensive Assessment.

The Committee also agreed that in order to assign priorities for assessments beyond those practicable in 1990, it would be necessary to review next year the amount and quality of information available for future assessments. It **recommends**, therefore, that for other stocks or stock groups in (a), (b) and (c) above, reports on progress towards a Comprehensive Assessment be available at next year's meeting, with a view to their assessment in 1991. These reports should address the agenda item headings specified for the stocks and stock groups to be assessed in 1990 (e.g. see Annex I for eastern North Pacific gray whales).

8.2 Intersessional Working Groups and Meetings

The following proposed meetings were identified by the Committee.

(i) Workshop on the Genetic Analysis of Cetacean Populations (*Rep. int. Whal. Commn* 39:133).
(ii) Workshop on Alternative Management Procedures (Item 7.2.2); and
(iii) Special Meeting of the Scientific Committee on Eastern North Pacific gray whales (Item 6.8).

8.3 Work Plan for 1989/90

During the discussion of Items 6 and 7, the Committee had made several recommendations for work to be carried out in the coming year. This included the Workshops and Special Meeting identified under Item 8.2. In addition, much work would need to be done by national groups to ensure that all relevant material would be available in time for next year's meeting for the proposed assessments of Southern Hemisphere and North Atlantic minke whales. In this regard, the Committee set up two *ad hoc* working groups to discuss this work and to draft provisional agendas for sub-committee meetings at the 1990 annual meeting. These were discussed under Item 15.

9. SCIENTIFIC PERMITS

9.1 Guidelines for review of Scientific Permits

The Committee agreed that it would structure its discussions, as last year, under the five headings given in *Rep. int. Whal. Commn* 39:154, whilst retaining all the previous guidelines. The Committee agreed to discuss only those aspects of research programmes directly related to scientific permit catches under this item, although it noted that in some of the presentations by the proposers, some mention was made of other aspects of wider research programmes.

9.2 Review of research results based on existing Scientific Permits

9.2.1 Japanese feasibility study

The Committee agreed to examine the papers dealing with the 1987/88 data before considering the results from 1988/89 alone.

Presentation of analyses of 1987/88 data

SC/41/SHMi3 examined methodological aspects of estimating biological parameters from field survey data. The Japanese programmes covered a wider latitudinal area than commercial catching and a line-transect sampling procedure was adopted, with the aim of covering the total research area uniformly. The sampling procedure was detailed in SC/40/Mi18. Despite this approach, unequal sampling was inevitable given that larger schools are easier to detect and that a smaller proportion of whales were collected from larger schools. In view of this the data were stratified by school size (solitary, schools of two animals, schools of more than two). The age composition was obtained by averaging the estimates for three strata weighted by the estimated relative abundance of the strata. Variances were obtained using the bootstrap resampling method. Solitary whales were found to be younger than those in schools and school size was larger nearer the ice edge than offshore. The paper examined the question of whether the dominant factor for the heterogeneity of mean age is school size or locality. The analysis presented found the most appropriate model was one which had no significant difference in mean age between inshore and offshore areas but for which the mean age of solitary whales is significantly different (younger) than those in schools (SC/41/SHMi1). Whales appear to form schools after reaching age at sexual maturity. Analysis of the data by sex is given in SC/41/SHMi2 in detail. The authors noted that the narrow longitudinal bounds of the research area meant that the results could not be considered conclusive and that further studies are required. They stressed that if

biassed estimates are to be avoided then uniform sampling and correct detection of heterogeneity and subsequent post–stratification of the data are essential.

SC/40/SHMi2 examined the age-composition and segregation in the Southern Hemisphere minke whale based on the 1987/88 data. The raw data were converted to an estimated age distribution using the methodology described in SC/41/SHMi3. This distribution, which revealed a decreasing pattern from youngest to oldest ages and was considerably different to that from commercial whaling, revealed relatively fewer animals in the 5–15 year range. While several hypotheses could be put forward to explain this, the authors considered that at present the most likely explanation is the small sample size. Segregation was examined by school size and locality (see SC/41/SHMi3) using Akaike Information Criterion values. This revealed the following trends:

(1) although the ages of males did not differ among locations (inshore/offshore) or school size (one, two, more than two), sexually mature males tended to be in larger schools;
(2) immature females tended to be found offshore as single animals;
(3) sexually mature females tended to be found near the ice-edge in larger schools.

SC/41/SHMi1 presented estimated numbers of minke whale schools and individuals based on the 1987/88 programme. It is summarised rather briefly here as it was discussed in more detail in Annex G. The approach used to estimate abundance is based on school size; estimates of the number of schools by school size were made using the hazard rate model and the variance was estimated using the bootstrap resampling method. The results indicated that smaller schools had a smaller search half-width, with significant differences between single animals and schools of four or more. Final estimates for the number of whales in the research area were 8,000 (CV 0.65) from one vessel and 9,500 (CV 0.26) from the other.

Correlation coefficients among values of search half-width, number of schools detected, length of trackline and number of schools estimated were calculated. The authors made a series of suggestions to improve procedures and noted that data from 1988/89 may improve these estimates.

SC/41/SHMi18 examined the distribution of minke whales in the research area in 1987/88 in relation to temperature data obtained from 67 XBT observations using an index Q200m (the mean temperature of water within 200m of the surface). It was found that those waters with high densities of minke whales were those with lower Q200m values.

SC/41/SHMi19 discussed genetic variability and differentiation in mtDNA in minke whales from the Sea of Japan, the western North Pacific and the Antarctic (both ordinary and diminutive forms). Material for the diminutive form was obtained from the special permit catches. It is discussed in Annex D.

Discussion of analyses of 1987/88 data

Gunnlaugsson commented on the valuable approaches in SC/41/SHMi1 and 3 which provided information of general applicability on both the sighting process and on obtaining information on the age and sex distribution. Sigurjónsson commented on the quality of the documents presented and the large volume of work these represented. He also noted the value of sampling over a wide geographical range and that SC/40/Mi18 had indicated that material had been collected that would allow biochemical genetic work to be conducted which might have a bearing on stock identity. Kasuya responded that additional results would be presented to the Committee as they became available.

Cooke noted with appreciation the hard work that had gone into the preparation of these papers. He recalled that a major aim of the feasibility studies had been to determine if it is possible to obtain unbiassed samples in contrast to those obtained by the commercial catch. In this regard he enquired if the authors of SC/41/SHMi1–3 considered if this had been successful and, if so, whether the data had yet been used to estimate the sex ratio and pregnancy rate.

In response Kasamatsu stated that he believed the results so far were encouraging and that the procedure of combining sampling and sightings worked well. The analyses presented made some suggestions on how to address problems arising out of non-stratification due to small sample sizes. Kishino noted that the inhomogeneity in distribution of the sexes made estimation of the sex ratio problematic and will require a stratified estimate of abundance by sex. Kato reported that the pregnancy rate data had not yet been analysed.

There was some discussion on the diminutive form of the minke whale. It was established that it is very difficult to identify at sea unless seen close to in good sea and weather conditions.

Presentation of 1988/89 data

SC/41/SHMi14 provided a report and some preliminary data analyses of the 1988/89 study which had taken place from 12 January-31 March 1989. A paired-vessels sampling strategy was employed (a single vessel strategy had been used for most of the 1987/88 programme) in order to increase the sampling rate from smaller schools and to try to obtain improved estimates of g(0). A total searching distance of about 9,600 n.miles was covered, during which 630 minke whale schools (340 primary and 290 secondary) were seen. Sampling was attempted on 290 of the 340 primary schools encountered and the paired-vessel scheme improved the sampling rate for schools of three or more (but not the solitary animals). A total of 241 whales were sampled, including five of the diminutive form. Poor weather for over half the cruise and other reasons resulted in the catch being about 20% less than expected. Four of the diminutive form animals were taken at 62°S, just to the north of the Antarctic Convergence, the most southerly records to date.

Preliminary analyses of the data indicated that: (1) the animals sampled were smaller than those taken by commercial whaling in the same area in both sexes; (2) mature males and immature animals dominated in the northern area, while pregnant females predominated in areas of high concentrations such as waters off Cape Adare and inside the Ross Sea; (3) mature males and immature animals tended to be solitary while mature females were in larger schools, although this varied by locality; (4) no distinctive change in biological characteristics was found during the research period although a decrease in density was observed off Cape Adare.

SC/41/SHMi15 summarised information from a cruise in lower and middle latitudinal waters as part of the research programme. During the first part of the cruise (15 November-16 December 1988) 15 schools of minke whales were seen – 6 southern form, 2 dwarf form and 7

unidentified to form. Only one 'like minke' whale was found in the second part of the cruise (24 February-13 March).

9.2.2 Iceland

Presentation

In 1988, Iceland took 68 fin whales and 10 sei whales under scientific permit. SC/41/O 33 reported on the status of research projects under Iceland's four year research programme. Sigurjónsson stressed that the paper presented progress reports of all studies conducted, some of which are long term projects; comprehensive reports could not be provided until the end of the programme. He also noted the new agreed estimate of the fin whale stock of 11,563 (CV 0.261) given in Annex G. Last year, the provisional estimate was 6,436.

SC/41/Ba3 reported on upward trends in age at sexual maturity in fin whales over the last 20 years, a reverse trend to what had been observed in preceding decades. This is commented on in Annex F. The paper also noted annual variations in fecundity (as measured by the frequency of corpora lutea). This subject was also addressed using hormonal immuno-assay techniques in SC/41/Ba9. SC/41/Ba6 examined the body condition of fin and sei whales, noting that blubber thickness and lipid content was greatest in pregnant females and least in lactating females and revealing between-year variations in body condition and concurrent changes in fecundity. Studies on the reliability of age readings are described in SC/41/Ba8 and a final report should be available next year.

SC/41/O 22 examines trends in abundance of blue and humpback whales based on data collected by catcher boats from both the commercial whaling and scientific permit whaling periods. The increasing trends found are discussed in Annex F. Time budget data from the commercial and scientific whaling operations are examined in SC/41/O 22. In 1986–88 improvements were made in collecting sightings data onboard the two whaling vessels in operation. Sightings and effort were recorded in accordance with line-transect methodology (primary/secondary, group size, angles, distances, etc.) to obtain density estimates of the different species at different time and area. Analysis is in progress.

During the 1988 season, four Discovery marks were recovered (SC/41/ProgRep Iceland). Of particular interest was a mark from a fin whale marked off Newfoundland in 1979, this is the first recovery of a mark recovered in Iceland from the marking programme in Canadian waters. In addition, the marked animal should provide information on the accumulation of growth layer groups in earplugs. The animal had been marked with quinacrine and one earplug has been sent to Canada for reading.

Work continued on projects designed to examine the ecological role of whales in Icelandic waters. Sampling effort for zoo– and phytoplankton was doubled in 1988 and samples have been analysed and the data are being examined in the light of other environmental data collected on the whaling grounds and information on the food and energetic data collected for the sampled whales. Studies to improve estimates of krill abundance are continuing, and a food-web model is being constructed, which is based on observations of whale abundance, weight, food selectivity and energetic requirements.

Biochemical studies are summarised in SC/41/O 32. The original programme concentrated on electrophoretic studies, for which most data on whale species have accumulated. Studies of genetic variation at 40 enzyme loci showed that there is a high heterozygosity in fin whales: the results do not answer the question as to whether the fin whales caught off Iceland and Spain are from the same population but they do show that they are similar. The inter-year variation found in allele frequencies for fin whales may be due to the dispersion of young males from other breeding grounds into the Icelandic feeding grounds. In contrast the results for sei whales reveal little annual variation suggesting that the same 'herd' of sei whales returns to Iceland each year. This uniformity means that smaller sample sizes are needed to continue these studies in sei whales than in fin whales (this is supported by the results from the DNA studies).

As techniques in molecular genetics have been developed, these have been incorporated into the Icelandic programme. SC/41/Ba5 explores the use of DNA fingerprinting techniques using an alfa-globin HVR probe. The results reveal considerable genetic variation in fin and sei whales from Icelandic waters, providing no evidence that the populations have been through a 'bottleneck' or that close inbreeding occurs. SC/41/O 31 discusses a study using a human cDNA probe on four balaenopterid species. This study shows that the study of the complement (C4) system is of value for both population genetics and immunogenetics.

Tissue samples are also being used in chemical contaminant analyses.

Comments and Discussion

Ohsumi commented on the value of the wide ranging research programme, noting the improvements in our biological understanding of the stock, which had come from careful and detailed research.

Harwood, Arnbom, Chapman, Holt, de la Mare, Lankester and Lyrholm while agreeing that the research had been carried out in a detailed manner, noted that the component of the programme related to the catch did not appear to be significantly improving our existing knowledge in terms of management or the Comprehensive Assessment. For these purposes the most valuable information was coming from the non-lethal part of the programme, in particular the sighting surveys.

There was some discussion on the value of information on biological parameters to management and the Comprehensive Assessment. Holt and de la Mare commented that such information was not likely to be of any major importance to the new management procedures being developed by the Committee. They also noted that while information on temporal changes in biological parameters might provide supplementary information for management purposes, the data from this programme would not be useful due to the non-random nature of the sampling. Consequently they did not believe that the programme contributed either to management or the Comprehensive Assessment.

Sigurjónsson responded that the non-random sampling would not affect the overall conclusion with respect to the observed trend in age at sexual maturity reported in SC/41/Ba3.

Cooke noted with appreciation the work carried out to examine the inter-reader variability of age readings (SC/41/Ba8) noting that this had used data available from the commercial catch taken previous to 1986. However he commented that this information had not been incorporated into the analysis in SC/41/Ba3. He believed

that is was necessary to do so in order to ascertain whether collection of further samples could be useful.

In response Magnusson and Sigurjónsson noted that the value of information on biological parameters and their temporal trends is recognised in both Annexes F and G. Information on trends, such as the recent increase in age at sexual maturity (for which the catching strategy was not a problem) shown in SC/41/Ba3, could only be obtained from a long time series of data. Furthermore, although a valid point of concern, the preliminary study on the level of reading variability indicated in SC/41/Ba8 would not alter the trend revealed in SC/41/Ba3. Walløe concurred with this view and that information on biological parameters was important to management.

A more detailed account of the range of views expressed concerning the value of biological parameters to the Comprehensive Assessment is given in Annexes F and G.

Tillman and Holt commented that the work on genetic markers did contribute towards the Comprehensive Assessment but noted that such work can be accomplished via non-lethal means. Tillman also considered that SC/41/Ba3 provided a useful preliminary examination of the effect of ecological factors on whale stocks but noted that as yet the Committee had received no guidance from the Commission as to whether this constituted a critical research need.

In response to the comment on genetic markers, Arnason noted that much of the Icelandic research, in common with research in other parts of the world, involved the electrophoretic examination of proteins and enzymes. Samples for this work could not be obtained by non-lethal means.

9.2.3 Norway

Walløe provided some background information to the 1988 Norwegian Scientific permit catch, which was based upon a slightly revised version of the programme presented in SC/40/Mi7 reviewed by the Committee at last year's meeting *Rep. int. Whal. Commn* 39:56–9. Blix reported that a total of 29 minke whales (21 males) were taken between 3–28 August 1988 off the coast of Northern Norway (SC/41/ProgRep Norway). It was stressed that any evaluation of the results of the 1988 catch should be considered in the light of the proposal for 1989 (SC/41/NHMi12) which is discussed in detail under Item 9.3.3 below. It was also important to remember that these are pilot studies aimed at addressing methodological questions only.

Considerable effort was put into improving and developing new methods of age determination of minke whales. Little demographic data exists for this stock, particularly due to problems in age determination. The work reported in SC/41/ProgRep Norway uses a combination of three techniques based on tympanic bullae: (1) acid etching and optical microscopy; (2) proton induced x-ray emission analysis; and (3) electron microscopy using an x-ray microprobe on thin sections of bullae. The need for further samples to develop and confirm this approach was identified. Blix noted that earlier collections of bullae could not be used as these have cracked in storage over time.

Another major area of study related to energetics, with the eventual aim of providing information for inclusion into a multi-species model. SC/41/NHMi7 examined food selection and energy uptake. Of the 28 animals investigated, herring was by far the most common food item, being found exclusively in 19 stomachs and with other species in six further stomachs. Only one stomach was found to be empty. The data collected also indicated microbial digestion of the prey. Work to investigate the digestibility of different food items using *in vitro* techniques is progressing.

SC/41/NHMi8 examined body temperatures and temperature gradients in newly killed minke whales. The results suggest that deep body temperatures are lower (around 35°C) than generally found in terrestrial eutherian mammals. Temperature gradients across the blubber also appear smaller than usually assumed. This has implications for previous estimates of basal metabolic rates for large whales and for ecosystem modelling. SC/41/NHMi19 examined the respiratory tract of minke whales in the context of heat loss. SC/41/O 7 examined the data collected from 15 whales in terms of comparative marine mammal studies of energetics.

Biochemical studies (mtDNA and isozymes) are continuing and the former is being examined in co-operation with Denmark.

Comment and Discussion

Several members of the Committee had detailed questions or comments on the individual studies. Albert noted that some information from the studies had also been found in bowhead whale studies i.e. the lower deep body temperature and the possibility of microbial digestion. Arnbom noted that the effect of chasing time needs to be addressed and treated consistently in studies involving measurement of temperature gradients. Blix responded that this was being examined, although he noted that he believed that the time from impact of the harpoon to the time the measurements are taken may prove to be a more important factor.

In response to a question from Tillman, Walløe stated that simultaneous sampling of potential prey species had not taken place in 1988. He noted that it may occur in 1989 and would certainly occur in later years.

Horwood and Holt commented that they found it difficult to evaluate the results of the feeding studies given the lack of information on the use to which the results are to be put.

Holt recalled the discussions of last year, noting the views expressed by himself and others (*Rep. int. Whal. Commn* 39:57) that there was insufficient information presented to determine whether the data to be obtained would be critical to the proposed multi-species model or whether the model itself represented a critical research need and therefore that the programme as presented was unlikely to facilitate the Comprehensive Assessment and did not address research needs identified by the Scientific Committee. Arnbom, Chapman, Clark, Cooke, de la Mare, Koch, Lankester, Lyrholm, Payne and Tillman concurred with these views. They did not believe the results presented gave them any reason to alter this conclusion.

9.3 Review of new or revised Scientific Permit proposals

9.3.1 Japan

Before discussing the proposal for the 1989/90 permit catch in detail, the Committee agreed that it would be useful to discuss a series of papers presented to the meeting that addressed the general question of information obtainable from catch-at-age data.

De la Mare presented an analysis of the properties of estimating age-specific natural mortality and trends in recruitment using the types of age and abundance data sought under the Japanese Research Programme (SC/41/O 1). The data were assumed to comprise age samples free of the effects of age-specific selectivity and abundance data proportional to population size. Simulations were used to examine the likely precision of estimated mortality schedules, including results from the ideal situation where the age samples are a perfect representation of age abundance of the population. The results from using a time series of twenty annual abundance estimates with a CV of 0.15 (which is at the lower end of the range currently achieved in IDCR sightings surveys) show that estimates of age specific natural mortality are not precise, even with perfect age data. The author concluded that back-calculation of trends in recruitment was not reliable with the range of estimated natural mortality schedules obtained.

Schweder commented that he believed that the conclusion of the paper, that 'any' estimates obtained, even if continued for 40 years, would not lead to useful estimates for determining historical trends in recruitment, was overstated, in that the conclusion only applied to the estimation method used in the paper. He also believed that age profiles, even without absolute values, were of importance to management. De la Mare reiterated that the conclusion was based on the use of perfect age data and that the only uncertainty arose from the variability in the abundance data.

Butterworth and Punt had used a slight amendment of last year's draft protocol (*Rep. int. Whal. Commn* 39:137–8) to determine the potential of age structure data collected from Antarctic minke whale catches to reveal the magnitude of any recruitment trend prior to exploitation and any more recent changes to such a trend (SC/41/SHMi17). It was argued in the paper that such information was pertinent to the estimation of sustainable harvest rates for these Antarctic stocks. Catch curve slope estimates were shown to be confounded by the effects of historic commercial catches. A crude VPA-like estimator provided estimates of recruitment trend changes and net recruitment rate which showed little bias. The precision of these estimates was, however, quite inadequate for the levels of discrimination required for management purposes. Nevertheless there was scope for improvement of the estimator, and this might lead to the provision of estimates of adequate precision.

SC/41/SHMi17 recommended revision of the draft protocol, to incorporate more complex age-specific selectivity functions and ageing error. However, the Committee agreed that these were relatively minor aspects, and that the draft protocol as it stood was adequate to provide a means to address whether or not techniques making use of catch-at-age data would be able to discriminate between values of population dynamics parameters which are within the ranges that are realistic for whale populations.

In discussion, Cooke noted that this paper did not address the key issue that had been brought up in previous Scientific Committee discussions on this matter, which was not whether catch-at-age data can provide estimates of net recruitment rates when used in conjunction with abundance data but whether such estimates are superior to those obtained from abundance data alone. Butterworth agreed that this question needed to be addressed.

SC/41/O 16 presented a modified version of the Bayesian cohort model proposed last year in SC/40/O 25. The modification was introduced to allow detection of linear time trends in age dependent natural mortality rate and linear time trends in recruitment. To overcome problems of the cohort model not providing a unique solution (SC/41/O 1), an estimation procedure is proposed which uses roughly controlled sampling effort as well as catch-at-age data, and incorporates the prior information that age effects (changes in natural mortality with age) and cohort effects (changes in recruitment) change smoothly.

In this paper it is assumed that catch sizes are negligible compared to the population size and that age selectivity is constant. From this information the optimal model is selected using Akaike's Bayesian Information Criterion (ABIC). The paper reports on a series of simulation studies carried out in accordance with the draft protocol agreed last year (*Rep. int. Whal. Commn* 39:38). The authors concluded that the results show the proposed estimation procedure to be promising. Two factors particularly affect the estimated results. The first is the size of the population and the second is variation in sampling effort. The simulations reveal that at lower population sizes, estimated trends in recruitment, particularly for the earliest years, differ considerably from the true values principally because the procedure neglects the effect of historic catches on the age structure. Any revised model should take this into account. The second factor is variability in sampling effort which can cause biases in the age effect and the cohort effect. The author noted that further work to address these concerns and to develop a procedure applicable to more realistic situations is being undertaken.

Cooke, de la Mare and Holt noted that in effect this approach is similar to those examined in SC/40/O 1, 15, 16 and SC/40/SHMi17. In addition, the conclusions reached are similar in that while age dependent natural mortality rates and net recruitment rates can be estimated simultaneously given a time series of abundance data, the major problem is that such estimates are very imprecise because of the large variances associated with the abundance estimates. Attention was again drawn to the fact that the question of whether estimates of net recruitment using such methods were superior to estimates obtained from abundance data only were not addressed.

Butterworth commented that while a series of abundance estimates from surveys could provide net recruitment rates for the period they spanned, they provided no information on rates for the years before surveys commenced. The potential advantage of continuing to collect catch-at-age data was that estimates of net recruitment rates could then be calculated for those earlier years as well. This addressed the question of possible historical changes in trend in recruitment rate (if not the actual net recruitment rate values themselves), which was particularly relevant to the management of Southern Hemisphere minke. However he noted that any revised model needed to be better able to incorporate the effects of past catches. Harwood, Holt, de la Mare and Chapman considered that the interpretation of estimated historical trends in recruitment would be problematic and that a more critical need was reliable estimate of net recruitment rates.

Raftery and Magnusson believed that the method of SC/41/O 16 was promising and encouraged further work by the authors. Raftery noted that a related model had been

used successfully to solve similar problems in human demography (Nakamura, 1982, *Proc. Inst. Statist. Math.*, 29:77–97; 1986, *Ann. Inst.Statist. Math.*, B 38:353–70). He noted that at present the ABIC was used to select not just the optimal model itself but also the associated hyperparameter values. Variance estimation procedures which failed to take this into account will underestimate the variance (probably considerably, as he had found to be the case in analyses for the bowhead whale). A refined approach should incorporate variability in hyperparameters in any associated variance estimation procedure.

SC/41/O 15 presents a further proposed method for estimating age-specific natural mortality and estimating its precision using absolute abundance data and catch-at-age data. The age-specific natural mortality is considered to comprise two parts: the average level and deviation from that average (i.e. the pattern of age-specific mortality). Estimation of the former requires absolute abundance data; estimation of the latter does not. The precision of the average level is largely determined by the variance of the abundance estimate. Estimation of the deviation for each age requires a large sample size. However the author believed that fitting a curve relating age-dependent mortality and age (i.e. assuming that this changes smoothly), should allow a useful estimate to be obtained given a reasonable sample size and time between sampling. The paper explored the technique in the context of the proposed Japanese research take. The author concluded that, whilst not sufficient for providing very precise estimates, a sample size of 400 could produce useful information on natural mortality. He stressed that particular effort should be placed on improving the variance of sightings abundance estimates. He also commented that he would be exploring the possibility of incorporating a VPA or cohort analysis approach in his procedure as used in SC/41/SHMi17.

Butterworth noted that it would be interesting to see how the method performed if applied to data generated according to the protocol in *Rep. int. Whal. Commn* 39:137–8. He also commented that the estimated average mortality rate would be time dependent because it included the effects of past fishing mortality to some extent. Evaluation of the method using the protocol would help to determine if this effect is of quantitative consequence.

Detailed discussion of the 1989/90 proposal

Ikeda introduced the 1989/90 research permit proposal (SC/41/SHMi13). He noted that the proposal should be viewed in conjunction with the original proposal submitted by Japan in 1987 (SC/39/O 4). SC/41/SHMi13 outlines the modifications made to the original proposal and the research plan for 1989/90. As clarified earlier in the meeting the proposed 1989/90 catch to be taken in Area IV is considered to be 400 minke whales for the purposes of this review. Other matters covered in his presentation are dealt with under the relevant guidelines below.

(A) The Proposal

The relevant guideline is as follows.

'A Statement as to whether the permit proposal adequately specifies the four sets of information required under paragraph 30 of the Schedule.' (*Rep. int. Whal. Commn* 36:133)

1. 'Objectives of the research;' (Sched. Para. 30)
2. 'Number, sex, size and stock of the animals to be taken;' (Sched. Para. 30)
3. 'Opportunities for participation in the research by scientists of other nations; and' (Sched. Para. 30)
4. 'Possible effect on conservation of the stock'. (Sched. Para. 30)

Horwood, Holt, Lankester and Tillman noted that the objectives of the programme for which catches will be taken in 1989/90 are given in SC/39/O 4, SC/41/SHMi13 and two working papers presented to the meeting (Annex O1). They believed that these working papers gave substantial additional aims to the previous documents and were more explicit in some respects. However, since the objectives are spread over several documents and are different in all those documents, they considered that the objectives of the research were inadequately specified. Following this comment, Ohsumi responded that the documentation presented explicitly stated the objectives.

Sigurjónsson commented that he believed it was perfectly natural for the objectives of a research proposal which had been developed over three years to appear in more than one document. In particular he noted that the objectives as presented in the documents complemented rather than contradicted each other. Therefore he concluded that the objectives of the research had been adequately specified.

De la Mare, Holt, Tillman, Chapman and Lankester noted that the programme implied that the estimates of biological parameters could be used to estimate parameters of direct management interest such as MSY, MSYL and RY. They suggested that it is not sufficient to say that the research is directed towards the rational management of a stock, but that the proposal needs to show how the research will answer questions which need to be answered, and that the other components of the problem can be solved. Accordingly, regardless of whether age dependent mortality could be reliably estimated or not, the proposal did not show that the whole problem of estimating the relevant management parameters constituted a feasible objective.

The Committee agreed that the proposal specified the number, sex, size and stock of animals to be taken in so far as was possible given the random sampling strategy specified. The Committee also agreed that the opportunities for participation by scientists of other nations had been adequately specified and that the possible effect on the conservation of the stock had been addressed.

(B) Objectives

The relevant guidelines are as follows:

1. 'Comments on the objectives of the research to be carried out under the proposed scientific permit, including in particular how they might relate to research needs identified by the Scientific Committee;' (*Rep. int. Whal. Commn* 36:133)
2. 'The proposed research is intended, and structured accordingly to contribute information essential for rational management of the stock;' (*Rep. int. Whal. Commn* 37:25)
3. 'The research addresses a question or questions that should be answered in order to conduct the comprehensive assessment or to meet other critically important research needs;' (*Rep. int. Whal. Commn* 38:27–8)

In his opening presentation, Ikeda had drawn attention to the two general objectives of the original proposal: the estimation of biological parameters required for management and the elucidation of whales in the Antarctic marine ecosystem. Detailed objectives are also given in SC/39/O 4, and in particular a major component was the determination of the age distribution of the population and the estimation of age-specific natural mortality rates. Annex 1 of SC/41/SHMi13 elaborates further on the

objectives of the 1989/90 programme with respect to biological parameters. In particular, based upon the results from the feasibility study, the monitoring of recruitment has become a further major objective (SC/41/SHMi13).

Tillman (Annex O2) examined the objectives of the proposal in light of the Committee's recent work in preparation for the Comprehensive Assessment. In summary, he noted that the Committee's development of new management procedures which did not require *a priori* estimates of net recruitment, natural mortality rate, MSY or MSY level, in conjunction with the unresolved issues over what information can be obtained from catch at age data, led him to conclude that the proposed research catch will neither contribute information which is essential for the future rational management of these stocks nor contribute to progress on the Comprehensive Assessment. Chapman, de la Mare, Holt, Cooke, Arnbom, Lyrholm, Swartz, Lankester and Perrin associated themselves with the views expressed by Tillman in Annex O2 and with his conclusion.

Horwood noted that SC/41/SHMi13 reiterated that the main objective of the overall programme as outlined in SC/39/O 4 was the estimation of age-specific mortality rates, since this had been the main reason for failures to agree catch limits. In 1987, he and others (*Rep. int. Whal. Commn* 38:56, 145) had disagreed with this interpretation, considering that the problem was one of estimating replacement yields. On this basis he did not consider it met any of the criteria on objectives given in *Rep. int. Whal. Commn* 39:154.

He noted further, however, that this year, an additional objective has been introduced (SC/41/SHMi13), the estimation of recruitment of one year old whales in absolute terms. If such an exercise could be successfully accomplished, that is, the estimation of absolute levels of mortality and age–specific mortality rates, together with absolute recruitment, then he considered it would contribute to research needs of the Scientific Committee, and would contribute information of substantial significance to rational management. Because of the time scale of the programme it could not contribute to the Comprehensive Assessment. He noted that the value of the programme would nevertheless depend upon a potentially successful methodology.

Butterworth commented that, while he agreed with Tillman that information on biological parameters (including MSY rates and replacement yield), was not essential for the new management procedures under development, the Punt and Butterworth procedure, for example, could readily incorporate such information and this would considerably improve its performance. Tanaka and Magnusson concurred with this view with respect to their procedures. In addition Magnusson referred to his comments under Item 7 that such information was also useful to help to tune the control parameters during the development phase for these procedures.

Sigurjónsson agreed with Horwood's comments on the contribution of this programme to the research need of the Scientific Committee. He further noted that Tillman's view of the lack of importance of information on biological parameters to the Comprehensive Assessment appeared inconsistent with recommendations made for the special meeting on gray whales, particularly with respect to information on the Soviet catch (Item 6 and Annex I). This view was supported by Hester who also commented on the value the US NMFS apparently placed on biological parameters for the management of dolphin stocks (Annex I, Appendix 4). Walløe agreed with Butterworth's and Sigurjónsson's views above.

De la Mare commented that it was not inconsistent to conclude that the proposed research was not essential for rational management because the objectives had been formulated outside the framework of a management procedure. De la Mare and Harwood commented that because the information gained from the research constituted only ancillary data for management then it was unnecessary to collect such data independently of a management procedure. Data sufficient for the ancillary uses specified in Annexes F and G could be collected during the normal course of whaling operations. They also noted that the time scale for the objectives to be met (if, in fact, they could be) was such that they would not be useful to developers of management procedures. Holt, Chapman, Cooke and Lankester concurred with these views.

Ikeda's response to Annex O2 is given in Annex O3. In summary he believed that the information obtained from implementation of the Japanese research programme may lead to development of more robust and reliable procedures than those new management procedures envisaged so far. He also noted that continued monitoring of biological parameters (including estimation of MSY rates and replacement yields) and demographics would allow better prediction of future trends in population dynamics and contribute to the rational management of the stocks. He also believed that the information obtained will contribute to the Comprehensive Assessment.

Tillman and Holt commented that they found the statement in Annex O3 regarding the relationship of the Japanese research catch to the development of new management procedures to be completely contrary to the premise of the procedure being put forward by Sakuramoto and Tanaka. They pointed out that the description of the Sakuramoto and Tanaka procedure given in Annex E indicated that it does not use a population model of any kind and does not require estimates of the MSY rate, the MSY level or replacement yield. They observed that an inconsistency therefore existed between the objectives of the Japanese proposal for a scientific catch and the development of the Sakuramoto and Tanaka management scheme. They concluded that, if the Commission chose this scheme as a basis for the future rational management of whale stocks, then the Japanese research catch would in no way contribute information which would be essential for the future application of that scheme.

Tanaka repeated that while his procedure did not require such information, such information could be incorporated into it and improve its performance.

(C) Methodology

The relevant guidelines are as follows:

1. 'Comments on the methodology of the proposed research and an evaluation of the likelihood that the methodology will lead to achievement of the scientific objectives. These comments may also include evaluation of the methodology in terms of current scientific knowledge;' (*Rep. int. Whal. Commn* 36:133)
2. 'The objectives of the research are not practically and scientifically feasible through non-lethal research techniques'; (*Rep. int. Whal. Commn* 37:25)
3. 'The research addresses a question or questions that cannot be answered by analysis of existing data and/or use of non-lethal research techniques'; (*Rep. int. Whal. Commn* 38:27–28)

4. 'The number, age and sex of whales to be taken are necessary to complete the research and will facilitate the conduct of the comprehensive assessment'; (*Rep. int. Whal. Commn* 37:25)
5. 'Whales will be killed in a manner consistent with the provisions of Section III of the Schedule, due regard being had to whether there are compelling scientific reasons to the contrary'; (*Rep. int. Whal. Commn* 37:25)
   [The Commission agreed that it has been intended by this for the Committee to report if cold grenade harpoons were used in special permit catches. (*Rep. int. Whal. Commn* 38:13)]
6. 'The research is likely to yield results leading to reliable answers to the question or questions being addressed'; (*Rep. int. Whal. Commn* 38:27–28)

Ikeda drew attention to certain amendments to the research methodology of the original programme as outlined in SC/41/SHMi13 in addition to the methodological advances reported in SC/41/O 15 and 16. In particular he referred to improvements in the sampling methodology and in the rotation of research areas and the timing between sampling. Further details of the methodology are given in SC/41/SHMi13.

Horwood, Holt, Tillman, Lankester and de la Mare noted that in the past two years, questions had been raised over the ability to collect a random sample and to estimate trends in age dependant mortality. Subsequent studies have shown that improvements have been made in sampling methodology (SC/41/SHMi2, 3), substantially reducing many of those major concerns. As regards the estimation methods, it was recognised last year (*Rep. int. Whal. Commn* 39:37) that trends in age specific rates could be estimated with adequate sample size, and this is confirmed by current studies (SC/41/O 1, 15). Even in these studies though, a functional form has to be fitted instead of rates calculated for each age, for reasonable sample sizes. However, the above studies (SC/41/O 1, 15) show that although a trend or functional shape could be adequately fitted, the important estimation of the absolute levels of mortality can be achieved only with a large variance. In addition, to estimate any replacement rate or yield, the estimated recruitments must be multiplied by those estimated mortality rates, and variances calculated. This exercise has not been done but clearly any estimated replacement yields would have enormous variances, of impractical value.

They further noted that other techniques have considered the use of catch-at–age and other data to determine recruitment and mortality rates simultaneously (e.g. SC/41/O 16, 17, plus many other published studies). Such recruitment rates have not been successfully obtained, and at least one current Japanese approach (SC/41/O 16) is still under development. No methodology has been specified for the estimation of MSY rates and MSY level.

Consequently they considered that it has not been demonstrated that a methodology has been proposed that will lead to the ultimate aim of resolving the problem of 'the failure of the IWC/SC to recommend agreed catch limits' by the estimation of replacement rates, and that the proposed mathematical methodology addresses only a part of the total programme.

The question of methodology is also examined in the opening section of Item 9.3.1. It is clear from this discussion that there is no consensus within the Committee on this issue.

The Committee noted that all whales taken during the programme will be killed using an explosive grenade harpoon.

(D) Effect of catches on the 'stock'

The relevant guidelines are:

1. 'A review of the most recent information on the stock or stocks concerned, including information on any exploitation, stock analysis and recommendations by the Scientific Committee to date (including, where appropriate, alternative analyses and conclusions and points of controversy).' (*Rep. int. Whal. Commn* 36:133)
2. 'An evaluation of the specification in the permit proposal of possible effect on conservation of the stock.' As appropriate the Scientific Committee may carry out its own analysis of the possible effects.' (*Rep. int. Whal. Commn* 36:133)
3. 'The research can be conducted without adversely affecting the overall status and trends of the stock in question or the success of the comprehensive assessment of such stocks;' (*Rep. int. Whal. Commn* 38:27–28)

SC/41/SHMi13 addresses the question of the effect of catches on the stock. The best estimates of population size for the Area IV population agreed by the Scientific Committee (*Rep. int. Whal. Commn* 39:43) were 72,357 (CV 0.156) for the total population and 47,611 (CV 0.160) for the exploitable (>6 years) population in 1978/79. Using these data, data for Area IVW in 1984/85 and the Pella-Tomlinson model with MSY rates of 1–4% gave replacement yield estimates for animals of 6+ years of 314–872 for the total stock and 161–377 for the Area IVW population (*Rep. int. Whal. Commn* 39:81–2). The 1989/90 programme envisages a catch of 400 animals throughout the whole of Area IV, including animals of ages 1 and over, not 6 and over. For this reason the proposers of the programme conclude that the latter will neither adversely affect the overall status of the stock nor affect the success of the Comprehensive Assessment.

Holt commented that repeated future catches of 400 whales from Area IV may or may not be below the replacement yield given in *Rep. int. Whal. Commn* 39:81–2. However, he noted that the research catches will include a high proportion (up to 30%) of animals younger than the age at recruitment to the commercially exploited stock (6 years). Even if adequate estimates of population parameters were available, a simple calculation of current replacement yield with an age at recruitment of one year, as suggested in SC/41/SHMi13, would be quite inappropriate as a response to the questions posed in the guidelines above; the research sampling will have a delayed effect of several years on the 'stock', as normally defined, and no attempt has been made to calculate this, either by the Japanese Scientists or by the Committee. Therefore no answer can be given at this time to the question posed, but it would not be correct to assume that the effect will be negligible.

Ohsumi responded that the new Japanese programme has been designed to collect samples randomly from the total population including the animals younger than age 6. Therefore, the replacement yield for the total population would be greater than that of the exploitable population only. In addition, the programme is to be implemented with a two year cycle which requires a catch in one area in every other year, making the average catch per year one half of the proposed sample size. He considered that such a catch would have no adverse effect to the stock in question.

Butterworth commented that analyses giving replacement yields corresponding to the Committee's best estimate or the total population are presented in *Rep. int. Whal. Commn* 39:82, and that the values shown for current replacement yield would approximately double in the context of a biennial catch.

The Committee had not been able to carry out any analysis of the effects of a take of 400 animals on this stock at this meeting. It was therefore unable to provide advice on the effect of the proposed catch on this stock.

(E) Research co-operation

The relevant guideline is:

1. 'Comment on the adequacy and implications of specified arrangements for participation by scientists of other nations'. (*Rep. int. Whal. Commn* 36:133)

SC/41/SHMi13 Annex 2 documents the provisions made for scientists of other nations. The Committee agreed that these are adequate.

9.3.2 Iceland

The Committee noted that it had discussed the essentially unchanged programme over the last four years (*Rep. int. Whal. Commn* 36:31–2; *Rep. int. Whal. Commn* 37:29; *Rep. int. Whal. Commn* 38:53; and *Rep. int. Whal. Commn* 39:59–60). Sigurjónsson commented that although the proposal for fin whales had not been changed, some new information was available at this meeting. In particular the provisional estimate of 6,436 for this stock had been revised to 11,563 (CV 0.261) as noted under Item 6.6. He also referred to discussions on the value of biological parameters at this meeting under Item 7 and Annexes F and G. The Committee therefore agreed to confine itself at this meeting to a discussion of the only major change to the programme for 1989; the reduction in the proposed take of sei whales from 20 to 10 whales.

Sigurjónsson noted that the original programme for the take of 40 sei whales envisaged pooling of the data across years to obtain estimates of biological parameters, rather than an examination of temporal trends in their values. The programme was also aimed at energetics and genetic studies. The decision to reduce the catch to 20 and then 10 whales had been taken by the Government of Iceland. This reduction will influence the originally expected results. However the studies so far indicated that a sample size of 10 was sufficient for the genetics studies (see Item 9.2.1) and the energetics studies.

Tillman, Chapman, de la Mare, Hammond, Holt, Lyrholm, Lankester, Payne and Swartz commented that the possibility of examining genetic markers using non–lethal means should be considered.

9.3.3 Norway

The Norwegian programme described in SC/41/NHMi12 is an extension of the pilot study put forward last year as part of the broader programme described in SC/40/Mi7. It is proposed that a total of 20 whales be taken in 1989. Although SC/41/NHMi12 indicated that a future catch of some 300 whales should be taken at a later date, the Committee agreed to limit its discussion to the proposal for 1989. Wallløe informed the Committee that the original proposal had been integrated into a comprehensive marine mammal programme. Blix noted that the 1989 studies are primarily aimed at continuing the 1988 work with respect to new methodology, and in particular in relation to refining the new methodology concerning age determination, and improving methods of obtaining information on feeding, digestion, energetics and stock identity. He believed the programme should be considered not only in terms of the scientific catch but also in the context of the extensive sightings programmes being conducted (including the Norwegian contribution to the NASS-89 North Atlantic Sightings Survey) and the experimental acoustic work aimed at identifying the breeding and calving grounds.

Wallløe also drew attention to the fact that the two models (WHAERG, a whale energetics model and MULTSPEC, a multi-species model for the Barents Sea) referred to in the objectives of the original programme (SC/40/Mi7) were not presented in detail in this year's documentation, despite comments that insufficient information had been presented last year. This was because they were currently being subjected to a sensitivity analysis. They would be presented to the Committee when this analysis was completed. However he did not believe that this affected the value of the pilot study presented in SC/41/NHMi12, which was primarily concerned with methodology.

Reilly encouraged the Norwegian scientists to complete the WHAERG/MULTSPEC sensitivity analyses. He noted the likelihood that uncertainty regarding the abundance of minke whales would swamp the uncertainty regarding food habits and energetics in the output from these models. Schweder concurred, and noted the large effort (NASS-89) planned to improve the abundance estimate. Smith expressed disappointment at the apparent de-emphasis of these models in the Norwegian research program because the use of formal models to provide a critical framework for guidance and evaluation of the programme had been one of its strongest points.

Before the Committee discussed the proposal in terms of the guidelines as expressed in Annex O of last year's report (*Rep. int. Whal. Commn* 39:154), Horwood expressed two general concerns about the presentation and documentation of the Norwegian proposal. The first was of a scientific nature, and was that the overall objectives, as outlined in SC/41/NHMi12 and more expansively in 'Framework for a Marine Mammal Research Programme' were so general as to make identification and evaluation difficult. The second was of a presentational nature in relation to the tasks of the Scientific Committee, which, without excluding any additional scientific elements, was to consider the 18 guidelines given in Annex O. The documentation presented was not even arranged under the five general headings of Annex O and was thus not helpful to the conduct of the Committee's business. He noted that this criticism was not restricted to this proposal and had been made in earlier discussions of scientific permits.

Holt, de la Mare, Lankester and Swartz concurred with these views and also noted that it was very difficult to assess a pilot study in isolation, without having adequate information concerning the overall programme of which it was a part. The Committee then reviewed the proposal according to Annex O (*Rep. int. Whal. Commn* 39:148).

(A) The Proposal

The relevant guideline is as follows:

A statement as to whether the permit proposal adequately specifies the four sets of information required under paragraph 30 of the Schedule (*Rep. int. Whal. Commn* 36:133)

1. 'Objectives of the research;' (Sched. Para. 30)
2. 'Number, sex, size and stock of the animals to be taken;' (Sched. Para. 30)
3. 'Opportunities for participation in the research by scientists of other nations; and' (Sched. Para. 30)
4. 'Possible effect on conservation of the stock.' (Sched. Para. 30)

Last year the Committee had noted that the proposal did adequately specify the objectives of the Research (*Rep. int. Whal. Commn* 39:56). This year it noted that two aspects of those objectives had changed. The first concerned the study relating to the implanting of satellite tags in minke whales (see Item 6.2) – it had been agreed that this did not in fact require a scientific permit, although the possibility of mortality could not be ruled out. The second change concerned the change in emphasis with respect to the objective concerning the obtaining of data on body composition, fat content and thermal radiation, with less emphasis being placed on using the data for calculation of parameters for ecosystem modelling. However, Walløe noted that using the data for this purpose remains the longer term objective, once the sensitivity analysis is completed.

With respect to the number, sex, size and stock of the animals to be taken, the Committee agreed that these had been adequately specified, in so far as was possible, given problems in determining length and sex before capture. Twenty animals are to be taken in total: six from the Lofoten area between 25 June – 1 July (these are expected to have an equal sex ratio and be 7–8m in length based on previous catch data); seven from the Bear Island area between 2–10 July (expected to be about equal sex ratio, 7–8m); and seven animals from the eastern Barents Sea between 11–20 July (expected to be more females, 7-8m).

The Committee agreed that the proposal did adequately specify the opportunities for participation in the research by scientists of other nations.

It also agreed that the proposal did address the question of the possible effect on the stock.

(B) Objectives

The relevant guidelines are as follows:

1. 'Comments on the objectives of the research to be carried out under the proposed scientific permit, including in particular how they might relate to research needs identified by the Scientific Committee;' (*Rep. int. Whal. Commn* 36:133)
2. 'The proposed research is intended, and structured accordingly to contribute information essential for rational management of the stock;' (*Rep. int. Whal. Commn* 37:25)
3. 'The research addresses a question or questions that should be answered in order to conduct the Comprehensive Assessment or to meet other critically important research needs;' (*Rep. int. Whal. Commn* 38:27–8)

It should be noted that the discussion below relates only to the objectives of the proposal, and not methodologies.

The Committee noted the similarity of guidelines (1) and (3) above in the light of its discussions on the overall priority it has assigned to the Comprehensive Assessment.

In addition to the general objectives given last year, SC/41/NHMi12 specified detailed objectives for the 1989 proposal aimed at improving methodologies to address three central questions: (1) the number and age and sex distribution of the population, (2) what do the whales eat and (3) their energy requirements (using a physiological model, WHAERG).

Horwood commented that the specific objectives had to be viewed in the context presented last year, that of a multi-species approach and model. Even accepting that such a model is reasonable, which is debatable, he believed that the documentation presented did not demonstrate that the measurements sought in this proposal were of any significance to the results of this model and thus that the objectives presented were not of significance to the Comprehensive Assessment nor did they represent a critical research need in the context of multi-species management. Chapman, Holt, de la Mare, Lyrholm, Arnbom, Lankester and Tillman concurred with this view.

In response Walløe commented that even without a presentation of the specific details of the model, he believed that the type of parameter required was apparent. In particular he stressed that the study was examining methodological problems, for which details of the model were not relevant.

Sigurjónsson concurred with this view.

(C) Methodology

The relevant guidelines are as follows:

1. 'Comments on the methodology of the proposed research and an evaluation of the likelihood that the methodology will lead to achievement of the scientific objectives. These comments may also include evaluation of the methodology in terms of current scientific knowledge:' (*Rep. int. Whal. Commn* 36:133)
2. 'The objectives of the research are not practically and scientifically feasible through non-lethal research techniques.' (*Rep. int. Whal. Commn* 37:25)
3. 'The research addresses a question or questions that cannot be answered by analysis of existing data and/or use of non-lethal research techniques;' (*Rep. int. Whal. Commn* 38:27–28)
4. 'The number, age and sex of whales to be taken are necessary to complete the research and will facilitate the conduct of the comprehensive assessment;' (*Rep. int. Whal. Commn* 37:25)
5. 'Whales will be killed in a manner consistent with the provisions of Section III of the Schedule, due regard being had to whether there are compelling scientific reasons to the contrary;' (*Rep. int. Whal. Commn* 37:25)
   [The Commission agreed that it has been intended by this for the Committee to report if cold grenade harpoons were used in special permit catches. (*Rep. int. Whal. Commn* 38:13)]
6. 'The research is likely to yield results leading to reliable answers to the question or questions being addressed' (*Rep. int. Whal. Commn* 38:27–28)

The Committee agreed that the discussion of these guidelines could be centred on four areas: (i) sample sizes; (ii) whether the proposed methodology will answer the questions being asked: (iii) whether the questions could be answered by analysis of existing data or non-lethal research; (iv) whether non-explosive harpoons were being used.

Walløe explained that the number of animals to be taken was that estimated to be necessary to complete the work begun in 1988. In particular fresh samples were needed to finalise work on the ageing methodology (which he hoped could be supplemented by material from the Southern Hemisphere), to continue work on microbial fermentation and development of *in vivo* tests for microbial VFA production and development of *in vivo* (natural) marker techniques, to confirm the energetics findings, and to obtain information on food preferences in these other areas.

Holt noted that the inadequate specification of the objectives of the study made it impossible for him to comment on the suitability of the sample size.

Chapman, Lankester and Tillman commented that even if the samples were only required to examine methodological questions, the information presented did not allow them to determine whether or not the sample size was more or less than required.

Sigurjónsson and Ohsumi believed that since the proposal addressed the question of a qualitative assessment of methodologies, the number suggested was reasonable.

De la Mare commented that to confirm the proposed new method for ageing would require some independent age information. He noted that previous studies using tympanic bullae had compared the ages obtained with those obtained from earplugs. Kato noted that such studies had found that bullae appeared to be more useful in ageing young animals. Wallløe responded that such questions were being examined and that in particular he hoped that comparison with material from Southern Hemisphere stocks would provide information on this.

Holt drew attention to last year's report (*Rep. int. Whal. Commn* 39:58), in which it was stated that preparatory work for all studies would include a review of all available information from existing data, and asked if such a review had been undertaken.

Blix responded that little or no existing material was relevant to the studies being undertaken. As explained earlier, the bullae from earlier operations were not in a suitable condition to be examined using the new techniques. No data on feeding was available for the Barents Sea area after the 1 July. No detailed information existed with respect to the energetics studies proposed. The only samples for genetic work were those from the 1988 catch; material from West Greenland would be examined in the co-operative study with Denmark.

The Committee was informed that all whales taken would be killed using the new penthrite grenade.

(D) Effect of catches on the stock

The relevant guidelines are:

(1)'A review of the most recent information on the stock or stocks concerned, including information on any exploitation, stock analysis and recommendations by the Scientific Committee to date (including, where appropriate, alternative analyses and conclusions and points of controversy)'.
(*Rep. int. Whal. Commn* 36:133)

(2)'An evaluation of the specification in the permit proposal of 'possible effect on conservation of the stock'. As appropriate, the Scientific Committee may carry out its own analysis of the possible effects.' (*Rep. int. Whal. Commn* 36:133)

(3)'The research can be conducted without adversely affecting the overall status and trends of the stock in question or the success of the comprehensive assessment of such stocks.'
(*Rep. int. Whal. Commn* 38:27–28)

The Committee recognised that it does not have an agreed assessment for this stock, which had been classified as a Protection Stock.

The Committee noted the estimates obtained for this stock of minke whales from the 1987 North Atlantic Survey, of around 19,000 (CV 0.16) or 17,000 (CV 0.18) depending on decisions about which survey blocks to include (*Rep. int. Whal. Commn* 39:45). This year the Committee received an estimate from a 1988 Norwegian cruise (which covered part of the Northeastern stock area) of 23,381 (CV 0.155). The estimate for the same area for the 1987 survey was 12,459. This is discussed further under Item 6.2 and in Annex G. Due to the fact that the 1988 survey was conducted in a different year to the survey of the rest of the area, the Committee has not attempted to provide a new estimate for this stock.

The Committee noted that although no definite proposal for the future years of the programme had been submitted, it was informed that larger catches, perhaps of the order of 300 whales, were being considered (SC/41/NHMi12). The Committee was unable to consider the effects of any such take associated with the full programme. In terms of assessing the effect of the 1989 take only, the Committee agreed that the effect would be negligible. As last year it stressed that the effect of a small take in a single year would always be negligible. The Committee agreed, for similar reasons, that the 1989 take would not adversely affect the status or trends of the stock or the success of the Comprehensive Assessment.

(E) Research co-operation

The relevant guideline is:

(1)'Comments on the adequacy and implications of specified arrangements for participation by scientists of other nations.'
(*Rep. int. Whal. Commn* 36:133)

The Committee noted that the proposal did incorporate allowance for participating by scientists from other nations and that some limited funding was available, particularly for projects involving co-operation with Norwegian scientists. It also noted that requests for samples would also be considered.

In discussion Cooke and Holt noted that in the past, the Committee's consideration of this item had tended to focus solely on participation in field research. They believed it was equally important that the analysis phase is also incorporated and that the data obtained are made as widely available as possible.

Wallløe informed the Committee that they welcomed co-operation with scientists from other nations in both field work and analysis. He also reported that all data would be made available when the analysis is completed.

10. SECOND INTERNATIONAL DECADE OF CETACEAN RESEARCH

10.1 Review results for 1988/89

(a) Radio-telemetric study of the behaviour of blue, fin and humpback whales

The report of this work was presented as SC/41/O 10. It was discussed in Annex D.

(b) Analysis of photographs for North Pacific humpback whales: preliminary work towards estimating juvenile mortality

This project has not yet been completed. No progress report was available.

(c) IWC/IDCR Southern Hemisphere minke whale cruise, 1988/89

The report of this cruise is given in SC/41/SHMi7. Joyce reported on the lack of progress being made in organising a catalogue of natural marking photographs from these cruises. The Committee agreed that the Secretariat should write to the relevant researchers urging them to submit such photographs.

(d) Analysis of IDCR photographs of minke whales

This matter is reported in SC/41/SHMi11 and discussed in Annex G.

(e) Proposed meeting on the mortality of cetaceans in fishing nets and traps

A revised proposal is discussed under Item 10.2 below.

10.2 Review proposals for 1989/90

All proposals recommended for support here will be subject to the Committee's guidelines on data availability agreed last year (*Rep. int. Whal. Commn* 39:61).

(a) IWC/IDCR Southern Hemisphere minke whale cruise 1989/90

The Committee **recommends** that this cruise (outlined in Annex P) be funded as a contribution to the Comprehensive Assessment.

(b) Meeting on the mortality of cetaceans in fishing nets and traps

The Committee last year developed terms of reference for the meeting and recommended that it be funded. The Commission approved the meeting in principle but postponed it because of budgetary limitations and a wish to give primary emphasis to immediate needs for the Comprehensive Assessment (*Rep. int. Whal. Commn* 39:27).

The Committee again **recommends** that this meeting be held as described in Annex Q. It was confirmed that the meeting will be technical in nature (see terms of reference in *Rep. int. Whal. Commn* 39:153) and that the participants should be scientific experts and not specifically delegates from IWC member nations. The Committee noted that a Swedish WWF contribution of £5,000 had reduced the amount required from the Commission for the meeting to £25,000.

In this context the Committee discussed the potential problems for cetaceans posed by drift gillnet fisheries in the Tasman Sea and southwest Pacific Ocean.

Cawthorn reported that a fleet of between 160–170 Asian vessels is involved in a recently established, unregulated, high-seas drift gillnet fishery in international waters of the Tasman Sea and along the subtropical convergence zone in the southwest Pacific, east of New Zealand to 140°–130°W. The fleet, targetting albacore tuna, sets approximately 5,100 km of nets 10m-15m deep every 24 hours, across the migratory routes of sperm, humpback, right, Bryde's whales and other species of cetaceans. The entanglement of marine mammals in drift gillnets being worked east of New Zealand was first reported to biologists there in early 1987. Although the numbers and species taken were not recorded, small whales and fur seals were reported to be a common incidental take.

Concern over incidental catches of marine mammals in fisheries of this type is supported by evidence from the North Pacific, North Atlantic and Indian Oceans where incidental mortalities of small cetaceans have been disturbingly high. By analogy with the situation off the western US coast (SC/41/PS14), the potential exists for incidental catches of young animals of the larger baleen whale species, including humpback whales. The Tasman Sea-southwest Pacific drift gillnet fishery is sufficiently large to warrant the immediate collection of incidental catch data.

Morimoto expressed his government's view that issues concerning the incidental take of marine mammals in fisheries activities should be in principle dealt within the framework of regional fisheries organisation, and, because there are no grounds for stating that fishing vessels operating on the high seas must accept foreign scientific observers on board, in light of the provisions of the UN Law of the Sea, incidental catch data should be collected under the right and responsibility of flag states. However, Japan recognises the importance of data collection and plans to do this.

Kasuya stressed the urgent need of the monitoring from a scientific viewpoint and suggested his preference of offering opportunities to local scientists to participate in a monitoring programme as a voluntary measure by fishing countries.

The Committee noted the importance and urgency of this issue (with the Japanese Government reservation). The Committee *urges* the Commission to request involved countries to place scientific observers onboard the fishing vessels to monitor cetacean mortality. These could be local or international observers. It noted that New Zealand has a body of observers who would be available for such monitoring.

Unsolicited research proposals

Five research proposals were submitted to the Committee this year and were reviewed by an *ad hoc* working group (Annex R). In the light of this review the Committee **recommends** that, in the advice to proposers, the Secretariat informs them that the Commission allocates funds on an annual basis. Multi-year proposals, therefore, would normally be considered for funding one year at a time. This has implications for whether or not a proposal is recommended for funding by the Committee. There may be a problem if the research is valuable but requires more than one year to achieve its objectives. The Committee further **recommends**, therefore, that proposers be advised to submit proposals which can be divided into discrete annual units.

Those proposals recommended for funding are summarised below. Details are given in Annex R.

(1) Continued research on the population structure of sperm whales off the Galapagos Islands (SC/41/RP1)

The Commission has funded earlier work on this project. It **recommends** that funding be made available provided skin samples are collected from known animals using the latest biopsy darts.

(2) A photo-identification catalogue for North Atlantic fin whales (SC/41/RP3)

The need for this work had been identified by the Workshop on Individual Recognition (SC/40/Rep 1). The Committee **recommends** that it be funded in full.

(3) Continued research on the behaviour of blue, fin and humpback whales using radio telemetry (SC/41/RP5)

The Committee **recommends** that funding be made available providing the proposal is modified to include double marking of animals and emphasis is given to marking a smaller number of animals and following them for longer periods.

11. REVIEW OF INDIAN OCEAN SANCTUARY

The Indian Ocean Sanctuary was established by the Commission as an area where commercial whaling was to be prohibited for a 10 year period beginning 24 October 1979 (Schedule para. 7). The Commission has set up a Technical Committee Indian Ocean Sanctuary Administrative Sub-Committee, which at last year's meeting agreed to actions to be implemented through the Secretariat and the Scientific Committee to collect information on, *inter alia*, scientific research by Indian Ocean states (*Rep. int. Whal. Commn* 39:16).

The Indian Ocean Sanctuary Administrative Sub-Committee requested the Scientific Committee 'to bring together and assess relevant information about cetaceans since the establishment of the Indian Ocean

Sanctuary. In particular, the Committee should as far as possible compare information from within and outside the Sanctuary as a means of evaluating the recovery of whale stocks with the more general suspension of commercial whaling'. Also, 'The Scientific Committee should be requested to make suitable arrangements through the Secretariat to contact IWC and non-IWC Indian Ocean states to obtain the information'.

The Secretary wrote to all Indian Ocean states in December 1988 inviting them to provide information on their national research programmes on cetaceans. Included with this request was a partial summary of scientific research in the Indian Ocean Sanctuary since it was established in 1979, in the form of a bibliography compiled at the scientific meeting held in the Seychelles in February 1987, and the contents list of a forthcoming special publication (UNEP, in press).

The only response received to these enquiries was from Australia, which has provided a document setting out its research and involvement in the Indian Ocean and a comprehensive list of publications (TC/41/IOS9).

The Committee considered the information available on research in the Sanctuary area and publications and commented on coordination efforts among Indian Ocean states. It then discussed whether there is any evidence of recovery of whale stocks since Sanctuary designation and whether higher priority should be given to research inside the Sanctuary, in particular that relevant to the Comprehensive Assessment.

It was noted that in document TC/41/IOS5 up to approximately half the publications resulted from work undertaken or prepared as a result of the declaration of the Sanctuary. The Committee was not aware of details of additional results of activities by IWC Member states, but it noted that India, Oman and the Seychelles had supported research. It was the view of the Committee that while some important work has been completed and special Sanctuary status may have encouraged greater interest in the area, on the whole, the Sanctuary has not provided the stimulus for research originally envisaged. There has been less coordination between Sanctuary states than hoped, in part because each nation has its own set of priorities, and whale research is generally not a high priority.

With regard to the recovery of stocks within the Sanctuary, it was pointed out that most whaling in the Southern Hemisphere (except on minke whales) had ceased by the time the Sanctuary was so designated and therefore it was impossible to evaluate the importance of the Sanctuary for recovery of stocks.

The Sanctuary could provide a focus for studies of southern baleen whales on their winter breeding grounds, an aspect that might form part of research under the Comprehensive Assessment. However such studies could be carried out as well in other warm waters of the Southern Hemisphere.

One important benefit of the Sanctuary has been increased contacts with some Sanctuary states by outside researchers on the need for further work. In some cases then the Sanctuary designation has helped to obtain heretofore unavailable information. One problem identified is obtaining permission for research using vessels in waters under national jurisdiction; access to some Sanctuary state waters has been restricted. This problem does not arise only in the Indian Ocean, nor has the Committee reason to believe it is more acute there than elsewhere. However, the Indian Ocean, particularly the western part, has a high proportion of its waters under national jurisdictions creating potential logistic problems for pelagic research. Coordination by international organisations such as UNEP was viewed as one potentially useful method to facilitate future research, for example for permit purposes and contact with non-IWC Member states. It was pointed out however that national legislation of some Indian Ocean states may control certain kinds of research, and thus may affect access to requested areas of the Sanctuary.

In view of the fact that there is a pause in commercial whaling worldwide, and research can be conducted just as easily outside as inside the Sanctuary, the Committee believes that the Indian Ocean Sanctuary provides no special advantage for the scientific study of whales. This could, of course, change if or when commercial whaling is resumed. Should, however, Sanctuary states provide a unified exemption for access to their waters under an international flag, for example, then significant new research might be carried out with Commission or IWC Member state support. Until such financial and political support is obtained, the scientific purposes of the Sanctuary designation will remain largely unfulfilled.

12. SMALL CETACEANS (also see Annex F)

12.1 Pilot whales

12.1.1 North Atlantic

The Committee reviewed the life history and status of populations of pilot whales in 1987 (*Rep. int. Whal. Commn* 38:51). At that time the large programme of research on pilot whales taken in the drive fishery at the Faroe Islands was at a very early stage and it was therefore agreed to review pilot whales again in two years, at this year's meeting.

The Committee wishes to recognise and commend the very great effort and cooperation that have made the international research programme at the Faroes possible and productive and to thank the participants for the many useful papers and progress reports submitted to this meeting.

Stock identity

The Committee reviewed the available new information on stock identity (SC/41/SM5, 10, 17, 21, 28) and concluded that, while the limited data on movements, life history and parasites suggest that individual pilot whales do not routinely move between major regions in the eastern Atlantic or between the eastern and western North Atlantic, there is as yet no clear evidence of the existence of two or more stocks or breeding populations in the North Atlantic.

To address this question, the Committee **recommends** that genetic comparisons be carried out between pilot whales from the Faroes and from other regions in the North Atlantic using both analyses of isoenzyme allelic frequencies and appropriate analyses of DNA. Tissue samples from the western North Atlantic may be available at the Smithsonian Institution.

Abundance

The data are not sufficient to allow estimation of abundance of the entire North Atlantic, but a number of estimates have been made for different areas within the North Atlantic.

For the eastern North Atlantic, NASS-87 yielded three estimates for different parts of the survey area that total around 100,000 pilot whales (SC/41/SM10): 72,000 (CV 0.4) for the area covered by the Faroese vessel, 18,950 (CV 0.5) for areas covered by the Icelandic vessels in closing mode and 12,945 (CV 0.25) for the area covered by the Icelandic vessels in passing mode. A series of logistic and experimental protocol factors were identified that need to be considered as potential analytical problems. It was agreed that, while the probable balance of the potential biasing factors could not be determined with the available data and information, the estimates have greater uncertainty than indicated by the CVs attached to them. Several suggestions for reanalysis of the data, design of future surveys and research to improve estimation of school size were made. An additional problem is that the surveys did not cover the entire area known to be occupied by pilot whales in the eastern North Atlantic at that time of the year. The Committee **recommends** that, if estimation of pilot whale abundance is an objective of the surveys, the survey be extended to better determine the area occupied during the survey period. It was noted that the NASS-89 surveys would be carried out further to the south than the NASS-87 surveys.

In the western North Atlantic, the population of pilot whales off Newfoundland had been most recently (1982) estimated at 6,700–19,600. A sighting survey begun in 1980 from research vessels engaged in fishery research off the northeastern USA resulted in estimates of abundance ranging seasonally from 4,000–10,000 whales (SC/41/SM18). An aerial survey in the same region yielded estimates of 10,000–12,000. Both these estimates and those from the shipboard surveys could not be evaluated because of the lack of estimates of variances and details concerning survey design and data analysis. A further difficulty is that the two species of pilot whales overlap in distribution along the US east coast; the Committee expressed the hope that the surveys would continue, at adequate frequency, and that the area covered would be extended to the east because of the likely occurrence of pilot whales there.

Migration

There is very little evidence on migration. Various studies suggest seasonal changes in local abundance and longshore as well as offshore-onshore movements. It was agreed that availability of prey is likely to be the major factor determining seasonal movements.

Because of the importance of information about migration to questions of stock identity and status and because the pilot whale is a species particularly suitable for radio-telemetry studies, the Committee **recommends** that the proposed project using satellite-linked transmitters at the Faroes to study movements, described at this meeting two years ago, be undertaken.

Life history

Results of studies of age determination and anomalies in deposition of dentine in pilot whale teeth were presented (SC/41/SM4). The results of a calibration study indicate that one growth layer group (GLG) is deposited annually in both dentine and cementum. The depositional anomalies may be related to stress or other external factors and it is **recommended** that incidence of marker lines and other anomalies in teeth be examined in more detail to determine possible links with oceanographic conditions, food availability and life history events.

Progress reports were presented for various studies of growth and reproduction in pilot whales at the Faroe Islands and Iceland, including research on foetal sex determination and sex ratio (SC/41/SM12), male seasonality (SC/41/SM11) and age-related changes in reproductive parameters (SC/41/SM13, 26).

Social organisation and breeding system

The results of genetic fingerprinting studies provide a preliminary model of pilot whale social structure (SC/41/SM3). Reproductively active males move between schools, staying with a single school no more than a few months. The pods may be considered as matrilines. Results of an isoenzyme allelic frequency study reinforce this picture. An interesting question is that of how and when adult males transfer from one pod to another; few sightings of single pilot whales have been made around the Faroes.

Seasonal change in body condition

There is a pronounced annual cycle in body fat condition in pilot whales at the Faroes, with peak condition achieved just before the spring (SC/41/SM5). Food availability is the most likely factor driving this cycle.

Mass die-offs

Several reports were received of unexplained deaths of unusually large numbers of small and large cetaceans of several species. These included the appearances of numerous carcasses of sperm, killer and pilot whales on beaches and in coastal waters of Norway (SC/41/O 5), reports of 'many' freshly dead pilot whales floating in the water off the Shetland Islands and the beaching of approximately 600 dolphins and pilot whales on the coast of western France after a large storm early this year. The Committee **recommends** that efforts be made to determine the causes of death in any new such die-offs. These efforts should include examination of the carcasses by veterinarians experienced in marine mammal pathology.

Population dynamics

No new information was available on population dynamics, but it is **recommended** that attention be given to research on this topic using the Faroese frequency-at-age data. The Committee noted that the extensive demographic information which has been, and will be, generated by the Faroese research programme could form the basis for a valuable mathematical model of the population dynamics of pilot whales, and possibly other odontocetes. It therefore **recommends** that such an integrated model should be developed.

Ecology

In contrast to the results of earlier studies, the stomachs of all pilot whales examined at the Faroes in 1986–88 have contained no fleshy squid or fish remains (SC/41/SM13). It was concluded that the whales did not eat in nearshore waters in recent years. Absence in stomach contents of densely occurring species of fish, such as cod and blue whiting, indicates that the whales exercise some choice of prey.

Levels of some contaminants (DDT, PCBs and Hg) are comparable to those in similarly-sized whales from other parts of the North Atlantic, but significant differences in DDT, PCBs and cadmium have been encountered among pods at the Faroes (SC/41/SM21, 22). Levels of cadmium in some pods were very high. Studies are continuing.

A new species of trematode was described from the Faroese samples (SC/41/SM28). Differences in species composition of parasite loads between whales from the Faroes and from other parts of the North Atlantic, indicate that individual whales may spend their entire lives in one region.

Exploitation

Large numbers of pilot whales have been removed from the North Atlantic. In the continuing fishery at the Faroes, 1,690 were landed in 1988 (SC/41/ProgRep Denmark). In the western North Atlantic, the by-catch of pilot whales by foreign flag mackerel vessels in the US EEZ jumped sharply in 1988 to 140 and may have been larger in earlier years when the then larger mackerel fishery was unmonitored. It is **recommended** that the historical data for this fishery be examined to estimate earlier removals of pilot whales.

The existence of a past Icelandic drive fishery was confirmed (SC/41/ProgRep Iceland), and the Committee **recommends** that the historical data for that fishery and for strandings be obtained and reported.

Status

The level of incidental mortality in the western Atlantic is not well enough known, and the current population estimates have not been available for sufficient examination and do not cover sufficient area to allow reliable conclusions about status to be drawn. The level of take in the Faroese fishery has been maintained for at least four hundred years, with cyclic fluctuations having a periodicity of about 120 years, and is small relative to the abundance estimates given (SC/41/SM10), but the potential biases in these estimates, and particularly uncertainties concerning net reproductive rates, do not allow status to be assessed with confidence.

12.1.2 Other populations

The Committee considered estimates of pilot whale populations in the Antarctic based on sightings data from the IDCR cruises (SC/41/O 20) and concluded that analytical difficulties and uncertainties with the estimates, due to the main objective of the cruises being large-whale census and the small number of pilot whale sightings, rendered them of questionable utility for estimating pilot whale abundance.

Catches of pilot whales in Japanese waters are changing in stock composition (SC/41/ProgRep Japan). The small-type whaling fishery has expanded to include the southern form stock; 28 animals of this form were taken by these vessels in 1988. This may have occurred because of reduced access to larger whales. At present the total annual take by all fleets of 493 represents about 1% of the estimated 53,000 whales in the stock. Because it is possible that onshore and offshore populations are involved in the putative single stock, the Committee considers it urgent that the stock-structure question be addressed before the catches are increased.

12.2 Information on other stocks

12.2.1 Northern bottlenose whale

It was suggested last year that the Committee could usefully investigate re-assessment of the status of the northern bottlenose whale, a provisional Protection Stock.

The available information was reviewed and it was concluded that re-assessment of the stock would be premature. Gunnlaugsson noted that the estimates of abundance in Icelandic and Faroese waters (SC/40/O 30-revised) are likely to be biassed downwards because of lack of adjustment for the long dive times of the species. It was noted that the results of the survey of Norwegian waters reported in SC/41/O 4 are not relevant to bottlenose whale assessment, because the survey took place in July, when most bottlenose whales have migrated to the south. SC/41/O 22 gives sightings data from Icelandic whalers for the period 1979–1988. The frequency of recorded sightings has increased over the period, but the quality of the data needs further investigation. In addition, the number of sightings, typically ten to twenty per vessel-season, is insufficient to allow detection of other than large trends. The paper shows that there is a clear change in the distribution of the animals on the whaling grounds west and southwest of Iceland during the season. In the late season the sightings were concentrated at the northwestern boundary of the grounds.

Three bottlenose whales were taken in the drive fishery in the Faroes (SC/41/ProgRep Denmark). The Committee notes with concern that these catches were taken from a Protection Stock. Bloch reported that she is gathering historical data on the bottlenose whale drive fishery in the Faroes and will report on them at next year's meeting. The Committee agrees that these data will be important in any future assessment and welcomes them.

12.2.2 Dolphins associated with tuna in the eastern Pacific

The Committee last year noted its concern about the continuing high mortality of dolphins and recommended (1) that every effort be made to reduce it and estimate its impact in the stocks, (2) that behavioural and gear research be carried out to lower kill rates, (3) that kills be reported on a stock-by-stock basis and (4) that the level of biological sampling be increased.

Kill estimates

During 1988, more than 40% of the trips by tuna vessels carried observers (from the IATTC on the US NMFS). Cooperation from the nations and industries involved has grown steadily over the last few years. The international observer program resulted in an estimate of 78,927 or 84,881 dolphins killed in 1988, depending on the method used (SC/41/SM6). This is lower than in 1986 (by 40%) and 1987 (by 20–25%) (see Fig.1 in Annex H). The Committee notes that the IATTC has estimated the kill on a stock-by-stock basis and offers its thanks for such a prompt and full response to its recommendation. The kill estimates for earlier years have been revised on a stock-by-stock basis and are given in Appendix 2 to Annex H. The portion of the decline from 1986 to 1988 not due to decrease in effort has not been analysed to determine the contribution of bettered performance in releasing dolphins, and it is **recommended** that the methodology to do this be developed.

The Committee noted the continued high kill of eastern spinner dolphin (about 20,000 in both 1987 and 1988). While the indices of abundance do not indicate a declining trend in the stock, it expressed concern about the uncertainties surrounding the indices and the possible impacts of the kills on this stock and the stocks of offshore spotted and common dolphins. The Committee again **recommends** that the efforts to reduce the kill be continued by all the agencies and nations involved.

Biological sampling
The level of animals sampled did not increase from 1987 to 1988 (Annex H, Table 1), but new procedures and incentives have been put in place in an attempt to increase the quantity and quality of the samples; the result of these efforts will be reported to next year's meeting.

US sightings surveys
The estimates for most stocks based on the 1988 survey were higher than previous estimates; most of the increases were too large to be explained biologically (SC/41/SM31). Use of an alternative analytical procedure (pooling across geographical strata) damped the year-to-year fluctuations for some stocks but not for others.

It was pointed out that more than half the sightings of (and sets on) southern offshore spotted dolphins by tuna vessels were south of the area searched by the research vessels; this mismatch could result in problems in management.

The Committee **recommends** that the presently pooled Baja neritic and northern common dolphin stocks be treated separately in the survey and analyses.

The relationship between dolphin abundance and oceanographic variables
A report was presented on progress in research on this topic, the goal being to develop a basis and method for adjusting stock boundaries to take into account large scale changes in habitat due to environmental events such as the recent El Niño. The preliminary results indicate significant and complementary shifts in habitat features and occurrence of spotted and common dolphins, the former associated with a thermocline of intermediate depth and the latter with a shallow thermocline.

Efforts to reduce the kill
The main development in this area has been the recent international workshops held in Costa Rica and Colombia. The Costa Rica meeting concentrated on ways to reduce dolphin kill and was attended by participants from nearly all of the nations involved in the fishery (listed in Annex H).

The Committee notes with pleasure the continued effort by the IATTC and the several nations involved to reduce the kill. It **recommends** that research to develop improved gear and methods to reduce kill rates be continued.

12.2.3 Porpoises
Consideration of most of the contributed information on phocoenids was deferred to next year. The two issues considered are discussed below.

Line transect survey of harbour porpoise
The Committee reviewed the methodology and results of a line-transect survey of harbour porpoises in the Bay of Fundy and offered advice for improvement of the methods and design.

The Japanese take of Dall's porpoise
The Committee is extremely concerned about the great increase in take of Dall's porpoise in the Japanese hand-harpoon fishery, from about 13,000 in 1987 to about 39,000 in 1988 (SC/41/ProgRep Japan). There is evidence that the porpoise meat is being substituted in commerce for whale meat because of the decrease in access to large whales. The take is from two stocks in unknown proportion, estimated to contain about 105,000 porpoises in the aggregate (see Fig. 1 and Table 2 in Annex H). There may be some over–reporting involved in the 1988 estimate, but other catches in an international gillnet fishery are not included. The Committee concludes that the present take is clearly unsustainable. Depending on the stock composition of the catch, the situation may be even worse for one of the stocks than immediately apparent.

The Committee believes that it is urgent that the catch be reduced at least to the levels of previous years (which themselves may have been too high) and that assessments of status of the stocks be carried out, to determine safe levels of catch for the two stocks independently. It **recommends** that catch statistics be collected and reported on a stock-by-stock basis, and that the Republic of Korea be requested to report by-catches of Dall's porpoise (and other cetaceans) in its squid gillnet fishery to the IWC.

12.2.4 Baird's beaked whale
A 50% increase in the Japanese national quota (from 40 to 60; SC/41/ProgRep Japan) is a one-year emergency increase for the small-type whaling fleet to partially replace the former catch of minke whales pending settlement of the question of whether there will be a take of minke whales in the future.

The Committee noted that new abundance estimates have been made for Baird's beaked whale of 2,500 in the coastal stock and 1,000 additional within the 200-mile zone of Japan in the Sea of Japan and the Okhotsk Sea (SC/41/ProgRep Japan). The estimate of 2,500 is lower than the earlier estimate of 4,220 (*Rep. int. Whal. Commn* 36:383). The Committee did not review the data or analyses that were used for the new estimate.

12.2.5 Other species
Documents containing information on other species are listed in Annex H.

12.3 Takes of small cetaceans in 1988
Reported takes are summarised in Annex H Appendix 3. As in past years, the data in the IWS and progress reports are incomplete, and the Committee again **recommends** that the member nations be requested to complete catch and by-catch statistics to the IWC.

12.4 Stranding programmes
The Committee notes that data from strandings are useful in determining distribution and movements, both necessary to stock assessment, and therefore **recommends** that member nations not having strandings reporting programmes take steps to establish them.

12.5 1990 meeting
At next year's meeting the sub-committee on small cetaceans will review populations of phocoenids.

13. DATA PROCESSING AND COMPUTING NEEDS FOR 1989–90

Progress on data processing and computing projects in the past year is discussed under Items 4.3.2 and 4.3.3. For data coding projects to be carried out in 1989–90, the Committee **recommends** the following priority order:

(1) 1989/90 IWC/IDCR cruise data coding;
(2) completion of coding of Antarctic land station catches since 1946;

(3) coding of catch data required for the priority stocks to be considered in 1990 and 1991, in particular validation of minke catch data already coded by Iceland and coding of pre-1977 Japanese coastal minke data;
(4) coding of pre-1949 North Atlantic and North Pacific catch data;
(5) coding of pre-1946 Southern Hemisphere land station catches;
(6) coding of pre-1931 Southern Hemisphere pelagic catches.

In order that data required for consideration of priority stocks in 1990 be available, in addition to that in (3) above, the Committee **recommends** that the Commission request the Government of Canada to submit all minke whale catch data which they hold.

In addition the Committee **recommends** that the following tasks be carried out by the Secretariat in the following year:

(1) completion of a control program for use in screening tests of management procedures;
(2) carry out all screening trials for the NMP based management procedure (see Item 7.2.2);
(3) validate both new versions of the HITTER/FITTER program that allow estimation of confidence limits, provided that full documentation is also made available by the authors;
(4) completion of data files on Antarctic baleen whale catches and on sightings densities by species, month and 1° square;
(5) development of a general computer program for the implementation of the variable coverage probability analysis with advice from Cooke (see Section 7.5.4);
(6) a study of the effect of possible differences in the way schools are identified in Passing and Closing Mode, in collaboration with Hiby;
(7) an investigation of the possible basis for the observed difference between density estimates from Closing and Passing Mode surveys on the Southern Hemisphere IWC/IDCR cruises, in collaboration with Butterworth.

These recommendations were drawn up on the assumption that on-going projects relating to stock estimation (such as the analysis of data from the Southern Hemisphere IWC/IDCR assessment cruises) described during the meeting would continue. In addition, as a background task, the Secretariat should continue to document its holdings of computer programs.

14. FUNDING REQUIREMENTS FOR 1989–90

14.1 Protocol for awarding of contracts

The Committee had not identified any contract studies this year and this Item was not discussed.

14.2 Comprehensive Assessment

The funding implications of work recommended under Item 8 are provided in Table 4. A total of £107,100 is required for these projects.

14.3 Other research items

The funding implications of projects outlined under Item 10.2 are listed in Table 5. A total of £63,000 is requested for these projects.

Table 4

Comprehensive Assessment activities

Activity	£
(1) Workshop on management procedures	23,500
(2) Special Meeting on Eastern North Pacific gray whales	23,000
(3) Attendance of invited participants at 1990 Annual Meeting	18,000
(4) Coordination of SH and NA minke whale assessments	4,000
(5) GPS navigation system for aerial surveys	3,600
(6) IDCR Southern Hemisphere minke whale cruise 1989/90	35,000
Total	107,100

[1] For intersessional travel costs incurred in the standardisation and coordination of data preparation and analysis for the Comprehensive Assessment of Southern Hemisphere and North Atlantic minke whale stock groups.
[2] Recommended under Item 6.4.5 and is described in Annex J.
[3] Will mainly contribute to the Comprehensive Assessment after 1990.

Table 5

Funding for other research activities

Activity	£
(1) Meeting on cetaceans mortality in fishing nets	25,000
(2) Sperm whale population structure in the Galapagos Islands	14,500
(3) North Atlantic fin whale photo-identification catalogue	12,000
(4) VHF radio telemetry of blue, fin and humpback whales	11,500
Total	63,000

14.4 Priorities

A total of £170,100 is required for the items identified above. The Committee stressed that in Items 14.2 and 14.3 it had only included those projects of the highest priority. It **strongly recommends** that all of these projects are funded. The Committee believes that it is important to draw the Commission's attention to the importance of the above activities, especially those relating to the Comprehensive Assessment. The role of invited participants at the 1990 Annual Meeting was seen to be especially important in this context.

15. INITIAL AGENDA FOR 1990 MEETING

The Committee had proposed that at its 1990 Annual Meeting it attempt assessments of Southern Hemisphere and North Atlantic minke whales as part of the Comprehensive Assessment, and that reports on progress towards a Comprehensive Assessment be presented for other stocks or stock groups (Item 8.1). The reports of the Workshops and Special Meeting identified under Item 8.2 will also need to be considered as part of the Comprehensive Assessment. The Committee had also proposed that a considerable amount of work be carried out at the Annual Meeting on the further development of alternative management procedures (Item 7.2.2). The Committee further recognised that it may be required to review research results based on existing Scientific Permits and to review new or revised Scientific Permit proposals.

The Committee was concerned about the heavy work load proposed for its 1990 Annual Meeting. It believed that it would not be possible to complete the proposed work unless a working group on alternative management procedures met for three days before the start of the meeting. The Committee recognised that arrangements had not been made to cover such a meeting but **recommends** that every attempt should be made to accommodate it.

The Committee noted that a considerable period of time had been taken up at recent meetings discussing the results of scientific permit catches and reviewing continuing permit proposals. It believed that, given the workload already associated with the Comprehensive Assessment for the 1990 meeting and the high priority this was accorded, as little time as possible should be accorded to discussing scientific permits. It was agreed that results from scientific permit catches should only be discussed in so far as they are relevant to the Comprehensive Assessment of the priority stocks identified. Discussion of continuing permits should be confined as far as practicable to major changes in objectives or methodology. New scientific permit proposals should, of course, be subjected to the normal scrutiny required by the Commission.

A proposed schedule for the Annual Meeting was discussed. The Committee agreed that the time normally allocated to sub-committees should be taken up with the two groups conducting assessments of Southern Hemisphere and North Atlantic minke whales.

The two *ad hoc* working groups set up to discuss planning for an assessment of Southern Hemisphere and North Atlantic minke whales reported to the Committee. It was agreed that the two draft agendas which had been prepared would be circulated for review as soon as possible after the end of this year's annual meeting of the Scientific Committee. The Committee noted that the success of its work at its 1990 meeting depended upon the relevant data (in a standard format) being available at the meeting. It **recommends** that such data be lodged with the Secretariat in sufficient time for them to be used at the meeting. Members representing Denmark, Iceland, Japan and Norway noted that this would be done. This is discussed further under Item 18.3. The Committee also noted that the two groups conducting assessments of Southern Hemisphere and North Atlantic minke whales would require considerable computing support, comparable to the levels of support provided by the Secretariat before the implementation of the moratorium.

The Committee appointed convenors for the two working groups to coordinate intersessional work. It recognised that this task would involve substantially more work than was usually the case.

16. PUBLICATIONS

The Committee agreed, in accordance with the procedures outlined in *Rep. int. Whal. Commn* 32:63, that the Editorial Board should comprise Donovan, Braham, Brownell, Harwood, Hammond, Horwood, Perrin and Tillman.

17. ELECTION OF OFFICERS

Brownell and Hammond were re-elected Chairman and Vice-Chairman, respectively.

18. OTHER BUSINESS

18.1 Secretariat's response to requests from the public for information on whale numbers

This item was introduced by Holt, who had requested that it be discussed. He noted that the Secretariat receives numerous such requests and responds essentially by sending a table of figures with an explanatory letter. These figures are regarded by journalists, specialist authors and public officials concerned with whales and whaling as authoritative. They have recently appeared in government documents and in publications of international organisations.

The tables, headed 'Estimates of total population sizes of each whale species' are annotated as 'indications of the orders of magnitude of the total population sizes, based on the latest estimates published in the scientific literature' and the reader is warned of uncertainty in these numbers. The tables include estimates both of current numbers and of initial, pre–exploitation numbers.

Holt believed that the Secretariat has done its best to follow its own simple guidelines. Nevertheless, he thought there was a problem in keeping the table up-to-date. The effect of quoting numbers for all stocks may give an impression of greater knowledge about numbers of certain species than we now believe we have. The Committee has also received new estimates, which are not reflected in the table because they had not been formally adopted.

As the Committee is engaged in an attempt to reassess all such numbers he suggested that it would now be more appropriate for the Secretariat to respond to such requests with a simple explanation of the Comprehensive Assessment process and a promise of information after the 1990 meeting.

There was some discussion of Holt's views within the Committee. Some members suggested that one option was for the Secretariat to compile a revised table, listing estimates of stocks recently considered by the Committee, and giving their dates, the area of ocean to which they refer, the segment of the population (i.e. total or exploitable) to which they apply, the confidence intervals around the estimates and any other caveats reported.

The Secretary noted that such a table would be far too complex for the majority of people requesting information from the Secretariat, many of whom were school children. As noted, the table at present provides order of magnitude estimates of current and initial estimates of total population size by hemisphere with a warning about the uncertainty of these estimates. A table along the lines suggested above would however be more suitable for any 'professional' enquiries, although simply providing relevant references may be more appropriate.

The Committee expressed its confidence in the Secretariat adequately to reflect the results of the Committee's work. It suggests that the current table should not be sent out prior to re-evaluation and update in the light of this discussion.

18.2 Effect of oil spills on cetaceans

The Committee discussed Annex S, the report of the *ad hoc* working group on the effect of oil spills on cetaceans. It expressed great concern over the possible impact of oil spills on cetaceans and recognised the need for appropriate and practical measures to prevent and mitigate the impacts of petroleum exploration, development and transportation. In addition, the Committee called for the

formulation of appropriate and realistic contingency plans for containment of oil spills and mitigation of their effects on the marine environment in general and cetaceans in particular.

The Committee **recommends** that detailed data on oil spills and their effects be acquired in a timely manner and be made readily available to provide documentation of the effects of oil spills on wildlife and to allow for appropriate rescue and rehabilitation programmes for cetaceans. In order to further the prediction of the impact of oil spills, the Committee urged that the following actions be undertaken:

(1) detailed clinical records be kept of marine mammals which are being treated or rehabilitated;
(2) rehabilitated animals be monitored after release to assess their long-term survival;
(3) pathological examinations be conducted of marine mammals suspected to have died in association with an oil spill;
(4) appropriate tissues be collected from oiled animals for the analysis of hydrocarbon contamination and its effects;
(5) short– and long-term studies be conducted on cetaceans in and near areas where oil spills have occurred in order to assess effects on behaviour, distribution, habitat use (e.g. prey species) and demographic parameters;
(6) tissues of marine mammals from direct or incidental fisheries as well as from strandings in areas where oil spills have occurred, are collected and evaluated.

18.3 Data availability for the 1990 Comprehensive Assessment

There was some discussion of the question of data availability for the 1990 meeting in the light of the revised guidelines for data availability agreed last year (*Rep. int. Whal. Commn* 39:31–2), particularly in relation to sightings data from the North Atlantic. The Committee agreed that it was important for relevant data to be made available sufficiently before the meeting to allow Committee members to carry out analysis and present them at the meeting.

In order to facilitate its work at the 1990 meeting, therefore, the Committee **recommends** that the Commission urge the relevant authorities to

(1) make existing data available to accredited persons upon request as soon as possible and preferably by the end of 1989; and
(2) similarly make data collected during the remainder of 1989 available as soon as possible and preferably at least two months before the meeting.

The Committee recognised that efforts to make data available in a suitable format will be enhanced by the work of the convenors of the two species sub-committees (Item 15). The Committee agreed that any requests for data should be copied to the Secretariat and relevant convenor as soon as possible.

18.4 Availability of Norwegian catch and effort data

Commenting on a statement by Holt in SC/41/O 8 (Appendix 2), Walløe referred to the fact that all Norwegian catch data and effort data for the period 1938–1986, insofar as they exist, had been lodged with the Secretariat prior to the 1988 meeting. All existing data, including data on bycatches (bottlenose, killer and pilot whales) had thus been made available according to the normal rules of the Commission (*Rep. int. Whal. Commn* 39:45).

The Secretary informed the Committee that the statement by Holt arose as a result of a misunderstanding between the Secretariat and Norway as to the conditions under which the data were held.

19. ADOPTION OF REPORT

The report was adopted by the Committee. Before adopting the report, the Committee expressed its thanks to the Secretariat for their hard work and cheerful service during the meeting.

Annex A
List of Participants

ANTIGUA & BARBUDA
R. Payne

AUSTRALIA
W.K. de la Mare
F.B. Michaelis

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I. Christensen
K. Foote
E. Øen
N. Øien
T. Øritsland
T. Schweder
L. Walløe

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SPAIN
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H. Quiroga
C. Sanpera

SWEDEN
T. Arnbom
T. Lyrholm

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LOCAL SCIENTISTS
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