Annex H
Report of the Standing Working Group on Environmental Concerns

Members: Reilly (Convenor), Addison, Berggren, Best, Borchers, Born, Carlson, Childerhouse, Clark, Clarke, DeMaster, Donahue, Donovan, Ensor, Fabbri, Findlay, Finley, Friday, Fujise, Givens, Goto, Hakamada, Hammond, Hatanaka, Hofmann, Kato, Kawachi, Kasuya, Kim, Kock, Komatsu, Lawrence, Lens, Moronuki, Nakamura, Nishiwaki, Notarbartolo di Sciara, O'Hara, Øien, Palka, Pastene, Pérez-Cortés, Perrin, Pinedo, Polacheck, Reijnders, Robineau, Rogan, Rojas Bracho, Senn, Shimadzu, Simmonds, Smith, Stachowitsch, Swartz, Thiele, Tomita, Van Waerebeek, Von Bismarck, Wade, Walløe, Walters, Witting, Yamamura, Zhu.

1. CONVENOR'S OPENING REMARKS

Reilly welcomed the participants.

2. ELECTION OF THE CHAIR, APPOINTMENT OF RAPPORTEURS

The group elected Reilly as its Chairman. Donahue acted as rapporteur.

3. REVIEW OF DOCUMENTS AVAILABLE

Documents of relevance to the Standing Working Group (SWG) included SC/50/E1-9, SC/50/SM2 and SM11, SC/50/O7, O11 and O32, SC/50/CAWS18, SC/50/AS15, O'Hara *et al.* (1998), Kemper and Gibbs (1998), Simmonds (1997) and Hofmann (1998).

4. ADOPTION OF AGENDA

The Agenda was adopted as given in Appendix 1.

5. POLLUTANT AND CONTAMINATION ISSUES

5.1 Review of progress on research initiative

Last year the Commission adopted a Resolution endorsing the recommendation of its Scientific Committee to (a) initiate a research programme to establish pollutant cause-effect relationships in cetaceans (Aguilar *et al.*, 1997); and (b) to hold and fund a Planning Workshop as the first phase in implementing the proposal. The Committee established a Steering Group (Aguilar, Bjorge, Donovan and Reijnders [Convenor]) to organise the Planning Workshop. The Workshop, which will last 3-4 days, will be held in November 1998 in Barcelona, Spain. The Steering Group has identified, and will soon contact, persons representing institutions or organisations that might be interested in the analyses and/or sample collection and funding. In addition, advisory experts on specific subjects, e.g. toxico-pathology will be invited. The Steering Group expects approximately 30 participants. The agenda for the Workshop will include:

(1) objectives of the programme;
(2) identification of variables to be measured with respect to pollutants, indicators, biological variables and pathology;
(3) analytical techniques to be used with respect to pollutants, indicators, biological variables and pathology;
(4) sampling (by species, area and variable to be measured),
  (a) sample size and composition (age, sex),
  (b) collection method,
  (c) short-term storage,
  (d) long-term storage and shipment;
(5) designation of responsible laboratories with respect to,
  (a) sample collection,
  (b) analyses;
(6) organisation and coordination,
  (a) coordinator and Steering Group,
  (b) timetable,
  (c) budget and funding,
  (d) report and publications;
(7) report of the Planning Workshop.

It was stressed that in the original proposal the programme was intended to address specifically the main recommendation of the IWC Pollution Workshop held in Bergen. Further, researchers should be encouraged to address the other recommendations of that Workshop and consider other species and sources of samples. The group noted that the priorities of the IWC Research Programme were not meant to imply that other approaches were untenable, including the opportunistic collection of data from stranded animals, although data from such sources were likely to be subject to the concerns identified at the last meeting of the SWG (IWC, 1998).

In this context, it was noted that the Parties to ASCOBANS at their Meeting in Bonn, December 1997, expressed strong support for the aforementioned IWC Research Programme and they recommended that the Parties seek ways to facilitate the execution of that Programme.

The SWG was informed that sufficient funds were available for the Planning Workshop, at which further discussions regarding the financing of the entire research project would take place. It was re-iterated that sufficient

funding for the overall Programme had not yet been secured and sources of potential funding were encouraged to consider supporting the project.

The duration of the Research Programme is expected to be at least four years. The products of the Programme are expected to include an integrated report of all the Programme's components, a set of guidelines to assist others who wish to pursue similar research projects and a summary of the entire Programme in terms of the identified parameters

5.2 Other topics

The SWG reviewed three documents related to pollutants and chemical contamination. O'Hara presented a summary of SC/50/E5, an analysis of contaminant levels in bowhead whale tissues. Resulting mean levels of metals in bowhead liver and kidney samples were considered low or normal for most mysticete species. Unlike levels detected in some odontocetes, mercury (Hg) levels in these tissues were low and not a cause for concern. Mean levels of metals in blubber, epidermis, and muscle were considered low or normal for most mysticete species. The mean cesium-137 (Cs-137) levels (Bq/kg w.w.) were considered very low and the increasing rank for tissues is blubber < kidney/liver < skin/muscle. Preliminary data indicated that strontium-90 (Sr-90) and plutonium (Pu-239/240) were mostly below detection levels and thus very low. Polonium-210 (Po-210) was above detection level at approximately 5Bq/kg and considered low. Most (7 of 11) of the organochlorines measured occurred at higher levels in longer (older) males. In females, hexachlorobenzene appeared to decrease with increasing length while levels of other contaminants did not change. Overall, bowhead tissues had relatively low levels of most natural and anthropogenic contaminants of the inorganic, organochlorine and radionuclide classes when compared to other marine mammal species. From a subsistence perspective, kidney samples represented a significant source of cadmium (Cd) which requires further investigation. Levels for other elements presented no cause for concern regarding subsistence.

In discussion, the dependency of SC/50/E5 on extrapolation using information from non-cetacean species to identify the potential effects on cetaceans was noted. Using information from non-cetacean species for assessing these potential effects is not ideal; however, the paucity of cetacean-derived data leaves researchers with few alternatives. The use of in vitro assays using mysticete cell cultures to assess cellular responses to metals is being pursued. The use of proper toxico-pathology was also emphasised. The use of bone to study accumulating radionuclides was suggested. Bone-accumulating radionuclides like Sr-90 were measured in soft tissues, but bone was not collected because the study's priority was to address human exposure. It was noted that the lack of information on bioavailability (absorption) in humans critically hampers a proper risk assessment for consumers of marine mammal tissues. It was also noted that an assessment of the potential effects on humans is subject to critical threshold levels, which have been changing over time with the identification of more sensitive indicators ('biomarkers') and critical life stages (such as exposure in utero and via lactation).

Simmonds summarised SC/50/E6, an opportunistic study of organochlorine and mercury concentrations in tissues from a sample of cetaceans from the northeast Atlantic. The data again confirm that levels in small cetaceans in this region are high and suggest that the eastern Irish Sea is a 'hot spot' of contamination. Data were presented for blubber, liver and kidney from most animals sampled. Organochlorine concentrations generally correlated closely with lipid content in all tissues sampled. However, there were notable exceptions where high levels were recorded in the kidney of one animal and the liver of another. Simmonds noted that this phenomenon might be expected in cetaceans and related to blubber lipid mobilisation or the failure of elimination systems. Discussion of the significance of blubber lipid mobilisation (and consequently lipophillic contamination) followed, in which the usual pattern of age-related accumulation was noted. Hammond noted that female bottlenose dolphins in the Moray Firth in Scotland were more heavily afflicted by skin lesions than males. One hypothesis was that this related to regular lipid mobilisation in mature females.

SC/50/SM11, a report on the progress of toxicological and pathological investigations of harbour porpoises from the North and Baltic Seas and from waters around Greenland, was summarised briefly. Contents and patterns of chlorinated contaminants in harbour porpoise blubber samples indicated significant variation between the three areas, suggesting that contaminant levels examined could be indicative of separate populations.

In addition to these three documents, the SWG reviewed briefly and endorsed the protocol for skin/blubber biopsy collection for the study of chemical pollutants presented in Appendix 2.

6. CLIMATE CHANGE AND HABITAT

6.1 Review of progress on SOWER 2000 planning

6.1.1 Report of e-mail group

Reilly reported that the SO-GLOBEC small-scale process study originally planned for 1999/2000 has been delayed until 2000/2001 because of ship scheduling conflicts. Consequently, SO-GLOBEC's small-scale process study will not occur concurrently with CCAMLR's large-area synoptic survey to estimate total krill biomass. Re-iterating the unique opportunity that the research activities planned by SO-GLOBEC and CCAMLR present for the IWC to conduct research on the distribution of whales in relation to their environment and prey, the SWG discussed alternatives regarding IWC participation in these CCAMLR and SO-GLOBEC research activities. The SWG agreed to proceed with the existing proposal to work with CCAMLR in 2000 by having IWC observers conduct whale sightings during CCAMLR's synoptic krill survey in Area 48. After discussing the implications of the one year delay in the SO-GLOBEC small-scale process studies, the SWG re-confirmed its decision to work with SO-GLOBEC despite the delay. Thus, the SWG re-iterated its support for the collaborative research activities with SO-GLOBEC and CCAMLR, which were originally proposed at last years meeting and were subsequently endorsed by the Commission.

6.1.2 CCAMLR

Kock summarised SC/50/O11, which re-iterated that research activities planned by CCAMLR present a unique research opportunity for the IWC to conduct research on whale distribution in relation to prey distribution and the environment over a range of spatial and temporal scales. Several areas of mutual interest between the Scientific Committees of CCAMLR (SC-CCAMLR) and the IWC were identified:

(1) coordination of CCAMLR and IWC research activities;
(2) analysis of historical and recent datasets;
(3) CCAMLR surveys as platforms of opportunity for whale sightings;
(4) considerations for re-establishing minke whales as a monitoring species in the CCAMLR Ecosystem Program (CEMP);
(5) annual exchange of information.

To better achieve collaboration between CCAMLR and the IWC, the formation of a liaison group between the Scientific Committees of the IWC and CCAMLR was suggested. The SWG noted that the establishment of such a group was also endorsed by the Commission and recommended that this endorsement be forwarded to the 1998 meeting of the WG-EMM and SC-CCAMLR for final consideration. The SWG was informed that the first planning workshop for the CCAMLR Area 48 study would be held in June 1998 in La Jolla, California with a second workshop to follow the WG-EMM meeting in India. Committee participation was encouraged and Reilly confirmed that he would be attending the planning workshop in La Jolla. The SWG agreed that it would be especially beneficial to collaborate in the area of methodology development because of the similarities in krill and whale survey methodologies.

The CCAMLR planning workshop in La Jolla will focus on a retrospective analysis of existing physical and biological data for Area 48. The workshop convenor asked if the IWC could provide the following information for the area of interest: (1) an inventory of the relevant IWC data, (2) summaries of those data (graphic and tabular presentations), and (3) the actual datasets. Allison notified the SWG that there were two kinds of relevant data, namely the IWC catch data, which were available without restrictions and have already been transferred to CCAMLR, and other data for which restrictions need to be worked out before being released. Shimadzu informed the SWG that Japanese catch records would be made available to CCAMLR. Biological data, except age and reproductive status, for these catch records would also be made available. He indicated that the scouting boat data would also be accessible to CCAMLR. Reilly suggested that a small working group be established within the SWG to identify other sources of data that may be relevant for that area and to prepare a paper with these data for presentation at upcoming CCAMLR meetings.

A Working Group consisting of Allison, Borchers, Findlay, Hammond, Kato, Kock, Reilly, Slooten and Thiele was established to facilitate collaboration between the IWC and CCAMLR. Furthermore, the SWG suggested that the following persons from countries participating in the CCAMLR Area 48 krill survey communicate with their national CCAMLR representatives regarding these collaborative efforts: Hammond (United Kingdom), Kato (Japan), Reilly (United States), Thiele (Australia) and Findlay (South Africa). Russia was identified as a potential participant in the Area 48 study for which contact persons could be appointed at a later date.

6.1.3 SO-GLOBEC

A report of the SO-GLOBEC Planning Group (Hofmann, 1998) was presented, which outlined SO-GLOBEC's updated implementation plan for its 2000/2001 small-scale process studies. One outcome of this planning meeting was a narrowing of the project's focus in terms of target species and location, although an ecosystem approach of studying habitat, predators, prey, and competitors was still intended. The modifications to the existing SO-GLOBEC science and implementation plan included the following:

(1) selection of Antarctic krill (*Euphausia superba*) as the primary target species, including a focus on habitat, prey, predators, and competitors of this species;
(2) temporal expansion of the programme to a year-round study, with an emphasis on austral winter processes.

Two primary field sites were identified for the study: the Antarctic Peninsula region, and 70°E and the surrounding area. The Antarctic Peninsula area would be studied year-round through a multi-nation, multi-ship effort in order to obtain the recommended seasonal coverage, especially in the austral winter. Studies in the 70°E region would be primarily seasonal. Use of additional research sites, such as those occupied by national programmes, was encouraged providing studies there related to SO-GLOBEC research questions. Activities at these sites would be more seasonally limited, mostly to the austral summer, but would provide a slightly different focus for each area despite some overlap in activities. In addition to the SO-GLOBEC Programme, associated programmes were identified that support SO-GLOBEC-related research. For example, the Australian Southern Pelagic Monitoring Cetacean Program includes collection of cetacean sightings throughout the Antarctic 'season' on all voyages, a multidisciplinary winter polynya voyage (July-September 1998), and a fine-scale krill survey (1999/2000). It was suggested that the IWC could use the data from the 1999/2000 fine-scale survey as a pilot study to test data collection methodologies in preparation for its participation in the CCAMLR 2000 and SO-GLOBEC 2000/2001 projects. Given this suggestion, the importance of discussing optimal research methodologies at the upcoming Sightings Workshop in St Andrews was stressed. The SWG was informed that SO-GLOBEC also considers the 1998 polynya study as a good opportunity for methodology testing and expects the information from the project to be incorporated into its regional planning workshops. The first regional planning meetings for the SO-GLOBEC programme will occur in the next six months and the IWC was encouraged to participate, especially regarding input on the types of data that would be most suitable to collect in order to study linkages between baleen whales and their habitat and prey. The SWG agreed that it was important for the IWC to get involved early on with the planning of both the SO-GLOBEC and CCAMLR programmes.

Hammond presented an observer's report of the SO-GLOBEC Planning Group meeting in March 1998 (Appendix 3). Three items recommending IWC action were identified at the meeting:

(1) participation in SO-GLOBEC regional planning meetings;
(2) provide input on preferred measurements for small-scale process studies in order to increase overall the comparability of data by defining standard core measurements and methods;
(3) nominations of IWC participants for SO-GLOBEC working groups on data management and modeling.

A Working Group under the SWG, consisting of Fukuchi, Hammond, Hofmann, Palka, Reilly and Rogan, was established to facilitate collaboration between the IWC and SO-GLOBEC. Appendix 4 lists five SO-GLOBEC planning activities that will require IWC input in preparation for the 2001 field programme. Individuals to represent the Scientific Committee in these activities will be identified in consultation with the Chairman of the Committee.

6.1.4 Sightings Workshop

6.1.4.1 REPORT OF E-MAIL GROUP

As agreed at the last Scientific Committee meeting, an intersessional workshop is being planned to develop sightings and analysis methods for cetacean components of multidisciplinary research programmes. This Sightings Workshop is tentatively scheduled for late March 1999 and will be held in St Andrews, Scotland. Borchers presented a draft agenda and reported that potential participants and the workshop budget had been left for consideration by the full SWG at this meeting. The SWG found the agenda to be well organised and comprehensive but was concerned that the entire agenda could not be accomplished. After modifying the agenda to exclude trend estimation methods, the SWG agreed to the draft agenda. The group also noted the importance of having GLOBEC and CCAMLR participants at the workshop, especially in light of the sampling and analytical methodologies that may be common to all three groups.

A Steering Group, consisting of Borchers, Donovan, Hammond, Hoffman, Kato, Kock, Palka, Reilly and Thiele, was established to complete planning for the Sightings Workshop. The group was asked specifically to prepare a draft budget for the Commission, name invited participants and identify potential participants to present the review materials identified in the Workshop's draft agenda, item 2. The proposal, draft budget and planning schedule for the Sightings Workshop can be found in Appendix 5. Details regarding invited participants and sources of review papers will be determined through intersessional correspondence.

6.2 Habitat

The SWG reviewed several documents related to habitat. SC/50/E1 investigated minke whale sightings in relation to sea surface temperature in Area II (Weddell Sea) of the Antarctic using data from IWC/IDCR cruises from 1981/82 and 1986/87. Substantial differences in minke whale distribution were found between 1981/82 and 1986/87 and were attributed to yearly variation in oceanographic features of the Weddell Gyre. In 1986/87 the cold-water intrusion with sea ice in mid-January extended from the Antarctic Peninsula to 20°W, whereas in 1981/82 the feature only extended to 40°W. High densities of minke whales were observed in areas corresponding to the margin of the cold-water intrusion and in the region of offshore fronts between the cold-water and warm-water intrusions in 1986/87. In 1981/82, the cold-water intrusion was observed farther westward and the warm-water intrusion, although present, was weaker than in 1986/87. No clear offshore fronts were apparent between the cold- and warm-water intrusions in 1981/82 when higher concentrations of minke whales were observed in coastal areas and near sea ice edges.

Reilly thanked the authors for presenting SC/50/E1, which he cited as one type of study pertinent to the SWG's interest. He was encouraged that the large IWC/IDCR databases were being examined in relation to environmental variables and looked forward to similar investigations in the future. The discussion that followed noted it would be interesting to extend this type of study geographically and temporally. While noting the advantageous combination of environmental and top predator sightings data, the SWG noted that other accessible datasets containing more comprehensive oceanographic data exist and could further elucidate this relationship. The European Center for Medium Range Weather Forecasting (ECMWF) was identified as one source of such data. Some concern was expressed that sea surface temperature was not sufficiently indicative of the general oceanography and circulation of this environment in this part of the Southern Ocean. Thus, the potential benefit of using additional datasets that could provide more extensive measurements of the water column was re-iterated.

In SC/50/E2, interspecific relationships in density among whales on Antarctic feeding grounds were examined using sightings data from the Japanese Antarctic Research Program (JARPA) from 1989/90 to 1995/96 and the IWC/IDCR from 1978/79 to 1987/88. Environmental gradient effects were examined to determine their influence on potential interspecific relationships in cetacean densities. Differences in densities relative to environmental gradients between mysticetes and odontocetes were identified. Sperm whales and ziphiid densities were low in the continental shelf waters where minke whale densities were highest. No density associations between minke and humpback whales were found in any area. Density distributions of killer and minke whales were positively correlated. Between sperm whales and ziphiids no specific relationship in density was found. Environmental gradients were identified as the major factors covarying with the distributions and densities of whales in the area. However, after excluding these environmental gradient effects, a significant positive correlation in densities of minke and blue whales was observed except in the highest density areas of minke whales and of blue whales.

Reilly expressed his appreciation to the authors for submitting SC/50/E2, which incorporates environmental variables into an analysis of whale distributions and densities. The group recommended being cautious when drawing conclusions about interspecific interactions based on an empirical study such as this one. Although the group thought it inappropriate to draw conclusions regarding interspecific competition from such a study, it was encouraged by the environmental and multi-species aspects of the research.

Kato summarised SC/50/E3 on the oceanographic sampling during the IWC/SOWER/Blue whale cruises in 1995/96 and 1996/97. CTD and XBT profiles were collected in the middle latitudinal areas of the Southern Hemisphere. Although the primary purpose of the cruises was to establish criteria for distinguishing between true and pygmy blue whales, it was acknowledged that collecting oceanographic data concurrently with sightings data was important to studying whales' distributions. Kato informed the SWG that these data will be submitted to the IWC Secretariat and will be made available to the public with some restrictions. He also indicated that a continuation of this type of oceanographic sampling on subsequent cruises was intended.

DeMaster presented SC/50/CAWS18 which addressed critical habitat and abundance of right whales in the southeast Bering Sea. Based on data collected during a survey in the summer of 1997, density and abundance estimates for right whales for the middle and outer shelf domains of the southeast Bering Sea were made. In addition, the oceanographic conditions and features supporting the right whale population in this area were studied. In conjunction with retrospective analyses of sighting data since 1985, the results of this survey suggest that right whales predictably occupy the middle shelf and near-Inner Front regions of the Bering Sea shelf during the summer. These results are not consistent with historical distributions based on whaling records, although survey coverage of the areas of highest historical distribution was not possible during the summer 1997 cruise. The paper noted three

anomalous oceanographic conditions occurring in the Bering Sea during the summer of 1997. An extensive coccolithophore bloom was coincident with warmer than average sea surface temperatures and low macronutrient concentrations.

The density and abundance estimates were derived from the two sightings of right whales made during the survey. Since so few right whales were sighted, the probability of detection was based on sightings data for humpback whales. The SWG noted the difficulty of trying to produce reliable abundance estimates for rare animals with limited sightings data. However, it was encouraged that the researchers concentrated their survey efforts in an area where they predicted finding right whales based on previous sightings data and oceanographic characteristics. DeMaster noted that the marine mammal component of the cruise, which had a primarily oceanographic focus, was a 'piggyback' project and consisted of a small fraction of the entire scientific personnel. He cited this project as a good example of cooperation between biological and oceanographic researchers. The senior author of the paper (Tynan) intends to collect additional sightings data aboard a similar cruise in 1999, pending further funding.

DeMaster brought to the attention of the SWG to a recently published paper regarding the ecological importance of the Southern Boundary of the Antarctic Circumpolar Current (Tynan, 1998). Historical data on cetacean distribution and krill catches were used to show the importance of the Southern Boundary of the Antarctic Circumpolar Current to the complex and predictable food web of the Southern Ocean. It was noted that some of the cetacean distribution data used may be compromised because of unreported catches of whales by Soviet pelagic whaling operations. The author does not expect any changes in the original data source to significantly affect the reported results. The SWG noted that this study was the result of another successful piggyback operation. Reilly commented on the interest and importance of this paper for the SWG's long-term work on the ecology of whales in the Southern Ocean.

7. OTHER CONCERNS

7.1 Noise

Simmonds presented summaries of SC/50/E8 and E9. These papers provided overviews of the complex topic of noise in the oceans and its potential significance for marine mammals. It was noted that this topic is often difficult to address because of its highly technical and specialist nature, and a lack of published material coupled with a preponderance of grey literature. Both papers reviewed a number of topics including marine mammal audition, sensitivities to sound and the established sources of noise in the marine environment. It was suggested that observations indicating that an animal seemingly tolerates, and does not obviously respond to, a noise does not necessarily mean it was unaffected. However, behavioural responses typically were used to try to evaluate such impacts and Richardson *et al.* (1995) proposed a useful conceptual framework within which this might be considered (i.e. zones of audibility, responsiveness, masking, and possibly a zone of discomfort and injury). Various indicators of each type of response (such as the displacement of individuals or populations) can be sought. Overshadowing such impacts are considerations that relate to habituation and sensitisation. With respect to physical hearing damage (such as that concerning permanent threshold shift), the levels of energy required are presently unknown, although there was some evidence that vessel traffic may have caused this in one area (Andre *et al.*, 1997). SC/50/E8 and E9 considered established sources of marine noise as well as identifying the following new and potential important sources.

(1) Seismic surveys, which are extending now into deeper waters as technology improves, potentially bring such noise sources into more cetacean habitats. Sperm whales have been found to be displaced to an estimated distance of 60 km when seismic surveys took place in the Gulf of Mexico (Mate *et al.*, 1996). More recently, it has been confirmed that seismic guns also produce a significantly high frequency component in addition to the better-studied low frequency lobe (Goold and Fish, In press). Therefore, they are likely to be perceived by odontocetes as well as mysticetes, and indeed avoidance behaviour has been indicated in common dolphins in the northeast Atlantic Ocean (Goold, 1996).
(2) Sonars have been used in whaling since World War I and have recently provoked new controversy and concern, particularly during three research projects testing the responses of whales to the US Navy's Surveillance Towed Array Sensor System Low Frequency Active (SURTASS-LFA) sonar system.
(3) Other 'new' sources include those relating to the Acoustic Thermometry of Ocean Climate (ATOC) programme and the increasingly widespread use of acoustic anti-predation devices. The latter include 'seal scammers' employed in fish farms to deter predators as well as those attached to nets to reduce or eliminate bycatch. SC/50/E8 provided an example of the levels of noise produced by 'seal scammers' on fish farms in the Shetlands, Scotland. At a distance of 600m, levels were some 60dB above background. Some sources appeared to be pinging continuously. Further investigation of these devices was encouraged.

During its discussion of these papers and additional material presented by Clark (Appendix 6), the SWG noted the difficulty of assessing the potential impact of various sources of anthropogenic noise on marine mammal populations. The issue was raised of noise affecting marine mammals in ways currently undetectable to researchers. A serious handicap is the difficulty of obtaining various measurements that may better reveal an animal's responses to noise (e.g., heart rate). Irrespective of this, it may not always be accurate to assume no impact is occurring even in the absence of a measured response. Overlying these issues is the difficulty in defining the level at which an impact might be biologically significant. Thus, two concerns were identified when assessing studies that attempt to measure the impact of noise on marine mammals: (1) measuring the appropriate variables in a statistically sound way, and; (2) the biological significance of a response. Clark reported that sufficient sample sizes have been obtained in studies under the ATOC Marine Mammal Research Programme to address adequately the issue of statistical power in that study for some behavioural responses. However, in two of the three SURTASS-LFA research projects that have been conducted, Level I behavioural responses were not observed, and small sample sizes will limit the power of statistical analyses.

Previous studies conducted in grey whale breeding lagoons were discussed that compared responses of whales to novel versus more routine sounds. Novel sounds (such as pure tones and certain non-biological sounds) appeared to elicit more overt, obvious responses (such as flight or cessation of vocalisation) than more regularly occurring

sounds (e.g., outboard motors) to which the animals may be more accustomed. In addition, killer whale sounds were found to elicit an obvious flight response. Thus, the context of the sound was identified as an important aspect of the overall issue.

The SWG noted the large scope of assessing the impact of noise (both anthropogenic and non-anthropogenic) on marine mammals, and many important issues were identified here. While recognising that this issue is relevant and important, the SWG agreed that attempting a major initiative on the impact of noise on cetaceans was not within the current purview of the group. Furthermore, it was noted that given the limited amount of reliable data on the issue, it might be premature to conduct such a review. Since many sources of low frequency sound, such as the high levels of shipping noise, are not being monitored currently and information pertaining to similar sources (e.g., military exercises involving low frequency sound in the Mediterranean) is not readily available, the extent of information was thought to be presently insufficient to recommend a major initiative on this subject.

The need for more information on effects of noise also drew attention to a more general question regarding how to measure behavioural responses, a question which also arose in the sub-committee on Whalewatching (Annex J) and is discussed in the Report of the Workshop on the Comprehensive Assessment of Right Whales (SC/50/Rep4). Recognising both the importance of this issue and the gaps in the knowledge necessary to assess related impacts, a more comprehensive evaluation of the relevant sources of noise and their frequency ranges was suggested. Specific ideas included, for example, the more extensive use of pop-up acoustic recorders to better determine existing ambient noise levels in order to improve our characterisation of the underlying noise field. The importance of looking at the response side of the issue was also noted. A furthering of our understanding of the fundamental biological and physiological mechanisms involved, and an identification of methodologies appropriate to measuring the effects of noise on animals were recommended. The interdisciplinary nature of the investigations identified as relevant to addressing the larger issue of noise and marine mammals was emphasised.

7.2 Ozone depletion

DeMaster summarised SC/50/E4 on the mechanisms by which ozone is destroyed, the recent trends in ozone depletion in polar regions, and the sources of ozone and UV/B measurement in the Arctic. Ozone depletion occurs when chlorine activation occurs (during cold winter periods) and sunshine is present. Thus, ozone loss typically occurs in February and March. Factors contributing to the non-homogeneous pattern and interannual variability of ozone depletion were reviewed. The 1997 polar-averaged, column-integrated ozone depletion was approximately 21% and was comparable to the depletions observed during the previous four winters. Sources of ozone measurement in the Arctic include several satellites and ground stations. Geographic coverage by the ground stations is patchy and is thought not to sample the Arctic adequately. The paper lists several ongoing programmes investigating ozone depletion in the Arctic.

The SWG was reminded of the thorough summary of the potential impacts in the Arctic and the Sub-Arctic presented in Hayman and Parr (1997). It had been noted there that potential ecological consequences of ozone depletion include altered trophic interactions, reduced biomass production, changes in species composition and diversity and alterations of biochemical processes.

The SWG noted that while several studies have been undertaken on the relationships between UV and various biological processes, such as photosynthesis in plankton and larval fish development, further research to elucidate the connections between ozone depletion and biological productivity was encouraged.

7.3 Physical and biological habitat degradation

An idea was presented for an intersessional workshop on habitat degradation and its effect on cetacean populations (Appendix 7). After considerable discussion it was agreed that the preferable course might be to combine important aspects of the proposal with one recommendation from the Right Whale Workshop to focus on defining and estimating critical habitat for cetaceans. It was agreed that a proposal combining these two initiatives would be presented to Plenary if one could be developed at this meeting.[1]

As discussed at last year's meeting, the review of information on certain environmentally related activities, such as oil and seismic exploration, would be helpful to focus the Committee's work on these issues in the future. Thiele informed the SWG that she and V. Peddemors were preparing such reviews.

The SWG noted the submission of SC/50/O7, which reported oceanic debris observations from the eastern edge of the Indian Ocean Whale Sanctuary, and thanked the authors for bringing this information to the attention of the Committee.

7.3 Effects of fisheries

Kemper and Gibbs (1998) reported marine mammal entanglements in tuna farms in South Australia. The SWG noted that because plans to build similar fish farms in other countries have been proposed, they are a potential source of marine mammal mortality.

The SWG recognised that SC/50/SM2 included information on bycatch of cetaceans in fisheries, but did not consider at this point that it was its function to compile such information, which was reviewed elsewhere in the Committee (Annex I). The group considered it an appropriate subject for an in-depth review at a later date.

7.4 Disease and mortality events

O'Hara summarised O'Hara *et al.* (1998), which presented results of a viral serologic survey of bowhead whales in Alaska. Although the impact of the viruses identified on bowhead whales could not be determined from this serological study, the level of exposure to the various viruses and the disease distribution were studied. Disease ecology was identified as a potentially informative way to understand better the effect of various environmental alterations such as climate change and habitat degradation on animals. However, it was stressed that more background work on how disease impacts animals, be it through direct mortality or through nutritive or reproductive level effects, needs to be pursued. The SWG agreed that such a scientific basis was required for understanding effects on cetaceans of complex environmental problems and encouraged studies in this direction.

[1] Editors note. After the conclusion of the sub-committee, it was agreed to try to develop a proposal for next year.

Simmonds presented SC/50/E7 which drew the SWG's attention to possible new opportunities for collaboration arising from recent international developments, particularly those relating to the 'Year of the Ocean,' and identified some major perturbations in the marine environment that occurred since the last meeting. These included the pinniped mortalities in Latin America associated with the El Niño phenomenon. The authors suggested that any similar associated losses in cetacean populations would be more difficult to detect. They also noted that this winter a further series of sperm whale multiple live stranding events had occurred in the North Sea (SC/50/ProgRep Germany).

Simmonds also presented Simmonds (1997) which suggested a framework to consider cetacean strandings. The SWG noted that attempts to understand better the meaning of cetacean strandings were important, albeit ambitious. Nevertheless, it was recognised that information gathered from strandings, when viewed from a larger context and considering possible environmental effects, could help build a basis for understanding these events. Von Bismarck informed the group of the ongoing programme 'HEED Global Change' at Harvard University, which organises historic data in one standard format, assesses the integrity and coverage of the data, and provides a method for interpreting marine mammal stranding events in the context of coastal environmental change. The programme proposes a global marine mammal monitoring network and offers its methodology and skills towards such an effort.

8. ARCTIC

SC/50/E4, which is of relevance to this Item, was discussed under Item 7.2.

In SC/50/AS15, large annual variations in the number of bowhead whales at Isabella Bay, Baffin Island were reported, with few whales being observed in El Niño years. The author reported that regional distribution patterns are consistent with historical data and provide a better understanding of the influence of climate and ice on behaviour and distribution. For further discussion of this paper, see Annex G.

The subject of environmental concerns in the Arctic was discussed further under Item 9. The SWG agreed to establish an e-mail group to address this subject, and members interested in participating were instructed to contact DeMaster or O'Hara.

9. LONGER-TERM PRIORITIES AND DIRECTIONS

In further discussion of Arctic environmental issues, it was agreed that a research initiative focussing on Arctic cetaceans would be appropriate at some time in the future. Some members commented that because the Small Cetacean sub-committee was intending to focus on white whales and narwhals at the 1999 Scientific Committee meeting, this will provide an impetus for the SWG to focus on environmental concerns for these species, which had been identified as priority species in both the Pollution and Climate Change Workshops. It was agreed that both this project and the habitat definition/degradation initiative would be of lower priority in the coming year than the two ongoing research initiatives.

SC/50/E7 mentioned some recent marine environmental perturbations with comments on the implications for the IWC. In a vein similar to this paper, some members proposed to form an informal information review group to collect and review intersessional developments in the marine environment likely to impact cetaceans, and to provide the SWG with what might be called an 'Annual State of the Cetacean Environment Report.' The group might collaborate with the Emergency Task Force of the Marine Mammal Action Plan. Slooten, Simmonds and von Bismarck offered to act as focal persons for information collection and report production.

The SWG was informed that ICES has formed a Working Group on Marine Mammal Habitat Issues. It was noted that many of the concerns (pollutants and contaminants, noise, etc.) the group is addressing are shared by the SWG. Donovan and Reijnders will participate and represent the SWG's interests in future meetings of the ICES Working Group.

After considerable discussion, the SWG agreed that its priorities for the near-term and mid-term could be summarised as follows.

(1) The two ongoing research initiatives were identified as having the highest priority:
   (a) significance of pollutants and chemical contaminants on cetaceans;
   (b) baleen whale habitat and prey studies in the Southern Ocean related to climate change (with CCAMLR and SO-GLOBEC).
(2) The following two projects were considered next in priority:
   (a) identifying and evaluating the parameters defining cetacean habitats, and use of those to evaluate the effects of physical and biological habitat degradation on cetaceans;
   (b) investigating effects of environmental change on populations of Arctic cetaceans.
(3) The SWG identified a number of other issues it considered important, but that were not identified as priority items for the upcoming year. They include:
   (a) investigating the impact of environmental factors found in individual cetaceans for consequences on the population level;
   (b) investigating the possible impact of oil pollution on cetacean health.

10. INTERSESSIONAL WORK PLAN

Intersessional activities were planned under the agenda Items given in Table 1 (estimated costs given in brackets).

Table 1

Planned intersessional activities.

Item	Activities
5.	Pollutants and contaminants Prepare and hold the Planning Workshop (Barcelona, November 1998) related to the pollutant and contaminants research initiative (no new funds required)
6.	Climate change and habitat Complete planning and conduct the Sightings Workshop (St Andrews, March 1999) (£25K) Continue planning activities in conjunction with CCAMLR and SO-GLOBEC for the SOWER 2000/2001 programme (£7K)
7.	Other concerns Refine proposal for a workshop on habitat definition/degradation, and, if funding is secured, hold the workshop intersessionally (no estimate available yet)
8.	Arctic Establish an e-mail group to identify potential issues and activities related to assessing environmental effects on Arctic cetaceans (no cost)

11. OTHER BUSINESS

There was no other business discussed.

12. ADOPTION OF REPORT

The report was adopted as amended.

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Appendix 1

AGENDA

1. Convenor's welcoming remarks
2. Adoption of Agenda
3. Arrangements for meeting
   - 3.1 Election of Chairman
   - 3.2 Appointment of rapporteur(s)
4. Review of documents
5. Pollutants and contaminants
   - 5.1 Review of progress on research initiative
   - 5.2 Other topics
6. Climate change and habitat
   - 6.1 Review of progress on SOWER 2000 planning
     - 6.1.1 Report of e-mail group
     - 6.1.2 CCAMLR
     - 6.1.3 SO-GLOBEC
     - 6.1.4 Sightings Workshop
       - 6.1.4.1 Report of e-mail group
   - 6.2 Habitat
7. Other concerns
   - 7.1 Noise
   - 7.2 Ozone depletion and UV/B
   - 7.3 Physical and biological habitat degradation
   - 7.4 Effects of fisheries
   - 7.5 Disease and mortality events
8. Arctic
9. Longer-term priorities and directions
10. Intersessional work plan
11. Other business
12. Adoption of report

Appendix 2

SKIN/BLUBBER BIOPSY PROTOCOL

M. Moore

Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543-1049, USA

Skin/blubber biopsy protocol – fixed samples only

Need

Vials of 10% formalin. After biopsy is retrieved, place on ice pack until you can work on the sample. Please try and keep the time delay as short as possible. Less than an hour is OK, more than three hours reduces sample quality.

To divide the samples

(Pursue instrument and biopsy tip clean up as needed by chemistry agenda if there is one). Remove biopsy from dart by pulling out with forceps from the threaded end. Make a pair of cuts through the whole plug, with the plug on the cutting plate, to generate a 2mm or less, central slice. Place the slice in formalin – in the fluid-filled plastic vial. Take the two outer remaining pieces. Cut off skin and place in DMSO. Place blubber in the glass vial for chemistry. Place blubber vial on ice and freeze in regular freezer as soon as possible. Keep formalin slice at room temperature. **Do not freeze.** Label all vials with Date, ID and Lat. Long. The fixed slice need not have the full depth of skin, or blubber. The area of special interest is 2mm above the 4mm below the skin/blubber (black/white) interface, with as much surface area as possible in two dimensions. The slice can be as thin as you can cut it (see Fig. 1).

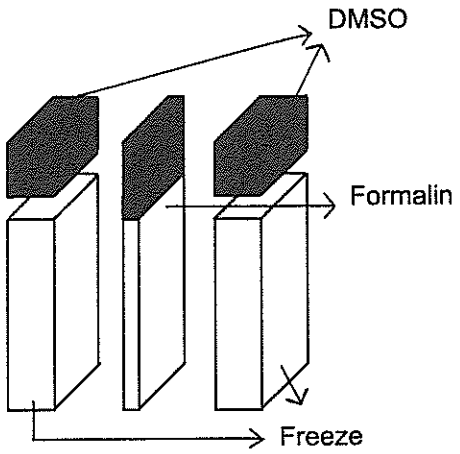

Fig. 1.

The protocol is easy to do in the field and is compatible with genetic and organic chemistry agendas. The volume of hazardous reagent (formalin) is very approximately 3ml per sample.

Skin/blubber biopsy protocol – fixed and frozen

Need

Styrofoam box or cooler for keeping samples cold and shipping frozen samples. Scalpel handle, blades, forceps, cutting plate, methylene chloride, liquid soap, vials of 10% formalin, glass vials for chemistry, marking pens, freezer block, parafilm, dental brushes.

Prior to shooting, clean tip thoroughly with soap and water if possible, using the dental brush to get inside. Dip in methylene chloride using forceps to hold. After biopsy is retrieved, place on ice pack until you can work on the sample. Please try and keep the time delay as short as possible. Less than an hour is OK, more than three hours is pushing it.

To divide the samples

It is possible to do this in a *Zodiac* – a small tray would help – the lid of a cooler will do. Clean cutting plate with soap and water – at least at start of day. Wipe dry and rinse with methylene chloride between samples. Assemble a scalpel blade in its handle, wash with soap and rinse in methylene chloride before use. (None of the clean up protocol needs to be followed if you are not freezing for chemistry analysis – the fixed samples are unaffected by handling as long as they are not frozen or overheated.) If you have to use a lubricant on the dart use KY jelly, not any grease based ointment if you are sampling for chemistry. If dart is flamed, follow this with a methylene chloride rinse.

Remove biopsy from dart by pulling out with forceps from the threaded end. Make a pair of cuts through the whole plug, with the plug on the cutting plate, to generate a 2mm or less, central slice. Place the slice in formalin – in the fluid-filled plastic vial. Take the two outer remaining pieces. Cut off skin and place in DMSO. Place blubber in the glass vial for chemistry. Place blubber vial on ice and freeze in regular freezer as soon as possible. Keep formalin slice at room temperature. **Do not freeze.** Label all vials with Date and ID. The fixed slice need not have the full depth of skin, or blubber. The area of special interest is 2mm above and 4mm below the skin/blubber (black/white) interface, with as much surface area as possible in two dimensions. The slice can be as thin as you can cut it (see Fig. 1).

The protocol is easy to do in the field and is compatible with genetic and organic chemistry agendas. The volumes of hazardous reagents (formalin and methylene chloride) are small.

Appendix 3

OBSERVER'S REPORT OF THE MEETING OF THE SOUTHERN OCEAN GLOBEC PLANNING GROUP, PARIS, FRANCE, 17-20 MARCH 1998

P.S. Hammond

The GLOBEC Southern Ocean Planning Group met for the second time during the GLOBEC Open Science Meeting held at UNESCO Headquarters, Paris, France, 17-20 March 1998. The objectives of the SO-GLOBEC meeting were to assess the current state of planning for Southern Ocean GLOBEC field activities and to set a time line for possible field studies in the Antarctic Peninsula and 70°E regions.

At the first SO-GLOBEC Planning Meeting, held in San Diego, CA, 1-3 August 1997, it was decided that field activities would take place beginning in field season 1999/2000. The field activities were to be concentrated in the Antarctic Peninsula area and the 70°E region, have six months of continuous coverage, and encompass the summer and winter seasons. At the end of the August 1997 meeting there was a possible ship schedule scenario for the Antarctic Peninsula that would provide the coverage needed to address the SO-GLOBEC science objectives. However, since then the objectives of several national Antarctic programmes have changed, requiring changes in ship schedules. As a consequence of these changes, the primary field effort for SO-GLOBEC will now be delayed until 2000/2001. It has been determined that sufficient ship resources will be available within this time frame to provide year-round coverage in the Antarctic Peninisula region and seasonal coverage, especially in the winter, in the 70°E region. The next effort for SO-GLOBEC will consist of focussed regional planning meetings that will design the field study efforts. These meetings will take place within the next six to eight months. Participation by the IWC in these planning efforts is encouraged.

Prior to the 2000/2001 SO-GLOBEC field effort there will be studies in limited regions that will provide information related to SO-GLOBEC science objectives. The particular emphasis of these studies will be on winter processes, especially the overwintering strategies of Antarctic krill (*Euphausia superba*). Potential studies within this time frame comprise a March-May 1999 German cruise and three Australian cruises in 1999 (July-August, September-October, December) that will focus on demographic features of krill populations. The Australian cruises will provide a limited time series of winter to summer changes. The British Antarctic Survey core programme at South Georgia in 1999/2000 is focussed on various aspects of krill biology. The results of these field efforts will be incorporated into planning for the larger field effort.

The SO-GLOBEC Planning Group identified a critical need for standardization of techniques that should occur across regions. In particular, there is a need to standardize winter krill measurements. A set of core measurements for the next two-year period prior to the larger field effort is required. An effort is now underway through SO-GLOBEC to define standard core measurements and methods so that data from different regions and times can be directly compared. Input from the IWC on measurements for the short-term focus studies (1999/2000) is requested.

Given the multinational effort required for a year-round SO-GLOBEC field programme, the need for a central coordination office was identified. At present, discussions are underway with the individuals/nations that have expressed an interest in hosting this office. It is anticipated that the SO-GLOBEC coordination office will be established within the next six to eight months. It will be separate but coordinated with the International GLOBEC Planning Office at the Plymouth Marine Laboratory in England. This will allow coordination with other International GLOBEC and IGBP programmes.

SO-GLOBEC is in the process of setting up working groups on data management and modelling. Nominations for membership in these working groups have been received and additional nominations are being solicited. Nomination of individuals from the IWC community would be welcome.

IWC participation in SO-GLOBEC was welcomed by all members of the Planning Group. It was felt that IWC participation could only benefit the science objectives of SO-GLOBEC. It was also believed that collaboration between SO-GLOBEC and IWC would further the IWC interests in determining potential effects of climate change on cetaceans. The SO-GLOBEC field effort will provide an opportunity to map the distribution and estimate the relative abundance of cetaceans in relation to krill distribution and abundance in the Antarctic Peninsula and 70°E regions. By supplementing existing studies with other vessels it will also allow investigation of changes in baleen whales foraging behaviour in response to changes in krill distribution and abundance.

Collaboration with the IWC provides SO-GLOBEC with an opportunity to obtain information on top predators.

Appendix 4

IWC PARTICIPATION IN SO-GLOBEC

(Exclusive of field activities)

1. Nomination of an individual for SO-GLOBEC Modelling Working Group (D. Palka):

   Provide support for individual to attend working group meetings;
   1 meeting/18 months;
   Potential venue - British Antarctic Survey, Cambridge, England.

2. Nomination of an individual for SO-GLOBEC Data Management Working Group (C. Allison):

   Provide support for individual to attend working group meetings;
   1 meeting/18 months;
   Potential venue - to be determined.

3. Designate individual(s) to attend Antarctic Peninsula field study planning meeting and provide support to attend meeting (Reilly and/or Hammond, depending on venue):

   Meeting to occur in early autumn 1998 (3-4 days);
   Potential venue is US or Germany (AWI).

4. Designate individual(s) to attend 70°E field study planning meeting and provide support to attend meeting (D. Thiele):

   Meeting to occur in early autumn 1998;
   Potential venue is Hobart.

5. Request input from IWC on measurements and methodologies for short term focus studies in 1999-2000 (E. Rogan):

   Done by e-mail, no financial support needed.

Appendix 5

PROPOSED WORKSHOP TO DEVELOP SIGHTING SURVEY METHODS FOR MULTIDISCIPLINARY CRUISES

At its 1996 meeting the IWC Scientific Committee agreed upon several long-term objectives for research that may allow the prediction of the effects of environmental change on cetaceans. These can be combined into an overall objective to

> 'Define how spatial and temporal variability in the physical and biological environment influence cetacean species in order to determine those processes in the marine ecosystem which best predict long-term changes in cetacean distribution, abundance, stock structure, extent and timing of migrations and fitness'.

At its 1997 Annual Meeting, the Committee endorsed the research proposal 'Baleen whale habitat and prey interactions in the Southern Ocean' (referred to here as the SOWER2000 programme) as a means for addressing the above overall objective. The Committee concluded that an intersessional workshop would be an effective means to develop methods for data collection and analysis for whale sighting surveys to be conducted as part of multidisciplinary resource assessment cruises, as proposed in the SOWER2000 research programme.

The proposed surveys differ from the standard IWC sightings surveys in two fundamental ways.

(a) First, the primary goal of collecting sightings data is not to estimate total abundance of whales of a population or stock, but rather to quantify the relationships between whales and their environment and prey. In the context of SOWER2000, this will be done to gain information and test hypotheses on processes linking whales to their environment and prey, to provide insight into likely effects of climate change.

(b) Second, the primary activities of the cruises will be directed at plankton and oceanography in the case of SOWER2000 (but may be other items on other cruises, such as fish or cephalopods). Consequently the amount of time available to close on sightings will be limited, and most effort from vessels sampling plankton and oceanography will have to be in so-called passing mode.

An e-mail group was established to work intersessionally '...towards developing more detailed information including a draft agenda, suggested venue and budget and potential participant list.' Building on the work of that group, the SWG proposes the following.

Objectives

General objective: To develop methods for data collection and analysis for cetacean sightings surveys to be conducted as part of multidisciplinary resource assessment cruises.

Specific objective: To develop methods for use on the SOWER2000 programme.

Steering Committee

Borchers and Hedley (Convenors), Donovan (IWC), Hammond, Hofmann (SO-GLOBEC), Kato, Kock (CCAMLR), Palka, Reilly, Thiele.

Venue: University of St Andrews, Fife, Scotland.
Date: 5 days, 23-27 March 1999 (to be confirmed).

Draft Agenda

In the context of the SOWER2000 programme, and more generally, there are three types of sightings survey which need to be considered by the proposed workshop:

(1) 'piggyback' surveys (on CCAMLR and/or SO-GLOBEC vessels in the SOWER2000 context);
(2) small-scale surveys using IWC vessels(s) in conjunction with SO-GLOBEC (or equivalent) survey vessels, to estimate the small-scale distribution of whales in relation to prey, oceanographic and environmental variables; and
(3) larger-scale surveys using IWC vessels(s) in conjunction with vessels gathering data on the large-scale distribution of prey, oceanographic and environmental variables (CCAMLR vessels in the SOWER2000 context).

In addition, (2) or (3) might be combined with (1). The workshop should consider design and analysis methods for each type, as well as design and analysis for combinations of types. While the workshop will consider methods for multidisciplinary surveys in general, it will prioritise methods and issues relevant to the SOWER2000 programme.

With this in mind, the following agenda is proposed:

1. Overview of the SOWER2000 programme.

2. Reviews
   - 2.1 Design, procedures and operational constraints
     - 2.1.1 Review of similar full or pilot surveys conducted in the past
     - 2.1.2 Review of CCAMLR & SO-GLOBEC survey design and operational constraints
   - 2.2 Analysis methods
     - 2.2.1 Reviews of analysis methods for sightings, environmental and prey data, and associated data requirements
       - 2.2.1.1 Multivariate ordination methods
       - 2.2.1.2 Spatial modelling methods
       - 2.2.1.3 Distance sampling methods
       - 2.2.1.4 Other relevant methods
     - 2.2.2 Review of methods used by CCAMLR and SO-GLOBEC to analyse their data
   - 2.3 Overview of methods of integrating process models and survey data

3. Operational characteristics of the multidisciplinary cruises, and how to best collect sightings data on each type of survey
   - 3.1 Closing *vs* Passing mode
   - 3.2 School size estimation methods
   - 3.3 Responsive animal movement
   - 3.4 Use of complementary survey platforms (e.g. a helicopter operating from a ship; passive acoustics)
   - 3.5 Data gathering aids (computerised data entry, binoculars, angle boards, distance estimation aids)
   - 3.6 Target species considerations
   - 3.7 Other

4. Use of the data for making inferences about things other than relationships between whales, their prey and their environment
   - 4.1 Increasing the precision of abundance estimates
   - 4.2 Estimation of cetacean distributions

5. Recommendations
   - 5.1 Design of cetacean component within multidisciplinary surveys
   - 5.2 Analysis methods for sightings, environmental and prey data
   - 5.3 Recommendations regarding Cruise Planning Meeting for 2000/1 survey in conjunction with SO-GLOBEC in Area I.
   - 5.4 Identification of further work needed

6. Other

Workshop documents

The success of the workshop will depend on the preparation and presentation of papers giving background information and papers dealing with proposed survey and analysis methods. Below is a tentative list of topics to be covered by solicited documents.

The Steering Committee will develop guidelines to be distributed to prospective authors to focus the reviews on issues relevant to the workshop. Unsolicited papers on relevant topics which will help further the aims of the workshop would also of course be most welcome.

1. Logistic constraints for SOWER2000
   - 1.1 Cetacean survey from CCAMLR vessels
   - 1.2 Cetacean survey from SO-GLOBEC vessels
   - 1.3 IWC Survey vessels
2. Review of survey methods
   - 2.1 SO-GLOBEC
   - 2.2 CCAMLR
   - 2.3 Australian fine-scale krill process survey
   - 2.4 Similar multidisciplinary surveys
   - 2.5 Cetacean surveys
   - 2.6 Data gathering aids
     - 2.6.1 Computerised data entry
     - 2.6.2 Acoustics
     - 2.6.3 Other
3. Review of existing and proposed analysis methods
   - 3.1 Distance sampling methods
   - 3.2 Multivariate ordination methods
   - 3.3 Spatial modelling from line transect data
   - 3.4 Small-scale process study analysis
   - 3.5 SO-GLOBEC analysis methods
   - 3.6 CCAMLR analysis methods
4. Integrating process models and survey data
   (Models for investigating the effect of a changing environment on cetaceans must ultimately integrate small and large-scale process models with empirical models featuring spatial, oceanographic and/or environmental covariates so that uncertainty in all components is correctly handled. While the development of integrated models is beyond the scope of this workshop, data collection on the SOWER2000 and similar surveys should be informed to some extent by this ultimate use of the data)
   - 4.1 Overview of integrated analysis methods
   - 4.2 Implications of integrated analysis for data collection methods

Schedule

Some relevant meetings which will involve IWC input in relation to the SOWER2000 Programme:

(a) 26th–28th June 1998: CCAMLR Logistics and Planning meeting for their large-scale synoptic krill survey in 1999/2000.
(b) Early Northern Hemisphere Autumn 1998: SO-GLOBEC Planning meeting.

Workshop schedule:

(1) Immediately after the 1998 IWC meeting: invite participants; send background material (including annotated draft agenda and extracts from IWC reports

and the report of the intersessional planning meeting to discuss research on climate change and cetaceans) to possible participants, CCAMLR and SO-GLOBEC.

(2) As soon after 1998 IWC meeting as possible:
   (a) solicit workshop papers;
   (b) submit documents to SC-CCAMLR chairman and CCAMLR secretariat describing workshop and encouraging participation (Reilly to attend CCAMLR large scale synoptic krill survey logistics and planning meeting).

(3) Before autumn 1998 SO-GLOBEC Planning Meeting: Submit document(s) to SO-GLOBEC meetings describing workshop and encouraging participation. (IWC Scientific Committee member to attend SO-GLOBEC Planning Meeting.)

(4) February 1999: circulate meeting agenda, arrangements and (as far as possible) workshop papers.

(3) March 1999: hold workshop and produce report.

Budget

15 Invited Participants:	£24,500

SO-GLOBEC will fund the attendance of SO-GLOBEC scientist(s) at the workshop.

Funding for CCAMLR scientist(s) to attend the workshop will be sought from CCAMLR.

Equipment & Consumables:	£500
Total:	**£25,000**

Appendix 6

ON THE SUBJECT OF THE POTENTIAL IMPACT OF HUMAN-MADE NOISE ON WHALES

C.W. Clark

Recently there has been a dramatic increase in awareness of the potential impact of anthropogenic noise on marine mammals. The publicity surrounding this issue has highlighted our general ignorance on the subject and led to a tremendous amount of interest in and speculation about the likely consequences of exposing whales to man-made, underwater noises. My point here is to encourage continued awareness of the potential problem, while proposing that solutions should best come through scientific research and careful evaluation of evidence. The subject is complex, and real progress will come from interdisciplinary collaborations between biologists, oceanographers, underwater acousticians, auditory physiologists and statisticians.

Payne and Webb (1971) were the first to publish on this subject as it relates to the impact of shipping noise on baleen whale communication. They hypothesised that the increase in low-frequency ocean noise resulting from the increase in ocean shipping, starting with the advent of engine driven ships in the 19th century, could reduce the area over which animals can communicate by several orders of magnitude. In 1992-93, ATOC (the oceanographic research project led by Walter Munk at Scripps and intended to provide the critical empirical data by which to validate existing models of ocean-atmospheric heat exchange) was a lightening rod for concern on the impact of noise on marine mammals. The ATOC source transmits an m-sequence of coded '1's and '0's (a phase shifted 75Hz, 30Hz bandwidth signal at a source level of 195 dB re 1 μPa-1m) through the ocean, and receptions of the signal at remote sites are used to estimate the average ocean temperatures along multiple deep-ocean pathways. Post-processing gain allows detection (NOT audition) of the coded signal at ranges out to 5,000km, and the source signal samples the entire water column. There are two sources presently installed on the seafloor, both at depths of approximately 900m. One source is on the Pioneer seamount 85km off central California, and the other 14km off north Kauai, Hawaii. To date all use of the sources, except for brief periods of engineering testing, have been under the direction of a marine mammal research program.

Lack of basic information on auditory thresholds, behavioural responses, and numbers and distributions of whales made it difficult to predict the level of impact from ATOC sound transmissions. Lack of scientifically based evidence to bracket the risk combined with a broad passion for whales led to speculation that the ATOC sound could deafen whales, drive certain species to extinction, and otherwise wreak havoc on the ocean environment. This over reaction did have the positive effect of drawing together various scientific groups with vested interests in ocean systems. These initiated constructive discussions between scientists, concerned citizens, regulatory agencies and environmental groups which furthered the process of identifying the major gaps in knowledge and the research priorities that would provide information about the potential impact of man-made underwater sounds on whales. Sometimes, the lack of evidence on the subject was cited as good reason to do nothing. Other ongoing or planned acoustic research experiments that had not come forward to ask for either a permit or authorisation, continued; having seen that in the United States at least, it was best to avoid admitting that one was using sound to explore the ocean.

In summer 1996, the US Navy publicly announced that it would develop an Environmental Impact Statement (EIS) for its Surface Towed Acoustic Surveillance System Low Frequency Active (SURTASS-LFA) sonar. Many outreach meetings were held, a panel of scientific experts was formed to review present knowledge and recommend directions for research, and a sequence of research projects was planned (referred to as the LFA-Scientific Research Program = LFA-SRP). It is interesting to note that the two programs (ATOC and LFA-SRP) that have included significant marine mammal research programs to actually gather evidence on the potential impacts of man-made low-frequency sounds on marine mammals have received the greatest criticism. Clearly the issue is of great concern, and these research programs are only the first steps toward resolving the matter.

What is the basis for concern that low-frequency sound could harm whales? Essentially it is as follows.

(1) Whales are known to produce a great variety of sounds in the 10-1000Hz frequency range. Since whales produce sound, and light does not provide as effective a modality for communicating underwater, then whales rely on sound for survival more than they rely on any other sensory system. Dolphins use sounds for echolocation to 'image' their environment and are therefore a supporting example for the notion that whales rely mostly on sound.
(2) Sound travels a long way underwater and human activities introduce a lot of sound into the ocean. The physics of sound propagation in the ocean is a rapidly advancing science. Over the past 50 years humans have learned how to exploit underwater sound transmission properties as a means of probing the ocean, especially for industrial, military and scientific purposes. Noise from commercial shipping is by far the greatest anthropogenic contributor to ocean noise in the frequency band below 100Hz.
(3) There is a potential conflict between the animals' dependency on sound for survival and our increasing use of and production of low-frequency sounds. We do not yet know enough about what levels of sound exposure could physically harm whales. We do not know very much at all about the biological functions of acoustic signalling behaviour in whales and over what ranges this behaviour is used. Basic understanding of the functional significance of acoustic signalling behaviour are necessary to know the level of impact of such things as masking or acoustic interference.

There are a few, well supported cases where whales have been shown to react to human-made low-frequency (<500Hz) underwater sounds by avoiding some area surrounding the sound source. Thus, gray whales responded to playback of industrial noises by avoiding the area within 100-200m of the source, while bowhead whales have been observed avoiding (at ranges of *ca* 20km) areas of high industrial noise activity.

To the best of my knowledge, no observed responses by whales to human-made underwater sounds have been interpreted as biologically significant. The eastern Pacific gray whale population has increased throughout this century in the face of increasing human-made noise, even though animals have abandoned a calving/breeding lagoon when industrial activity was high. All indications are that the population of humpbacks that come to breed and give birth off Hawaii is increasing despite an increasing level of human activity (commercial and recreational) on and under the water.

Efforts to define potential noise impacts have oversimplified the mechanisms of impact by assuming that animals are responding to the sound's received level, rather than some other acoustic features of the sound field (e.g., sound gradient, bearing rate, spectral distribution). In most cases, estimating received level has used very simple models (spherical or cylindrical spreading loss) for predicting transmission loss between the sound source and the whale. Such models are relatively accurate at close range to a sound source (< 1km, where a good rule of thumb is –60dB loss at 1km), but these are not good predictors of sound exposure when animals are further from the source or when the source is not omnidirectional. Depth of the whale and its dive depth profile are critical for estimating sound exposure and its history of exposure. Most recently, collaborations with oceanographers and underwater acousticians have resulted in procedures for accurately estimating acoustic exposure by using sophisticated, empirically verified, models of transmission loss. It is imperative when attempting to determine relationships between low-frequency sound impact and animal responses, that sound exposure parameters be derived from an empirically verified transmission loss model and that depth of the animal is properly accounted for. Even in the best of circumstances one should expect estimates of acoustic exposure level for a given range and bearing from a sound source to have an uncertainty of ± 4-5dB.

Impacts can be divided into two categories, those that cause physical damage and those that only elicit a behavioural response. Physical damage may or may not have a biological impact, but it is widely agreed that such an impact is unacceptable. Physical harm to an animal will most likely occur either at a very high exposure level over a short time period, or after repeated and long-term exposure to high levels. There are no definitive data on what acoustic levels are damaging, but a typical assumed level has been that damage could occur from exposure to broadband received levels of > 180dB re 1 μPa.

A behavioural response can be obvious; for example, an observation of an individual whale orienting and swimming away from a sound source. It can also be statistical, for example the average swimming speed for a sample of whales is significantly different than that of a control group. Extrapolation of biologically significant impact based on a behavioural response requires interpretation of the biological context and some hypothetical extrapolation to a scale that involves a population. Thus, for example, migrating animals will most likely respond differently to a given sound source than will feeding animals. A few observations of animals responding to a noise source or a result indicating a statistically significant response is not necessarily evidence of a biologically significant or population level impact.

We have just completed several months of field research off north Kauai studying the responses of humpbacks to the ATOC sound. For California, we have just restarted the marine mammal research program, which includes aerial surveys, elephant seal translocations, and acoustic monitoring using seafloor acoustic recording units. All field research is expected to end in 1998. To date, there are no results from any of the ATOC marine mammal research indicating biologically significant responses. However, a few statistically significant differences have been found. For example, with sperm whales, when the average distance of all groups seen in the same aerial survey is the unit of analysis, there is a significant difference between whales seen during periods with ATOC transmissions compared to periods without ATOC transmissions. There is no statistically significant difference when the unit of analysis is the average distance of the group. There is no acoustic feature (estimated received level or number of exposures) that can be directly related to this statistically determined effect since the average sound exposure levels for the control and experimental conditions are essentially identical.

All three phases of the LFA-SRP project have been completed. In Phases I and III, when the actual vessel operating the LFA source was used to generate a sound field, there were no obvious and consistent responses during playback of the LFA sounds. In Phase I there was a statistical difference in the number of blue or fin whales producing patterned sequences of sounds, where the number of whales was determined subjectively during the field work. This result has not yet been verified from quantitative analysis of

the recorded data. In Phase I some animals were exposed to received levels as high as 150dB re 1 μPa and appeared to behave normally. In Phase III, although there were a few cases when a humpback whale terminated singing or moved away from the vessel, most whales continued to sing and engage in social interactions during exposure to LFA, even in cases when the received level at the whale was as high as 140-145 dB re 1 μPa. These results were surprising to the biologists collecting behavioural response data, since we expected responses at received levels of this magnitude. We did, however, observe responses to the approach of the observation vessel collecting behavioural response data in both Phase I and Phase III and to the tagging vessel (in both Phase II and Phase III). In Phase II we did see obvious responses by gray whales as they deflected around the playback source when it was moored *ca* 2km off the coast and source levels were as high as 185 dB re 1 μPa-1m. This response was not observed when the source was moored ca. 4km off the coast and source levels were as high as 200 dB re 1 μPa-1m.

At this point, data analyses and interpretations are still underway, but should be completed within the next year.

REFERENCE

Payne, R. and Webb, D. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Ann. NY Acad. Sci.* 188:110-42.

Appendix 7

SUGGESTED STEPS TO FURTHER RESPOND TO THE COMMISSION'S DIRECTIVE ON ENVIRONMENTAL CONCERNS

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In Resolution 1997-7 the Commission directed the Scientific Committee to provide '...regular up-dates to the Commission on environmental matters that affect cetaceans...'. Specifically, the Resolution noted that the Standing Working Group on Environmental Concerns (SWGEC) had identified eight topics of particular importance: (1) climate/environmental change; (2) ozone depletion and UV-B radiation; (3) chemical pollution; (4) impact of noise; (5) physical and biological habitat degradation; (6) effects of fisheries; (7) Arctic issues; and (8) disease and mortality events.

The first three have been addressed by two workshops, which have led to corresponding research initiatives. We believe that it is **imperative** that they be fully implemented and be supported as the first priority.

Clearly, it is also beneficial for the success of the existing proposals and the work of the SWGEC that it continues to be pro-active and find ways to develop its broad agenda, including consideration of cumulative impacts.

Addressing outstanding environmental concerns

We recommend that a practical way to address a substantial part of the outstanding agenda is an intersessional workshop to consider 'biological and physical habitat degradation.' We believe that this might be best approached by a regional or species-specific program or a combination of both approaches.

We note the recommendation from the Right Whale Workshop, held in Cape Town, South Africa from 19-25 March 1998:

'It [the Workshop] noted the increasing importance the Scientific Committee has placed on environmental change and habitat studies (e.g. IWC, 1998). In this context it recommends that the Committee considers convening a workshop to develop approaches to quantify key features of whale habitats, including trophic structure; right whales should be considered as potential key species.'

Proposed broad objectives:

(1) to describe the parameters which define cetacean habitat;
(2) evaluate how these parameters affect cetaceans, particularly with respect to physical and biological degradation;
(3) identify and if need be develop objective criteria to measure such changes;
(4) determine methodology to assess significance of habitat degradation including cumulative effects.

We note that this would require a multidisciplinary approach.

The above objectives and further details of the focus and organisational aspects of the proposed workshop should be elaborated by a steering group.

The Central Institute for Research on the Marine Environment (ICRAM) of Italy has offered to host and assist in the organisation of such an intersessional workshop. The involvement of the Institute, its location, and the expertise that it provides will facilitate the attendance of suitable experts.

We note that the Mediterranean and Black Sea region could provide a good focus because:

(a) the Mediterranean is subject to intense human impact resulting in substantial coastline modifications, large-scale eutrophication and major algal events, extensive invasion of alien species and major shipping;
(b) the Mediterranean is also home to an estimated 4,000 fin whales which may be endemic;
(c) the Black Sea is a well-documented example of an 'ecosystem-flip' – where alien species (i.e. ctenophores) now dominate – with potentially associated problems for cetaceans.