Annex K

Report of the Standing Working Group on Environmental Concerns

Members: Reilly (Chair), Al Kiyumi, Amaha Ozturk, Baba, Berggren, Bickham, Birtles, Bjørge, Borsani, Bräger, Brownell, Butterworth, Childerhouse, Clark, Deimer, DeMaster, Diake, Ensor, Forde, Fortuna, Fossi, Friday, Fujise, Fukui, Gales, George, Gidding, Goodman, Groch, Groenvik, Hatanaka, Haug, Hedley, Hofmann, Ilyashenko, Iñiguez, Kato, Kawahara, Kell, Kim, Kock, Krahn, Lauriano, Lawrence, Leaper, Lee, Lima, Lyrholm, Magloire, Manzanilla, Marsili, Matsuoka, Minton, Moore, Mori, Morishita, Murase, Nagatomo, Nakatsuka, Nishiwaki, Northridge, Okamura, Olafsdottir, Oosthuizen, Ozturk, Palazzo, Palka, Pantoja, Park, Parsons, Perrin, Perry, Rademeyer, Rambally, Reeves, Reijnders, Rennie, Ridoux, Ritter, Rogan, Rojas-Bracho, Rose, Sadler, Senn, Shimada, Simmonds, Sohn, Stachowitsch, Suydam, Taylor, Thiele, Tsidulko, Urban, Urquiola, Vikingsson, Walløe, Walters, Watkins, Weinrich, Weller, Williams, Wilson, Witting, Yamakage, Yamamura.

1. CONVENOR'S WELCOME AND OPENING REMARKS

Reilly welcomed the participants and noted that after a two year absence from the Scientific Committee he looked forward to an interesting meeting.

2. ELECTION OF CHAIR

Against his better judgement, Reilly was elected Chair.

3. APPOINTMENT OF RAPPORTEURS

Krahn, Friday and Simmonds agreed to act as rapporteurs.

4. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

5. REVIEW OF AVAILABLE DOCUMENTS

The following documents were identified as relevant to the business of the Standing Working Group: SC/55/El-11, SC/55/E14-21, SC/55/Repl, SC/55/019, SC/55/1A4, SC/55/SHI4, SC/55/SHI7, Taylor (2003), Širovic *et al.* (2004), Thiele (2002), Hofmann *et al.* (2002), Matsuoka *et al.* (2003).

6. MODELLING CETACEAN-FISHERIES INTERACTIONS, INCLUDING RESULTS FROM INTERSESSIONAL WORKSHOP

Northridge presented SC/55/Repl (this volume), the report of the modelling workshop on cetacean fishery competition held at the Southwest Fisheries Science Center (SWFSC) in La Jolla, California, USA in June 2002. He thanked the SWFSC for having been able to host the meeting at the last minute, after the invitation for the original venue had been withdrawn. The Workshop had been held in response to a request by the Commission (IWC, 2002).

At the 52nd meeting of the Scientific Committee a central question, to be the main objective of future deliberations had been established. This question was 'how are changes in abundance of cetaceans likely to be linked (in the short- and long-term) to changes in fishery catches?' Initially a Symposium and Conference had been proposed to address this question but funding had not been obtained to pursue this. Instead a more focused workshop on modelling methods and data requirements was proposed. The agreed Terms of Reference for the workshop were to:

(1) review existing modelling approaches that might be useful to address the overall objective;
(2) identify the constraints and data requirements in the existing models or modelling approaches that limit our ability to answer the above question;
(3) describe the advantages and disadvantages of the various approaches, bearing in mind the areas for which they were developed; and
(4) identify those approaches that seem most likely to be able to answer the above question, and provide guidelines as to when and where they might be used (e.g. depending on the likely level of data availability).

The Workshop began with an overview of existing modelling approaches by John Harwood, and went on to consider data requirements and availability. Topics covered included cetacean population size and structure, fisheries assessment data, the population size and structure of prey and competitor species, cetacean consumption rates, diet composition, inter-species linkages and uncertainty in data.

The Workshop reviewed all the available major modelling approaches that deal with top predators and multispecies fisheries interactions. These included ECOPATH and ECOSIM (as the Ecosim with Ecopath package), Minimum Realistic Models such as MULTSPEC and SEASTAR, Bioenergetic Trophodynamics and models of Antarctic Systems, including a newly described index of Predator Influence that is more widely applicable outside the Antarctic.

A shortage of time restricted the conclusions of the Workshop to some general points, including a list of important issues for further consideration.

The Workshop **concluded** that despite recent advances, most multi-species models are still at developmental stages. It therefore **agreed** that no single approach could be recommended at this stage to provide reliable information of

value to consideration of cetacean dynamics in an ecosystem context. However, this does not necessarily rule out the possibility that useful inferences might be drawn if a number of different modelling approaches were to yield qualitatively similar results. The Workshop also **agreed** that despite these difficulties, the consideration of ecosystem interactions between fish stocks and cetaceans is potentially an important research topic.

The Workshop **agreed** that there is currently no system for which we have suitable data or modelling approaches to be able to provide reliable quantitative management advice on the impact of cetaceans on fisheries or fisheries on cetaceans. If the Commission wishes to pursue this further, the Workshop warned that a considerable investment in time and resources would be required but recommended that:

> It would be most sensible to concentrate on those areas or systems where there is most chance of success, based on a number of factors including the simplicity of the system, availability of data, the ability to collect data in the future, and the likelihood that any predictions can be tested in some way.
>
> In terms of model development, further work is needed to incorporate the effects of uncertainty in modelling assumptions and data. It is also important that environmental variability in the short-term and the long-term should be taken into account.

The Workshop also **agreed** that simulation studies will be required to test the sensitivity of model predictions to uncertainty in the data (and model assumptions) and the ability of field techniques to detect the reliability of predictions. The iterative link between modelling and data requirements requires further investigation. The experience of the Scientific Committee in such work might represent a valuable IWC contribution to cooperative studies in addition to providing cetacean data and expertise.

In terms of data availability, the Workshop noted that it is not possible to generalise and that requirements will be case specific. There will be very considerable data requirements (preferably time series) and this suggests that collaboration with other bodies (such as ICES) will be required.

The most important consideration in all modelling approaches concerns the issue of functional responses, and the Workshop **recommended** that these should be looked at in more detail.

The Workshop also highlighted the fact that cetaceans are just one part of the system that needs to be modelled, and **recommended** that the most productive way forward would be for the IWC to seek to collaborate with other bodies with a broader range of expertise in other parts of the system. More specifically, cooperative links would best be established with other long-term ecosystem studies, particularly those that include top predator dynamics as an integral part.

The Standing Working Group (SWG) thanked Northridge and the other members of the Steering Group for their considerable work in arranging the Workshop, and for the helpful report. It was noted that such workshops, which bring together scientists from within the SC with outside experts, make a substantial contribution to the quality of scientific advice provided to the Commission.

The SWG noted that the Workshop was not intended to address the possibility of cetacean-fishery interactions for any specific system, but rather to evaluate existing modelling approaches for their potential use in addressing these issues. The SWG **agreed** with the Workshop conclusion that for no system at present are we in the position, in terms of data availability and model development, to provide quantitative management advice on the impact of cetaceans on fisheries or of fisheries on cetaceans. To reach such a position will require a considerable investment in time and resources. However, this does not rule out the possibility that useful inferences might be drawn if a number of different approaches yield qualitatively similar results.

The SWG **agreed** with the conclusion of the Workshop that consideration of ecosystem interactions between fish stocks and cetaceans is a potentially important research topic in a general sense, but there was disagreement as to whether further pursuit of this matter was likely to be helpful in providing advice to the Commission regarding the management of whale populations.

If the Commission wishes to pursue this further, there are a number of important issues that will need to be explored. Of primary concern are the concepts surrounding functional response curves and choices of these. Other issues to be considered include incorporating behavioural ecology using optimal diet and foraging theory, controlled perturbation experiments on model ecosystems, the large body of theory and empirical research on food webs, and the exploration of theory to see to what extent and under what circumstances model ecosystems show counter-intuitive responses to perturbations.

The SWG **agreed** that there is considerable expertise on ecosystem modelling outside of the Scientific Committee. Given this, if the matter is to be pursued further, the IWC is probably not the best forum to lead this work. A more productive approach would be to work in cooperation with other bodies to ensure that cetaceans are included in their work. The SWG **recommended** that a workshop be held on the issue of functional response curves, but that the IWC might take a secondary role to organisations with more expertise.

Walløe drew the SWG's attention to two workshop reports from the North Atlantic Marine Mammal Commission (NAMMCO, 2002; 2003), which address similar subject matter.

SC/55/SHI7 presented results of an initial model of minke whale-blue whale-krill interactions, developed as a first step in investigating the major predator-prey interactions in the Antarctic. Blue whales and minke whales both feed primarily on krill, and share a similar feeding range in the Antarctic. In the early 20th century, the large baleen whales in the Antarctic were heavily harvested, some to near extinction. Blue whales were taken for almost 60 years, before being officially protected in 1964. Harvesting of the smaller minke whales commenced only in the l970s. The population probably increased during the mid-20th century, likely in response to increased krill abundance following the depletion of the large baleen whales. Recent studies show recoveries of some of these large baleen whale species in response to protection, and also a possible recent decrease in the minke whales as the larger whales recover. SC/55/SH17 investigated whether the abundance trends indicated by survey and other information for these species can be explained by considering only harvesting and the predator-prey interactions between these species. Using the historical catch data for blue whales and minke whales, a simple age-aggregated model including species interactions is fitted to the observed abundance estimates for these species. Uncertainties in the abundance estimates and the biological parameters are taken into account in this process by considering plausible ranges for their values. The trends indicated in the abundances of the species can broadly be replicated by the model, provided the parameter values show certain features. These include: (1) blue whales are able to maintain their birth and krill consumption rate until krill

abundance drops to relatively low levels; and (2) both minke and blue whales show relatively high growth rates if krill is abundant, but the minke growth rate falls more rapidly as krill abundance drops. The model suggests two interesting features of the dynamics of these species:

(1) A substantial decrease in krill biomass from the 1970s to the 1990s due to the rapid increase in minke whale abundance, and hence krill consumption, following the depletion of the larger baleen whales.
(2) A recovery of blue whales in spite of the recent minke whale decrease and impact on krill abundance, because blue whales are better able to tolerate decreased krill abundance.

Future projections for these species show a gradual increasing trend in blue whale abundance, with a gradual decrease in minke whale abundance, and with large amplitude oscillations superimposed. Long term monitoring of biological parameters and abundance are essential to provide a basis for verification or otherwise of such predictions. For future work, the authors are considering refining the model structure, incorporating age-structure, some other major predator species that feed on krill, and some spatial structure.

In discussion, concern was raised that SC/55/SH17 predicts large fluctuations in krill, minke whale and blue whale biomass and that the model might be inherently unstable. Butterworth replied that mathematically the model has a stable coexistence equilibrium. This is a preliminary analysis designed to give qualitative results. In future analyses, additional complexity to be added to the model will dampen the fluctuations. Nevertheless, he considered that the oscillations are real, although the amplitude of these oscillations indicated by the model is too large.

Taylor asserted that the evidentiary basis of SC/55/SH17 was weak. He pointed out that blue whales have barely recovered even to an estimated 1% of their pristine population size and is only one of many species that feeds on krill. Thus it is highly implausible that this tiny population recovery could elicit a functional response in such a wide range of far greater biomass consumers. Classic ecology recognises that, for there to be competition, guild level consumption must exceed prey productivity; this is unlikely in an already depleted system. Evidence for interspecific competition has rarely been shown, and it is generally found that species consuming the 'same' prey species, partition their feeding niches behaviourally, spatially, or temporally and avoid direct competition. Also lacking is evidence for the presumed krill surplus, the presumed competitive release of minke whale populations following depletion of blue whales, and the presumed crabeater seal declines. Other populations of putative competitors like Antarctic fur seals have been growing.

It was also argued that the models do not even approach capturing the complexity of the krill food web and present little new information. They are simple two-species competition models with differential functional response, and model behaviour which can easily be tuned to mimic the supposed population changes has been well known for some decades.

The authors explained that the recent (from about 1970) low levels of krill and the decline of minke whales in the model is unrelated to the increase in blue whale abundance. Blue whale abundance is currently too low for them to be a major component of the Antarctic food web. Current krill and minke whale declines are due to the oscillatory nature of their predator-prey dynamics. The authors argued that the Antarctic is an ideal place to attempt this type of modelling because of the relatively simple food web and the large magnitude of the perturbation from earlier whaling. There is indirect evidence for a krill surplus after declines in the abundance of large whale species which can be inferred from the behaviour of other species: fur seals increased in concordance with minke whales (Payne, 1977), whaling vessels in the 1940s and l950s report increased sightings of minke whales (Ash, 1962), there is evidence of changes in age-at-maturity for minke whales over this period consistent with a density-dependent response (Thomson *et al.*, 1999), and catch-at-age analyses (Butterworth *et al.*, 1999) support the increase of minke whales during the 1940-1960 period. The authors disagreed that tuning such models to reflect likely blue and minke whale abundance trends was readily and easily achieved.

There was general agreement that the current model should be extended to include additional species (such as humpback whales and pinnipeds) to more accurately model the Antarctic food wed. However, there is enormous uncertainty in estimating the abundance of other krill predators such as fish, seals, birds and other whales.

Concern was also raised that the current model is not easily extended in this way, and that the assumptions of the model are not the typical food web assumptions of niche partitioning and niche overlap. For further work, a qualitatively different model is needed. Butterworth reiterated that this is an initial model and that future models will incorporate additional food web complexity and spatial structure to address these issues.

Concern was raised that the paper did not discuss the krill fisheries and whether the decrease in krill biomass might be related to this fishery. Krill biomass in the Scotia Sea has fluctuated and no correlation with predators has been found except for local effects. Butterworth cautioned that data on krill biomass is from a short time period and over small areas. The present krill fishery is also located in a limited area and negligible by comparison with krill abundance at the circumpolar level. The magnitude of these local fluctuations in krill biomass may be of negligible consequence on the circumpolar level.

Watkins informed the SWG that analysis is being conducted on the Discovery expedition data and other historical surveys to attempt to provide information on past krill density. The general impression at the moment is that krill density was higher in the first half of the last century than it was in the second half.

The SWG thanked the authors for their presentation, agreed that no conclusions can be made at this time, and encouraged them to extend their model to better capture the Antarctic food web.

SC/55/IA4 provided a speculative hypothesis about the impacts of killer whale predation on marine mammal populations in the Southern Hemisphere, arising out of a similar hypothesis from the North Pacific and Bering Sea (Springer *et al.*, 2003). Killer whales prey on a wide variety of different species, including all large cetaceans in the Southern Hemisphere. Industrial whaling caused major declines in these whale populations, reducing their biomass to perhaps 20% of original levels. It is possible that killer whales consequently increased their predation rates on other marine mammal species (notably southern elephant seals, southern sea lions and Antarctic minke whales), resulting in declines in their populations. An estimated 2% of the current diet of 'Type A' killer whales consists of large whales, although this estimate is crude, and is dependent on just a few stomach contents. Perhaps 10% of killer whale diet may,

therefore, have been large cetaceans before reductions caused by industrial whaling; in turn, this would imply that the proportion of pinnipeds in their diet may have increased from 24% to 25% from World War II to the l960s. SC/55/IA4 used simple population models and estimated consumption rates for killer whales, to show that observed declines in some populations of southern sea lions and southern elephant seals can be explained by a 1% increase in year-round killer whale diets. However, an appreciably lower recent estimate for Antarctic minke whales (Branch and Butterworth, 2001) would require too many additional deaths to be caused by increased killer whale predation.

According to SC/55/IA4, killer whale predation on young minke whales could explain the under-representation of young age classes in JARPA catch records. However, it was questioned whether calves migrated far enough south to be at risk of killer whale predation. Branch noted, however, that only a small percentage of calves need to be taken for this hypothesis to fit, and they could be taken at lower latitudes.

Gales expressed a number of concerns with SC/55/IA4. First of all, the evidence for diet composition is unreliable, based mainly on a few older papers with doubts about species identification. In addition, there are considerable problems in inferring diet composition from stomach contents when many killer whales could have scavenged on carcasses. Also there are major temporal and spatial issues here, with killer whales almost certainly feeding mostly on seals in the Antarctic pack ice, and this likely comprises most of the pinniped component of the diet. Second, the decline in southern elephant seals on Campbell Island is most likely due to predation by New Zealand sea lions, which have been observed removing almost entire cohorts of this small and declining population. Third, the declines in southern elephant seals are most likely linked to trophic changes driven by large scale, long-term changes in ocean processes. A large body of literature exists on this subject, and the only site where killer whale predation is thought to possibly influence southern elephant seals at the population scale is on Marion Island where the population is small and has actually increased in recent years. Finally, declines in southern sea lions have been linked strongly to issues associated with bycatch, direct human take, and consequences of limiting foraging options to the benthos. Evidence for killer whale predation operating at a population scale is extremely weak.

Brownell noted that population trends for southern elephant seal species seem to be more complex than is easily described by killer whale predation. The population on South Georgia is approximately 55% of the world population of breeding females (100,000 seals) and is not declining. The southern sea lion population at the Falkland Islands is depleted but killer whales are unlikely to be the reason for that decline. The populations of southern sea lions and southern elephant seals at Peninsula Valdes, Argentina are increasing despite killer whale predation. In general, regime shifts and climate change are the most parsimonious explanations of southern elephant seal declines.

Branch agreed that diet composition data for killer whales are limited. However, data on trophic changes are also limited, and there are no good data on the total abundance of prey. He disagreed that Marion Island is the only area where killer whale predation influences southern elephant seals at a population level.

Cooke noted that the relationship between killer whale predation events, sightings of these events, and killer whale diet composition may be complex. Uncertainty exists in estimates of how much meat and blubber are obtained from each kill. Comparisons of estimated mortality and observed predation events would be useful.

Brownell stated that killer whale predation has been hypothesised to have caused the decline in sea otter populations in the Aleutian Islands (Estes *et al.*, 1998). However, there are few actual sightings of killer whale predation on sea otters, and eagle predation of sea otter pups and pollution were not explored by the authors. In addition, sea otter populations in the Commander Islands have not declined. Other data on the status of western North Pacific pinniped populations also do not support this hypothesis.

Wade raised a concern that the data in Fig. I of SC/55/IA4, which described catches of large cetaceans and declines in harbour seals, Steller sea lions and sea otters in the North Pacific, are more complex than actually described. The sea otter trend data are from the Aleutian Islands. The trend data for harbour seal abundance come from a single island near Kodiak in the Gulf of Alaska, which is approximately 1,000 miles from the Aleutians. Finally, there are no Steller sea lion data available prior to 1980 so it is unknown whether the decline of this population began in 1980 or prior to that date.

SC/55/El6 described DNA-based identification of prey species represented in whale faeces. The diet of whales is an important aspect of their ecology. The authors have previously demonstrated that the krill component of blue whale diet can be identified to species level from krill DNA that survives digestion by the whale and can be purified from whale faeces (Jarman *et al.*, 2002). SC/55/E16 described experiments that demonstrate that the DNA of any prey item can be potentially identified. A 'universal' method for detecting eukaryotic DNA was applied to fin whale faeces, and DNA sequences from distantly related eukaryotes were characterised from this sample. The prey DNA detection methods were also tested on faecal samples from a range of whale species and shown to be effective. The use of DNA-based methods for examining whale diet is widely applicable and potentially more accurate as a means of reconstructing the species composition of whale diet than morphologybased methods.

Investigations of diet are central to the study of theoretical and applied ecology, and a suite of methods has been developed, each of which is tailored to the system and species under study. SC/55/E15 described a two stage simulation/empirical model developed to examine the potential biases that result from three methodological approaches for determining whale diet: two rely on an examination of remains in the whale's forestomach, and one relies upon the identification of prey from DNA remains in whale faeces. The authors used minke whales from the northeast Atlantic as an example. The simulation results showed that a simple measure of presence or absence of prey DNA in faeces provides the most accurate and precise estimator of proportional importance of prey types. The model also provides some estimates of the degree to which analysis of prey remains in whale forestomachs may bias an estimate of the proportional contribution of different prey. Further applications of this model will be used to determine the sensitivities of the various methodological approaches to changes in foraging behaviour and performance. The utility of genetic prey identification for powerful qualitative diet studies (measuring hard and soft bodied prey) has been previously demonstrated (Jarman *et al.*, 2002).

Haug expressed surprise that diet composition results might be more reliably obtained by sampling DNA after the prey has passed through the digestive tract than by sampling

stomach contents. He also reported that, for North Atlantic minke whales, relative frequency of occurrence is used to estimate diet composition because frequency of occurrence can be imprecise. A disadvantage of DNA based identification of prey species is that consumption is not estimated. Haug and Murase raised concerns that it might be difficult to collect faecal samples, and effort data would be helpful for evaluating the efficiency of sample collection.

Markers are being used in captive feeding studies to confirm that heterogeneity in the transit time of material through the digestive tract is reduced when samples are collected at the end of digestion rather than at the beginning. Relative frequency of occurrence will be explored in future work. To date, effort has only been expended in developing the DNA technique. Faecal samples have been collected opportunistically, and future fieldwork is necessary for collecting effort data.

7. SOUTHERN OCEAN CLIMATE CHANGE: EFFECTS ON CETACEANS

7.1 Cooperation with SO-GLOBEC and CCAMLR

Thiele and Moore had arranged a substantive update on joint activities under both the Southern Ocean Global Ocean Ecosystems Dynamics Program (SO-GLOBEC) and the Convention on Antarctic Marine Living Resources (CCAMLR) by inviting guests from each to give formal spoken presentations on recent progress and findings of their multidisciplinary programmes. However, the mini-symposium originally planned was presented on a smaller scale due to funding short-falls.

Jon Watkins of the British Antarctic Survey (BAS) gave a presentation summarising BAS-CCAMLR studies, and Eileen Hofmann of Old Dominion University (USA), and chair of International SO-GLOBEC, summarised the latter programme. Posters on related subjects were displayed for the Scientific Committee outside the meeting rooms. Authors and titles of posters are listed in the reference section of this Annex.

7.1.1 How interannual and long-term changes are likely to affect Antarctic krill populations (Jon Watkins, BAS)

Antarctic krill (*Euphausia superba*) are found throughout the Southern Ocean with particularly high densities in the Scotia Sea. Time series of krill abundance between 1991 and 2002 at several localities within the Scotia Sea indicate that there is marked interannual variation, with suggestions of cyclical patterns and some degree of consistent changes between sites. There are marked interactions between the physical environment and population dynamics of krill. For example, current hypotheses of krill population dynamics in the Scotia Sea suggest that sea ice conditions impact population dynamics of krill through effects on egg production and larval survival through the first winter, as well as on regional immigration of young adults into the South Georgia population. Simple population models can be used to reproduce the general patterns of fluctuation in biomass caused by variation of year-class strength as a result of environmental variations.

Long-term environmental variation can be seen in sea ice and air temperature data over the last century in the South Orkney region. There has been a marked change in the probability of encountering cold years since 1950. Using such data within the krill model leads to a change in krill biomass over the last century with a reduction in biomass occurring between 1950 and 1970. In addition to long-term change, at the circumpolar scale spatially coherent physical variability is manifest through the Antarctic Circumpolar Wave. Modelling krill variability at this scale results in cycles in the population biomass although apparent correlations as a result of the cyclical physical variation can be misleading and changing the frequency of perturbations has major impacts due to interactions between the year-class structure of the population and the physical periodicity.

Future climate change scenarios for the Southern Ocean remain somewhat unclear due to the relatively unpredictable effect of sea ice. However, changes in temperature, sea ice extent, water mass structure, current speed and frontal positions are likely to have profound effects on krill reproduction, recruitment, biomass and distribution.

To better understand possible changes current long-term datasets need to be maintained and extended to increase coverage in the Southern Ocean. In particular there is now a need for improved understanding of circumpolar processes that can only come through international collaboration in order to conduct large scale observations and develop suitable large scale models.

7.1.2 Southern Ocean Global Ocean Ecosystems Dynamics Programme (Eileen Hofmann)

It is the strong linkage to climate and close coupling between trophic levels that resulted in the choice of the Southern Ocean as a study site for the Global Ocean Ecosystems Dynamics (GLOBEC) programme. Southern Ocean GLOBEC (SO-GLOBEC) has as a primary objective the understanding of the physical and biological factors that contribute to enhanced Antarctic krill growth, reproduction, recruitment and survivorship throughout the year. This includes the study of predators and competitors of Antarctic krill, such as penguins, seals, cetaceans, fish and other zooplankton. The emphasis on habitat and top predators, as well as Antarctic krill, is a first in international interdisciplinary Antarctic science. A strong focus of SO-GLOBEC is on understanding processes in the austral winter, especially the processes that allow krill to overwinter and survive.

The SO-GLOBEC field programme consists of multidisciplinary oceanographic research programmes focused near 70°E, the southeastern Weddell Sea, the Scotia Sea-South Georgia region, and along the western Antarctic Peninsula. Studies in the first three regions are part of the Australian, UK, and German Antarctic programmes. The SO-GLOBEC field programmes in the western Antarctic Peninsula region are undertaken by the USA and Germany.

The US SO-GLOBEC field studies are focused on Marguerite Bay and environs, along the western Antarctic Peninsula. During 2001 and 2002 this programme undertook 11 cruises: 4 process cruises, 4 survey cruises and 3 mooring deployment/retrieval cruises. IWC observers participated in eight of these cruises. The mooring cruises deployed current meter mooring and Acoustic Recording Packages (ARP's) for recording whale sounds. The moorings remained in the water for one year, were retrieved, and redeployed for a second year. These represent the first long-term moored current and acoustic measurements made in Antarctic continental shelf waters.

The US SO-GLOBEC survey cruise studies are based on data collected from conductivity-temperature-depth (CTD) casts, Acoustic Doppler Current Meter measurements, a Multiple Opening/Closing Net Environmental Sampling Sensing System (MOCNESS) and a Bio-Optical Multifrequency Acoustical and Physical Environmental Recorder (BIOMAPER II). These data provide repeated

realisations of hydrographic structure, upper water column currents, nutrients, phytoplankton, micro-zooplankton, mesozooplankton and Antarctic krill distributions. Seabird and cetacean surveys were conducted during daylight hours and sonobuoys were deployed. Other activities consisted of Remotely Operated Vehicle (ROV) operations and deployment of surface drifters.

Studies on the process cruises consisted of ship-based laboratory experiments of zooplankton and Antarctic krill physiology, under-ice diving to characterise the sea ice habitat, sea ice biota, collection of animals for experiments and focused net tows. Additional efforts on the process cruises consisted of placing satellite tags on Adelie penguins and crabeater seals, physiological studies of these animals and characterisation of the environmental structure.

Preliminary results from the US SO-GLOBEC programme highlight the importance of Circumpolar Deep Water in structuring the marine food web along the western Antarctic Peninsula. This water mass provides heat, salt and nutrients to the continental shelf. Areas where this water mass are found are characterised by higher phytoplankton production, increased krill abundance and increased abundance of top predators, such as humpback and minke whales. There is strong correlation between presence of whales and hydrographic boundaries produced by the onshelf intrusion of Circumpolar Deep Water.

Planning is now ongoing for a follow-on programme to SO-GLOBEC. Details of the current state of planning for this programme, entitled Integrated analyses of Circumpolar Climate interactions and Ecosystem Dynamics in the Southern Ocean (ICCED), are given in SC/55/E14. It is hoped that the IWC will also participate in this programme.

Hofmann closed by noting that the total cost of the US SO-GLOBEC programme was about $20 million USD. This includes the costs of 11 cruises, mooring arrays and scientific support for about 40 science investigators.

The IWC did not contribute significant financial support to SO-GLOBEC, but should consider doing so in the future, to continue effective collaboration (see Appendix 2).

7.1.3 SWG discussion

The proposed ICCED programme will begin in 2007 and continue for at least 10 years. It will include extensive deployment of remote instrumentation to measure a broad suite of variables, and if funding can be secured, acoustic recorders to detect whale calls. The instrument locations will be linked via ship-based studies.

El Niño-Southern Oscillation effects may occur in the Southern Ocean ecosystem but would be very difficult to detect among the other complex interannual patterns present. In answer to a question as to what constitutes 'long-term' in the analyses presented, Watkins noted that existing series of direct measurements are generally 20 years or less, but that investigators were looking back 100 years or more from indirect or proxy measurements.

The current krill fishery takes less than 100 mt/yr, but it took nearly 500,000 mt/yr during the mid-1980s. Given the substantial total krill biomass such takes are unlikely to contribute to krill conservation problems, but local depletions are possible and the fishery is managed by CCAMLR to avoid such negative effects on either the resource or its predators.

The time series of krill biomass (estimated as a function of ice extent) presented by Watkins for the 20th century through to the present indicated staged, and in some periods dramatic, declines. Current levels are at 50% or less in relation to levels estimated for the 1950s. It was noted that if this model result reflects true patterns, it could contribute to an explanation of putative declines in minke whale abundance over the past 30 years, and may have other substantial implications for the management advice provided by the Scientific Committee (SC) on Southern Hemisphere whales.

Concern was expressed that these model results should not be taken as documented evidence of actual pattern change in krill biomass, especially given the difficulties encountered in attempts to link fish recruitment or biomass changes to environmental measures. Watkins noted that direct measurements of krill biomass for this long period and throughout the Antarctic do not exist. He explained that the model of changes in krill biomass was based on a strong association observed in the Scotia Sea during recent decades, but like all models is a simplification of patterns that may have occurred. In this case it must be assumed that the observed relationship between krill biomass and ice extent from recent years holds throughout the Antarctic and for the duration of the 100+ years examined. The model and its results are currently in review for journal publication.

Perryman and colleagues had reported to the meeting (SC/55/BRG2) and in previous SC reports that gray whale calf production is highly correlated with patterns of seasonal and interannual ice formation in the Bering and Chukchi Seas where they feed. It was queried whether such associations might occur for Antarctic baleen whales. Watkins replied that sea ice provides important habitat for krill, and consequently variation in sea ice extent effects krill recruitment. This in turn may affect baleen whales and other krill predators, but such a relationship has not been examined.

Thiele and Moore summarised a number of separate documents reporting the activities and results arising from IWC-CCAMLR and IWC-GLOBEC collaboration.

Thiele (2002) provided an update of the collaboration between the IWC and SO-GLOBEC in the Western Antarctic Peninsula. The 2000/01 Antarctic season marked the start of field collaboration between the two organisations.

The programme in the Western Antarctic Peninsula (WAP) conducted visual surveys from ships, small boats and helicopters, tissue biopsy and individual photo-identification studies. The work was conducted in close collaboration with scientists from Scripps Institute of Oceanography and the USA National Oceanic and Atmospheric Administration (NOAA) involved in the deployment of new passive acoustic monitoring tools. A broader joint programme has been developed which builds on the IWC/SO-GLOBEC/ CCAMLR collaborative framework. This programme plans to address ecological objectives and major gaps in knowledge of basic distribution, movement and variability issues through an integrated Southern Hemisphere scale programme. While a major component of the programme is the large-scale deployment of ARPs around the Antarctic and the Southern Hemisphere ocean basins, this will be done in parallel with a series of fine-scale research focal sites in each of the five oceanic regions in Antarctica: east Antarctica (Australia), Antarctic Peninsula (USA), Weddell Sea (Germany) and others.

The Marguerite Bay WAP study provided an unprecedented opportunity to use a range of historical and new cetacean research tools within a multidisciplinary research framework. The preliminary results are interesting: baleen whale distributions were strongly associated with bathymetric features and hydrographic fronts; humpback

whales remain in the WAP throughout autumn; minke whales remain through the winter; fin whales occur over a relatively short season; and blue whales occupy the region almost year-round.

Further development of the programme is reported in SC/55/E14 and discussed above in Hofmann's presentation.

SC/55/E9 reported on IWC participation in five multidisciplinary research cruises in the Southern Ocean since the 2002 Annual Meeting. Intersessional activities included planning meetings, pre-analysis collaboration, proposal development and presentation of work at international conferences, particularly at the 2nd International GLOBEC Open Science Meeting in Qingdao, China, October 2002. Two cetacean papers will be published in late 2003 in the first volume of the US SO-GLOBEC Special Issue of *Deep Sea Research*. The IWC is invited to continue its participation in national and international efforts in the Southern Ocean in the next few years through collaborative synthesis, analysis projects and field work. In the longer term the IWC is well placed to build on recent collaboration and to ensure whale ecology becomes a core component of the next phase in this region (i.e. OCEANS/ICCED initiative). The development of ARPs is an important component in a circumAntarctic approach to investigating the connections between whale ecology and the variability and dynamics of Antarctic ecosystems.

SC/55/E10 reported on collaboration between the IWC and national programmes conducting multidisciplinary ecosystem research in the Antarctic under SO-GLOBEC and CCAMLR. Members of the SC participated in five national programme cruises between April 2002 and April 2003. Visual survey, passive acoustic and tissue biopsy work was conducted by IWC observers and collaborating passive acoustics scientists. Preliminary results from these cruises include: mapped distribution patterns of cetaceans from visual survey sighting data; individual photo-identification records; species identification and positions of animals recorded by sonobuoys; and descriptions of environmental conditions observed or recorded as part of the multidisciplinary effort.

The IWC commenced collaborative research with CCAMLR in the Southern Ocean during the 1999/2000 austral summer as part of the SOWER 2000 programme (Reilly *et al.*, 2000; Hedley *et al.*, 2001). The IWC then developed collaboration with SO-GLOBEC in a series of multi-season and multi-year cruises.

Cruises under the US SO-GLOBEC programme were multidisciplinary and comprised standard mooring cruises, line transect surveys over a constant grid, and process studies at selected locations, all within the Western Antarctic Peninsula (WAP) study region around Marguerite Bay. These began in March 2001 and were completed in March 2003. A total of eleven cruises were conducted under US SO-GLOBEC, and the IWC participated in eight of these.

The initial German SO-GLOBEC effort comprised one cruise in April/May 2001 to the WAP study area and an ice covered area to the south. The IWC participated in this cruise. The main German SO-GLOBEC effort will commence in March 2004 with the first in a series of three cruises to a study area in the Weddell Sea. The IWC will participate in these cruises. The UK British Antarctic Survey (BAS) contribution to SO-GLOBEC comprised joint SO-GLOBEC/CCAMLR objectives in a survey in the Scotia Sea in early 2003. Members of the SC participated on this cruise. Preliminary findings have been detailed in the papers, posters and reports noted in SC/55/E9.

Two SO-GLOBEC cruises were conducted by Australia in the East Antarctic study area. One cruise took place in January 2001 and the second took place in the same area in January 2002 (see SC/55/E17). The IWC did not participate in these cruises, however the long-term cetacean research programme run by Thiele (Southern Ocean Cetacean Ecosystem Program, SOCEP) did participate (see SC/55/E17).

SC/55/E17 described Australian SO-GLOBEC surveys conducted off the Mawson coast in the Australian Antarctic Territory (AAT) in 2000/01 and 2002/03. Krill abundance, krill distribution, whale diversity and distribution differed between years and within the survey period. There were obvious differences between the two surveys in terms of patchiness and density of krill, with the 2002/03 Antarctic Marine Living Resources (AMLR) survey having very low abundance relative to the 2000/01 KACTAS survey. The KACTAS survey showed a high degree of clumping of krill and much greater density and biomass overall than KAOS. The reasons for these vast differences in krill density are not yet understood, however a number of avenues of analysis are being pursued. Penguin diet and foraging also differed between the two surveys. Despite results confounded by differing methodologies between surveys, marked differences in the spatial pattern and species diversity of cetacean sightings were apparent. The large differences between survey years, as well as unexpected differences in krill and whale distributions in the same area within a very short time are important examples of variability and the dynamic nature of this system.

SC/55/E8 described a system to include comprehensive sea ice data collection within cetacean line transect surveys in the Antarctic which had been developed and trialled in the 2002/03 season (see Appendix 3 for details). Some issues were identified during field trials concerning the use of the two data collection systems simultaneously, generally concerning doubling-up of data entry across systems. These issues are relatively simple to resolve, and a series of steps is proposed to address them. The final version of one integrated sea ice and whale survey logging program will be completed for final trials in 2003/04. The results of the field trials and an integrated system for recording cetacean line transect survey data and sea ice data will be presented to the SC in 2004. The development of a simple, yet comprehensive field system should ensure maximum adoption across programmes and platforms, and provide directly comparable datasets.

Moore then described the results of cetacean detections via passive acoustic methods (SC/55/SHI4 and Širovic *et al.*, 2004). As part of the coordinated visual and acoustic sampling for cetaceans that was integrated into the broad-scale SO-GLOBEC oceanographic programme, eight passive Acoustic Recording Packages (ARPs) were deployed off the Antarctic Peninsula from March 2001 through February 2003. ARPs are self-contained weighted instruments that rest on the seafloor and record all sounds in the 5-250Hz frequency band (i.e. 500Hz sampling rate) for periods of up to 400 days. Very few IWC sighting records exist for blue ($n = 10$) and fin ($n = 27$) whales off the Antarctic Peninsula (roughly, Area I) over the past 20 years; the ARPs exceeded all expectations by recording a total of 258,706 calls from blue whales and 72,194 calls from fin whales during the two-year deployment. Calls from both species exhibited a strong seasonal pattern, with greater variability seen in the eight-day windowed call histograms from blue whales. Blue whale calls were recorded between September and May (average of 177 days/year), with peak calling in March and April. Fin whale calls were present

between February and May (average of 51 days/year), with peak calling in May. Of note, blue whale calls were recorded nearly year-round on the northernmost ARP (located at 62.17°S latitude, 62.10°E longitude, Širovic *et al.*, 2004, fig. 1). Overall, more blue whale calls were tallied in 2002, a year when the study area experienced relatively heavy sea-ice cover, compared to 2001 when the study area had a 60-day shorter sea ice cover period.

These results complement the physical and biological data from the SO-GLOBEC programme and provide the first full year records of blue and fin whale occurrence in this sector of the Antarctic. These data will be correlated with oceanographic parameters during the analysis and synthesis phase of SO-GLOBEC, anticipated for 2004-06, and the authors plan further deployments of ARPs around the Antarctic if funding can be secured.

Moore also presented two related papers that described blue whale calls recorded world-wide (SC/55/SH7) and solely in the Antarctic (SC/55/SH5). The Antarctic-type blue whale call is one of nine regionally-specific call types (songs) described for blue whales in the world ocean. Blue whale songs are stereotypic signals consisting of two to three diagnostic units. Songs range from those containing only simple frequency-modulated (FM) units (usually recorded in oceanic basins) to those comprised of FM and complex units containing pulsive sounds and harmonics (usually recorded in continental shelf habitats), with songs exhibiting the greatest number of complex units recorded in the Indian Ocean basin. While the behavioural significance of blue whale song remains poorly understood, it is suggested that songs be used as provisional stock identifiers until genetic or other data can be used to answer the question of population boundaries. Moore noted that an analysis of blue whale genetic samples from the Southern Hemisphere (SC/55/SH9) showed distinct differences among three geographic regions that complement the distinct song-types as presented in SC/55/SH7. The results in SC/55/SH5 provide further support that the Antarctic blue whale song-type is unique to waters surrounding the continent, and attributable to 'true' blue whales.

In discussion of the reports presented by Thiele and Moore, it was noted that the multidisciplinary cruises covering seasons not previously studied, and in particular the new acoustic approaches, will allow scientists a much broader view of whale distribution than has to date been possible and will improve understanding of both temporal and spatial scales of distribution. In addition, the combination of acoustic and genetic investigations will allow improved resolution of related questions of population structure and habitat use.

However, scientists are not yet able to interpret acoustic detections as records of abundance. It is not yet possible to distinguish between a few whales calling many times and many whales calling a few or only a single time. Work is in progress on this important subject for blue whales off California.

It was noted that while only a single blue whale sighting was detected visually during the IWC-GLOBEC cruises, the acoustic devices had recorded blue whale occurrence for a duration of nine months over a broad part of the area. The locations where blue whale calls were recorded were inshore of the area searched during shipboard sightings surveys. Given the relatively small number of instruments and their spatial deployment it was not possible to triangulate specific locations within the study grid. It is hoped that follow-up studies (e.g. ICCED) will be able to deploy many more ARPs to make this possible.

The acoustic threshold defined for detecting blue whale calls was set relatively high to produce conservative results (Širovic *et al.*, 2004). It was noted that if this threshold had been lower an even higher number of blue whale detections would have been likely.

The possible implications of results from the IDCR/SOWER cruises were briefly discussed. It was noted that most of the sightings and all of the acoustic records of minke, blue and other whale species had occurred farther south, closer to and within the ice, than the area covered by the IWC sightings surveys. This may have substantial implications, depending upon the timing of whale migration to and from the ice-edge zone and timing of the IWC surveys. If the whales (primarily minke) recorded as overwintering in the ice in fact spend entire years there, they would not be detected by the sightings surveys.

Hofmann recounted the observation made in her presentation that whale distribution showed a strong association with hydrographic boundaries produced by the onshelf infusion of Circumpolar Deep Water where it impinges on the shelf. These areas are also known to support populations of other krill predators and should be examined more closely to better understand patterns of baleen whale distribution in the Southern Ocean.

Members of the SWG expressed appreciation to SO-GLOBEC for the considerable amount of time and effort spent collecting and analysing data for this extensive and important project. The SWG **recommended** that the IWC-GLOBEC collaboration continue.

SC/55/E19 reported on Antarctic ice-edge definition. During discussions last year it became apparent that the term 'ice-edge' had not been defined for use in cetacean analysis and/or discussions. This caused some confusion with interpretation. An *ad hoc* Working Group was tasked with providing the SC with an accepted definition of the ice-edge as used by other marine science disciplines in the Antarctic.

Satellite-based analyses of Antarctic sea ice cover have defined sea ice extent as 'the cumulative area of all gridded cells having at least 15% sea ice concentration' (Zwally *et al.*, 2002). In addition, comparisons of Antarctic ice-edge location from ship data with Special Sensor Microwave/ Imager (SSM/I)-derived (i.e. satellite-derived) ice-edge locations for the same dates and longitudes show that the 15% threshold typically used for satellite data is a good estimate of the true ice-edge location (Worby and Comiso, 2001). For analyses of sea ice anomalies, Kwok and Comiso (2002) also relied on sea ice extent from satellite passive microwave data provided by the National Snow and Ice Data Center (NSIDC); they defined the mean ice-edge as 'the mean latitudinal location of the SMMR (Scanning Multichannel Microwave Radiometer) and SSM/I ice-edge over 1° sectors around the Antarctic continent'. For use in combined oceanographic analyses of cetacean distribution and density, a similar definition of Antarctic sea ice extent (or ice-edge) of ice concentration > 15% would be useful to complement the climatological definition. Sea ice area is defined as 'the cumulative area of the ocean actually covered by sea ice and is calculated by summing the product of the area of grid cells and their sea ice concentration' (Zwally *et al.*, 2002).

In discussion it was noted that the current IWC definition for ice-edge was developed given information available during the cruises, and that the more general definition given above may not be easily applicable in the field. It was concluded that the most important matter here is to always define explicitly which definition is being used when

reporting results, so that others are not misled. It would be beneficial for the IWC to adopt the more general definition to bring it into concordance with most other institutions studying the ice-edge and its effects, but the SWG was not in full agreement as to whether this would be possible or advisable given the logistic issues noted above.

Matsuoka *et al.* (2003) reported on the relationship between large whale distributions and the southern boundary of the Antarctic Circumpolar Current (ACC) using JARPA 1997/98 survey data. Longitudinal distributions of humpback, southern right, large male sperm and southern bottlenose whales were concentrated between 80°E and 110°E during austral summer in the Antarctic (south of 60°S). Results of XCTD (eXpendable CTD) analyses in this area indicated a large meander of the southern boundary of the ACC that seemed to be moving north along the continent rise to 61°S and then slowly moving down to 63°S between 80°E and 120°E. It was considered that this longitudinal section was a high productivity area formed by large-scale upwelling with nutritious bottom waters due to the effect of the southern Kerguelen Plateau. High-density areas of humpback whales were observed along the large meander of the southern boundary of the ACC between 80°E-110°E. Southern right, large male sperm and southern bottlenose whales were also concentrated in this longitudinal section, although they were distributed on the Antarctic continental slope. Several whale species, especially humpback, southern right, large male sperm and southern bottlenose whales used this section as their key feeding area, although it seemed that they were segregated from each other in their feeding habits. Abundance estimates of humpback and Antarctic minke from this survey were 11,739 (CV = 0.45) and 19,342 (CV = 0.22) individuals, respectively.

The SWG thanked Matsuoka for his contribution and encouraged future analyses of cetacean distribution versus oceanographic variables.

8. HABITAT-RELATED ISSUES

8.1 POLLUTION 2000+

SC/55/E21 reported that progress with POLLUTION 2000+ had been hindered by postponement of a principal investigator/Steering Group workshop scheduled for March 2003 due to travel concerns resulting from the Iraq war. The interim report presented was, therefore, a status overview rather than an in-depth report of results (Appendix 4).

Many analyses have been completed for the bottlenose dolphin sub-project. Preliminary findings on Cytochrome P450 (CYP1A1) immuno-histochemistry analyses show that CYP1A1 expression was seen in endothelial cells, vascular smooth muscle and nerve cells, but not in connective tissue, epidermis and adipocites. Surprisingly, CYP1A1 expression is apparently not related to sex, age, length or weight. This is important because it may imply that interpretation of CYP1A1 expression could be made without knowledge of those parameters. Statistical analyses of the relationship between Cytochrome P450 expression and contaminant concentrations are underway.

Preliminary findings of immunological analyses found stress-associated perturbations in animals' immune profile. Changes found were a drop in total white blood cell count, loss of memory T lymphocytes and a reduced cell function of B lymphocytes. These stress responses were supported by elevated levels of cortisol and glucose. The degree of these stress-associated changes need to be compared to contaminant loads, as it is hypothesised that the healthiest animals will demonstrate the least changes in some or all immunological parameters.

For the harbour porpoise sub-project, progress has been made on immunohistochemistry analyses. However, low CYP1A1 expression has been found and it is therefore questionable whether additional analyses of enzyme activity should be conducted.

Reijnders described plans for completion of the POLLUTION 2000+ sub-projects. For bottlenose dolphins: (1) in-depth integration and interpretation of all biomarker data and contaminant concentrations will be conducted following completion of analyses of individual project components; and (2) additional sampling of animals from a relatively low polluted area (Charlotte Harbor) and a relatively high polluted area (Mediterranean) is needed. For harbour porpoises: (1) analyses of samples obtained thus far must be completed; and (2) after the results are analysed, decisions must be made about further sampling and analyses.

A work plan and related budget for 2003/2004 was presented. After prioritising the planned activities, a request was put forward to the IWC, to co-fund the project with an amount of £52,000.

Reijnders reported that he expects at least four papers from the bottlenose sub-project to be presented to the SC next year, including papers relating contaminants to retinol, immunohistological, enzyme induction and immunological biomarkers. In addition, there will be a major multivariate analysis undertaken to integrate results from all the biomarkers which should provide another paper. However, it was noted by Reijnders that the ability to attract additional funding for this project will ultimately determine the products that are completed and the project success.

Several in the group expressed concern about the lack of funds for finishing the project and the Chair suggested that Reijnders prepare a document for next year's meeting summarising the associated problems and what the Commission will gain from completion of this project. Reijnders indicated that this is actually part of the work plan for 2003/2004 and will be undertaken at next year's meeting.

There continues to be strong support for the POLLUTION 2000+ initiative and the SWG endorsed its continuation.

SC/55/E18 used skin biopsies in a preliminary assessment of the ecotoxicological status of a SW Mediterranean segment population of striped dolphin. A geographical trend of contamination has been found with PCB and DDT levels decreasing from north (Ligurian Sea) to SE (Ionian Sea). Ten striped dolphins were sampled with a biopsy pole during a survey of the Eolian area in summer 2002. Levels of CYP1A activities in biopsy samples from the Aeolian population were three and five times lower, respectively, than the levels previously found in the Ligurian and Ionian striped dolphin groups. Moreover, OC levels were significantly higher in the Ligurian samples compared to the Aeolian group. These results suggest that the non-lethal approach (skin biopsy) is suitable for investigating bioaccumulation of OCs, as well as CYP1A induction in free-ranging Mediterranean striped dolphins. In addition, CYP1A induction may be an early sign of exposure to OCs, including those with endocrine disrupting capacity.

Discussion focused on whether biopsy samples used for pollutant analyses could also be used to examine the genetics of the dolphins to see if there are some sub-populations present which might be indicated from some of the contaminant results. Fossi indicated that the entire biopsy sample is usually used for chemical analyses, but in future samplings some of the skin might be made available to answer this question.

8.2 State of the Cetacean Environment – consider form of SOCER

The preliminary version of the State of the Cetacean Environment Report (SOCER) was presented by its editors (SC/55/E7). Rose noted that the report had been produced in response to a request from the Commission for such an overview (IWC, 1998; IWC, 2001, p.56) and last year the format and process of SOCER production had been reviewed. The long-term goal is to produce a document that is well informed, up to date and accessible to the Commission.

The focus of this year's edition is the Atlantic Ocean, Black Sea and the Mediterranean Sea. The SOCER also includes an additional global section relating information of global importance. As SOCER covers a wide range of topics, a glossary had been added to aid the understanding of non-experts.

Recent results, analyses, events and developments concerning the marine environment in these regions were summarised in each of five categories: chemical pollution; climate change; habitat protection/degradation; disease and mortality events; and noise impacts. For each of these categories, both positive (e.g. the creation of marine sanctuaries) and negative (e.g. oil spills) entries were included. All entries were referenced regarding source or submitter — the majority came from peer-reviewed publications. The SOCER is not intended to be exhaustive, but rather a brief 'snapshot' of the cetacean environment for the non-specialist reader. Notable entries for this year included the Prestige taker oil spill off the coast of Spain, the report in *Nature* of a 90% decline in predatory fish stocks from pre-exploitation levels, and the recent Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) cetacean status review.

A contribution form was finalised and placed on the IWC web site. A solicitation letter and first draft were sent out via the Secretariat to members of the Scientific Committee in February (it is intended that such a letter will be sent out earlier next year). Other requests for information were sent to e-mail lists, including MARMAM. The editors reported a good response from their solicitations and included seven additions to the draft in a revised paper to the SWG.

The Chair expressed his thanks to the editors and noted that the emphasis on published papers provided a much-improved review. It was queried how the editors achieved balance between published and unpublished accounts in the report. The editors responded that emphasis had been placed on published work. They also referred to the SOCER submission forms that the contributors had been asked to use and stressed their role in helping to judge which contributions were important. Whilst the editors had rejected some material originating only from the popular media, they still felt that some events without a peer-reviewed source should be mentioned, e.g. the Prestige oil spill. Such matters might not reach the scientific literature for some time. They also encouraged would-be contributors to send information earlier in the year and preferably full papers rather than abstracts. Rose offered to be the repository of such submissions, especially reprints sent via post.

Several members of the group said that they had already found the SOCER a useful source of information. Taylor noted in particular the usefulness of reporting the successful application of regulation.

Stachowitsch queried whether the group would like to see a new category added listing 'new literature'. For example, it had been proposed this year to include mention of a new book on marine mammal toxicology. This idea was supported.

It was concluded that the process leading to the current SOCER draft had been satisfactory and that a useful product had been produced. The SWG recommended that the SOCER should become an Appendix to its report for the Commission. The full SOCER is available on the IWC website (*www.iwcoffice.org*).

8.3 Arctic issues

SC/55/E3 described how five parameters (lipid percent and classes, contaminant concentrations and profiles, and fatty acid profiles) were measured by blubber depth in two cetacean species: white and killer whales. The conclusions from this study indicated that blubber biopsy techniques seldom result in samples that give information completely representative of that obtained from full-thickness or even outer layer blubber samples obtained via necropsy. However, if carefully interpreted, biopsy samples can provide useful information for several types of analyses. For example, biopsy samples can provide adequate information on lipid classes present in the sampled blubber layer, but cannot provide information on depth-related changes in the lipid class profile. Measured contaminant concentrations of biopsy samples are generally within a factor of two of those obtained via necropsy for these species, therefore results based on analyses of biopsy samples from monitoring studies may be of sufficient accuracy to determine whether the animals are highly-contaminated and thus at risk of contaminant-related health effects. In contrast, fatty acid profiles from outer blubber layers collected via biopsy are substantially different from the metabolically active inner layer and are therefore unlikely to be useful in attempting to make correlations with the fatty acid profiles of potential prey. Thus, biopsy results are best interpreted with caution and in conjunction with results from blubber depth profiling on the same cetacean species.

It was queried whether there could be any difference in lipid loss depending on whether the sampled animal was dead or alive. Krahn confirmed that this would be the case, as temperature affects lipid mobility. She noted that it would be helpful to design a biopsy dart that could close at the end. The SWG noted there could be implications of this finding for ongoing pollution work. Krahn agreed that the interpretation of some data might need to be revisited. It was suggested that the standardisation of biopsy darts would help to facilitate comparisons between populations. Although the sample sizes were small, these observations were consistent with what has been seen in bowhead whales. Several group members commended the work and Krahn noted that she planned to continue these investigations.

Moore informed the group that a new research initiative focused on the sub-Arctic is being developed under the GLOBEC organisational umbrella. The new initiative is called Ecosystem Studies of Sub-Arctic Seas (ESSAS) and will provide opportunities for collaborative studies of cetacean ecology. A science plan should be available later this year via the GLOBEC web site (*http://www.globec.org*).

8.4 Habitat degradation

SC/55/E2 provided an update on the current state of the 'Nautical Steps' (NS) tourist development. A recent analysis of the project was undertaken by a market research firm (EDAW). The study showed that FONATUR (the developer) overestimated the demand for marina space by

600%. For example, NS reports that more than 60,000 big boats will be attracted from the USA to Mexico by 2014. EDAW reported that the demand will support about 10,000 annual boat visits to the coast of Baja California. The study indicated that only 5,500 berths will be needed, but FONATUR wants to provide 26,000.

To evaluate this project, detailed specifications will be needed. Unfortunately, FONATUR has not provided project specifications detailed enough to evaluate potential threats to cetaceans and other marine life. Among others, potential problems include: (1) increased vessel traffic and collisions; (2) uncontrolled whalewatching; (3) chemical and noise pollution; (4) disturbance of important feeding, breeding and nursing locations; and (5) other ecosystem disturbances or alterations. The distribution of blue whales and the movements of fin whales overlap with potential NS project sites, so disturbance to their habitat and normal behaviour is of concern.

Last year, the Committee recommended that: (1) the Commission request information from the Government of Mexico on the specific locations and types of construction comprising NS; and (2) the Commission request the Government of Mexico take steps to insure the maintenance of habitat important to cetaceans (IWC, 2003, p.341). The Government of Mexico presented a document (SC/55/O19) that was well received. After considering the available information, the SWG expressed concern over the potential effects of this commercial development on local cetaceans and their habitats. The SWG expressed disappointment that specific information requested last year was not made available in SC/55/O19, and therefore reiterated its request for this information.

M. Taylor gave an update on recent publications relevant to the framework outlined in the Habitat Degradation Workshop Scoping Group Meeting Report (Simmonds *et al.*, 2002a). Taylor (2003) was developed from Taylor (2002) and has been published along with a response from Shelden *et al.* (2003). Taylor also noted Myers and Worm (2003), which reported on large declines in predatory fish populations resulting from industrial fisheries. Dalla Rosa *et al.* (2002) reviewed killer whale populations worldwide and the threats from habitat degradation, climate change and other factors. It was produced (as a background paper) to support the listing of killer whales under the CMS (Convention on Migratory Species) last year.

SC/55/E6 was provided as a resource to assist planning and research decisions. Some factors causing habitat degradation are already addressed within IWC research programmes, such as POLLUTION 2000+. Other factors are less well covered. Taylor suggested a general conclusion that comparative studies are likely to be the mainstay of research connecting environmental effects with cetacean health and demography by seeking correlations for populations that experience a wide array of different levels of putative factors. As always the key concern is designing studies to be broad enough to cover enough of a range of potential causes that there is sufficient statistical power to avoid bias from confounding factors. Much needs to be done on the interactions and synergies among the multiple stressors affecting cetacean health. Models have been developed, and need to be tested whenever possible. Interactions with climate change are less easy to characterise, and research could fruitfully focus on possible synergies or potentiating effects. Of these, the retreat of polar sea ice is perhaps the most profound impact in high latitudes, opening up previously remote areas to shipping and extractive industry.

The relevance of the discussions this year about the risk status of the three Black Sea cetacean species in the Small Cetaceans sub-committee was also noted. These populations are threatened by fundamental habitat changes.

It was noted that for several years, the Scientific Committee of the IWC has been contemplating the significance of habitat degradation for cetaceans. A workshop to take this forward has been recommended. Preparation for this workshop was progressed at a special meeting held in Rome, June 2001 (Simmonds *et al.*, 2002a). Several potentially complementary approaches to furthering work on cetacean habitat assessment were considered with a long-term view to quantification. It recommended 'a broad focus that would bring together habitat evaluation and cetacean population demographics' and provided a revised proposal for a three day workshop of some 25 experts to the Scientific Committee (Simmonds *et al.*, 2002b). In addition to endorsement by the Scientific Committee, the proposal was also recognised in Resolution 1.9 of the first Meeting of Parties to ACCOBAMS and identified as one of the Agreement's 18 International Implementation Priorities for 2002-2006.

The workshop would consider the following points:

(1) Review and aid development of the concept of a habitat quality index to be used in classifying quality/ functioning of marine ecosystems in biological and physical terms.
(2) Review and aid development of the concept of cetacean critical habitat and the development of quantifiable indices that may be applied to it; including assessment of marine mammal health.
(3) Develop the concept of cetacean habitat quality indices based on information from (1) and (2) above.
(4) Review and aid development of modelling approaches as part of a framework and methodology to assess the significance of changes in such measurable parameters, with a view to developing a strategy for:
    (a) monitoring critical habitat quality;
    (b) identifying thresholds which may affect cetaceans; and
    (c) assessing proposals for activities that might affect cetacean habitat.
(5) Review relevant available information on:
    (a) cetaceans and their habitats and, in particular, studies that allow comparisons to be made between segments of populations that appear to be responding to different levels of environmental stress; and
    (b) studies of major perturbations of cetaceans habitat.

Information of two kinds were identified as potentially of particular importance to the workshop:

(1) Habitat quality assessment and the use of habitat quality indices. The significance of these indices may be determined for marine mammals by comparing them with 'vital parameters' (i.e. population demographics – see Fig. 1 of Simmonds *et al.*, 2001).
(2) Demographics — i.e. consideration of populations where there is an indication in measured population parameters of environmental disruption.

The workshop would be tasked to consider the appropriate 'links' – i.e. between environmental changes and changes at the population level. For example, as suggested by the

Scoping Group: (1) Impact to habitat; (2) Habitat to condition/health of animal; (3) Cetacean condition/health to 'vital life parameters'; (4) Life history to population stability; (5) Population persistence to community composition. The Scoping Group also recommended that particular consideration should be given to link (2) and an approach using comparative multivariate analyses. In this approach, several geographically distinct stocks of a species are identified for which good demographic and habitat data are available or readily obtainable. Habitat elements that vary among these sites sufficiently (and which are sufficiently independent of variations in other elements) are selected for multivariate analysis. It may be desirable to create a habitat quality index using principal components that summarise statistically significant variation among sites in the set of habitat elements; including *inter alia* prey abundance/variance, pollutant levels, noise levels, fishing intensity, temperature and salinity.

Funds had not been found to support the Habitat Degradation Workshop last year, despite hopes to the contrary and the SWG reiterated its ongoing support for the workshop and **recommended** that it should be held if funds are found.

After consideration of SC/55/E1, the SWG noted that the authors should consider some apparent limitations of their methods. This study carried out a comparative analysis to investigate whether there is a relationship between inshore versus offshore habitat use and the incidence of skin tattoo lesions. The analysis fails to control for phylogeny (a requirement of any comparative analysis) and would be better carried out at the species or even genus level. From the data in Table 2 of SC/55/E1, the analysis could only be carried out for bottlenose dolphins where the available sample size is too small to draw any conclusions. This paper could be significantly improved by inclusion of more data within taxonomic level (preferably species level), because as yet it does not convincingly demonstrate a relationship between inshore lifestyle and skin tattoo disease.

Wilson described the results of a related study (Wilson *et al.*, 1999) on epidermal lesions in ten populations of bottlenose dolphins. The populations were drawn from three oceans and a variety of habitats with widely differing natural and anthropogenic circumstances. Skin condition of the dolphins differed significantly between populations and the study sought to determine whether any factors could be found that were correlated. Of the natural and pollution related factors examined, strong relationships were found between the skin condition of each dolphin population and the local hydrographic conditions (particularly water temperature and salinity). The authors concluded that if epidermal lesions in dolphins were to be used to study the impacts of human related pollution, efforts would be needed to take account of the natural hydrographic factors first. These findings also raise the possibility that changes in freshwater influx into marine systems or alterations in water temperature might have implications for epidermal health in cetaceans.

SC/55/E20 described observations on the impact of the petroleum industry in South-Santa Cruz province, Patagonia (Argentina), an area of high biodiversity and highly changeable weather, often including very strong wind. The paper reported two petroleum-related accidents (a stranded tanker and a leak from a production platform). Some recommendations and actions were presented, including the recommendation that local contingency plans should include an environmental impact evaluation.

The Chair thanked the author and noted that little information had previously been received from this part of the world and that more would be welcome. Iñiguez noted that oil development at sea in Argentina is a relatively new issue. Weller noted that independent reviews of oil spill plans were conducted elsewhere and might also be helpful in this case.

8.5 Acoustic issues

SC/55/E4 noted that the development of wind farms in the marine environment is set to expand rapidly in the future as governments strive to meet greenhouse gas emission targets and renewable energy commitments. Marine wind farms constitute a new development in the marine environment and one for which the associated environmental impacts remain largely unexplored. Areas of particular concern, including those related to development within important cetacean habitat were discussed in the paper. The seventh meeting of the Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) had recognised the threat from marine wind farms and its scientific council was instructed to assess existing and potential threats from marine wind farms at the next Meeting of the Parties. However, despite the rapid expansion that is planned for wind farms, to date there is only a relatively small number of reports and papers that relate to their potential environmental impact, as outlined in SC/55/E4.

Some trends in the present and future development of marine wind farms are evident. At present, all marine wind farms are limited to shallow (less than 10m deep) near-shore waters, within approximately 5km of the coast. However, plans are now being made for large-scale development further offshore out to EEZ boundaries. Current marine wind farms have been on a small scale, generally less than 20 turbines, but future plans are considering farms with hundreds of turbines. The largest marine wind farm to date is sited at Horns Reef, Denmark. It came into operation in December 2002 and has 80 turbines. The actual size of the turbines has also been increasing; for example, Germany and the Netherlands are developing a wind turbine in excess of 100m high that produces in the region of 4.5MW. Larger scale development, larger turbines and plans to develop further offshore have wider implications for environmental impact.

As far as the authors of SC/55/E4 were aware, 12 operational marine wind farms exist and all of these are in Europe. Worldwide, a number of marine wind farms are in various stages of development. There are projects under construction, projects with approval, planned projects that are still under consideration and a number of other project proposals.

Coastal regions of the North and Baltic Seas are set to become hot spots for development because many European countries have extensive plans for future projects both near-shore and beyond their respective territorial waters: Germany, Denmark and the UK in particular. Germany has plans to build very large turbines and situate them more than 100km offshore in depths of 20-35m.

The authors of SC/55/E4 urged that marine wind farms should not be developed without due consideration given to the possible environmental consequences and that this should be done via appropriate environmental impact assessments.

A number of participants expressed their concerns about marine wind farm development in their region. The SWG noted the large scale of such developments planned in Germany (i.e. 200km^2 each) and that fisheries were looking at the potential for deploying set-nets amongst the turbines. It was also noted that hundreds of turbines were planned for the US East Coast in the absence of any policy for the outer continental shelf region. There can be a problem of terminology relating to this issue, in that the wind farm industry tends to refer to all marine farms as 'offshore'. The SWG also noted the potential threat posed by the electricity cables, primarily to fish, connecting farms to the shore.

The SWG concluded that the rapid development of marine wind farms was a substantial concern and **recommended** that full independent and publicly-accessible environmental impact assessments should be conducted wherever they are planned. The SWG noted that biological surveys might be needed in many regions to adequately inform the ETA process. Publication in peer-reviewed literature of studies considering associated impacts was also urged.

SC/55/E5 provided a brief review of some of the most recent research relating to noise in the marine environment, including studies on particular noise sources (i.e. vessels, aircraft, ocean experiments, acoustic harassment devices, seismic surveys and military activities). It also considered some recent advances in understanding noise impacts and presented some recommendations for future action on noise pollution. Simmonds highlighted that the debate about how powerful noise (military or otherwise) may precipitate strandings or otherwise harm cetaceans continues and a recent event where some coastal cetaceans appeared to be exposed to powerful sonar has added to concerns. The event occurred in Haro Strait (5 May 2003) and David Bain (pers. comm.) observed the behaviour of a number of cetacean groups during the passage of a naval vessel. He reported that, after the ship had passed, Dall's porpoises were observed travelling away from it at high speed. Porpoising minke whales (an unusual behaviour for them) were also reported from the locality. In the presence of the vessel, the killer whales of 'J pod' were observed behaving normally until the sonar became audible in air. They then moved inshore and grouped tightly. Bain described the group's behaviour as 'inconspicuous'. The sonar 'pings' were reported to be so powerful that they could be heard by visitors along the shoreline of San Juan Island.

The SWG expressed its **strong concern** about this event.

The issue of potential confusion between Low Frequency Active Sonar (LFAS) and other military sonars was briefly discussed. Clark mentioned that considerable progress has been made in understanding marine noise pollution, including refined acoustic propagation modelling packages that quantify noise and allow impacts on populations to be explored. He further noted that software tools are also becoming available to quantify estimates of noise exposure levels for individuals and populations of animals. These tools provide a conceptual framework for investigating noise exposure as a noise dosage. The challenge remains as to how to interpret the biological impact of physiological or behavioural responses to anthropogenic noise exposure.

Simmonds noted that the Whale and Dolphin Conservation Society (WDCS) has recently completed a review of the marine noise pollution issue (Dolman *et al.*, 2003) and concluded an action plan, as presented in SC/55/E4. Simmonds stressed one aspect of this: 'that an independent body should be established to initiate, promote, monitor and fund marine noise research'. In addition, the USA Marine Mammal Commission (MMC) had recently received substantial funding to investigate these matters. During discussion another event was also noted: on 25 September 2002, a group of marine mammal scientists (including members of the Scientific Committee) found two freshly dead Cuvier's beaked whales with no signs of external trauma. They subsequently learned that a seismic survey was being conducted nearby using air guns (263 dB re 1 microPa(at)lm). This event was the first observation implicating low-frequency seismic exploration in whale strandings.

The SWG noted:

(1) the importance of the emergent threat of noise pollution to cetaceans and other elements of marine ecosystems, including the increase in the deliberate deployment of powerful noise sources that radiate noise over large areas; and
(2) the potential of the Scientific Committee to assist in the development and interpretation of studies aimed at elucidating the potential consequences of introduced noise for cetaceans.

The SWG **recommends**:

(a) that an approach be made by the Scientific Committee to the USA MMC to give consideration to the exchange of information and potentially the development of cooperative research in order to combine the expertise of both bodies;
(b) that workshops generated under the auspices of the USA MMC 'noise programme' should include Scientific Committee representation where appropriate; and
(c) that appropriate representatives of the USA MMC should be invited to attend the next Scientific Committee meeting to discuss progress in this field.

In addition, the SWG **agreed** to establish an intersessional correspondence group (see Annex U) to further develop the noise agenda of the group, including identifying topics for future review, such as the demographic or physiological consequences of exposure to loud noise sources and synergistic effects. The intersessional group will also try to identify other bodies (in addition to the USA MMC) that will assist in this.

9. WORK PLAN AND PRIORITIES FOR 2003/04

The following intersessional groups and chairs were agreed:

(1) Acoustic issues: Clark
(2) SO-GLOBEC/CCLAMR: Thiele
(3) POLLUTION 2000+: Reijnders
(4) SOCER: Rose and Stachowitsch
(5) Arctic issues: Moore
(6) Habitat Degradation Workshop: Simmonds
(7) Define focus for 2004 meeting: Gales
(8) Ice-edge definition: Thiele

The SWG decided to appoint a correspondence group (composed of Clark, Gales, Moore, Reijnders, Rojas-Bracho, Rose, Simmonds, Stachowitsch, Thiele) to define the focus of the SWG's work for next year. Rojas-Bracho agreed to chair this Steering Group. The group will contact the convenors of next year's sub-committees and attempt to focus the SWG's work on an issue of importance to the other groups.

The SWG agreed the following budget request:

Table 1

SWG budget request.

Title	Funds required (£)	Justification
POLLUTION 2000+	52,000	Appendix 4
SO-GLOBEC	86,900	Appendix 2
Habitat Degradation Workshop	15,500	IWC (2003) pp. 318-319
Preparation for SOCER	3,000	2 months salary, copying charges, phone costs

Simmonds commented that, as was the case in previous years, he and other members of the SWG were hopeful that they would be able to secure additional funds for the Habitat Degradation Workshop from sources outside of the IWC. He also informed the SWG that an offer to host the meeting has been made by the University of Siena and that the workshop is of interest to ACCOBAMS.

Members of the SWG expressed concerns that there are insufficient funds to support the Invited Participants that are needed for the SWG to complete its work. For example, the Mini-Symposium on High Latitude Climate Change Effects which was scheduled for this year occurred on a much abbreviated scale due to limited funds for Invited Participants. This symposium should be attempted again in a couple of years after analysis and synthesis of the joint IWC, SO-GLOBEC and CCAMLR work has been completed.

Following completion of scheduled business the SWG discussed ways to improve its effectiveness and methods of operation. Results of this discussion are summarised in Appendix 5.

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Appendix 1

AGENDA

1. Convenor's welcome and opening remarks
2. Election of Chair
3. Appointment of rapporteurs
4. Adoption of Agenda
5. Review of available documents
6. Modelling cetacean-fisheries interactions, including results from intersessional Workshop
7. Southern Ocean climate change effects on cetaceans
   - 7.1 Cooperation with SO-GLOBEC and CCAMLR
     - 7.1.1 How interannual and long-term changes are likely to affect Antarctic krill populations
     - 7.1.2 Southern Ocean Global Ecosystem Dynamics Programme
     - 7.1.3 SWG discussion
8. Habitat-related issues
   - 8.1 POLLUTION 2000+
   - 8.2 State of Cetacean Environment – consider form of SOCER
   - 8.3 Arctic issues
   - 8.4 Habitat degradation
   - 8.5 Acoustic issues
9. Work plan and priorities for 2003/04

Appendix 2

IWC COLLABORATION IN THE SOUTHERN OCEAN: BUDGET REQUEST

D. Thiele and S. Moore

The IWC has participated in five multidisciplinary research cruises in the Southern Ocean since the 2002 Annual Meeting. The IWC has contributed relatively minor funds towards participation in these multi-million dollar multidisciplinary programmes. The additional data series available to the IWC from other disciplines as a result of these collaborations includes extensive data on krill distribution, patch dynamics, sea ice extent, type and cover,

sea ice formation and structure, krill abundance, currents, tides, productivity, physical oceanography, biological oceanography, biodiversity of other predators.

As an integral part of participating in these national SO-GLOBEC and CCAMLR field programmes, we also took part in analysis, collaboration meetings and proposal development. We have presented our work in poster form and spoken presentations at international conferences, particularly at the 2nd International GLOBEC Open Science Meeting in Qingdao, China, October 2002 (see SC/55/E9). In addition, we have submitted two cetacean research papers to be published in late 2003 in the first volume of the US SO-GLOBEC special issue of *Deep Sea Research*. A considerable amount of new data, of importance to many sub-committees (SH, E and IA) has resulted from these cruises, and will continue to be presented to the IWC SC as the synthesis and analysis phase continues.

The IWC is invited to continue its participation in national and international efforts in the Southern Ocean in the next few years through collaborative synthesis and analysis projects and field work. In the longer term the IWC is well placed to build on recent collaboration and to ensure whale ecology becomes a core component of the next major phase of marine science focus in this region (OCEANS/ICCED initiative). The development of the ARPs around the Antarctic initiative is an important component in a circum-Antarctic approach to investigating the connections between whale ecology and the variability and dynamics of Antarctic ecosystems.

We have developed collaboration with many nations and programmes, to ensure that the IWC can be involved in the major research efforts in the Antarctic well into the future. The time frames for collaboration require that negotiations, planning, submission of proposals etc be initiated well ahead, often years ahead, of any cruises.

This financial year we have committed to collaboration in the field with the following programmes:

(1) German SO-GLOBEC Weddell Sea cruise: the first in a series of three planned cruises to one study site over 2 years in the Weddell Sea.
(2) US Ross Sea mooring cruises: the first of two cruises to the same study area in the Ross Sea.
(3) US Western Antarctic Peninsula SO-GLOBEC cruise: follow-on to the studies in Marguerite Bay under US SO-GLOBEC.

All cruises will include visual survey and passive acoustic monitoring with both sonobouys during voyage and the deployment of year round recording devices (ARPs).

Last year a funding allocation of £15,000 was allocated to this project, and an additional amount of £25,477, which had already been allocated from the Environment Research Fund, was brought forward to result in a total allocation of £40,477 pounds for 2001/02.

This work directly addresses the following Resolutions from the Commission:

1994-13 Resolution on research on the environment and whale stocks (IWC, 1995);
1995-10 Resolution on the environment and whale stocks (IWC, 1996);
1998-5 Resolution on environmental changes and cetaceans (IWC, l999a);
1998-6 Resolution for the funding of work on environmental concerns (IWC, 1999b);
1999-5 Resolution for the funding of high priority scientific research (IWC, 2000);
2000-7 Resolution on environmental change and cetaceans (IWC, 2001, pp.56-57).

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Appendix 3

REPORT OF THE AD HOC WORKING GROUP ON ICE DATA COLLECTION IN THE ANTARCTIC

D. Thiele, V. Peddemors, R. Leaper, K. van Waerebeek and S. Hedley

Abstract

A system to include comprehensive sea ice data collection within cetacean line transect surveys in the Antarctic was developed and trialled in the 2002/03 season. Some issues were identified during field trials concerning the use of the two data collection systems simultaneously, generally concerning doubling up of data entry across systems. These issues are relatively simple to resolve, and a series of steps are proposed to address these and complete a final version of one integrated sea ice and whale survey logging program for final trials in 2003/04. The development of a simple, yet comprehensive field system should ensure maximum adoption across programmes and platforms, and provide directly comparable datasets.

Background

The *ad hoc* Working Group on ice data collection in the Antarctic was formed to develop, trial and evaluate a standardised and simple system to record ice data during cetacean field studies in the Antarctic (Thiele *et al.*, 2003). The importance of understanding the linkages between ice-ocean processes, whale distribution, abundance and movements, and the dynamics of other Antarctic marine biota, particularly whale prey species has been highlighted in several presentations to the Scientific Committee. Field experience in this region and work alongside sea-ice and other marine science disciplines have highlighted the need for a standardised ice data collection method for use on whale research platforms in or near the ice. The development and implementation of a standardised method for these data would provide comparability between datasets (many of which have common standardised methods of sighting survey data collection), which is not currently possible. The implementation of this system will also provide scope for ensuring that biologically useful ice information is collected routinely.

Methods

The Working Group completed the majority of the tasks assigned to it and the results are presented here.

Arctic ice data collection methods

Thiele consulted with Moore and Worby on systems in place for collection of Arctic sea ice data. Arctic sea ice is quite different to Antarctic sea ice, and it was determined that use of an Arctic ice system would not be useful.

ASPeCt Observing Antarctic Sea Ice CD

This CD-Rom was developed under the auspices of SCAR (Scientific Committee on Antarctic Research) and GLOCHANT (Global Change and the Antarctic) and combines an ice observation training program linked to a data entry system. The ice data collected under the protocols on this CD have been identified by expert sea ice physicists as those needed to ground truth satellite imagery, and provide data points at a scale that can be used to quantitatively assess the complexity of the sea ice environment. Although the CD was designed to generate standardised data for heat exchange/flux effects of sea ice, the categories of data recorded are also important in a biological sense (ice thickness, ice type, snow cover), not least because features of the environment that affect physical flux conditions and rates are impacting directly on the conditions for living, or habitat of organisms. This CD system is used on research vessels throughout the Antarctic and by contributing data in the ASPeCt standard format, access to these considerable datasets can be gained.

Working Group members were provided with the Observing Antarctic Sea Ice CD (Worby, 1999) for initial assessment as to its potential for integration with other field data collection systems already in place on most whale surveys in the Antarctic. The CD program was reviewed and recommended for trials during the 2002/03 Antarctic season, to be used in conjunction with the Wincruz Antarctic[1] sighting survey program. The sea ice CD program requires data record entries every hour, however a 30 minute interval between entries was recommended as this seemed more appropriate to some of the finer scale relationships that need investigation. The CD data provides a broad continuous ice environment context for the sightings point data.

Wincruz Antarctic

The Wincruz Antarctic program has been used as the standard line transect sightings survey logging program on many whale research programmes in the Antarctic since the IWC-CCAMLR surveys in 1999/2000. This program originally did not have any prompts or data entry boxes for ice information and in that form would not be suitable for integration with the sea ice CD program. In addition to filling out sea ice data from the CD, these data also needed to be entered directly into the whale sighting database at the time of sightings.

A series of modifications (in the form of additional drop down menus and prompts for sea ice information and photographic records) were made by Rob Holland in 2002 in consultation with the group. The changes had to be completed in a short time frame to be ready for the 2002/03 austral summer cruises, and it was expected that some fine-tuning would be necessary after the field trials were completed. The new version of Wincruz Antarctic can be found at *http://swfsc.nmfs.noaa.gov/prd/ecology/wincruz.html.*

Field trials

The new Wincruz Antarctic logging program was set up to prompt observers to record data on the ASPeCt program CD, or on the hard copy forms generated from the CD. During the field trials the two systems were linked through these prompts and the sea ice training program on the ASPeCt CD. The system was trialled on three SO-GLOBEC cruises during the 2002/03 season: (1) Australian SO-GLOBEC on *Aurora Australis* Voyage 4 (V. Peddemors, P. Hodda, C. Bell, S. McKay); (2) IWC/SO-GLOBEC collaboration cruise (British Antarctic Survey/UK SO-GLOBEC/CCAMLR) on the *James Clark Ross* (R. Leaper, K. van Waerebeek); and (3) US SO-GLOBEC mooring cruise on the *L M Gould* (D. Thiele, D. Glasgow).

Issues

The field trials revealed many positive aspects to the new system, and some problems which will hopefully be rectified before the final system is trialled during the 2003/04 Antarctic season.

The ASPeCt sea ice data collection tutorial system was unanimously agreed to be straightforward and well designed. Once observers learn how to record ice accurately, the forms are easy to fill in. However, the ASPeCt data forms are time consuming to complete when also trying to record sightings on a separate logging program. Methods to address this are proposed below. In addition, the ASPeCt program does not provide any option for recording ice bergs or ice of land origin (broken off shelves etc) or for ice cover less than 5%, which in some regions (e.g. off parts of the Antarctic Peninsula) account for most of the ice encountered. This is due to the fact that there is a systematic program for collecting these data separately. When adapting the ASPeCt form into the sighting system for the final version, the collection of iceberg data (180° arc ahead of trackline) and any percentage of ice cover will be included.

Wincruz Antarctic had some problems that need to be fixed; most of these are minor and are not the result of changes made for the field trials. The major issue with Wincruz Antarctic is the output data from the das generated txt files, which are not readily transferred into any database

[1] Wincruz Antarctic is a free software program developed by Robert Holland at the Southwest Fisheries Science Centre, La Jolla, USA for cetacean surveys in the Antarctic. The software is available at *http://mmdshare.ucsd.edu/software.html.*

structure (i.e. Access or Excel). This means that all sightings records have to be hand entered, again into a database or a macro must be written to transfer data. The data storage format means that even with a macro (which requires some programming skills), the nightly task of checking data and transferring it to a database is time consuming. This means that these data are not readily accessible to produce simple summaries of effort and sightings.

Solutions to these problems are relatively straightforward and the Working Group will reconvene in the next intersessional period to iron out the issues and to complete a final version ready for final trials in the 2003/04 season.

Recommendations

The Working Group recommends:

(1) Use of a standardised system of ice data collection similar to that used during trials in the 2002/03 Antarctic season, but with some critical changes (i.e. a laptop based system that integrates the features of a sighting survey logging program such as Wincruz Antarctic with the data format required by the ASPeCt Observing Antarctic Sea Ice CD).

The Working Group recommends the following work to be completed in the intersessional period prior to the 2003/04 Antarctic season:

(1) Determine potential for Wincruz Antarctic to be adapted to address issues with output data format and integration of ASPeCt data form mimic.
(2) Determine same for other line transect sighting surveys programs if Wincruz Antarctic changes are not possible.
(3) Finalise sighting survey logging program (Wincruz Antarctic or other) integration with ASPeCt Observing Antarctic Sea Ice CD forms and allow for the collection of iceberg data (180° arc ahead of trackline) and for any percentage of ice cover on form.
(4) Standardise the collection of digital photographs of ice: (a) around the vessel; and (b) at sightings. For example for (a) take one photo every 30 minutes with the camera pointed directly ahead of the platform (180° and for (b) place sighting position in centre of frame and always link photo to written description of ice habitat at sighting (in addition, labelling of digital images is a simple process that can be carried out each night along with data validation process – labels and boxes can be used to show actual spot where whale surfaced in ice).
(5) Working Group to write up protocols for this as it integrates into sighting protocols; survey protocols will be updated and archived with the IWC Secretariat.
(6) Link above to ACCESS database with provision for all data types currently stored in Wincruz Antarctic and ASPeCt.
(7) Include facility in new system to print out data form for SCAR/ASPECT in same format as ASPeCt Observing Antarctic Sea Ice CD and for these data to download into whale sighting database for ease of use by both whale and sea ice programs.
(8) Print out colour photo quality booklet versions of ASPeCt image library of sea ice[2] designed for outdoor use.

In addition the Working Group recommends the following protocols for data collection:

(1) Visual survey teams should train in sea ice data collection on board using both the CD and colour printed format of the ASPeCt Observing Antarctic Sea Ice CD.
(2) Where two laptops can not be run simultaneously on the survey platform (one for ASPeCt training images and one for Wincruz Antarctic or other sighting logging program) the colour printed version of sea ice examples and images from the ASPeCt Observing Antarctic Sea Ice CD should be used as a reference when recording ice data.
(3) Sea ice data should be recorded regularly every 30 minutes in the ASPeCt Observing Antarctic Sea Ice form within the new survey sighting program.
(4) Sea ice data should also be recorded at all whale sightings in the ice (180° arc to horizon in direction of sightings and ice habitat at exact position of whale) until sightings become too dense (this will depend on number of observer teams and many other factors).
(5) A photograph of ice conditions (preferably digital) where whale sighting occurred should be maintained in the logging system.

ACKNOWLEDGEMENTS

We would like to thank Tony Worby for providing the ASPeCt Sea Ice CD's, and for providing additional advice and Rob Holland and Sharon Hedley for a considerable amount of work advising and making changes to Wincruz Antarctic before the austral summer. This work would not have been possible without the hard work and reporting from all of the observers on the IWC/SO-GLOBEC surveys (Russell Leaper, Koen Van Waerebeek, Deb Glasgow) and the SOCEP team on the Australian SO-GLOBEC survey (Paul Hodda, Shannon McKay, Catherine Bell).

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[2] Printing out a copy of the ASPeCt Sea Ice CD image library: when you put the CD in your machine, instead of hitting 'START', open up the folder called 'FILES'. In here you will find two pdf files called 'IMAGELIB' and lib_pics which contain all the images and definitions contained in the image library. The image lib file is about 40 pages long and has the terminology and small pictures of ice types, while lib_pics has large versions (one A4 page in size) of the sea ice images used for training.

Appendix 4

INTERIM REPORT ON POLLUTION 2000+ (2002-2003)

P. Reijnders, R. Wells, A. Aguilar, A. Bjørge and G. Donovan

1. INTRODUCTION

The IWC POLLUTION 2000+ programme was further implemented during the past year. The status of the analyses to be carried out under the two sub-projects (bottlenose dolphins and harbour porpoise post mortem calibration study) is described here. This paper is intended to give an overview, rather than an in-depth analysis of results.

2. BOTTLENOSE DOLPHIN SUB-PROJECT: PROGRESS DURING 2000-2003

Project summary

As part of the IWC POLLUTION 2000+ programme, live bottlenose dolphins were sampled to evaluate potential biomarkers of organochlorine contaminant (OCs) exposure and effects. The approach involved sampling dolphins expected to reflect a large range of environmental contaminant conditions ('dose'), and then investigating variation in potential biomarkers ('response') relative to these contaminant situations ('doseresponse'). PCBs were identified as the chemicals of interest for this programme, because of their widespread global distribution and the extensive information on the effects of these compounds for a variety of mammals.

Original plans called for biopsy darting of dolphins in: (1) the Mediterranean Sea to obtain samples from dolphins likely to carry high concentrations of PCBs in blubber; (2) obtaining blubber samples during capture/release operations in Sarasota, Florida (a site presumed to be intermediate in terms of PCB pollution); and (3) the Bahamas Islands to obtain samples from relatively 'clean' dolphins. The small sample masses obtained from biopsy darting do not permit sufficient testing for the full suite of potential biomarkers. Capture-release operations in Sarasota Bay provided detailed information on health and body condition, as well as the larger blubber sample masses and samples of blood and urine needed for 'ground-truthing' the potential biomarkers. Problems encountered in access to the Bahamian field site following initial sampling led to exploratory biopsy darting to obtain blubber samples from dolphins in Charlotte Harbor, Florida, a less-developed estuary south of Sarasota Bay. Eleven biopsy samples were collected from the Bahama Islands (7 males, 4 females) during 2000, and also from Charlotte Harbor (9 males, 2 females) during 2001. Five samples were collected from the Mediterranean Sea (Aguilar and Borrell, 2001).

The Sarasota Bay bottlenose dolphin community provided opportunities to sample individual dolphins, providing extensive background information on life history, reproductive histories, ranging patterns and health (monitored for four successive generations). The Sarasota-based research programme has been developing methods for assessing the population status and health of coastal bottlenose dolphins, not only to monitor the risks to the populations themselves, but also to assess their use as sentinels of the health of marine ecosystems (Wells *et al.*, In press). Research on the resident Sarasota Bay dolphin community has been ongoing since 1970, and about 140 identifiable individuals, mostly of known gender, age and genetic relationships, are currently under study (Irvine and Wells, 1972; Irvine *et al.*, 1981; Scott *et al.*, 1990a; Wells, 1991; 2003). Population monitoring efforts benefit from the fact that at least 60% of inshore dolphins on the west coast of Florida are individually identifiable from dorsal fin features, facilitating direct counts and mark-recapture estimates (Wells and Scott, 1990; Wells *et al.*, 1996a; b; 1997). Using photographic identification techniques (Scott *et al.*, 1990b) it is possible to define individual home ranges (e.g. relative to contaminant sources) and measure female reproductive success as well as monitor population-level trends in abundance, losses and other vital rates (Wells and Scott, 1990). In addition, the shallow waters of much of the habitat of inshore bottlenose dolphins facilitate safe capture and release operations, in which dolphins can be examined by biologists and veterinarians and sampled for subsequent health-related analyses. Matched blubber, blood and urine samples were collected from 47 dolphins from Sarasota Bay during June 2000 and 2001. The sample includes a representative cross-section of the resident dolphin community (~140 individuals), with sampled dolphins ranging in age from 2 to 50 years (Table 1).

Table 1
Summary of Sarasota Bay bottlenose dolphins sampled during 2000-2001.

Age class	Females	Males
0-10	11	10
11-20	5	5
21-30	1	2
31-40	4	3
41-50	4	2
Total	25	22

Status of analyses: samples

The numbers and masses of samples available for each of the specific analyses varied with the type of tissue required, the difficulty of obtaining the sample and the timing of identification of the analysis as part of the programme. For the Sarasota Bay dolphins sampled during capture/release, analyses of blood samples for chemistry, hematology, reproductive hormones, thyroid hormones and immune function are either underway or have been completed; the remaining blood, blubber and urine sample analyses remain to be completed (Table 2).

Status of analyses: data

Analyses of samples are either completed or underway, as summarised below:

Table 2
Status of sample analyses supported by samples collected from Sarasota Bay bottlenose dolphins, 2000-2001.

Tissue	Analysis	Total	Females	Males	Status
Blubber	PCB concentration	47	25	22	Complete
	Immunohistochemistry	47	25	22	Complete
	Enzyme induction: activity	21	11	10	In progress
	Luciferase	16	9	7	To be completed
	Retinol (Vitamin A)	47	25	22	Complete
Blood	Chemistry, hematology	47	25	22	Complete
	Reproductive hormones	47	25	22	Complete
	Thyroid hormones	47	25	22	Complete
	Immune response	47	25	22	Complete
	Total PCBs	21	11	10	To be completed
	Coplanar PCBs	21	11	10	To be completed
	Porphyrins	47	25	22	To be completed
	Luciferase	47	25	22	To be completed
	Vitamin A	47	25	22	To be completed
Urine	Porphyrins	38	16	22	To be completed

Life history analyses
Determination of age is complete for the live capture-release samples, and gender determinations are complete for both the live capture-release and the biopsy dart samples; these data have been distributed to the co-investigators (Wells, Hohn).

Clinical blood analyses
Chemistry and hematology: preliminary analyses of relationships to contaminant residue concentrations have been completed by Ailsa Hall, and no significant relationships were found (Wells, Rowles, Rhinehart, Hall).

Reproductive hormone analyses
Analyses of relationships to contaminant residue concentrations are underway (Wells, Rowles, Rhinehart, Hall).

Thyroid hormones
Preliminary analyses of relationships to contaminant residue concentrations are underway (Wells, Rowles, Rhinehart, Hall).

Blubber organochlorine pollutant concentrations
Analyses are complete and data have been distributed to co-investigators (Borrell, Aguilar).

Blubber Retinol concentrations
Analyses are complete, and data have been distributed to co-investigators (Aguilar, Borrell, Tornero).

Blood Retinol (Vitamin A) concentrations
To be completed (Borrell, Aguilar).

Enzyme induction analyses
To be completed (Wilson).

Immunological analyses
Preliminary analyses completed. Results are presented below (Stott).

Luciferase analyses
To be completed (Brouwer).

Porphyrin analyses
To be completed (Fossi).

Immunohistochemistry
Analyses are underway. Preliminary results are presented below (Wilson).

PRELIMINARY FINDINGS

CYP1A immunohistochemistry analyses: Joanna Wilson, Woods Hole Oceanographic Institution

Materials and methods

Integument samples (epidermis and underlying blubber) were collected from temporarily captured free-ranging bottlenose dolphin in Sarasota, Florida, as part of an ongoing health and population assessment. This long-term monitoring programme collects photographic identification data, age, sex, reproductive events and genetic relationships within the population. Captures took place in June of 1999, 2000 and 2001. All biopsies were taken from the same site on the dorso-lateral aspect and fixed in 10% neutral buffered formalin. Biopsies were the full depth of the integument. Matched samples of blubber were placed on ice and stored at −20°C. During 2000 and 2001, matched biopsy samples were also snap-frozen in liquid nitrogen for catalytic determination of CYP1A1 (these analyses are not yet complete).

Immunohistochemical analysis of CYP1A expression
CYP1A expression was examined using immunohistochemistry, as previously described for fish (Smolowitz *et al.*, 1991). Briefly, the formalin-fixed samples were embedded in paraffin and sectioned at 5μm. Sections were deparaffinated, hydrated and stained immunohistochemically using a peroxidase anti-peroxidase detection system (Signet Laboratories, Dedham, MA) with the monoclonal antibody 1-12-3 to scup (*Stenotomus chrysops*) CYP1A as the primary antibody. This antibody recognises an epitope specific to CYP1Al in mammals and detects CYP1A in taxonomically diverse vertebrates including cetaceans (Stegeman and Hahn, 1994). Amino-9-ethylcarbazole (AEC) was used as the chromogenic substrate for visualisation of CYP1A. Nuclei were made visible by hematoxylin counterstaining. Stained sections were evaluated under light microscopy for stain occurrence (scale of 0-3) and stain intensity (scale of 0-5) in each cell type. CYP1A expression was calculated as the product of the stain occurrence and intensity to generate a semi-quantitative index (scale of 0-15). A linear relationship between this staining index and CYP1A protein content detected by immunoblot was shown previously (Woodin *et al.*, 1997).

Results

Integument samples were collected from 59 bottlenose dolphins (23 males, 33 females, 3 unknown sex) from a resident population in Sarasota Bay, Florida. Matched blubber samples were taken for 47 animals for determination of contaminant and retinol concentrations. Males and females ranged in age from 2-43 and 2-50 years, respectively. Ages were evenly distributed; in males 45% (28% females) and 55% (72% females) of samples were from animals less than and greater than the age of sexual maturity, respectively. Males and females reach sexual maturity at 10 and 5 years of age, respectively. Ages were known in 80% of the animals sampled.

CYP1A1 expression was seen in endothelial cells of the arterial system and capillaries, vascular smooth muscle and nerve cells. The nerve cell staining may include some

fibroblasts, which are difficult to distinguish with this technique. CYP1A1 expression was not seen in epithelial cells of the epidermis, connective tissue, adipocytes and the perineurium (dense connective tissue that surrounds the peripheral nerve bundle). CYP1A1 expression was not significantly different between males and females for any tissue type (data not shown) and therefore, males and females were combined for subsequent analyses. CYP1A expression was lowest in nerve cells and highest in endothelial cells. CYP1A expression was statistically different between each tissue type. Endothelial CYP1A1 expression was significantly greater than CYP1A1 expression in either vascular smooth muscle or peripheral nerves. Vascular smooth muscle had greater CYP1A1 expression than peripheral nerves.

Endothelial CYP1A1 staining differed within the dermis. Some cetaceans, including bottlenose dolphins have predominantly connective tissue and little or no adipocytes near the epidermal/dermal interface. In this region (referred to in this report as the upper dermis), endothelial CYP1A1 expression was significantly lower than in the rest of the dermis where adipocytes were the dominant cell type. The upper dermis corresponds, in part, to the region often referred to as the outer blubber in many studies of lipid and fatty acid content in cetaceans. Endothelial cells in the lower dermis, distinguished by the predominance of adipocytes, had higher CYP1A1 expression than the upper dermis.

CYP1A1 expression in endothelial cells from the lower dermis was correlated with CYP1A1 expression in both nerve cells ($r = 0.62$, $p < 0.05$) and vascular smooth muscle ($r = 0.57$, $p < 0.05$). In contrast, CYP1A1 expression in endothelial cells from the upper dermis was not correlated to CYP1A1 expression in any other cell type. CYP1A1 expression was correlated between vascular smooth muscle and nerve cells ($r = 0.72$, $p < 0.05$). The life history parameters of age, length and weight did not appear to have a strong influence on CYP1A expression as they were not significantly correlated in any cell type, regardless of whether sex was used as a grouping factor.

Discussion

Vascular endothelial CYP1A1 staining has been regularly seen as the predominant cell type expressing CYP1A1 in cetacean biopsies (Angell *et al.*, 2004). The regional differences in vascular endothelial CYP1A1 have been seen in common dolphin and offshore bottlenose dolphin biopsies (J. Wilson, unpublished data) but have not been seen in all cetacean species examined (C. Miller, pers. comm.). The reasons for such regional differences in CYP1A1 expression are unknown; differences in regional blood flow/perfusion and/or lipid dynamics may play a significant role. A complicating factor for most of the CYP1A1 biopsy work performed by J.J. Stegeman and M.M. Moore, Woods Hole Oceanographic Institution, is the lack of information on the depth of the dermis versus the depth of the biopsy into the dermis. In this study, biopsies spanned the full depth of the dermis, however comparisons to other research are difficult because for all other species studied to date, biopsies spanning the dermis are lacking.

The cell types that express (endothelial cells, vascular smooth muscle, nerve cells) and do not express CYP1A1 (connective tissue, epidermis, adipocytes) in this study agree with most other species examined to date (Angell *et al.*, 2004). Fibroblast staining has been seen in the connective tissue of some cetaceans (Angell *et al.*, 2004) but was not seen in this study or in another study of bottlenose dolphins (J. Wilson, unpublished data).

Surprisingly, CYP1A1 expression does not appear to be related to sex, age, length or weight. This is important information for the interpretation of biopsies from offshore animals or coastal populations which lack the long-term study for which the Sarasota FL bottlenose dolphin have been the subject of. This may imply that interpretation of CYP1A1 expression may be made without knowledge of these parameters.

Future directions

Statistical analyses of the relationships between contaminants and CYP1A1 expression are underway. Initial correlations showed a strong relationship between CYP1A1 expression in both endothelia (lower dermis) and vascular smooth muscle and several contaminants: aldrin, total PCBs and total DDT. Vascular smooth muscle CYP1A1 expression was also correlated with α-HCH. CYP1A1 expression, in any cell type, did not correlate with retinol, HCB, βHCH and γHCH concentrations in the blubber. However, these correlations were based on a small subset of the samples. There were samples below the detection limit in the contaminant dataset. When the initial correlations were performed, missing data were deleted in a casewise manner resulting in a much smaller number of samples for the correlations. Efforts are underway to deal with those samples below the detection limit and instead perform a stepwise model of the contaminant-CYP1A1 relationship.

Frozen samples were also taken from a subset of bottlenose dolphins sampled in 2000 and 2001. These samples are very small and careful consideration of how to process them is needed. Since the samples are too small to make microsomes from individual animals there are several options on how to proceed. First, one could pool samples and prepare microsomes from the pool for catalytic assays and possibly immunoblots. Determining the appropriate samples to pool and statistical comparisons with the immunohistochemistry data would be difficult. Second, one could pool samples to make S-9 homogenates (less purified preparation than microsomes) for catalytic assays only. The same difficulties apply to this option as for above but fewer samples would need to be pooled to ensure a sufficient sample. Although immunoblotting would not be possible, certainly there would be more pools (than with microsomal preparations) and any variability in the data would be better characterised. Third, one could extract total RNA and perform a semi-quantitative or possibly quantitative RT-PCR determination of CYP1A1 mRNA levels. A semi-quantitative RT-PCR assay for CYP1A1 has been established by C. Godard and J.J. Stegeman (Woods Hole Oceanographic Institution), and has been used in other cetacean species (sperm whale, striped, common, spotted and bottlenose dolphins) with very small biopsy samples (≥0.lg), similar to that included in this study (C. Godard, pers. comm.). This option should prevent pooling of samples but would determine CYP1A1 mRNA levels and not catalytic activity as will be done for the harbour porpoise study.

Immunologic analyses: Jeff Stott, University of California, Davis

Immunological analyses were conducted on a total of 26 dolphins sampled in 2000. All 26 animals were analysed twice for a total of 52 datasets. The first sample was taken immediately upon capture and the 2nd sample just prior to release of the animal (typically a time-lapse of about 2.5 hours).

Analysis of lymphocyte function was conducted on all samples using three different mitogens to induce cell proliferation. ConA and PHA are predominantly T cell mitogens while PWM stimulates both T and B cells. Each mitogen was used at two concentrations (1.0 μg/ml and 0.1 μg/ml) to facilitate identification of animals with 'some' degree of lymphocyte dysfunction (low concentration of mitogen) versus those with lymphocyte suppression (substantial dysfunction based upon reduced response to both concentrations of mitogen). The low concentration of mitogen stimulates lymphocytes very well but disturbances such as stress can result in decreased response while the response to optimal concentration of mitogen (1.0 μg/ml) remains unaffected.

Criteria for lymphocyte dysfunction were arbitrarily established as those with an OD less than 1.0 for the Lo mitogen concentration, a difference between the OD of the Hi minus Lo response being greater than 1.0 and a ratio of the OD of the Hi concentration/Lo concentration being greater than 1.5.

Two animals showed overt T cell suppression (met all three criteria for both T cell mitogens), 13 animals had some degree of dysfunction (met 1 criteria for 1 mitogen), and 39 animals appeared normal.

Identification of leukocyte profiles was done by using both a complete blood cell count and analytical flow cytometry. Total white blood cell counts were used to establish absolute numbers of multiple sub-populations identified by a classical differential smear and flow cytometry. Neutrophils, eosinophils, monocytes and total lymphocytes were identified by both a classic differential smear and analytical flow cytometry. Analytical flow cytometry was used exclusively to identify all B lymphocytes (CD21-positive), B lymphocytes expressing CD19, all T lymphocytes (CD2-hi, CD45R lo). Density profiles of all these cell-surface antigens was recorded as this has the potential to shed some light on the activation status of the cell (i.e. low density expression of CD19 on B lymphocytes results in an increased threshold for activation and is thus a marker of reduced cell function; increased density of CD19 on B lymphocytes indicates an active and ongoing B cell response). Two markers for MHC class II proteins were utilised to identify both the percent cells expressing these proteins (expressed on all monocytes and B lymphocytes; variable expression on T lymphocytes). Density of expression typically increases as a function of leukocyte activity.

Flow cytometry was also used to identify cell surface expression of adhesion proteins on neutrophils, monocytes and lymphocytes. One marker was specific for a form of CD11/18 that is expressed only on leukocytes that have been acted upon by chemokines produced due to tissue injury and/or an active immune response. Two additional markers do not have human homologues, are expressed on all leukocytes and can be modulated in density due to as yet unknown stimuli.

Presence of inflammation was identified using a bioassay for interleukin 6(IL-6). IL-6 production is induced immediately upon a tissue insult and is responsible for induction of the acute phase response. As this cytokine acts as a hormone and gains access to the peripheral blood, it is an excellent and sensitive marker of active inflammation. Thirty seven dolphins had no detectable IL-6, 12 had very low levels of IL-6 (1.5 to 5.0 Units) and 2 had substantial levels of IL-6.

As mentioned above, two blood samples were obtained from each dolphin sampled in 2000, one immediately upon capture and again just before release. This was conducted in an attempt to determine if stress associated perturbations in the animals immune profile were more exacerbated in those animals having the greatest load of contaminants. Significant perturbations were identified in the 2nd blood sample compared to the first. These changes were as follows. Total white blood cell counts dropped with the most significant changes being in eosinophils and lymphocytes. While less dramatic, significant decreases were also noted in neutrophils and monocytes. Analysis of lymphocyte sub-populations using flow cytometry also demonstrated significant stress-associated changes. The most dramatic changes were a loss of circulating memory T lymphocytes and a decrease in the density of CD19 on B lymphocytes. A decrease in the density of CD19 on B lymphocytes raises the threshold for a B cell to become activated following stimulation. Cortisol and blood glucose were dramatically elevated in the 2nd blood sample, further demonstrating the stress response. Significant alterations in lymphocyte function were not noted. The degree of all stress-associated changes needs to be compared to contaminant load as one could hypothesise that the healthiest animals will demonstrate the least change in some or all of the immunological parameters. Analyses of samples from 2001 remain to be completed.

3. HARBOUR PORPOISE SUB-PROJECT: PROGRESS DURING 2000-2003

The samples of harbour porpoises obtained for this study were obtained from bycaught animals collected in the Bay of Fundy. A summary of the samples is given in Tables 3 and 4.

Table 3

Summary of Bay of Fundy harbour porpoises sampled during summer 2001 for the post-mortem calibration study.

Estimated age class*	Females	Males
< 1		1
Sexually immature (1-3)		3
Mature	1 (pregnant)	1
Total	1	5

*Based on length; age estimation using growth layer groups in teeth will also be carried out.

Progress has been made on immunohistochemistry analyses. However, very low CYP1A expression has been found, and it is therefore to be decided by the Steering Group, whether further EROD and western blot analyses are worthwhile. Other planned analyses were delayed by complications in obtaining CITES permits for shipping samples from the USA to Europe. This is largely solved now, and samples have been sent to the respective laboratories.

4. PLANS FOR PROJECT COMPLETION

Bottlenose dolphin sub-project

There are two main lines of activity. Firstly, an in-depth integration and interpretation of the IWC POLLUTION 2000+ data relative to biomarkers and PCB and pesticide concentrations has to occur upon completion of analyses of individual project components. Preliminary analyses have, in many cases, simply examined relationships with total PCBs. Examination of relationships with specific congeners of interest remain to be done. Many of the data have become available only recently, and some of the data analyses remain

Table 4

Types of samples collected from the Bay of Fundy harbour porpoises in summer 2001.

Sample	Analysis	Number of samples collected at each time point					Status
		Immediate	3 hr	9 hr	24 hr	48 hr	
Blubber	PCB	5	6	5	6	6	Pending
	Immunohistochem.	5	6	6	6	6	Pending
	Enzyme induction	5	6	6	6	6	Pending
	Luciferase	5	6	6	6	6	Pending
	Retinol	5	6	6	6	6	Pending
Blood	Miscell. analyses*	5	0	0	0	0	Pending
Liver	Enzyme induction	1	0	0	0	6	Pending
	Porphyrins	1	0	0	0	6	Pending
	Retinol	1	0	0	0	6	Pending
Histopath		0	0	0	0	6	Pending

*Chemistry, reproductive hormones, thyroid hormones, immune response, PCB, co-planar PCB, porphyrin, retinol, luciferase.

to be completed. It would be advisable for the principal investigators to meet to reach consensus concerning statistical analyses of the data to the level of evaluating potential biomarkers, and to collaborate on analyses, interpretation and report preparation. Such a meeting was planned for March 2003 in Boston, but had to be postponed due to travel concerns resulting from the initiation of the war in Iraq.

Secondly, an additional set of samples has to be collected from Charlotte Harbor (relatively clean area) and the Mediterranean (relatively highly polluted area) animals.

Harbour porpoise sub-project

The major activities under this study are to complete the planned analyses. In addition, the numbers of available bycaught animals is presumably only half of what is expected to be the required number to carry out proper analyses on impact of postmortem time on biomarkers. It is envisaged to first analyse the results obtained from the 176 samples obtained so far (from 5 animals), and then decide on further sampling as well as the type of biomarkers to be analysed. Decisions about the completion of this sub-project, were to be made at the scheduled meeting of the Steering Group. However, as mentioned in the previous section that meeting was postponed.

5. WORKPLAN 2002-2003 AND RELATED BUDGET

Work plan

(1) Finalise analyses of bottlenose dolphin samples.
(2) Finalise analyses of harbour porpoise samples.
(3) Integrated multi-variate analyses of the results from PCB and biomarkers analyses.
(4) Review of data of the harbour porpoise post-mortem calibration sub-project thus far and consider how far the sampling and results (including sex- and age-class composition aspects) have gone towards meeting the objectives of this sub-project. Based on this determine the extent (if any) of further sampling required and any further steps.
(5) Intersessional meeting of involved laboratories to: (a) complete process of synthesising and integrating results from multi-variate analyses of all datasets (under 1, 2, 3 and 4); (b) decide on reporting (type/number and time-schedule of publications and authorship); and (c) recommend on execution of planned activities under Phase II of POLLUTION 2000+.
(6) Decide upon complementary collection of bottlenose dolphin samples (number and type) from Charlotte Harbor and the Mediterranean or alternative sites.
(7) Intersessional planning meeting of SG to finalise Phase I and decide on activities under Phase II, including time-frame.

Budget

Table 5

Budget (£).

Harbour porpoise sub-project	
Collection of samples	8,000
Analyses	28,000
Sub-total	**36,000**
Bottlenose dolphin sub-project	
Collection of samples	13,000
PCB analyses	8,000
Sub-total	**21,000**
Intersessional laboratory and Steering Group meeting	18,000
Total	**75,000**

Recognising the budgetary situation of the IWC, the necessary work has been prioritised, taking into account the possibility of obtaining external funding and in-kind funding as well as scientific priorities as follows:

First priority activities	
Harbour porpoise sub-project	
Collection of samples	8,000
Analyses	28,000
Bottlenose dolphin sub-project	
Collection of samples	13,000
PCB analyses	8,000
Sub-total	**57,000**
Balance still available	-5,000
Requested budget from IWC	**52,000**

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Species glossary

Sperm whale	*Physeter macrocephalus*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Minke whale	*Balaenoptera acutorostrata*
Bowhead whale	*Balaena mysticetus*
Gray whale	*Eschrichtius robustus*
Right whale	*Eubalaena borealis*
Cuvier's beaked whale	*Ziphius cavirostris*
Gervais' beaked whale	*Mesoplodon europaeus*
Blainville's beaked whale	*Mesoplodon densirostris*
Beluga (white) whale	*Delphinapterus leucas*
Long-finned pilot whale	*Globicephala meleas*
Kill whale	*Orcinus orca*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*
Dusky dolphin	*Lagenorhynchus obscurus*
Bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Risso's dolphin	*Grampus griseus*
Striped dolphin	*Stenella coeruleoalba*
Indo-Pacific humpback dolphin	*Sousa chinensis*
Harbour porpoise	*Phocoena phocoena*
Dall's porpoise	*Phocoenoides dalli*
Burmeister's porpoise	*Phocoena spinipinnis*
Tucuxi	*Sotalia fluviatilis*
Caspian seal	*Phoca caspica*
Harbour seal	*Phoca vitulina*
Ringed seal	*Phoca hispida*
Polar bear	*Ursus maritimus*
Sea otter	*Enhydra lutris*
Rhesus monkey	*Macaca mulatta*
Tuna	*Thunnus spp.*
Swordfish	*Xiphias gladius*
Common mussel	*Mytilus edulis*

Appendix 5

WHERE TO GO FROM HERE? A SYNTHESIS OF AN INFORMAL DISCUSSION

Steve Reilly and Nancy A. Friday

There are many potential issues of concerns for cetaceans which are driven by human-induced environmental changes. The SWG on Environmental Concerns is the only forum for the Scientific Committee (SC) to address these issues. In combination, this has resulted in a very diverse agenda. Although progress has been made on many of the issues that currently comprise the agenda, attempting to cover all topics in all years runs the risk of not covering any topic well. This issue is not a new problem for sub-committees of the SC. Although it is important to keep a few standing issues on the agenda, particularly those mandated by the Commission, limiting the focus to a single topic each year would facilitate noticeable progress on individual issues. This yearly focus could be a geographic area, a single species or group of species, or an environmental issue.

The SOCER may be an avenue for keeping the SWG up to date on environmental issues of concerns for cetaceans while allowing the SWG to focus its attention on a specific topic each year. In addition, in years when the SWG focuses on a geographic region, the SOCER could be used as an introduction to issues of concern in that area.

As much as possible, the yearly focus should relate to topics being discussed or of major interest in other sub-committees of the SC. This connection to other

sub-committees has a number of benefits. First, it will allow the SWG to inform the SC and the Commission about environmental issues which are directly related to SC topics that are generally explored without considering the environment in which the species occur. In addition, coordinating with other sub-committees may alleviate the difficulty of supporting sufficient Invited Participants to address the SWG's work as these Invited Participants would be able to contribute to multiple sub-committees.

Each year, the SWG should coordinate with the conveners of the other SC sub-committees in order to identify an issue to which the SWG could contribute in a meaningful way with data and/or analyses. In this way, the SWG would be able to increase the cohesion of the SC. Two possible topics for future meetings are multi-species issues and the Southern Hemisphere ocean processes that may affect the SC's advice on minke whales.

Finally, it is suggested that a major review article of the yearly topic be produced each year, during the intersessional period. This review article could be used as a starting point for that year's discussion, and it would update the Commission and the general scientific community on the topic at hand. After completion of the SC discussion, this review article should be submitted to *The Journal of Cetacean Research and Management* for publication.