Annex K

Report of the Standing Working Group on Environmental Concerns

Members: Moore (Convenor), Aguilar, Alter, Alves, Andreu, Baba, Baird, Bejder, Bjørge, Bøthun, Bräger, Brandon, Brownell, Campbell, Cañadas, Cerchio, Charrassin, Chilvers, Clark, Collins, Cozzi, Deimer-Schuette, Donoghue, Engel, Fenrnandez, Ferguson, Findlay, Flores, Fossi, Freitas, Fuentes, Gales, Gallego, Galletti, Gaspari, Gedamke, Givens, Groch, Grønvik, Holm, Ilyashenko, Iñíguez, Jaramillo Legorreta, Kaschner, Kock, Koski, Krahn, Lauriano, Lens, Liebschner, Lovell, Luna, Lusseau, Marsili, Mate, Mattila, Mazzariol, Melton, Miller, Moon, Murphy, Nicolau, Northridge, Øien, Oviedo, Palacios, Panigada, Parsons, Pavan, Podesta,, Punt, Reeves, Ribeiro, Ridoux, Ritter, Robbins, Rogan, Rojas-Bracho, Rosa, Rose, Rosenbaum, Rowles, Santos, N, Santos S, Scheidat, Scordino, Sequeira, Siciliano, Siciliano, Simmonds, M., Stachowitsch, Strbenac, Suydam, Taylor, Tejedor, Urban, Vasquez, Vazquez, Vely, Verborgh, Víkingsson, Weinrich, Weller, Williams, Yamakage, Yasokawa, Ylitalo, Young, Zerbini.

1. CONVENOR'S OPENING REMARKS

Moore welcomed the participants to the Standing Working Group on Environmental Concerns (SWG)

2. ELECTION OF CHAIR

Moore was elected Chair

3. ADOPTION OF AGENDA

The adopted Agenda is given in Appendix 1

4. APPOINTMENT OF RAPPORTEURS

Ylitalo and Taylor were appointed rapporteurs. Krahn assisted in compilation of the report.

5. REVIEW OF AVAILABLE DOCUMENTS

E1, E2, E4-E10, E12-E21; O20; SC/61/Rep2, SC/61/Rep4; Di Guardo (2008); Fernández *et al.* (2008); Krahn *et al.* (2008); Herman *et al.* (2008); Simmonds and Elliott (2009); Parsons *et al.* (2009); Van Bressum *et al.* (2006) and Murphy *et al.* (in review).

6. REVIEW REPORT OF THE 2ND WORKSHOP ON CETACEANS AND CLIMATE CHANGE

A Workshop entitled 'Cetaceans and Climate Change' was held at the University of Siena's Certosa di Pontignano, in Siena, Italy from 21-25 February 2009 (SC/61/Rep4). This was the second workshop on the effects of climate change on cetaceans, the first being held in Hawaii in March 1996 (IWC 1997). Planning for the 2nd Workshop was undertaken by a Scoping Group in 2008 (IWC 2009), where the conclusions of the 1st Workshop were reviewed. At the outset of the Workshop, it was noted that it was an opportune time to re-examine the subject of the possible effects of climate change on cetaceans due to the recent publication of the 4th Report of the International Panel on Climate Change (IPCC/AR4) in November 2007 (*http://www.ipcc.ch/*). The terms of reference for the Workshop were to bring together and enhance collaborations among experts in cetacean biology, modelling, marine ecosystems and climate change, as well as to review the current understanding and to improve conservation outcomes for cetaceans under climate change scenarios described in IPCC/AR4 by: (1) identifying existing long-term cetacean environmental datasets that can be analysed and included in models in relation to climate change variables; (2) determining patterns that may be attributable to climate change via analyses of these datasets; (3) modelling mechanisms to consider cause and effect relationships, provide predictions and identify data gaps that, if filled, would improve our understanding of the effects of climate change on cetaceans; and (4) providing timely advice related to cetacean research, conservation and management via peer reviewed publications.

The Workshop was sponsored by the governments of Australia, Germany, the UK and the USA, with additional support from Humane Society International and the Whale and Dolphin Conservation Society. The SWG noted the help given to this workshop by the Workshop on Climate Change and Adaptation in the Eastern Pacific, held in Heredia, Costa Rica from 9-11 February 2009 (see below).

6.1 Review of outcomes from relevant workshops

Workshop participants first reviewed outcomes from four relevant meetings. The first was a just-completed Workshop on Climate Change and Adaptation in the Eastern Pacific, held in Heredia, Costa Rica from 9-11 February which focused on 'adaptation' to climate change (e.g., warming and the development of sensitivity indicators for cetaceans (the workshop report is available at: *https://rcpt.yousendit.com/697106146/05745f406dde33ecb0c047325b82e568*). The second, the Joint CCAMLR-IWC Workshop to Review Input Data for Antarctic Marine Ecosystem Models, was held in Hobart, Australia from 11-15 August 2008, focused on the implications of climate change for marine mammals that are endemic to, or that seasonally occupy Antarctic waters. One over-arching outcome was that members of both CCAMLR and IWC Committees developed a far greater appreciation of the function, activities and range of expertise in each group, which was seen as a key to further targeted and strategic collaborations. The third workshop, held 4-6 March 2007, was sponsored by the US Marine Mammal Commission (MMC) and resulted in a report entitled 'A Framework for Monitoring Arctic Marine Mammals' (Simpkins *et al.* 2007). The last workshop, convened 17-18 January 2009 in Tromso, Norway by the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF), charged the Marine Expert Monitoring Group (MEMG) with developing protocols to monitor potential effects of climate change on Arctic marine biodiversity, including cetaceans.

The adoption of the marine mammal species list developed during the MMC workshop (Simpkins *et al.* 2007) provided a linkage between the work of the MMC and CAFF MEMG on the topic of effects of climate change on Arctic marine mammals. This linkage was bolstered when Workshop participants incorporated that same Arctic marine mammal species list, as well as a conceptual diagram outlining the components of a comprehensive plan for monitoring the status of a marine mammal species or population (SC/61/Rep4: Fig 1) into their scheme for monitoring the effects of climate change on Arctic cetaceans. Finally, it was noted that the theme of effects of climate change on cetaceans has been the theme of several recent scientific society and general public meetings indicating the growing public concern on this topic.

6.2 Development of sensitivity indicators

To set the scene, Workshop participants discussed cetacean populations' response to direct and indirect effects of climate change, including the development of sensitivity indicators and impacts from the interaction of climate change with persistent organic pollutants (POPs). With regard to the development of sensitivity indicators, the World Conservation Union (IUCN) has identified five groups of biological traits that make species susceptible to climate change (IUCN 2008), to which Workshop participants added potential examples for cetaceans (SC/61/Rep4: Table 1). Ultimately, the IUCN plans to use biological trait indices in combination with spatial projections of climate change from General Circulation Models to assess 'climate-change susceptibility' and to use these to complement their Red List assessments of extinction risk.

In more focused work, Laidre *et al.* (2008) developed a sensitivity index specifically for Arctic marine mammals that was based upon nine variables deemed likely to have the greatest influence on species/population response and vulnerability to climate change. The potential to extend methods used by Laidre *et al.* (2008) to other species was discussed at the aforementioned Costa Rica workshop, and was further reviewed by Workshop participants.

The SWG agreed that the objective of establishing sensitivity indicators should be to assess vulnerability and adaptability of cetaceans to climate change.

6.3 Changes in the biological environment

Workshop participants reviewed aspects of the physical and biological environment with respect to baleen whales and climate change (1) in the Southern Ocean; and (2) the Pacific Arctic Region; and (3) in regard to small cetaceans in temperate and tropical habitats. A special review was provided on oceanography and cetaceans in the eastern tropical Pacific (ETP) as an example of where cetacean sighting time-series spanning over two decades can be integrated into ecosystem models. The review noted that two modes of oceanic variability are well defined in the ETP: the El Nino Southern Oscillation and the Pacific Decadal Oscillation. This led to an illustrative presentation on the role of modelling in examining the impacts of climate change on management strategies. Although several modelling approaches have the potential to assist in evaluating the potential impacts of climate change, the two discussed were full ecosystem models and minimal realistic models. Development of full ecosystem models is computationally very challenging due to the need to link a variety of components that may operate on different temporal and spatial scales. Regardless of model type, it is essential to fully consider uncertainty in the various components of the operating model when evaluating management strategies.

Presentations on the application of biochemical tools (stable isotopes, fatty acids, trace elements) and ancient DNA analysis provided background on the use of these approaches to investigate effects of climate change on cetaceans at annual to centennial time scales. Participants agreed that these approaches represent valuable alternatives to photo-identification and sighting data and results of such studies can provide important insights to observed shifts in dietary or population structure in cetacean populations.

Case studies of the effects of climate on cetaceans highlighted long-term datasets available for the Southern Hemisphere (humpback and Southern right whales), the Pacific Arctic Region (bowhead and ENP gray whales), waters offshore West Greenland (bowhead, minke, beluga and narwhal), and cetaceans in the riverine and shallow waters of Bangladesh (Ganges River and Irrawaddy dolphin).

6.4 Working groups

The Workshop divided into three working groups (Arctic, Southern Ocean and Small Cetaceans) whose terms of reference were to consider and report back on:

(1) the ability to measure: (a) population trajectories; (b) habitat use; and (c) distribution of the cetaceans in their region (including consideration of practicality of conducting sampling, status of current knowledge, temporal and spatial scales of data and climate-related effects and the ability to detect changes);

(2) in light of (1), consideration should be given to appropriate 'indicator' species or populations and parameters that might be selected that are representative of ecological niches or function, regions, hypothesized vulnerabilities and/or adaptability and potential explanatory variables that might be related to observed changes in distribution and habitat use should they occur; and

(3) taking into account (1) and (2), a recommendation for long-term research projects that are most likely to lead to an improved understanding of how cetaceans are responding or might respond to a range of climate change scenarios in their regions, including specifics on affected species/populations and field and analytical methods.

6.4.1 Southern Ocean Working Group

The working group on Southern Ocean whales noted the relevance of the baleen whale and toothed whale summaries prepared for the recent CCAMLR-IWC workshop (SC/61 Rep2) which provide a contemporary reference of Southern Ocean cetacean datasets (summarized and reviewed in SC/F09/CC2). Data on different species varied considerably, with humpback and southern right whales representing the two species for which available data on population trend and habitat use represent the greatest utility for studies investigating the effects of climate change. The workshop emphasized the value of long-term data series and encouraged substantially more analysis on these, particularly IDCR/SOWER and relevant multi-disciplinary studies. The working group identified several contrasting Southern Ocean regions where the nature and extent of climate-related change were different (South Georgia, the Antarctic Peninsula and Eastern Antarctica) and for which relevant cetacean data sets exist. The SWG recommended that studies on humpback and southern right whales in these regions be developed, with a focus on determining measurable responses to climate change in these contrasting environments.

6.4.2 Arctic Working Group

The Arctic working group adopted the list of Arctic cetaceans and associated abundance estimates provided in Simpkins *et al.* (2007) as a starting point for development of a summary table related to population status. Temperate cetacean species agreed by the CAFF MEMG were added to the initial table and rankings of high, medium and low were assigned to columns labelled 'Population Trajectories,' Summer Distribution' and 'Habitat Use,' based upon the ability to measure these parameters as demonstrated by available field and analytical methods (Table 3; SC/61/Rep 4). Eleven populations were identified that ranked high in at least two categories and that coincided with datasets 10-40 years in length. The eleven populations were subsequently ranked with regard to eight biological parameters (e.g., prey availability, diet, survival and reproductive rates, body condition pollutants, individual movements and spatial/temporal distribution) useful for creating models informative in studying the effects of

climate change. From these rankings, three recommended outline studies emerged: (A) Single Species-Regional Contrast; (B) Trophic Comparison and (C) Distribution Shift. The Workshop could not develop specific recommendations regarding analytical methods due to time constraints, but encouraged the development of detailed analytical and modelling plans under the general guidelines set forth above.

6.4.3 Small Cetacean Working Group

In the work done on small cetaceans in Siena, it was noted that the Working Group had taken an approach different from those of the other two Working Groups, reflecting the state of development of the topic area. A small cetacean case study was provided that considered cetacean assemblages in the riverine and shallow waters of Bangladesh. Here, the waterways of the Sundarbans mangrove forest are inhabited by two freshwater-dependent cetaceans: the Ganges river dolphin (*Platanista gangetica gangetica*) and the Irrawaddy dolphin (*Orcaella brevirostris*). The distribution of both species is sharply determined by different requirements of salinity, depth and turbidity, but similar requirements related to geomorphology (Smith *et al.*, 2008). Given the sensitivity of both species to salinity changes, these animals may be an efficient model for gauging the effects of declining freshwater supplies and sea-level rise on the same species elsewhere in their range, and possibly other cetaceans subject to similar environmental pressures. In addition, studies of this cetacean community may provide fundamental insights on the nature and magnitude of more general ecological effects (e.g. changes in the abundance and species composition of lower-level trophic communities) and a basis for developing appropriate management responses. Baseline information and trained local expertise are available, thus offering a solid ground for long-term studies and monitoring.

6.5 Conclusions and Recommendations to the Scientific Committee

It was noted that knowledge about climate change had advanced substantially since the first IWC Workshop, and that there is now less emphasis on the consequences of ozone depletion and more emphasis on greenhouse gas emissions and effect of temperature increases. The SWG recommended that IWC member countries and relevant organizations: (1) take the potential effects of climate change on cetaceans seriously and include these considerations in relevant climate-related and conservation management initiatives, including implementation of emission controls; and (2) support the research recommendations given in SC/61/Rep4, which will be further elaborated at subsequent meetings of the Scientific Committee.

There are a number of recommendations for future research given throughout SC/61/Rep4 that are important and are highlighted below.

6.5.1 Modelling approaches

After further discussion on the strengths and limitations of existing modelling approaches, and in regard to analysis needs, the SWG recommended that: (1) some priority be accorded to developing models that can integrate the demographic and spatial consequences of climate change; (2) effort be allocated to exploring the value of developing ecosystem models that begin with baleen whale dynamics rather than building bottom-up ecosystem models; (3) the scenarios used in the *Implementation Simulation Trials* for the RMP and the *Evaluation Trials* for the AWMP should be re-evaluated in light of discussions at the Workshop and additional trials which consider climate impacts added if necessary. Specifically, it was noted that for the first time variability in sea-ice cover, an environmental 'icon' of climate change, was used in an assessment of the eastern stock of North Pacific gray whales (SC/61/AWMP2) prepared to evaluate the performance of the Strike Limit Algorithm (SLA); (4) where possible, further correlative studies should be undertaken in order to improve the conceptual understanding of population processes, and hence enable the development of a set of testable hypotheses; (5) the predictions and levels of uncertainty with respect to the many IPCC modelling exercises need to be carefully reviewed with respect to choosing the most appropriate (including taking into account temporal and spatial scales and separating out factors such as mean overall SST warming from the changes in the positions of fronts and water masses) for incorporation into modelling exercises with respect to cetaceans; and (6) telemetry studies should be used and resultant cetacean movement patterns evaluated via multivariate analysis using a range of environmental variables, with the results of these analyses used as basis for developing hypotheses regarding the mechanisms which influence animal movements.

The SWG recognized the need to take into account cumulative effects in modelling work. Although there is as yet no well-defined analytical approach to address this, such approaches are in development.

6.5.2 Southern Ocean Working Group

With regard to the Southern Ocean, the SWG endorsed a number of specific recommendations for future work, including: (1) further investigation of the IDCR/SOWER datasets (and others) to investigate possible changes in killer whale abundance, given their unique role as predators of other whale species; (2) further investigation of the use of autonomous bottom mounted acoustic recorders to obtain long-term datasets for fin and blue whales; (3) continued investigation and analysis of individual identification data for blue whales (genetic and photographic) for potential mark-recapture studies; (4) resolution of the controversy over the interpretation of whaling data to infer long-term changes in sea-ice (De La Mare, 2008); (5) further efforts (e.g. telemetric) to examine the movements and feeding ecology of Antarctic minke whales in winter; (6) further studies into the interactions between large whales and the overall productivity of the marine ecosystem.

The SWG recommended that every effort be made by researchers to participate in co-operative studies that can address matters of important conservation concerns, including the potential effect of climate change. In particular, it recommended that (1) the established photo-identification catalogues of humpback whales be investigated with respect to the estimation of demographic parameters; and (2) the continued collection of these photo-identification data to allow hypotheses regarding the causes of changes in population growth rate, including environmental change, to be investigated.

The SWG again emphasised the great value of long-term datasets and recommended that funding be provided to ensure their continuation. In particular, the SWG recommended emphasis on cetacean studies which allow comparisons between contrasting regions where data on a wide range of ecosystem components are available. The SWG noted that regionally comparative studies on southern right whales and humpback whales from Eastern Antarctica, the Antarctic Peninsula and South Georgia are likely to be particularly informative, and recommended their continued development and implementation. Although timing of events in other taxa such as pinnipeds has not shown clear relationships with climate, the SWG recommended that where data exist, these should be examined with respect to timing of arrival on and departure from the breeding grounds particularly with respect to different components of the population. The SWG also recommended further investigation of data from the multi-disciplinary cruises where cetacean data have been collected (including CCAMLR 2000, SO-GLOBEC and BROKE surveys).

The SWG particularly noted the ongoing work within the Scientific Committee with respect to trends in abundance of Antarctic minke whales and possible links to environmental factors such as sea ice and it recommended that this work continue. The SWG recommended the coordination of methods and seasonal timing of such surveys if comparisons between regions are to be possible. Although the Southern Ocean Working Group from the workshop was unable to develop specific research recommendations in the time available, the SWG recommended that the development of detailed recommendations should be developed in tandem with the Southern Ocean Research Partnership (SORP).

6.5.3 Arctic Working Group

With regard to the Arctic, the SWG recommended that work continue on development of the three outlined studies (defined in 6.4.2 above) and that this work must be undertaken before specific recommendations on analytical methods and modelling can be made. It was noted that the recommended studies are based upon extant databases of 10-40 years, which then provides a 20-50 year timeline for investigation and modelling of climate-related events. The SWG encouraged continued development of detailed analytical and modelling plans, under the general guidelines set forth for each of the three outlined studies.

6.5.4 Small Cetacean Working Group

Given the large number of species/populations and the wide variety of habitats occupied, work on developing recommendations for small cetaceans was challenging. The Workshop developed hypotheses focused on changes in (1) temperature, (2) freshwater input and (3) sea level rise. A provisional list of candidate indicator species and geographical areas and datasets were provided, but the SWG recognized that this is not an exhaustive list and that a more formal examination of available datasets and their applicability for such studies is required.

The SWG commended the Sundarbans case study (Smith *et al.*, 2008) and strongly encouraged future conservation efforts with respect to anticipated effects of altered hydrologic regimes, sea level rise and other climate-related impacts in combination with other anthropogenic factors in this area and with respect to the development of MPAs.

A range of hypotheses that might be investigated for small cetaceans (SC/61 Rep 4) were considered. The SWG recommended that the sub-committee on Small Cetaceans consider these, as well as the suggested indicator species and research situations, with the aim of identifying specific research projects.

6.6 Implications for the work of the IWC and collaboration with other international organisations and initiatives

The implications for the work of the Scientific Committee and especially the work of the Sub-committee on Small Cetaceans, the SWG and the working group on ecosystem modelling are made clear in the SC/61/Rep4, as is the need for the RMP and AWMP scenarios to be re-examined and, if necessary, modified. In addition, it was noted that the conservation management plan approach should also take climate change issues into account.

With respect to the Commission itself (including the Conservation Committee and the Aboriginal Whaling Sub-Committee), the SWG notes in particular the recommendations made under Item 8.1 in SC/61/Rep4. As the Scientific Committee has stressed on many occasions before, work on the possible effects on climate change and indeed all work related to ecosystem modelling (and the necessary datasets) is not something that can be accomplished by the IWC in isolation. Clearly, there is a need for international and multi-disciplinary efforts and the SWG recommended that collaborative work with other relevant bodies (e.g. ACCOBAMS, CCAMLR, SO-GLOBEC, Arctic Council, and others) continues and is expanded. In most cases this needs to be at a greater level of involvement than simply an exchange of observers at meetings.

With respect to the Arctic Council, its ongoing work on monitoring Arctic biodiversity under the CAFF Circumpolar Marine Biodiversity Monitoring Program (*http://www.cbmp.is*) and the recently-completed Arctic Marine Shipping Assessment (AMSA) was noted. Furthermore, it will be important to maintain a dialogue with the Arctic Council[1]. The same applied to CCAMLR[2], including interactions at the level of ongoing working groups. More generally, it was noted that many bodies were currently investigating climate change effects, but often consideration of cetaceans is not included. Two exceptions to this are the ICES Working Group on Marine Mammal Ecology in the North Atlantic (IWC/61/4; Appendix B) and the PICES Marine Bird and Mammal Advisory Panel (PS-MBM) in the North Pacific (IWC/61/4; Appendix G), both of which include cetaceans in their multidisciplinary research plans. The SWG felt that collaboration among international groups should be strongly encouraged, not only for the sake of cetacean conservation and management but also because cetaceans are potentially good indicator species. An ongoing dialogue with the IUCN on the development of sensitivity indicators was also recommended. Finally, it was agreed that it is desirable to identify large-scale science programmes into which cetacean monitoring could be integrated. One such is the oceanographic ENSO monitoring program by the Permanent Commission for the SE Pacific (ERFEN, which includes the countries spanning the west coast of South America from Colombia to Chile).

In general discussion of SC/61/Rep4, it was suggested that southern hemisphere humpback whale breeding stocks B and C should be included in Table 2 of SC/61/Rep4 . It was noted that in fisheries, the empirical approach drives the ultimate decisions with regard to climate change rather than the mechanistic approach. Cetacean studies should produce data that are compatible with those of fisheries if the connection to climate change is to be made in an ecosystem context. The SWG suggested changing 'correlative studies' to 'multivariate studies' when referring to analyses into the relationships between cetaceans and their environment.

The SWG endorsed the report and recommendations of the workshop (SC/61/Rep4). The SWG thanked the organizers of the workshop for their hard work in organising, obtaining funding and conducting the Climate Change Workshop.

6.7 Papers related to Climate Change

SC/61/E8 presented the 'tertiary effects' of climate change noting that these have been defined as impacts on cetaceans at the population or community level resulting from changes in human actions due to climate change. For example, climate change may result in increased hunting pressure on near-shore dolphins and whales (e.g., off Asia, Latin America, Africa) as the availability of other marine resources diminishes. Potential tertiary effects have also recently been highlighted in the Arctic context following the loss of sea ice and could include increases in ship strikes, industrial activity, fisheries activities (potentially causing increased bycatch and prey depletion) and acoustic injury and exposure to noise pollution.

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1 http://www.arctic-council.org/

2 http://www.ccamlr.org/

Tertiary effects may be highly significant for some cetacean populations, but have been little considered in recent reviews of climate change (e.g. Simmonds and Elliot, 2009) and were not considered by the recent IWC workshop on climate change due to time constraints. Thus, SC/61/E8 was designed to provide an overview of this topic and augment the workshop report.

The SWG noted that, although concern about impacts of climate change on cetaceans has been largely focused on polar species, the evidence presented here suggests that tropical coastal cetaceans may also be particularly vulnerable to tertiary effects. Table 2 (potential tertiary effects) in SC/61/E8 provides examples of relevant policy mechanisms at national, regional and international levels. It was requested that increased shipping in the Arctic should be added to Table 2 and suggested looking at the Arctic Council website for a new publication (Arctic Marine Shipping Assessment) that looks at the impacts of anticipated shipping changes in the Arctic.

The SWG concluded that because tertiary (and other) impacts of climate change are likely to evolve rapidly over the coming years and decades, it is important that cetacean conservation and management plans include regular reviews to allow such plans to adapt to new information. Noting the speed with which climate change could affect cetaceans and the difficulties of mitigating its direct effects given the current state of knowledge, a practical approach in many instances may be to address tertiary effects. The SWG urges policy makers, regulators, and others involved in cetacean management to consider tertiary effects and recommended that risk assessment is conducted as part of management plans that address these impacts in addition to primary and secondary impacts. It is important that these effects on cetacean populations are considered in policy decisions regarding adaptation to climate change.

7. REVIEW PROGRESS IN PLANNING FOR POLLUTION 2000+ PHASE II

Data obtained from Pollution 2000+ Phase I, as well as from other contaminant studies over the past 15 years, have provided a broader foundation from which to evaluate the state of the science and plan for future pollutant studies for cetaceans. The ultimate goal of Pollution 2000+ is to be able to predict population-level effects of pollutants on cetaceans. The SWG reiterated the findings of the Pollution 2000+ Phase II Workshop (see SC/59/Rep6) and recommended that a strong modelling effort that utilizes a tiered risk assessment paradigm should form the foundation of further studies. In addition, further development of appropriate endpoints for cetaceans (including the use of biomarkers to determine contaminant exposure and effects, appropriate study populations, and appropriate modelling) would be needed.

Using the objectives listed in the report on Pollution 2000+ Phase II Workshop (SC/59/Rep6) as a starting point, the members of the SC proposed the following modified goals for the programme:

(1) develop an integrated modelling and risk assessment framework to assess cause-effect relationships between pollutants and cetaceans at the population level, building on the progress made during Phase I and on recent research, using modification of a tiered risk assessment paradigm;

(2) extend the work to new species as appropriate; and

(3) validate further biopsy sampling techniques for use in addressing issues related to pollution, including legacy contaminants and new contaminants of concern and associated indicators of exposure or effects.

Since the completion of Pollution 2000+ Phase I, issues have emerged that place cetaceans at risk for adverse effects. Although certain populations of cetaceans have been exposed to relatively high levels of 'legacy' persistent organic pollutants (POPs; e.g., PCBs and DDTs) that have now been banned, other toxic chemicals are 'emerging' (e.g., flame retardants) that are of equal or increasing concern. Cetaceans may be exposed to these new contaminants of concern, but an overwhelming number of these compounds are not being monitored. Thus, little is known about their fate and effects in wildlife. In addition, when feasible, the SC should identify situations that might trigger or accelerate synergistic interactions between climate change, contaminant exposures, and population level impacts. In cetaceans, cumulative effects can be associated with anthropogenic and natural forces (e.g., industrial development, climate change and exposure to pollutants). Therefore, cumulative effects should be a priority for evaluation as a component of the overall risk assessment and modelling framework for the next phase of Pollution 2000+.

As part of the prioritization process for evaluating pollutants of concern in populations of cetaceans and biological impacts of pollutants on populations, the SC should consider the impacts of climate change on these factors. In addition, when feasible, points should be predicted that might trigger or accelerate synergistic interactions between climate change, contaminant exposures, and population level impacts. Cumulative effects of these interactions must also be addressed. In cetaceans, these can be associated with anthropogenic and natural forces (e.g., industrial development, climate change and exposure to pollutants). Furthermore, cumulative effects are a priority for evaluation as a component of the overall risk assessment and modelling framework for the next phase of Pollution 2000+.

Given these issues, it is time to re-evaluate and prioritize the pollutants of concern that may directly or indirectly affect populations of cetaceans. Of particular interest are those compounds that are persistent and bioaccumulative. In addition, with climate change, the redistribution of legacy contaminants into marine ecosystems may occur. Therefore, the initial component of Phase II should focus on the risk assessment and modelling framework for evaluating the suite of pollutants (both legacy and emerging contaminants of concern) that pose a potential risk for cetacean populations.

The SWG endorsed the proposal for the Workshop (see Appendix 2) and this item has been added to the Work Plan (see Item 11.2).

In discussion, scientists working in other nations were encouraged to participate in the SWG; if they are not able to participate, they are encouraged to provide information to Scientific Committee delegates. For example, some work has been done examining stratification of contaminants and lipids in killer, bowhead and gray whales and these data useful for the validation of biopsy techniques.

Two papers reported on the contaminant levels in cetaceans bycaught in Korean waters. The first paper (SC/61/E4) investigated concentrations of persistent organic pollutants (POPs) measured in liver and blubber samples collected from minke whales and common dolphins entangled in fishing gear along the Korean coasts in 2006. The concentrations of POPs found in common dolphins were significantly higher than those measured in minke whales, which can be explained by differences in habitat use and diet. Significant differences based on sex were found for certain classes of POPs measured in the minke whale tissues, with males containing higher levels than females. Common dolphins, in contrast, did not show differences in POP concentrations based on sex. Although the overall levels of POPs measured in these two cetacean species were lower or similar to the concentrations reported in cetaceans from other regions of the world, the concentrations are in the range that have been associated with adverse effects (e.g., endocrine disruption and immunosuppression).

The second paper (SC/61/E5) provided information on the levels and profiles of perfluorinated compounds (PFCs), which are emerging contaminants of concern, measured in livers of common dolphins and minke whales bycaught in Korean coastal waters in 2006. In general, the levels of PFCs measured in the current study were lower than those reported in cetaceans from other locations worldwide, with the exception of animals collected from India, Brazil and Canadian Arctic. The levels of some PFCs were significantly higher in the dolphin samples compared to those of minke whale, which can be explained by the differences in habitat and diet. In general, the average concentrations of PFCs in male minke whales were elevated compared to those of females. In common dolphins, no differences in accumulation of these compounds were found based on sex. The profiles of PFCs measured in the current study were different than those previously reported in cetaceans sampled in other countries, suggesting a specific source of PFCs in to Korean coastal waters.

In discussion, the authors of SC/61/E4 and SC/61/E5 noted that the tissue samples of the cetaceans were collected during necropsies conducted by the Coast Guard. As a result, no specifics were provided with regard to the blubber samples (e.g., sampling location of the blubber on the animal, depth of blubber specimen collected). Standardization of sampling procedures and analytical methods (e.g., appropriate PCB congeners to include in summed values) are important aspects to consider when making comparisons across studies.

Three papers related to biomarkers and pollution were presented to the SWG. SC/61/E17 described a method to measure a suite of sensitive non-lethal biomarkers in skin biopsy of fin whales to evaluate the toxicological status of this mysticete in the Pelagos Sanctuary (Mediterranean Sea) and in the Gulf of California (Sea of Cortez-Mexico). Using this 'multi-trial-diagnostic-tool' (field and *in vitro* slices study), the authors of SC/61/E17 combined molecular biomarkers and gene expression with analysis of chemical contaminants. The diagnostic-tool applied to skin biopsies, highlighted differences in contaminant levels and molecular and gene expression biomarker responses between the two populations, revealing a higher toxicological stress in the Mediterranean fin whales. The presence of a higher toxicological stress in the Pelagos population was pointed out by higher levels of contaminants in comparison to Cortez specimens and by biomarkers such as the CYP1A1 induction, the up-regulation of ERα and E2F-1 genes, combined with the lack of CYP2B induction in both field and *in vitro* (slices) experiments. Moreover, of particular concern was the finding of high levels of polybrominated flame retardants in the Mexican whale specimens.

In SC/61/E18, the toxicological status of common bottlenose dolphin in the Adriatic Sea was evaluated using a non-lethal 'multi-trial-diagnostic–tool' applied to skin biopsy samples. The results of these analyses were compared with those obtained on animals sampled from two other areas: the Strait of Gibraltar and the Sicily Channel. When the multi-trial biomarker tool was applied to skin biopsies, differences were found in contaminant levels and molecular biomarker responses between sexes (male greater than female) and among these three areas, revealing a lower toxicological stress in the bottlenose dolphins of the central Adriatic Sea. Higher levels of PCBs and DDTs were found in males from the Strait of Gibraltar compared to those of the Adriatic Sea and the Sicily Channel. These data confirm a high toxicological stress to which the bottlenose dolphins inhabiting the Strait of Gibraltar are exposed. This preliminary study showed the high sensitivity of this diagnostic methodology in defining the 'ecotoxicological status' of cetacean populations inhabiting different areas and suggested that the state of the environment in the eastern central Adriatic Sea is under anthropogenic influence. Nevertheless, the small sample size prevents further conclusions on the impact of POPs on this population, so the sample size should be increased.

A description of a method to culture fibroblast cells from skin biopsies of long-beaked common dolphins and Bryde's whales from the Gulf of California (Sea of Cortez, Mexico) as an alternative methodology to lethal ecotoxicological studies was reported in SC/61/E13. In particular, the susceptibility of these species to environmental contaminants can be evaluated with the qualitative and semi-quantitative immunofluorescence analysis of target proteins in fibroblast cell cultures subjected to different mixtures and doses of various classes of chemical contaminants. The primary findings of this pilot study were the successful culturing of fibroblast skin cells of long-beaked common dolphin and Bryde's whale specimens and the detection of CYP1A1 and CYP2B in the long-beaked common dolphin and Bryde's whale fibroblast cells. In addition, preliminary results detected differences in the induction phenomena in the dolphin cells for different mixtures of contaminants.

In discussion, the SWG noted that comparisons can be made between contaminant studies only if results are reported in a standard format. For example, lipophilic compounds should be lipid-normalized and trace elements should be reported on a dry weight basis. The apparently higher levels of PBDE flame retardants measured in fin whales from the Gulf of California compared to animals from the Mediterranean Sea were of interest to members of the SWG. The sources of PBDEs to the Gulf are not known, but are interesting in that a recent US study reported biota from the Southern California Bight, a highly populated region of the US, had the highest levels of PBDEs measured in coastal U.S. waters (Kimbrough *et al.* 2009). Elevated levels of PBDEs are associated with urban centres but they can also be transported to regions via atmospheric deposition or from sewage spills. Additional fin whale biopsy samples, as well as biopsy specimens of odontocetes from the Gulf of California have been collected and will be analyzed to determine if this regional PBDE trend continues. Members of the SWG also noted the utility of the non-lethal 'multi-trial-diagnostic–tool' described in SC/61/E17 and SC/61/E18 as indicators of toxicological stress across a range of geographical regions. These biomarkers are robust as they have been studied in other wildlife taxa and laboratory animals for which their mechanisms are well understood.

8. RECEIVE STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER)

The 2009 edition of the State of the Cetacean Environment Report (Appendix 3) is devoted to the Pacific Ocean and, as in past years, also contains a global section. It provides information for Commission and Scientific Committee members on issues in the marine environment relevant to cetaceans, or on developments in cetacean populations that reflect environmental concerns. The SOCER is based on a thorough search of the scientific literature on cetaceans and the marine environment from 2007 up until the 2009 SC meeting. The SOCER consists of four parts, succinct entries on: (1) the Pacific and (2) global events (under headings corresponding to key issues identified by the Standing Working Group for Environmental Concerns), (3) a glossary of terms used in the report (species names, ecological terms, pollutant types), and (4) a set of tables providing an overview of specific pollutant levels in cetaceans. Next year's SOCER will be devoted to the Arctic Ocean and the editors requested submissions from Scientific Committee members.

In the Pacific, fisheries interaction topics predominated in the papers summarized in SC/61/E1; this was a regional 'hot topic' for research. Also in the Pacific, there were several papers reporting on stocks of killer whales that are at risk, including an Alaskan pod that may be near extinction and a pod off the northwest coast of the U.S. that was recently listed as endangered.

Under noise impacts (both regionally and globally), SC/61/E1 reported on several papers that examined masking; this reflects the increasing awareness of the potential impacts that masking may have on cetaceans. Globally, stress responses of marine mammals to noise exposure are a growing focus of researchers working on acoustic impacts.

There were a number of papers from the Pacific region summarizing new contaminants in marine mammal tissues or an increasing prevalence of certain contaminants, including flame retardants. One paper reported the first record of a particular flame retardant (HBCD) in southeast Asia in dolphins.

Globally, a growing body of literature is focusing on emerging diseases, which parallels the work being pursued in the SWG. A series of papers in a special issue of Diseases of Aquatic Organisms noted that several pathogens and diseases can be transmitted from marine animals (including cetaceans) to humans and in the other direction, from humans to marine mammals.

Climate change also remained a 'hot topic' of research. One paper of interest (focusing on molluscan lineages) concluded that global warming would be beneficial for some species, enabling them to expand into the Atlantic from the Pacific as Arctic ice melts. Another paper examined the concept of synergy – the idea that multiple stressors might combine in a way that results in a greater negative impact than additive effects might suggest. The paper, which conducted a meta-analysis of 171 studies in marine systems, concluded that synergy of multiple stressors might be quite common in nature.

Recent positive developments included the decision by the Mexican government to compensate fishermen in the Gulf of California for removing gillnets from vaquita habitat. The vaquita is critically endangered and gillnets are their primary threat. In Korea, the coastal city of Incheon has begun paying fishermen to collect marine debris and this program has already resulted in the removal of 18,000 tons of marine debris from local waters. This program could perhaps serve as a model for other locations. And lastly, underwater communications cables are no longer a threat to deep-diving cetaceans due to improvements in technology and placement.

The editors requested that SWG members respond to the annual request for submissions. The SWG thanked the editors for SOCER, noting the utility of the information provided in the annual report.

9. REVIEW PROGRESS OF CETACEAN EMERGING AND RESURGING DISEASE (CERD)

The Cetacean Emerging and Resurging Disease (CERD) Working Group (WG) reviewed their recent accomplishments and upcoming plans for the seven tasks that were identified at SC/61 through intersessional email and conference call participation.

Expand the CERD membership. Efforts are underway to expand the intersessional email group and CERD membership by inviting participation of additional national experts and field/discipline specialists.

Diagnostic Laboratories. Several members of the SWG identified fields for the development of a table listing diagnostic laboratories and/or experts that are participating in regional marine mammal disease. These fields included: laboratory or expert name, address, contact (email, phone #), service lab (y/n), collaborative research (y/n), cetacean research experience (y/n). Fields relevant to pathogen laboratories include: BSL Level, pathogen type, diagnostic modality. Fields relevant to toxin laboratories include: toxin types and diagnostic modality.

Skin Disease Definitions. A subgroup of CERD has been established to further the efforts of standardization of lesion descriptions and, when possible, etiology for specific large whales. The subgroup will enhance communication and collaboration electronically through such mechanisms as social networking or websites, so that the subgroup can have a forum for their deliberations with a focus on skin lesions in mysticetes. This network can be tied into the Virtual Microscope capabilities provided by the National Oceanic and Atmospheric Administration (NOAA).

Disease Identification and Standardisation and Case Definition. The U.S. Working Group (WG) on Marine Mammal Unusual Mortality Events (MMUME) has taken the criteria developed by the CERD WG at SC/60 and have expanded or clarified the criteria and performed preliminary rankings of some top priority pathogens. The U.S. WG on MMUME will continue assessing and prioritizing 190 pathogens of marine mammals over the next six months with input from CERD WG members. The CERD WG also developed criteria for attributing case definitions. These criteria have been proposed as follows:

> *Suspect:* likelihood of exposure or compatible clinical signs or mortality factors
>
> *Probable:* presumptive exposure or either compatible clinical signs, mortality with compatible gross or microscopic lesions, or spatial & temporal proximity to confirmed case(s)
>
> *Confirmed:* meets criteria for Probable Case and documented exposure under accepted criteria of exposure for that specific pathogen or toxin

Expand the emergency response steering committee and further enhance capacities and communications between stranding networks. The WG has developed a spreadsheet (containing stranding network points of contact, response area, and type of response for each country) for regional review and editing. The SWG noted that ICES and the Shipstrike Working Group also maintain lists of stranding networks by country and these lists should be used as a validating tool for the stranding network spreadsheet. The SWG also noted several upcoming stranding training workshops or capacity building efforts in several locations, including: Jamaica, Panama, India, Bangladesh, Pakistan, and US. The WG has identified opportunities for technical information transfer and on-site training for stranding network members at the University of Las Palmas, Canary Islands and The Marine Mammal Center, Sausalito, California, USA.

The SWG thanked the CERD for their contributions and the group's planned activities were added to the Work Plan (see 11.3).

In SC/61/E20, the consequences of the 2006-07 *Morbillivirus* epizootic on the well-known population of long-finned pilot whale in the Strait of Gibraltar were investigated. Photo-identification techniques allowed estimating the basic life parameters of the pilot whale population in the Strait of Gibraltar. Survival rates were found to be 0.985 for adults in 1999-06 with a total abundance of 350 animals in 2006. Secondly, a 2006-07 *Morbillivirus* epizootic was estimated to induce a 21.2% reduction in the survival rate (decreasing to 0.776) and to cause a total of 78 deaths (including natural mortality) between summer 2006 and summer 2007.

In discussion of SC/61/E20, the authors were thanked for presenting this detailed examination of the consequences of a *Morbillivirus* epizootic in pilot whales.

10. OTHER HABITAT-RELATED ISSUES

10.1 Anthropogenic sound and cetaceans

SC/61/E10 presented information on and results from a recent model that quantifies acoustic masking of individuals and populations of baleen whales as a result of anthropogenic sound sources. The paper included the basic concepts in an algorithm (Clark *et al.* in review, MEPS) that quantifies acoustic masking as a result of spatial, spectral, and temporal changes in a whale's acoustic habitat from shipping noise. In SC/61/E10 some results of masking were presented for singing fin, singing humpback, singing bowhead and calling right whales, where the primary sound source was shipping noise and a secondary consideration was sound from a seismic airgun array.

There were four primary messages in SC/61/E10: (1) The mechanical and analytical tools exist for measuring and quantifying the spatio-spectral-temporal variability in different whale acoustic habitats; (2) These have been merged into an algorithm and implemented in a model that quantifies a relative measure of acoustic masking for individuals and populations, and this model addresses the issue of cumulative impact from multiple sources of masking; (3) Model results indicate that different species experience very different levels of masking as a result of their species-specific bioacoustical adaptations and behaviours; and (4) The results lead to and support the concept of a marine acoustic ecology and the notion that individuals, and thus populations, incur a cost when there are changes to their acoustic habitats, and those costs are of particular concern when the ecological changes occur at rates and levels to which animals are poorly adapted.

During discussion, the author of SC/61/E10 noted that these acoustic masking levels are not directly damaging to the cetaceans, but do appear to inhibit their ability to communicate with their conspecifics. One foreseen difficulty is how to evaluate the risk from masking effects on whale behaviour. A huge next step would be to determine how to translate this type of model into changes in life history parameters. The author has observed that, off New England, USA, as noise levels increase due to vessel traffic or weather events, right whales in the area stop calling. Although there is evidence that noise is having an effect on the population, it is difficult to translate the impact that chronic high noise environments have on survivorship of the population. A question was asked about the potential effects of chronic noise on bowhead whales, if the whales were calling and not singing, in the masking model. The author replied that the acoustical habitat loss would be similar to that experienced by the right whale during calling. Furthermore, it was noted that one of the sites used in the models of SC/61/E10 was the Stellwagen Bank National Marine Sanctuary, a feeding ground for North Atlantic right, humpback, fin and other whales. Although no one knows how baleen whales find their prey, it is likely that acoustic cues play an important role. Although SC/61/E10 concentrated on communication, man-made noise in this region may also affect an animal's ability to locate prey. If this effect is consistent, it may provide a causal mechanism by which disturbance could affect an individual's vital rates or life history parameters. It was also noted that long inter-calf intervals in North Atlantic right whales were prominent in the mid-to late-1990's, and have returned to shorter periods since that time. There has been speculation that these longer intervals were prey-based, but it may be worthwhile to examine those years to determine whether any unusual man-made noise pulses existed that could have had an influence.

The SWG then focused on Parsons *et al.* (2009), which provides a critique of seismic survey guidelines that were developed by the United Kingdom government and that have become the standard of international mitigation measures for noise pollution during seismic surveys. The authors asserted that relatively few aspects of these measures have a firm scientific basis or proven efficacy. The authors conclude that these guidelines do not offer adequate protection to marine mammals, given, *inter alia*, the complex propagation of airgun pulses; the difficulty of monitoring in particular the smaller, cryptic, and/or deep-diving species; lack of enforcement; and lack of baseline data. In addition, in light of recent research and ongoing concerns, the authors suggest that the guidelines should be updated to ensure adequate protection of cetacean species and to address data gaps.

Papers SC/61/E15 and SC/61/E16 presented information about chronic stress in marine mammals. The physiological stress response is activated immediately upon the perception of a threat by the animal—releasing adrenalin and noradrenalin—and causes numerous physiological and biochemical changes, including increases in heart rate and respiratory changes. Meanwhile, a hormone cascade causes the release of glucocorticoids from the adrenal cortex that in turn induce changes such as an increase in blood glucose and suppression of non-essential activities (e.g., digestion, immune activity, growth). Stress (acute and chronic) has been linked to numerous disease states and sequelae (e.g. immunosuppression, impaired fertility and cardiovascular disease) in mammals, including marine mammals. For example, cardiovascular pathology resulting from stress has been documented in odontocetes (Cowan and Curry 2008). In addition, *in utero* exposure to glucocorticoids can lead to life-long health problems for neonatal animals.

Anthropogenic disturbance, for example underwater noise, has the potential to produce a prolonged stress response in marine mammals. Cetaceans could begin to avoid certain areas if the disturbance reaches a certain threshold. However, some cetaceans may remain in areas critical to breeding, feeding or other important biological functions, even when those certain thresholds are reached. Chronic stress and its sequelae could result from exposures to this type.

Stress can also significantly affect the physiology of animals without triggering obvious behavioural changes (Beale, 2007). Chronic stress associated with boat traffic disturbance was discussed in the Whalewatching sub-committee with respect to identifying population-level effects, but this issue may also be of interest to the SWG. Due to the potential of stress in critically altering life history parameters (e.g. disease susceptibility, reproductive rates, mortality rates), the authors of SC/61/E16 suggested that the SWG highlight research on the importance of chronic stress, in particular the problem of synergistic effects of multiple stressors on the demographics of cetacean stocks. A workshop on chronic stress will be held later this year (details are listed in SC61/E15).

With regard to SC/61/E15 and SC/61/E16, the SWG discussed the difficulty associated with measuring the effects of multiple stressors on marine mammals. Studies have been conducted on birds near airports and on mammals, to determine the cumulative effects of multiple stressors. In some cases, stress effects have been found to be damaging and even lethal for certain animals. However, these effects have not been examined extensively in marine mammals. With limited resources, it is important to focus on measuring the appropriate effects of stress in marine mammals. However, determining the cumulative effects associated with multiple stressors (although difficult) is likely to be more informative than measuring the effects of a single stressor. The SWG expressed interest in receiving a report of the chronic stress workshop outlined in SC/61/E15 at next year's Scientific Committee meetings.

SC/61/E19 reported concerns about increases in offshore ambient noise due to commercial shipping that have resulted in the International Maritime Organization developing technical guidelines to reduce shipping noise. Targets to reduce the contribution from shipping noise to ambient noise have also been endorsed by the IWC Scientific Committee. At frequencies below 300Hz, the underwater noise signature from large vessels will be

dominated by propeller cavitation and the noisiest vessels are likely to be those that suffer excessive cavitation. Based on the distribution of source levels across merchant fleets reported in SC/61/E19, the noisiest 10% of vessels may contribute between around 48% and 88% of the total sea area ensonified by shipping noise to a given level, depending on assumptions about propagation conditions. Thus noise reduction targets could most easily be achieved by targeting measures at a relatively small percentage of the noisiest vessels. These measures may also result in efficiency savings which could pay back initial costs within 1 or 2 years.

Reductions in overall ambient noise achieved through quieting the noisiest vessels may also assist whales in avoiding collisions with quieter vessels and contribute to a reduction in ship strike mortality. Many data gaps remain and this hinders the understanding of factors that contribute to the variation in noise output from different vessels. There is a clear need for systematic studies of vessel noise. The equipment and deployment of recording devices for studies of whale vocalisations, combined with individual vessel tracking, may provide opportunities to obtain data on noise signatures from ships.

The SWG asked the author of SC/61/E19 if standards had been established to reduce shipping noise. The author reported that a working group from International Marine Organization (IMO) produced a report on shipping noise standards at the 58th session of the IMO. The report (IMO 2009) will be made available to the public in July 2009.

A steering group was asked to define and prioritize an agenda item on anthropogenic sound that the SWG would consider as part of its deliberations at SC/62. The steering group proposed that the agenda item would focus on the impacts of long-term chronic exposure to high levels of anthropogenic sound, with a primary focus on shipping. Although the steering group recognized that there are other matters to consider related to masking and potential impacts from chronic exposure to other source types (e.g., pile driving, seismic airguns, alternative energy activities) and how they might impact other marine mammal taxa (not just low-frequency specialists), given the limited time expected and resources available for SC/62 these source types would not be priority items for SC/62. The SWG agreed that the steering group's agenda should be added to the Work Plan (see Item 11.3). The SWG noted the common interest and focus on acoustic impacts with the work of the Whalewatching sub-committee.

An update on the 2008 mass stranding of melon-headed whales in Madagascar was presented to the SWG. Mass strandings (defined as stranding events involving three or more animals) of melon headed whales were first documented in 1957 and have now been observed worldwide. The frequency of these events has increased since the 1970s, mainly in the North Pacific. For some of these mass stranding events, evidence suggests a causal relationship with anthropogenic activities. On 31 May 2008, 100 to 200 melon-headed whales stranded in a large and complex inter-tidal lagoon in the northwestern coast of Madagascar. Hydrocarbon industry exploration activities were reported to have been occurring in the waters proximate to this mass stranding event. The Madagascar Government (GOM) and local communities began an initial response. Subsequently, at the request of the GOM, an international mass stranding response team (MSRT) was dispatched to the site from across the world. The goals of the MSRT were to assess the condition of live animals, facilitate their return to open waters, perform necropsies, and collect the scientific information to evaluate the potential cause for deceased stranded animals. Interviews were conducted during and after the stranding response to establish the best timeline possible. Following the operational/rescue phase, additional information gathering and data synthesis were completed to investigate the causality of the mass stranding by independent scientific review (ISR). As the process was moving to ISR, there was a change in Government in Madagascar, which resulted in an unforeseen delay in reviewing all the scientific information that was presented to the Ad Hoc Committee from the Government. Efforts are underway to proceed with the ISR process and complete the scientific evaluation into the potential causes of the mass stranding event.

In discussion, some additional details were requested about the industry activities ongoing at the time. It was suggested that the ISR complete its business first, before details that could prejudice the review be discussed. It was noted that all parties are cooperating and working together in the ISR process; all parties attending the SWG that have information have indicated that they will continue to provide requested information to the ISR. It was also suggested that, given the worldwide increase of mass stranding events, there is a need examine a number of mass stranding events collectively in order to identify potential common patterns and correlations.

The SWG welcomed this update and looked forward to further updates with the conclusion of the ISR of the Madagascar Mass Stranding Event (MMSE). This hopefully will entail an examination of the MMSE in the context of other mass stranding events, particularly where there are implications of acoustic stimuli. Understanding the complexities of the response, and subsequent investigative process, are valuable 'lessons-learned' for the entire cetacean scientific community, especially with the worldwide increase of mass stranding events and the need for effective and rapid response. The SWG also recalled the unusual mass stranding event of common dolphins in the south coast of the UK. It was noted that investigations into that event were still ongoing.

10.2 New information on marine renewable energy and cetaceans

In SC/61/E6 and SC/61/E7, information was provided on marine renewable energy developments (MREDs). Many European countries are particularly well placed to generate energy from the sea, especially the more westerly nations such as Portugal and the UK, with their extensive coastlines and exposure to high winds, strong currents and powerful waves. In addition to wind power generators, wave and tidal (both tidal stream and tidal range) generators are now being developed, tested and installed (SC/61/E6 provides an introduction the range of devices being developed and the technology involved and SC/61/E7 looks at their locations and stage of development including energy capacity and the year that the operation started).

As wave and tidal devices are still relatively new, little is known about their potential impact on wildlife. SC/61/E6 expands on the indicative list of MRED-related threats provided by Simmonds and Dolman (2008) and identifies potential problems including underwater and surface noise, contamination of the local environment, entrapment, entanglement or collision, as well as electrical and electromagnetic disturbance to marine life. A wide range of concerns is raised by this preliminary review of MRED technologies and by extrapolation from other more fully developed offshore industries. It was suggested that that MREDs and their interactions with cetaceans could be a topic for a future meeting of the SWG in the near future.

In discussion, it was suggested that a comprehensive cost-benefit analysis be conducted to evaluate the relative impacts of existing and emerging energy sources. Such an analysis could include aspects of energy exploration, development, production, and consumption; ecological impacts; and social aspects.

Given the increasingly widespread nature of such developments and the swiftness with which they are now being deployed, the SWG recommended that further research should be conducted into the impacts of marine renewable technologies.

10.3 New information on sampling and/or mitigation technologies

SC/61/E21 highlighted the hazards for cetaceans associated with conventional removal of old sea-dumped ammunition by blasting. High sound pressure and explosion-related shock waves can lead to severe injury and hearing impairment in marine mammals at considerable distance from detonation sites. Alternative techniques to render old ammunition harmless are available. As a consequence, detonations in the marine environment can be avoided in most cases in order to minimize harm to marine mammals. Advanced techniques for treatment of ammunition are freezing, the use of robotic equipment, Water Abrasive Suspension cutting, disposal in a Static Detonation Chamber and photolytic destruction of explosive substances. If underwater detonations cannot be avoided, suitable mitigation measures must be introduced. In test detonations, it was possible to reduce the danger area by over 98% using a double bubble curtain.

The SWG discussed the underwater hazards to cetaceans such as explosives associated with ammunition as described in SC/61/E21, nerve gas and disposed nuclear or radioactive materials. Maps are available describing the locations of some of these hazards but it was noted that, in some cases, the distribution of ammunition is changing. For example, in the Mediterranean, trawling in these areas (which are targeted because they have been previously avoided by fishers and are therefore productive) has displaced ordinance and explosive devices out of these areas.

SC/61/E9 used a literature review, internet searches, and communications with personnel working with unmanned aerial systems (UAS) to identify the capabilities of UAS throughout the world. The authors assessed their ability to replace manned aerial surveys for marine mammals, sea turtles and sea birds; monitor sea ice and other physical features and serve as platforms for search and rescue operations that are conducted by oil and gas exploration and production companies working in offshore Arctic and sub-Arctic waters. The vast majority of the systems identified were either too expensive or their capabilities did not meet minimum standards necessary to perform the tasks required of them. Eight systems were identified that might be able to perform some of the desired tasks. Several other systems had similar capabilities but had not been tested or would require upgrades. Installation of high-definition (HD) video and better stabilization systems would improve UAS performance. It is recommended that development of HD video with real-time data transmission and improved stabilization systems for UAS be pursued and that side-by-side comparisons of a few of the best systems be conducted.

The SWG discussed the utility and limitations of UAS described in SC/61/E9 to monitor cetaceans during offshore exploration and production activities. The oil industry is currently testing UAS during offshore exploration activities but they are limited to a 1.8 km radius from base. The current data transmission systems of UAS do not provide HD videos because they do not have a method for transmitting the information back to base. It is not known how data collected via UAS compare to manned aerial systems data, because side-by-side comparisons have not been conducted in the field. Future assessments of these two systems will need to be conducted to determine the utility of UAS, especially for large study areas, remote regions and harsh weather conditions.

10.4 New information on small cetacean predator/prey dynamics

No new information was available under this item.

10.5 25-year record of dead stranded bowhead whales in the Chukchi/Beaufort Seas

SC/61/E12 presented information on bowhead whale strandings. In 2008, there were five dead, stranded bowheads in the region of the north slope of Alaska reported to National Marine Fisheries Service (NMFS). The number of dead whales caused some alarm in the local community, given the changes in climate and level of industrial development the area is experiencing. The North Slope Borough-Department of Wildlife Management (NSB-DWM) queried NMFS for a list of reported dead, stranded bowhead whales over the last 25 years. NMFS provided NSB-DWM with a list of five whales, none of which were examined beyond photographs. The five 2008 cases were described. These cases illustrated the need for greater cooperation between industry, NMFS and the NSB-DWM with respect to dead marine mammal sightings. In order to facilitate examination of cases such as these, planned stranding surveillance and response activities by the NSB-DWM were described.

In discussion of SC/61/E12, it was noted that sharp force traumas, blunt force traumas and a mixture of sharp and blunt force trauma are found in animals struck by a ship. The SWG noted that histochemical techniques to detect fat emboli have been found in severe traumas, such as ship strike, and can be used to confirm that the animal was alive when the trauma occurred. The SWG was not aware of specific biochemical markers that are unique to ship strike traumas that would take the place of careful and complete necropsies. Blunt force trauma is very difficult to determine, as it usually requires a thorough physical examination of the animal and is often confounded by the decomposition state and accessibility of the carcass.

10.6 Executive Summary ICMMPA

In SC/61/O20, the relevant scientific aspects of the first International Conference on Marine Mammal Protected Areas (ICMMPA) were highlighted. The IWC was one of several sponsors of this conference, which hosted over 200 scientists, managers and policy-makers from 40 countries during the first week of April, 2009, on the Island of Maui, Hawaii, USA. While much of the conference was focused on management, education and enforcement issues, it was widely understood that scientific information provided the foundation for virtually all aspects of this management tool. Therefore, several panels and workshops were devoted to scientific topics. In particular, examples of various research survey techniques were presented from MMPAs around the world, some using inexpensive platforms of opportunity and others developing innovative new technological approaches. In addition, approaches to understanding and mitigating common threats (e.g., sound, entanglement, and ship strike) were presented. Finally, workshops were held to discuss criteria for determining and mapping critical habitat. More detailed reports from these panels and workshops will be available in the proceedings of the conference, which will be posted on its website, *www.ICMMPA.org*, when they are finalized.

The conference produced several recommendations, many of them geared toward management. The recommendations that are relevant to the Scientific Committee included: (1) the continuation of this type of communication between MMPAs; (2) a commitment to capacity-building and the sharing expertise and resources between MMPAs; (3) acknowledgement of the urgent need to define and identify critical habitat for cetaceans, and to map it along with overlying threats worldwide; (4) a recommendation for MMPAs to act as catalysts and partners for research initiatives that may include efforts outside of their boundaries, but that will inform what is happening within; (5) support for the research goals and cooperation exemplified by the Southern Ocean Research Partnership, which was announced at the conference; and (6) encouragement of MMPAs to become centres of research innovation and excellence.

The conference web site will be maintained and updated, and the Agence des Aires Marines Protégées of the Government of France has committed to hosting the next ICMMPA conference in late 2011, likely on the island of Martinique. The last recommendation has stimulated the U.S. Sanctuary program to initiate a plan to establish its MPAs containing marine mammals as 'sentinel sites' for acoustic research and monitoring.

11. WORK PLAN

11.1 SOCER
The focus of the SOCER for SC/62 will be the Arctic Region.

11.2 POLLUTION 2000+, Phase II Workshop
The SWG approved a proposal for the Workshop 'A Cetacean Risk Assessment Modelling and Chemical Prioritization Workshop' and appointed a steering group with Ylitalo as convener. Details and estimated costs are given in Appendix 2.

The SWG established an intersessional work group to develop the validation plan for biopsy techniques. The work group will communicate through intersessional email and conference calls.

11.3 Anthropogenic Sound
The SWG has recommended the following as agenda items for anthropogenic sound that were developed by a small working group:

(1) overall the general issue of potential chronic effects of anthropogenic noise on marine mammals and their acoustic habitats should be addressed;

(2) the primary focus in SC/62 should be the issue of acoustic masking from low-frequency (<1,000 Hz) shipping noise on marine mammals;

(3) papers should address, as feasible, the issue of potential influences of noise masking from an ecological perspective; and

(4) the formation of an intersessional steering group to refine the specific topics to be covered at SC/62, to identify potential IPs, and to identify and provide FI papers.

(5) Robert Suydam has been selected to chair this intersessional group.

11.4 Review progress on work from the three working groups of the 2nd Climate Change Workshop
The three working groups were the Arctic, Southern Ocean and Small Cetaceans. Due to a Workshop recommendation, the Scientific Committee sub-committee on Small Cetaceans has been asked to consider the hypotheses that link climate to small cetacean population trajectories. All three working groups will be asked to report progress to SC/62.

11.5 Review progress of the Cetacean Emerging and Resurging Disease (CERD) working group
The SWG recommended specific tasks to be performed for IWC62 through intersessional email and conference call participation:

(1) Continue to expand the intersessional email group and CERD membership by inviting participation of additional national experts and field/discipline specialists

(2) The skin disease subgroup (chair Rosa) will develop standardized lesion descriptions, characteristics, and classifications for a few major skin lesions in mysticetes and develop case definitions for a few specific skin diseases of known etiology. If possible, they may meet at the Biennial meeting of the Society of Marine Mammalogy in October 2009 to further this work.

(3) Utilizing the fields developed for diagnostic laboratories, the WG will identify regional experts who will be willing to provide the information and complete the first round of diagnostic laboratories by region, ocean basin or country.

(4) Members of the CERD WG will participate in the 'prioritization of pathogens of concern' work that is being undertaken by the U.S. Working Group on Marine Mammal Unusual Mortality Events. A report from that group will be provided to the CERD WG for review relative to specific cetacean pathogens and for presentation during SC/62.

(5) Expand the emergency response steering committee (Fernandez-chair)

- (a) Coordinate with International Union for Conservation of Nature (IUCN), ICES and other international response-planning efforts.
- (b) Develop response coordination plan using a regional approach.
- (c) With co-hosts seek funding for preparedness and response for international marine mammal die-off, mass stranding responders, or other emergency responses.

(6) Enhance capacities and communications between stranding networks

- (a) Review, edit and finalize the list of stranding networks and ensure that it is validated against the list maintained by ICES and the Shipstrike Working Group.
- (b) Take advantage of opportunities to host national, regional, and international stranding network training workshops and capacity-building efforts in those areas in which they are needed.
- (c) Develop a list of persons or organizations who would be interested in participating as trainers in such workshops

(7) Create a CERD website that will include the following items previously listed in the SC/60/E work plan (*this item has been deferred to 2011 after some of the above are developed*):

11.6 Other habitat related issues
11.6.1 New information on habitat-related issues (e.g., renewable energy, marine protected areas)

12. ADOPTION OF REPORT
The report was adopted 8 June 2009 at 11:55.

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Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of chair
3. Adoption of agenda
4. Appointment of rapporteurs
5. Review available documents
6. Review Report of the 2nd Workshop on Cetaceans and Climate Change
    - 6.1 Overview of Report of the Joint CCAMLR-IWC Workshop
    - 6.2 Papers relevant to cetaceans and climate change
7. Review progress in planning for POLLUTION 2000+, Phase II
    - 7.1 Papers relevant to planning for POLLUTION 2000+, Phase II
8. Receive State of the Cetacean Environment Report, SOCER
9. Review progress on Cetacean Emerging and Resurging Disease (CERD) working group
    - 9.1. Papers relevant to the CERD working group activities
10. Other habitat related issues
    - 10.1 New information on anthropogenic sound and cetaceans
    - 10.2 New information on renewable energy and cetaceans
    - 10.3 New information of sampling and/or mitigation technologies
    - 10.4 New information on small cetacean predator/prey dynamics
    - 10.5 25-year record of dead stranded bowhead whales in the Chukchi/Beaufort
    - 10.6 Executive Summary ICMMPA
11. Work Plan
12. Adoption of Report

Appendix 2

PROPOSAL FOR A CETACEAN RISK ASSESSMENT MODELLING AND CHEMICAL PRIORITIZATION WORKSHOP

Rationale

The ultimate goal of Pollution 2000+ is to evaluate or assess population-level effects of pollutants on cetaceans, should these occur. Information gleaned from Pollution 2000+ phase I, as well as from other contaminant studies, risk assessment efforts and modelling studies over the past 15 years, have provided a broader foundation from which to evaluate the state of the science and plan for future studies. The SWG has identified that three steps are critical for achieving the Pollution 2000+ goals: (1) developing a modelling and risk assessment framework for evaluating population-level effects, (2) developing a framework for prioritizing chemicals of concern to cetaceans, and (3) validating and critically assessing biopsy techniques according to their ability to provide critical data for the assessment of chemical impacts on cetaceans. Establishing a risk assessment and modelling framework is a complicated effort and will require an initial in-depth meeting with experts in modelling, risk assessment, biology, chemistry, toxicology and health. The modelling and risk assessment framework will evaluate cause-effect relationships between pollutants and cetaceans at the population level, building on progress made during Phase I and on recent research, using modification of a tiered risk assessment approach. The framework should: (1) be relevant to studies of all species and chemicals of concern as information or techniques become available; (2) incorporate a number of potential modelling approaches, including both bottom-up and top-down methods; and (3) focus on the types of data and models that are already available or appear likely to be available in the near future.

Work proposed: Three-day workshop for Pollution Programme Phase II, ideally scheduled for February 2010 at the Marine Mammal Center in Sausalito, CA, USA (Four days for report authors)

Workshop Goals

(1) Develop an integrated modelling/risk assessment framework for evaluating the cause and effect relationships between pollutant exposure and cetacean populations

- (a) Further refine the conceptual model developed at the Workshop in Barcelona (SC/59)
- (b) Develop the draft modelling / risk assessment framework
- (c) Review and assess modelling approaches to meet the framework

(2) Evaluate existing models that could be tested and develop a plan for testing these models with available datasets

(3) Assess the model characteristics needed and a plan for developing new models if needed

(4) Develop a prioritization framework to evaluate the broad number of environmental pollutants

(5) Identify data needs and available datasets or case studies that would be appropriate for the models that are exposure driven, source driven or effects driven.

Steering Committee: Burkhardt-Holm, Donovan, Fossi, Hall, Rosa, Rowles, Simmonds and Ylitalo

Convenor: Gina Ylitalo

Chairperson: To be appointed

Date and Location: Winter 2010, The Marine Mammal Center in Sausalito, CA

Participants: 10-15 participants including toxicologists, analytical chemists, cetacean biologists, modellers, epidemiologists, risk assessor, and health assessment experts

Outputs:

(1) Modelling and risk assessment framework to guide the Phase II;

(2) prioritization framework to evaluate chemicals of concern for cetaceans that would be used in the modelling; and

(3) list of appropriate available datasets that might be used for the modelling and risk assessment efforts.

Costs: £6000 carried over from last year (2008) will be put towards this proposal. We have formulated the budget below and request an additional £9,020 to hold this workshop. This will bring available funds to £15,020 total.

Support for ten participants:

Room: 4 nights @ £94/nights (£ 375 total)	£3750	
Board: per diem, 4 days @ £31/day (£ 124 total)	£1240	
Airfare: £438-1252	£9388	
Miscellaneous:		£ 642
		Total: £15,020

Terms of Reference for Review Papers:

(1) Overview of chemical pollutants and toxicology

- (a) Applications and volume use
- (b) Chemical properties
- (c) Exposure pathways
- (d) Transfer/biomagnification capability
- (e) Biological effects

(2) Overview of existing risk assessment and toxicological models that have been used for a range of taxa

(3) Overview of existing cetacean and other marine mammal datasets

(4) Overview of methods for identification and evaluation of environmental pollutants that may pose population health risks for cetaceans.

DRAFT AGENDA

1. Introductory Items
    - 1.1 Welcome and introductions
    - 1.2 Terms of reference
    - 1.3 Election of chair and appointment of rapporteurs
    - 1.4 Adoption of agenda
    - 1.5 Listing of documents available
2. Overview of Chemical Pollution
    - 2.1 Review of Pollution 2000 Phase I
    - 2.2 Review of environmental chemicals and toxic properties
    - 2.3 Review of pathways of exposure
    - 2.4 Review of biological impacts
    - 2.5 Review of cetacean studies
3. Review of Risk Assessment
4. Evaluation of analytical modelling and risk assessment strategies
    - 4.1 Types of models
    - 4.2 Strengths and weaknesses of models and assessment
    - 4.3 Data requirements for models (type and format)
    - 4.4 Identification of data trials
5. Production of framework for prioritization
6. Conclusions and recommendations

Appendix 3

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2009

EDITORS: M. STACHOWITSCH*, N.A. ROSE¥ AND E.C.M. PARSONS+

INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 and 1998-5, directed the Scientific Committee (SC) to provide regular updates on environmental matters that affect cetaceans. After submission of a prototype State of the Cetacean Environment Report (SOCER), Resolution 2000-7 welcomed the concept of the SOCER at the 52nd Annual Meeting in Adelaide, Australia, and 'request[ed] the annual submission of this report to the Commission'. The first full SOCER (SC/55/E7) was submitted in 2003 and focused on the Mediterranean and Black Seas and the Atlantic Ocean. Subsequent SOCERs have focused on the Pacific Ocean, the polar seas, and the Indian Ocean. This cycle has been continued, with each SOCER also including a Global section addressing information that applies generally to the cetacean environment. SC/61/E1 (SOCER 2009) focuses once again on the Pacific Ocean, summarising key papers and articles that have been published from 2007 through 2009 to date.

PACIFIC OCEAN

Habitat protection/degradation

General

The impact of coastal development on small cetaceans

Coastal development, especially in densely populated areas, is a form of habitat degradation for small cetaceans. Hong Kong can serve as a case study because of the massive development there and because the city has addressed cetaceans (primarily the Indo-Pacific humpback dolphin) in environmental impact assessments more than anywhere else in the world. The mitigation measures used for large construction projects include bubble curtains, exclusion zones, ramping up of piling hammers, acoustic decoupling of noisy equipment, vessel speed limits, no dumping policies and curtains to hold back silt. One of the most important measures was to conduct surveys to monitor the density and behaviour of the animals in three phases: before, during and after the period of potential disturbance.

(SOURCE: Jefferson, T.A., Hung, S.K. and Würsig, B. 2009. Protecting small cetaceans from coastal development: Impact assessment and mitigation experience in Hong Kong. *Mar. Pol.* 33: 305-311)

* Department of Marine Biology, Faculty of Life Sciences, University of Vienna, Austria
¥ Humane Society International, Washington, DC, USA
+ University Marine Biological Station Millport (University of London), Great Cumbrae, Scotland and Department of Environmental Science and Policy, George Mason University, Fairfax, Virginia, USA

New information about recently discovered small population of Indo-Pacific humpback dolphins

A recent survey of a newly discovered (2002) population of Indo-Pacific humpback dolphins in coastal waters of the eastern Taiwan Strait revealed an estimated 99 individuals. Their main distribution area is subject to extensive industrialization and habitat degradation and measures approximately 500 km². The assessment led to a categorization as 'Critically Endangered' according to IUCN Red List criteria. The continued existence of this population is unlikely without '*effective and precautionary* in situ *conservation effort*', a conclusion applicable to several very small populations of cetaceans.

(SOURCE: Wang, J.Y., Yang, S.C., Hung, S.K. and Jefferson, T.A. 2007. Distribution, abundance and conservation status of the eastern Taiwan Strait population on Indo-Pacific humpback dolphins, *Sousa chinensis*. *Mammalia*: 157-165)

Fisheries Interactions

Anthropogenic scarring in western gray whales

Contact with fishing gear and collisions with vessels are potentially serious factors influencing the survival chances of the critically endangered western gray whale. A multi-year (1995-2005) survey off Sakhalin Island, Russia, used photo-identification data to examine this threat based on visible scarring. Twenty percent of the 150 individuals had detectable scarring, of which 19% reflected at least one previous entanglement, and 2% indicated survival of at least one vessel collision. These are considered to be minimum estimates and point to trap nets as being the anthropogenic interaction leading to the most fatalities in this population.

(SOURCE: Bradford, A.L., Weller, D.W., Ivashchenko, Y.V., Burdin, A.M. and Brownell Jr., R.L. 2009. Anthropogenic scarring of western gray whale (*Eschrichtius robustus*). *Mar. Mamm. Sci.* 25: 161-175)

Dolphin bycatch in New Zealand

A 2001-2005 study that examined short-beaked common dolphin bycatch during trawling for jack mackerel identified geographical area as the greatest influence on bycatch risk. Fishing depth, total winch time and light conditions were also major risk factors. Identifying risk factors is an important first step in reducing bycatch, and the authors noted the need for early exploratory data analysis and the creation of a well-designed database. Moreover, bycatch cannot be considered in isolation but rather as one of a number of non-natural sources of mortality.

(SOURCE: Du Fresne, S.P., Grant, A.R., Norden, W.S. and Pierre, J.P. 2007. Factors affecting cetacean bycatch in a New Zealand trawl fishery. *DOC Research & Development Series* 282: Department of Conservation, Wellington. 18 pp.)

Bycatch of common dolphins in Southern Australia

Bycatch of short-beaked common dolphins by the large purse-seine fishery in South Australia has led to serious concerns over the long-term viability of local dolphin populations. Fishermen reported only a small percentage of the actual encirclements and mortalities. After establishment of a Code of Practise (CoP) that included a number of avoidance and release strategies, the rates of encirclement and mortality dropped by 87% and 97%, respectively. The average response time of fishermen to encirclement also decreased by 77%, and the proportion of encircled animals that subsequently died fell from 21% to 5%. Improvements to the CoP could make this fishery a 'best practise' example. This overall management issue has become complicated by the discovery of a marked genetic differentiation between dolphins from South Australia and Tasmania, suggesting a minimum of two genetic populations here. This situation has implications for conservation management strategies here and elsewhere: wide-ranging species with seemingly uniform distributions can actually show unexpected degrees of genetic differentiation, calling for better identifying population boundaries.

(SOURCE: Hamer, D.J., Ward, T.M. and McGarvey, R. 2008. Measurement, management and mitigation of operational interactions between the South Australian sardine fishery and short-beaked common dolphins (*Delphinus delphis*). *Biologic. Conserv.* 141: 2865-2878; Bilgmann, K., Möller, L.M., Harcourt, R.G., Gales, R. and Beheregaray, L.B. 2008. Common dolphins subject to fisheries impacts in Southern Australia are genetically differentiated: implications for conservation. *Anim. Conserv.* 11: 518-528)

Entanglements of marine mammals and seabirds along the US Pacific coast

The entanglement databases of seven organizations operating along the US west coast documented 454 entanglements involving 31 bird and nine marine mammal species between 2001 and 2005. One sperm whale was killed in monofilament netting and one humpback whale in crab pot and line, with a second humpback being successfully disentangled from crab pots and fishing line. The entanglement materials were mostly fishing related; the recovered specimens represent an unknown proportion of entangled animals that die at sea. The entanglement frequency during these years points to a persistent problem.

(SOURCE: Moore, E., Lyday, S., Roletto, J., Litle, K., Parrish, J.K., Nevins, H., Harvey, J., Mortenson, J., Greig, D., Piazza, M., Hermance, A., Lee, D., Adams, D., Allen, S. and Kell, S. 2009. Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. *Mar. Poll. Bull.*, in press, available online 2 April 2009)

The vaquita – last ditch effort to help world's most endangered marine mammal

The population of the vaquita or Gulf of California harbour porpoise, known to science only since 1958, has fallen from a historical population estimated in the low thousands to 567 in 1991 to probably 150 today. Every year about 20-30 vaquitas get caught in gillnets and drown. The Government of Mexico has initiated a new plan that will buy fishing boats, create new jobs for fishers, replace gillnets with other gear, and provide compensation to stay out of core vaquita habitat. This is a step in the direction scientists have called for: '*immediate action, not more data*'.

(SOURCE: Morell, V. 2008. Can the vaquita be saved? *Science* 321: 676)

Entanglement of humpback whales in Alaska

Entanglement of humpback whales in fishing gear is a potentially significant source of serious injury and mortality. A two-year study in Alaska that examined the caudal peduncles of whales for scars revealed that most animals (71%) had been non-lethally entangled at some time in their lives. The annual rate of scar acquisition was considered to be a more powerful measure of contemporary entanglement rates. This value was 8% between 2003 and 2004.

(SOURCE: Neilson, J.L., Straley, J.M., Gabriele, C.M. and Hills, S. 2009. Non-lethal entanglement of humpback whales (*Megaptera novaeangliae*) in fishing gear in northern Southeast Alaska. *J. Biogeog.* 36: 452-464)

Strategy to promote recovery of endangered Hector's dolphin in New Zealand

The populations of New Zealand's endemic Hector's dolphin (ca. 8000 individuals) have declined to 27% of the 1970 size and are predicted to continue declining. Two management strategies have been proposed to promote recovery: 1) expanding the current two protected areas into four

strategically-sited areas and 2) reducing fishery mortality to levels approaching zero. The call for urgent action is supported by the considerations that, at rates of current decline, future management efforts will become increasingly expensive, logistically difficult and likely to fail.
(SOURCE: Slooten, E. 2007. Conservation management in the face of uncertainty: Effectiveness of four options for managing Hector's dolphin bycatch. *Endang. Spec. Res.* 3: 169-179)

Sperm whales attracted to longline fishing

Sperm whales are the largest marine mammals that take advantage of human fishing activities (by removing fish from lines), and such depredation may be increasing. The whales are apparently attracted to the fishery operations by acoustic cues, and this study indicated that the whales interrupt their normal activities and approach boats due to the sound (i.e., cavitation) created by changing propeller speeds in certain phases of fishing (rather than hydraulic or fishing gear noise). Such research is an important step in identifying the sounds that promote these undesirable encounters. Management strategies such as reducing the detection range of these cues and producing 'false cues' might reduce the attraction.
(SOURCE: Thode, A., Straley, J., Tiemann, C.O. and O'Connell, V. 2007. Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. *J. Acoust. Soc. Am.* 122: 1265-1277)

Dolphin populations fail to recover after fishery threat reduced

In the eastern tropical Pacific, the abundances of eastern spinner and northeastern pantropical spotted dolphins were reduced to an estimated one-third and one-fifth of pre-fishery levels, respectively, by the late 1990s. They were determined to be 'depleted' in 2002. Two studies examined why the populations have failed to recover at the rate expected after the halting of massive direct mortalities during yellowfin tuna fishing ('fishing on dolphins'). Surveys carried out here by the US National Oceanic and Atmospheric Administration between 1987 and 2003 showed that the fishery continues to have population-level effects (impact on calf survival and/or birth rates, at least in the spotted dolphins) beyond the direct effects of bycatch. These results underline that ceasing highly damaging fishing practices, or replacing them with less harmful approaches ('fishing on logs', chasing and encircling but later releasing dolphins), does not necessarily guarantee rapid recovery of affected dolphin species.
(SOURCE: Wade, P.R., Watters, G.M., Gerrodette, T. and Reilly, S.B. 2007. Depletion of spotted and spinner dolphins in the eastern tropical Pacific: Modelling hypotheses for their lack of recovery. *Mar. Ecol. Prog. Ser.* 343: 1-14; Cramer, K.L., Perryman, W.L. and Gerrodette, T. 2008. Declines in reproductive output in two dolphin populations depleted by the yellowfin tuna purse-seine fishery. *Mar. Ecol. Prog. Ser.* 369: 273-285)

Limits to bycatch mortality of small cetaceans in Canada's Pacific region

In British Columbia, small cetaceans are bycaught in salmon gillnet fisheries. To determine whether these mortalities exceed sustainable levels, calculations were done for three species (Pacific white-sided dolphins, Dall's porpoises and harbour porpoises). Based on minimum abundance estimates and maximum rates of population increase, and factoring in uncertainty, the results showed that estimated bycatch in 2004 and 2005 exceeded only the most precautionary limits and only for the two porpoise species. Future priority should focus on better determining species-specific entanglement rates. Canada's management objective is to maintain favourable conservation status of cetacean populations, and harbour porpoises in these waters are a species of 'Special Concern' because they are considered to be highly sensitive to human activities.
(SOURCE: Williams, R., Hall, A. and Winship, A. 2008. Potential limits to anthropogenic mortality of small cetaceans in coastal waters of British Columbia. *Can. J. Fish. Aquat. Sci.* 65: 1867-1878)

Marine Debris

Marine debris collection in Korea

Nearly half of the 115,000 tons of marine debris generated each year in Korea (Ministry of Maritime Affairs and Fisheries) is sea-based, i.e., Styrofoam from aquaculture and ropes from fishing vessels and aquaculture. Using a fund generated from provinces contributing to the land-based marine debris inflow into coastal waters, the city of Incheon established an incentive program that pays fishermen to collect marine debris and bring it back to port. The city has thus purchased a total of 18,000 tons of debris during the period 2002-2007 (at US$5.00 per 40 litre bag). Beyond tackling the prevention of debris, such innovative programs are a positive step forward: they save the government money, involve local residents, and reduce a pervasive form of marine pollution that is known to affect cetaceans.
(SOURCE: Cho, D-O. 2009. The incentive program for fishermen to collect marine debris in Korea. *Mar. Poll. Bull.* 58: 415-417)

Floating marine debris in southern Chile

Floating marine debris (FMD) impacts marine wildlife by entanglement, ingestion and transport of encrusting fauna. Relatively high abundances of FMD (1-250 items/km) were detected by ship surveys in southern Chile (2002-2005). Eighty percent of the FMD was Styrofoam, plastic bags and plastic fragments. Most of this material originated from the intensive mussel and salmon mariculture industry here. These coastal waters are home to at least one threatened dolphin species, the Chilean dolphin.
(SOURCE: Hinojosa, I. A. and Thiel, M. 2009. Floating marine debris in fjords, gulfs and channels of southern Chile. *Mar. Poll. Bull.* 58: 341-350)

Chemical pollution

Numerous publications documented cetacean contaminant levels from the Pacific Ocean between 2006 and 2009. Maximum recorded butyltin levels are summarised for the Pacific in Table 1; Table 2 summarises maximum trace element levels; Table 3 summarises maximum fluorinated hydrocarbon concentrations; and Table 4 summarises maximum organic contaminant levels.

Persistent organic pollutants may be a risk for Southern Resident killer whales

Researchers measured persistent organic pollutant (POP) levels in Chinook salmon to investigate the consumption of these contaminants by Northern and Southern Resident killer whales on the Pacific coast of North America. It was estimated that killer whales consume up to 1.248 µg PCB day^{-1}; 0.085 HCH day^{-1}; 0.489 DDT day^{-1}; 0.674 µg PBDE day^{-1}; 0.055 µg PCDD day^{-1}; and 0.078 µg PCDF day^{-1}. Canadian guidelines for maximum contaminant concentrations to be consumed by mammalian wildlife were close to, or exceeded by, salmon from the Deschutes and Lower Fraser Rivers for PCBs and salmon from the Duwamish River for DDT. The conclusion was '*that the endangered southern resident killer whales are exposed to much higher concentrations of* [POPs] *than their northern counterparts through the consumption of more* [POP]-*contaminated Chinook salmon, and may increase their consumption of salmon in order to compensate for the reduced lipid content observed in southerly Chinook*'.

(SOURCE: Cullon, D.L., Yunker, M.B., Alleyne, C., Dangerfield, N.J., O'Neill, S., Whiticar, M.J. and Ross, P.S. 2009. Persistent organic pollutants in Chinook salmon (*Oncorhynchus tshawytscha*): implications for resident killer whales. *Environ. Toxicol. Chem.* 28: 148-161)

High mercury levels in cetacean meat on sale for human consumption in South Korea

Cetacean meat on sale for human consumption in South Korea was tested for mercury contamination. Levels of mercury up to 41 μg. g^{-1} (wet weight) were detected in red meat (muscle tissue) and up to 156 μg. g^{-1} (wet weight) in liver. All samples were higher than Japanese health regulation limits for mercury contamination in marine foods and all but Cuvier's beaked whale and harbour porpoise meat were above Korean regulation safety limits. The researchers concluded: '*men and women who plan to have children, in addition to pregnant women and developing children, should restrict their consumption of Hg-contaminated products from odontocetes*'. Bottlenose dolphin, false killer whale and killer whale tissues were the most heavily contaminated. Moreover, the analysed J-stock North Pacific common minke whale meat had mercury levels twice as high as J-stock or O-stock meat for sale in Japan.

(SOURCE: Endo, T., Ma, Y.U, Baker, C.S., Funahashi, N., Lavery, S., Dalebout, M.L., Lukoschek, V. and Haraguchi, K. 2007. Contamination level of mercury in red meat products from cetaceans available from South Korea markets. *Mar. Poll. Bull.* 54: 669–677)

Increasing contaminant levels in melon-headed whales and high contaminant transfer rates to calves

Concentrations of fluorinated hydrocarbons, polybrominated diphenyl ethers (PBDEs) and organochlorine compounds were determined in the tissues of 48 melon-headed whales stranded in Japan in 1982, 2001-2002, and 2006 (see also Table 4). Concentrations of the main fluorinated compounds increased tenfold between 1982 and 2002 (PFOS and PFOSA, although the latter declined between 2002 and 2006). Two other compound classes (PFNA and PFDA) increased significantly from 2001/2002 to 2006. Concentrations of PCBs, DDT, and HCB decreased between 1982 and 2002/2006. However, levels of chlordane and PBDEs increased, suggesting more recent inputs of these contaminants into the environment. Contaminant levels were also compared between two pregnant whales and their foetuses: the amount of fluorinated hydrocarbons transferred to the foetuses was much higher than of PCBs or brominated hydrocarbons. Approximately 85% of a mother's body burden of contaminants was estimated to be transferred to the offspring during gestation and lactation. These studies suggest increasing fluorinated and brominated hydrocarbon contamination in Japanese coastal waters, and the high level of placental transfer of these hydrocarbons has implications for neonate cetacean health.

(SOURCES: Hart, K., Kannan, K., Isobe, T., Takahashi, S., Yamada, T.K., Miyazaki, N. and Tanabe, S. 2008. Time trends and transplacental transfer of perfluorinated compounds in melon-headed whales stranded along the Japanese Coast in 1982, 2001/2002, and 2006. *Environ. Sci. Technol.* 42: 7132–7137; Kajiwara, N., Kamikawa, S., Amano, M., Hayano, A., Yamada, T.K., Miyazaki, N. and Tanabe, S. 2008. Polybrominated diphenyl ethers (PBDEs) and organochlorines in melon-headed whales, *Peponocephala electra*, mass stranded along the Japanese coasts: maternal transfer and temporal trend. *Environ. Pollut.* 15: 106-114)

Killer whales may face life-long risk from persistent organic pollutants

Models were developed to examine POP-related health risks in killer whales. Modelled PCB concentrations in the Northern and Southern Resident killer whales of the Pacific coast of North America responded slowly to declines in environmental pollutant loads, especially in adult males. Projections suggest that the Northern Resident population could fall below current guidelines for maximum contaminant concentrations to be consumed by mammalian wildlife by 2030 while the Southern Residents, listed as endangered under the US Endangered Species Act, may not do so until at least 2063. The use of models provides managers with benchmarks against which the effectiveness of contaminant mitigation can be measured. The results of these models provide little confidence that simple consumption guidelines afford protection to long-lived animals such as killer whales.

(SOURCE: Hickie, B.E., Ross, P.S., MacDonald, R.W. and Ford, J.K.B. 2007. Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. *Environ. Sci. Technol.* 41: 6613-6619)

Trace element-contaminated prey consumption may be a risk for Hong Kong dolphins and porpoises

Stomach contents of finless porpoises and Indo-Pacific humpback dolphins from Hong Kong waters were analyzed for trace element and organochlorine contamination. A risk assessment of the impact of consuming contaminated prey was conducted using a model incorporating contaminant dose guidelines for terrestrial mammals and humans. For trace elements, when using the terrestrial mammal guidelines only, arsenic was considered a risk, but most arsenic in marine fish is in a low toxicity organic form, suggesting the risk is low. However, when using human health guidelines, there was a risk from cadmium, chromium, copper, nickel and mercury. For PCBs, humpback dolphins had concentrations of up to 2.1 μg g^{-1}; finless porpoises up to 0.29 μg g^{-1}. Finless porpoises were considered to be at lower risk than humpback dolphins from consuming PCBs in their diet (using terrestrial mammal guidelines); the situation with humpback dolphins warranted further investigation. The researchers did not incorporate PCB bioaccumulation into their model.

(SOURCES: Hung, C.L.H., Lau, R.K.F., Lam, J.C.W., Jefferson, T.A., Hung, S.K., Lam, M.H.W. and Lam P.K.S. 2007. Risk assessment of trace elements in the stomach contents of Indo-Pacific humpback dolphins and finless porpoises in Hong Kong waters. *Chemosphere* 66: 1175-1182; Hung, C.L.H., Xu, Y., Lam, J.C.W., Jefferson, T.A., Hung, S.K., Yeung, L.W.Y., Lam, M.H.W., O'Toole, D.K. and Lam P.K.S. 2006. An assessment of the risks associated with polychlorinated biphenyls found in the stomach contents of stranded Indo-Pacific humpback dolphins (*Sousa chinensis*) and finless porpoises (*Neophocaena phocaenoides*) from Hong Kong waters. *Chemosphere* 63:845-852)

First report of the flame retardant HBCD in marine mammals in Southeast Asia

Environmental contamination by brominated flame retardants (BFRs) has become a serious concern (due to, *inter alia*, persistence, bioaccumulation, and possible adverse effects on humans and wildlife). Hexa-bromocyclododecanes (HBCDs) are intensively used as BFRs, with an annual consumption of 22,000 metric tons (in thermal insulation foam and furniture upholstery). This first report of HBCD contamination in marine mammals detected the chemical in blubber samples of all finless porpoises and Indo-Pacific humpback dolphins collected from the South China Sea between 1990 and 2001. Values were higher in the humpback dolphins (31-380 ng/g lipid weight) than in the finless porpoises (4.7-55 ng/g lipid weight), which was attributed to habitat (estuarine, industrial zone in the former, more ocean-influenced waters in the latter). Overall, values tended to increase from 1990 to 2001.

(SOURCE: Isobe, T., Ramu, K., Kajiwara, N., Takahashi, S., Lam, P.K,S., Jefferson, T.A., Zhou, K. and Tanabe, S. 2007. Isomer specific determination of hexabromocyclododecanes (HBCDs) in small cetaceans from the South China Sea – levels and temporal variation. *Mar. Poll. Bull.* 54: 1139-1145)

Metal toxicity associated with kidney damage and bone malformations in South Australian dolphins

In South Australia, significantly more cadmium, copper, and zinc in the liver were observed in dolphins with evidence of advanced kidney damage. Metal and selenium concentrations in the liver were similar in groups with various degrees of bone malformation. Two dolphins had high metal burdens, kidney damage and evidence of bone malformations, indicating possible severe and prolonged metal toxicity. Another dolphin showed some renal damage, but had no other symptoms; this was unlikely to be caused by metal toxicity. Multiple metal toxicity symptoms should be examined together in order to distinguish metal toxicity from unrelated conditions.

(SOURCE: Lavery, T.J., Kemper, C.M., Sanderson, K., Schultz, C.G., Coyle, P., Mitchell, J.G. and Seuront, L. 2009. Heavy metal toxicity of kidney and bone tissues in South Australian adult bottlenose dolphins (*Tursiops aduncus*). *Mar. Environ. Res.* 67: 1-7)

Organochlorine contaminants and enzyme expression

Cytochrome P450 (CYP) enzymes assist in metabolising (neutralising) substances such as environmental pollutants and carcinogens. DNA sequences from CYPs isolated from minke whale liver were examined to determine if organochlorine contaminants (OCs) affected their expression. The livers of 19 mature males were collected during JARPN II. Statistical analyses showed no significant correlation between CYP expression and OC levels, suggesting that either these contaminants do not alter CYP expression or the levels in minke whale liver are not sufficient to alter expression.

(SOURCE: Niimi, S., Kim, E-U., Iwata, H., Watanabe, M.X., Yasunaga, G., Fujise, Y. and Tanabe, S. 2007. Identification and hepatic expression profiles of cytochrome P450 1-4 isozymes in common minke whales (*Balaenoptera acutorostrata*). *Comp. Biochem. Physiol.* Part B 147: 667-681)

New polybrominated compounds identified in Australian marine mammals

Australian marine mammals are bioaccumulating elevated concentrations of a range of polybrominated natural products. One natural form (2,2'-diMeO-BB 80) was found in the blubber of selected marine mammal samples at concentrations of 200-1800 ng g^{-1} lipid weight, which represents the highest concentration reported for this compound in environmental samples. Three novel polybrominated dimethoxybiphenyls (PBDMBs) were identified in the same samples. These may represent either new or transformed natural products. In either case, the environmental relevance of natural and related PBDMBs needs to be investigated in more detail.

(SOURCE: Vetter, W., Turek, C., Marsh, G. and Gaus, C. 2008. Identification and quantification of new polybrominated dimethoxybiphenyls (PBDMBs) in marine mammals from Australia. *Chemosphere* 73: 580-586)

Disease and mortality events

General

High prevalence of skin lesions in bottlenose dolphins off California

A photo-identification study in a 500 km² area off Santa Monica, California, between 1997 and 2007 revealed that of 637 bottlenose dolphins examined for skin lesions, 79% showed at least one type of lesion. Offshore animals showed more lesions than coastal animals. Lesions can be a sign of disease and may be related to anthropogenic factors, making their high presence a cause of concern.

(SOURCE: Bearzi, M., Rapoport, S., Chau, J. and Saylan, C. 2009. Skin lesions and physical deformities of coastal and offshore common bottlenose dolphins (*Tursiops truncatus*) in Santa Monica Bay and adjacent areas, California. *Ambio* 38: 66-71)

Harmful Algal Blooms (HABs)

Unusual marine mammal mortality event off California correlated to toxic algal bloom

An unusual stranding event of marine mammals off California in 2002 included both inshore and offshore foraging cetaceans: long-beaked common dolphins, short-beaked common dolphins, bottlenose dolphins and gray whales. A correlation in time was established between this event and blooms of marine algae (diatoms) of the genus *Pseudo-nitzschia*, which produce the neurotoxin domoic acid. This toxin is known to cause death in marine birds, sea lions and humans (amnesic shellfish poisoning). This provides further evidence that harmful algal blooms pose a threat to cetaceans. Such blooms have been linked to anthropogenic effects, specifically to eutrophication.

(SOURCE: Torres de la Riva, G., Kreuder-Johnson, C., Gulland, F.M.D., Langlois, G.W., Heyning, J.E., Rowles, T.K. and Mazet, J.A.K. 2009. Association of an unusual marine mammal mortality event with *Pseudo-nitzschia* spp. blooms along the southern California coastline. *J. Wildlife Diseases.* 45: 109-121)

Ship strikes

Ship-strike rates of large whales off the coast of Washington State

Records (1980-2006; n = 130) of large whale strandings in Washington State, USA, revealed that seven species had evidence of ship strikes. Of these, fin whales had the highest rate (five ante-mortem strikes and two possible post-mortem strikes) – six of these strikes occurred during 2002-2006. Six gray whales also presented 'possible ship strike' injuries, although these animals are more abundant in the area than fin whales. There was one possible ship strike of a humpback whale despite an abundance of these animals occurring in shipping lanes. There were species-specific differences in ship-strike rates, suggesting some species may be more vulnerable to ship strikes than others.

(SOURCE: Douglas, A.B., Calambokidis, J., Raverty, S., Jeffries, S.J., Lambourn D.M. and Norman, S.A. 2008. Incidence of ship strikes of large whales in Washington State. *J. Mar. Biol. Assoc. UK* 88: 1121-1132)

Oil spills

Transient killer whale group may go extinct

Killer whales were photographed in oil after the 1989 'Exxon Valdez' oil spill, but preliminary damage assessments were inconclusive. Photo-identification methods used to monitor two killer whale populations for five years before the spill were continued for 16 years afterward. The AB resident pod and the AT1 transient group suffered losses of 33 and 41%, respectively, in the year following the spill. By 2005, the AB pod had not recovered to pre-spill numbers and its rate of increase was significantly less than that of other resident pods. The AT1 group continued to decline and is now listed as depleted under the US Marine Mammal Protection Act. The simultaneous losses of large numbers of individuals from two (ecologically) separate groups and the absence of other obvious perturbations strengthens the link between the mortalities, lack of recovery, and the oil spill. '*It is clear that resident killer whale pods, even under optimal conditions, may take decades to recover from the impacts of an oil spill or other disturbance, particularly if reproductive females and/or juvenile females are lost… The outlook for the AT1 Group is bleak and the group will likely go extinct within the next several decades*'.

(SOURCE: Matkin, C.O., Saulitis, E.L., Ellis, G.M., Olesiuk, P. and Rice, S.D. 2008. On-going population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* 356: 269-281)

Disease

Infection by *Toxoplasma* in a striped dolphin from Costa Rica

A stranded striped dolphin on the Pacific coast of Costa Rica, which later died, was diagnosed with severe meningoencephalomyelitis, and the sporozoan *Toxoplasma gondii* was isolated from the brain. The mechanism of infection of this potentially lethal parasite remains unknown, with one explanation being that oocysts of the sporozoan are washed from land into the sea via runoff contaminated by cat excrement. Although the prevalence of *T. gondii* in bottlenose dolphins from the USA is very high, this is the first report from this species.
(SOURCE: Dubey, J.P., Morales, J.A., Sundar, N., Velmurugan, G.V., Gonzales-Barrientos, C.R., Hernández-Mora, G. and Su, C. 2007. Isolation and genetic characterization of *Toxoplasma gondii* from striped dolphin (*Stenella coeruleoalba*) from Costa Rica. *J. Parasitol.* 93: 710-711)

High rate of *Brucella*-linked fatalities in Costa Rican striped dolphins

Between August 2004 and April 2007, 10 striped dolphins live-stranded on the Pacific coast of Costa Rica, and all displayed '*swimming problems compatible with neurologic disorders*' and died within 48 hours. All animals tested positive for *Brucella* antibodies and the six dolphins examined in detail demonstrated the presence of *Brucella* bacteria in multiple organs. A pregnant animal and her foetus demonstrated that this pathogen can be passed to unborn offspring. The animals examined had encephalitis, specifically non-suppurative meningitis. The authors expressed concerns about zoonotic infection, particularly in people who handled the infected animals, and noted that in Costa Rica '*other stranded dolphins have been transferred to privately owned swimming pools or to slaughter for use as a food source for humans and domestic animals*.'
(SOURCE: Hernández-Mora, G., González-Barrientos, R., Morales, J.A., Chaves-Olarte, E., Guzmán-Verri, C., Baquero-Calvo, E., De-Miguel, M.J., Marín, C.M., Blasco, J.M. and Moreno, E. 2008. Neurobrucellosis in stranded dolphins, Costa Rica. *Emerg. Infect. Dis.* 14: 1430-1433)

Possible *Brucella* infection in dolphins from Solomon Islands

Antibodies to the bacterium *Brucella* were found in serum samples of 53% of the 58 Indo-Pacific bottlenose dolphins tested from Solomon Islands. *Brucella* bacteria species are the causative agent of brucellosis, a serious debilitating disease in humans and an important cause of abortion and sterility in domestic animals. The host range for *Brucella* spp. has recently expanded to include marine mammals, including cetaceans, around Europe and North and South America as well as the Arctic Sea. This is a first report from Pacific waters.
(SOURCE: Tachibana, M., Watanabe, K., Kim, S., Omata, Y., Murata, K., Hammond, T. and Watarai, M. 2006. Antibodies to *Brucella* spp. in Pacific bottlenose dolphins from the Solomon Islands. *J. Wildlife Sci.* 42: 412-414)

Aspergillosis fungus infection in stranded melon-headed whale

A melon-headed whale calf stranded in the Philippines and was diagnosed with lung lesions containing a fungal infection; the animal later died. The cause of death was respiratory failure due to severe bronchopneumonia caused by *Aspergillus fumigatus* infection. Such fungal mycoses are primarily seen in immunosuppressed hosts. This is the first report of fungal respiratory disease in any marine mammal in the Philippines.
(SOURCE: Torno, C.S., Buccat, M.C. and Masangkay, J.S. 2008. Aspergillosis in a melon-headed whale (*Peponocephala electra*). *Philipp. J. Vet. Med.* 45: 49-57)

Direct exploitation

Genetic methods suggested as tool to better document illegal takes of rare whales in Micronesia

IUU fishing is known to occur on marine megafauna such as cetaceans in the tropical Indo-Pacific. A rare ginkgo-toothed beaked whale, first described in 1958 and known from less than 30 specimens, was found frozen on a longline vessel in Guam after being taken in Micronesian waters. Taking such an animal is currently not prohibited by law in Micronesia, but the importation to Guam represented a contravention of CITES and the US Marine Mammal Protection Act. Molecular monitoring could be a powerful and relatively inexpensive tool to address this threat to rare cetaceans.
(SOURCE: Dalebout, M.L., Robertson, K.M., Chivers, S.J. and Samuels, A. 2008. DNA identification and the impact of illegal, unregulated, and unreported (IUU) fishing on rare whales in Micronesian waters. *Micronesica* 40: 139-147)

Historical overexploitation during illegal whaling in the North Pacific

Information on historical catches of whales is crucial to helping determine former population sizes and understand current recovery trends. This collection of 18 formerly secret internal reports by Soviet scientists (available for the first time in English translation) documents dramatic declines in abundance, disappearances of whales from previously populous feeding and breeding grounds, and a decline in the average size and age of animals in the catch. The most affected species were the North Pacific right whale (the most critically endangered population of large whales in the world) and sperm whale.
(SOURCE: Ivashchenko, Y.V., Clapham, P.J. and Brownell Jr., R.L. (eds) 2007. Scientific reports of Soviet whaling expeditions in the North Pacific, 1955-1978. *NOAA Technical Memorandum NMFS-AFSC-175*: 1-81)

Efforts to assess the impact of live captures of bottlenose dolphins in Solomon Islands

Live captures and export of Indo-Pacific bottlenose dolphins from Solomon Islands began in 2003. The IUCN Global Plan of Action for the Conservation of Cetaceans states that small cetaceans should not be captured unless their population has been assessed and shown capable of sustaining the removals. An IUCN workshop was convened to examine a range of topics, from management goals and assessment options to cultural and other local considerations. At the current permitted level of exports (100 individuals per year), the population would have to be at least 5,000 to 10,000 individuals, but the population is in fact estimated to be well below 5,000. The near-shore distribution of this population makes it particularly vulnerable to exploitation and other anthropogenic threats.
(SOURCE: Reeves, R.R. and Brownell, R.L., Jr. (eds). 2009. Indo-Pacific bottlenose dolphin assessment workshop report: Solomon Islands case study of *Tursiops aduncus. Occasional Paper of the Species Survival Commission*, No. 40, IUCN, Gland, Switzerland. 53 pp.)

Climate change

Northern Pacific climate alters offspring sex ratio in northern elephant seals

In northern elephant seals, where foraging resources are partitioned by sex, warmer sea surface temperature anomalies reduce or disperse prey resources for gestating females in the North Pacific Ocean. Such conditions favour the production of male offspring. Anthropogenic global warming is predicted to warm the North Pacific, which could alter basin-scale productivity, increase nutritional stress and alter sex ratios in mammalian populations where foraging resources are partitioned by sex. This warrants examining a potential effect in cetaceans.
(SOURCE: Lee, D.E. and Sydeman, W.J. 2009. North Pacific climate mediates offspring sex ratio in Northern elephant seals. *J. Mamm.* 90: 1-8)

Noise impacts

Sonar

U.S. Navy limits use of low-frequency active sonar

Under an agreement between the US Navy and conservation organizations, the Navy will restrict the use of its Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar to defined military training areas in the North Pacific Ocean. The LFA signal can sometimes be detected across entire ocean basins and has the potential to disrupt whale behaviour hundreds of miles away. The agreement includes other protective measures such as seasonal and coastal exclusions.
(SOURCE: News. 2008. *Mar. Poll. Bull.* 56: 1678–1679)

Seismic surveys

Seismic survey mitigation and monitoring off Sakhalin Island

This paper summarised the results of the mitigation and monitoring program for western gray whales during a 3-D seismic survey by Exxon Neftegas Limited, conducted during 17 August – 9 September 2001 off Sakhalin Island, Russia (see entries below). Existing mitigation and monitoring practices for seismic surveys were evaluated to identify 'best practices' and two buffer zones were established: a 1 km 'safety' buffer (whose intent was to avoid injury) prevented exposures to levels of sound greater than 180 dB re 1 µPa (rms) and a 4-5 km 'feeding' buffer (whose intent was to avoid displacement from feeding areas) was established to prevent exposures greater than 163 dB re 1 µPa (rms). Trained marine mammal observers monitored whales within these buffers. Additional measures included: 1) rescheduling the program to avoid the spring arrival of migrating whales; 2) reducing the survey area by 19% to avoid waters less than 20 m deep (feeding whales concentrate here); 3) reducing the number and total volume of air guns by about half relative to initial plans; and 4) using 'ramp-up' or 'soft-start' procedures. This program provided new information about underwater sound propagation and gray whale responses during exposure to seismic surveys. The authors concluded that '[subsequent] *research in 2002-2005 suggested no biologically significant or population level impacts of the 2001 seismic survey*'.
(SOURCE: Johnson, S.R., Richardson, W.J., Yazvenko, S.B., Blokhin, S.A., Gailey, G., Jenkerson, M.R., Meier, S.K., Melton, H.R., Newcomer, M.W., Perlov, A.S., Rutenko, S.A., Würsig, B., Martin, C.R. and Egging, D.E. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environ. Monit. Assess.* 134: 1-19)

Behavioural changes in gray whales in response to 3-D seismic surveys

Land-based surveys (using scan sampling and surveyor's theodolites) were used to monitor western gray whale behaviour during seismic survey operations off Sakhalin Island. None of the whales were exposed to received levels greater than 163 dB re 1 µPa (rms) (see entry above). The seismic survey had no statistically detectable effect on individual or group numbers, nor did it affect nearly half (6 of 11) of the measures for movement and behaviour (including linearity of movement, changes in swimming speed, mean direction of movement, number of blows per surfacing, surface blow rate or time at the surface). However, other variables were significantly affected and '*these results…indicated that gray whales increased their speed, changed directions less, moved further from shore, and stayed underwater longer between respirations when estimated received sound energy from the seismic survey increased*'.
(SOURCE: Gailey, G., Würsig, B. and McDonald, T.L. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. *Environ. Monit. Assess.* 134: 75-91)

Gray whales off Sakhalin Island shift distribution in response to seismic surveys

In an analysis of the impacts of 3-D seismic surveys on the distribution of western gray whales feeding off Sakhalin Island, models predicting distribution were developed and aerial surveys of actual whale distribution were conducted. The surveys indicated a significant shift in distribution during seismic surveys into areas that received lower levels of sound, although whales appeared to remain in the overall region. This shift occurred despite all animals being beyond the established 4 km exclusion zone, and thus being exposed to received levels of noise under 163 dB re 1 µPa (rms). Another study on feeding activity in the region found no observable change in feeding in response to seismic surveys.
(SOURCE; Yazvenko, S.B., McDonald, T.L., Blokhin S.A., Johnson, S.R., Meier, S.K., Melton H.R.,. Newcomer, M.W., Nielson R.M., Vladimirov, V.L. and Wainwright, P.W. 2007. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environ. Monit. Assess.* 134: 45-73; Yazvenko, S.B., McDonald, T.L., Blokhin S.A., Johnson, S.R., Melton H.R.,. Newcomer, M.W., Nielson, R.M. and Wainwright, P.W. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environ. Monit. Assess.* 134: 93-106)

Shipping

Humpback whales increase feeding call rate in the presence of increased vessel noise

In Glacier Bay, Alaska, humpback whale feeding calls during conditions of high vessel noise and lower background noise were compared for differences in acoustic structure, use, and organization using 'information theoretic measures'. High vessel noise was associated with an increased rate and repetitiveness of calls and a decrease in information transmission in vocalisations. Such analyses can help determine the effects of vessel noise on humpback whale communication. This approach '*may also be adapted for wider application to many species where environmental noise is thought to be a problem*'.
(SOURCE: Doyle, L.R., McCowan, B., Hanser, S.F., Chyba, C., Bucci, T. and Blue, J.E. 2008. Applicability of information theory to the quantification of responses to anthropogenic noise by southeast Alaskan humpback whales. *Entropy* 10: 33-46)

Killer whales vocalise louder when boat noise increases

As boat numbers increased around killer whales in Puget Sound, and the noise level to which the animals were exposed also increased, the whales increased the source level of their calls, presumably to overcome the masking effects of this noise. The researchers noted that '*increasing vocal output to compensate for noise might have energetic costs, lead to increased stress levels, or degrade communication among individuals which could affect their activity budget. At some level, background noise could also completely impede the use of calls by killer whales for communicative functions*.'
(SOURCE: Holt, M.M., Noren, D.P., Veirs, V., Emmons, C.K. and Veirs, S. 2009. Speaking up: Killer whale (*Orcinus orca*) increase their call amplitude in response to vessel noise. *J. Acoust. Soc. Am.*125: 27-32)

GLOBAL

General

Marine mammals more threatened than land mammals

A comprehensive review of the conservation status and distribution of the world's mammals compiled data on all 5487 known species, including marine mammals. The researchers noted that '[c]*ompared with land species, threat levels are higher among marine mammals, driven by different processes (accidental mortality and pollution, rather than habitat loss), and are spatially distinct (peaking in northern oceans, rather than in Southeast Asia)*'. Marine mammals also comprise a disproportionate number of the poorly known species. This combination – greater threats and fewer data – emphasises the priority marine mammals, including cetaceans, warrant from international conservation policy.
(SOURCE: Schipper, J. plus 129 additional authors. 2008. The status of the world's land and marine mammals: Diversity, threat, and knowledge. *Science* 322: 225-230)

Marine mammal conservation

Despite protective legislation in many countries, marine mammal conservation efforts have achieved mixed results: some species show signs of recovery following centuries of exploitation, whereas others have perished or are in steep decline. The authors assert that to '*avoid or at least to minimize further losses, human societies must be willing to assess and alter their values and activities that compete with, or otherwise contribute to, the demise of marine mammals and marine ecosystems*'. They further conclude that conservation must become a fundamental construct of the daily lives of global citizens. They list the requirements for achieving effective conservation: '*a clear vision of future conservation goals and the roles of societies in achieving them, long-term planning and commitment of funding/resources, rigorous science to resolve critical uncertainties, precautionary protection of habitats and ecosystems in the face of such uncertainty, and an interdisciplinary, comprehensive approach to conservation that engages the social sciences and humanities to elevate the value of conservation over short-term economic gain and many other competing values*'. They conclude that '*Without the social will to make such changes, the future for marine mammals looks bleak*'.
(SOURCE: Reynolds, J.E. III, Marsh, H. and Ragen, T.J. 2009. Marine mammal conservation. *Endang. Species Res.* 7: 23-29)

Habitat protection/degradation

General

The effect of multiple anthropogenic stressors in marine systems

A key issue in (eco)toxicology concerns the combined impact of two or more stressors on organisms, with the three theoretical effects being antagonistic (lower than the sum of the individual components), additive, or synergistic (greater than the sum of the individual components). This synthesis of 171 studies showed that, overall, the combined effect of two stressors was synergistic, and that adding a third stressor doubled the number of synergistic interactions. This suggests that, in nature, where more than two stressors almost always exist, such synergies may be quite common.
(SOURCE: Crain, C.M., Kroeker, K. and Halpern, B.S. 2008. Interactive and cumulative effects of multiple human stressors in marine systems. *Ecol. Letts.* 11: doi 10.111/j.1461- 0248.2008.01253.x)

Spreading dead zones

'Dead zones' – areas of hypoxia and eutrophication – have spread exponentially since the 1960s and have serious consequences for ecosystem functioning. Dead zones have now been reported from more than 400 systems, affecting a total area of more than 245,000 square kilometres, and are probably a key stressor on marine ecosystems. The authors state that 'dead zones' '*now rank with overfishing, habitat loss, and harmful algal blooms as major global environmental problems*.'
(SOURCE: Diaz, R.J. and Rosenberg, R. 2008. Spreading dead zones and consequences for marine ecosystems. *Science* 321: 926-929)

Guidance on model use when trying to identify important habitat

Habitat modelling can help define and manage marine protected areas (MPAs) or to predict the impact of climate change on species distribution. This study compared the predictive accuracy of two model types: presence-only models and presence-absence models. Absence data is difficult and expensive to verify for cetaceans, which spend considerable time underwater. Nevertheless, presence-absence methods are recommended for modelling cetacean distribution because they more accurately reflect complex habitat. However, the use of some presence-only techniques could be useful when extensive surveys are not feasible. This method also allows the use of opportunistic data sets (e.g., collected by recreational or whale-watching vessels) or the merging of data from different surveys.
(SOURCE: Praca, E., Gannier, A., Das, K. and Laran, S. 2009. Modelling the habitat suitability of cetaceans: Example of the sperm whale in the northwestern Mediterranean Sea. *Deep-Sea Research I* 56: 648–657)

Whales no longer entangled in submarine cables

Before the 1960s, at least 16 whales (primarily deep-diving sperm whales) were reported entangled in submarine telecommunication cables. These reports ceased by the 1960s due to major changes in submarine cable design, deployment, and maintenance, as well as advances in marine surveying. Modern cable has characteristics that minimize entanglement risk, and is commonly buried below the seabed. Better marine surveys allow for accurate cable placement in areas where entanglement is most likely (e.g., sperm whale habitat). This is an excellent example of advances in technology minimizing and even eliminating a source of risk for a deep-diving cetacean.
(SOURCE: Wood, M.P. and Carter, L. 2008. Whale entanglements with submarine telecommunication cables. *IEEE J. Oceanic Engineer.* 33: 445-450)

Fisheries Interactions

Management reform may prevent fisheries collapse

A global database of fisheries institutions and catch statistics in 11,135 fisheries from 1950 to 2003 was examined to determine whether catch shares (individual rights to fish, versus industry-wide quotas) could slow or prevent fisheries collapse. By 2003, the fraction of fisheries using catch shares that had collapsed was about half that of other fisheries. However, a blanket endorsement of catch shares was not expressed. The analysis looked at only one type of catch shares (individual transferable quotas) and catch shares are only one aspect of management reform that must include additional economic and social changes. Nevertheless, catch shares may help prevent not only the loss of commercial fisheries, but also the depletion of the prey base for marine predators, including cetaceans.
(SOURCE: Costello, C., Gaines, S.D. and Lynham, J. 2008. Can catch shares prevent fisheries collapse? *Science* 321: 1678-1681)

The impact of whale predation on fisheries

Certain governments have called for a cull of whales to protect economically important fish stocks. Using fisheries data available from the scientific literature, various databases, and input during regional stakeholder workshops, ecosystem models were developed to examine the potential increase in biomass of commercially important fish that would result from a reduction in whale abundance, focusing on northwest African and Caribbean ecosystems. This focus was due to increasing calls for whale culling in these regions. The authors determined that for '*a wide range of assumptions about whale abundance, feeding rates, and fish biomass, even a complete eradication of baleen whales in these tropical areas does not lead to any appreciable increase in the biomass of commercially exploited fish*'. They concluded that the 'whales eat fish' paradigm distracts developing regions from addressing the real problems facing their fisheries; e.g., overexploitation of their marine resources by distant-water fishing fleets. The authors stated that '*it is important to recognize that the goal of ecosystem-based management is to manage the whole system for long-term sustainability rather than modifying particular trophic levels in an attempt to maximize fishery yield*'.
(SOURCE: Gerber, L.R., Morissette, L., Kaschner, K. and Pauly, D. 2009. Should whales be culled to increase fishery yield? *Science* 323: 880-881)

Fisheries management less effective when a single-species approach is taken

This paper reviewed information available from observer programs, estimates, statutes, and regulations for bycatch of marine mammals and other taxa in US fisheries. The USA has a large fishing region, diverse fisheries (with consequent diverse bycatch), and domestic legislation that commits significant resources to bycatch reduction and can therefore be considered a good proxy for an 'ideal' domestic regulatory regime to reduce bycatch. However, taxon-specific legislation (e.g., the U.S. Marine Mammal Protection Act) has generally led to a single-taxon approach to regulation, '*resulting in more expensive and potentially less effective management than if overlapping problems were addressed together*'. Although important progress has been made toward reducing bycatch here, the taxon-specific approach and the lack of perspective on cumulative impacts has reduced the effectiveness of regulation. One recommendation is to extend the approach used for marine mammals to other taxa (e.g., sea turtles and seabirds). While this may seem to divert resources from cetaceans, ultimately such a multi-species approach could have important benefits for them and their habitat, in the USA and elsewhere.
(SOURCE: Moore, J.E., Wallace, B.P., Lewison, R.L., Žydelis, R., Cox, T.M. and Crowder, L.B. 2009. *Mar. Pol.* 33: 435-451)

Marine Protected Areas

Habitat preference modelling can provide guidance to managers of protected areas

This study determined the distribution of several marine mammal species (harbour porpoises, minke whales, and harbour and grey seals) that regularly occur within a MPA established in Scotland to protect one species (bottlenose dolphins). The MPA protects not only the species for which it was designated, but also these other species. The species' distribution patterns were significantly related to environmental parameters and highlight locations for further research. Multi-species modelling can provide a biological basis for determining which specific areas within a MPA should be given highest conservation priority and for creating management zones within those areas.
(SOURCE: Bailey, H. and Thompson, P.M. 2009. Using marine mammal habitat modelling to identify priority conservation zones within a marine protected area. *Mar. Ecol. Prog. Ser.* 378: 279-287)

Chemical pollution

Mercury exposure alters genetic mechanisms in bottlenose dolphin cells

Methylmercury and PFOS are worldwide pollutants that biomagnify in the environment and are therefore found in relatively high concentrations in top marine mammal predators. Exposure of bottlenose dolphin cell cultures to these two compounds triggered cell stress, significantly altering their gene expression. Such alterations of normal cellular biology may lead to changes in the health of marine mammals.
(SOURCE: Mollenhauer, M.A.M., Carter, B.J., Peden-Adems, M.M., Bossart, G.D. and Fair, P.A. 2009. Gene expression changes in bottlenose dolphin, *Tursiops truncatus*, skin cells following exposure to methylmercury (MeHg) or perfluorooctane sulfonate (PFOS). *Aquat. Toxicol.* 91: 10-18)

Flame retardant recognized as emerging health risk for marine mammals

One commercial form of PBDE, Deca-BDE, has surpassed the concentrations of PCBs and DDT in some environments. This compound, which remains on the general market in North America but is slated to be banned in Europe, is accumulating in marine sediments. This is now recognized as a threat for marine organisms higher up the food chain, in particular because it breaks down into more persistent, more bioaccumulative, more toxic and more mobile compounds.
(SOURCE: Ross, P.S., Couillard, C.M., Ikonomou, M.G., Johannessen, S.C., Lebeuf, M., MacDonald, R.W. and Tomy, G.T. 2009. Large and growing environmental reservoirs of Deca-BDE present an emerging health risk for fish and marine mammals. *Mar. Poll. Bull.* 58: 7-10)

Disease and mortality events

Disease

Emerging diseases in marine mammals

Emerging and resurging diseases are apparently increasingly affecting marine mammals, including cetaceans. This is interpreted as reflecting a broad environmental distress syndrome involving, among other things, increases in tumours and infections, as well as anthropogenic and algal toxins that can harm both marine mammals and humans. Tracking marine organisms as sentinels helps evaluate aquatic ecosystems, identify damaging environmental trends, and focus public attention on ocean health issues.
(SOURCE: Bossart, G.D. 2007. Emerging diseases in marine mammals: From dolphins to manatees. *Microbe* 2: 544-549)

Brucella infection could cause population-level impacts in cetaceans

A stranded harbour porpoise off the west coast of Scotland was found with a large lesion on its testis; a smear test confirmed the cause to be *Brucella* spp. The animal was deemed to have died from encephalitis; due to the nature of microscopic lesions in the brain, the encephalitis was also believed to have been induced by *Brucella*. The authors concluded that '*The…pathology and* Brucella *spp. bacteria…within the testicle of this harbour porpoise adds to the evidence that* Brucella *spp. infections may be significant in sea mammal population dynamics via adverse effects on fertility*'. The findings of this study are important, bearing in mind the high occurrence rate of *Brucella* infection and testicular lesions in baleen whale populations, such as common minke whales. This study indicates population level effects could result from such infection.
(SOURCES: Dagleish, M. P., Barley J., Finlayson, J., Reid, R.J. and Foster, G. 2008. *Brucella ceti* associated pathology in the testicle of a harbour porpoise (*Phocoena phocoena*). *J. Comp. Path.* 139: 54-59; Ohishi, K., Zenitani, R., Bando, T., Goto, Y., Uchida, K., Maruyama, T., Yamamoto, S., Miyazaki, N. and Fujise, Y. 2003. Pathological and serological evidence of *Brucella* infection in baleen whales (Mysticeti) in the western North Pacific. *Comp. Immunol. Microbiol. Infect. Dis.* 26: 125-136)

New progress in distinguishing *Brucella* types in marine mammals

Samples were taken from a range of marine mammals, including cetaceans: harbour porpoises, Atlantic white-sided dolphins, white-beaked dolphins, bottlenose dolphins, common dolphins, striped dolphins and minke whales. The *Brucella* species in the cetaceans and other marine mammals could be readily distinguished from those in terrestrial animals, and the cetacean *Brucella* strains fell into two groups, with either dolphins or porpoises as their preferred host. This is a step forward in better understanding the distribution, ecology and genetic relatedness of *Brucella* isolates from marine mammals.

(SOURCE: Dawson, C.E., Stubberfield, E.J., Perrett, L.L., King, A.C., Whatmore, A.M., Bashiruddin, J.B., Stack, J.A., and MacMillan, A.P. 2008. Phenotypic and molecular characterisation of *Brucella* isolates from marine mammals. *BMC Microbiol.* 8: 244)

New method for identifying dolphin and porpoise morbilliviruses

Morbilliviruses are some of the most devastating viruses known. In cetaceans, dolphin morbillivirus (DMV) and porpoise morbillivirus (PMV) cause serious respiratory and central nervous system disease. This ultimately leads to stranding and death and has been associated with mass mortalities. Compared to conventional methods, the new PCR-based approach described in this paper, used for identifying and differentiating infections caused by DMV and PMV, is cheaper, quicker, easier to scale up, less prone to cross-contamination, and has better limits of detection and specificity.

(SOURCE: Grant, R.J., Banyard, A.C., Barret, T. and Romero, C.H. 2009. Real-time RT-PCR assays for the rapid and differential detection of dolphin and porpoise morbilliviruses. *J. Virolog. Meths.* 156: 117-123)

Contact with marine mammals poses health risks for humans

In a survey of marine mammal workers, 50% of 483 respondents reported suffering an injury and 23% a skin rash or other reaction. Severe illnesses including tuberculosis, leptospirosis and brucellosis were also documented. Human contact with cetaceans during strandings or 'swim-with-the-dolphin' programs, particularly interactions with diseased animals, harbours a risk for transmission of infectious disease. This risk may increase if the marine environment deteriorates and if the incidence of disease increases. Another tuberculosis transmission (captive sea lions to humans) has also recently been reported.

(SOURCE: Hunt, T.D., Ziccardi, M.H., Gulland, F.M.D., Yochem, P.K., Hird, D.W., Rowles, T. and Mazet, J.A.K. 2008. Health risks for marine mammal workers. *Dis. Aquat. Org.* 81: 81-92; Kier, A., Klarenbeek, A., Mendelts, B., van Soolingen, D. and Koeter, G. 2008. Transmission of *Mycobacterium pinnipedii* to humans in a zoo with marine mammals. *Int. J. Tuberc. Lung Dis.* 12: 1469-1473)

Zoonoses: Potential transmission of infectious disease between marine vertebrates and humans

A special issue of the journal *Diseases of Aquatic Organisms* was devoted to the role of marine vertebrates, including cetaceans, as transmitters of infectious diseases to humans. Beyond risk to humans who directly consume marine mammals, various pathogens and animal hosts pose human health risks. For example, California sea lions, elephant seals and western gulls in the Channel Islands, California, harboured *Salmonella* bacteria to varying degrees, with the mammals showing higher rates than observed in other regions. A survey of 15 species each of marine mammals and seabirds, and 3 species of shark, along the northwest coast of the USA revealed a broad range of bacteria resistant to multiple antibiotics. *Brucella* and *Giardia* were the most commonly detected bacteria. Dolphins, porpoises, seals, gulls, eiders and one shark species also had potentially human-infecting *Giardia intestinalis* in their faeces. Gulls, which frequent wastewater and landfill trash sites, may be an important reservoir and transmitter for human-derived faecal pathogens in coastal areas. One study confirmed for the first time the presence of *Brucella* in the marine mammal population of the German North Sea (47 of 426 common seals, 2 of 298 harbour porpoises, 1 of 34 grey seals), primarily in the lung. Another provided the first report of a herpes simplex-like infection in a stranded bottlenose dolphin (Canary Islands). In all cases, the prevalence of diverse pathogens in marine ecosystems raises concerns about how diseases might be transmitted among different host species, including humans. The editor concluded that '*It is perhaps no surprise that human activities pose a greater threat to marine vertebrate health than vice versa, and that while the proximate concern may be the risk of humans acquiring infectious agents from marine vertebrates, the ultimate issues lie with the need to modify human activities on many scales*'.

(SOURCE: Moore, M. (ed.) 2008. Marine vertebrate zoonoses. *Dis. Aquat. Org. Special 3* 81(1): 1-92)

Lobomycosis in inshore and estuarine dolphins

An increasing number of lobomycosis cases are being reported in humans and cetaceans, with confirmed reports in common bottlenose dolphins (Brazil, US Atlantic coast, Europe) and in the Guiana dolphin (Suriname). One case of dolphin-to-human transmission involving close contact with an aquarium attendant is known. The potential for zoonotic transmission of this disease, and its many poorly understood pathological and clinical aspects, call for further study.

(SOURCE: Paniz-Mondolfi, A.E. and Sander-Hoffmann, L.S. 2009. Lobomycosis in inshore and estuarine dolphins. *Emerg. Infect. Dis.* 15: 672)

New method to determine immune status of bottlenose dolphins

A new method (cELISA) has been developed to measure the serum immunoglobulin levels in bottlenose dolphins. Free-ranging animals had higher levels than two managed populations, probably due to the higher parasite load of the former. This approach may help evaluate the factors that potentially affect the health status of cetacean species in general and, ultimately, the health status of the marine ecosystem.

(SOURCE: Ruiz, C.L., Nollens, H.H., Venn-Watson, S., Green, L.G., Wells, R.S., Walsh, M.T., Nolan, E.C., McBain, J.F. and Jacobson, E.R. 2009. Baseline circulating immunoglobulin G levels in managed collection and free-ranging bottlenose dolphins (*Tursiops truncatus*). *Develop. Comp. Immunol.* 33: 449-455)

Nocardiosis in marine mammals

Ten cases of nocardiosis – a significant cause of mortality in marine mammals, caused by various species of *Nocardia* bacteria – were evaluated in marine mammals, including 10 cetacean individuals: Atlantic bottlenose dolphin, beluga whale and killer whale. The lung and thoracic lymph nodes were affected in 8 of the 10 individuals. Five *Nocardia* species were pathogenic in the cetaceans. Most aspects of this disease, such as the manner of transmission, the differences between cetaceans and pinnipeds, and the difference between captive and free-ranging animals, remain to be fully studied.

(SOURCE: St. Leger, J.A., Begeman, L., Fleetwood, M., Frasca Jr., S., Garner, M.M., Lair, S., Trembley, S., Linn, M.J. and Terio, K.A. 2009. Comparative pathology of nocardiosis in marine mammals. *Vet. Pathol.* 46: 299-308)

Stranding

New method to estimate causes of mortality in marine mammals

Stranding networks can help monitor the health of marine mammals. Based on case studies of California sea otters and Florida manatees, a new methodology was developed to extract even better information from stranding data. Specifically, a new statistical approach divides the total mortality rate into cause-specific mortality rates. This has potential use for population simulations, to identify changes in cause-specific mortality rates and to provide insights into mortality factors that limit species population growth over time and space. The approach would also be applicable to cetacean populations.

(SOURCE: Joly, D.O., Heisey, D.M., Samuel, M.D., Ribic, C.A., Thomas, N.J., Wright, S.D. and Wright, I.E. 2009. Estimated cause-specific mortality rates using recovered carcasses. *J. Wildlife Dis.* 45: 122-127)

Stress

Small cetacean stress response could lead to higher mortality than expected

A review of the pathology of bycaught, stranded, or captive small odontocetes found several similarities suggesting that this taxon can show general but extreme physiological stress responses to 'a perceived threat'. Pathologies included lesions such as band necrosis in cardiac and smooth muscles, injury to the intestinal mucosa, renal tube necrosis and muscle contraction in, and narrowing of the bronchi. Prolonging the alarm response triggering these pathological changes may result in widespread tissue injury. '*These observations may explain why 'sensitive' species die abruptly from handling or transportation, and why the mortality of highly stressed beach-stranded animals is very high*'. This response would potentially lead to mortality in small odontocetes from chronic stress, or higher rates of mortality than expected from anthropogenic activities, such as fishery interactions.

(SOURCE: Cowan, D.F. and Curry, B.E. 2008. Histopathology of the alarm reaction in small odontocetes. *J. Comp. Path.* 139: 24-33)

Climate change

Worst case scenario predictions on climate change already achieved

The International Scientific Congress on Climate Change held in Copenhagen in March 2009 concluded that the current state of knowledge on climate change painted a grim picture: '*Recent observations confirm that, given high rates of observed emissions, the worst-case IPCC scenario trajectories (or even worse) are being realized. For many key parameters, the climate system is already moving beyond patterns of natural variability…These parameters include global mean surface temperature, sea-level rise, ocean acidification, and extreme climatic events. There is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts*'.

(SOURCE: International Scientific Congress on Climate Change. 2009. Key science messages from the climate conference. 10-12 March 2009, Copenhagen, Denmark. Available from http://climatecongress. ku.dk/speakers/keymessagesandsummary.ppt. See also http://www.copenhagenclimatecouncil.com)

Greenhouse gas emissions rise to record levels

Carbon dioxide emissions '*are rising faster than the worst-case scenario drawn up by the Intergovernmental Panel on Climate Change (IPCC)*'. Carbon dioxide levels rose almost a full percentage point more than the IPCC predicted (3.5% versus 2.7%) for the period 2000-2007. China now ranks first among emitters of carbon dioxide, responsible for 21% of the world's emissions, up from 14% seven years ago. The USA is second, at 19%. India is fourth, but may soon overtake third place Russia. Other greenhouse gases, such as methane and nitrous oxide, also reached record high levels in 2007.

(SOURCES: News in Brief. 2008. Carbon dioxide emissions rise to record levels. *Nature* 455: 582; News in Brief. 2008. Greenhouse gases hit modern-day highs. *Nature* 456: 558-559)

Current status of polar sea ice

Sea-ice cover in the Arctic in 2008 did not break 2007's record of the smallest ice extent since satellite records began. There was 9.4% more ice at 2008's summer minimum than in 2007. However, the reduction over the Bering and Chukchi Seas may have already reached a 'tipping point'. A half dozen climate models, the best at predicting observed changes in sea ice to date, predict the complete loss of summer sea ice in the Arctic in about 30 years. In the Antarctic, modelling suggests that the sea ice/shelf could collapse relatively rapidly (in one to several thousand years). The rate at which small Antarctic ice shelves are melting is probably increasing dramatically. The West Antarctic ice sheet may begin to collapse when surrounding ocean temperatures warm by roughly 5ºC. More modelling work will be needed to predict if these scenarios will occur. Another study determined that warming in the Antarctic extends well beyond the Peninsula to cover most of West Antarctica, '*an area of warming much larger than previously reported*'. This study found that surface warming trends were positive in both East and West Antarctica. Two separate modelling exercises looked at possible sea-level changes due to melting polar ice. One model showed that some coastal sites will see sea-level rises significantly higher (or, less commonly, lower) than previously predicted, with a greater sea-level rise in the oceans bordering North America and in the Indian Ocean than elsewhere. The other showed that sea-level rise generally may be lower than previously assumed, due to physical limitations of ice discharge from glaciers.

(SOURCES: News in Brief. 2008. Arctic ice shrinks less this year than last. *Nature* 455: 441; Kerr, R.A. 2009. Arctic summer sea ice could vanish soon but not suddenly. *Science* 323: 1655; Mitrovica, J.X., Gomez, N. and Clark, P.U. 2009. The sea-level fingerprint of West Antarctic collapse. *Science* 323: 753; Pollard, D. and DeConto, R.M. 2009. Modelling West Antarctic ice sheet growth and collapse through the past five million years. *Nature* 458: 329-333; Ray, G.C., Hufford, G.L., Krupnik, I.I. and Overland, J.E. 2008. Diminishing sea ice. *Science* 321: 1443-1444; Steig, E.J., Schneider, D.P., Rutherford, S.D., Mann, M.E., Comiso, J.C. and Shindell, D.T. 2009. *Nature* 457: 459-463)

New review of climate change and cetaceans

Climate change will potentially affect various cetacean species and populations, in particular those with a limited habitat range or that specialize in certain prey species (e.g., linkage between sea ice and krill). The IWC has addressed this issue in two workshops (1996, 2009). The challenges require innovative, large-scale, long-term and multinational response from scientists, conservation managers and decision makers. Moreover, the reactions to emerging developments and changes will need to be swifter.

(SOURCE: Simmonds, M. and Eliott, W.J. 2009. Climate change and cetaceans: Concerns and recent developments. *J. Mar. Biologic. Assoc. UK* 89: 203-210)

Species expansion, from the Pacific to the Atlantic via the Arctic, anticipated as warming continues

Global warming has already resulted in the northward expansion of several temperate marine species (including some cetaceans) into higher latitudes. As warming continues, North Pacific marine species (across all taxa) are expected to spread '*through the Bering Strait into a warmer Arctic Ocean and eventually into the temperate North Atlantic*'. Because Pacific marine species tend to be larger and better competitors than their Atlantic counterparts, few Atlantic to Pacific migrations are expected. This suggests that the long-term prospects of Pacific cetaceans are less dire than those of Atlantic species.

(SOURCE: Vermeij, G.J. and Roopnarine, P.D. 2009. The coming Arctic invasion. *Science* 321: 780-781)

Ocean warming may decrease diversity of deep-water cetaceans

The open oceans comprise most of our biosphere. Based on long-term sighting data of deep-water cetaceans from the Atlantic, Pacific and Indian Oceans, seasonal and geographic changes in diversity are best predicted by sea-surface temperatures. Accordingly, the predicted response to ocean warming will be a decline of diversity across the tropics (and increases in higher latitudes). This approach indicates that the effects of global warming on cetaceans will go beyond species with restricted ranges and specialized habitat requirements (e.g., polar, inshore or riverine species).

(SOURCE: Whitehead, H., McGill, B. and Worm, B. 2008. Diversity of deep-water cetaceans in relation to temperature: Implications for ocean warming. *Ecol. Letts.* 11: 1198-1207)

Noise impacts

General

Ocean acidification will increase reach of noise pollution

Climate change may increase the threat posed to cetaceans (and other marine life) by marine noise. The predicted acidification of the ocean as the result of increasing carbon dioxide levels (and other atmospheric pollutants such as sulphur and nitrogen compounds) could potentially reduce sound absorption, i.e., sound will likely travel farther underwater. The 0.12 decrease in ocean pH that has already occurred has resulted in low- and mid-frequency sounds travelling 10-15% farther. Thus, anthropogenic noise is travelling farther, and in the future this effect will be exacerbated. The sound frequencies most greatly affected would be below 1 kHz, but there would be effects up to 10 kHz. By 2050, sound propagation up to 10 kHz would increase by at least 30% (but more likely up to 60%).

(SOURCE: Hester, K.C., Peltzer, E.T., Kirkwood, W.J. and Brewer, P.G. 2008. Unanticipated consequences of ocean acidification: A noisier ocean at lower pH. *Geophys. Res. Letts.* 35: L19601)

Great variability in sound transmission in water – distance of effect difficult to estimate

This study focused on the ability of dolphins to detect acoustic deterrent devices or 'pingers', but also found a great variability in sound propagation distance, which is not easily explained by acoustic models of sound spreading. Factors such as constructive and destructive interference and sound reflection from the surface and bottom substrates contributed to what was typically a 10-15 dB or more variation in sound levels. This calls for incorporating large margins of error when calculating sound impact distances or estimating sound levels at a distance in the marine environment.

(SOURCE: Shapiro, A.D., Tougaard, J., Jorgensen, P.B., Kyne, L.A., Balle, J.D., Bernardez, C., Fjalling, A., Karlsen, J. and Wahlberg, M. 2009. Transmission loss patterns from acoustic harassment and deterrent devices do not always follow geometrical spreading predictions. *Mar. Mamm. Sci.* 25: 53-67)

Anthropogenic noise exposure and stress in marine mammals

A workshop on the potential and likely consequences of noise-induced stress for individual marine mammals and their populations was held in Lanzarote, Canary Islands in June 2007. The results, published in the *International Journal of Comparative Psychology,* drew from the available information on human and animal physiology and psychology and considered the importance of context (including any previous stressor exposure) in assessing behavioural responses. The workshop noted that it is '*expected that exposure to noise can…lead to a physiological stress response in [marine mammal] species either directly or indirectly through annoyance, a secondary stressor*'. They also noted that '*many consequences of exposure to noise can result in a cascade of secondary stressors…all with potential negative if not disastrous consequences*'. Moreover, short exposures to stressors may result in long-term consequences, and acclimation to stressors cannot be assumed from behavioural reactions alone (e.g., failure to flee a stressor does not mean the animal has acclimated to it). The workshop concluded that '*it is reasonable to extrapolate information regarding stress responses in other species to marine mammals, because these responses are highly conserved among all species in which they have been examined to date*. *As a result, we determined that noise acts as a stressor to marine mammals*'. Future research should focus on noise-induced stress responses, requiring careful study design.

(SOURCE: Wright, A.J. and Highfill, L. (eds.) 2007. Considerations of the effects of noise on marine mammals and other animals. *Int. J. Comp. Psychol.* 20(2-3): iii-viii, 89-316)

The effectiveness and limits of using passive acoustic methods to detect beaked whales

Due to the long, deep dives of beaked whales, visually detecting these acoustically vulnerable cetaceans when they are submerged is problematic. Likewise, poor weather and low visibility conditions reduce the effectiveness of visual monitoring. Passive acoustic monitoring (PAM) is often recommended to improve beaked whale detection under these conditions. An evaluation of PAM effectiveness determined that these whales might be detected during calm weather conditions, although detection probability reduces considerably with distance. An animal beyond 4 km would likely be detected only in conditions of unusually good sound transmission. Moreover, because diving beaked whales are often silent, a listening period of 140 minutes would be required to reliably detect animals. Therefore, PAM would be an effective mitigation measure only if the zone of impact of an anthropogenic noise source did not extend beyond 4 km, the activity was being conducted in calm weather and the vessel was stationary for at least 2 hours prior to the noise-producing activity.

(SOURCE: Zimmer, W.M., Harwood, J., Tyack, P.J., Johnson, M.P. and Madsen, P.T. 2008. Passive acoustic detection of deep-diving beaked whales. *J. Acoust. Soc. Am.* 124: 2823-2832)

Cetacean Hearing

Finless porpoise utilize low frequency sounds – conservation implications

Although porpoises are assumed to be high frequency hearing specialists (e.g. 100-150 kHz), researchers in China discovered that Yangtze river finless porpoise neonates produced low-frequency (2-3 kHz) pulsed sounds, and because '*the neonates emit low-frequency sounds more frequently when they are apart from the mother*' it was assumed that these are calls from the neonates to the mother. Although not discussed by

the authors, these findings are important because lower frequency sounds may have greater impacts on this taxon than previously thought, particularly during a sensitive life stage. Of particular concern would be low frequency sounds such as shipping noise.
(SOURCE: Li, S., Wang, K., Wang, D., Dong, S. and Akamatsu, T. 2008. Simultaneous production of low- and high-frequency sounds by neonatal finless porpoises (L). *J. Acoust. Soc. Am.* 124: 716-718)

Exposure to mid-frequency sounds and temporary threshold shift in a bottlenose dolphin
An experiment was conducted on a bottlenose dolphin to determine the exposure levels from mid-frequency sounds (similar to active sonar pings) needed to cause temporary threshold shift (TTS), and to develop a model to predict TTS onset. The test subject was an 18-year-old, captive-born dolphin with a history of use in acoustic experiments – auditory evoked potential methodology was used. The results indicated that significant TTS occurred with longer but not shorter exposures. Higher source levels were required to induce TTS for shorter exposures. Recovery rates were relatively consistent but did show some indications that different exposure times may relate to different recovery rates. Some behavioural reactions, possibly indicative of aversive response to the stimulus, were observed. These results suggest that, as in terrestrial mammals, predicting bottlenose dolphin TTS is complicated.
(SOURCE: Mooney, T.A., Nachtigall, P.E., Breese, M., Vlachos, S. and Au, W.W.L. 2009. Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. *J. Acoust. Soc. Am.* 125: 1816-1826)

Seismic Surveys

Evaluation of seismic survey guidelines
The United Kingdom's statutory conservation agency, the Joint Nature Conservation Committee (JNCC), developed guidelines in 1995 to minimise acoustic disturbance of marine mammals by oil and gas industry seismic surveys. These were the first national guidelines to be developed and have subsequently become the standard for international mitigation measures of seismic surveys. However, relatively few aspects of these measures have a firm scientific basis or proven efficacy. Existing guidelines do not offer adequate protection to marine mammals, given the complex propagation of airgun pulses; the difficulty of monitoring in particular the smaller, cryptic, and/or deep-diving species, such as beaked whales and porpoises; limitations in monitoring requirements; lack of baseline data; and other biological and acoustical complications or unknowns. Current guidelines offer a 'common sense' approach to noise mitigation, but in light of recent research and ongoing concerns, they should be updated, with broader measures needed to ensure adequate species protection and to address data gaps.
(SOURCE: Parsons, E.C.M., Dolman, S.J., Jasny, M., Rose, N.A., Simmonds, M.P. and Wright, A.J. 2009. A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practise? *Mar. Poll. Bull.* 58: 643-651)

Testing the efficacy of the 'ramp-up' procedure as a mitigation measure for seismic surveys
The 'ramp-up' or 'soft-start' is a standard mitigation measure used in seismic surveys. However, the efficacy this mitigation measure is poorly documented. A pod of 15 short-finned pilot whales was monitored before, during, and after a 30-min ramp-up procedure used in a 2-D seismic survey off Gabon. No change in behaviour was apparent during the initial period of the ramp-up. However, after 10 min, the nearest subgroup of animals turned sharply away from the airguns. After a subsequent period of milling, the group made a 180° change of course to travel in the opposite direction from the seismic vessel. This observation suggests that the whales initially demonstrated an avoidance response to the ramp-up. However, the movement away from the source was limited in time and space.
(SOURCE: Weir, C.R. 2008. Short-finned pilot whales (*Globicephala macrorhynchus*) respond to an airgun ramp-up procedure off Gabon. *Aquat. Mamm.* 34: 349-354)

Shipping

Commercial vessels have the potential to affect whale communication
This study suggested that, in certain areas characterized by relatively heavy commercial shipping traffic, vessel noise is at levels and within frequencies that warrant concern among managers regarding the ability of whales to maintain acoustic contact. Accordingly, the authors recommended '*the use of passive acoustic monitoring data to aid regional managers and maritime transport stakeholders in the development of proposals to the [International Maritime Organization], national regulatory agencies, and/or regional/local conventions to reroute and/or consolidate shipping traffic to minimize exposure of sensitive species to noise and risk of ship strike'*. They also recommended '*buffers for marine protected areas…with dimensions determined by the sensitivity of local species and local noise conditions)*'. The concept of voluntary 'quiet zones' should be tested or implemented where appropriate. Finally, the authors recommended '*that future research explore the potential for using data from quasi-permanent, continuously recording passive acoustic monitoring systems to evaluate differences in ship noise profiles under different 'quieting' treatments*'.
(SOURCE: Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M. and Wiley, D. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. *Environ. Manage.* 42: 735-752)

Exposure to boat noise reduces humpback whale singing behaviour
A study on humpback whales in the Abrolhos Marine National Park in Brazil evaluated the responses of whales to boat traffic (e.g., whale-watching vessels) by measuring changes in male singing activity. The fluctuation in the number of singers over time was modelled in response to several variables, including exposure to boats, tide height and lunar phase. Boat traffic had an important negative effect on singing activity. Lunar phase and time of day also affected singing behaviour. The conclusion: adaptive management should aim at reducing the number of times whales are exposed to noise from each boat, which can improve the whale-watching experience and reduce the impact on male singing behaviour. It would also be '*important to address the need for enforcement of existing management guidelines, which clearly depends on political will and better prioritization of governmental resources*.'
(SOURCE: Sousa-Lima, R.S. and Clark, C.W. 2008. Modeling the effect of boat traffic on the fluctuation of humpback whale singing activity in the Abrolhos National Marine Park, Brazil. *Canadian Acoustics* 36: 174-181)

Sonar

Review of strategies designed to reduce impact of military active sonar on marine mammals
Naval exercises, particularly those generating loud sounds such as sonar, are known to have an impact on at least certain cetacean species. The authors outline the three main standard methods to mitigate such impacts, namely planning the time and area for exercises, using certain operational procedures, and monitoring the animals to maintain an exclusion zone. The current shortcomings (e.g., mitigation during night-time and

bad weather) are outlined and a call for improved international standards is made. The conclusion: the '*environmental duty of care*' does not need to come at the expense of navy training.
(SOURCE: Dolman, S.J., Weir, C.R. and Jasny, M. 2009. Comparative review of marine mammal guidance implemented during naval exercises. *Mar. Poll. Bull.* 59: 465-477)

Review of strandings associated with military active sonar use

Cetacean mass strandings associated with naval mid-frequency sonar use have mostly involved beaked whales, with common pathologies, although other cetacean species have also stranded coincident with naval exercises. Current mitigation measures have focused on preventing auditory damage (hearing loss), but the authors concluded that there are significant flaws with this approach. Behavioural responses, which occur at lower sound levels than those that cause hearing loss, may be more critical. The authors recommended revising current mitigation measures to address this. Moreover, important cetacean habitats should be avoided by naval vessels during training exercises using active sonar systems.
(SOURCE: Parsons, E.C.M., Dolman, S.J., Wright, A.J., Rose, N.A. and Burns, W.C.G. 2009. Navy sonar and cetaceans: Just how much does the gun need to smoke before we act? *Mar. Poll. Bull.* 56: 1248-1257)

Some cetacean responses to sonar may be anti-predator responses

Several recent reviews have examined the state of knowledge regarding impacts of anthropogenic noise on marine mammals. This newest review concludes that '*Although acute responses to intense sounds have generated considerable interest, the more significant risk to populations of marine mammals is likely to stem from less visible effects of chronic exposure*'. One explanation for beaked whale mass strandings associated with sonar exercises is that the fundamental frequencies of the sonar signals are quite similar to the calls of killer whales (a beaked whale predator). '*In this case it may literally be more appropriate to call the response an anti-predator response rather than simple disturbance*'. Anti-predator responses cost animals not only time and energy, but also lost opportunities. This review '*suggests the importance of some areas of research that have received less attention than observation of disturbance…The theories of predator risk and allostasis may help to provide a framework for progress in understanding the consequences to individuals and populations of disturbance caused by anthropogenic sound*'.
(SOURCE: Tyack, P.L. 2008. Implications for marine mammals of large-scale changes in the marine acoustic environment. *J. Mammal.* 89: 549-558)

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GLOSSARY

Species glossary

Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Killer whale	*Orcinus orca*
Beluga whale	*Delphinapterus leucas*	Melon-headed whale	*Peponocephala electra*
Blainville's beaked whale	*Mesoplodon densirostris*	North Pacific right whale	*Eubalaena japonica*
Common bottlenose dolphin	*Tursiops truncatus*	Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Common dolphin (long-beaked)	*Delphinus capensis*	Pantropical spotted dolphin	*Stenella attenuata*
Common dolphin (short-beaked)	*Delphinus delphis*	Risso's dolphin	*Grampus griseus*
Common minke whale	*Balaenoptera acutorostrata*	Short-finned pilot whale	*Globicephala macrorhynchus*
Cuvier's beaked whale	*Ziphius cavirostris*	Sperm whale	*Physeter macrocephalus*
False killer whale	*Pseudorca crassidens*	Spinner dolphin	*Stenella longirostris*
Fin whale	*Balaenoptera physalus*	Stejneger's beaked whale	*Mesoplodon stejnegeri*
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	Striped dolphin	*Stenella coeruleoalba*
Gray whale	*Eschrichtius robustus*	Vaquita	*Phocoena sinus*
Guiana dolphin	*Sotalia guianensis*	White-beaked dolphin	*Lagenorhynchus albirostris*
Harbour porpoise	*Phocoena phocoena*	California sea lion	*Zalophus californianus*
Hector's dolphin	*Cephalorhynchus hectori*	Western gull	*Larus occidentalis*
Humpback whale	*Megaptera novaeangliae*	Chinook salmon	*Oncorhynchus tshawytscha*
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*	Jack mackerel	*Trachurus novaezelandiae*
Indo-Pacific humpback dolphin	*Sousa chinensis*	Yellowfin tuna	*Thunnus albacares*

Element glossary

Ag	silver	Cu	copper	Pb	lead
As	arsenic	Fe	iron	Se	selenium
Cd	cadmium	Hg	mercury	Sn	tin
Co	cobalt	Mn	manganese	Zn	zinc
Cr	chromium	Ni	nickel		

Glossary of terms

2,2'-diMeO-BB 80: See PBDMB.
µg: Microgram.
Allostasis: This term refers to mechanisms that allow an organism to regain equilibrium in the face of external challenges; compare to 'homeostasis', which represents mechanisms to regain equilibrium in the face of internal changes.
Aquaculture: Finfish or shellfish farming.
BFR: Brominated flame retardant.
Bioaccumulation: Increase in concentration of a pollutant from the environment to the first organism in a food chain.
Biomagnification: Increase in concentration of a pollutant from one link in a food chain to another.
Biomarker: A biological indicator, *e.g.,* blood chemical levels, of health status or pollutant level.
Brominated: Containing the element bromine.
Butyltin: A class of toxic chemicals commonly used in anti-fouling paints on ship hulls (as tributyltin or dibutyltin, a break-down product of tributyltin).
cELISA: Competitive enzyme labeled immunosorbent assay.
Chlordane: A chlorinated hydrocarbon used as a pesticide.
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora.

CoP: Code of Practise.
dB: Decibel – a logarithmic measure of sound pressure level.
DBT: Dibutyltin. See butyltin.
DDE: The organochlorine dichlorodiphenyldichloroethylene, a product of the breakdown of DDT.
DDT: The organochlorine pesticide dichlorodiphenyltrichloroethane that tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.
Diatom: Common type of phytoplankton, a one-celled alga encased in a silica cell wall. The species *Pseudo-nitzschia australis* produces domoic acid, which poisons mammals, causing paralysis and reproductive failure.
Dieldrin: A chlorinate hydrocarbon used as an insecticide.
Domoic acid: See diatom.
DPT: Diphenyltin is used in polymer manufacturing. See phenyltin.
Dry weight: Dry weight, as opposed to wet weight, is a basis of measurement whereby concentrations of a substance are compared with dry content (*i.e.,* all water is removed) of a material.
Eutrophication: Input of nutrients into an aquatic system, typically associated with excessive plant growth and oxygen depletion.
FMD: Floating marine debris.
Fluorinated: Containing the element fluorine.
HAB: Harmful algal bloom. Population explosion of certain phytoplankton species (algae) that produce toxic substances that can harm higher levels of the marine food chain and humans who consume contaminated seafood.
HBCD: hexabromocyclododecane, a flame retardant.
HCB: Hexachlorobenzene, an environmentally persistent organochlorine fungicide.
HCH: Hexachlorocyclohexane, a neurotoxic pesticide. The most well known HCH is lindane (γ-HCH), an environmentally persistent agricultural insecticide.
Hypoxia: Low oxygen levels.
Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1000 Hertz).
IUCN: International Union for Conservation of Nature.
IUU: Illegal, unregulated, and unreported (used in reference to commercial fishing).
JARPN II: Japanese Whale Research Programme under Special Permit in the Western North Pacific – Phase II
Lipid weight: A basis of measurement whereby concentrations of a substance are compared to the lipid (fat) content of a material.
Lobomycosis: A chronic fungal infection of the skin affecting humans in South America and two species of dolphins.
Masking: A phenomenon wherein the frequency and intensity of ambient noise covers up or 'masks' a biologically important signal, making it undetectable by a receiver.
MBT: Monobutyltin (see butyltin).
MeHg: Methyl mercury.
Milling: When a group of cetaceans circles in a small area or moves about haphazardly, sometimes seen when the group is foraging, but also a sign of impending direction change. Sometimes indicative of distress.
Morbillivirus: A family of viruses that are typically highly infectious and pathogenic – the family includes measles, dog distemper and dolphin morbillivirus. A number of mass mortality events have been associated with viruses from this family.
MPT: Monophenyltin. See phenyltin.
Neurotoxin: Any toxin acting on nerve cells.
Nocardiosis: An infectious bacterial disease typically affecting the lung and causing pneumonia and a high rate of mortality in humans (50%).
Oocyst: Thick-walled spore phase of certain sporozoans, such as *Toxoplasma*.
Organochlorine: Organic compounds that contain chlorine. Many are toxic and used as pesticides. Most of these compounds persist in the environment (are not biodegradable) and also tend to accumulate in fatty tissue (*e.g.,* blubber) of cetaceans and other marine organisms.
Pathogen: A disease-causing agent (*e.g.,* bacterium, virus).
PBDE: Polybrominated diphenyl ether(s), a widely used class of flame retardants in textiles, furniture upholstery and plastics.
PBDMB: Polybrominated dimethoxybiphenyls, brominated natural products of which the form 2,2'-dimethoxy-3,3',5,5'-tetrabromobiphenyl (2,2'-diMeO-BB 80) is the most commonly found in Queensland marine mammals.
PCB: Polychlorinated biphenyls (209 different forms that contain differing numbers of chlorine atoms arranged in various positions on the aromatic rings) are industrial organochlorines that were manufactured to be used in electrical transformers and other applications. These man-made chemicals do not occur naturally and all traces reflect pollution.
PCR: Polymerase chain reaction.
Perfluorinated compounds: A class of environmentally persistent molecules with fluorine atoms attached, used in many industrial applications including fire-fighting foams, pesticides and surface coatings. See PFOS.
PFNA: Perfluorononanoate.
PFDA: Perfluorodecanoate.
PFDoDA: Perfluorododecanoate.
PFOS: Perfluorooctane sulfonate.
PFOSA: Perfluorooctanesulfonamide.
PFUnDA: Perfluoroundecanoate.
Phenyltin: A class of organotin compounds that are used for a variety of industrial purposes, similar to butyltins and in some cases similarly toxic.
Phytoplankton: Free-floating marine plants (versus zooplankton – free-floating marine animals).
Sound pressure level: A measure of the intensity of sound, in decibels.
Sporozoan: Parasitic unicellular organisms of the class Sporozoa, often pathogenic, most of which reproduce sexually and asexually in alternate generations, often in different hosts, by means of spores.
TBT: Tributyltin. See butyltin.
TPT: Triphenyltin is used as an active component of antifungal paints and agricultural fungicides. See phenyltin.
Trophic level: Each level in a food chain, including decomposers, producers (photo- and chemo-synthesizers), and consumers.
Wet weight: See dry weight.
Zoonoses (plural): Singular, zoonosis. Infectious diseases that can be transmitted from vertebrate animals to humans or in the reverse direction.

Table 1

Maximum butyltin concentrations in cetacean tissues from the Pacific (μg.g^{-1}).

Location	Species	Tissue	Weight	MBT	DBT	TBT	ΣBT	MPT	DPT	TPT	ΣPT	Reference
Thailand	Bryde's whale	blubber	wet	0.093	0.037	0.083	0.213	0.057	0.014	0.802	0.872	Harino *et al.*
		heart	wet	0.057	0.021	0.035	0.134	0.055	0.061	0.166	0.237	(2007)
		kidney	wet	0.080	0.039	0.054	0.162	0.019	0.025	0.081	0.106	
		liver	wet	0.063	0.036	0.071	0.147	<0.001	0.006	0.202	0.202	
		lung	wet	0.098	0.019	0.025	0.142	<0.001	<0.001	0.055	0.055	
		muscle	wet	0.049	0.021	0.028	0.098	0.021	0.007	0.035	0.041	
		stomach	wet	0.067	0.020	0.078	0.021	0.007	<0.001	0.250	0.250	
	False killer whale	blubber	wet	0.093	0.053	0.245	0.391	0.067	0.010	0.081	0.158	Harino *et al.*
		heart	wet	0.064	0.049	0.236	0.349	0.112	0.011	0.165	0.263	(2007)
		kidney	wet	0.273	0.129	0.299	0.408	0.096	0.014	0.310	0.366	
		liver	wet	0.916	2.870	1.071	4.86	0.549	0.028	0.592	1.14	
		lung	wet	0.636	0.033	0.115	0.784	0.027	0.014	0.008	0.043	
		muscle	wet	0.066	0.424	0.242	0.732	0.052	0.017	0.694	0.763	
		spleen	wet	0.038	0.032	0.138	0.208	0.011	0.007	0.023	0.041	
	Pygmy killer whale	blubber	wet	0.061	0.058	0.022	0.141	<0.001	0.007	0.406	0.413	Harino *et al.*
		muscle	wet	0.073	0.434	0.140	0.647	0.027	0.005	0.104	0.136	(2007)
	Short-finned pilot whale	blubber	wet	0.140	0.056	0.127	0.323	0.041	0.017	<0.001	0.058	Harino *et al.*
		heart	wet	0.042	0.041	0.132	0.215	0.034	0.012	0.015	0.061	(2007)
		liver	wet	0.148	0.244	0.154	0.546	0.037	0.013	0.016	0.063	
		muscle	wet	0.063	0.028	0.100	0.191	0.052	0.009	0.006	0.067	
	Sperm whale	blubber	wet	0.036	0.018	0.055	0.109	<0.001	0.011	0.402	0.413	Harino *et al.*
		liver	wet	0.033	0.133	0.139	0.285	0.045	0.011	0.050	0.106	(2007)
		muscle	wet	0.033	0.041	0.020	0.094	<0.001	0.008	0.269	0.277	
	Bottlenose dolphin	blubber	wet	0.026	0.009	0.004	0.038	<0.001	<0.001	0.007	0.007	Harino *et al.*
		heart	wet	0.022	0.012	0.018	0.045	<0.001	<0.001	0.010	0.010	(2008)
		kidney	wet	0.019	0.042	0.023	0.079	<0.001	<0.001	<0.001	<0.001	
		liver	wet	0.037	0.293	0.225	0.555	<0.001	<0.001	0.005	0.005	
		lung	wet	0.016	0.012	0.006	0.031	<0.001	<0.001	<0.001	<0.001	
		muscle	wet	0.014	0.009	0.009	0.031	<0.001	<0.001	0.003	0.003	
	Finless porpoise	blubber	wet	0.016	0.013	0.007	0.031	<0.001	<0.001	<0.001	<0.001	Harino *et al.*
		heart	wet	0.021	0.012	0.019	0.047	<0.001	<0.001	0.006	0.006	(2008)
		kidney	wet	0.016	0.009	0.009	0.034	<0.001	<0.001	0.002	0.002	
		liver	wet	0.027	0.073	0.031	0.122	<0.001	<0.001	<0.001	<0.001	
		lung	wet	0.019	0.014	0.004	0.037	<0.001	<0.001	0.006	0.006	
		muscle	wet	0.019	0.009	0.006	0.034	<0.001	<0.001	<0.001	<0.001	
	Long-beaked common	heart	wet	0.025	0.024	0.036	0.085	<0.001	0.002	0.009	0.011	Harino *et al.*
	common dolphin	kidney	wet	0.015	0.024	0.017	0.056	<0.001	<0.001	0.001	0.001	(2008)
		liver	wet	0.093	0.588	0.471	1.152	<0.001	<0.001	<0.001	<0.001	
		lung	wet	0.018	0.015	0.007	0.04	<0.001	<0.001	<0.001	<0.001	
		muscle	wet	0.016	0.013	0.033	0.062	<0.001	0.005	0.01	0.015	
	Indo-Pacific humpback	blubber	wet	0.009	0.006	0.002	0.017	<0.001	<0.001	0.062	0.062	Harino *et al.*
	dolphin	heart	wet	0.013	0.008	0.004	0.025	<0.001	<0.001	0.011	0.011	(2008)
		kidney	wet	0.016	0.016	0.005	0.037	<0.001	<0.001	0.004	0.004	
		liver	wet	0.023	0.127	0.015	0.165	<0.001	<0.001	<0.001	<0.001	
		lung	wet	0.010	0.006	0.001	0.017	<0.001	<0.001	<0.001	<0.001	
		muscle	wet	0.012	0.002	0.002	0.016	<0.001	<0.001	<0.001	<0.001	
	Spotted dolphin	blubber	wet	0.086	0.067	0.019	0.161	<0.001	0.015	0.015	0.018	Harino *et al.*
		heart	wet	0.088	0.022	0.025	0.133	<0.001	0.020	0.006	0.022	(2008)
		kidney	wet	0.101	0.346	0.033	0.480	<0.001	0.006	0.003	0.009	
		liver	wet	0.082	0.131	0.062	0.275	<0.001	0.005	0.002	0.005	
		lung	wet	0.048	0.041	0.012	0.095	<0.001	0.004	0.002	0.005	
		muscle	wet	0.051	0.030	0.022	0.095	<0.001	0.004	0.004	0.006	
	Spinner dolphin	blubber	wet	0.069	0.015	0.013	0.097	<0.001	0.005	0.004	0.009	Harino *et al.*
		heart	wet	0.066	0.018	0.034	0.118	<0.001	0.007	0.004	0.011	(2008)
		kidney	wet	0.057	0.024	0.032	0.113	<0.001	0.007	0.001	0.008	
		liver	wet	0.098	0.218	0.085	0.401	<0.001	0.007	0.002	0.009	
		lung	wet	0.059	0.016	0.014	0.089	<0.001	0.009	0.002	0.011	
		muscle	wet	0.046	0.020	0.030	0.096	<0.001	0.005	0.002	0.007	
	Striped dolphin	blubber	wet	0.116	0.026	0.015	0157	<0.001	0.017	0.014	0.018	Harino *et al.*
		heart	wet	0.066	0.027	0.043	0.136	<0.001	0.010	0.062	0.062	(2008)
		kidney	wet	0.105	0.032	0.042	0.179	<0.001	0.010	0.004	0.014	
		liver	wet	0.066	0.176	0.136	0.378	<0.001	0.019	0.007	0.019	
		lung	wet	0.046	0.019	0.018	0.083	<0.001	0.010	0.004	0.012	
		muscle	wet	0.036	0.015	0.028	0.079	<0.001	0.009	0.016	0.016	

(SOURCE: Harino, H., Ohji, M., Wattayakorn, G., Adulyanukosol, K., Arai, T. and Miyazaki, N. 2007. Accumulation of organotin compounds in tissues and organs of stranded whales along the coasts of Thailand. *Arch. Environ. Contam. Toxicol.* 53: 119–125; Harino, H., Ohji, M., Wattayakorn, G., Adulyanukosol, K., Arai, T. and Miyazaki, N. 2008. Accumulation of organotin compounds in tissues and organs of dolphins from the coasts of Thailand. *Arch. Environ. Contam. Toxicol.* 54: 145-153).

Table 2

Maximum trace element concentrations in cetacean tissues from the Western Pacific (μg g^{-1}).

Location	Species	Tissue	Weight	Hg	Cd	Zn	Pb	As	Co	Cr	Cu	Fe	Mn	Ni	Se	Ag	Sn	Reference
New Zealand	Common dolphin	Blubber	Wet	1.7	0.19	100	-	1.7	<0.02	<0.1	4.5	26	0.11	0.71	20	<0.02	0.063	Stockin *et al.* (2007)
		Liver	Wet	110.0	21	73		0.32	<0.02	<0.1	14	250	4.8	<0.1	39	1.2	0.09	
		Kidney	Wet	8.1	52	37		0.13	0.031	<0.1	5.4	150	0.78	<0.1	6.4	0.033	0.05	
Northwest Pacific Ocean	Common minke whale	Muscle	Wet	0.43	-	-	-	-	-	-	-	-	-	-	-	-	-	Endo *et al.* (2007a)
	Cuvier's beaked whale	Muscle	Wet	0.43	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Blainville's beaked whale	Muscle	Wet	3.30	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Stejneger's beaked whale	Muscle	Wet	3.57	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Harbour porpoise	Muscle	Wet	0.54	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Finless porpoise	Muscle	Wet	1.81	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Common dolphin	Muscle	Wet	1.89	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Pacific white-sided dolphin	Muscle	Wet	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Risso's dolphin	Muscle	Wet	1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Common bottlenose dolphin	Muscle	Wet	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	
	False killer whale	Muscle	Wet	41.0	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Killer whale	Muscle	Wet	13.3	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northern Japan	Killer whale	Liver	Wet	97.8	11.5	93.5	-	-	-	-	16.3	335	3.64	-	-	-	-	Endo *et al.* (2007b)
		Kidney	Wet	10.4	18.0	30.9	-	-	-	-	4.53	156	1.18	-	-	-	-	
		Muscle	Wet	1.46	-	38.6	-	-	-	-	1.95	178	0.27	-	-	-	-	
South Australia	Indo-Pacific bottlenose dolphin	Liver	Wet	2651	99.95	453	14.15	-	-	-	73.71	-	-	-	1188	-	-	Lavery *et al.* (2008) and (2009)
		Bone	Wet	-	0.33	-	16.00	-	-	-	-	-	-	-	-	-	-	
	Common bottlenose dolphin	Liver	Wet	772	20.00	68	0.11	-	-	-	85.04	-	-	-	253	-	-	Lavery *et al.* (2009)
		Bone	Wet	-	-	-	1.11	-	-	-	-	-	-	-	-	-	-	
	Common dolphin	Liver	Wet	165	10.92	175	0.13	-	-	-	71.18	-	-	-	63	-	-	Lavery *et al.* (2009)
		Bone	Wet	-	-	-	2.41	-	-	-	-	-	-	-	-	-	-	

(SOURCES: Stockin, K.A., Law R.J., Duignan, P.J., Jones, G.W., Porter, L., Mirimin, L., Meynier L., and Orams, M.B. 2007. Trace elements, PCBs and organochlorine pesticides in New Zealand common dolphins (*Delphinus* sp.). Sci. Total Environ. 387: 333–345; SOURCE: Endo, T., Ma, Y.U, Baker, C.S., Funahashi, N., Lavery, S., Dalebout, M.L., Lukoschek, V. and Haraguchi, K. 2007a. Contamination level of mercury in red meat products from cetaceans available from South Korea markets. *Mar. Poll. Bull.* 54: 669–677; Endo, T., Kimura, O., Hisamichi, Y., Minoshima, Y. and Haraguchi, K. 2007b. Age-dependent accumulation of heavy metals in a pod of killer whales (*Orcinus orca*) stranded in the northern area of Japan. *Chemosphere* 67: 51-59; Lavery, T.J., Butterfield, N., Kemper, C.M., Reid, R.J. and Sanderson, K. 2008. Metals and selenium in the liver and bone of three dolphin species from South Australia, 1988-2004. *Sci. Tot. Environ.* 390: 77-85; Lavery, T.J., Kemper, C.M., Sanderson, K., Schultz, C.G., Coyle, P., Mitchell, J.G. and Seuront, L. 2009. Heavy metal toxicity of kidney and bone tissues in South Australian adult bottlenose dolphins (*Tursiops aduncus*). *Mar. Environ. Res.* 67: 1-7).

Table 3

Maximum fluorinated hydrocarbon concentrations in cetacean tissues from the Pacific (ng g^{-1}).

Location	Species	Tissue	Weight	PFOS	PFOSA	PFNA	PFDA	PFUnDA	PFDoDa	ΣPFC	Reference
Japan	Melon headed whales	Liver	Wet	117	111	20.9	20.5	101	22.8	215[#]	Hart *et al.* (2008)
Hong Kong	Indo-Pacific humpback dolphin	Liver	Wet	693	37.6	21.6	40.2	120	10.9	361[#]	Yeung *et al.* (2009)
	Finless porpoise	Liver	Wet	262	7.82	12.2	8.52	34.3	2.23	186[#]	

(SOURCE: Hart, K., Kannan, K., Isobe, T., Takahashi, S., Yamada, T.K., Miyazaki, N. and Tanabe, S. 2008. Time trends and transplacental transfer of perfluorinated compounds in melon-headed whales stranded along the Japanese Coast in 1982, 2001/2002, and 2006. *Environ. Sci. Technol.* 42: 7132–7137; Yeung, L.W.Y., Miyake, Y., Wang, Y., Taniyasu, S., Yamashita, N. and Lam, P.K.S. 2009. Total fluorine, extractable organic fluorine, perfluorooctane sulfonate and other related fluorochemicals in liver of Indo-Pacific humpback dolphins (*Sousa chinensis*) and finless porpoises (*Neophocaena phocaenoides*) from South China. *Environ. Poll.* 157: 17-23).

[#] Highest mean value.

Table 4

Maximum organic contaminant levels in cetacean tissues from the Pacific (µg.g^{-1}).

Location	Species	Tissue	Weight	ΣHCH	HCB	DDE	DDD	*o,p'*-DDT	*p,p'*-DDT	ΣDDT	ΣPCB	Dieldrin	Σ PBDE	Σ Chlordane	HP-epox	TCPMe	TCPMOH	Reference
USA	Killer whale	Blubber	lipid	1.30	1.60	-	-	-	-	160	180	-	15	14.0	-	-	-	Krahn *et al.* (2007)
Japan	Finless porpoise	Brain	wet	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-	Kunisue *et al.* (2007)
	Striped dolphin	Brain	wet	-	-	-	-	-	-	-	0.62	-	-	-	-	-	-	Kunisue *et al.* (2007)
	Melon-headed whale	Blubber	lipid	0.43	0.51	-	-	-	-	73	34	-	0.51	6.9	0.23	0.092	0.36	Kajiwara *et al.* (2007)
		Brain	wet	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	Kunisue *et al.* (2007)
	Killer whale	Blubber	lipid	-	6.24	237	-	-	-	240	68.2	-	0.64	79.7	-	-	-	Haraguchi *et al.* (2009)
New Zealand	Common Dolphin	Blubber	lipid	0.004	0.13	3.9	0.14	0.32	0.14	4.43	1.634[1]	0.1	-	0.036		-	-	Stockin *et al.* (2007)

SOURCES: Haraguchi, K., Yohsuke Hisamichi, Y., Endo, T. 2009. Accumulation and mother-to-calf transfer of anthropogenic and natural organohalogens in killer whales (*Orcinus orca*) stranded on the Pacific coast of Japan. *Sci. Total Environ.*407: 2853–2859; Kajiwara, N., Kamikawa, S., Amano, M., Hayano, A., Yamada, T.K., Miyazaki, N. and Tanabe, S. 2008. Polybrominated diphenyl ethers (PBDEs) and organochlorines in melon-headed whales, *Peponocephala electra*, mass stranded along the Japanese coasts: maternal transfer and temporal trend. *Environ. Pollut.* 15: 106-114; Krahn, M.M., Hanson, M.B., Baird, R.W., Boyer, R.H., Burrows, D.G., Emmons, C.K., Ford, J.K.B., Jones, L.L., Noren, D.P., Ross, P.S., Schorr, G.S. and Collier, T.K. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. *Mar. Pollut. Bull.* 54: 1903–1911; Kunisue, T. , Sakiyama, T., Yamada,T.K., Takahashi, S., and Tanabe, S. 2007. Occurrence of hydroxylated polychlorinated biphenyls in the brain of cetaceans stranded along the Japanese coast. *Mar. Pollut. Bull.* 54: 963–973; Stockin, K.A., Law R.J., Duignan, P.J., Jones, G.W., Porter, L., Mirimin, L., Meynier L., and Orams, M.B. 2007. Trace elements, PCBs and organochlorine pesticides in New Zealand common dolphins (*Delphinus* sp.). *Sci. Total Environ.* 387: 33.

[1] 45 PCB congeners.