Annex K

Report of the Standing Working Group on Environmental Concerns

Members: Moore (Convenor), Amaral, Aruna, Baldwin, Bejder, Bjørge, Brito, Brockington, Brownell, Campbell, Cañadas, Castellote, Cerchio, Charrassin, Chilvers, Clark, Collins, Cozzi, De Quiros, De Stephanis, Deimer-Schüette, Donoghue, Edwards, Ferguson, Fernández, Flóres, Fossi, Gales, Gallego, Galletti, Gedamke, Groch, Holm, Iñíguez, Jaramillo-Legorreta, Jérémie, Kock, Koski, Lauriano, Lens, Liebschner, Lovell, Luna, Lusseau, Marcondes, Mate, Mattila, Moore, Nelson, Øien, Palka, Panigada, Parsons, Podestá, Punt, Reeves, Ridoux, Ritter, Rojas-Bracho, Rosa, Rose, Rosenbaum, Rowles, Scordino, Simmonds, Sironi, Stachowitsch, Štrbenac, Suydam, Taylor, Uoya, Urbán, Vazquez, Vély, Víkingsson, Weinrich, Weller, Werner, Williams, Wright, 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

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

5. REVIEW OF AVAILABLE DOCUMENTS

SC/62/E1-E14; SC/62/BRG3, SC/62/SH12, SC/62/SH20, SC/62/WW2, SC/62/WW5; Alter *et al*. (2010); Clark *et al*. (2009); Dolman and Simmonds (2010); and Hildebrand (2009).

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

SOCER provides an annual update, requested by the Commission, on: (a) environmental matters that potentially affect cetaceans; and (b) developments in cetacean populations/species that reflect environmental issues. The topics are organised according to the environmental concerns identified by the IWC. The SOCER is based on papers published in peer-reviewed journals between 2008 and 2010 and is tailored for a non-scientific audience.

The report consists of a regional (in 2010, the Arctic region) and a global section and includes a glossary of species and scientific terms. The bibliometric analysis has been shifted into a separate paper (SC/62/E2). The editors of SOCER request that Scientific Committee members submit entries in the form of pdf files of published papers (in 2011, the region of focus will be the Southern Ocean), whereby the traditional submission form will remain valid for more recent, ongoing or breaking developments not yet available in published form. This is designed to avoid delays in crucial information because, as one SOCER entry points out, conservation-related papers take three times longer to be published than papers of other biology specialists.

The overwhelming issue in the literature published in 2008-10 for the Arctic was climate change (i.e. rate of ice loss and ecosystem shifts) but many of the papers in the review period had already been summarised in previous SOCER global sections because of their global significance (see, e.g. the summary of Huntington and Moore, 2008 in Stachowitsch *et al.*, 2008). There were few pollutant studies specifically on cetaceans in 2008-10, but the Arctic Monitoring and Assessment Programme (AMAP) 2009 Assessment of Arctic Pollution Status (*http://www.amap.no/*) provides a comprehensive review of pollutant levels in the Arctic (SC/62/E1 did not review this report as it was itself a review and was not specifically focused on marine mammals).

Globally, the environmental issue that progressed most over the past year seemed to be underwater noise, especially disturbance from boat traffic, impacts of sonar on beaked whales (for which researchers are getting a clearer idea of why these animals seem to be affected more than other species) and the acoustic impacts of wind farms (discussed in SC/62/E7 and SC/62/E8). During discussion, it was noted that the Arctic was covered in special issues of *Ecological Applications* in 2008 (Volume 18, Supplement) and *Science of the Total Environment* in 2010 (Volume 408, Issue 15). Next year the SOCER will focus on the Southern Ocean. The editors of the SOCER requested that SWG members respond to the annual submission request by the Secretariat's requested deadline. The members of the sub-committee thanked the authors for compiling the SOCER.

SC/62/E2 offered a bibliometric analysis of the cetacean scientific literature, based on a 2004 request from the then-Chair of the Scientific Committee as an addition to the established SOCER format. The analysis evaluated two different databases - one maintained by the Natural History Museum of Los Angeles County and the BIOSIS database. It was determined that for 2005-08, there was a relatively steady percentage of papers being published (nearly half) that were focused on conservation topics and this was probably an underestimate. An earlier era (35 years earlier) was then examined and it was determined that there has been a shift in focus from basic biology topics to conservation topics in cetacean research, even though much is still to be discovered about cetacean biology. This reflects a similar trend in other biological disciplines, such as coral reef ecology. Clearly understanding threats facing cetaceans has gained in importance within the research community, within the policy community, and even within funding agencies and sources, which often include a conservation focus in their funding criteria. Therefore the growing focus on conservation issues in forums such as the IWC Scientific Committee is appropriate.

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

7.1 Workshop report

An intersessional Workshop on POLLUTION 2000+ was hosted by Drs Frances Gulland and Jeff Boehm of The Marine Mammal Center in Sausalito, California from 22-24 February 2010. Fifteen participants with expertise in chemical contaminants, toxicology, cetacean biology, veterinary medicine and biomarkers of contaminant exposure and effects, participated in this event. The goals and objectives of the Workshop included the following:

(1) develop integrated modelling approaches and a 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;
   (b) develop the draft models and risk assessment framework;
   (c) review and assess modelling approaches to meet the framework;
   (d) evaluate existing models that could be tested and develop a plan for testing these models with available datasets; and
   (e) assess the model characteristics needed and a plan for developing new models if needed;
(2) develop a prioritisation hazard identification framework to evaluate the broad number of environmental pollutants; and
(3) 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.

Several presentations were given that provided information on risk assessment frameworks, chemicals of emerging concern, contaminant exposure and effects in cetaceans as well as modelling approaches and case study examples. Biomarkers of chemical exposure and effects were also discussed, with the workshop purposefully selecting those that have been validated in cetaceans and would most likely provide relevant information for population-level assessments, such as those affecting reproduction or survival.

The Workshop agreed upon an international prioritisation survey of subject matter experts in chemical contaminants, marine mammals and/or toxicology. To develop the survey, the general approach was to establish cetacean (based on diet composition and trophic level), geographical and contaminant categories (based on chemical properties, bioaccumulation and exposure potential); assess existing information on contaminant exposures and biological effects (negative impacts on reproduction and health); determine where information was strong enough to prioritise contaminants; develop an international survey format; and identify and query subject matter experts. It was agreed that once the survey had been finalised, each Workshop participant would send the survey to 2-3 subject matter experts, with a cover letter from the POLLUTION 2000+ Steering Committee. The Workshop proposed that the survey would be finalised in spring 2010, and would then be sent to subject matter experts and a report compiled during 2010. A final report on the prioritisation survey results will be presented to the 2011 Scientific Committee meeting.

Data gaps and research needs were identified by the Workshop, with most of the short, medium and long-term research requiring new efforts or additional support of existing efforts. In addition, the following recommendations were made by the Workshop.

(1) Improve existing concentration-response (CR) function for PCB-related reproductive effects. Re-initiate efforts to derive a CR function based on surrogate species for reproductive effects in relation to PCB exposure.
(2) Derive additional CR functions to address other endpoints (i.e. survival) in relation to PCB exposure. This may be accomplished using a multi-stage modelling approach. Additional CR functions could be derived using data from surrogate species (e.g. experimental studies and/or wildlife and human epidemiological studies) as well as through synthesis of recently acquired information from small cetaceans (European harbour porpoise strandings and US bottlenose dolphin capture-release health assessments).
(3) Integrate improved concentration-response components into a population risk model (e.g. individual-based model) for one or more case study species (e.g. bottlenose dolphin and/or humpback whale).
(4) Develop new biomarkers and improve the linkages between lower and higher levels of organisation (molecular $\rightarrow$ individual $\rightarrow$ population). The highest priority for biomarker development should include those with direct relevance to population-level endpoints such as reproduction and survival.

Some of the cetacean populations proposed for case study models by the workshop may not be appropriate. For example, the US Navy dolphins are moved frequently from facility to facilty and thus their contaminant levels could change. Rowles noted that they were proposed as a potential model and have not yet been agreed upon by the Navy. When the Navy animals are moved their food may not significantly change as far as contaminant burdens and nutritional quality are concerned. The Navy veterinarian programme has long-term health information on their animals and has a strong interest in the development of biomarker and health indices. The bottlenose dolphin case study model presented in the workshop report was an example of how PCB exposure could affect calf survival and potentially influence the dolphin population. PCBs may have other effects on fecundity or survival that were not incorporated in to this model.

The SWG also noted that it is difficult to make the critical link between exposure effects on the health of individuals and how that translates to the population health trends and, that an advantage of working with cetaceans is the availability of tissue banks that can serve as great resources for population genetic studies. At a special session on evolutionary toxicology at the European Society of Environmental Toxicology and Chemistry meeting held in Seville in late May 2010, it was proposed that an approach such as this would be quite useful.

The SWG also noted that the ICES Working Group on Marine Mammal Ecology (WGMME) met in the Azores 12-15 April 2010 and that one of the WGMME's Terms of Reference was: 'Review the current contaminant loads reported in marine mammals in the ICES area, the cause–effect relationships between contaminants and health status, and the population-level effects of environmental impacts.' The WGMME also made several recommendations with regard to pollutants in marine mammals that are listed in the report that is available at *http://www.ices.dk/reports/ACOM/2010/WGMME/wgmme_final_2010.pdf*. The SWG endorsed the recommendations of the ICES WGMME.

Moore thanked the Workshop convenors for the report as it gives a solid foundation and framework to move forward with POLLUTION 2000+ Programme.

7.2 Other pollution information

The main objective of SC/62/E9 was to apply, for the first time, a suite of sensitive non-lethal biomarkers in skin biopsy of the mysticete species Bryde's whale (*Balaenoptera edeni*) to evaluate the toxicological status of this cetacean in the Gulf of California. A 'multi-trial-biomarker-tool' was developed, combining protein biomarkers (western blot of CYP1A1, CYP2B) with concentrations of organochlorines (OCs) and polycyclic aromatic hydrocarbons (PAHs) measured in this species. The levels and effects of OCs and PAHs in skin biopsies of fin whale (*Balaenoptera physalus*) populations of the Gulf of California and the heavily polluted areas of the Mediterranean Sea were also examined. Higher levels of DDTs, PCBs and PAHs were detected in the zooplankton-eating fin whales compared to the fish-eating Bryde's whales; in contrast, much higher levels of both CYP1A1 and CYP2B were detected in the fish-eating species. These data suggest a peculiar evolutionary process of the two isoforms of CYP in the fish-eating Bryde's whales, demonstrating similar levels of both cytochromes similar to the odontocete species resident in Sea of Cortez (C. Fossi, pers. comm.). The interspecies investigation shows the presence of a higher 'toxicological stress' in the Pelagos fin whale population (Mediterranean Sea) highlighted by warning signs such as higher levels of DDTs, PCBs and PAHs, elevated levels of CYP1A1 induction and, as previously reported by Fossi and collaborators, the up-regulation of ERα and E2F-1 genes, combined with a lack of CYP2B induction in both field and *in vitro* experiments.

The development of new tools to detect the effects of persistent organic pollutants (POPs), emerging contaminants of concern and PAHs on Mediterranean cetaceans using a suite of sensitive biomarkers was described in SC/62/E10. A multi-response *in vitro* method to detect toxicological effects of contaminant mixtures was examined using slice integument biopsies of stranded and free-ranging animals. In this study, an *in vitro* assay using skin biopsy and liver slices was applied, combining molecular biomarkers (western blot of CYP1A1, CYP2B) and gene expression levels (qRT-PCR of CYP1A1, HSP70, ERα and E2F-1) in response to chemical contaminant exposure (OCs, PBDEs, PAHs) for stranded Mediterranean *Stenella coeruleoalba*. The main goal of this experiment was to identify among the various assays, the biomarker and/or series of biomarkers that best allows us to diagnose the presence of a specific class of pollutants (OCs, PBDEs, PAHs) or a mixture of them for future investigations in field studies.

The SWG noted that making comparisons of PAH biomarkers between two cetacean populations could be difficult as PAHs are transient and exposure levels are not known. However, wild cetaceans are likely to be exposed to a mixture of chemicals so developing a wide range of biomarker techniques for biopsy samples that can cover a variety of chemical contaminant classes, as well as any potential synergistic effects would be useful. In order to compare data among studies, the SWG recognised the importance of standardisation of contaminant concentration reporting (e.g. wet weight, lipid weight, dry weight).

Rowles and Ylitalo provided an overview of the Deepwater Horizon MC252 oil spill that occurred in the Gulf of Mexico. On 20 April 2010, an explosion occurred on the semi-submersible Deepwater Horizon oil-drilling platform situated approximately 50 miles southeast of the coast of Louisiana. The fire resulting from the explosion could not be extinguished, and as a result, the oil platform sank and crude oil began spilling into the waters of the Gulf of Mexico approximately 5,000 feet below the surface on 22 April 2010. At the time of the SWG meeting, attempts to cap the oil riser had been unsuccessful and crude oil continued to enter the marine waters of the Gulf of Mexico.

In response to this spill, the Wildlife Branch of the Unified Command, including State and Federal Trustees and the responsible party, developed response networks for marine mammals, sea turtles and birds. Additional resources (financial, physical, and experts) were used to enhance the capacity of the established stranding networks in the Gulf of Mexico. Four facilities were identified and supplied for de-oiling of manatees, dolphins and sea turtles. In addition, staff members from the national stranding program are rotating through the response teams. Other experts such as husbandry staff from public display facilities and the Navy as well as veterinary experts in wildlife from North America have been contracted to assist. To date, these personnel have responded to 31 stranded dolphins and 277 sea turtles, most of which have been dead. In addition to the stranding response, there are on water efforts to find and rescue dead and live turtles.

Clean up efforts that include skimmers, trawls and the Big Gulp also have the potential to trap or kill sea turtles and some turtles have been collected during these operations. It is highly likely that others have been incidentally killed during response actions. In addition there are efforts underway to protect nesting beaches both from the oil and from the mitigation or clean up. Protocols and assessments are underway to determine the appropriate action once hatchlings emerge.

As part of this event, Natural Resource Damage Assessments have begun and over 20 technical working groups are fully operational. A bottlenose dolphin project along the coastal areas from Louisiana to the west coast of Florida has started and includes pre-spill photo-id and biopsies. That project may continue throughout the response time period and into the post clean up time periods. In addition, since the first week of May aerial surveys over the area have been conducted utilising fixed wing aircraft and helicopters. These will be continuing periodically over the following months. Future plans include boat-based surveys, possibly tagging and biopsy of the offshore cetaceans, surveys for manatees, and boat based assessments of turtles including some nest success assessments. Longer term planning for assessments of these species as well as the prey and habitat upon which they depend is underway.

The SWG discussed fishing enforcement, categorisation of oiled marine mammals and sea turtles, as well as lessons learned thus far with respect to the oil spill. Due to the large extent of this spill and the potential impacts on marine resources in the region, information obtained from this event will increase our ability to respond to similar events in the future. The SWG **commended** all groups that are responding to impacted marine mammals and turtles in the region.

The SWG needs to learn as much information as we can from this tragedy so that we: (1) can accurately assess impacts; and (2) are better prepared for potential future oil spills. The SWG **strongly recommended** that the United States Government and the responsible party:

- search for and examine as many cetacean carcasses as possible that may have been impacted by the spill through detailed necropsies and thorough tissue sampling;

- analyse tissues for contaminants specifically related to spilled oil (i.e. polycyclic aromatic hydrocarbons, dispersants and mixtures of the two);
- provide detailed chemical composition of the dispersants that have been used in the Gulf of Mexico. The chemical composition of dispersants is currently considered proprietary in the United States. Because dispersants can be toxic and may have negative impacts on cetaceans, damage assessment scientists need to understand the chemical composition of dispersants; and
- develop and examine a suite of biomarkers that will be useful for understanding impacts from the spilled oil and use of dispersants in the Gulf of Mexico. Understanding the efficacy of biomarkers for future assessments may allow for assessing exposure or sublethal impacts from exposure to spilled oil, dispersants and clean-up efforts by biopsying live animals.

The situation in the Gulf of Mexico also emphasises the need to have adequate baseline data before oil and gas exploration, development or production occurs in an area. There are relatively few baseline data available in the Gulf of Mexico that are available for predicting, mitigating or measuring impacts. Therefore, for member governments with on-going or planned offshore oil and gas activities within their territories the SWG **strongly recommended** the collection of the following baseline data as soon as possible:

- contaminant levels in cetaceans, their prey and in sediments, especially polycyclic aromatic hydrocarbons (PAHs) but also other contaminants that may interact with PAHs;
- biomarker levels in cetaceans and their prey;
- abundance and distribution of cetaceans and their prey; and
- condition of habitat (i.e. water quality, sediment quality, etc.).

The SWG **strongly recommended** contingency planning for oil spills in areas of oil and gas development. The SWG looks forward to receiving further information on the studies into the effects of this spill at future meetings.

8. REVIEW PROGRESS OF CETACEAN EMERGING AND RESURGING DISEASE (CERD) WORKING GROUP

SC/62/E5 reviewed the recent accomplishments and upcoming plans of the Cetacean Emerging and Resurging Disease (CERD) Working Group (WG), as follows.

Skin disease
The Skin Disease Subgroup made some progress on the development of a website for skin lesions in cetaceans and on the standardisation of skin lesion/disease descriptions.

Diagnostic laboratories and veterinary experts
Utilising the fields developed at last year's meeting for diagnostic laboratories, the WG has identified regional experts who would be willing to provide the information and complete the draft list of diagnostic laboratories by region, ocean basin or country. Regional experts have been identified for the following countries: Argentina, Belgium, Brazil, Canada, Germany, India, Netherlands, Spain/Canary Islands, United Kingdom and the United States.

Prioritisation of pathogens in cetaceans
Based on recommendations for prioritisation of pathogens for the CERD and needs identified by the Working Group on Marine Mammal Unusual Mortality Events in the US, a pathogen assessment and prioritisation scheme was developed and implemented in 2010 as a pilot assessment with a small number of Subject Matter Experts (SMEs) identified by the Working Group on Marine Mammal Unusual Mortality Events. The details of this pilot study are described in SC/62/E4.

Emergency response
In addition to the southern right whale mortality in Peninsula Valdez, Argentina (see SC/62/Rep1), an increase in stranding and mortality of humpback whales occurred in Brazil over the last four years. In Australia's western coast an unexpected die-off of 46 humpback whales occurred in 2009 (SC/62/SH24). These facts highlight the needs of enhancing communication between the different networks and discussion of these mortalities in a larger perspective. In addition, the emergency response team assisted in the response to a sperm whale mass stranding along the Adriatic coast of Italy in December 2009 and to a beaked whale mass stranding in the Azores.

Enhance capacities and communications between stranding networks
Over the past year there were several efforts by different individuals or organisations to enhance the capacities of existing stranding programmes, build or initiate stranding programmes in areas that had no programme, or better coordinate regional networks. As a part of this effort stranding training and capacity building workshops were held in four regions: West Africa, Caribbean, Brazil and India as well as a meeting in the US.

Caribbean
Three workshops were held this year in Panama, Curaçao and Guadeloupe. These workshops were a priority action identified by UNEP's Specially Protected Areas and Wildlife (SPAW) Programme's Marine Mammal Action Plan (MMAP) for the Wider Caribbean Region (WCR) (information available at *http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/marine-mammals*), modelled after the first Eastern Caribbean stranding response workshop held in Trinidad and Tobago in 2005.

Panama
NOAA in collaboration with, and with the support of, the National Environmental Authority of the government of Panama, the Regional Activities Center for the Protocol for Specially Protected Areas and Wildlife of the Cartagena Convention, the Commonwealth of Puerto Rico Marine Mammal Rescue Program, and the University of Las Palmas, Canary Islands convened a Regional Marine Mammal Stranding Response Training Workshop for Spanish-speaking nations of the Wider Caribbean Region on 22-23 April 2010 in Panama City, Panama. Over 100 participants from 12 countries including Venezuela, Colombia, Panama, Dominican Republic, Belize, Costa Rica, Guatemala and Nicaragua attended the workshop. The Workshop provided marine mammal stranding response training and participants discussed capacity building for stranding response in the wider Caribbean.

French Caribbean Territories Regional Workshop
The Regional Workshop for the French-speaking Caribbean Territories in response to marine mammal strandings was held from 8-10 January 2010 in Bouillante, Basse Terre

in Guadeloupe. The Workshop hosted thirty participants, representing Protected Area management organisations, government departments and non-governmental organisations from five French-speaking islands and territories (Guadeloupe, Haiti, French Guiana, Martinique and St Martin).

Curaçao Workshop
The Dutch Caribbean Regional Workshop for Effective Implementation for Marine Mammal Stranding Response (DCSW) was hosted by at the Curaçao Sea Aquarium from 5-7 November 2009 in the Netherland Antilles. The Southern Caribbean Cetacean Network (SCCN) (*http://www.sccnetwork.org/home*), recently established in Curaçao, organised this stranding workshop in cooperation with the Dutch Caribbean Nature Alliance (DCNA) (*http://www.dcnanature.org/welcome/index.html*), and with the Eastern Caribbean Cetacean Network (ECCN) (*http://www.eccnwhale.org*). The goal of the workshop was to build capacity, to review the techniques and protocols for responding to stranding incidents for marine mammals and to facilitate possibilities for collaboration in the Dutch Caribbean Islands.

Brazil
The first Seminar for Training Veterinarians in Aquatic Mammal Necropsies was organised by the Brazilian Government and held at the Centro Mamíferos Aquáticos (Aquatic Mammals Center). This event occurred in Itamaraca Island, from 12-16 April 2010 and was attended by nearly thirty professionals from all regions of Brazil.

India
A first-of-its-kind Marine Mammal Stranding Workshop was held at the Central Marine Fisheries Research Institute (CMFRI), Kochi, India from 21-23 January 2010. This event was organised by NOAA and CMFRI with funds provided by the Indo-US Science and Technology Forum (IUSSTF), India and NOAA. The workshop was aimed at increasing awareness and interest in marine mammals among the scientific community and the local public, and to provide the necessary impetus and training to collect relevant stranding data and create regional stranding networks in different parts of coastal India. A more specific goal was to communicate the inherent scientific value of data collection from stranded animals, maintaining a stranding database, and engaging in environmental stewardship to conserve and protect marine habitats and their inhabitants. Forty-two participants from 23 organisations attended the workshop. A follow up regional Marine Animal Necropsy Training and Stranding Workshop is proposed for January-February 2011 at the Madras Veterinary College Chennai, India.

West Africa
As part of the effort to address the Illegal, Unreported, Unregulated fishery bycatch of non-target species including cetaceans, NOAA has been working with various partners to enhance the capacity of countries to adequately detect bycatch. For West Africa this effort has been focused on observer and stranding capacity building for marine mammals and sea turtles.

National Stranding Meeting (United States)
NOAA held the second National Marine Mammal and Sea Turtle Health and Stranding Conference (*http://reefshark.nmfs.noaa.gov/pr/stranding/*) at the National Conservation Training Center in West Virginia from 6-9 April 2010. The conference had more than 260 participants from the US, Canada, South Africa, West Africa, India, Caribbean, UK, the Netherlands, Brazil and Argentina. It included didactic teaching, laboratories, stranding scene investigations, necropsies, panels and workshops on topics such as forensic science, euthanasia, mass stranding response, epidemiology, emerging diseases, sound in the ocean, oil spill response and marine mammal and sea turtle medicine. The conference was a fantastic way for building collaboration and communication within US networks and between US networks and those in other countries.

Inventory of Stranding Networks
Utilising information from the ICES Working Group (2009) and the IWC Ship Strike Working Group (2009), a broad inventory of global stranding networks has been developed. The inventory contains the contact information for stranding networks in alphabetical order by country. The CERD Working Group needs to determine recommendations for maintaining and accessing the information.

The University of Las Palmas, Canary Islands and the Marine Mammal Center, Sausalito, California have both indicated a willingness to host interns or persons to gain additional experience in stranding response and necropsies. Other mechanisms for capacity building, training and outreach have been discussed and electronic mechanisms for enhancing communication are being explored.

The SWG acknowledged the accomplishments of the Working Group and **commended** the CERD for their contributions.

SC/62/E4 summarised a cetacean pathogen assessment and prioritisation scheme. Numerous microbes have been isolated and reported in cetaceans. These reports have varied from the isolation of a bacterial species once in one animal to the association of a virus to numerous mass mortality events. During 2009-10, the task of prioritising cetacean pathogens was undertaken on behalf of the Working Group on Marine Mammal Unusual Mortality Events US, as a survey using a small number of SMEs. The results of this survey may serve as a pilot study for the CERD task on a broader scale. The survey evaluated pathogens utilising the following factors:

- likelihood of marine mammal exposure to the pathogen;
- if exposed, likelihood of marine mammal illness;
- if exposed, likelihood of marine mammal death;
- if exposed, likelihood of marine mammal epizootic (often implying high probability of animal to animal transmission); and
- public health implications: zoonotic, reportable in the US or emerging/re-emerging diseases among humans.

The study used a total of 76 pathogens for which there were peer-reviewed publications describing those pathogens in marine mammals. Although there are numerous additional pathogens observed in marine mammals, this study focused on those identified in peer-reviewed published reports. Raw risk scores and weighted risk scores (incorporating survey participants' confidence in their risk ratings), were used to prioritise pathogens for large cetaceans and small cetaceans. Adequate published data were only available to prioritise pathogens for small cetaceans; therefore, the results are reported only on small cetaceans. The ten highest priority pathogens (with the highest total scores) among small cetaceans were morbillivirus, parapoxvirus, *Brucella* spp., anisakis, calicivirus, herpesvirus, nasitrema, *Clostridium* spp., *Escherichia coli* and toxigenic *Escherichia coli*.

Of the 76 pathogens included in the survey, 27 (35.5%) were potentially zoonotic, and 12 (15.8%) and 20 (26.3%)

were associated with reportable and emerging/re-emerging human diseases in the United States, respectively. The next steps for prioritisation would be to broaden the SMEs participating in the study to include more experts from other countries. In addition a process for evaluation of emerging pathogens and those without peer-reviewed publications should be developed that may address the significant time lag in getting information peer-reviewed and published in a timely manner.

The SWG **commended** the pathogen prioritisation work of the CERD and acknowledged the importance of developing a process for evaluating emerging pathogens that are not yet published in peer-reviewed journals. In general discussion of SC/62/E4, it was noted that the southernmost record of lobomycosis in a bottlenose dolphin in South America was reported in May 2010. Although CERD is not currently tasked to compare the pathogens present in cetaceans to those present in terrestrial species, the SWG expressed an interest to examine pathogen ecology and the interactions of pathogens throughout the ecosystems in which they reside. The SWG noted that this approach is supportive and is part of the global and national 'One Health' approach to medicine (*http://onehealthinitiative.com/index.php*) highlighting the importance of the integration of surveillance systems in wildlife, domestic animals, public health and environmental health.

The importance of disease and dolphins captured for dolphinariums was illustrated with the case of live-captured Solomon Island Indo-Pacific bottlenose dolphins that, despite having been exposed to the zoonotic pathogens *Brucella* and *Toxoplasma* (Omata *et al.*, 2005; Tachibana *et al.*, 2006), were exported to a facility in Cancun, Mexico where members of the public would be swimming with animals.

As an example of a One Health approach it was noted that the US Agency for International Development (USAID) has provided funding for a large programme to enhance capacity and establish a comprehensive and interconnected intervention package for Emerging Pandemic Threats due to infectious disease transmission from animals to people. It will be implemented through five projects as follows.

(1) PREDICT: to monitor for and increase the local capacity in 'geographic hot spots' to identify the emergence of new infectious diseases in high-risk wildlife such as bats, rodents and non-human primates that could pose a major threat to human health.
(2) RESPOND: to strengthen the human capacity of countries to identify and respond to outbreaks of newly emergent diseases in a timely and sustainable manner.
(3) IDENTIFY: working with the UN World Health Organization (WHO), UN Food and Agriculture Organization (FAO), and the World Organization for Animal Health (OIE) to support the development of laboratory networks and strengthened diagnostic capacities in the 'geographic hot spots' for new emergent diseases.
(4) PREVENT: to build an effective behaviour change communication response to zoonotic diseases, support efforts to characterise 'high-risk' practices that increase the potential for new disease threats from wildlife or wildlife products to spread and infect people, and formulate behaviour change and/or communication strategies and interventions that meet the challenges posed by the emergence of a new infectious disease.
(5) PREPARE: to provide technical support for simulations and field tests of national, regional and local pandemic preparedness plans to ensure that countries have the capacity to implement response plans effectively during pandemic events.

The programme is focusing on 24 countries in wildlife outbreak hotspots, but does not include capacity building for infectious diseases of marine species.

The SWG **commended** projects that integrate a One Health approach to build capacity in countries that are responding to diseases that are shared by people and wildlife or are transmitted between people, domestic animals and wildlife. However the SWG expressed concern that the current efforts do not include marine species, in particular cetaceans. The SWG **recommended** that marine species be considered by USAID and other organisations including OIE and WHO that are implementing approaches to One Health. These programmes should integrate marine mammal disease surveillance and communication into the capacity building and surveillance programmes in all countries. The CERD WG should work with these organisations to identify areas of cooperation and enhancement.

9. REVIEW NEW INFORMATION ON ANTHROPOGENIC SOUND AND CETACEANS, FOCUSING ON MASKING SOUNDS

The SWG has included an item on underwater sound on its annual agenda each year since 2004, when a mini-symposium on anthropogenic noise was conducted as part of the SWG's sessions (IWC, 2005). The scope of the 2004 symposium was broad, with presentations on: (i) the effects of noise on marine animals, including possible synergistic effects; (ii) physical acoustics and ambient noise; (iii) audition and physiology of hearing; and (iv) whale communication and behaviour. Conversely, in 2006, a two-day pre-meeting of the SWG was convened to specifically address the potential for seismic surveys to impact cetaceans (IWC, 2006). The terms of reference for the pre-meeting were to review: (i) information on seismic sound sources and their effects on cetaceans; (ii) case studies where seismic surveys were conducted near cetaceans or in 'critical' habitats; (iii) current mitigation and monitoring programmes, including an evaluation of their effectiveness; and (iv) potential impacts to cetaceans, including recommending changes to mitigation and monitoring during all phases of seismic surveys. In most other years, information on underwater sound has been considered under a 'generic' agenda item (e.g. Review new information on acoustics) under the standing 'Other habitat related issues' item on the agenda. Frequently, recommendations developed at the 2004 and 2006 meetings regarding steps to address the effects of anthropogenic sound on cetaceans were reiterated at these annual meetings.

In 2009, a presentation was made on low-frequency 'masking sound'. This presentation precipitated the notion of making this a focal-topic for presentation within the SWG sessions at this year's meeting.

9.1 Concerns related to anthropogenic masking of low-frequency sounds

Acoustic masking from anthropogenic noise is increasingly being considered as a threat to marine mammals, particularly low-frequency specialists such as baleen whales. Low-frequency ocean noise has increased in recent decades, often in habitats with seasonally resident populations of marine

mammals, raising concerns that noise chronically influences life histories of individuals and populations. In contrast to physical harm from intense anthropogenic sources, which can have acute impacts on individuals, chronic effects such as masking from noise sources has been difficult to quantify at individual or population levels, and resulting effects have been even more difficult to assess. Clark *et al*. (2009) represents an analytical paradigm to quantify changes in an animal's acoustic communication space as a result of spatial, spectral and temporal changes in background noise, providing a functional definition of communication masking for free-ranging animals and a metric to quantify the potential for masking of communication. The sonar equation, a combination of modelling and analytical techniques, and measurements from empirical data can be used to calculate time-varying spatial maps of potential communication space for singing fin (*Balaenoptera physalus*), singing humpback (*Megaptera novaeangliae*) and calling right (*Eubalaena glacialis*) whales. These examples illustrate how the measured loss of communication space as a result of differing levels of noise is converted into a time-varying measure of communication masking. This proposed paradigm and mechanisms for measuring levels of communication masking can be applied to different species, contexts, acoustic habitats and ocean noise scenes to estimate the potential impacts of masking at the individual and population levels.

Moore thanked the intersessional steering group chaired by Suydam, as well as Gedamke for his overview presentation on masking.

Several papers were presented on this topic. SC/62/E3 presented information regarding potential negative effects on the reproduction and survival of fin whales by shipping and airgun noise. Seafloor recorders were deployed in the western Mediterranean Sea and adjacent NE Atlantic waters during 2006-09 to monitor noise levels and fin whale presence. Acoustic parameters of 20Hz pulses (inter-pulse interval, pulse duration, pulse bandwidth, pulse centre and peak frequencies) were compared for areas with different shipping noise levels, different shipping intensities in the Strait of Gibraltar and during seismic airgun events. Statistically significant differences were detected between noise contexts. In general, both temporal and spectral parameters of their vocalisations were negatively correlated with ambient noise levels. In high noise conditions such as intensive shipping activity or airgun activity, 20Hz pulse duration shortened, bandwidth decreased and centre and peak frequencies decreased. The author of SC/62/E3 discussed how these results are interpreted as a compensation mechanism to noise, to reduce masking of their signals. Fin whales position their calls in a frequency band of lower ambient noise level and increase signal redundancy. However, this mechanism increases energy costs by forcing the whales to use suboptimal frequencies in an activity that can last for long periods of time and song functionality might be compromised by shifts in acoustic parameters that might carry important biological information.

The author indicated that paper SC/62/SD2 describes how pulse interval and pulse bandwidth are acoustic parameters that carry information regarding the identity of the population. SC/62/E3 also presented results from the analysis of fin whale movement patterns during a scientific seismic survey. Bearings to singing whales indicated that whales moved away from the airgun source and out of our detection area for a time period that extended well beyond the duration of the airgun activity. The author highlighted that the reaction to airgun shots occurred when the seismic survey vessel was at an approximate distance of 285km, indicating that fin whales might be sensitised to this acoustic stimulus, reacting to the presence of this particular noise rather than to its intensity. However, shipping noise in the Strait of Gibraltar reached noise levels well above the airgun shots but fin whales did not leave the area nor cease their acoustic display, suggesting that they might have been habituated to this continuous noise source. The continuous nature of shipping noise as well as the intensive frequency of seismic surveys in marine areas of interest to geophysicists, could easily induce a negative chronic effect in fin whale fitness. Both habituation and sensitisation processes, particularly in a chronic context, could have negative effects on their reproduction success and survival by the increase in energy expended due to the shift in spectral and temporal parameters of their vocalisations, spatial displacements and song functionality compromise by the compensation mechanism to noise masking.

The author indicated that the seismic survey identified in paper SC/62/E3 had scientific purposes and their airgun array was much smaller than commercial surveys. In Europe, scientific surveys are commonly not regulated and controlled as are commercial surveys and thus become an important environmental concern. The SWG **recommended** that scientific surveys should be regulated and controlled in the same legal frame as are commercial surveys (at least for Spain since the author has confirmed a clear legal lack over these particular type of surveys in the Spanish EEZ), since seismic surveys may utilise source arrays as large or larger than commercial arrays, and would have similar potential impacts on cetaceans. Similarly, the author commented that current mitigation procedures and guidelines are far from effective for low frequency specialists such as balaenopterids. Results from this paper demonstrate how fin whales reacted to airgun shots at an approximate distance of 285km. Based on these results, the only effective mitigation procedures would be spatial and seasonal restrictions. However, knowledge of spatio-temporal distribution of most mysticetes is very limited and spatial and seasonal restrictions are rarely applied. The SWG **recommended** that baseline data be collected regarding seasonal and spatial distribution of mysticetes in areas of interest for the geophysical community (both scientific and commercial) before survey operations.

SC/62/E12 reported on a distant seismic survey that was recorded on three autonomous long-term acoustic recorders deployed between Tasmania and the Antarctic continent. These instruments were located approximately 450, 1,500 and 2,800km from the survey site. Recordings were analysed for the presence of airgun signals with hourly 13-minute sound files from a five-day period separated into 'seismic' *vs* 'non-seismic' files for analysis. Sound levels across a 20-50Hz bandwidth were calculated for 1 sec. samples and compared between the seismic and non-seismic datasets to assess the percentage of time that sound levels increased due to the presence of airgun signals. During seismic operations, a distinct shift of the entire distribution of sound pressure levels in the 1 sec. samples occurred suggesting even during 'quiet' periods between shots, sound levels remained slightly elevated. Compared to mean background noise during 'non-seismic' periods, noise levels were increased on the closest logger by between 6-15dB for 32% of the time when airgun shots were recorded. During non-seismic periods, sound levels were thus elevated less than 1% of the time. Sound levels were elevated by more than 3dB for 52%

of the time during seismic surveys, compared to just 6% of the time during non-seismic periods. On the central logger, levels were increased by 6+dB for 22% of the time during seismic periods, as compared to just 2% during non-seismic periods. Levels were increased by 3+dB for 51% of the time during seismic periods, compared to 7% during non-seismic periods. And finally, on the southern-most logger, levels were elevated by at least 3dB for 50% of the time during seismic, compared to 19% during non-seismic periods. At this stage, we have not attempted to calculate how these increases in background noise levels would impact on the detection ability of whales that vocalise in this 20-50Hz bandwidth. But clearly, the noise increases would decrease the detection range of biological signals or at least make them more difficult to detect at reasonable ranges from a source.

It was noted that the papers presented focused primarily on what might be termed 'absolute masking', in that it represents the end of communication capabilities. There will almost certainly be impacts related to reduction in information transfer and quality, which would arise from what might be termed 'partial masking', as well as the initiation of stress responses, at lower levels of noise exposure. The SWG **recommended** that the masking potential of anthropogenic sources be quantified and acoustic measurements be standardised to ensure that datasets among researchers are comparable.

SC/62/E13 described variation in right whale contact calls with new data from Auckland Islands southern right whales. This research was conducted in late July and early August 2007 and 2008, during two research trips to the Auckland Islands. Recordings of southern right whales were made in Port Ross, generally in the presence of large numbers of right whales. A total of 171 contact calls have been classified and analysed thus far from these recordings; 123 from 2007 and 48 from 2008. Contact call start frequency of Auckland Island southern right whales is not differentiated from contemporary southern right whales from the south Atlantic, although it is greater than that of all historical right whale recordings and lower than that of contemporary recordings of both northern right whale species. The maximum frequency of Auckland Island southern right whale contact calls is not differentiated from contemporary or historic recordings of southern right whales but is lower than that of all northern right whale species. While historic recordings of these Auckland Island southern right whales are not available, the current description of their sounds represents a valuable dataset for comparison with north and south Atlantic right whales whose contact calls have been hypothesised to have increased in frequency as a result of exposure to anthropogenic noise. Unlike other populations of right whales, these Auckland Island animals live in an environment with exceptionally low levels of anthropogenic noise, given the isolation of the breeding ground and their likely Southern Ocean feeding areas.

In discussion it was noted that some factors might exacerbate masking (i.e. hearing loss from chronic low level noise exposure and/or age). It was also noted that there are difficulties when looking at differences between, rather than within, populations. The authors pointed out that previous studies making comparisons between populations have been used to suggest anthropogenic noise alters calling behaviour. With that in mind, the authors suggested SC/62/E13 describes a valuable dataset of right whale calls from whales likely to have an exceptionally low level of exposure to anthropogenic noise.

In SC/62/SH20, breeding Stock X was discussed as an endangered population of geographically, demographically and genetically isolated humpback whales, resident in the western Arabian Sea, with an estimated population of 82 (95% CI 60-111) individuals. Recent information from range countries, in particular Oman, reveals that threats to this population are escalating, expanding and intensifying. Human population growth rates in the region are among the highest in the world (>3%), and economic development includes rapid and large-scale coastal construction projects and growth of fisheries, shipping and other industries. In the Gulf of Masirah, Oman, a large new port is currently under construction and will divert shipping traffic from one of the world's busiest shipping lanes across an area of humpback whale habitat where previous dedicated boat surveys have recorded some of the highest encounter rates. This area is also among other locations in the region where seismic surveys and other hydrocarbon exploration activities (such as exploratory drilling) are ongoing or planned.

The SWG noted the great concern expressed about this population's status in the Southern Hemisphere sub-committee and about fisheries pressure in the Bycatch sub-committee. Further, as an apparently non-migratory, resident population, acoustic masking presents threats to the abilities of these animals to use acoustics for functions relating to life, including foraging, mating and mother-calf contact. The SWG **strongly recommended** that further research is conducted on Breeding Stock X, including studies directed at quantifying the impacts of acoustic disturbance and masking, in order to obtain information of value to conservation planning and protection of this population.

SC/62/BRG3 summarised observations of cetaceans off western Kamchatka from published literature and other sources. The waters off the western coast of Kamchatka in the Okhotsk Sea are highly productive and produce a large fraction of the total Russian commercial fish and shellfish catches. This region is also the site of a sizeable oil and gas lease area, which is in the exploratory phase of development. While fisheries-related research has been conducted off western Kamchatka for several decades, there has been essentially no directed research on cetaceans and other marine mammals. In total, 351 sightings of 14 cetacean species have been recorded from the 1940s until the present. The sightings included six endangered species: bowhead whales, humpback whales, blue whales, sei whales, North Pacific right whales and gray whales. The low number of sightings of large whales in recent times (in contrast to apparently high historical abundance implied from whaling data) likely reflects a lack of appropriate survey effort as well as low numbers, at least for gray, bowhead, blue and right whales. Given the diversity and conservation status of species using this area, further research is required, notably in light of the potential impacts of oil and gas development. In this regard, plans for the West Kamchatka license area have progressed, with seismic operations set to resume in the summer of 2010. Development of the Koryakia-1 block in adjacent Shelikhov Bay is anticipated in the near future.

Information made available to the SWG concerning a programmatic environmental impact statement by DMNG (a seismic company in the Russian Far East), indicated that there are plans for numerous seismic surveys over the next 10 years in many parts of the Sea of Okhotsk as well as in Anadyr Bay and the Chukchi and East Siberian seas. This implies that most populations of large whales in the region will be increasingly exposed to airgun noise during the open-water season.

In light of the need for further information on the status of cetaceans off western Kamchatka, and the potential impacts on endangered species of oil and gas development in the region, the SWG **recommended** that additional surveys for cetaceans be conducted in the area. The SWG also **recommended** conducting seismic surveys and other potentially disturbing industrial activities, during times of lower cetacean density (i.e. during spring and autumn, outside the primary feeding season) whenever possible.

Suydam described seismic surveys planned for the Chukchi and Beaufort seas off Alaska in 2010. Statoil plans to conduct a combined 2D (i.e. broad scale) and 3D (i.e. fine scale) seismic survey in the Chukchi Sea using a 3,000in^3 airgun array. The survey will occur for 60 days beginning in late July or early August. ION Geophysical plans to conduct a 2D seismic survey across the Alaskan Beaufort Sea using a 4,330in^3 array. They intend to begin in early October and continue into December. There will be sea ice present at that time so an icebreaker will precede the source vessel and the airgun array and streamer will be towed below the surface to avoid ice. This survey was planned in order to avoid disturbing bowheads during the indigenous hunt that occurs in the Beaufort Sea in September and October. In addition to the seismic surveys, other industrial activities are planned including: (1) surveys to document ice gouging and strudel scouring; (2) barging; and (3) exploratory drilling in each of the Beaufort and Chukchi seas (those drilling operations were recently postponed until at least 2011). The US and Canadian Coast Guards are also planning a seismic survey to document the extended continental shelf, as part of a multinational effort related to the Law of the Sea. Further, seismic surveys are planned for the Canadian Beaufort Sea and the Russian Chukchi Sea in 2010. There will be a large amount of anthropogenic sounds in the waters of the Beaufort and Chukchi Seas in 2010. Typically, concerns have largely focused on the behavioural impact to bowheads and other marine mammals from industrial sounds. With such widespread activity, there is an increasing need to understand and mitigate cumulative impacts, including the possibility that anthropogenic noises are masking sounds produced by whales and hindering important life functions, as well as temporal displacements from critical areas.

The SWG was informed that industry has initiated a Joint Industry Program (JIP), funding research into an alternative technology called marine vibroseis. The goal of the JIP is to have an alternative source operational within the next few years. The SWG **encouraged** this research and **recommended** continued development of alternative methodologies with lower source levels. Additional information on survey technologies can be found in Weilgart (2010), the Okeanos workshop report 'Alternative technologies to seismic airgun surveys for oil and gas exploration and their potential for reducing impacts on marine mammals' (available from: *http://www.sound-in-the-sea.org/download/AirgunAlt2010_en.pdf*).

9.2 Other factors related to masking

Jensen *et al*. (2009) studied the masking effects of small (2 and 4 stroke) outboard engines on common bottlenose dolphins and short-finned pilot whales. They found that at 50m and a boat speed of 5 knots, communication ranges for pilot whales were reduced by 58% and for bottlenose dolphins by 26%. At 10 knots and a distance of 200m there was approximately a 70% decrease in communication distance for both species, with approximately a 90% reduction for pilot whales and over 80% for bottlenose dolphins at 50m. At 2.5 knots, at 50m, there was little masking noise. Moreover, the boats produced substantive broadband noise (up to 200dB re 1μPa peak to peak) when the boats changed gears, which could occur several times a minute when the small boats were manoeuvring – a common occurrence for both whalewatching vessels and also small-boat based studies of focal small cetacean groups.

Dunlop *et al*. (In press) was briefly summarised, which reported an increase in humpback whale aerial behaviour correlated with increasing natural ambient noise levels as wind speeds increased. It was suggested that this increased aerial behaviour allowed communication in a noisier environment, i.e. to overcome masking. It was noted that this might result in additional energetic costs to breeding humpback whales.

9.3 Case studies

A brief summary of the discussions and conclusions of the Workshop on Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals (SC/62/E6) was reported to the SWG. The original report should be seen as the definitive document (available at *http://www.sound-in-the-sea.org/download/CIA2009_en.pdf*). It was reported that the workshop participants agreed that effective management should include comprehensive cumulative impact assessments (CIAs), which should include noise and its various effects. CIAs are especially needed to appropriately account for non-lethal and sub-lethal effects of human disturbance, including stress-related effects that can reduce reproductive rates and/or increase 'invisible mortality' (i.e. unmeasurable, given existing survey and detection methods). At very low data levels, an estimation of the cumulative exposure to human activities (or even simply a list of activities and locations) should be possible. Marine mammal distribution and abundance information can then be overlaid on this and, if data permits, population models, in particular individual-based models, can then be used to estimate the resulting cumulative impacts. With enough data, it should also be possible to consider physiological processes within an individual to better account for the interactions between the disparate initial effects upon an animal. A new way of considering this conceptually was presented to the SWG. Participants of the workshop agreed that the introduction of anthropogenic noise sometimes introduced incidentally and the presence of other tangible threats should be reduced to the maximum extent possible to allow marine mammal populations to more resiliently face the now-unavoidable consequences of climate change, some of which are already becoming evident. They also noted that CIAs were better suited to marine spatial planning and ecosystem-based management, rather than the project-based management approaches that are currently used.

The SWG **recommended** that member governments work to develop a quantitative approach for assessing cumulative impacts. Assessments should incorporate the various ways that anthropogenic sounds might impact cetaceans and their prey.

The SWG was informed of a 2008 study on shipping noise in coastal waters of British Columbia, Canada. Large between-site differences in ambient noise levels were persistent over the six-month deployment in 2008.

Smaller differences were found between ambient noise levels in critical habitats for northern and southern resident killer whales during shorter pop-up deployments in 2009. Sound propagation models indicated that container ships moving through these waters ensonify large areas, and this

could mask substantial fractions of the foraging space of a humpback whale in the vicinity. In geographically complex regions (e.g. archipelagos or convoluted passages), this sound propagation is similarly complex, but it appears generally that whales would receive less 'advance warning' acoustically from a ship that is approaching in such habitats than they would from the same sound source in open ocean. The apparent link in this case between acoustic propagation and ship-strike risk in geographic bottlenecks would benefit from integrating acoustic studies and density surface modelling in a spatially-explicit risk assessment (Williams and O'Hara, 2010).

Lusseau presented SC/62/WW5, a summary of progress from a project tasked to develop a formal mathematical structure from the Population Consequences of Acoustic Disturbance (PCAD) conceptual framework (available at *http://www.nap.edu/catalog*). The working group was convened by the University of California Santa Barbara with support from the Office of Naval Research and is meeting every six months over a three year period. During these meetings modellers and field researchers meet to develop approaches and discuss the feasibility to fit them to a wide range of existing data to try parameterising the agreed models. This PCAD working group has made significant progress over the first two meetings. It decided to develop three statistical models to provide the linkages from disturbance to population dynamics. Work has focused on the first models (disturbance to physiological conditions). It developed a state space modelling approach (SSM) based on Lorenz and McFarland's concepts (the hydraulic model and its subsequent extensions) that behaviour emerges from the interactions between the motivational states of individuals and the environment. Motivational states and physiological conditions (at first here body condition) are hidden processes that are linked to observed behaviour. The parameters of these processes are then inferred (exploring both maximum likelihood and Bayesian estimation methods) by fitting these SSMs to behavioural time series. First implementations with simple systems (southern elephant seals at-sea movement) proved extremely successful and body condition time series could be estimated and validated against body weight when the seals returned to the colony. A similar, albeit more complex, framework was developed for coastal dolphin population case studies and will be implemented over the next year. The working group is happy to continue reporting to the Scientific Committee on progress.

It was noted that the motivational state-space approach to the PCAD framework was creative; however, the PCAD working group needs to acknowledge the limitations of the original US National Research Council model. For example, it has been shown that behavioural responses cannot reliably be used to infer disturbance impact in animals without extensive contextual information, which has not been fully incorporated into the framework. While energetic condition and related concepts such as hunger are included in the working framework, almost no consideration has been given to psychological condition. Anxiety, cognitive bias and other stress-related conditions will greatly affect motivation, behavioural responses to disturbance and the ultimate impact on vital rates. Furthermore, overall psychological condition may be influenced by non-behavioural consequences of acoustic exposure, including masking, which are also missing from the framework.

While it was noted that this is just a framework and simplicity is valuable, these omissions may have serious implications for the accuracy and widespread application of the PCAD framework and should be explicitly recognised to avoid any mis-application, especially in management settings. In response, Lusseau noted that the modelling approach was flexible enough to incorporate the type of alternative pathways mentioned. The group was currently focusing on energetic pathways because it meant that parameters could be estimated by fitting the state space frameworks to existing behavioural and demographic data. However, this did not preclude extending frameworks in the future when more information becomes available. Importantly, this approach will allow constructing contrasting frameworks and testing or validating them against observations. This is a significant step in developing quantitative methods to address non-lethal effects of disturbances. The SWG encouraged the work of the PCAD working group and looks forward to receiving updates in the future.

In SC/62/SH12 passive acoustic monitoring was used to document the temporal and spatial distributions of singing humpback whales off the coast of northern Angola, off the Congo River outflow, and test for impacts of seismic survey activity on the number of singing whales. Two Marine Autonomous Recording Units (MARUs) were deployed between March and December 2008, in the offshore environment (at 15km and 24km offshore). Numbers of humpback whale singers per hour were counted for the period from 24 May to 1 December Application of General Additive Mixed Models (GAMMs) indicated significant seasonal and diel variation. Seismic survey activity was heard regularly during two separate periods during the deployments, during July and later in the season during mid-October/November. Assessment of a measure of Received Level (RL), Peak Power, of seismic survey pulses as an effect on the number of singers yielded a significant impact: in GAMMs for both MARUs, the number of singers significantly decreased with increasing RL of seismic survey pulses. This suggests that the breeding display of humpback whales is disrupted by seismic survey activity, and thus merits further attention and study.

The SWG welcomed this study and others examining potential changes in whale acoustic behaviour in response to anthropogenic noise. In studies like these, the SWG **recommended** that the detectability of whale calls during exposure and non-exposure periods be quantified.

Gedamke discussed the recently funded project 'Behavioral Response Study with Australian humpback whales and seismic air guns'. This large scale, five-year research programme has been jointly funded by the E and P Sound and Marine Life Joint Industry Programme (JIP) and US Minerals Management Service. This project aims to provide information that will reduce the uncertainty in evaluating impacts of seismic surveys on humpback whales. It will also assess the effectiveness of ramp-up as a mitigation measure, with the potential to improve design of ramp-up. There will be two experimental regimes and two study sites: one offshore of Western Australia and one inshore on the east coast of Australia. One experimental regime, used only at the offshore site, will be the exposure of whales to a commercial seismic airgun array. The second regime will involve controlled exposure of whales to components of ramp-up, and will be used at both sites to compare responses to the same stimuli between sites. The inshore site allows detailed and high resolution observations by using land-based observations and thus provides a larger amount of whale response information and a higher degree of experimental control than possible at the offshore site; while the offshore site will allow for examination of reactions to a

full-scale commercial seismic array. Research is planned to commence in September 2010.

The SWG welcomed this as a well-designed study that has the potential to greatly inform the discussion. The authors were encouraged to bring results of the work to the sub-committee as the study is undertaken and completed. Further, it was noted that the nested block design to control for a wide variety of variables is also being used in impact studies being considered by others, such as the LaWE being designed by the whalewatching sub-committee. Hence, the authors were requested to also present any power analysis that helps inform necessary sample sizes to reach appropriate conclusions, since they may be useful across the Scientific Committee.

9.4 Progress in reducing low frequency sounds from shipping

Over the past 50 years, the world's commercial shipping fleet has roughly tripled and vessels have become much larger. Concomitantly, low-frequency ambient noise in many especially coastal areas of the ocean has increased at a rate of roughly 3dB/decade. Although there is variability among regions this has resulted in an estimated overall average increase of at least 20dB from pre-industrial conditions to the present (Hildebrand, 2009).

The recognition of noise from commercial shipping as an important component to this increase in ambient noise has been recognised by scientists for roughly 40 years, but has been brought to the attention of industry only recently. Specifically, the US National Oceanic and Atmospheric Administration (NOAA) convened workshops in 2004 and 2007 to engage representatives of the international shipping industry, as well as scientists, engineers, environmentalists and government representatives in cooperative dialogue regarding incidental noise radiated from vessels and potential impacts on marine life. Engineers and specialists in vessel quieting participated in both workshops and concluded that the most promising initial target for vessel quieting were propulsion systems, primarily retrofit or redesign of propellers.

A key outcome of the 2007 workshop was the submission of an information paper 'Shipping Noise and Marine Mammals' by the US delegation to the International Maritime Organization (IMO MEPC, 2007). In 2008, Okeanos hosted a follow-on symposium in Hamburg, Germany (Wright and Okeanos Foundation for the Sea, 2008) - available at *http://www.sound-in-the-sea.org/download/ship2008_en.pdf*) that resulted in the provision of a specific goal of noise reduction from commercial shipping (i.e. sound in the 10-300Hz frequency band) of 3dB in 10 years and 10dB in 30 years. This goal was subsequently endorsed by the Scientific Committee (IWC, 2009). Later that year and resulting from the combined efforts of the NOAA symposia and the Okeanos workshop, a specific proposal was made by the US delegation to the IMO Marine Environment Protection Committee (MEPC) for the formation of a Correspondence Group (CG) to:

> 'identify and address ways to minimise the introduction of incidental noise into the marine environment from commercial shipping to reduce the potential adverse impact on marine life, in particular develop non-mandatory technical guidelines for ship-quieting technologies as well as potential navigation and operational practices.'

The resulting CG, which included representatives from 17 nations and 12 non-governmental organisations, consulted with hull and propeller design engineers and, in 2009, submitted two reports focused on technical and practical aspects of vessel quieting. A third report from the CG, providing additional recommendations on vessel quieting is anticipated for the 61st meeting of the IMO in September 2010.

Additional recent efforts with regard to the impact of shipping noise on the marine environment include the completion by the Arctic Council of the Arctic Marine Shipping Assessment (AMSA; see *http://arctic-council.org*) and the development of standards for the measurement of vessel noise (Bahtiarian, 2009). While the focus of the AMSA is marine safety and marine environmental protection, the SWG noted particularly one recommendation (of 17) given as:

> 'Addressing impacts on marine mammals: that the Arctic states decide to engage with relevant international organisations to further assess the effects on marine mammals due to ship noise, disturbance and strikes in Arctic waters; and consider, where needed, to work with the IMO in developing and implementing mitigation strategies.'

This recommendation further emphasises the central nature of the IMO with regard to efforts to mitigate the effects of shipping noise (and strikes) on whales. Lastly, the SWG noted the upcoming Sustainable Ocean Summit (SOS), hosted by the World Ocean Council (WOC), which aims to bring together industries that use and impact the oceans (e.g. shipping, oil and gas, dredging, offshore renewable energy, fishing aquaculture and tourism) to catalyse collaboration among these sectors to address cross-cutting marine environmental issues including ocean noise from commercial shipping and other human activities.

The IMO MEPC has had 'Noise from commercial shipping and its adverse impact on marine life' on its programme since 2008 (IWC/62/4). In 2009, the General Assembly of the IMO granted the IWC observer status when it approved the proposed Agreement of Co-operation between IMO and IWC. This provides an unprecedented opportunity for both organisations to advance the overarching goal of reducing noise from commercial shipping worldwide. With reference to the IWC's awareness of the critical nature of acoustic communication to whales and that interference, or masking, of this communication is to some extent preventable, the SWG **strongly recommended** that:

(1) the goal of noise reduction from shipping advanced in 2008 (i.e. 3dB in 10 years; 10dB in 30 years in the 10-300Hz band) be actively pursued;
(2) new and retro-fit designs to reduce noise from ship propulsion be advanced within the goals of the IMO, when and wherever practicable; and
(3) the IWC and IMO continue to work collaboratively to advance the goal of worldwide reduction of noise from commercial shipping when and whereever practicable including reporting progress on noise measurements and implementing noise reduction measures.

10. REVIEW PROGRESS ON WORK FROM THE SECOND CLIMATE CHANGE WORKSHOP

The Second Climate Change Workshop (IWC, 2010) resulted in a series of recommendations summarised under three headings corresponding to working groups established at the workshop: Arctic, Southern Ocean and Small Cetaceans. Recommendations from the workshop were reviewed and endorsed by the SWG at last year's meeting, and subsequently adopted by the full Scientific Committee at last year's meeting. Progress on those recommendations is summarised below.

With regard to the Arctic, three study themes were endorsed: (a) Single Species-Regional Contrast; (b) Trophic Comparison; and (c) Distribution Shift. It was thought that work must be undertaken within each of these categories before specific recommendations on analytical methods and modelling can be made. With regard to theme (a), planning discussions have been completed for a comparison of physical indicators of climate change and available data on population dynamics and behavioural ecology of the B-C-B and HB-DS populations of bowhead whales. There are extensive, but not always corresponding, data for both populations, each of which occupies habitats undergoing rapid physical alterations with regard to changes to seasonal sea ice and (potentially) other bio-physical parameters. A list of available physical and biological datasets is being assembled, after which a formal outline and timeline for completion of the proposed study will be developed.

Brandon and Simmonds presented Alter *et al*. (2010) noting that last year the Scientific Committee recommended that countries should pay more attention to the tertiary concerns arising from climate change – the topic of the paper and something that was also emphasised, but not fully developed, at the IWC's Second Climate Change Workshop. The context to this is that while climate change is expected to affect cetaceans primarily via loss of habitat and changes in prey availability, additional consequences may result from climate-driven shifts in human behaviours and economic activities.

Vulnerability scores were calculated for each species of cetacean taking into account potential shifts in climate-driven human behaviour. The greatest identified threat across species would be an increase in fisheries effort at higher latitudes. Bycatch is one of the biggest conservation issues for cetaceans and fisheries expansion would affect most, if not all species outside the tropics. At the species level, gray whales received the highest cumulative vulnerability score. This is due to their wide latitudinal range and generally coastal habitats. Not surprisingly, polar species were also identified as vulnerable. Increases in shipping, oil and gas exploration and fishing due to the loss of Arctic sea ice are highly likely to exacerbate acoustic disturbance, ship strikes, bycatch and prey depletion for Arctic cetaceans.

However, while concerns about impacts of climate change on cetaceans have largely focused to date on polar species, the evidence presented in Alter *et al*. (2010) suggests that tropical coastal and riverine cetaceans are also particularly vulnerable to those aspects of climate change that are mediated by changes in human behaviour. This category includes many species that are already threatened or endangered, such as the South Asian river dolphin, Indo-Pacific humpback dolphin, Irrawaddy dolphin and finless porpoise.

The recommendations from this research include the following: (1) information about cetacean populations should be incorporated into national, regional and international climate adaptation decisions wherever possible; and (2) human-mediated impacts of climate change should be included in cetacean conservation and management plans. The Management Procedures and *Implementation Reviews* of the IWC can provide a working model for other conservation organisations. Such scheduled scientific reviews will be a necessary ingredient in providing effective conservation advice during coming years and decades, given the potential for rapid and not always predictable human behavioural responses to climate change.

Simmonds presented an update of plans for the small cetaceans and climate change Workshop and its draft agenda. This is a follow up to the IWC's Second Workshop on Climate Change held in Siena in 2009. Fuller details are in the report of last year's Scientific Committee and it was felt last year that it would be helpful to give further consideration to this topic via a small workshop. This suggestion was taken to the Commission and a number of countries committed to support it, including Austria who offered to host it in Vienna. However, it was not confirmed that adequate funds to hold the workshop were available until late last year and the convener, in consultation with the steering group, decided it would be better to postpone it until after IWC/62. Simmonds noted that the steering group recommended two main focal points and one minor one:

- restricted habitats – estuaries, reefs, environmental discontinuities, rivers and shallow waters;
- range changes – i.e. evidence of changes in distributions, reasons and consequences; and
- the Arctic Region (to be considered via a presented review).

Plans will be finalised via the steering group and the workshop is likely to be held in Vienna in November.

The SWG welcomed the information as it relates to small cetaceans and climate change and suggested that the Steering Group used a broad definition of restricted habitat.

The Report from the Second Workshop on Cetaceans and Climate Change in Siena, February 2009 (IWC, 2010) recommended that studies on southern right whales with distributions off South Georgia, the Antarctic Peninsula and the eastern Antarctic be developed with a focus on determining measurable responses to climate change. The SWG provided an update on the responses of the southern right whale population of Península Valdés, Argentina to climate driven changes on their feeding grounds off South Georgia. The Patagonian right whale population has been surveyed annually since 1970 (Payne, 1986). Most right whales give birth once every three years. Calving intervals of 2, 4 and 5 years indicate calving failures (Knowlton *et al.*, 1994). The first 30 years of the study showed that females had fewer calves than expected (experienced calving failures) following years of low krill abundance on the whales' feeding ground off South Georgia (Leaper *et al.*, 2006). Increasing climate variability at South Georgia since 1990 has limited krill abundance and increased fur seal mortalities and pupping failures (Forcada *et al.*, 2008) and could be having similar effects for other krill predators including southern right whales.

Beginning in 2005, the Patagonian right whale population began to experience a succession of high mortality events on their nursery ground at Península Valdés with 322 whales dying over a five-year period including 291 calves (90%). No common cause has been found for the deaths despite intensive efforts of the Southern Right Whale Health Monitoring Program in Argentina. The Southern Right Whale Die-Off Workshop (SC/62/Rep1) identified three possible hypotheses to explain the peaks in calf mortalities: 'a decline in food availability, biotoxin exposure and infectious disease' and 'acknowledged that some combination of factors may be involved.' The possibility that the deaths could have been caused by low food abundance or biotoxins could indicate a possible relationship to changes in sea surface temperatures and climate change. Analysis in Leaper *et al*. (2006) showed the Patagonian right whales' sensitivity to changes in krill abundance and was based on results from the most recent population model reported in Cooke *et al*. (2003) that included aerial survey data from 1971-2000. Aerial surveys continued to be conducted every year since 2000 and analysis of the survey data is complete

Table 1
Some potential impacts to cetaceans during the lifetime of marine renewable energy technologies (from Dolman and Simmonds, 2010).

Wind	Tidal	Wave
Construction		
1. Pile driving (physical damage and noise disturbance/displacement) 2. Similar problems from other forms of attachment 3. Increased vessel movements/associated pollution risk.	1. Pile driving (physical damage and noise disturbance/displacement) 2. Similar problems from other forms of attachment 3. Increased vessel movements/associated pollution risk.	1. Pile driving (physical damage and noise disturbance/displacement) 2. Similar problems from other forms of attachment 3. Increased vessel movements/associated pollution risk.
Operation		
1. Habitat degradation and individual/population displacement 2. Operational noise	1. Habitat degradation and individual/population displacement 2. Operational noise 3. Collisions with exposed blades	1. Habitat degradation and individual/population displacement 2. Operational noise 3. Collisions with structures 4. Entanglements with mooring lines
Maintenance		
1. Anti-fouling releases 2. Increased vessel activity	1. Anti-fouling releases 2.Increased vessel activity	1. Anti-fouling releases 2. Increased vessel activity
Decommissioning		
1. Use of explosives or noisy techniques 2. Fate of decommissioned plants	1. Use of explosives or noisy techniques 2. Fate of decommissioned plants	1. Use of explosives or noisy techniques 2. Fate of decommissioned plants

up to 2008. Cooke is working on a model to cover the whole period from 1971-2008 and once that model is completed Leaper will update his analysis of the relationship between changes in sea surface temperature and calving success. Resighting data of known females with calves across the years with high calf mortalities has shown an increase in 2 and 4-year intervals (indicating calving failures) but the data have to be modelled to see if these changes are significant.

11. OTHER HABITAT RELATED ISSUES

11.1 Marine renewable energy development

SC/62/E7 provides an update to papers previously provided to the Scientific Committee on this theme. There has been a rapid expansion of marine renewable energy devices (MREDs) in European seas as governments strive to meet renewable energy commitments. Today there are some 89 such sites in various stages of development (most of these are wind farms), representing a five-fold increase in numbers since 2000, and a concomitant major increase in the size of planned developments. This paper charts the rapid expansion of MREDs in Europe, including the very large new wind parks planned in UK waters which are far larger in extent than anything that has gone before them and significantly further out to sea.

Dolman and Simmonds (2010) considered marine renewables in a Scottish context. They noted that the UK aims to generate a total of 33GW (gigawatts) of offshore wind energy. Its implementation strategy includes the development of ten offshore wind farms within Scottish territorial waters. In addition, the Scottish Government's target of meeting 50% of Scotland's whole electricity demand from renewable energy by 2020 means that marine wind, wave and tidal farms will be developed along Scottish coastlines, and also out into deeper offshore waters as technology develops. Development on such a scale could have impacts on populations of marine species including baleen whales, such as fin and minke whales; deep diving species such as sperm whales; and white-beaked dolphins, common dolphins and white-sided dolphins, whose distributions, abundances and population trends are relatively little known in Scottish waters. Dolman and Simmonds (2010) identified a series of concerns (Table 1).

Some underwater devices will also be large (for example, the turbines of one device have a diameter of approximately 15 to 20m) and may be positioned in arrays across the habitats that cetaceans frequent. The consequences of encounters between cetaceans and such devices are as yet unknown. Dolman and Simmonds (2010) recommend that the Scottish Government complete full and transparent Marine Spatial Planning, including consideration of cumulative impacts, before moving to license appropriate sites.

SC/62/E8 makes an initial assessment of the possible benefits and disadvantages of marine renewable energy developments, further to a request for such consideration made at last year's Scientific Committee meeting. For example (in addition to the benefit of moving away from exclusive dependency on fossil fuel energy generation) it has been suggested that, if appropriately managed and designed, MREDs may increase local biodiversity and potentially benefit the wider marine environment by acting as both artificial reefs and fish aggregation devices. They might also act as *de facto* marine-protected areas. The extent to which marine renewable sites may cause fisheries to be excluded (or encouraged) currently seems to be unclear. Other matters that remain particularly unclear include the costs of maintenance visits to installations at sea; the collision and entanglement risk created by devices at sea and so forth. This paper concludes that given the demand for renewable energy, engineering and policy decisions made in this field in the near future will have a significant impact on the state of the marine environment. The industry is still in its infancy and so the evidence-base for its impacts is currently poorly developed. Hence there is a need for all stakeholders to engage in wide-ranging ecologically-orientated research to help more fully understand and mitigate undesirable impacts of MREDs and aid good decision making. In conclusion, Simmonds noted that the scale of marine renewable developments, the speed of their development and the many questions about their impacts, both good and bad, mean that the Scientific Committee could usefully help to define the research needed to move this issue along and might usefully review this matter further.

The SWG thanked the authors for their impressive work and extensive list of potential impacts of wind farms.

Given concerns about the impacts of marine renewable developments discussed this year – and especially at this time relating to the pile driving used to anchor wind turbines – and that neighbouring countries may be simultaneously operating pile driving in adjacent sea areas (e.g. in the North Sea) without any coordinated attempt to reduce combined noise levels and disturbance, the SWG **strongly recommended** that countries cooperate to limit impacts on marine wildlife from marine renewable development. The SWG also recommended that the relevant national authorities should seek and immediately deploy effective mitigation measures that should evolve as new information becomes available through an open and flexible adaptive management process. This should include precautionary thresholds agreed between neighbouring countries for the sound energy emitted during pile driving and/or timely coordination of the building action, as well as the monitoring of existing vessel traffic, the electromagnetic field surrounding the infrastructure related to the wind farms, and the possible pollution (e.g. from hydraulic fluid and antifouling treatments) in their subsequent operation. It was commented that recent studies have shown that impacts of wind farm related pile-driving could be quite substantial. For example, Tougaard *et al*. (2009) reported displacement of harbour porpoises to a distance of at least 20km, and a survey of harbour porpoise habitat in relation to proposed wind farm sites finding that nearly 40% of German EEZ harbour porpoise stock could be impacted by wind farm construction (Gilles *et al.*, 2009). The SWG also noted that oil rigs often involve pile driving, like wind farms, and vibrations and sounds are produced during rig operation. A recent study noted porpoises clustering and feeding around an offshore gas extraction rig (Todd *et al.*, 2009), which seemed to be acting like an 'artificial reef', although such clustering behaviour around oil and gas rigs may mean that these animals are exposed to chronic noise and are at risk from spills during rig operation.

The SWG discussed one point of the ICES WGMME Terms of Reference in the 2010 report that was to 'review the effects of wind farm construction and operation on marine mammals and provide advice on monitoring and mitigation schemes'. It was noted that the ICES mitigation recommendations sought to find the levels of acute noise that animals could tolerate and mitigate based on these levels. It was emphasised that tolerance of noise is not equivalent to there being no impacts of noise, as animals may 'tolerate' a stressor because a habitat is essential for example, or because external effects are subtle. Animals exhibiting 'tolerance' could still be negatively impacted in a way that could be biologically significant (e.g. suffering stress). The SWG **endorsed** the recommendations of the ICES WGMME.

11.2 Other habitat studies

In order to establish a baseline map of cetaceans and other pelagic megafauna (sirenians, seabirds, sea turtles, large fish, large sharks and rays, etc.) across the French EEZ, the French Agency for Marine Protected Areas (AAMP) conducted a series of surveys allowing hotspots of abundance and diversity to be identified and a future monitoring scheme to be established. SC/62/E14 described the general design, current progress and future perspectives of the Recensements des Mammiferes Marins et autre Megafaune Pelagique par Observation Aerienne (REMMOA) project. This paper is intended to help exchange information with scientists and stakeholders that would be interested in participating in these regional scale cooperations.

A dedicated aerial survey methodology, following standard protocols, was preferred to ship surveys for its cost-effectiveness. The general design corresponds to published protocols prepared for small cetaceans, but data for other marine mammals (large whales, sirenians), seabirds, sea-turtles, large teleosts and large elasmobranchs, as well as human activities (fishing vessels, boating and merchant ships, marine debris >0.5m size), were collected.

The first surveys were conducted from February-March 2008 across the EEZ of Martinique and Guadeloupe (Caribbean; 123,000km², 8,400km or 71h of effort) and in October 2008 off Guiana (138,000km², 7,800km or 63h of effort). From December 2009 to April 2010, a survey was conducted in the southwest Indian Ocean region. It was designed and implemented regionally under the framework provided by the Indian Ocean Commission (IOC; a regional agreement including Comoros, France/Réunion, Madagascar, Mauritius, Seychelles), i.e. a study region of approximately 5,000,000km² where we deployed about 90,000km or 500h of effort. During the Caribbean survey, a total of 55 sightings of cetaceans were collected, including 12 different taxa. In the Guiana survey, 140 sightings of cetaceans were collected that included 10 different taxa. In the southwest Indian Ocean, 1,274 sightings of cetaceans were collected on effort, including 17 different taxa.

In the near future, the South Pacific regions will be surveyed during 2010-11 (French Polynesia) and 2011-12 (southwest Pacific Ocean around New Caledonia and Wallis and Futuna). Finally, the Atlantic survey is planned for 2012-13. Given the surface areas to be covered for these highly mobile pelagic organisms, a regional approach is highly recommended. To build the conditions for such cooperations, contacts have to be established with these countries and regional agreements identified to act as frameworks for these collaborations. The study areas will ultimately include all sectors of the French EEZ in the tropical Atlantic (French Caribbean and Guiana), Indian (Reunion Island, Mayotte and the Scattered Islands) and south Pacific (French Polynesia, New Caledonia, Wallis and Futuna) Oceans. The general aim of the analyses carried out so far was to map regional diversity and relative abundance of cetaceans and other megafauna across oceanic regions and identify zones where hotspots of abundance or biodiversity overlap with hotspots of human activities. The analytical strategy was exemplified from the Caribbean survey, but must be considered as provisional since analytical effort will develop and diversify as new surveys become available.

Panigada informed the SWG about similar systematic monitoring of density and abundance, conducted through aerial survey effort, of the most common cetacean species of the Pelagos Sanctuary and the seas surrounding Italy (plus other large megafauna, including elasmobranchs and turtles).

Aims of these programmes, funded by the Italian Government, are to inform conservation measures throughout the Mediterranean Basin and are priority actions in a number of other international bodies (e.g. the Sanctuary Management Plan, ACCOBAMS, the Specially Protected Areas and Biodiversity Protocol under the Barcelona Convention, the EU Habitat Directive and the Convention on Biological Diversity).

As part of this effort, a series of aerial surveys has been conducted throughout the Pelagos Sanctuary in winter and summer 2009 and in the Ionian Sea. Other surveys are planned in the Tyrrhenian Sea and the Sea of Sardinia, plus another survey covering the whole Pelagos Sanctuary area.

The SWG **commended** the authors' study and noted the impressive advancements of current methodologies giving the authors the ability to correlate cetaceans with specific habitats as well as other megafauna. The author clarified that this study was conducted out of the tradewind season to ensure favourable sea state conditions, but eliminated the possibility of observing large whales in their breeding grounds. The SWG also urged the authors to expand their study to include a passive acoustic component.

11.3 Update on 2008 Madagascar stranding

Following on from the update presented in last year's sub-committee meeting on the 2008 Madagascar Mass Stranding Event (MMSE), progress has been limited since the change in Government just over a year ago. Two potential scenarios to move forward with an Independent Scientific Review Panel (ISRP) are given below.

(1) National Office of the Environment (ONE) would be an appropriate body to request and oversee the establishment of the ISRP. It is part of their mandate as the parastatal organisation responsible for ensuring compliance with environmental impact assessments. They could be supported by an independent body – such as IUCN – in the oversight of this panel.
(2) The Environmental Governance Commission could potentially serve as a venue to bring up with the Government and/or ONE the need for the establishment of the ISRP to assess the results of the MMSE.

The SWG welcomed this update and thanked The Wildlife Conservation Society and its partners' continuing efforts to bring the results of the MMSE to an appropriate conclusion through an ISRP process, as well as keeping the SWG updated on the current challenges and progress. Given the international importance of drawing some conclusions about the MMSE, the SWG **encouraged** that all efforts to convene the ISRP are considered, and recommended that all parties continue to support and contribute relevant information to an ISRP.

12. WORK PLAN

12.1 SOCER (State of the Cetacean Environment Report)

(1) Receive the SOCER: focus area = Southern Ocean.

12.2 POLLUTION

(2) Review progress on recommendations from the 2010 Workshop (SC/62/Rep4).
(3) Review new information on impact of oil and dispersants on cetaceans.
(4) Review outcomes from new work.

12.3 CERD (Cetacean Emerging and Resurging Disease)

(5) Review progress of the CERD Working Group.

12.4 Anthropogenic sound

(6) Review progress on recommendations from 2010 focus sessions on masking sound.
(7) Focus topic: sounds from pile installation.
(8) Review approaches as available from other international forums (e.g. Report from European Union) with regard to mitigation of effects of anthropogenic sound on cetaceans.

12.5 Climate

(9) Review report from Climate Change-Small Cetaceans Workshop.
(10) Review progress on work from the Second Climate Change Workshop.

12.6 Other habitat related issues

(11) Focus topic: marine renewable energy development (MREDS), global review.

The SWG agreed to keep these items in its work plan for next year. The SWG also thanked Moore for chairing the group.

13. ADOPTION OF REPORT

The report was adopted at 09:20 on 7 June 2010.

REFERENCES

Alter, S.E., Simmonds, M.P. and Brandon, J.R. 2010. Forecasting the consequences of climate-driven shifts in human behavior on cetaceans. *Mar. Policy*. 34(5): 943-954.

Bahtiarian, M.A. 2009. ASA standard goes underwater. *Acoustic Today* 4: 30-36.

Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., van Parijs, S.M., Frankel, A. and Ponirakis, D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Mar. Ecol. Prog. Ser.* 395: 201-22.

Cooke, J., Rowntree, V. and Payne, R. 2003. Analysis of inter-annual variation in reproductive success of South Atlantic right whales (*Eubalaena australis*) from photo-identification of calving females observed off Península Valdés, Argentina, during 1971-2000. Paper SC/55/O23 presented to the IWC Scientific Committee, May 2003, Berlin (unpublished). 16pp. [Paper available from the Office of this Journal].

Dolman, S. and Simmonds, M.P. 2010. Towards best environmental practice for cetacean conservation in developing Scotland's marine renewable energy. *Mar. Policy* 34: 1021-27.

Dunlop, R.A., Cato, D.H. and Noad, M.J. In press. Your attention please: increasing ambient noise levels elicits a change in communication behaviour in humpback whales (*Megaptera novaeangliae*). *Proceedings of the Royal Society B*.

Forcada, J., Trathan, P.N. and Murphy, E.J. 2008. Life history buffering in Antarctic mammals and birds against changing patterns of climate and environmental variation. *Global Change Biology* 14: 2473-88.

Gilles, A., Scheidat, M. and Siebert, U. 2009. Seasonal distribution of harbour porpoises and possible interference of offshore wind farms in the German North Sea. *Mar. Ecol. Prog. Ser.* 383: 295-307.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Mar. Ecol. Prog. Ser.* 395: 5-20.

International Maritime Organization Marine Environment Protection Committee. 2007. Any other business - shipping noise and marine mammals, submitted by the United States. 6pp. MEPC 57/INF.4.

International Whaling Commission. 2005. Report of the Scientific Committee. Annex K. Report of the Standing Working Group on Environmental Concerns. *J. Cetacean Res. Manage. (Suppl.)* 7:267-81.

International Whaling Commission. 2006. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 8:1-65.

International Whaling Commission. 2009. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 11:1-74.

International Whaling Commission. 2010. Report of the Workshop on Cetaceans and Climate Change, 21-25 February 2009, Siena, Italy. *J. Cetacean Res. Manage. (Suppl.)* 11(2):451-80.

Jensen, F.H., Bejder, L., Wahlberg, M., Aguilar Soto, N., Johnson, M. and Madsen, P.T. 2009. Vessel noise effects on delphinid communication. *Mar. Ecol. Prog. Ser.* 395: 161-75.

Knowlton, A.R., Kraus, S.D. and Kenney, R.D. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Can. J. Zool.* 72(7): 1,297-305.

Leaper, R., Cooke, J., Trathan, P., Reid, K. and Rowntree, V. 2006. Global climate change drives southern right whales (*Eubalaena australis*) population dynamics. *Biology Letters* 2: 289-92.

Omata, Y., Hammond, T., Itoh, K. and Koichi Murata, K. 2005. Antibodies against *Toxoplasma gondii* in the Pacific bottlenose dolphin *(Tursiops aduncus*) from the Solomon Islands. *J. Parasitol.* 91: 965-67.

Payne, R. 1986. Long term behavioral studies of the southern right whale (*Eubalaena australis*). *Rep. int. Whal. Commn (special issue)* 10: 161-67.

Stachowitsch, M., Parsons, E.C.M. and Rose, N.A. 2008. State of the cetacean environment report (SOCER) 2008. Paper SC/60/E1 presented to the IWC Scientific Committee, June 2008, Santiago, Chile (unpublished). 24pp. [Paper available from the Office of this Journal].

Tachibana, M., Watanabe, K., Kim, S., Omata, Y., Murata, K., Hammond, T. and Watari, M. 2006. Antibodies to *Brucella* spp. in Pacific bottlenose dolphins from the Solomon Islands. *J. Wildl. Dis.* 42: 412-14.

Todd, V.L.G., Pearse, W.D., Tregenza, N.C., Lepper, P.A. and Todd, I.B. 2009. Diel echolocation activity of harbour porpoises (*Phocoena phocoena*) around North Sea offshore gas installations. *ICES J. Mar. Sci* 66: 734-45.

Tougaard, J., Carstensen, J., Teilmann, J., Skiv, H. and Rasmussen, P. 2009. Pile driving zone of responsiveness extends beyond 20km for harbour porpoises (*Phocoena phocoena* (L.)). *J. Acoust. Soc. Am.* 126: 11-14.

Weilgart, L.S. 2010. *Report of the Workshop on Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and their Potential for Reducing Impacts on Marine Mammals, held by Okeanos - Foundation for the Sea, Monterey, California, USA, 31st August-1st September 2009*. Okeanos - Foundation for the Sea, Auf der Marienhole 15, D-64297 Darmstadt. 29pp.

Williams, R. and O'Hara, P. 2010. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. *J. Cetacean Res. Manage.* 11(1): 1-8.

Wright, A.J. and Okeanos Foundation for the Sea. 2008. *International Workshop on Shipping Noise and Marine Mammals, held by Okeanos - Foundation for the Sea, Hamburg, Germany, 21st-24th April 2008*. Okeanos - Foundation for the Sea, Auf der Marienhole 15, D-64297 Darmstadt. 34pp.

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. Receive the State of the Cetacean Environment Report, SOCER
7. Review progress in planning for the POLLUTION 2000+ Phase II
   - 7.1 Workshop report
   - 7.2 Update on oil spill in the Gulf of Mexico
8. Review progress of CERD Working Group
9. Review new information on anthropogenic sound and cetaceans, focusing on masking sounds (e.g. noise from shipping and other low frequency sources)
   - 9.1 Concerns related to anthropogenic masking of low-frequency sounds
   - 9.2 Other factors related to masking
   - 9.3 Case studies
   - 9.4 Progress in reducing low frequency sounds from shipping
   - 9.5 Recommendations
10. Review progress on work from the Second Climate Change Workshop
11. Other habitat related issues
    - 11.1 Marine renewable energy development
    - 11.2 Mapping diversity of cetaceans and other pelagic megafauna
    - 11.3 Update on 2008 Madagascar stranding
12. Work plan
13. Review and adopt report

Appendix 2

POLLUTION 2000+ WORK PLAN PROPOSAL

Based on the Phase II Intersessional IWC POLLUTION 2000+ Workshop results, the Steering Committee recommends the following two tasks.

I. Complete the chemical prioritisation survey and analyses

The Workshop had developed a 'prioritisation hazard identification framework' to evaluate the broad number of environmental pollutants of concern to cetaceans. It also agreed that the most appropriate way to use this framework is to undertake an international prioritisation survey of the appropriate experts in marine mammals and/or toxicology.

The desired outcomes from this survey are:

(1) a prioritised list of chemicals of concern;
(2) a prioritised list of species at risk; and
(3) identification of potential hot spots.

To achieve this, each Workshop participant will distribute the survey to 2-3 subject matter experts, with a cover letter from the Steering Committee and request their part in the survey. Experts will have expertise in marine mammals, toxicology or analytical chemistry and the list of such experts will be developed by the Steering Committee. The survey will be sent to the appropriate experts, the results compiled and a final report submitted to the 2011 Annual Meeting.

II. Risk assessment modelling to determine the impact of pollutants on cetacean populations

We propose that modelling exercises be undertaken following the recommendations of the Phase II Intersessional IWC Pollution 2000+ Workshop (IWC/62/Rep4). This will involve the development and implementation of two

demonstration projects, using the risk assessment framework (based on an individual based model approach) outlined by Hall and Schwacke (Hall *et al*., 2006). Work will require the assistance of a post-doctoral research assistant for a period of two years, under the direct supervision of Schwacke and Hall with input and guidance from the POLLUTION 2000+ Steering Committee.

This work will be a two-year project. The Steering Group will provide a progress report to the 2011 Annual Meeting and a final report to the 2013 Annual Meeting.

Completion of this work will allow the Scientific Committee to make substantial progress on four modelling recommendations of the Workshop as follows.

(1) *Improve the existing concentration-response (CR) function for PCB-related reproductive effects in cetaceans*. This involves re-initiating efforts to derive a CR function based on surrogate species for reproductive effects in relation to PCB exposure. The CR component will be improved by conducting a literature search and integrating additional data into the model from recent studies.

(2) *Derive additional CR functions to address other endpoints (i.e. survival) in relation to PCB exposure.* This requires a multi-stage modelling approach, e.g. a series of functions that provide a connection from PCB exposure → functional immune endpoints → increased pathogen susceptibility → increased likelihood of mortality.

(3) *Integrate improved concentration-response components into a population risk model (i.e. individual-based model) for two case study species: bottlenose dolphin and humpback whale.* This is the primary deliverable for the study. These two species have been chosen as demonstration projects since they represent a small and large cetacean species for which sufficient relevant data already exist on both exposure and vital rates for specifically defined populations. The model will be developed with a user-friendly interface such that it can be distributed throughout the scientific community for use and development for other species and endpoints where sufficient life history, contaminant exposure and vital rate data exist. The overall objective is to determine the magnitude of the risk to a population (as measured, for example, by potential population growth rate) from contaminant exposure at various levels, which would ultimately allow the 'pollution risk' to be compared with other population-level risks faced by these species (e.g. the impact of bycatch or prey availability).

(4) *Implement a CR component for at least one additional Contaminant of Concern (COC).* The COC would be determined by the steering committee based on given knowledge for likelihood of exposure and toxicity. This will involve a literature search to parameterise the additional CR component and investigate changes in model outcome assuming both additive and synergistic effects.

Budget

The overall cost of the project would be £123,168. This assumes that the postdoctoral position will be shared between Sea Mammal Research Unit (SMRU), St Andrews, Scotland and NOAA, Charleston, SC, USA. A steering committee meeting will be held at SMRU at the end of Year 1 to review progress of the project and to prioritise contaminants of concern for inclusion in the framework.

Total budget for two-year project [UK £ pounds]

Total budget for two-year project (£).

Budget item	Justification	Cost
Postdoctoral salary	£55,356/year for 2 years	£110,713
Travel to SMRU	£2,076 for travel x 2 trips	£4,152
POLLUTION 2000+ Committee Review	Travel for 4 persons to SMRU for 3-4 days work	£8,303
Total		£123,168

Total budget for year one

Postdoctoral salary: £55,356
Travel to SMRU: £2,076

Total budget for year two

Postdoctoral salary: £55,356
Travel to SMRU: £2,076
Travel (for four persons) to SMRU for POLLUTION 2000+ Committee Review: £8,303

REFERENCE

Hall, A.J., McConnell, B.J., Rowles, T.K., Aguilar, A., Borrell, A., Schwacke, L., Reijnders, P.J.H. and Wells, R.S. 2006. Population consequences of polychlorinated biphenyl exposure in bottlenose dolphins - an individual based model approach. *Environ. Health Perspect*. 114, Suppl. 1:60-64.

Appendix 3

CERD WORK PLAN

Proposed work plan for the CERD Working Group to be performed for IWC/63 through intersessional e-mail and conference call participation.

(1) The skin disease subgroup (Rosa [Chair], Brownell, Carlson, Galletti, Marcondes, Mattila, Robbins, Rosa, Rowles and Weller) will continue progress for web-based access.
(2) Utilising the fields developed for diagnostic laboratories, the Working Group will complete the identification of diagnostic laboratories by region, ocean basin or country.
(3) Building on a One Health concept, coordinate with other wildlife disease surveillance efforts such as USAID Emerging Pandemic Threats programme, OIE Working Group on Wildlife Diseases, or other national, regional or international efforts for capacity building, training and outbreak investigations.
(4) Complete the prioritisation of pathogens survey and analyses and provide a report at next year's meeting.
(5) Expand the emergency response steering committee (Fernandez [Chair], Brownell, Jepson, Marcondes, Rosa, Rowles, Uhart and Urban):
    (a) coordinate with International Union for the Conservation of Nature (IUCN), ICES and other international response-planning efforts;
    (b) develop response coordination plan using a regional approach;
    (c) identification of potential funding sources for preparedness and response for international marine mammal die-off, mass stranding responders or other emergency responses; and
    (d) coordinate responses as needed or requested.
(6) Enhance capacities and communications between stranding networks:
    (a) finalise a web-based database of stranding networks that integrates the ICES, ship strike and emergency response databases and provide access for periodic updates; and
    (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.
(7) Provide scientific advice and experts for investigations of die-offs or outbreaks across and within national and regional boundaries (Marcondes [Chair], Brownell, Rowles and Uhart):
    (a) coordinate and assist with mortality investigations of large whales in the Southern Hemisphere.
(8) Create a CERD website that will include the following items previously listed in last year's work plan [*this item has been deferred to 2012 until after some of the above are developed*].

No funding is requested from IWC at this time.

Appendix 4

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2010

Editors: M. Stachowitsch*, N.A. Rose** and E.C.M. Parsons+

INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 (IWC, 1998) and 1998-5 (IWC, 1999), directed the Scientific Committee 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 (IWC, 2001) 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 (Stachowitsch *et al.*, 2003) 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 the newest information that applies generally to the cetacean environment. SC/62/E1 (SOCER 2010) focuses on the Arctic Ocean, summarising key papers and articles that have been published from 2008 through 2010 to date.

ARCTIC OCEAN

General

BELUGA WHALES IN ALASKA LISTED AS ENDANGERED

The Cook Inlet beluga whale population near Anchorage, Alaska, has been listed as an endangered species under the US Endangered Species Act because the population is not recovering despite protection measures. The population declined by nearly 50% between 1994 and 1998, with current numbers between 3-400. Recovery has apparently been hindered by strandings, developments along the inlet, oil and gas exploration, industrial activities, disease and predation by killer whales.

(SOURCE: News-in-Brief. 2008. *Mar. Pollut. Bull.* 56: 1,962.)

Habitat protection/degradation

General

THREATS TO ARCTIC MARINE MAMMAL SPECIES

Threats to Arctic marine mammal species include climate change, environmental contaminants, offshore oil and gas activities, shipping, hunting and commercial fisheries. Oil and gas exploration is occurring in Baffin Bay and the Barents, Beaufort and Chukchi Seas, with additional upcoming exploration in Eurasia, increasing the potential for oil spills from extraction or shipping and transfer accidents. Fisheries in Arctic waters have been limited, but fisheries bodies are preparing for the opening of new fisheries in the near future as a result of easier Arctic access as sea ice recedes. Fishing in the Arctic could lead to conflict between marine mammals and fisheries, if marine mammal prey species are taken (as targeted catch or bycatch). The projected impacts of climate change are numerous: '*Climate change has reduced arctic sea ice, lengthened periods of open water, and raised water temperatures in marginal seas; changes that are expected to continue or even accelerate…Loss of sea ice means fewer habitats for ice-dependent or ice-associated marine mammals...Changes in water temperature will undoubtedly alter primary productivity, the resulting food web, and prey fields for marine mammals...Warmer waters and changed distributions of marine mammals will affect disease prevalence and spread...Furthermore, as sea ice recedes, human activity will increase in the region because shipping and offshore development become economically feasible and advantageous*'.

(SOURCE: Huntington, H.P. 2009. A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades. *Marine Policy* 33: 77-82.)

CHANGES IN ARCTIC ECOSYSTEMS

A review of changes in Arctic ecosystems warns of the effects of changing geochemical cycles, shifts in distributions, invasive species and an increase in extreme environmental events. It highlights that '*some of the most rapid ecological changes associated with warming have occurred in marine and freshwater environments, associated with changes in sea ice dynamics and external nutrient loading*'. It discusses the lack of research and understanding of Arctic ecosystems, which are often ignored by managers as these systems are relatively species-poor. The review concludes that the '*extensive changes in living components of the Arctic associated with recent climate change documented here have been rapid and widespread across terrestrial, freshwater, and marine systems. Foreseeing and mitigating the ecological consequences of future climate change will require more intensive, multidisciplinary monitoring of both the physical drivers of these systems and biological responses to them*'.

(SOURCE: Post, E., Forchhammer, M.C., Bret-Harte, M.S., Callaghan, T.V., Christensen, T.R., Elberling, B., Fox, A.D., Gilg, O., Hik, D.S., Høye, T.T., Ims, R.A., Jeppesen, E., Klein, D.R., Madsen, J., McGuire, D., Rysgaard, S., Schindler, D.E., Stirling, I., Tamstorf, M.P., Tyler, N.J.C., van der Wal, R., Welker, J., Wookey, P.A., Schmidt, N.M. and Aastrup, P. 2009. Ecological dynamics across the Arctic associated with recent climate change. *Science* 325: 1,355-1,358.)

CURRENT STATUS OF POLAR SEA ICE

There has been a decreasing trend in summer sea ice cover for the past several decades. The minimum extent of summer sea ice in 2009 was 5.36 million km^2, 690,000 km^2 more than the second lowest sea ice extent ever recorded in 2008, and 1.06 million km^2 greater than the record minimum sea ice extent recorded in 2007. Nonetheless, ice extent was the third lowest recorded, and 1.68 million km^2 below the average extent recorded for 1979-2000, a decline of 11.2% per decade relative to this average value. Satellite image data also show a thinning of sea ice, with a decrease of nearly 0.7m between 2004 and 2008.

(SOURCES: Ray, G.C., Hufford, G.L., Krupnik, I.I. and Overland, J.E. 2008. Diminishing sea ice. *Science* 321: 1,443-1,444; Kerr, R.A. 2009. Arctic summer sea ice could vanish soon but not suddenly. *Science* 323: 1,655; National snow and ice data center. 2009. Arctic sea ice extent remains low; 2009 sees third-lowest mark. 6 October 2009, *http://nsidc.org/news/press/20091005_minimumpr.html*; Kwok, R. and Rothrock, D.A. 2009. Decline in Arctic sea ice thickness from submarine and ICESat records: 1958-2008. *Geophys. Res. Lett.* 36: L15501.)

*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.

RATE OF ICE LOSS IN ANTARCTICA AND GREENLAND IS ACCELERATING

Between 1990 and 2000, melting of both the Greenland and Antarctic ice sheets accelerated. A recent satellite data evaluation of ice sheet loss suggests that this loss is increasing even faster. The mass of both Antarctica and Greenland have decreased, with the rate of ice mass loss doubling in Greenland, and more than doubling in Antarctica between 2002 and 2009. The edges of the ice sheets in both locations were shown to be thinning, which is linked to accelerating flow.

(SOURCES; Velicogna, I. 2009. Increasing rates of ice mass loss from the Greenland and Antarctic ice sheets revealed by GRACE. *Geophys. Res. Let.* 36: L19503; Kerr, R.A. 2009. Both of the world's ice sheets may be shrinking faster and faster. *Science* 326: 217; Pritchard, H.D., Arthern, R.J., Vaughan, D.G. and Edwards, L.A. 2009. Extensive dynamic thinning on the margins of the Greenland and Antarctic ice sheets. *Nature* 561: 971-975.)

Marine debris

MARINE PLASTIC DEBRIS AN ISSUE EVEN IN ARCTIC WATERS

Of 102 birds (fulmars) collected in the Canadian high Arctic, 31% had pieces of plastic in their digestive system; 2% of the items was 'industrial' (beads/pre-production pellets), while 98% was 'user' ('post-consumer') plastic. Although the incidence here was lower than the 79-100% occurrence reported in the North Pacific, North Atlantic or North Sea, the proportion represented an increase over the past three decades. The Arctic marine ecosystem is therefore also affected by the worldwide pattern of increasing pollution from marine plastic debris.

(SOURCE: Mallory, M.L. 2008. Marine plastic debris in northern fulmars from the Canadian high Arctic. *Mar. Pollut. Bull.* 56: 1,501-1,504.)

ENTANGLEMENT OF MARINE MAMMALS IN MARINE DEBRIS IN SOUTHEAST ALASKA

Entanglement in marine debris is a contributing factor to Steller sea lion injury and mortality in southeast Alaska and northern British Columbia. Packing bands, rubber bands, nets, ropes and monofilament line were the most common neck entangling items, whereas the most commonly ingested fishing gear were lures, longline gear, hook and line, spinners/spoons and bait hooks. Marine debris is clearly a threat even in remote waters, and such items are also known to affect cetaceans.

(SOURCE: Raum-Suryan, K.L., Jemison, L.A. and Pitcher, K.W. 2009. Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions. *Mar. Pollut. Bull.* 58: 1,487-95.)

Chemical pollution

ANTHROPOGENIC SOURCES: A STRONG CONTRIBUTOR TO MERCURY LEVELS IN ARCTIC WILDLIFE

A comparison of mercury (Hg) levels in historical and pre-industrial *versus* present-day tissue samples from Arctic species showed that the median man-made contribution today is over 92%. The steep onset of mercury exposure began in the latter half of the 19th century and represents an order-of-magnitude increase. The analysis of beluga whale teeth showed that the large 20th century effect on this species occurred mostly before 1960, when man-made Hg had already attained 75% of the total. Older animals exhibited a larger man-made percentage than younger animals, which was predicted because of the multiplicative effects of lifetime bioaccumulation of Hg. In a second study, the Hg contents of Beaufort Sea beluga whales were linked to the Hg contents of their prey: highest Hg levels in the whales matched highest food web Hg levels. This points to a variation in dietary Hg uptake and underlines the importance of examining Hg sources at the bottom of the food web along with food web length.

(SOURCES: Dietz, R., Outridge, P.M. and Hobson, K.A. 2009. Anthropogenic contributions to mercury levels in present-day Arctic animals – a review. *Sci. Total Environ.* 407: 6,120-31; Loseto, L.L., Stern, G.A., Deibel, D., Connelly, T.L., Prokopowicz, A. Lean, D.R.S., Fortier, L. and Ferguson, S.H. 2009. Linking mercury exposure to habitat and feeding behaviour in Beaufort Sea beluga whales. *J. Mar. Syst.* 74: 1,012-1,024.)

POLAR COD SUGGESTED AS A SPECIES TO MONITOR FUTURE OIL POLLUTION IN THE ARCTIC

Arctic waters are predicted to open as a trade route and site of oil and gas exploration due to climate-related loss of ice. This would be associated with an increased risk of oil pollution, as the Arctic is subject to a specific set of additional risk factors such as rough weather conditions and drifting icebergs. Spilled petroleum hydrocarbons persist longer at the low temperatures here and cleaning up spills in such remote regions is difficult, posing an additional potential threat to cetaceans. Due to the high abundance and circumpolar distribution of polar cod, these fish are suggested to be well-suited organisms to monitor oil pollution.

(SOURCE: Jonsson, H., Sundt, R.C., Aas, E. and Sanni, S. 2010. The Arctic is no longer put on ice: Evaluation of Polar cod (*Boreogadus saida*) as a monitoring species of oil pollution in cold waters. *Mar. Pollut. Bull.* 60: 390-395.).

INSUFFICIENT FUNDING AND RESEARCH ON OIL SPILLS IN THE ARCTIC

One of the predicted effects of global warming is increased boat traffic and oil exploration in the Arctic. This increases the risk of oil pollution in these waters. The logistics of combating oil spills here are more difficult than elsewhere: oil degrades much more slowly in cold waters, the Arctic has fewer locations from which to launch cleanup efforts, and the fate and recoverability of oil under ice is unknown. Elsewhere, under ideal conditions, cleanup crews can recover 30% of spilled oil. That figure would be much lower in the Arctic, making it virtually certain that most of the oil will remain in the environment. The US national oil-spill research plan has not been updated in over a decade and the funds spent to study spills in the Arctic are inadequate here compared to Norway, for example.

(SOURCE: Torrice, M. 2010. Science lags on saving the Arctic from oil spills. *Science* 325: 1,335.)

Climate change

IMPORTANT ROLE OF ARCTIC SEA ICE IN PUMPING CARBON DIOXIDE INTO THE OCEANS

Arctic sea ice apparently plays a much larger role than previously recognised in capturing and removing carbon dioxide from the atmosphere and storing it in the world's oceans. Current climate models do not factor in the role of sea ice, which increases the seasonal uptake of CO_2 in the region by 50%. The predicted total loss of summer sea ice from the Arctic within the next few decades may have dramatic effects on this role, leading to further increases in CO_2 in the atmosphere and thus further altering key cetacean habitats.

(SOURCE: News. 2009. *Mar. Pollut. Bull.* 58: 1,593.)

NEW EVIDENCE INDICATES AN ICE-FREE ARCTIC WITHIN A DECADE

Ice thickness was measured in early 2009 along a 450km route across the northern Beaufort Sea by the Catlin Arctic Survey and analysed by the Polar Ocean Physics Group, University of Cambridge. The data show that the ice layer consisted of relatively thin 'first year ice' rather than the normal, thicker, multi-year ice. These data support the emerging thinking that the Arctic Ocean will be largely ice-free in summer within a decade. Beyond the broad climate feedbacks that this may set in motion, increasing ship traffic across this

ocean would pose a potential threat (e.g. ship strikes, noise, pollution) to cetaceans and other marine mammals. In the USA, the North Pacific Fishery Management Council has banned fishing trawlers from following the retreating Arctic ice and fishing in previously ice covered waters.

(SOURCES: News. 2009. *Mar. Pollut. Bull.* 58: 1,770; News. 2009. *Mar. Poll. Bull.* 58: 462.)

ARCTIC MAY REMAIN ICE-COVERED IN WINTER DESPITE WARMING

The late Cretaceous period (65-99 million years ago) is often regarded as a possible indicator of what a world with elevated carbon dioxide levels could look like. Carbon dioxide levels were in excess of 1,000 ppm (possibly four times current concentrations). Temperatures in the Arctic Ocean are estimated to have been up to 15°C during this period and the pole was probably ice free. However, a new study analysing sediment deposition patterns has suggested that there may have been thin, seasonal ice cover in the winter. This suggests that even with atmospheric CO_2 levels much higher than present, winter sea ice may still occur, although in much smaller amounts, with subsequent implications for Arctic ecosystems.

(SOURCE: Davies, A., Kemp, A.E.S. and Pike, J. 2009. Late Cretaceous seasonal ocean variability from the Arctic. *Nature* 460: 254-259.)

TWO THOUSAND YEARS OF ARCTIC CLIMATE DATA SHOW COOLING TREND, THEN ABRUPT WARMING IN PAST 50 YEARS

An extensive analysis of climate proxy data over a 2,000 year period indicated a long-term cooling trend in the Arctic. During the 20th century, following that trend, temperatures should have continued to cool, but this trend was reversed; the last half of the 20th century was the warmest in the 2,000 year proxy data record. The researchers conclude that '*our synthesis, together with the instrumental record, suggests that the most recent 10-year interval (1999-2008) was the warmest of the past 200 decades. Temperatures were about 1.4°C higher than the projected value based on the linear cooling trend and were even more anomalous than previously documented*'.

(SOURCE: Kaufman, D.S., Schneider, D.P., McKay, N.P., Ammann, C.M., Bradley, R.S., Briffa, K.R., Miller, G.H. and Otto-Bliesner, B.L., Overpeck, J.T. and Vinther, B.M. 2009. Recent warming reverses long-term Arctic cooling. *Science* 325: 1,236-1,239.)

CLIMATE CHANGE IMPACTS ON ARCTIC SEALS AND WHALES

In a warmer Arctic, endemic marine mammal species will face extreme levels of habitat change, most notably a dramatic reduction in sea ice. The authors identify three cetacean species as 'ice-loving' (pagophilic) – bowhead whales, white whales and narwhals – based on, among other factors, their lack of dorsal fins, their thick blubber and their ability to break young ice with their backs. Altered distributions and foraging are predicted for bowheads and white whales, which are also vulnerable to increases in pollution levels. Narwhals, which are less numerous, have a significantly more restricted distribution, are less flexible in their choice of habitats and food types, and are ranked among the three most sensitive species to climate change among Arctic endemics. For dolphins, porpoises and migrating whales, a range of potential effects are cited, among them range expansions and mis-matched migrations; i.e. timing of arrival will not match prey peaks. Finally, all of these changes could substantially alter predator-prey dynamics throughout the region.

(SOURCE: Kovacs, K.M. and Lydersen, C. 2009. Climate change impacts on seals and whales in the North Atlantic Arctic and adjacent shelf seas. *Sci. Progr.* 91: 117-150.)

CHANGING ARCTIC OCEAN CONDITIONS CAUSING A SHIFT IN PHYTOPLANKTON COMPOSITION

Warming temperatures, increasing freshwater inputs from melting ice, increased direct sunlight, increasing precipitation, and less ice coverage are changing the nature of the Arctic Ocean. An analysis of the effects of these changes on phytoplankton concluded that, although total plankton biomass stayed roughly the same, '*the smallest phytoplankton cells thrive but larger cells languish*', with a net shift to smaller phytoplankton size, and a change in species composition. The authors state that '*[p]icoplankton-based systems tend not to support large exports of biogenic carbon…for extraction (*e.g. *harvest)*'. This means that the carrying capacity of this changing system for marine mammal populations, and also human fisheries, would likely be diminished.

(SOURCE: Li, W.K.W., McLaughlin, F.A., Lovejoy, C. and Carmack, E.C. 2009. Smallest algae thrive as the Arctic Ocean freshens. *Science* 326: 539.)

INCREASED CATCHES OF NARWHALS IN GREENLAND ATTRIBUTED TO CLIMATE CHANGE

Catch statistics show a significant increase in narwhal catches by hunters in Siorapaluk, the northernmost community in Greenland, after 2002. Hunters attribute this to changes in sea-ice conditions providing boat access to the hunting area earlier in the season. This calls for collaborative management schemes and sustainable quotas for this stock. The goals are local acceptance of regulations and the ability to respond rapidly to climate change. The developments here could serve as a template for climate-change-induced effects on other hunted Arctic whale species.

(SOURCE: Nielson, M.R. 2009. Is climate change causing the increasing narwhal (*Monodon monoceros*) catches in Smith Sound, Greenland? *Polar Res.* 28: 238-245.)

ABRUPT CLIMATIC CHANGE COULD OCCUR IN THE ARCTIC WITHIN A COUPLE OF YEARS

Ice core data from Greenland suggest that the warming periods succeeding the previous two glacial periods may have been even more dramatic than previously thought, with changes in the ice cores indicating dramatic shifts in atmospheric circulation patterns within just a 1- to 3-year period. This ultimately led to warming of air temperatures over a 50-year period. The study '*confirms the potential for extremely abrupt reorganizations of the Arctic atmospheric circulation, whether going from cold to warm or vice versa*' and that major and abrupt changes in Arctic climate have occurred before, leading to air temperature increases of as much as 10°C.

(SOURCE: Steffensen, J.P., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M., Johnsen, S.J., Jouzel, J., Masson-Delmotte, V., Popp, T., Rasmussen, S.O., Röthlisberger, R., Ruth, U., Stauffer, B., Siggaard-Andersen, M.-L., Sveinbjörnsdóttir, Á.E., Svensson, A. and White, J.W.C. 2008. High-resolution Greenland ice core data show abrupt climate change happens in few years. *Science* 321: 680-684.)

OCEAN ACIDIFICATION AND ICE MELTWATER REDUCES ARCTIC CALCIUM CARBONATE, AFFECTING PHYTO-PLANKTON

The decreasing pH due to increased carbon dioxide dissolved in seawater, and an increased input of freshwater from melting ice sheets, have decreased levels of a soluble form of calcium carbonate (aragonite). Because this calcium carbonate is essential for marine phytoplankton in the Arctic (especially diatoms), this reduction '*will affect both planktonic and benthic calcifying biota and therefore the composition of the Arctic ecosystem*'. As a result, the authors warn that '*the Arctic ecosystem may be at risk and requires*

observation in order to predict future possible impacts on marine organisms, fisheries'.

(SOURCE: Yamamoto-Kawai, M., McLaughlin, F.A., Carmack, E.C., Nishino, S. and Shimada, K. 2009. Aragonite undersaturation in the Arctic Ocean: Effects of ocean acidification and sea ice melt. *Science* 326: 1,098-1,100.)

Noise impacts

General

UNDERWATER NOISE FROM ARTIFICIAL ISLAND FOR OIL AND GAS DEVELOPMENT TRAVELS 7KM UNDERWATER

Northstar Island is a manmade island for oil and gas development in the Beaufort Sea, 5km offshore in 12m of water. Sounds were recorded during ice-auguring, pumping, backhoe trenching the seafloor and pile driving at substantial distances from the site, with pile driving producing the loudest sounds. Sound levels were above ambient for a distance of up to 7.5km from the site. Levels of sound transmitted by ice were also measured and these were above ambient for a distance of up to 10km from the site (and levels were above ambient in air up to 3km from the island).

(SOURCE: Greene, C.R., Blackwell, S.B. and McLennan, M.W. 2008. Sounds and vibrations in the frozen Beaufort Sea during gravel island construction. *J. Acoust. Soc. Am.* 123: 687-695.)

GLOBAL

General

CONSERVATION PAPERS TAKE THREE TIMES LONGER TO BE PUBLISHED THAN PAPERS IN OTHER BIOLOGY FIELDS

A review of time taken to publish papers found that conservation scientists can take more than three times longer to submit manuscripts and have papers published than other biology specialists. The delay between last data collection and submission for conservation papers was 696 days (i.e. nearly two years), compared to just 189 days for evolution papers. Rejection rates were also much higher for conservation papers. The longer time did not reflect editorial processes, the number of authors on a paper or the time spent being rejected from other journals. The delay is probably because of: (a) lack of competition among conservation biologists, making publication less urgent; (b) lack of funding and conservation biologists being involved in other (income-generating) activities, with publishing taking a lower priority; or (c) conservation research being conducted by a different demographic compared to other biological fields, for example, by government scientists, who may require papers to be vetted by their agencies before publication. The researchers conclude that '*[t]he cause for the excess submission delay in conservation papers must be determined and addressed; research that is critical for conservation of our planet's biodiversity is being delayed before it even reaches the desks of journal editors*'. This has implications for reviews such as the State of the Cetacean Environment Report, which review publications on a cyclical basis.

(SOURCE: O'Donnell, R.P., Supp, S.R. and Cobbold, S.M. 2010. Hindrance of conservation biology by delays in the submission of manuscripts. *Conservation Biology* 24: 615-620.)

Habitat protection/degradation

General

ABSENCE OF REACTION IS NOT ABSENCE OF IMPACT

It is sometimes claimed that cetaceans will eventually habituate to a disturbance (such as underwater noise), or if animals appear to have habituated to a disturbance, then it is not having an adverse impact. True habituation is defined as a learning process that occurs over time. What many refer to as habituation is in fact 'tolerance'. Sensitive animals may be the first to be displaced from a population as the result of disturbance, leaving 'tolerant' animals. This could lead to the mistaken conclusion that no adverse impact has occurred if a study is conducted after the disturbance is in place. Moreover, many factors could potentially cause animals to tolerate disturbance: the importance of a disturbed area for feeding or breeding, the investment an animal has made in a site (e.g. establishing a territory, learning information about local resources), lack of appropriate habitat to move to, or increased competition or predation outside of the current habitat. Therefore, lack of displacement does not indicate lack of disturbance. Moreover, physiological factors (e.g. increased 'stress' responses) can affect the fitness of animals even when no behavioural response is observed. In summary, with respect to disturbance, absence of evidence (such as displacement or behavioural changes) is not evidence of absence (of a negative effect on cetaceans). Managers should therefore be precautionary in their decisions.

(SOURCE: Bejder, L., Samuels, A., Whitehead, H., Finn, H. and Allen, S. 2009. Impact assessment research: use and misuse of habituation, sensitization and tolerance in describing wildlife responses to anthropogenic stimuli. *Mar. Ecol. Prog. Ser.* 395: 177-185.)

OFFSHORE WIND FARMS A POTENTIAL THREAT TO CETACEANS

Offshore wind farms are a highly propagated form of renewable energy production. They can potentially affect cetaceans in two ways: by noise from construction, operation, and decommissioning and by creating physical structures in the animals' habitat. The authors begin by pointing out the difficulty in determining potential impacts due to uncertainties about cetacean distribution. They then demonstrate that a protected population of bottlenose dolphins would have been injured by the noise of pile-driving within 100m of this activity (wind turbine installation) and that behavioural disturbance (modified behaviour) could have occurred up to 50km away.

(SOURCES: Thompson, P.M., Lusseau, D., Barton, T., Simmons, D. Rusin, J. and Bailey, H. 2010. Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. *Mar. Pollut. Bull.*, In press, doi:10.1016/j.marpolbul.2010.03.030; Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G. and Thompson, P.M. 2010. Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. *Mar. Pollut. Bull.*, In press, doi:10.1016/j.marpolbul.2010.01.003.)

WATER QUALITY STANDARDS FOR CETACEANS

Cetaceans are potentially vulnerable to a wide range of human and livestock disease agents, and sewage effluents are a key route by which such pathogens can be transferred. The EU Habitats Directive requires Member States to consider the potential impact of sewage discharges on protected wildlife populations. There is ongoing discussion whether water quality standards for human bathers can be applied to develop standards for coastal dolphins. Considering that the standards for human bathers are based on extremely limited scientific data, and that the relevant data collection from wild populations of dolphins would be nearly impossible, the author argues that more precautionary measures should be introduced to reduce disease risks to cetaceans.

(SOURCE: Thompson, P.M. 2007. Developing water quality standards for coastal dolphins. *Mar. Pollut. Bull.* 54: 123-127.)

Fisheries interactions

BUBBLE LESIONS FOUND IN OTHER MARINE MAMMAL SPECIES – LINKED TO EFFECTS OF BYCATCH

Gas bubble lesions were discovered in short-beaked common and Atlantic white-sided dolphins and harbour porpoises, as well as harbour, gray and harp seals, that had been bycaught

in fishing gear. In total, 15 out of 25 bycaught animals exhibited bubble lesions. This pertained especially to those animals that had a longer time from collection to necropsy, were brought to the surface faster or from greater depths, and which had higher body core temperatures. Forty-one stranded animals of various species were also examined and only one animal, a Cuvier's beaked whale, possessed bubble lesions. Bubbles were found in brain, heart, liver, lung, spleen, pancreas, gonad, intestinal and lymph node tissues, as well as skeletal tissues, blood and even in the eye. It was suggested that normal diving behaviour allows animals to offload gases through anatomical and physiological adaptations, while entanglement in fishing gear prevents this natural behaviour and leads to bubble lesions. The authors stress '*when gas bubbles are encountered in beached animals, serious consideration should be given to these findings and any resultant pathology, because it seems that animals that have been able to surface normally blow off supersaturated gases, and for bubbles to persist, this may represent a pathologic condition perhaps reflecting stressors that have precluded behaviours that normally manage gas tensions to keep bubble growth to a minimum*'. One relevant aspect of this information is that bubble lesions in bycaught animals may affect the survivorship of such animals that are released.

(SOURCE: Moore, M.J., Bogomolni, A.L., Dennison, S.E., Early, G., Garner, M.M., Hayward, B.A., Lentell, B.J. and Rotstein, D.S. 2009. Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. *Vet. Pathol.* 46: 536-547.)

Marine debris

FLOATING NET DEBRIS FATAL TO SPERM WHALES

The cause of death of two stranded male sperm whales off the northern California coast was determined to be plastic fishing net pieces and rope. The stomachs of the two animals contained 134 different types of nets ranging in size from 10cm² to 16m². The size and age of the pieces suggested that the material was ingested from the surface as debris and not bitten off from active gear. In addition to well-documented entanglements, ingestion of marine debris can be fatal to large whales.

(SOURCE: Jacobsen, J.K., Massey, L. and Gulland, F. 2010. Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). *Mar. Pollut. Bull.*, In press, doi:10.1016/ j.marpolbul.2010.03. 008.)

PLASTIC MARINE DEBRIS COLLECTS AND DISTRIBUTES PERSISTENT ORGANIC POLLUTANTS

Beyond the negative impacts of plastic debris with regard to ingestion and entanglement of marine organisms, such plastic has now been shown to accumulate a wide range of persistent organic pollutants (POPs). Preproduction thermoplastic resin pellets (which are melted and formed into inexpensive consumer goods) and post-consumer plastic fragments collected at the North Pacific Gyre, California, Hawaii and Guadelupe Island, Mexico, contained PCBs, DDT and PAHs. Plastic can therefore adsorb, accumulate and transport POPs over great distances, and these pollutants enter the food web when marine organisms consume such debris.

(SOURCE: Rios, L.M., Moore, C and Jones, P.R. 2007. Persistent organic pollutants carried by synthetic polymers in the ocean environment. *Mar. Pollut. Bull.* 54(8): 1,230-1,237.)

Marine Protected Areas

VOLUNTARY SHIPPING AVOIDANCE AREA SHOWS HIGH COMPLIANCE AND REDUCES SHIP STRIKE RISK

The International Maritime Organization adopted the Roseway Basin Area on the Scotian Shelf in the northwest Atlantic as a voluntary avoidance area to reduce the risk of vessel strikes to North Atlantic right whales. Vessel positions were monitored 12 months before and 6 months after the area's designation; vessel-operator compliance stabilised at 71% within the first 5 months of implementation. It was estimated that the risk of vessel strikes in the area was reduced by 82% overall. It was concluded that such shipping avoidance areas, even if voluntary, could play a role in decreasing risk to cetaceans from ship strikes. Such areas provide yet another useful strategy, beyond conservation areas, traffic separation schemes and mandatory vessel speed reductions, to protect endangered whales.

(SOURCE: Vanderlaan, A.S.M. and Taggart, C.T. 2009. Efficacy of a voluntary area to be avoided to reduce risk of lethal vessel strikes to endangered whales. *Conserv. Biol.* 23: 1,467-1,474.)

WHALE MANAGEMENT MAY REQUIRE LARGER PROTECTED AREAS

Human disturbances can have significant impacts on cetaceans. One mechanism is the repeated activation of stress responses, e.g. by noise, leading to chronic stress. Deep-diving and coastal species, as well as those targeted by whalewatching, may be particularly vulnerable. This calls for management attention, with one strategy being the establishment of protected areas. The authors argue that the lack of recovery of some species may be because such protected areas are too small. They call for larger exclusion zones, including acoustic buffer zones around Marine Protected Areas (MPAs), and for excluding sonar exercises from known or likely beaked whale habitats and their surroundings.

(SOURCE: Wright, A.J., Deak, T. and Parsons, E.C.M. In press. Size matters: Management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. *Mar. Pollut. Bull.*, In press.)

Chemical pollution

CONTAMINANTS DECREASE FIRST-YEAR SURVIVORSHIP RATES IN MARINE MAMMALS

Although not specifically directed at cetaceans, this study tracing survivorship patterns in grey seals produced information that demonstrates impacts of contaminants on marine mammal recruitment. Capture-recapture methods were used in conjunction with tags to estimate first-year survivorship. Higher levels of contaminants decreased likelihood of survival, with PBDE levels, followed by DDT and then PCB levels, being the classes of contaminants with the greatest impact. Although the mechanisms by which these contaminants cause mortality are unknown, their influence on recruitment rates demonstrates that they should be considered in cetacean population modelling.

(SOURCE: Hall, A.J., Thomas, G.O. and McConnell, B.J. 2009. Exposure to persistent organic pollutants and first-year survival probability in gray seal pups. *Environ. Sci. Tech.* 43: 6,364-6,369.)

Disease and mortality events

Disease

DOLPHINS' HEALTH SHEDS LIGHT ON HUMAN AND OCEAN HEALTH

Diseases in dolphins are similar to human diseases, and bottlenose dolphins may be the first natural animal model for type II diabetes. At least 50 new viruses have been discovered in dolphins, including the human papillomavirus. Coastal dolphin populations and human communities share the same seafood resources. Such a similar exposure with regard to diet, coupled with their much stronger exposure to ocean health threats (e.g. toxic algae, poor water quality) could make dolphins an important 'sentinel' species to provide information about the state of ocean health and

warning of how human health may be affected by exposure to contaminated coastal water or seafood.

(SOURCE: News. 2010. *Mar. Pollut. Bull.* 60: 491.)

SIGNIFICANT POPULATION-LEVEL IMPACTS PREDICTED OF EMERGING DISEASES

A review on diseases in cetaceans included potential impacts on populations, the impact of environmental stressors and possible zoonotic effects. Some pathogens can reduce reproductive rates, cause mortality directly, or cause mortality indirectly by synergistically increasing the severity of other infections. Such pathogens include morbilliviruses, papillomaviruses and the pathogens *Brucella* spp. and *Toxoplasma gondii*. Fungal infection, such as lobomycosis and lobomycosis-like disease (LLD), might also contribute to cetacean mortality. Contamination by environmental pollutants or other anthropogenic stressors probably increases the severity and hence mortality or morbidity resulting from these pathogens. The risks to human health resulting from zoonotic transfer of *Brucella* and *Toxoplasma* from cetacean carcasses and products may be much higher than assumed, because of the low likelihood of diagnosis of infection by these pathogens, particularly in developing countries.

(SOURCE: Van Bressem, M.F., Raga, J.A., Di Guardo, G., Jepson, P.D., Duignan, P.J., Siebert, U., Barrett, T., Santos, M.C.d.O., Moreno, I.B., Siciliano, S., Aguilar, A. and Van Waerebeek, K. 2009. Emerging infectious diseases in cetaceans worldwide and the possible role of environmental stressors. *Diseases Aquat. Org.* 86: 143-157.)

Stress

WHISTLE RATE AN INDICATOR OF STRESS IN COMMON BOTTLENOSE DOLPHINS

The rate of whistle production in common bottlenose dolphins was significantly higher during a capture-release operation on wild dolphins in Florida. Females with dependent calves produced higher whistle frequencies than females without calves. Whistling rate also decreased with repeated captures. The conclusion is that these whistles are indicators of stress and as such, '*acoustic monitoring holds promise as a non-invasive means of assessing the impact of potentially stressful situations on bottlenose dolphins*'.

(SOURCE: Esch, H.C., Sayigh, L.S., Blum, J.E. and Wells, R.S. 2009. Whistles as potential indicators of stress in bottlenose dolphin (*Tursiops truncatus*). *J. Mammal.* 90: 638-650.)

Climate change

HISTORICAL SEA LEVEL RECONSTRUCTION SUGGESTS WEST ANTARCTIC ICE SHELF COLLAPSE AND 7M+ SEA LEVEL RISE

To predict the potential effects of increasing global temperature, many researchers have looked to the last interglacial period (125,000 years ago), a period with comparable temperatures to those envisaged for the near future (+3-5°C). A recent study re-examined sea level estimates for this period, taking into account various geological and planetary processes, and estimated an interglacial sea level of at least 6.6m above present, relatively speaking, and perhaps as much as 9.4m above. Melting ice sheets in Greenland and Antarctica would have effectively contributed at least 2.5m of this rise apiece. It was postulated that, because of the volume of increase contributed by Antarctica, the west Antarctic ice sheet collapsed in its entirety. In summary, the imminent predicted increase in global temperatures (1.5-2°C) could lead to a higher sea level rise than previously thought.

(SOURCES: Kopp, R.E., Simons, F.J., Mitrovica, J.X., Maloof, A.C. and Oppenheimer, M. 2009. Probabilistic assessment of sea level during the last interglacial stage. *Nature* 462: 863-867; Clark, P.U. and Huybers, H. 2009. Interglacial and future sea level. *Nature* 462: 856-857.)

THE IMPACT OF OCEAN ACIDIFICATION ON IRON AND MARINE PRODUCTIVITY

There has been concern over the impacts of ocean acidification, resulting from increased levels of carbon dioxide dissolved in seawater, on corals and the tests of calcareous plankton (such as diatoms). A new study highlights the potential impact of acidification on levels of iron in the ocean. Iron is a major limiting nutrient for marine productivity. The study experimentally examined the effect that decreased pH, as predicted by projected CO_2 levels for 2100, would have on iron uptake by diatoms. The study suggested '*a lowering of the ocean water pH from increasing CO_2 may decrease iron availability to phytoplankton*' (Sunda). This could affect the ocean's ability to absorb more carbon dioxide and thus cause a positive feedback loop that may effectively increase carbon dioxide levels in the atmosphere. Marine productivity in general may also be impacted, which would have wide ecological effects.

(SOURCES: Shi, D., Xu, Y., Hopkinson, B.M. and Morel, F.M.M. 2010. Effect of ocean acidification on iron availability to marine phytoplankton. *Science* 327: 676-679; Sunda, W.G. 2010. Iron and the carbon pump. *Science* 327: 654-655.)

IMPACTS OF CLIMATE CHANGE ON CETACEANS FROM CHANGES IN HUMAN BEHAVIOUR

The increasing focus on the effects of climate change on cetaceans reveals consequences not only for polar species, but also potentially for tropical coastal and riverine species. Beyond the expected physical habitat and prey changes, climate change will also alter human behaviour in some regions to the detriment of cetaceans. This contribution presents a comprehensive table identifying the specific aspects of climate change that are relevant for 82 cetacean species. The authors note that addressing direct and human-mediated threats from climate change will require: (1) integrating knowledge about cetacean populations into climate adaptation decisions; and (2) including projections about how climate change may influence human behaviours into cetacean-specific management plans.

(SOURCE: Alter, S.E, Simmonds, M.P, and Brandon, J.R. 2010. Forecasting the consequences of climate-driven shifts in human behavior on cetaceans. *Mar. Pol.* doi:10.1016/j.marpol.2010.01.026.)

NEW TYPE OF EL NIÑO EVENT MAY INCREASE WITH GLOBAL WARMING

The El Niño event causes periodic shifts in climate every 3-8 years in the Pacific, resulting in warmer surface waters off the western coast of South America and the 'capping' of a cool water upwelling that normally brings nutrients to the surface. This has major effects on marine productivity here. Since the 1970s, events with high sea surface temperatures have occurred in the central Pacific, with cooler temperatures being reported in the east and west Pacific. This warming event is unlike the east Pacific warming apparent during an El Niño event, and has been called many names, including 'pseudo' or 'central' El Niño. A new climate modelling exercise concluded that this central El Niño is the result of anthropogenic warming and, as temperatures increase, will become more marked and prevalent, at the expense of the eastern, or typical, El Niño event. If this is correct, it could lead to major changes in weather patterns along with oceanographic processes and marine ecosystems in the Pacific.

(SOURCES: Yeh, S.W., Kug, J.S., Dewitte, B., Kwon, M.H., Kirtman, B.P. and Jin, F.F. 2009. El Niño in a changing climate. *Nature* 461, 511-514; Ashok, K. and Toshio Yamagata, T. 2009. The El Niño with a difference. *Nature* 461:481-484.)

Noise impacts

General

NEW WAY OF MEASURING NOISE IMPACT: COMMUNICATION SPACE

'Communication space' was posited as a new way of measuring the potential biological impacts of underwater noise on cetaceans. Cetacean calls can only be heard when they rise above ambient levels of sound in the environment; underwater noise can mask these calls. The area over which calls can be heard therefore decreases with increasing noise levels, reducing the ability of cetaceans to communicate with each other. Communication space was modelled for fin whales, right whales and humpback whales when commercial shipping vessels passed a specific location. The researchers determined that '*acoustic communication space for at least one species of baleen whale, the highly endangered North Atlantic right whale, is seriously compromised by noise from commercial shipping traffic*'.

(SOURCE: Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., Van Parijs, S.M., Frankel, A. and Ponirakis, D. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Mar. Ecol. Prog. Ser.* 395: 201-222.)

MARINE PROTECTED AREAS AND POSSIBILITIES FOR UNDERWATER NOISE MANAGEMENT

This review on the management of underwater noise identified several costs to marine mammals with consequences for fitness: '*compromised physiological function, diversion of time and energy, failure to detect important cues, impaired acoustical advertisement and communication, and reduced utilization of important habitats or resources*'. The authors criticised the attention focused on '*acute and immediate effects of intense noise exposures: hearing loss, injury, and death*', which examine individuals rather than populations, and they emphasise the need to consider the impacts of chronic noise even though sources are more diffuse and less easy to identify. The review concludes that MPAs could help to manage underwater noise and, due to the wide-ranging effects of anthropogenic sound, this may require establishing buffer zones around these areas. A case study of particular significance with respect to cetaceans is the Stellwagen Bank Marine Sanctuary, where anthropogenic noise levels from shipping '*were >82 dB 50% of the day and as high as 110 dB 5% of the day*'. To help remedy the problem, the authors called for: increased acoustic monitoring; incorporation of noise into environmental impact assessments via new tools (such as software showing visual representations of noise levels); new noise metrics and modelling techniques; better coordination between government agencies; and increased public education and outreach. They conclude that '*[t]he quietest marine and terrestrial environments must be vigorously protected, as they are the most vulnerable to noise intrusions. Exceptional environments for hearing natural sounds are also exceptional for detecting noise. Very little noise energy is required to substantially degrade listening conditions when the natural sound levels are very low. Like other crucial and endangered resources, quiet merits the highest standards for preservation and restoration*'.

(SOURCE: Hatch, L.T. and Fristrup, K.M. 2009. No barrier at the boundaries: implementing regional frameworks for noise management in protected areas. *Mar. Ecol. Prog. Ser.* 395: 223-244.)

REVIEW OF ANTHROPOGENIC SOUND IN THE OCEANS

A review of multiple anthropogenic noise sources in the oceans concludes that, for low frequencies, shipping is the dominant source, although seismic surveys, especially in deep water exploration, are also a major contributor. Airgun sounds could be heard in the North Atlantic almost continuously during summer months, at distances greater than 3,000km. For mid-frequency sound, sonar systems from about 300 vessels were a major contributor. Sonar is used by these vessels '*about 10% of the time these vessels are at sea*'. Acoustic harassment devices (seal scrammers) and multi-beam echosounders also contribute noise at mid-frequencies. Recreational and small boat traffic can also contribute substantial mid-frequency noise: '*[o]ver 17 million small boats are owned in the United States alone. Many of these boats use mid-frequency and high-frequency sonar for echolocation, also contributing to local ambient noise*'. At higher frequencies, depth sounders from ships are a major contributor. The potential reach of these sounds ranges from tens of metres (for high frequencies) to entire ocean basins (for low frequencies). The review calls for increased research into noise generation, in particular the characteristics of shipping noise affected by vessel size, speed, density and other factors.

(SOURCE: Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Mar. Ecol. Prog. Ser.* 395: 5-20.)

SOUND EXPOSURE LEVELS NOT AN OPTIMAL MEASURE TO PREDICT NOISE IMPACTS

One way to measure sound level, in particular with respect to its impacts on cetaceans, is sound exposure level (SEL). This metric combines both the sound intensity and the exposure duration, to derive the total amount of energy; i.e. two sounds can have the same total energy when one has a higher intensity but a proportionately shorter duration. Such a metric would theoretically make regulating sound impacts easier because there are many different types of sound (continuous such as shipping, single impulses such as explosions, or multiple pulses such as seismic survey airguns or sonar pings). In practise, however, SEL has drawbacks. When common bottlenose dolphins were exposed to sounds with identical SELs, but varying duration and intensity, temporary threshold shifts (TTS) were more likely to occur in animals exposed for longer periods. This study emphasises the importance of knowing the properties of the sound to which animals are exposed, as sounds of different types may not be easily and directly comparable when predicting possible impacts on cetaceans. The researchers also note that '*longer duration exposures will often induce greater amounts of TTS, which concurrently requires a greater amount of time for recovery*'.

(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: 1,816-1,826.)

MILITARY FUNDING APPEARS TO RESULT IN REPORTING BIAS IN UNDERWATER SOUND REVIEWS

Concerns have been raised that the US Navy provides 50% of the global research funds for marine mammal research (and 70% of underwater noise impact research), potentially influencing scientific reporting of impacts of underwater noise. An analysis of six reviews documenting effects of anthropogenic noise on marine mammals found that '*these reviews cite references showing noise has no effect on marine mammals at an increasing frequency as their funding moves from a conservation organization to independent to partial US military sources*'. The likelihood of a paper concluding that there is no effect of noise on cetaceans more than doubles if the researchers obtained funds from the US Navy. The researchers conclude that '*conflicts of interest may have led to a misrepresentation of the effects of noise on marine mammals in both the primary and secondary literature, and thus misinform public policy decisions*'.

(SOURCE: Wade, L., Whitehead, H. and Weilgart, L. 2010. Conflict of interest in research on anthropogenic noise and marine mammals: Does funding bias conclusions? *Mar. Pol.* 34: 320-327.)

Cetacean hearing

BEAKED WHALE HEARING SENSITIVITY CURVE APPEARS TO BE SIMILAR TO DELPHINIDS

One hypothesis why beaked whales appear to be more sensitive to underwater noise than other cetacean taxa has been that they are generally more sensitive to sound. However, when the hearing sensitivity of a stranded Gervais' beaked whale was opportunistically tested via auditory evoked potentials, its hearing sensitivity curve was similar to that of studied delphinids. The animal could detect sounds to a frequency of at least 80kHz (with greatest sensitivity at 40kHz).

(SOURCE; Finneran, J.J., Houser, D.S., Base-Guthrie, B., Ewing, R.Y. and Lingenfelser, R.G. 2009. Auditory evoked potentials in a stranded Gervais' beaked whale (*Mesoplodon europaeus*). *J. Acoust. Soc. Am.* 126: 484-490.)

Seismic surveys

HARBOUR PORPOISE TEMPORARY THRESHOLD SHIFTS (TTS) MEASURED IN RESPONSE TO SINGLE AIRGUN PULSES

A captive male harbour porpoise held in a sea pen was exposed to sound from a seismic survey airgun (20 cubic inches) placed at decreasing distance to the porpoise (150-14m). The airgun's sound predominated in lower frequencies (below 1kHz), but the porpoise was also exposed to higher frequencies (i.e. 2-5kHz; up to 150dB SPL). Auditory evoked potentials were measured in response to single pulses of the airgun, and the sound level at which TTS occurred was recorded. Aversive behaviour at 4kHz was observed at a SEL of approximately 20dB lower than that at which TTS occurred and the animal avoided the testing location for the rest of the 4½ month testing period. Recovery from TTS was slow for the porpoise, taking up to 55 hours. The levels of exposure at which TTS occurred were substantially lower than levels considered to have no effect under, for example, current US regulations. Moreover, this study measured the effects of single pulses: bearing in mind the long recovery period of the porpoise, the effect of normal airgun operation (repeated pulses) would probably be greater. Although it examined only one captive animal, the study illustrates the higher than expected sensitivity of porpoises to seismic survey noise.

(SOURCE: Lucke, K., Seibert, U., Lepper, P.A. and Blanchet, M.A. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *J. Acoust. Soc. Am.* 125: 4,060-4,070.)

TAGGED SPERM WHALES REDUCE FORAGING BEHAVIOUR IN RESPONSE TO SEISMIC SURVEYS

Eight sperm whales (7 foraging and 1 resting) in the Gulf of Mexico were exposed to seismic surveys and their behaviour recorded via tags. There was no significant change in behaviour state in the whales as the result of exposure, although the one resting animal began to forage immediately after the cessation of the seismic surveys, '*possibly indicating a delay in foraging during exposure*'. There was no apparent horizontal avoidance of the airguns; this raises doubt as to whether the current practice of 'ramping-up' (increasing sound levels gradually to allow animals to leave an area) is effective. Swimming behaviour did change, and acoustic behaviour associated with foraging decreased 19% during seismic exposure. This substantive change in underwater behaviour would not have been detected without the use of tags, and surface observations alone would not have recorded any noticeable change. The researchers state that '*our tag data indicate that exposure to airgun sounds may affect the foraging behavior of sperm whales at exposure levels well below the current 160 dB re1 µPa (rms) threshold used by [the US Government] to predict disruption of behaviour*'.

(SOURCE: Miller, P.J.O., Johnson, M.P., Madsen, P.T., Biassoni, N., Quero, M. and Tyack, P.L. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep Sea Research I* 56: 1,168-1,181.)

Shipping

MASKING EFFECTS OF SMALL OUTBOARD BOATS AND IMPLICATIONS FOR WHALEWATCHING GUIDELINES

Digital acoustic tags were first used to demonstrate that free-ranging delphinids in a coastal deepwater habitat are subjected to varying and occasionally intense levels of vessel noise. Vessel noise and sound propagation measurements from a shallow-water habitat were then used to model the potential impact of high sound levels from small vessels (2-stroke and 4-stroke outboard motor boats) on delphinid communication in both shallow and deep habitats, with bottlenose dolphins and short-finned pilot whales as model organisms. At 50m (a standard maximum approach distance for many whalewatching guidelines) and a boat speed of 5 knots, communication ranges for pilot whales were reduced by 58% and for bottlenose dolphins by 26%. At 2.5 knots, however, there was little masking noise. At 10 knots there was approximately a 70% decrease in communication distance for both species at 200m from the boats. At 50m, communication reduction was over 90% for pilot whales and over 80% for bottlenose dolphins. The boats emitted a loud broadband sound when they changed gears, which could occur several times a minute when manoeuvring around the cetacean groups (up to 200dB re 1 μPa pk-pk). Minimising gear changes would help reduce this boat disturbance. Multiple vessels near cetaceans could have additional impacts, as could following groups for long periods of time. This also has implications for researchers – following focal groups, at a close distance in a small boat, is a common method to study small cetacean behaviour. The authors warn that '*the behaviour and noise profiles of research vessels may be a source of potential bias in studies of free-ranging delphinids and should be considered when designing field experiments*'.

(SOURCE: Jensen, F.H., Bejder, L., Wahlberg, M., Aguilar Soto, N., Johnson, M. and Madsen, P.T. 2009. Vessel noise effects on delphinid communication. *Mar. Ecol. Prog. Ser.* 395: 161-175.)

Sonar

US GOVERNMENT PLEDGES TO INCREASE CETACEAN SURVEYS AND FURTHER INVESTIGATE UNDERWATER NOISE MITIGATION MEASURES

The US National Oceanic and Atmospheric Administration (NOAA), in response to a request from the US Council for Environmental Quality, has reviewed and revised its policy on underwater noise and will require more fine-scale boat-based and aerial surveys for cetaceans to gain a better understanding of the number of cetaceans that might be impacted by noise-producing activities (in particular military exercises). Moreover, NOAA will host two workshops. One will discuss the concept of an ocean noise budget, which will include discussion of areas where marine noise from human activities is elevated. A second workshop will work towards identifying marine mammal 'hotspots' and thus recognise important habitats. NOAA will also participate in discussing and negotiating mitigation measures during naval activities.

(SOURCE: Letter from Jane Lubchenco, NOAA Administrator to the US Council for Environmental Quality, 19 January 2010. *http://www.nmfs.noaa.gov/pr/pdfs/permits/lubchenco_letter.pdf.*)

BEAKED WHALE MASS STRANDINGS LINKED WITH NAVAL ACTIVITIES

Several papers in the journal *Aquatic Mammals* addressed beaked whale mass strandings coincident with naval exercises. One study found significant correlations between mass strandings and military exercises both in the Mediterranean and Caribbean. No such relationship was found for mass strandings in Japan or California. A second study, however, noted that 10 mass stranding events in Japan occurred close to a naval facility, even if they did not coincide with a specific exercise. An 11th Japanese stranding was also noted adjacent to a different military facility. The paper listed two stranding events that were definitively linked to sonar use during military exercises (Greece in 1996 and Bahamas in 2000) and 10 mass strandings with coincident naval exercises, although more exact details were not available (Greece in 1997, Italy in 1963, Spain in 1996, Madeira in 2000, and the Canary Islands in 1988, 1989, 1991, 2000, 2002, 2004). Twenty-seven mass stranding events occurred either at the same time naval vessels that could have been using sonar were sighted (Italy in 1963 and 1967, Canary Islands in 1985) or adjacent to naval facilities (the 11 Japanese strandings noted above, six mass strandings in Alaska, four in Puerto Rico, and one each in Hawaii, southern California and Key West, Florida). Eighty-one beaked whale mass strandings could not be associated with US naval bases or military exercises, although other military sonar sources could not be ruled out. Most (126 out of 136) beaked whale mass stranding events recorded since 1874 have occurred since the development of mid-frequency sonar. A third paper investigated gray whale stranding in relation to naval exercises off the Californian coast. Of a total of 180 stranding events identified between 1982 and 2007, approximately 40 coincided with naval exercises (*c.* 22%), but statistical analysis showed that stranding rates during naval exercises involving anti-submarine warfare were not significantly different from those during non-exercise periods.

(SOURCES: D'Amico, A.D., Gisiner, R.C., Ketten, D.R., Hammock, J.A., Johnson, C., Tyack, P.L. and Mead, J. 2009. Beaked whale strandings and naval exercises. *Aquat. Mamm*. 35: 452-472; Filadelfo, R., Mintz, J., Michlovich, E., D'Amico, A.D., Tyack, P.L. and Ketten, D.R. 2009. Correlating military sonar use with beaked whale strandings: what do the historical data show? *Aquat. Mamm*. 35: 435-444; Filadelfo, R., Pinelis, Y.K., Davis, S., Chase, R., Mintz, J., Wolfganger, J., Tyack, P.L., Ketten, D.R. and D'Amico, A.D. 2009. Correlating whale strandings with navy exercises off Southern California. *Aquat. Mamm*. 35: 445-451.)

BEAKED WHALES MORE LIKELY VULNERABLE TO NITROGEN-RELATED PATHOLOGIES THAN OTHER SPECIES

A model based on known physiological data was used to predict nitrogen levels in blood and tissues in three beaked whale species (Blainville's and Cuvier's beaked whales, and northern bottlenose whales). Dive length and diving lung volume had a large effect on nitrogen levels at the end of a dive; these species may generally have high levels of dissolved nitrogen in their tissues, making them vulnerable to decompression sickness, or the bends. Thus, nitrogen levels in tissues may end beaked whale dives before a lack of oxygen does. Moreover, the diving behaviour of Cuvier's beaked whales resulted in higher nitrogen levels, potentially explaining why this species in particular has been associated with strandings coincident with military exercises. Another paper examined the hypothesis that high levels of dissolved nitrogen (i.e. supersaturation) in cetacean blood leads to gas emboli or 'bubble lesion' formation when ascending into shallow waters. A trained common bottlenose dolphin performed 10-12 serial dives in a row with one minute gaps between dives, to depths of 30, 50, 70 and 100m, with the dolphin staying at each depth for 90 seconds. Blood samples and ultrasounds of blood vessels revealed no significant change. The results '*do not support the hypothesis that [nitrogen] supersaturation during repetitive dives contributes to [gas emboli] formation in the dolphin*', at least for bottlenose dolphins during normal diving behaviour. In the case of beaked whale strandings and cetaceans caught in nets, however, a rapid ascent may be one cause of bubble lesions.

(SOURCES: Hooker, S.K., Baird, R.W. and Fahlman, A. 2009. Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: *Ziphius cavirostris*, *Mesoplodon densirostris* and *Hyperoodon ampullatus*. *Respir. Phys. Neurobiol*. 167: 235-246; Houser, D.S., Dankiewicz-Talmadge, L.A., Stockard, T.K. and Ponganis, P.J. 2010. Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. *J. Exp. Biol.* 213: 52-62.)

TEMPORARY THRESHOLD SHIFTS FROM SONAR EXPOSURE IN A CAPTIVE COMMON BOTTLENOSE DOLPHIN

A study using actual recordings of mid-frequency sonar sound resulted in TTS lasting 20-40 minutes in a trained, captive common bottlenose dolphin at a SPL of 203dB (rms) or a SEL of 214dB re: 1 μPa^2 s. Considering the source level of standard mid-frequency sonar systems, this animal would had to have been 40m from the sound source for approximately 2 minutes for TTS to be induced. If the animal was closer, then TTS would have been induced within a shorter period, and conversely if further away a proportionately longer sound exposure would have been required. It was concluded that '*mid-frequency sonar can induce at least temporary physiological hearing loss in odontocete cetaceans, although repeated exposures are necessary to generate effects*'. However, the authors note '[*t*]*he results do not preclude other noise or sonar-induced effects on marine mammals, which may occur at lower sound levels*'.

(SOURCE: Mooney, T.A., Nachtigall, P.E. and Vlachos, S. 2009. Sonar-induced temporary hearing loss in dolphins. *Biol. Lett.* 5: 565-567.)

Offshore wind farms

HARBOUR PORPOISES LIKELY DISPLACED BEYOND 20KM FROM WIND FARM CONSTRUCTION SITE

The possible acoustic impacts of wind farms were assessed with regard to pile-driving during turbine construction. Acoustic recording devices (T-PODs) were placed at 7 and 20km from the construction site. During pile driving, acoustic detections of harbour porpoises decreased. There was no significant difference in the detection rates at 7 *versus* 20km. The '*size of the zone of responsiveness could not be inferred as no grading in response was observed with distance from the pile driving site but must have exceeded 21km*'. Porpoises were detected within the wind farm area during pile driving (although detection rates of porpoises within the farm were much lower than outside, whether pile driving was occurring or not). This suggested habituated/noise-tolerant harbour porpoises within the wind farm area.

(SOURCE: Tougaard, J., Carstensen, J., Teilmann, J., Skiv, H. and Rasmussen, P. 2009. Pile driving zone of responsiveness extends beyond 20km for harbor porpoises (*Phocoena phocoena* (L.)). *J. Acoust. Soc. Am.* 126: 11-14.)

IMPACTS OF WIND TURBINE NOISE PROBABLY MINIMAL

A study measuring the noise from three types of offshore wind turbines concluded that noise from rotating turbine blades would not adversely impact marine mammals, including harbour porpoises, because virtually all of the in-air noise would reflect off the ocean's surface. However, vibrations generated by machinery would likely be transmitted via the seabed and out into the water. Ambient

noise masked most of the sound so generated, except for frequencies below 500Hz (with SPLs of 109-127dB re 1μPa rms at a distance of 14-20m from the turbines' foundations). Harbour porpoise audiograms indicate that wind turbine sounds would be audible at 20-70m (potentially several kilometres for harbour seals). It was concluded that acoustic masking would be unlikely and that sound levels would not be high enough to cause significant acoustic impact (e.g. TTS), although behavioural changes might occur close to the turbines.

(SOURCE: Tougaard, J., Henriksen, O.D. and Miller, L.A. 2009. Underwater noise from three types of offshore wind turbines: Estimation of impact zones for harbor porpoises and harbor seals. *J. Acoust. Soc. Am.* 125: 3,766-3,773.)

Masking

HUMPBACK WHALES IN NOISY ENVIRONMENTS CHANGE BEHAVIOUR

If ambient noise increased (in this example, due to increasing wind speeds), humpback whales in Australia adopted more surface active behaviour. It was suggested that this behaviour (e.g. breaching) allowed communication in noisier environments. This has implications with regard to anthropogenic noise – humpback whales might adopt more surface active behaviour during breeding, which could have an energetic cost.

(SOURCE: Dunlop, R.A., Cato, D.H. and Noad, M.J. 2009. Your attention please: increasing ambient noise levels elicits a change in communication behaviour in humpback whales (*Megaptera novaeangliae*). *Proc. Royal. Soc. B*: In press.)

VARYING LEVELS OF NOISE ALONG RIGHT WHALE MIGRATION ROUTE COULD AFFECT BREEDING SUCCESS

'Pop up' acoustic recorders monitored ambient noise levels and calls of North Atlantic right whales in three areas along the whale's migration route: the Bay of Fundy, Cape Cod and Georgia. When whales produced louder calls, it was related more to peak noise levels than to the average ambient noise level in an area. Ambient levels were over 105dB re 1μPa in the frequency range of right whale calls (i.e. 50-350Hz) 20-30% of the time in Georgia (winter) and 53-63% of the time in Cape Cod, with the loudest location, the Bay of Fundy, having this level 85-95% of the time (summer). This high level in summer might affect reproduction by masking communication calls.

(SOURCE: Parks, S.E., Urazghildiiev, I. and Clark, C.W. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. *J. Acoust. Soc. Am.* 125: 1,230-1,239.)

Species glossary

Atlantic white-sided dolphin	*Lagenorhynchus acutus*
Beluga (white) whale	*Delphinapterus leucas*
Blainville's beaked whale	*Mesoplodon densirostris*
Bowhead whale	*Balaena mysticetus*
Common bottlenose dolphin	*Tursiops truncatus*
Common dolphin, short-beaked	*Delphinus delphis*
Cuvier's beaked whale	*Ziphius cavirostris*
Fin whale	*Balaenoptera physalus*
Gervais' beaked whale	*Mesoplodon europaeus*
Gray whale	*Eschrichtius robustus*
Harbour porpoise	*Phocoena phocoena*
Humpback whale	*Megaptera novaeangliae*
Killer whale	*Orcinus orca*
Narwhal	*Monodon monoceros*
North Atlantic right whale	*Eubalaena glacialis*
Northern bottlenose whale	*Hyperoodon ampullatus*
Pilot whale, short-finned	*Globicephala macrorhynchus*
Sperm whale	*Physeter macrocephalus*
Grey seal	*Halichoerus grypus*
Harbour seal	*Phoca vitulina*
Harp seal	*Pagophilus groenlandicus*
Steller sea lion	*Eumetopias jubatus*
Northern fulmar	*Fulmarus glacialis*
Polar cod	*Boreogadus saida*

Glossary of terms

Auditory evoked potential: An electrical response recorded from the auditory nerves following presentation of an acoustic stimulus.

Benthic: Of or related to the bottom level of the ocean, including the sediment or ocean floor.

Bioaccumulation: Increase in concentration of a pollutant within an organism over time.

Biogenic: Resulting from biological activity or living organisms.

Biomass: The total mass of living organisms in an area or ecosystem.

Biota: The plant and animal life of a region.

Brucella: Various species of bacteria that cause the disease brucellosis.

Calcareous: Mostly or partly composed of calcium carbonate.

Carrying capacity: The maximum population number of a species that an ecosystem can sustain indefinitely.

dB: Decibel – a logarithmic measure of sound pressure level.

DDT: The organochlorine pesticide dichlorodiphenyl-trichloroethane that tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.

Delphinid: Of the family *Delphinidae* (dolphins).

Diatom: Common type of phytoplankton, a one-celled alga encased in a silica cell wall.

Emboli: Plural of embolus, a clot (of blood or other material) in a blood vessel leading to circulation blockage.

Endemic: Found only in a particular geographic region.

Hg: Mercury.

Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1,000 Hertz).

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.

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.

MPA: A marine protected area.

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.

PAHs: Polycyclic aromatic hydrocarbons, which occur in oil, coal and tar deposits, and are produced as byproducts of fuel burning.

Papillomavirus: A family of viruses that can cause warts and may be a causative factor in some cancers.

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.

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.

Phytoplankton: Free-floating marine plants (*versus* zooplankton – free-floating marine animals).

Picoplankton: Very small phytoplankton (less than 2μm in diameter).

POP: Persistent organic pollutants, organic compounds that are resistant to degradation and thus persist in the environment.
ppm: Parts per million.
Sound pressure level: A measure of the intensity of sound, in decibels.
Temporary threshold shift: Temporary hearing loss.
Toxoplasma gondii: A parasitic one-celled organism that causes the disease toxoplasmosis.
Zoonotic: Capable of zoonosis. Zoonoses are infectious diseases that can be transmitted from vertebrate animals to humans or in the reverse direction.

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REFERENCES

International Whaling Commission. 1998. Chairman's Report of the Forty-Ninth Annual Meeting. Appendix 7. IWC Resolution 1997-7. Resolution on environmental change and cetaceans. *Rep. int. Whal. Commn* 48:48-49.

International Whaling Commission. 1999. Chairman's Report of the Fiftieth Annual Meeting. Appendix 6. IWC Resolution 1998-5. Resolution on environmental changes and cetaceans. *Ann. Rep. Int. Whaling Comm.* 1998:43-44.

International Whaling Commission. 2001. Chairman's Report of the Fifty-Second Annual Meeting. Appendix 1. Resolutions adopted during the 52nd annual meeting. IWC Resolution 2000-7. Resolution on environmental change and cetaceans. *Ann. Rep. Int. Whaling Comm.* 2000:56-57.

Stachowitsch, M., Rose, N.A. and Parsons, E.C.M. 2003. State of the cetacean environment report (SOCER) 2003: Second draft. Paper SC/55/E7 presented to the IWC Scientific Committee, May 2003, Berlin (unpublished). 13pp. [Paper available from the Office of this Journal].