Annex K

Report of the Standing Working Group on Environmental Concerns

Members: Rowles (Chair), Parsons (co-Chair), Amerson, Atkinson, Audunsson, Ayala, Barlow, Baulch, Baumann-Pickering, Bell, Bengtson Nash, Bjørge, Boyd, Castro, Charrassin, Cipriano, DeMaster, Feindt-Herr, Funahashi, Genov, George, Griffiths, Gulland, Hall, Haug, Houser, Holm, Iñíguez, Isobe, Jepson, Kemper, Ketele, Kucklick, Oviedo, Leslie, A., Leslie, M., Lovell, Luna, Manley, Mate, Marcondes, Mduduzi, Melcón, Moore, Moronuki, Murase, Oosthuizen, Palka, Panigada, Porter, Redfern, Reeves, R., Reeves, S., Rendell, Reyes, Ridoux, Ritter, Rojas-Bracho, Rosa, Rose, Rosenbaum, Simeone, Simmonds, Sironi, Smith, Stachowitsch, Stimmelmayr, Suydam, Tamura, Thomas, Truda, Venn-Watson, Víkingsson, Weinrich, Wilkin, Willson, Ylitalo, Ziccardi.

1. CONVENORS' OPENING REMARKS

Rowles and Parsons welcomed the participants to the Standing Working Group on Environmental Concerns (SWG).

2. ELECTION OF CHAIR

Rowles and Parsons were elected as Co-Chairs.

3. APPOINTMENT OF RAPPORTEURS

Manley, Rosa, Simeone and Ylitalo, were appointed as rapporteurs, with Rose assisting with the final report.

4. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

5. REVIEW OF AVAILABLE DOCUMENTS

The documents available to the SWG were identified as SC/66a/E01-09; SC/66a/Rep07; SC/66a/Rep09; Aksenov *et al.* (2014); George *et al.* (2015); Kellar *et al.* (2014); Laidre *et al.* (2015); Moore and Gulland (2014); Ritter *et al.* (2015); Schwacke *et al.* (2014);Van Bressem *et al.* (2014a; 2014b); Venn-Watson *et al.* (2015a; 2015b); and Yasunaga *et al.* (2014).

6. STATE OF THE CETACEAN ENVIRONMENT REPORT - SOCER

The SOCER provides an annual update, as requested by Commission Resolutions 1997-7 (IWC, 1998) and 1998-5 (IWC, 1999), on: (1) environmental matters that potentially affect cetaceans; and (2) developments in cetacean populations/species that reflect environmental issues. Resolution 2000-7 (IWC, 2001) welcomed the concept of the State of the Cetacean Environment Report (SOCER) and requested the annual submission of this report to the Commission. The first full SOCER (Stachowitsch *et al.*, 2003) was submitted in 2003 and subsequent editions initiated and continued a cycle of focusing on the following regions: Mediterranean and Black Seas, Atlantic Ocean, Pacific Ocean, Indian Ocean, Arctic and Antarctic Seas. Each SOCER also includes a Global section addressing the newest information that applies generally to the cetacean environment. The 2015 SOCER focuses on the Pacific Ocean, summarising key papers and articles published from *ca* 2013 through 2015 to date.

According to the Ocean Health Index compiled by the University of California, the overall health of the world's oceans is 67 out of 100. This index incorporates 10 human goals representing the key ecological, social and economic benefits that a healthy ocean provides. For the six major zones distinguished in the Pacific Ocean, five are at or below this score, with the Pacific northwest having the worst value (53). Fifteen countries bordering the Pacific received scores below 60 (i.e. in the bottom 25%).

One form of pollution has come to be particularly associated with the Pacific, namely marine debris ('Great Pacific Garbage Patch' in the Northern Hemisphere). A new study documents a similar accumulation in the South Pacific Subtropical Gyre. The amount of debris in east Asian Seas is expected to increase by up to 250 times in the next 10 years, and one study estimates the lost tourism revenues of a single debris pollution event on one beach in South Korea to have been $37 million. A significant number of all papers in the leading marine pollution journal are now devoted to marine debris, with microplastics increasingly reported as an issue (now also documented in a baleen whale).

Toxic algal blooms, as one known symptom of eutrophication, were reported to be an issue in Chinese waters. There have been 172 red tide events recorded from 1972-2009; their frequency increased considerably after 2000 (10 events per year). Importantly, the number of extensive toxic blooms (>1,000km²) increased considerably. Toxic blooms were also implicated in unusually high cetacean mortalities in Peru in 2014. An increasingly large number of papers have recently been devoted to pollution in Chinese waters, with high values for heavy metals and persistent organic pollutants recorded in fish and cetaceans, including many dolphin species and minke whales (*Balaenoptera acutorostrata*)(Yellow Sea).

The radioactive plume from the Fukushima nuclear accident has now reached Canadian shelf waters. Hector's (*Cephalorhynchus hectori*) and Maui's dolphins (*C. hectori maui*) continue to be severely threatened by interactions with fishing gear in New Zealand. Some progress is being made in oil spill preparedness and response in the eastern Pacific, with input by the International Maritime Organization (IMO).

On a global level, recent discoveries in environmental science give disturbing predictions. Studies on species extinction rates have shown that one in every four or five marine species is at a heightened risk of extinction. Historical analyses of extinction patterns have shown that mammals have a particularly high extinction risk and regional extinction risks are greatest in the Indo-Pacific, tropical south Pacific, and east Asia, followed by the North Atlantic, Indian Ocean, and sub-Antarctic islands; all important cetacean habitats. As recognised by the Commission (see

Item 12), marine debris is increasingly seen as a major threat to marine ecosystems and, as predicted by the SWG, microplastics have now been found in baleen whales. The threat posed by marine debris is likely to increase, as marine plastics are expected to increase tenfold by 2025.

However, the most troubling global issue is probably climate change, as global atmospheric carbon dioxide levels exceeded 400 parts per million this past year, a level not seen for between two to 23 million years. Projected climate change will likely result in more anoxic 'dead zones' in the ocean, as well as an increased rate of marine species extinction, which will lead to the extinction of at least 5% of all species. If current trends in greenhouse gas and aerosol emissions continue, the extinction rate may be as much as 16% of extant species and there may be as much as an 8.3°C rise in Arctic temperatures by 2100. Concern is also escalating for Antarctic ice sheets, as they may be more vulnerable than previously thought. Certainly ice loss is accelerating in many areas as the result of melting ice positive feedback processes and climate-influenced changes in wind patterns. There is, moreover, concern that these ice losses are likely irreversible.

On a more positive note, several priority setting exercises have developed lists of important research questions that, if answered, will greatly help both cetacean and marine conservation. Studies have illustrated that large whales can have important roles in marine ecosystems, such as in distributing nutrients, and recovering whale populations are now reviving these important ecosystem roles. Finally, a study on a marine protected area (MPA) for Hector's dolphins showed that designation of the MPA led to an increase in annual survivorship and an increase in population growth, showing that some MPAs can be effective as a cetacean conservation measure. The full SOCER 2015 report can be found in Appendix 4.

The SWG **thanked** the SOCER editors for compiling another thorough and informative summary.

In subsequent discussion, it was noted that the Ocean Health Index, compiled by the University of California at Santa Barbara, uses a comprehensive approach that incorporates multiple parameters in order to rank the health of ocean basins. However, this index is focused on human health, not marine species. Therefore, it was noted that the SWG might consider evaluating the Ocean Health Index components and pull out the parameters that are most relevant to cetacean health. It was also noted that an Ocean Health Index approach that was specific to cetacean-related factors might be a useful way to assess trends in the status of cetaceans and their environments.

When asked about the major issue of ocean acidification, it was noted that, whilst this year's SOCER did not contain many papers on ocean acidification, it is expected that, as the focus at SC/66b will be on polar seas, there will be more opportunity next year to look more closely at this important issue. The SWG **encouraged** the Scientific Committee members who work in polar ecosystems to submit materials for SC/66b.

7. POLLUTION

7.1 Pollution 2020

An individual based pollution model, the Effects of Pollutants on Cetacean Populations (SPOC), to investigate the risks to cetacean populations and their potential growth rates was developed under the IWC Pollution 2020 initiative (Hall *et al.*, 2013). This model was translated into a web based application for members of the SWG to test (SC/66a/E01). The web interface was demonstrated and SC/66a/E02 presented a further example of its application. This example used historical, published parameters and vital rates to prepare a simulated, baseline population for the two killer whale populations in the Pacific, the Northern and Southern Resident Killer Whales (*Orcinus orca*) (NRKW and SRKW). The model then simulated the population growth over 100 years and investigated the potential impact of exposure to polychlorinated biphenyls (PCBs) at different accumulation rates and their subsequent effects on reproduction and immunity. Preliminary results found that the potential population growth rate of the NRKW would only be substantially affected when a high proportion of the population were subsequently exposed to a newly introduced pathogen, such as during an epidemic. An annual accumulation of ~1mg/kg total PCBs resulted in levels in the adult females comparable to the published data. However, for the SRKW population, the model simulations suggested they were experiencing an accumulation of 5mg/kg total PCBs per year. At this level, in all scenarios, population growth rate (lambda) estimates fell to <1.0, suggesting that PCB exposure could result in a declining population following the introduction of a novel pathogen. However, if the accumulation of PCBs declined by 1% per annum after year 50 of the 100 years of simulated populations, this would result in a stationary population with lambda ~1.0. This modelling approach has been taken to assist in assessing the risks of PCB exposure to killer whale populations under various exposure conditions. However, not all the drivers of population change have been considered and these simulations are likely to represent worst case scenarios.

In discussion, it was noted that this model may be precautionary, as many models are, because the survival of calves is based on studies in mink, which are known to be very susceptible to these pollutants. While this program was not developed to model males, sperm quality may be affected by these contaminants, and so there may be an effort to include males in the model in the future. However, there are very little empirical data on how these pollutants affect females, and even less information on males, which may make including how any effects may change fecundity even more challenging. Changes in blubber thickness and how this may affect blubber contaminants are also not included in the model. At this stage incorporating blubber thickness or nutritional state would add additional complexity beyond the current boundaries of the model. While there is not currently a way to use a latitudinal profile of contaminant concentration (as the degradation of some contaminants is temperature dependent), the user can alter the rate of decline in contaminant inputs, over several runs of the model to simulate changes with time, which would give some indication of the effect of change with latitude. Lastly, it was noted that this model is an excellent visual tool to engage government officials and policy makers on a range of contaminant issues. The SWG expressed their thanks to Hall for all of the work that has gone into developing this model.

7.2 Oil spill response

7.2.1 Oil spill response and preparedness

Suggestions for engagement in oil spill responses based on experiences during the joint United Nations/Government of Bangladesh Sundarbans oil spill response mission were presented jointly by Ziccardi and Smith. The oil spill occurred on 9 December 2014, when an oil tanker collision spilled an estimated 350,000 liters of furnace oil

into the waterways of the world's largest mangrove forest in the Sundarbans, Bangladesh. Despite initial confusion, a response was mounted several weeks later by local and international experts. The joint response mission found that favorable tidal variations and oil collection efforts conducted by local communities and the Forest Department helped limit exposure of plants and animals to the spilled oil. The immediate environmental impacts to the mangrove and aquatic ecosystems appeared relatively mild and initial acute impacts to wildlife, including freshwater dolphins, appeared limited in scope. It was particularly fortunate that the oil did not overspill the shoreline into the mangrove forest which would have significantly worsened the effects on terrestrial and aquatic biodiversity. The safe removal and disposal of oiled debris remains a challenge and monitoring is required to assess the long-term effects of remobilisation of residual oil on the ecosystem and fishing livelihoods.

Based on the experience before, during, and after the Sundarbans Oil Spill Joint Response Mission, and recognising the extreme political and logistical challenges involved in mobilising an international oil spill response mission, there are several recommendations made by Smith to improve future international responses and assessments. The full Oil Spill Assessment Mission Report can be found at the UN Environmental Emergencies Centre website[1]. Of interest to SWG for oil spill response in geographic areas with cetaceans include the following.

(1) Terms of reference (TOR) should be agreed upon prior to a spill, to clarify roles, data management and interpretation, and the report writing and approval process.
(2) There is a vital need to include an ecological/sociological expert/coordinator whose mandate extends across the various expert teams. This person could provide specific guidance on rapid sampling techniques; data collection protocols; analysis and interpretation; choosing sampling sites; and perhaps most importantly on the integration of the results from the various teams into recommendations that reflect the ecological and sociological connections needed for making meaningful oil spill mitigation recommendations.
(3) The assessment teams should include trained responders with cetacean expertise.
(4) A general list of equipment and supplies needed for rapid oil spill assessments and response for cetaceans should be compiled ahead of time.
(5) Response teams working in local communities must include an independent, professional translator/communication specialist so that they can understand the actual situation and accurately communicate the responses they initiate to local people.

The SWG thanked those members who participated in this spill response for presenting their perspective on this incident and their insights for international oil spill response based on the response to this spill. The SWG **recognised** the difficulties of international oil spill coordination in areas that have limited resources.

Ziccardi presented an overview of international oil spill response efforts. IPIECA, the global oil and gas industry association for environmental and social issues, has developed Guidelines for Oiled Wildlife Response Planning in 2004. IPIECA was formed in 1974 after the launch of the United Nations Environment Program and is the industry's principal channel of communications with the UN. After the Deepwater Horizon (DWH) oil spill in 2010, industry began a major review of oil spill preparedness including wildlife response preparedness with guidelines for oil spills that were published in 2014. Further work involves the development of a Global Oiled Wildlife Response System and is funded by the Joint Industry Project, Phase II for 2015-16. The guidelines and the response systems will encompass many taxa, including marine mammals. The SWG noted that this system would be very useful for preparedness for future spills that involve marine mammals and their habitat and as part of preparedness planning for areas (e.g. marine mammal protected areas) and species of concern for conservation. The SWG **recommended** collaboration with this international planning effort to provide cetacean expertise and information as the system is developed.

Wilkin provided a short update on the ongoing Refugio oil spill response in Santa Barbara, California. Both pinnipeds and dolphins (32 combined live and 20 combined dead) have been responded to in this spill as of 30 May 2015. Up-to-date response numbers can be found on the Oiled Wildlife Care Network website[2]. It was noted that the ongoing pinniped Unusual Mortality Event (UME) has filled most of the local stranding network partners to capacity and they were unable to accept additional animals that have been affected by the spill, due to the space and effort requirements of de-oiling.

7.2.2 Impact assessment of cetaceans from the Deepwater Horizon oil spill

Three studies were presented on bottlenose dolphins as part of the Natural Resource Damage Assessment (NRDA) and UME investigation following the Deepwater Horizon (DWH) oil spill in 2010. The 2010 DWH disaster released millions of barrels of oil into the northern Gulf of Mexico (GoM). Natural and experimental exposure to oil has been linked to adverse health conditions in humans and animals, and studies on cetaceans were initiated.

The first study (Schwacke *et al.*, 2014) evaluated the potential health effects on bottlenose dolphins using capture-release health assessments conducted during the summer of 2011 in Barataria Bay, Louisiana, an area that received heavy and prolonged oiling, and in a reference site, Sarasota Bay, Florida, where oil was not observed. Dolphins sampled in Barataria Bay had abnormally low measures of adrenal hormones consistent with hypoadrenocorticism. Specifically, cortisol values were low in 44% of Barataria Bay dolphins compared to 0% of Sarasota Bay dolphins; and aldosterone was abnormally low in 53% of Barataria Bay dolphins compared to only 8% of Sarasota Bay dolphins. Additionally, Barataria Bay dolphins were five times more likely to have moderate to severe lung disease. Evidence of adrenal gland compromise and advanced lung disease in Barataria Bay dolphins were significantly greater in prevalence and severity than those in Sarasota Bay dolphins, as well as those previously reported in other wild dolphin populations. Further, the adrenal and pulmonary disease states observed in Barataria Bay dolphins were consistent with petroleum hydrocarbon exposure and toxicity.

A second study identified demographic clusters of bottlenose dolphin strandings within the Northern Gulf UME: January 2010-June 2013 (Venn-Watson *et al.*, 2015b). Demographic, spatial, and temporal clusters identified within the GoM UME included increased strandings in

[1]*http://www.ecenter.org.*

[2]*http://www.vetmed.ucdavis.edu/owcn.*

northern Louisiana and Mississippi (March-May 2010); Barataria Bay, Louisiana (August 2010-December 2011); Mississippi and Alabama (2011, including a high prevalence and number of stranded perinates); and multiple northern GoM states during early 2013. The location and magnitude of dolphin strandings during and the year following the 2010 DWH oil spill, including the Barataria Bay cluster from August 2010 to December 2011, overlap in time and space with locations that received heavy and prolonged oiling. Dolphin stranding numbers in Barataria Bay were high after the spill (August 2010), lasting through November 2011. These were the highest, most sustained dolphin stranding rates on record for Louisiana. Investigation into this cluster has demonstrated a lack of evidence for alternative causes of dolphin die-offs, including morbillivirus and biotoxins (Litz *et al.*, 2014). There is also no evidence that brucellosis played a leading role in this cluster. Additionally, the increased dolphin strandings that occurred in northern Louisiana and Mississippi before the DWH oil spill were likely due to different contributing factors, including cold temperatures and low salinity.

The third study was presented on adrenal gland and lung lesions in stranded bottlenose dolphins in GoM found dead following the DWH oil spill (Venn-Watson *et al.*, 2015a). A northern GoM cetacean UME involving primarily bottlenose dolphins in Louisiana, Mississippi, and Alabama began in 2010 and continued into 2014. Overlapping in time and space with this UME was the DWH oil spill, which was proposed as a contributing cause of adrenal disease, lung disease, and poor health in live dolphins examined during 2011 in Barataria Bay, Louisiana. To assess potential contributing factors and causes of deaths for stranded UME dolphins from June 2010 through December 2012, lung and adrenal gland tissues were histologically evaluated from fresh dead non-perinatal carcasses that stranded in Louisiana (including 22 from Barataria Bay), Mississippi, and Alabama. Results were compared to fresh dead stranded dolphins from outside the UME area or prior to the DWH spill. UME dolphins were more likely to have primary bacterial pneumonia (22% compared to 2% in non-UME dolphins, P=0.003) and thin adrenal cortices (33% compared to 7% in non-UME dolphins, P=0.003). In 70% of UME dolphins with primary bacterial pneumonia, the condition either caused or contributed significantly to death. Brucellosis and morbillivirus infections were detected in 7% and 11% of UME dolphins, respectively, and biotoxin levels were low or below the detection limit, indicating that these were not primary causes of the current UME. The rare, life-threatening, and chronic adrenal gland and lung diseases identified in stranded UME dolphins are consistent with exposure to petroleum compounds as seen in other mammals, and are consistent with the findings from the 2011 Barataria Bay live animal health assessments. Therefore, exposure of dolphins to elevated petroleum compounds present in coastal GoM waters during and after the DWH oil spill is proposed as a cause of adrenal and lung disease and as a contributor to increased dolphin deaths.

The SWG thanked the authors for these studies. In discussion it was noted that the diagnosis of the adrenal and lung disease was made primarily through blood cortisol and aldosterone in the live animals. In addition, the lung and adrenal diseases appeared to be evident within weeks to months and have remained present in the affected populations for several years. Continued monitoring of these populations is essential in order to understand the long-term impacts of the DWH event. It was also noted that thus far approximately 1,300 dead cetaceans have been found during the UME. A majority of the strandings have been common bottlenose dolphins, but carcasses of other cetacean species, including more pelagic species, have also been found. The investigation team fully recognises that offshore species that died during the spill would most likely not be detectable as stranded animals on the beach. The NRDA will result in an assessment of injury for coastal, shelf and deep water cetaceans. It was noted that only a few necropsies revealed direct inhalation or ingestion of oil and most of the deaths have been attributed to chronic and sublethal effects from the oil. While inhalation is suspected to be the main route for toxicity, ingestion and aspiration after ingestion have not been ruled out. Lastly, it was noted that initially there was no treatment for adrenal disease of live stranded cetaceans, because early on, this effect was unknown. However, once known, information was provided to the stranding networks so that appropriate treatment by the veterinary staff could be considered with live stranded cetaceans.

Mate presented an update on a tagging study of sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico (GoM) (first presented at SC/65a, see IWC, 2014b). Using data from 'location-only' Argos tags from 2001-05 and again from 2010-13 after the DWH oil spill and Advanced Dive Behavior (ADB) tags in 2011 and 2013, a relative measure of foraging effort was calculated as the number of accelerometer-derived jerk events per dive, and bottom depths were determined at each GPS location from archived data. ADB data identified three primary dive types: benthic foraging, mid-water foraging, and transiting (with few jerk events). Foraging effort was highly variable, as sperm whales covered large areas, suggesting sparsely distributed prey with occasional high-density aggregations. Tagged whale movements in 2011 depict a ~4,000km^2 oblong area of low-use habitat (LUH), including the DWH site, between whales in deeper waters and those on the upper slope. Six of eight whales conducted more benthic than mid-water foraging dives suggesting prey was more abundant there, or that they gained an advantage by foraging close to the bottom. One whale circumnavigated the LUH and >85% of its dives were categorised as 'transiting' with an average of <1 jerk event/dive, suggesting poor prey availability. One hypothesis is that benthic oil-contamination reduced bottom-dwelling fish and thus the squids that prey on them. If true, sperm whales represent the apex of a trophic cascade originating from bottom sediment fouling that may represent a means of monitoring long-term habitat loss.

The SWG thanked Mate for the update and **recommended** that GoM sperm whales in the vicinity of the DWH oil spill should be monitored to document the extent and duration of possible localised effects to better understand cumulative effects and possible long-term population consequences.

The SWG **expressed concern** for the impacts that the DWH oil spill had and may still be having on cetaceans in the GoM. The SWG noted that prevention of oil spills should be maximised. The SWG **reiterated** their recommendations from SC/65b that studies to determine long-term impacts on cetaceans in the GoM be continued, that baseline data be collected from other populations at risk, that knowledge about exposure and impacts be maximised, and that analytical methods for oil spill-related compounds be standardised. Finally, based on the concern of impacts to cetaceans, the SWG **recommended** planning begin for a workshop on oil spills and their impacts on cetacean populations and their habitats, and an intersessional working group was established to work on this.

7.3 Contaminant threat assessment

A questionnaire was used to poll the SWG members, as well as subject matter experts, about the contaminant issues that should be prioritised for future research. After the survey was closed, the results of the 'Prioritisation of Chemical Contaminants of Concern to Cetaceans' survey were presented to the SWG. A total of nine responses were received from SWG members with expertise in this topic. Across all question categories the legacy POPs remain of concern to cetaceans (along with the flame retardants and polycyclic aromatic hydrocarbons) and it was evident that coastal habitats are the regions of highest priority. Reproduction, reproductive success, and survivorship were likely to be affected through acute and chronic biological effects. The systems most likely to be affected by these compounds were endocrine, immune, and neurological. The SWG **recommended** that future studies focus effort on these body systems, geographic regions, including deep water regions, and compounds of concern.

7.4 Data integration and mapping

The SWG had agreed at SC/65b to hold a focus session on regional trends and status of persistent organic pollutants (POPs) in cetaceans. A number of experts were invited from Australia, Japan, the UK and the US and asked to provide the group with information and data for the major contaminant groups, in key cetacean species, across their regions. In some regions and for some cetacean species, monitoring POP concentrations in blubber samples has been carried out since the 1980s. However, the pattern of trends in these POPs, and therefore the current threat that these legacy contaminants may still pose, has not been investigated and the global extent of these surveillance efforts is not known. Some of these datasets now span more than 30 years, enabling regional trends to be investigated. Trends in POP concentrations in cetaceans from five main regions; the North Atlantic, the Mediterranean, the northeast and northwest Pacific, the Arctic and the Southern Ocean were discussed and the datasets available shown in Table 1. The table is not a comprehensive list of available datasets but provides an indication of the spatial and temporal coverage of key datasets for the main regions and species listed that were available at the present time. For example, recent data indicating current exposure status could also be included to highlight areas where these contaminants remain of concern. A summary of each subject-matter expert presentation is presented below.

Table 1

POPs in cetacean blubber - time series datasets.

Region	Species	1980s	1990s	2000s
Baltic	Harbour porpoise	-	X	X
NE Atlantic (UK/Europe)	Harbour porpoise	-	X	X
	Killer whale	-	X	X
	Bottlenose dolphin	-	X	X
	Common dolphin	-	X	X
	Striped dolphin	-	X	X
Mediterranean	Bottlenose dolphin	-	X	X
NW Pacific	Striped dolphin	X	X	X
	Melon headed whale	X	X	X
	Finless porpoise	X	X	X
NE Pacific	Gray whale	X	X	X
	Bowhead whale	-	X	X
	White whales	-	X	X
	Killer whale	-	X	X
W Bering Sea	Gray whale	-	X	X
NE Atlantic (US)	Bottlenose dolphin	-	X	X
Southern Ocean	Minke whale	X	X	X
	Humpback whale	-	X	X

7.4.1 North Atlantic and the Mediterranean Sea

New research was presented by Jepson on PCBs in European cetaceans, including a European meta-analysis of new and existing blubber PCB concentration data for four cetacean species, which included samples from over one thousand individuals: harbour porpoise (*Phocoena phocoena*), common bottlenose dolphin (*Tursiops truncates*), striped dolphin (*Stenella coeruleoalba*), and killer whales. Samples from necropsies of strandings or remote biopsies of free-living populations were used. Very high mean PCB concentrations ($\sum$18-25CBs mg/kg lipid weight) were found in common bottlenose dolphins and killer whales in the NE Atlantic and in bottlenose and striped dolphins in the Mediterranean Sea.

Current threats to cetaceans from POPs in Europe appear to be restricted solely to PCBs (Jepson *et al.*, 2016). Marked and ongoing declines in tissue concentrations of organochlorine pesticides (e.g. DDTs) have occurred in UK-stranded harbour porpoise and in western Mediterranean striped and common bottlenose dolphins. Similar declines have occurred in UK harbour porpoises for butyltins and brominated flame retardants following a 2004 EU-ban on commercial production. Time series analyses show that declines in PCB concentrations in European marine biota have now completely stopped following a mid-1980s EU ban on commercial PCB use and manufacture. Current blubber PCB concentrations in killer whales and common bottlenose and striped dolphins in European waters exceed all marine mammal PCB toxicity thresholds (by almost one order of magnitude), including those associated with suppression of reproduction. Mean PCB concentrations in male and female striped/common bottlenose dolphins and killer whales around the Iberian Peninsula and western Mediterranean Sea (120-325mg/kg lipid) are among the highest levels recorded in cetaceans.

These excessively high and temporally stable PCB exposures were associated with small populations, population declines, or range contraction in several dolphin species in both the NE Atlantic and Mediterranean Sea. The best-studied populations, like common bottlenose dolphins in the Sado estuary in Portugal and killer whales in the Strait of Gibraltar, had very low abundance and annual recruitment rates. In contrast, bycatch and other potential threats were only rarely recorded in European common bottlenose dolphins and killer whales as assessed through stranded animal necropsies or bycatch observer studies. This study concluded that legacy PCB pollution continues to pose major health and conservation threats to the top cetacean predators in Europe and will continue to impact these populations without significant mitigation to limit bioaccumulation through marine food webs.

In discussion, it was noted that the porpoise data were age-corrected, but there were not enough associated data to age correct the killer whale and common bottlenose dolphin data. However, the data for all of the species show high levels of contaminants across all species and individuals, so age does not appear to be a factor in contaminant load. It was also observed that the harbour porpoise had lower contaminant levels than the other species. This can be attributed to the relative trophic level and life history of harbour porpoise compared to the other studied species. In addition, there appears to be a possible age shift in the population of orcas in this region, as few or no calves have been produced. As a result, the populations are composed of only adult animals.

The SWG **agreed** that females may be more susceptible to these types of contaminants, due to contaminant recirculating when the lipid is mobilised to produce milk during lactation. High concentrations of POPs are also problematic for young calves that ingest contaminated milk. Due to their small mass, the dose to calves may be very large, making them more vulnerable to the effects of POPs. The SWG **agreed** that this issue of continued sources of PCBs is of concern in certain areas and **recommended** exploring ways to identify sources and further reduce PCB inputs into marine systems, such as mitigating the release of contaminants during sediment dredging operations, as well as considering methods to sequester PCBs that are already released into the environment. The SWG thanked Jepson for compiling and presenting these data.

7.4.2 Northwest Pacific

Isobe presented information on accumulation levels and temporal trends of POPs in striped dolphin, melon-headed whale (*Peponocephala electra*) and finless porpoise (*Neophocaena phocaenoides*) from Japan (Isobe *et al.*, 2009; 2011). All of the samples were taken from adult male animals that stranded along the Japanese coast between the 1970s and the present. There was a significant decreasing trend in PCBs and DDTs in striped dolphins and melon-headed whales, which may be a result of the global decreased use of these chemicals since the 1970s. In contrast, there was a significant increase of PBDEs and HBCDs in striped dolphins and melon-headed whales, which may be due to the increased use of these pollutants since the mid-1980s. The contaminant level temporal trends in finless porpoise were not as evident as they were in the other two species. As samples of finless porpoise were only taken from 2000-13, no trend was seen in pollutant levels. However, after correcting for body length, there was a significant temporal decrease in DDTs and PBDEs over the sample time period. All other compounds showed no obvious trend, suggesting the continuous environmental release of these chemicals due to their uninterrupted use in commercial products. Therefore, further studies on source identification and ecotoxicological risk assessment are warranted.

In discussion, it was noted that, while many of these samples were taken from animals that stranded during a mass stranding event, a clear link between contaminant load and the cause of the mass stranding event was not found. The SWG thanked Isobe for presenting these findings.

7.4.3 Southern Ocean

A literature review of POP burdens in marine mammals in Antarctica, Australia, and New Zealand was presented by Bengtson Nash. This review included 30 papers[3] that targeted 26 species over the past 50 years. Due to the limited species, methods, and analyte overlap, priority was given to male animals of representative cetacean families/species targeted repeatedly, and where results are reported on a lipid weight basis. A review of the available data for delphinidae species highlighted that there are great regional differences in contaminant burdens; however, the role of inter-species differences cannot be accounted for from this data set, and there are known contaminant hotspots in Australia without corresponding marine mammal data. Only two reports were sourced on POP contamination in New Zealand species. Of these, Stockin *et al.* (2007) provided lipid data, enabling a comparison between southeast Queensland short-beaked common dolphins in Australian and New Zealand North Island common dolphins, with levels of PCBs and HCB tracking each other closely at both locations. In Antarctica, seven published papers on POP burdens in minke whales were found; however, Yasunaga *et al.* (2014) consolidated data from, and built upon, these previous reports. From these data, in conjunction with Southern Hemisphere humpback whale (*Megaptera novaeangliae*) data from Bengtson Nash *et al.* (2013), a temporal record for the region was constructed. It was evident that levels of OCs appeared to have plateaued over the past two decades and no decline had occurred since implementation of the Stockholm Convention in 2004. As noted by Yasunaga *et al.* (2014), considerable trophic biomagnification was evident when baleen whale data were compared to killer whale data from animals sampled in the region in 2005 (Krahn *et al.*, 2008).

During discussion, it was noted that there were significant gaps surrounding levels and health effects in species dependent upon known contamination 'hot-spot' foraging grounds. In addition, it was suggested that model/regional representative species should be included under the Global Monitoring Plan of the Stockholm Convention. Despite the perceived pristine Antarctic conditions, the SWG noted that cetacean contaminant burdens are not insignificant in this region, as some aerosol pollutants have settled out over this region. Finally, the SWG noted the importance of monitoring polar species, especially in light of the possibility of changing nutritive status and prey base in the context of a changing climate. The SWG **strongly encouraged** long-term, comparable data sets to progress the field in this region, and also noted that a focus on resident and vulnerable species would be ideal. The SWG thanked Bengtson Nash for presenting the Southern Ocean data.

7.4.4 Northeast Pacific including the Arctic

The SWG received background information from Kucklick (pers. comm.) on factors that can influence concentrations of POPs in marine mammals. Contaminants concentrations in marine food webs are strongly influenced by the increase or decrease of human-related sources. Persistent organic pollutants listed under the Stockholm Convention such as PCBs, PBDEs, DDT, dieldrin and perfluorooctane sulfonate (PFOS) have been targeted for reduction or elimination from production. However, despite being phased out of production, many of these compounds, such as the PBDEs and PCBs, are still in use in various products or have diffuse environmental sources such as landfills and marine sediments. After a source has been reduced, concentrations in marine mammal populations may respond at different rates. This rate depends on the ambient environment's ability to mobilise POPs to sediments or the atmosphere away from food webs, with warmer locations generally mobilising POPs out of food webs faster than colder locations.

Kucklick also presented on POP concentration data in white whales (*Delphinapterus leucas*) from Alaska (Arctic region) and common bottlenose dolphins from western Florida (subtropical region), to demonstrate rates of change of POPs in these two species from two very different temperature regimes (Reiner *et al.*, 2011; Litz *et al.*, 2007). Blubber and liver from male and female white whales were collected from 1989 to 2005 from the Chukchi Sea and from Cook Inlet, Alaska as part of the Alaska Marine Mammal Tissue Archival Project (AMMTAP). Blubber samples were analysed for legacy POPs and hexabromocylododecane (HBCD, a flame retardant) and liver samples were analysed for perfluorinated alkyl acids (PFAAs) including PFOS. Common bottlenose dolphin blubber samples were collected from a resident population in Sarasota Bay, Florida from 2000

[3]As requested during Plenary, see Appendix 3 for the list of publications reviewed.

to 2012 during live-capture health assessments. Temporal trends were established after correcting for statistical covariates. Samples were analysed for the same compounds listed above except for HBCD and the PFAAs that were not measured. Concentrations of the legacy POPs in white whale blubber were not significantly related to year of collection. PFAAs, HBCDs, and PBDEs showed significant increase with year of collection. In common bottlenose dolphins, all compounds showed significant declines with year of collection, with an average half-life of all compounds in dolphin blubber of about three years. There were different rates of decline depending on the compound, with the fastest rate of decline seen for *trans* chlordane and the slowest for PBDEs. This illustrates that, while concentrations of POPs are generally lower in cetaceans from the Arctic versus those inhabiting more southern locations, changes reflected in the population differ. Consistent with other work in the Arctic, rates of change of legacy POPs are slow and increases with more recently-used compounds, such as the PBDEs, are seen in white whales. Common bottlenose dolphins inhabiting subtropical Sarasota Bay, on the other hand, show rapidly declining levels of POPs, likely resulting from source reduction efforts and mobilisation of these compounds out of the food web, probably through transport to the atmosphere or sediment burial. This illustrates that rates of change of POPs in cetaceans differs and this information should be included in assessing the long term risk of POPs to these animals.

A summary presentation of concentrations of POPs in blubber, brain, muscle, kidney and liver of North American cetaceans was presented by Ylitalo. Levels of these contaminants have been measured in several species, including fin whales (*Balaenoptera physalus*), white whales, killer whales, humpback whales, gray whales (*Eschrichtius robustus*), common bottlenose dolphins and striped dolphins. Although PCBs and DDTs have been routinely measured in cetaceans since the 1960s, comparing data over four decades is difficult due to the lack of percent lipid data reported during the early years and differences in summed PCB calculations that have occurred. Decreasing levels of PCBs, DDTs and organochlorine pesticides (OCPs) were found for killer whales from Washington State/British Columbia and Prince William Sound, Alaska, eastern North Pacific gray whales that stranded along the coast of Washington State and St. Lawrence belugas sampled from 1980s/90s to the 2000s; this trend was not found for certain POP classes determined in blubber of Cook Inlet belugas (PCBs, DDTs, OCPs) or juvenile gray whales (DDTs). Concentrations of the PBDE flame retardants, generally, have been increasing since the 1990s. Overall, the highest contemporary concentrations of POPs were measured in blubber of fish- and marine mammal-eating cetaceans that reside near heavily populated areas of North America, such as transient killer whales that occur off the west coast of North America and bottlenose dolphins from Brunswick, Georgia and Charleston, South Carolina, as well as dolphins sampled off the coast of southern California. Levels of POPs have been reported for various populations of bottlenose dolphins from the eastern Atlantic, killer whales from the eastern North Pacific, killer whales and belugas from Canadian waters, whereas limited information on POPs was found for beaked whales, eastern North Pacific harbour porpoise and large cetaceans from the Gulf of Mexico. In response to a question about the existence of data on the relationship between age of carcass and reliability of these contaminant analyses, it was noted that there is a small amount of work, but the field could benefit greatly from additional investigations. The SWG thanked Kucklick and Ylitalo for presenting these data and **recommended** that additional research be conducted in this area.

Discussion followed with questions about the design of the Alaska Marine Mammal Archival Tissue Project (AMMTAP). The SWG noted the utility of this type of archival system and **encouraged** development of programmes such as this at an international level using the standards of International Society of Biological and Environmental Repositories (ISBER).

Yasunaga *et al.* (2014) presented data on contaminant concentrations in Antarctic minkes whales (*Balaenoptera bonaerensis*). Concentrations of PCBs, DDT and its metabolites, hexachlorocyclohexane isomers (HCHs), hexachlorobenzene (HCB) and chlordane compounds (CHLs) were determined in the blubber of male Antarctic minke whales. The ranges of concentrations ($ng.g^{-1}$ lipid wt.) for each compound were PCBs: 7.7-89; DDTs: 29-340; HCHs: 0.20-4.3; HCB: 75-430; CHLs: 10-120, which were much lower than those in common minke whales (*Balaenoptera acutorostrata*) from the Northern Hemisphere. The levels of PCBs, HCHs, HCB and CHLs in Area IV were significantly higher than those in Area V, while the levels of DDTs in both areas were similar. For comparing the fate among four pesticides in the Southern Ocean, avoiding the effect of variance due to food intake, the ratios of the pesticides to PCBs, which has an extremely high chemical stability and environmental persistence, were examined. The HCHs/PCBs ratio decreased by a factor of about 20 in a span of 16 years in both Areas IV and V, while temporal trends of DDTs/PCBs, HCB/PCBs and CHLs/PCBs ratios were not observed. These results indicate that PCBs, DDTs, HCB and CHLs levels did not vary or slightly decreased in Areas IV and V during the study period. However, HCHs levels clearly decreased. Spatial differences seems to be related to differences in food intake among whales, and temporal differences seems to be related to the length stay of organochlorines in the Southern Ocean. The SWG thanked the author for presenting these findings.

During general discussion about POP contamination trends, it was noted that PCB occurrence is location-dependent, with many ties to the pelagic food cycle that have implications for mitigation efforts. In some cases, information on contaminant hot spots could be obtained from resource management monitoring programs or regulatory agencies. It was noted that there are some major sources of PCBs where information is not easily available. For example, Stilla *et al.* (2003) found that (pre-1970s) military submarines are contaminated with PCBs such that simple dermal contact with submarine material may pose a serious health risk. Information on these vessels and similar contaminated military material are likely to be classified, although the current move towards declassification of this information is allowing more information to be gathered on military sources of PCBs. The SWG also discussed the value of mapping and modelling efforts related to the mode of input of these contaminants (air versus land-based) in the context of the potential value of these predictions. It was also noted that the effects of declining concentrations of POPs on cetacean populations could be examined using pollution models, such as those developed as part of the IWC Pollution 2020 project. Information on contaminant hotspots, concentration trends analyses and potential effects at the population level, may be useful for Commission members, although rules for their use would need to be determined.

The SWG **expressed concern** about the high concentrations and continued persistence of PCBs, especially in the Northern Hemisphere, despite the overall decline in their use and manufacture, and **recommended** that research efforts continue in understanding their persistence in the environment. The SWG **recommended** the continuation of this effort to collect and collate additional contaminant data for cetaceans and the development of a cetacean POPs mapping tool.

The SWG identified the need, to better quantify the environmental impacts of PCB contamination, to determine PCB sources and to identify mechanisms to reduce further PCB input into the marine environment. Consideration of other confounding issues while examining these topics (especially with respect to immunosuppression), the impacts of pack ice and permafrost thaw on contaminants, and consideration of the presence of plastics was also discussed.

The SWG **agreed** to form an intersessional working group, convened by Jepson, with Terms of Reference as follows:

- assess the latest cetacean persistent organic pollutant (POP) data from Europe and elsewhere, as appropriate, with a specific focus on PCBs and what this information tells us about sources;
- define the current options to reduce cetacean PCB exposures in the marine environment and consider any novel options; and
- identify the current data-gaps in PCB exposure data for particular species and regions.

To conclude, the POP trend data provided by the experts will be collated by the Pollution 2020 steering group intersessionally for inclusion in a mapping initiative. The purpose of this follow up task would be to make the trends and status data available through a web application that could be interrogated to determine the potential 'hotspots' or regions where POPs are still of concern and in which species.

Additional published data will also be included and new data could be collected from publications via SOCER or other appropriate sources. This could be done using interns or by direct communication with the authors to assist in providing the data in the correct format in return for a DOI reference to the use of the data through the web portal. A demonstration of a similar interactive map showing air pollution was given by Hall. The data would also be used to inform the individual based pollution model (SPOC) by identifying where PCB concentrations are declining and at what rate. However, the quality of the data to be included in the maps must be maintained and restricted to those sets the SWG has most confidence in. The averages must be comparable and data reported on a lipid weight basis. The analytical standards required for the data and the meta-data fields that should be included will also be determined intersessionally.

The SWG thanked Hall for her efforts and **agreed** that making this database more broadly available, as well as adding in information collected via SOCER, or other mechanisms, to the database, would be of value. Adding data from SOCER is plausible, but the process for doing so should be considered and discussed further intersessionally with the editors.

Kucklick also presented information on the activities of the Arctic Monitoring and Assessment Program (AMAP) of the Arctic Council that summarised data on POPs in the Arctic. At a meeting in September 2013 in Ottawa, Canada, AMAP (Wilson *et al.*, 2014) identified temporal trend data sets on POPs from the Arctic so that they could be incorporated in the report to the Stockholm Convention. Several types of environmental sample data were summarised, including humans, air, fish, and marine mammals. Data activities were broken down by country and relevant leads were identified to facilitate pulling together the temporal trend data sets. A major task of the AMAP working group was to decide how to report POP data that often is reported differently by different groups. For example, the sum of reported PCB congeners can vary widely among data sets. The AMAP working group agreed on a minimum subset of data that included: a core set of PCBs (10 congeners) that were summed; PCB 153, BDE 47 and 99 were reported separately as well; toxaphene congeners (Parlar nomenclature) 26 and 50; *o,p'*- and *p,p'* DDT, DDE, DDD summed; *p,p'*-DDE reported separately; *cis*-, *trans*-chlordane and nonachlor; *trans*-nonachlor, heptachlor epoxide comprised chlordane with *trans*-nonachlor and were also reported separately; α- β- γ-cyclochlorocyclohexane (HCH) comprised SHCH; hexabromocyclododecane (HBCD), mirex, dieldrin, hexachlorobenzene (HCB), and perfluoroctane sulfonate (PFOS) were reported separately.

The second activity of the AMAP POP Expert Group was to prepare a summary on chemicals of emerging concern that are relevant to the Arctic. The group of experts met in Basel, Switzerland in 2014, following the Society of Environmental Toxicology and Chemistry European meeting to scope out a summary, and to assign appropriate writing leads for the report. The group identified the following list of compounds of emerging concern relative to the Arctic: Per- and poly-fluorinated compounds, brominated/chlorinated flame retardants, short-chained chlorinated paraffins, polychlorinated naphthalenes, hexachlorobutadiene, brominated/chlorinated natural products, alkyl tins, current use pesticides, siloxanes, phosphorus-based plasticisers, phosphorus-based flame retardants, pharmaceuticals/ personal care products, polycyclic aromatic compounds (PACs), and phthalates.

Cetacean data are a part of this summary; however, some classes of contaminants are likely to be relatively undetectable in cetacean blubber due to low bioaccumulation or biomagnification potential. The report is in draft form and should be available by the fall of 2015.

In discussion, it was noted that the list of classes of contaminants that are likely to be relatively undetectable in cetacean blubber due to low bioaccumulation was a best guess using what is currently known about these contaminants. Also, some of the pollutants on this list may not bioaccumulate, but are still toxic, and in some cases, exposure rates are so high that cetaceans may not be able to excrete the contaminants fast enough to avoid impacts. Therefore, these contaminants may still affect cetaceans, even though they do not bioaccumulate in tissues. The SWG thanked Kucklick for providing this very valuable summary.

8. CETACEAN DISEASES OF CONCERN (CDOC) AND MORTALITY EVENTS

8.1 CDoC[4]

SC/66a/E07 discussed information on the prevalence of the ectoparasite cyamid (*Cyamus ceti*) on bowhead whales (*Balaena mysticetus*) harvested for subsistence purposes from 1973 to 2014. This study was motivated by previous work on North Atlantic right whales (*Eubalena glacialis*).

[4]See explanation on p.47.

In those studies visual health assessment analyses indicated that the spatial distribution and abundance of cyamids was strongly correlated with host health and body condition. In this study, of the 645 whales examined, cyamids were present on 20% (n=134) of individuals, with low numbers of cyamids (<10 per whale) found on most whales. A few whales had 10s to 100s of cyamids on them. Logistic regression models were assessed for a subset of 134 whales, for which ectoparasite, morphometric and biological data were collected. Older whales had a higher probability of cyamid presence. Heavy infestation of cyamids appears to be related to compromised health in some cases. Variability in the prevalence and intensity of cyamids may serve as a bio-indicator of change in bowhead whale health and environmental conditions, especially in light of anticipated changes to arctic regions inhabited by these whales.

The authors noted that the cyamid assessment in bowhead whales is still a work in progress, and that they may have different conclusions with time. For example, there may be a cyclic nature to the occurrence of cyamids in bowhead whales. However, because no taxonomic work is being conducted currently on cyamids in bowhead whales, it would be difficult to determine if a shift in cyamid species (the same species being evaluated in gray whales) has occurred. The authors also noted that the baseline cyamid data is robust and will be able to help detect any changes in the environment with time.

During discussion, it was noted that cyamid clusters occur on the body of North Atlantic right whales and appear prominently near wounds. Often as healing occurs cyamid presence decreases. In contrast, subsistence hunters did not observe cyamids clustering around wounds of bowhead whales, though they noted that increased numbers of cyamids were cause for concern and resulted in additional scrutiny into the health of the animal. Cyamids might be good biosamplers (similar to ticks), as in the case of pathogens that are expressed in skin, such as morbillivirus, cyamids might possibly be used to detect changes in pathogens. If cyamids do harbor such pathogens they may potentially play a role in exposure or transfer of pathogens among cetaceans. For instance, southern right whale (*Eubalena australis*) mother-calf pairs could be assessed for transmission of pathogens via cyamids. For bowhead whales that have large numbers of cyamids, it heightens the need to more closely assess the health of those animals. The SWG thanked the authors for presenting these interesting findings.

SC/66a/E08 presented information on the natural morbidity and mortality rates of bowhead whales. The authors reported that mortality rates are similar to other arctic marine mammals but have the potential to increase with ongoing shifts in the environment, including climate change and increasing industrial development/ship traffic. Since Philo *et al.* (1993) reported an in-depth review of known causes of morbidity and mortality, a fair number of newly observed pathological conditions across organ systems have been observed in subsistence harvested bowhead whales in Barrow, Alaska. With the exception of hepatic fatty tumors (multiple observations since 2011), observed pathological findings represent individual case reports. The majority of findings are considered incidental without a significant negative effect on overall bowhead whale health and/or human consumption of these animals. Characterisation of scarring on bowhead whales (1990-2012) suggests, in order of prevalence, integumentary injuries being due to line entanglement (12%), killer whale attacks (8%), and ship strikes (2%). Toxins produced by harmful algal blooms have been measured in bowheads, but the available case numbers are too few to make meaningful statements about the potential for health implications. Bowhead whale strandings on the North Slope generally occur at a low rate of ~5%. Of interest is the first documentation of a confirmed killer whale predation on a bowhead whale on the North Slope. For bowhead whales, only one previous witness account of a killer whale attack on multiple bowhead whales in the vicinity of Saint Lawrence Island has been reported. No necropsy findings consistent with blunt and/or sharp force trauma due to vessel strikes have been observed. In conclusion, the current preliminary veterinary medicine-based health assessment suggests that Bering-Chukchi-Beaufort (B-C-B) bowhead whales harvested on the North Slope are healthy with very few natural disease conditions being present. These results provide additional lines of evidence in support of the recent findings on bowhead whale population size and body condition assessment work done by the North Slope Borough Department of Wildlife Management (NSBDWM) and the Alaska Eskimo Whaling Commission (AEWC), which suggest a thriving, growing and overall healthy B-C-B bowhead population. In addition the data presented provides important baseline information for B-C-B bowhead whales under changing Arctic conditions. Last but not least, the future health assessment work outlined in the paper will provide unprecedented retrospective health information for an ice-adapted large cetacean during the Arctic Anthropocene.

The SWG discussed the potential of standardising the assessment of health status of bowhead whales and other species of whales. Canadian researchers working on white whales have standardised measures but these have not necessarily been adopted globally. The authors noted that, although few bowhead whales are harvested in Canada each year, they have sent their protocols to Canada and Greenland and some collaboration on scar identification has been done among the groups. The SWG thanked the authors for bringing this information forward, noting that this is the longest health assessment data record for a large whale. The SWG **encouraged** collaborative efforts among researchers to standardise health status parameters for health assessments on both subsistence-harvested bowhead whales and white whales.

As part of a long-term cetacean study, small cetacean sightings were documented photographically during regular whalewatching trips of the Canary Island of La Gomera from 1996 through 2014, and anomalies of different types were analysed in Ritter *et al.* (2015). Such anomalies were categorised as: (a) skin lesions and injuries; (b) skin anomalies, e.g. distinct blotches, patchy scars, dents or bumps; and (c) skinny animals showing signs of emaciation. Anomalies were found in bottlenose dolphins, pilot whales, Atlantic spotted dolphins, rough-toothed dolphins and common dolphins. Emaciated animals were mostly bottlenose dolphins, also often involving a number of animals in the same group, indicating affliction of this species on a larger scale. A number of causations for each category of anomalies were considered including: (i) ship strikes and entanglement; (ii) skin diseases such as infections and scars from predators/parasites; and (iii) food shortage or internal diseases. In most cases, the true reason for the anomaly will remain unknown. However, documenting anomalies, even if conducted in a more non-systematic way from platforms of opportunity can contribute to assessing the health status of small cetacean populations. In multi-species habitats like the Canary Islands, the comparison of levels of affliction

can help understand the impact of anthropogenic threats to different cetacean species sharing the same environment.

The SWG noted that there is insufficient information on survivorship of the dolphins and other cetaceans from this area of the Canary Islands so it is difficult to determine the impacts of skin diseases on the survival and reproduction of these populations. The SWG thanked the authors for presenting these interesting findings, and **encouraged** inclusion of the skin disease photographs presented in the paper on the CERD [CDoC] website.

Van Bressem *et al.* (2014b) which gives information on tattoo-like skin disease lesions on Arabian Sea humpback whales (ASHW) reviewed from a photo-identification dataset generated from small vessel surveys conducted in Oman between 2000 and 2011 was presented to the SWG. The first documented case from the Balaenopteridae family with the disease was reported, and it was noted that 13 out of 60 whales out of the study period were affected, with increased prevalence from 15.6 % in 2000-02 to 30% in the period 2010-11. Maximum coverage of lesions was estimated at 40% of visible body size. During the course of the study, two other tattoo-like lesions were noted by the authors; on Bryde's whales from Thailand and South Africa and a humpback whale from Gabon. It was hypothesised that this condition may be more widely distributed than existing records document suggesting that further studies should investigate the distribution, epidemiology, trends and potential health impacts of the disease.

In discussion, it was noted that the results clearly show increasing prevalence of a disease, which is suspected to be associated with a suppressed immune system. Soviet whale take data also indicates this population to have a high prevalence of hepatic pathology (26 out of 38 captures). Taking into consideration the isolation, low genetic diversity (Pomilla *et al.*, 2014) and known population estimates from Oman (Minton *et al.*, 2008), emerging threats (Willson *et al.*, 2014) and five mortalities of ASHW over a five-month period in 2015, the SWG expressed its concern about future and continued health monitoring in this small, isolated population. For additional information on whales in Oman, see discussion around SC/66a/SH23. The SWG **recommended** that further efforts be initiated to evaluate the health of this population through health studies and enhancing the information on health and causes of morbidity and mortality from strandings and also **recommended** that technical support be offered and extended to stranding responders in Oman to assist with this effort. The SWG noted that the Ministry of Environment and Climate Affairs in Oman has requested the IWC provide entanglement response training and stranding response training. The members of CDoC might coordinate with the IWC to provide appropriate expertise on the health of this population.

Van Bressem *et al.* (2014a) discussed recommendations from a Research and Policy for Infectious Disease Dynamics (RAPIDD) workshop that was convened at Princeton University in August 2014 to discuss cetacean morbilliviruses. Cetacean morbillivirus (CeMV) is a distinct species within the Morbillivirus (MV) genus, and it has caused epidemics with high mortality in odontocetes in Europe, and the USA, individual cases of disease in numerous countries, and has also caused disease in mysticetes. The authors summarise how significant progress in our understanding of the epidemiology, molecular biology and pathogenesis of CeMV has been made since the first strains were detected in 1988. The paper made several recommendations for future research focus, including:

- use of next generation sequencing technologies to enhance detection and characterisation of CeMVs to better understand their evolution;
- further studies to confirm whether the SLAM cell receptor is indeed the primary immune receptor for CeMV;
- further studies to delineate host responses to CeMV strains and factors that determine the outcome of infection in cetaceans;
- development of mathematical models to examine long-term dynamic consequences of epidemics on odontocete populations, to determine in which populations CeMV are considered a true threat to conservation; and
- development of an integrative approach to the study of MV, including diagnostic techniques, epidemiological parameters, life history of the species affected, and environmental parameters, in order to provide a more complete picture of the ecology and evolution of CeMV.

In discussion, it was noted that the Princeton RAPIDD workshop had a One-Health perspective and workshop participants included international marine mammal veterinarians and biologists, as well as human health scientists. The workshop resulted in a publication with a large international authorship. The SWG **welcomed** this international collaboration on a disease of concern to cetacean populations worldwide and **recommended** that CDoC investigate these suggestions.

Rowles presented an update on the US mid-Atlantic coast morbillivirus unusual mortality event (UME), noting that the peak of morbillivirus cases in dolphins occurred in the autumn of 2013 off the coast of Virginia and northern North Carolina. Blubber contaminant analyses, including PCBs, are planned for a subset of the mid-Atlantic UME dolphins and control dolphins, including dolphins from Georgia that have very high PCB levels. However, a confounding issue is that morbillivirus, similar to PCBs, is also immunosuppressive, and thus may contribute to secondary effects and be a confounding factor in these efforts. In discussion it was noted that there have been a number of cetacean morbillivirus outbreaks in Europe since 1990, including dolphins and pilot whales in the Mediterranean Sea. The morbillivirus mortality events in the Mediterranean were associated with high PCB concentrations in the affected cetaceans. PCB exposure in marine mammals has been associated with immune suppression; thus, animals with high levels of these contaminants may be more susceptible to epizootics such as these. The SWG also discussed the types of health measurements taken during and after a UME, such as the US mid-Atlantic dolphin morbillivirus event. During the epidemic, biopsy skin and blubber samples were collected in areas of high mortality to evaluate stocks. In addition, live capture-release health assessments are planned for dolphins from the US Atlantic, which will include a number of health measures. The SWG also discussed collaborative efforts with regard to the morbillivirus outbreak in cetaceans from the US mid-Atlantic, noting that this investigation and the follow up work on phylogeny of cetacean morbilliviruses was a collaborative effort with other nations (e.g. Canada, Australia, Costa Rica). However, often during epidemics or die-offs communication between countries may not be rapidly disseminated as there is no one venue to communicate the information to other researchers in nearby regions. The ability to communicate timely and accurate information to managers and scientists in the epidemic zone and other associated areas is important.

The SWG **recognised** the importance of global understanding of the impacts of viruses on cetaceans and highly **encouraged** continued research in this study area. It was

also noted by the SWG that the newly established CDoC website and other communication tools may be able to serve as a communication site for these international outbreaks.

Aksenov *et al.* (2014) discussed a study assessing metabolite content in dolphin breath. An ongoing project is assessing the feasibility of using breath condensate collected from managed and wild bottlenose dolphins to non-invasively assess their health. To date, 500-1,000 volatile and non-volatile compounds are being reliably identified in dolphin breath condensate using a newly engineering breath collection device and liquid and gas chromatography/mass spectrometry. Initial results support that breath condensate may be a valuable indicator of ill dolphins.

In discussion it was noted that this technique is also being used to assess the health of wild populations of bottlenose dolphins, and there will be a forthcoming paper on these data. The SWG **welcomed** this paper and future papers, and encouraged the further development of this technique to assess the health of wild populations of wild cetacean populations. The SWG also **encouraged** the use of this technique to study 'stinky' gray whales, as this technique may help to answer some of the unresolved questions surrounding this issue. While breath analysis using the method in Aksenov *et al.* (2014) cannot be directly applied to large cetaceans, unmanned aircraft systems (UASs) may be used to capture breaths and freeze them for analysis.

Rosa presented information discussed at a pre-meeting that was held just prior to SC/66a in San Diego, California on 21 May, 2015 with participation (in person and via Skype) from a number of veterinary and marine mammal experts from a variety of organisations. The goals of the CDoC pre-meeting were to prioritise the needs of the international community with regards to emerging and resurging diseases of cetaceans (including infectious and non-infectious disease), and to determine the ideal role that the Commission might play with regards to disease surveillance, diagnosis, and risk management.

The pre-meeting facilitated an open dialogue amongst a small number of stakeholders on a number of relevant aspects of the future of CDoC, including: current and past research conducted; implementation of management measures; knowledge gaps and concerns; and information that the Commission can provide to assist managers in preparing for these impacts. A survey had been sent out to the broader CDoC steering group prior to the meeting and the results of this survey were reported at the meeting.

The SWG **recommended** the following.

- Endorse the change of name from Cetacean Emerging and Resurging Diseases (CERD) to Cetacean Diseases of Concern (CDoC) which better reflects the current needs of participating members.
- Increased resource allocation for CDoC focused especially on website finalisation and maintenance. This is particularly important for implementation of 'Phase 2' (the reporting function of the website).
- Improvement of outreach and capacity building to/between veterinarians and biologists, as well as between the Commission and non-Commission participants through a variety of mechanisms, such as listserves, sharing resource lists, and websites.
- The development and maintenance of a list of cetacean reference or diagnostic labs that would be available as a resource on the Commission website for cetacean biologists and veterinarians. The information on this list will be obtained through other bodies or requests to member countries.
- Continue to expand the extended expert list and maintain the quarterly CDoC updates.

It was noted that more diagnostic pictures are needed for the website resources, but that copyright laws will need to be considered when submitting pictures to CDoC. The SWG thanked CDoC for all of the work they have done on the website.

8.2 Strandings and mortality events

SC/66a/Rep09 provided information on the 2nd Workshop on Mortality of Southern Right Whales (*Eubalaena australis*) at Península Valdés that was held on 5-6 August 2014 in Puerto Madryn, Argentina. The report described how difficult both response and investigations can be when large numbers of whales die and strand during a short period of time. At least 672 southern right whales (mostly calves) died at Península Valdés, Argentina between 2003 and 2013, with a peak of 116 dead whales in one season only (2012). This was the largest mortality ever recorded for this species in one season. Although some whale mortalities are still occurring, they appear to be subsiding as only 23 dead whales were documented in 2014. The causes of the high number of dead right whales are still unknown. The three main hypotheses are: (1) kelp gull and southern right whale interaction and its effects on whale behaviour and health; (2) density-dependent processes and their effects on right whale population dynamics; and (3) a decline in food availability and its effects on right whale body condition and health. The response and investigation has involved cooperation among technical experts from many countries and relied heavily on established in-country programs, such as the Southern Right Whale Health Monitoring Program (established by a consortium of NGOs in Península Valdés in 2003) and the Red de Fauna Costera from Chubut province. The findings of the report were presented by Iñíguez and discussed in more detail in the Sub-committee on Bowhead, Right and Gray Whales (see Annex F, item 4.1). The SWG **welcomed** the information provided in this update on the southern right whale mortality in Península Valdés and **encouraged** continued investigations and cooperation among research groups to monitor the population's health and determine the causes of the mortalities.

The SWG received an update from Simeone on the Marine Mammal HealthMAP project that was presented previously as Simeone *et al.* (2014). Information on the occurrence of elevated California sea lion (*Zalophus californianus*) pup mortalities together with oceanographic data (e.g. sea surface temperature) was shown as an example of how the mapping system could be used.

In discussion, it was noted that the Marine Mammal HealthMAP contains information from California, but will soon be expanded to other regions of the US. The HealthMAP will serve both as a national and an international platform, by inclusion of various test cases. The SWG recognised that HealthMAP can provide information on marine mammal health and disease to help determine the potential impacts on populations and **encouraged** further development of this dynamic tool.

The SWG thanked all of the authors for their hard work and **encouraged** continued work on cetacean diseases.

Simeone presented information relating to strandings that was discussed during the CDoC pre-meeting held just prior to SC/66a. Baseline data collection was identified as a major area of concern for the future, as a large proportion of the knowledge of cetacean diseases stems from samples collected on stranded animals. Currently, the Commission

has two platforms relating to stranding. The first platform is the progress reports, which provide a variety of information from participating countries, including sightings, tissue and biological samples, fishery bycatch, and strandings. Since 2013, all progress report data have been entered into an online database, and reports can be generated by year of data collection. In the progress reports, member countries are required to report on stranding numbers, and include incidents of entanglement or ship strike. The strength of this list is based on what is submitted by each country, and should be considered an overview, instead of a complete list of strandings by country. CERD pre-meeting participants recommended discussing the stranding progress reports within the SWG, to determine the utility of the current fields, potential adoption of new fields, or expansion of the reports in a way that would provide more value to member countries (i.e. with a mapping function of strandings, or reporting mass stranding events). The SWG **agreed** with the recommendation and **tasked** the intersessional working group with these items, to report back to SC/66b.

The second platform is a list of stranding network information by country. The list was compiled in 2011, but it has not been updated since that time. CDoC pre-meeting participants recommended discussing the Stranding Network List, to determine the most appropriate way to gather more information, including:

- the spatial and temporal coverage of any networks, and methods to display this information (i.e. as a mapping feature);
- the type of information collected when a stranding is reported; and
- recommendations for continued use of the list, including updating the list, and/or centralisation of this list as a database.

The SWG **agreed** with this recommendation and **tasked** the intersessional working group with these items.

CDoC pre-meeting participants also discussed recent mysticete mortalities in Chile. Concern was expressed that a mass die-off of a pelagic whale species is occurring, with two events also reported in approximately the same area (46°S), in 2012 and in 2015, with a possible third event noted.

Further discussions in the CDoC pre-meeting highlighted the need to identify ways to improve the response capacity and identify the manner in which the IWC might assist in improving stranding response and investigations with member countries and non-member countries. In order to mount a rapid response, countries require a strong observation system, a reporting system, and support for an effective response guided by the national stranding organisations. Suggestions to accomplish included:

- encourage countries with cetacean stranding events to perform an internal debrief, to discuss logistics, successes, and areas for improvement;
- creation of a network to support initial observation and reporting;
- capacity-building for rapid response, including collaborations with foreign ministry and military;
- creation of a Public Service Announcement (PSA) campaign from the Commission to support awareness of cetacean strandings and the local response network;
- utilising technologies such as a mobile application or social media;
- improved communication structure for sample prioritisation in remote locations; and
- potential formation of an expert working group focused on stranding response, or a listserv for consultation.

CDoC pre-meeting participants discussed a workshop on 'Investigations of large mortality events and mass strandings', which was first proposed at SC/65b (IWC, 2014c). The initial proposed goals of the workshop were to establish common terminology, to facilitate consistency in investigation techniques, and to share information on potential solutions relative to causes, responses, and mitigation of stranding events. Participants of the pre-meeting highlighted the difficulty in arriving at standardised international definitions for mass stranding events, and the history of previous workshops with training in stranding response that produced less long-term change than was desired. Modifying some of the goals of the proposed workshop to ask that the workshop participants from a variety of countries present their historical stranding events, in order to compare responses between member countries, was suggested. These presentations will include discussion of successes, failures, and how the SWG can help to improve international response. Therefore, the structure of the workshop will be a forum to share stories and connect networks with similar response capabilities, as well as a discussion of typical/atypical mass stranding events, and their definitions in different countries. This will allow participants to understand differences in country definitions, but without a common goal of standardised definitions. The SWG **agreed** and **tasked** the intersessional working group with finalising the proposed workshop agenda.

The CDoC pre-meeting participants also discussed deliverables such as a publication or meeting report. This was deemed most viable if an author was predetermined and assigned this responsibility. Two possible papers were discussed: one focused on 'how to' or best practices on setting up a stranding network, and one paper that outlines a comparison of country stranding response efforts (invited papers), with a focus on successes and information sharing. A draft agenda for the workshop can be found in Appendix 2.

The SWG thanked Simeone for presenting this report. The SWG **recommended** that an intersessional group be established and convened by Simeone. The stranding intersessional group will determine how data from the National Progress Reports could be compiled into a single database. This same group will also work on developing the Investigations of large mortality events and mass strandings workshop. The SWG **strongly encouraged** governments to support the maintenance of stranding networks as an important source of data and, where possible, expand capacities. The standardised collection of data using appropriately elaborated necropsy protocols was also **recommended**.

9. EFFECTS OF ANTHROPOGENIC SOUND ON CETACEANS AND APPROACHES TO MITIGATE EFFECTS

9.1 Update on soundscape mapping

Although no update on the soundscape mapping was presented, the CetSOUND website, which was presented to the SWG last year[5], provides information on soundscape mapping.

9.2 Masking

The SWG has considered underwater sound on its agenda since 2004 (IWC, 2005, p.268). The SWG considered

[5] *http://cetsound.noaa.gov/cetsound.*

'masking sound' from low-frequency noise as a focal session at its 2010 meeting in Agadir (IWC, 2011, p.41). With respect to low frequency noise from shipping, the Scientific Committee has 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 Commission and International Maritime Organization (IMO) continue to work collaboratively to advance the goal of worldwide reduction of noise from commercial shipping when and wherever practicable including reporting progress on noise measurements and implementing noise reduction measures.

The SWG noted the IMO guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (MEPC.1/Circ.833) that were agreed in 2014. Implementation of these guidelines would provide a way to advance these recommendations. Unfortunately, some key experts on the 2010 focal-topic session were unable to attend the 2010 meeting due to travel-related difficulties. Since then there have been a number of advances in the mathematical and statistical techniques used to model population consequences of disturbance (PCoD), including the incorporation of underwater sound (New *et al.*, 2013a; 2013b). The SWG **recommended** a focal-topic session be held at the SC/66b meeting to: (a) update the SWG on progress made on 'masking sound' with a particular emphasis on noise from commercial shipping; (b) provide an overview of the PCoD framework; and (c) explore ways that the PCoD and similar frameworks could be modified to predict population consequences of acoustic masking.

The SWG **recommended** that the intersessional working group encourage participants to attend and identify subject matter experts to present at this focal-topic session, especially researchers that have expertise in drawing linkages among acoustics, foraging ecology, physiology, demography, statistics, and modelling dynamics of marine mammal populations.

9.3 Evaluation of stress and sound

At SC/65b, the work plan for the SWG included a discussion of future work on anthropogenic sound and stress in cetaceans. Further information was received on this topic.

Atkinson *et al.* (2015) reviewed current scientific knowledge of the physiology of the stress response in marine mammals. The relationship between noise exposure and the initiation and persistence of the stress response in marine mammals is hampered by a lack of information correlating the two, an incomplete understanding of the baseline variability and action of hormonal markers in marine mammals, and a limited capacity to collect samples from marine mammals without inducing handling artifact. Recent efforts to collect information on demographic, seasonal, and diel variability in the stress hormones (e.g. corticosteroids, catecholamines, and thyroid hormones) of bottlenose dolphins demonstrates various hormone-dependent patterns that must be accounted for in samples from wild populations, but which remain largely unknown for nearly all species. Similarly, baseline levels from 'unstressed' dolphins are lower than those collected from animals in the wild suggesting artifact from handling procedures, which is a potential issue for all wild animal sample collections. Handling stress has recently been shown to cause over ten to a hundred-fold increase in certain hormones on the order of tens of minutes in dolphins. However, the appearance of hormones or their metabolites in alternative matrices (e.g. faeces, blubber) demonstrates a time-lag that affords the opportunity to determine stress hormone levels in the hours and minutes prior to the induction of handling stress, or in some instances, without inducing handling stress.

A lack of baseline variability is confounded by questions that still exist about the function of hormones associated with the stress response, i.e. how they operate relative to what is known in terrestrial mammals. Evidence suggests that catecholamines may serve to reduce heart rate in diving marine mammals, counter to what is observed in terrestrial mammals, and profound behavioural reactions have been observed in marine mammals with no change in heart rate or monitored stress hormones. These findings, though few, suggest that marine mammals may have altered the function of hormones to accommodate a diving existence with significant time separated from oxygen. Similar modifications may exist to corticosteroid function, as ACTH appears to be a stronger secretegogue for aldosterone than it is for cortisol. Thus, caution must still be exercised in directly relating stress hormone function in marine mammals based upon knowledge of terrestrial counterparts.

Additional discussion was provided on the relationship between noise exposure and stress hormone levels. Relatively little information has been documented on the relationship between noise exposure and stress hormone levels, and the information that does exist is almost exclusively drawn from acute sound exposures. Questions regarding long-term exposures for the most part remain without investigation, although the relationship between the persistence of noise and chronic elevations in stress hormones may be the most critical component of the ocean noise phenomenon. A comprehensive approach to determining viable stress markers in marine mammals and the impact of the magnitude and duration of noise-induced hormonal changes needs to be assessed relative to animal health condition and energetic costs. Specifically, in order to better predict long-term impacts to marine mammal populations subjected to anthropogenic noise, studies need to be performed to look at the relationship between stress, bioenergetics, immunology, disease susceptibility, and reproductive capacity and effort.

In further discussion it was noted that the stress response resulted from the tested animals being presented with an unexpected, but routine, medical procedure. It was hypothesised that exposure of naive wild animals to much more stressful encounters (e.g. chased by boats or entanglement in fishing gear) would likely have a greater acute stress response. It was also noted that model cetacean species may not be representative for the stress response in other cetacean species, as paired species studies have noted opposite behavioural responses in species that are taxonomically similar. Many factors will need to be validated for individual species, but a starting point would be to select several model species and then refine in the future. As certain hormones such as glucocorticoids have many other important physiologic functions apart from the stress response, more work is needed to understand the multifactorial nature of these hormones. The physiologic stress response is a protective and necessary action for an individual, and if animals are unable to respond appropriately their survival is at risk. Of concern for the SWG are situations in which the animals are unable to respond appropriately (with either too much or too little hormone response) or when animals are

chronically stressed, as all three situations may negatively affect cetacean health. The SWG also discussed the importance of standardisation of hormone analysis. Some inter-laboratory comparisons have been attempted, but due to the large number of available tests there is not currently standardisation across the field. In addition it was noted that most investigators use tests that require commercial kits or products which may or may not remain available, making standardisation difficult. However the SWG **recommended** that researchers attempt standardisation whenever possible and focus on comparing trends and patterns instead of focusing on absolute numbers.

It was noted that similar discussions on stress evaluation were carried out in the Whalewatching Sub-committee a few years ago, and based on these prior discussions methodologies have progressed greatly. It was also noted that several funded projects on stress and anthropogenic sound will be completed over the next two years with subsequent peer-reviewed publications being produced. The SWG **recommended** that a future workshop be planned for 2017 or 2018 as part of the work plan.

9.4 Other sound related issues

Houser presented information on auditory evoked potentials (AEP), a method that is non-invasive and frequently used in hearing impaired human infants. The use of AEP has rapidly increased the rate at which information on hearing capabilities in marine mammals is obtained and is used routinely in live cetacean stranding situations in the US for evaluation of hearing. Currently, it is much more widely used than is behavioral audiometry, which is the standard to which AEP hearing thresholds are compared. AEP methods have enabled audiometric information to be obtained from species untested by behavioral methods or held under human care, as well as allowed the first quantification of population-level audiometry for a delphinid species (Houser and Finneran, 2006). The hearing information obtained is critical to meeting governmental goals of understanding baseline hearing for purposes of determining the potential impact of anthropogenic sound on marine mammals.

A number of issues hamper the use of AEP-acquired thresholds in establishing species-specific baseline hearing capabilities. One critical issue is the use of different methods for determining the hearing threshold in odontocetes. Methodologies vary across researchers and laboratories and can result in large differences in threshold estimates for the same species, or even the same individual. Furthermore, individual researchers utilise different means of calibrating the sound sources used as acoustic stimuli, potentially leading to conflicting estimates of the level of sound received at the animal being tested. As a result, regulatory agencies and the scientific community are challenged with considering disparate threshold measurements possibly on the order of tens of decibels not only across species, but potentially within a species depending on the research group reporting the thresholds.

Standardisation of approaches for threshold audiometry is sorely needed to make threshold estimates comparable across laboratories (Houser and Moore, 2014). In order to achieve standardisation of AEP methodologies for the testing of hearing in odontocetes cetaceans, a proposal for the development of an American National Standards Institute (ANSI) standard was balloted to the Acoustical Society of America Committee on Standards (ASACOS). The ballot passed in May 2015, initiating the establishment of an ASALOS working group (WG) that will consist of researchers currently utilising AEP methods for testing marine mammal hearing, experts in AEP usage that exist outside the marine mammal community, and interested federal and commercial organisations (e.g. US Navy, US National Marine Fisheries Service, seismic industry). The group will work towards a consensus methodology for testing the frequency range of hearing and the hearing sensitivity of odontocete cetaceans that will be proposed as the ANSI standard. With the recent initiation of a national database for storing AEP-determined auditory thresholds, standardisation will ensure consistency of methods used to obtain data for use by regulatory agencies and the scientific community.

The SWG thanked Houser for this presentation. The SWG **agreed** with the need for standardisation of scientific methods and analyses.

ACCOBAMS has a resolution that reaffirms that anthropogenic marine noise is a form of pollution, caused by the introduction of energy into the marine environment, which can have adverse effects on marine life (Resolution 5.15). In accordance with the ACCOBAMS Working Programme 2014-16, the ACCOBAMS Scientific Committee and the Secretariat are going to: (a) identify anthropogenic noise/cetaceans interactions hot spots in the ACCOBAMS area; and (b) map and develop a monitoring of sea ambient noise, particularly in cetaceans critical habitats. The SWG welcomes a report of this work to be presented at SC/66b.

To conclude the topic of underwater noise, it was highlighted that discussion on the effectiveness of Marine Mammal Observers (MMOs) as a mitigation measure for underwater sound was a topic of interest that has been included in the SWG work plan. The SWG **agreed** that papers on MMO effectiveness be encouraged for presentation at SC/66b.

It was noted that ACCOBAMS is also addressing the issue of MMOs and Passive Acoustic Monitoring (PAM) within the Mediterranean Sea, with the final objective that ACCOBAMS becomes the reference body on the MMO issue in the Mediterranean and Black Seas. A working document will be presented at the next ACCOBAMS scientific committee meeting at the end of 2015, to be turned into a Resolution to be approved by Countries at the next ACCOBAMS Meeting of Parties in 2016.

The SWG **encouraged** continuation of this international collaboration on issues of sound and marine mammals.

10. EFFECTS OF CLIMATE CHANGE ON CETACEANS

10.1 Report of the intersessional steering committee meeting

Simmonds presented an overview of the history of this issue within the Commission. The Commission held its first Workshop on climate change in Oahu, Hawaii in 1995 (IWC, 1997) and whilst this Workshop was successful in attracting scientists from around the world and concern was expressed about the implications of climate change for whales, it concluded that the Commission did not have the predictive powers to further develop this work.

The second Workshop was not convened until 14 years later and this was to a backdrop of growing concern regarding the accelerating rate of global environmental change (IWC, 2010c). From this Workshop came several recommendations focused around modelling approaches. A third climate change Workshop, held in 2010 (IWC, 2012), focused on small cetaceans. From this came particular concerns for those species with habitats restricted through

the presence of physical barriers, e.g. riverine species, or populations residing in 'ecological cul-de-sacs'. This Workshop also recognised that an improved understanding of how cetaceans interact with their environment is required to accurately predict responses to climate change. The importance of long-term datasets was stressed.

Simmonds then presented the report of the 2014 Climate Change Steering Group (SC/66a/Rep07). The Terms of Reference for the Group were '*To review work by the Scientific Committee to date; place this in the context of latest knowledge; and produce a plan for an on-going work programme by the Scientific Committee'.* The steering group took note of the work by the IWC to date including the outputs of the preceding workshops and the Commission resolution passed by consensus in 2009 (IWC, 2010a). In particular that the Commission had specifically endorsed the outcomes of the second Workshop and the associated recommendations of the Scientific Committee given in IWC (2010b), including:

- the need to expand the current international multi-disciplinary efforts and collaborative work with other relevant bodies;
- that the Commission had directed the Scientific Committee to continue its work on studies of climate change and the impacts of other environmental changes on cetaceans, as appropriate; and
- that it called on Contracting Governments, IGOs and NGOs to support the expansion of this important work.

The 2014 Climate Change Steering Group meeting was held immediately after the Third International Marine Conservation Congress, 14-18 August 2014, Glasgow, UK, which had been attended by most members of the Group and where various relevant papers had been presented. The Steering Group also took note of a recent workshop on climate change and cetaceans held under the auspices of ACCOBAMS and it also prepared a list of key recent publications given in Appendix 2 of the Climate Change Steering Group report (SC/66a/Rep07).

The Steering Group considered that progress on the topic may have been hindered in part by misconceptions regarding climate change as a subject area, and this could be partially resolved by clarifying and defining separate individual threats and issues currently falling under the blanket term of 'climate change'. There might also be an underlying assumption of futility of action, and the belief that work cannot be successfully progressed because of a lack of data and poor predictive power of available tools.

The Steering Group noted that predictive powers have improved for climate models. The Fifth IPCC Assessment Report (AR5) has been published, with the Working Group II Report 'Impacts, Adaptation and Vulnerability' released on 31 March 2014. Improved modelling methods predicting species- and ecosystem-level responses to climate change are being developed, and existing terrestrial models such as the bioclimatic envelope model have been refined to include demographic parameters and population dynamics, and applied to the marine environment. In addition, our understanding of the physiology, behaviour, and trophodynamics of oceanic top predators in response to climate change has also improved in recent years.

The Steering Group considered that whilst there has been some progress made, especially via the three Workshops, climate change has not yet been successfully embedded as a core element of the work of the Commission or the Scientific Committee. In order to achieve this, and to progress this area of endeavour, the Steering Group recommended the following steps.

(1) The Committee should hold a joint session of all its relevant sub-committees to consider this topic and agree a two-year work programme. This should include a review of existing workstreams to consider where climate change related matters might best fit. The matters that should be considered in this work programme are identified in (2) below.
(2) Every effort should be made to work expeditiously and in concert with other international multilateral bodies that are also trying to progress this topic including *inter alia* the Convention for Migratory Species (which has a comprehensive work programme on climate change, which this Steering Committee meeting considered), the Convention for Biological Diversity and the IUCN Species Survival Commission's Cetacean Specialist Group as well as their Red List sub-group.

The SWG **agreed** that the joint session in item (1) above was achieved with a joint session between the Working Group on Ecosystem Modelling and the SWG on Environmental Concerns, as well as representation from the Sub-Committee on Small Cetaceans. A two-year work programme will be developed by the climate change intersessional group which will report back to SC/66b. The SWG **agreed** with the recommendation for international collaboration and integration of datasets described in (2), and referenced additional potential collaborations, including the National Research Program (NRP), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the Distributed Biological Observatory (DBO)[6], that aim to provide an integrated ecosystem approach.

The Steering Group had also considered recommendations for future research and reiterated, in particular, the importance of maintaining long-term studies and giving consideration to defining and identifying restricted habitat. Its other recommendations related to:

- reviewing and identifying mathematical and statistical models that can integrate the demographic consequences of climate change;
- enhanced ongoing liaison between sub-committees;
- further consideration of existing data sets to investigate plausible climate change scenarios, noting that the report of the second Workshop also included a table of possible data sources that could be used to explore climate change impacts;
- ecological refugia;
- liaison with other relevant international initiatives; and
- facilitation of the development of unpublished relevant datasets and unanalysed biological materials.

The SWG **agreed** that a review of mathematical and statistical models is desirable, and that by further clarifying optimal models and a more defined focus and scope, this work will be more manageable. The SWG **recommended** that an intersessional working group refine their Terms of Reference to include clarification about the scope of this work, with a more explicit definition of the recommendations for research with actions for the intersessional group to achieve. In addition, because the SWG's recommendations encompass the work of several sub-committees, the SWG **recommended** expanding the intersessional working group to include members from the Working Group on Non-Deliberate Human-Induced Mortality of Large Whales, the Working Group on Ecosystem Modelling and the SWG

[6]*http://www.arctic.noaa.gov/dbo/.*

on Environmental Concerns. This should refine terms of reference to encompass SWG recommendations (a)-(f), and report back at SC/66b.

In order to provide effective evaluation of available observations and modeling tools, the SWG **agreed** to focus work on actionable activities that support the work of other sub-committees and the Commission. With reference to SC/66a/Rep07 and to discussions on the Arctic topic, the following foci (and links to other sub-committees) were **encouraged**:

(1) riverine/freshwater and coastal small cetaceans (connection with the Sub-committee on Small Cetaceans);
(2) large whales in polar habitats - ecosystem focus (LTER and DBO), and relationship to emerging issues of ship strike, entanglement and underwater noise (connection with the Working Group on Ecosystem Management and the Working Group on Non-Deliberate Human-Induced Mortality of Large Whales); and
(3) the development of further links with appropriate international bodies.

It was noted that the tools in development by the SWG (Pollution 2020 and CDoC activities) would support all three foci.

The SWG also **recommended** that efforts be made to find a suitable journal and editor for a special volume on cetaceans and climate change.

11. ARCTIC ISSUES

George *et al.* (2015) examined correlations between summer sea ice conditions and upwelling-favorable wind in the Beaufort Sea on the body condition of Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales. A summary can be found in Annex F. The SWG welcomed this study and **encouraged** further work in this area.

In March 2014, the IWC held a Workshop on the Impacts of Increased Marine Activities on Cetaceans in the Arctic (Reeves *et al.*, 2014). Four *priority recommendations* from the Workshop report provided a framework for discussion at SC/65b (IWC, 2015, pp.39-44); specifically, the development of a plan for climate change work focused in the Arctic region. Provisional responses to the four priority recommendations are provided below, followed by potential cooperative actions, as discussed by the SWG.

(1) Increased cooperation with the Arctic Council

The Arctic Council is comprised of six working groups[7], two of which (CAFF and PAME) lead projects where the IWC might consider near-term actions to increase cooperation with Arctic Council. The Conservation of Arctic Flora and Fauna (CAFF) is the biodiversity working group of the Arctic Council. Two activities where members of the IWC Scientific Committee have, or are, contributing expertise include: (a) the Arctic Biological Assessment - ABA; see Laidre *et al.* (2015); and (b) the Circumpolar Biodiversity Monitoring Program (CBMP). The CBMP includes a Marine Mammal Expert Network[8], where the cetacean focal species are white whales and bowhead whales. The mandate of the Protection of the Arctic Marine Environment (PAME) working group is to address policy and non-emergency pollution prevention related to the protection of the Arctic marine environment. Two areas where the IWC Scientific Committee could contribute expertise include: (a) the Arctic Marine Shipping Assessment (AMSA), specifically with reference to the 2013 AMSA Implementation Report, Theme II: 'Protecting Arctic People and the Environment'[9]; and (b) developing a framework for a Pan-Arctic Network of Marine Protected Areas. It was noted that development of a MPA Network is one (of 13) initiatives identified for action during the US Chairmanship (2015-17) of the Arctic Council.

Potential IWC cooperation with CAFF

The IWC Scientific Committee should work with the CAFF WG to support, where possible, the development of population estimates and interval-surveys to track trends, for non-B-C-B bowhead whale and high-Arctic beluga and narwhal populations (i.e. those listed without CV or CI and trend=unknown, in Laidre *et al.*, 2015).

Potential IWC cooperation with PAME

The IWC Secretariat should seek formal engagement with the PAME WG on the assessment of effects of ship noise, disturbance and strikes (AMSA, Theme IIG), and in the development of an MPA Network in Arctic waters.

(2) Increased cooperation with IMO

In November 2014, the IMO adopted the International Code for Ships Operating in Polar Waters (Polar Code), and related amendments to the International Convention for the Safety of Life at Sea (SOLAS).

Because it contains both safety and environment related provisions, the Polar Code is mandatory under both SOLAS and the International Convention for the Prevention of Pollution from Ships (MARPOL). The environmental provisions in the Polar Code were approved by the IMO's Marine Environmental Protection Committee (MEPC). On 15 May 2015 the IMO approved a prohibition for shippers to dump oil, oily waste or noxious materials into Arctic or Antarctic waters; a requirement for barriers to separate fuel tanks from ship's outer hulls, a limit on sewage discharge and a prohibition of trash disposal proximate to land or sea ice. There were no provisions included for new standards regarding introduction of invasive species, safe ship operations near protected species habitats or mitigation of underwater noise. In addition to the Polar Code, there are two IMO Resolutions relevant to IWC/SC activities: (a) voyage planning in remote areas (adopted in November 2007); and (b) ship reporting in the Arctic region (adopted November 2012). Currently, the mandatory ship reporting system applies only to ships in the Barents Sea area.

It was noted in discussion that a recent evaluation and relevance of a Particularly Sensitive Sea Area (PSSA) for the Bering Strait is now available (Hillmer-Pegram and Robards, 2015). This may be another avenue for consideration/cooperation between the IMO and the IWC.

Potential IWC collaboration with IMO

Based on the existing cooperative relationship with the IMO, the IWC Scientific Committee (or Secretariat) should enter into a dialogue regarding: (a) submission of a paper to IMO MEPC suggesting safe ship operations and mitigation of underwater noise with regard to cetacean habitats and seasonal movements along Arctic sea routes; (b) **endorse** the existing resolution on voyage planning for passenger ships; and (c) recommend the **expansion** of the resolution for a mandatory ship reporting system to other regions of the Arctic.

[7] *http://www.arctic-council.org/index.php/en/about-us/working-groups.*
[8] *http://www.caff.is/marine/marine-expert-networks/marine-mammals.*
[9] *http://www.pame.is/index.php/projects/arctic-marine-shipping/amsa/amsa-documents.*

(3) Increased-cooperation with stakeholders
Several actions were recommended for the Secretariat with regard to fostering increased interactions with stakeholders. The overarching goal is to express the interest of the IWC in cooperating with and providing advice on issues of mutual interest. The Secretariat stands ready to take action on this recommendation, via formal letter to specific stakeholders, once cooperative partners and actions are identified. The SWG **encouraged** SWG members to begin to identify cooperative partners and actions.

(4) Scientific matters
The Workshop report listed four recommendations for the SC. With regard to the first recommendation, it was noted that Laidre *et al.* (2015) provides a summary of arctic cetacean population status and, with regard to recommendation 2b, Moore and Gulland (2014) provide a framework for the development of a Marine Mammal Health Map (MMHM) to support the evaluation of non-direct threats to cetaceans. An intersessional Steering Group was formed to review and prioritise the remaining science-related recommendations, with the aim of reporting at SC/66b.

12. HABITAT

12.1 Marine debris

12.1.1 Report from 2nd Workshop
There have been two recent Workshops held under the auspices of the Commission related to marine debris. The first (IWC, 2014a) was focused on an evaluation of known effects of marine debris on cetaceans. The Workshop made many recommendations, including advice for the second Workshop, and highlighted the importance of trying to distinguish whether or not entangling gear was active or derelict at the time of entanglement. It also called for improved data-sharing and recommended that marine debris interactions should be reported by Commission members in National Progress Reports. It also recommended that debris sampling should be conducted during cetacean field studies, there should be improved efforts to work with industry and fishermen, and the Scientific Committee should work to further evaluate the risks of ingestion. The desirability of working in collaboration with other intergovernmental bodies on this issue was highlighted.

The second Workshop was held in August 2014 in Hawaii (IWC, 2014d), and participants from ten countries and representatives from the United Nations Food and Agriculture Organisation (FAO), the United Nations Environment Programme (UNEP), and the Convention for Migratory Species (CMS), along with relevant industry bodies and a number of non-governmental organisations concerned with marine debris, were in attendance. The primary objectives were to explore how the Commission can engage with the existing international and regional mitigation efforts concerning the management of marine debris, determine how best to ensure that these efforts are updated on cetacean-specific impacts of marine debris, and advise on how best the Commission can lead and engage in regions where marine debris has the greatest potential impacts on cetacean populations.

Topics that were discussed included fishing gear marking, potential gear modifications, methods for identifying debris hotspots, modelling approaches, and work conducted on other species, such as seabirds and turtles. In addition, debris ingestion, the role and responsibilities of the IMO's International Convention for the Prevention of Pollution from Ships (MARPOL), fishing gear recycling programs, and governmental and nongovernmental marine debris programs were also discussed. The Workshop agreed that the Commission's primary contribution should be to ensure that cetacean-related issues are adequately represented within existing initiatives, and that its strong scientific and other expertise is made available in collaborative efforts.

The Workshop also made specific recommendations for collaboration with the IMO and the South Pacific Regional Environment Programme (SPREP), the incorporation of data on marine debris into National Progress Reports in a standard format, and development of a global Commission entanglement database.

In addition the Workshop recommended that:

(a) a concerted effort be made to collect data using a standard approach that will allow a better assignation of entanglements;
(b) the Commission encourages the UN Committee on Fisheries (COFI) to complete its work on gear marking;
(c) the Commission encourages disentanglement and stranding teams to collect detailed information on entangling gear/material that is removed from whales, and on marine debris present in the immediate environment;
(d) the Scientific Committee explores ways of combining estimates of oceanic debris and information on cetaceans to identify priorities for mitigating and managing the impacts of marine debris on cetaceans;
(e) the Commission continues to support and develop its disentanglement network, and carefully consider incorporating the issue of all marine debris into the initial training programme component of the disentanglement training. It stresses the importance of involving the local fishing communities in the training;
(f) the Commission promotes and shares the model of expert training/capacity building into existing marine debris initiatives including the Global Partnership on Marine Litter as well as at the national level;
(g) the Secretariat examines ways in which it and Commission Members can most effectively communicate the Workshop's recommendations to the relevant target audience(s), including considering highlighting the Commission's work on the impacts of marine debris on cetaceans at meetings of other intergovernmental organisations, e.g. the forthcoming COFI in 2016; and
(h) the Commission develops improved methods to encourage its members and others to provide the marine debris related data discussed in this report and to provide progress reports on their work on marine debris as part of their national conservation reports.

The Workshop also strongly recommended that the Secretariat work with the secretariats of other intergovernmental organisations and Regional Fisheries Management Organisations (RFMOs) to ensure consistency of approach, synergy of effort and exchange of information to develop appropriate mitigation strategies that recognise that prevention is the ultimate solution, but that removal is important until that ideal is realised. It also recommended that individual Commission members collaborate with such initiatives and that the Commission continues to highlight

issues surrounding marine debris and cetaceans. The full list of recommendations from the Workshop can be found in IWC (2014d).

12.1.2 Other marine debris information

SC/66a/E05 provided an update on recent published research into marine debris and the impacts on cetaceans. New estimates of plastic waste inputs from land indicate that 4.8-12.7 million metric tonnes of waste entered the oceans in 2010 (Jambeck *et al.*, 2015). Without improvements in waste management, the cumulative quantity of plastics available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck *et al.*, 2015). Recent estimates of the global load of plastic on the ocean surface indicate size-selective sinks, such as millimetre-sized fragments that are removed from the ocean surface on a large scale, through nano-fragmentation, transference into food webs, or other processes (Cózar *et al.*, 2014). Arctic Sea ice and deep-sea sediments have also been identified as likely sinks for microplastics containing concentrations much higher than surface waters (Obbard *et al.*, 2014; Woodall *et al.*, 2014). The latest information demonstrates growing quantities of debris in the marine environment and further evidence of exposure of cetaceans to macro- and micro-debris, suggesting that debris poses a growing but poorly quantified threat to cetaceans and other species. Recent publications include cases of debris ingestion by Longman's beaked whale, *Indopacetus pacificus* (Kaladharan *et al.*, 2014); True's beaked whale, *Mesoplodon mirus* (Lusher *et al.*, 2015); harbour porpoise (SC/66a/E06); Guiana dolphin, *Sotalia guianensis* (Di Beneditto and Awabdi, 2014; Di Beneditto and Ramos, 2014); and humpback whale, *Megaptera novaeangliae* (Besseling *et al.*, 2015). In addition, there is a current effort within the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) on microplastics. Some projects are ongoing or planned for the near future which will look into concentration of microplastics in large cetaceans and preys in the ACCOBAMS region. Results will be available for discussion at future meetings of the Scientific Committee. Lastly, for the first time microplastics have been directly identified in cetacean species (True's beaked whale and humpback whale), with the application of a new technique for the detection and identification of microplastics in the digestive tract (Besseling *et al.*, 2015; Lusher *et al.*, 2015). Uptake of microplastics has also been demonstrated in a range of potential prey species, including plankton (Frias *et al.*, 2014; Setälä *et al.*, 2014), planktivorous fish (Boerger *et al.*, 2010) and pelagic and demersal fish (Lusher *et al.*, 2012), raising the likelihood of secondary as well as direct ingestion.

SC/66a/E04 provided an overview of some of the current international initiatives that are focused on marine debris. Further to the review of this matter by the IWC Conservation Committee last year, the Commission endorsed its recommendations that: marine debris should be a standing item on the Scientific Committee agenda; The impacts of microplastics and their associated contaminants on cetaceans are still not yet well understood (Fossi *et al.*, 2014). Overall, there has been an increase in the number of cases of ingestion and entanglements reported per decade (Baulch and Perry, 2014). While individual strandings cases provide important insights into the physiological impacts of debris, there is rarely any information on overall rates of debris ingestion or entanglement and debris-induced pathology and mortality in stranded animals, and there remains a clear need to better understand the consequences of these for populations (Browne *et al.*, 2015).

It was suggested that the SWG should explore ways of combining estimates of oceanic debris and information on cetaceans to identify priorities for mitigating and managing the impacts of marine debris on cetaceans, and marine debris might be considered as a topic for a 'Conservation Management Plan'. However, as such, it would be the first threats-based CMP.

As a standing agenda item of the SWG, marine debris as a topic would benefit from having a strategy for data collection and the encouragement of key lines of research associated with it. Suitable research priorities are considered in SC/66a/E05, but could include, in brief, identification and dissemination of necropsy protocols, the addition of information to national and international databases covering entanglement and ingestion, forensic investigations of retrieved fishing gear to determine if it was active at the time of entanglement, modelling and mapping to pin-point 'hotspots', and further research on marine debris impacts, including the impacts of microplastics.

In addition, the authors of paper SC/66a/E04 recommended that the Commission could seek to recognise existing international efforts to tackle the problem and contribute to these efforts via collaborations with relevant bodies and organisations. This should include:

(1) liaison with the Global Partnership on Marine Litter (GPML), including potentially signing on to the Honolulu Commitment, joining the GPML, and contributing to and sharing information with the Partnership in relevant focal areas, in particular land-based and sea-based sources of marine litter;
(2) developing a robust relationship with the UN Fisheries and Agriculture Organisation (FAO) that includes identifying areas for collaboration on the issue of abandoned, lost, or otherwise discarded fishing gear, as well as participation in COFI as an observer and following the FAO's work on relevant issues, such as gear marking, in order to provide recommendations to the Commission on best practise mitigation measures;
(3) applying for observer status with the IMO and participating in the Marine Environment Protection Committee; and
(4) joining the Global Ghost Gear Initiative (GGGI) and/or delegating members of the Secretariat and/or Committee to contribute via the Commission's Advisory Committee, and contributing to the development of the GGGI's data portal in order to further global efforts on the collection of data on ghost gear abundance and trends.

Finally, the authors recommended that Commission members give consideration to:

(1) committing to collecting information on marine litter occurrence, quantities, types and trends that can be shared with the GPML and contributing to data bases such as the one on ghost gear being developed by the GGGI;
(2) setting up a fund which can be used to contribute to marine litter solution projects run by partners in hot spot areas for cetacean entanglement/debris ingestion; and
(3) taking note of relevant reduction targets for marine litter that have been set nationally, regionally and internationally, including, where relevant, the EU's target for 30% reduction by 2020 and the Rio+20 2025 commitments.

It had been suggested that the SWG evaluate which organisations might be most effective so that the Commission can prioritise collaborative efforts with the most effective

initiatives. However, SC/66a/E04 did some assessment, and it was difficult to determine which organisations are the most effective, as they are all relatively new. The authors also noted other efforts to collaborate with some of these organisations (e.g. IMO) were occurring, and it would be prudent to work with those sub-committees to reduce duplication and ensure that all of the Committee's positions are represented within other organisations.

The SWG **recommended** that instead of a CMP on marine debris (since CMPs focus on species), the Commission should consider a threats-based conservation management plan at the Joint Meeting of the Conservation and Scientific Committees that follows SC/66a.

In recognising the need to provide robust advice to the Commission on the emerging threat to cetaceans of marine debris and in light of existing activities already underway in other IGOs, the SWG **agreed** that the focus of effort on this topic should:

(1) address key gaps in our understanding of the extent and significance of marine debris impacts on cetaceans;
(2) disseminate the outcomes of the IWC marine debris Workshops and, in particular, promote the standardised collection of ingestion and entanglement data during necropsies of stranded and bycaught cetaceans, including through the development of a standardised data collection forms and the dissemination of the necropsy guidance to strandings networks;
(3) facilitate the collation of relevant data, including via information requests to, for example, listservs such as 'MARMAM' and directly to strandings networks requesting submission of information/analyses to the Committee on:
    (a) occurrences and rates of debris ingestion and entanglement and pathology observed;
    (b) potential methods that may be used to help distinguish entanglement in active fishing gear as opposed to 'ghost' [lost/discarded] gear;
    (c) entanglement between vulnerable cetacean populations/species and marine debris may be of particular concern e.g. deep sea habitats; and
    (d) possible improvements to existing data collection/ monitoring activities or modelling/mapping techniques that could improve the provision of scientific advice;
(4) give consideration to whether more can be done to facilitate the collation and analysis of available data to investigate the impacts of debris ingestion and entanglement at an individual and population level, including that of microplastics, i.e. through the creation of specific databases or by improving interoperability between existing database initiatives;
(5) identify relevant information that IWC member nations should include in national progress reports to the Scientific Committee and Conservation Committee; and
(6) developing and maintaining a directory of researchers involved in investigating interactions between cetaceans and marine debris.

The SWG **agreed** that an intersessional correspondence group on marine debris under Simmonds will be established to assist in these endeavours.

In terms of the development of suitable liaison with other IGOs (as previously recommended by the IWC marine debris Workshops, the Committee at SC/65b, and elaborated in papers SC/66a/E04 and SC/66a/E05), and noting that the Commission may need to interact with some of them on a number of topics (e.g. IMO on noise, ship strikes and perhaps ship-originated wastes), the SWG **recommended** that the Secretariat liaise with members of the SWG's intersessional correspondence group on marine debris to identify appropriate opportunities.

SC/66a/E06 presented the results of an analysis of a stranding data from the German stranding database. Between 1990 and 2014, necropsies were performed on 533 harbour porpoise carcasses that were collected along the coast of Germany. During this time, nine cases of marine debris-porpoise interaction were recorded. Findings included external attachments of netting and fishing lines, as well as ingestion of plastic items and fishing lines. While comparably few cases were documented in the database, it is assumed that not all marine debris-porpoise interactions were detected and/or documented.

The SWG **agreed** that marine debris interactions may not have been found or recorded in historical data, especially if the cause of death was not fully attributable to marine debris. However, entanglement or ingestion of marine debris may contribute to the cause of death, as it may weaken the animal and make it more susceptible to other threats. Additionally, it was noted that the issue of microplastics is still emerging and methods to test for microplastics have only recently been developed (Besseling *et al.*, 2015; Lusher *et al.*, 2015); therefore, it is very unlikely that microscopic marine debris has been found and recorded in stranding data even when present. It is also important to remember that if an animal initially strands alive and dies on the beach, it may aspirate and/or ingest beach material that may contain micro-particles at the stranding site.

12.2 Other habitat issues

SC/66a/E09 summarised a spatial analysis of critical habitats for coastal cetaceans in Golfo Dulce, Costa Rica with consideration for a marina construction project. Golfo Dulce harbours critical habitats for coastal cetaceans, specifically critical foraging habitats for inshore common bottlenose dolphin and humpback whale nursing and calving habitat. There is substantial spatial overlap between the critical habitats for these coastal cetaceans. Additionally, Golfo Dulce is also affected by major coastal development projects, in particular the construction of a new marina. In the case of bottlenose dolphins, the spatial overlap of the new marina site and critical foraging habitat could result in the disruption of foraging in the mouths of the Tigre and Platanares Rivers. Such disruption in foraging could lead to negative effects in fitness of what may be a discrete, local population. Critical nursing and calving habitat for humpback whales is also impacted by the marina project (for both sub-populations of *Megaptera novaeangliae kuzira* and *australis*). The increase in maritime traffic would potentially increase the likelihood of collision between ships and humpback whale calves and juveniles. Additionally, maritime traffic would contribute to acoustic pollution, which would mask humpback whale singing in the sill area and could disrupt their breeding behaviour. Therefore, it is important to consider the spatiotemporal aspects within the context of management and conservation of local cetacean populations in order to avoid jeopardising critical habitats of these species.

The SWG **welcomed** this paper. While this study has been presented to the Costa Rican authorities, the fate of the marina project remains unclear. The SWG **expressed concern** over proposed coastal development in Golfo Dulce in light of the presence of critical habitat for humpback

Table 2
Two year work plan.

Topic	Subtopic 1	Subtopic 2	SC/66b	SC/67a
SOCER			Polar	Indian Ocean
Pollution	Pollution 2020	Continue to refine consequence model – focus on PAHs.	X	X
		In utero transfer analyses and modelling.	X	X
		Intersessional group on risk and mitigation for PCBs.	X	X
	Oil spill impacts	Planning oil spill Workshop.	Finalise agenda	Receive report
		Update on cetaceans and oil spills.	X	X
		Other oil spill related issues.	X	X
	Data integration and mapping	Determine format and establish maps.	X	X
Marine debris		Refer to Item 12; review intersessional progress and receive new information.	X	X
		Other marine debris recording and information.	X	X
CDoC (previously CERD)		Data input and website management.	X	X
		Progress on enhanced communications: maintain email lists, provide quarterly updates on disease issues, and outreach to non-IWC groups.	X	X
		CDoC planning pre-meeting.	-	X
		Other disease related issues.	X	X
Strandings and mortality events		Planning and hosting intersessional Workshop on mortality events and mass strandings (in conjunction with biennial SMM Conference).	Receive report	Progress on recommendations
		New information on strandings and mortality events.	X	X
		Update stranding list, progress reports, and international communication/ collaboration.	X	X
Effects of anthropogenic sound	Masking	Focus sessions on masking and population modeling e.g. PCoD, including soundscape progress.	X	Progress on recommendations
	Stress Workshop	Planning stress and sound Workshop.	-	X
	Mitigation and monitoring	Focus sessions to review MMO effectiveness.	Receive papers	-
	Other sound related issues		X	X
Climate change	Planning	Report back on intersessional work on recommendations and capacity building across the SC.	X	-
		Identification of a journal for a special volume on climate change and cetaceans.	X	-
		Report back on climate change foci as agreed by SWG.	X	X
Arctic		Prioritisation scheme for science recommendations of Workshop report.	X	-

whales and bottlenose dolphins, and **urged** the government of Costa Rica, paying due regard to the precautionary principle, to ensure rigorous impact assessments are undertaken, that potential negative impacts are fully mitigated, and that appropriate pre- and post-development monitoring is carried out. Further, the SWG **recommended** that the Secretariat write to the Ministry of the Environment and the Interinstitutional Commission of Marinas (Ministry of Tourism) of the Government of Costa Rica, to raise these concerns.

13. CONSIDERATION OF ENVIRONMENTAL CONCERNS IN LIGHT OF RESOLUTION 2014-4

Last year the Commission passed Resolution 2014-4 directing the work, finances and Rules of Procedure of the Scientific Committee and some sections were particularly relevant to the work of the SWG.

The SWG **recommended** that these sections be considered under its deliberations, the work plan, and the budget.

The SWG **agreed** that conservation-related SWG recommendations may be relevant to the wider international community and should be highlighted and compiled by the Secretariat.

In discussion it was noted that there is a need to continue to communicate critical conservation issues to the broader scientific community (e.g. marine debris). Therefore the SWG **recommended** that, in addition to the non-contracting governments, IGOs, and agencies noted above, the Secretariat should circulate relevant SWG recommendations to the wider marine mammal and scientific community (via outreach such as the MARMAM listserv).

14. WORK PLAN

See Table 2 for the work plan for the Sub-committee on Environmental Concerns.

15. ADOPTION OF REPORT

The report was adopted at 14:26 on 30 May 2015. The SWG thanked Rowles and Parsons for their guidance during the discussions and Manley, Rosa, Simeone, and Ylitalo for their efficient rapporteuring.

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Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of Chair
3. Appointment of rapporteurs
4. Adoption of agenda
5. Review of available documents
6. State of the Cetacean Environment Report - SOCER
7. Pollution
   - 7.1 Pollution 2020
   - 7.2 Oil spill impacts
   - 7.3 Contaminant threat assessment
   - 7.4 Data integration and mapping
8. Cetacean Emerging and Resurging Diseases (CERD) and mortality events
   - 8.1 CERD
   - 8.2 Strandings and mortality events
9. Effects of anthropogenic sound on cetaceans and approaches to mitigate effects
   - 9.1 Update on soundscape mapping
   - 9.2 Masking
   - 9.3 Evaluation stress and sound
   - 9.4 Other sound related issues
10. Effects of climate change on cetaceans
    - 10.1 Report of the intersessional steering committee meeting
    - 10.2 Other climate change related issues
11. Arctic issues
12. Habitat
    - 12.1 Marine Debris
      - 12.1.1 Report from 2nd Workshop
      - 12.1.2 Other marine debris information
13. Consideration of environmental concerns in light of Resolution 2014-4
14. Work plan

Appendix 2

PROPOSAL FOR AN IWC WORKSHOP

Proposed title of Workshop
Investigations of large mortality events, mass strandings, and international stranding response

Objectives/goals
- Bring together biologists, veterinarians, and stranding network investigators from various countries to facilitate the collaboration and coordination between national and regional programs on responses to and investigations of cetacean strandings, with a focus on unusual or large scale mortality events, mass strandings, and disease events.
- Identify common issues and share information on potential solutions relative to causes, responses, and mitigation of cetacean strandings.
- Promote international data sharing and mutual aid particularly for mass strandings and large mortality events.
- Discuss current terminology in use with regard to mass strandings, and Unusual Mortality Events, to better characterise and facilitate work between countries.

Scientific rationale
The Workshop will cover the issues of enhancing investigations and review of events, and enhanced collaboration and information sharing. Consistently responding to, evaluating and reviewing these events will enhance the SC in developing knowledge on the potential causes of these events and the impacts or risks for populations. Increased consistency and evaluations, knowledge on best responses and investigations, and increasing our ability to determine causes or contributory factors can best be done with enhanced international collaborations.

Likely scientific outcome
The likely outcome will be a collaborative paper on best practices for setting up a stranding network, or a comparison of country stranding response efforts with a focus on successes and information sharing.

Timetable
Workshop would be by invitation and would be a 1.5-2 day Workshop prior to the 2015 Biennial Meeting of the Society for Marine Mammalogy (SMM) in San Francisco, CA in December 2015. This will be a two-day Workshop of invited experts (approximately 20-25) for a focused discussion. An additional Workshop on mass strandings may be held as one of the pre-meeting SMM workshops.

Proposed Agenda

i. Welcome, introduction, background to the Workshop
ii. Appointment of Chair and rapporteurs and other meeting arrangements
iii. Review of Agenda
iv. Reporting/reviewing plans and procedures
    1. Background
        1.1 Scope of issues
        1.2 Description in context of role of IWC
    2. Presentations: Individual strandings
        2.1 Mysticetes
        2.2 Odontocetes
    3. Mass stranding events
        3.1 [Each presentation focuses specifically on successes and challenges in response, targeted sampling based on suspected cause, and unique aspects of mass stranding events; among other topics]
    4. Subsistence harvest
    5. Challenging contexts - identification of challenges and potential mitigation or solutions
        5.1 Remote locations
        5.2 Prioritisation of sampling for limited access/time
        5.3 Challenges for international assistance in either boots on the ground, consultation, or diagnostic assistance
        5.3 Challenging diagnoses
    6. Definitions
        6.1 Mass strandings
            6.1a Typical *vs* atypical
        6.2 Mortality events (US)
            6.2a Unusual *vs* repeated
    7. Best practices
        7.1 Coordination
        7.2 Response (live and dead)
            7.2 a Including necropsy/sample collection and safety issues
        7.3 Investigations of causes and contributing factors
        7.4 Guidelines for capacity building
        7.5 Guidelines for international cooperation responses
    8. Next steps
        8.1 Highlights for each country/response group
        8.2 Reporting system
        8.3 Mechanism for mutual aid

Appendix 3

LITERATURE REVIEWED FOR SOUTHERN OCEAN MARINE MAMMAL POP BURDENS PRESENTATION

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Appendix 4

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2015

Editors: M. Stachowitsch[10], E.C.M. Parsons[11] and N.A. Rose[12]

INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 (IWC, 1998) and 1998-5 (IWC, 1999), directed the Scientific Committee (SC) to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 (IWC, 2001) welcomed the concept of the State of the Cetacean Environment Report (SOCER) and requested the annual submission of this report to the Commission. The first full SOCER (Stachowitsch *et al.*, 2003) was submitted in 2003 and subsequent editions initiated and continued a cycle of focusing on the following regions: Mediterranean and Black Seas, Atlantic Ocean, Pacific Ocean, Indian Ocean, Arctic and Antarctic Seas. Each SOCER also includes a Global section addressing the newest information that applies generally to the cetacean environment. The 2015 SOCER focuses on the **Pacific Ocean**, summarising key papers and articles published from *ca* 2013 through 2015 to date.

PACIFIC OCEAN

General

T-PODS HELP IDENTIFY IMPROVEMENTS TO DOLPHIN PROTECTION AREAS

T-PODs were used to document habitat use by bottlenose dolphins in Doubtful Sound, New Zealand, over a 12-month period, collecting data over 76,104 hours. T-POD records show that dolphin distribution varied seasonally, with inner fiord sites being used most often in austral summer and autumn, and outer fiord sites during austral winter and spring. This seasonal pattern was positively correlated with surface water temperature. The data suggest that parts of the 'Dolphin Protection Zone', in which boat traffic and tourism is restricted, are used frequently while other parts are not. This provides a basis for refining the shape and size of the protected areas to make this management tool more effective.

(SOURCE: Elliott, R.G. Dawson, S.M. and Henderson, S.D. 2011. Acoustic monitoring of habitat use by bottlenose dolphins in Doubtful Sound, New Zealand. *NZ J. Mar. Freshwat. Res.* 45: 637-639.)

OCEAN HEALTH INDEX RATES EARTH'S OCEANS

The Ocean Health Index, compiled by the University of California at Santa Barbara, has released its third annual update. It rates the overall health of the earth's oceans at 67 out of 100. For the high seas, the Pacific values are:

Pacific eastern central: score 67 (global rank 100 of 236); Pacific southeast: 76 (global rank 26); Pacific northeast: 68 (global rank 85); Pacific southwest: 65 (global rank 115); Pacific northwest: 53 (global rank 208); and Pacific western central: 65 (global rank 113).

Pacific countries whose values (within their EEZs) were rated below 60 (and therefore in the bottom 25%) include (alphabetically) Cambodia, Colombia, Cook Islands, Costa Rica, El Salvador, Nicaragua, North Korea, Papua New Guinea, Panama, Peru, Philippines, Samoa, Taiwan, Tonga, and Vietnam.

(SOURCES: News. 2014. *Mar. Pollut. Bull.* 88: 3; *http://www.oceanhealthindex.org*.)

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[12]Animal Welfare Institute, Washington, DC, USA.

CONTINUED DECLINE OF NEW ZEALAND DOLPHIN POPULATIONS

The New Zealand dolphin, also known as Hector's dolphin, is endemic and endangered, with the North Island subspecies (Maui's dolphin) listed separately as critically endangered. The Threat Management Plan for Hector's dolphins identifies bycatch in gillnet and trawl fisheries as the number one threat. Fisheries mortality has resulted in rapid population declines, with total population size estimated at 27% of 1970 numbers. Reduced use of gillnets and trawling in NZ dolphin habitat has slowed population declines in some areas. A long-term study in the Banks Peninsula Marine Mammal Sanctuary (South Island east coast) shows a significant increase in survival rates (by 5.4%) and indicates that the previously rapid population decline of 6% per year has slowed substantially to 1% per year. Nationwide, NZ dolphin populations are predicted to continue declining under current management mainly due to continuing bycatch in areas with little or no dolphin protection measures (*e.g.* South Island north and west coasts). Extending protection to the 100m depth contour throughout NZ dolphin habitat should result in rapid population recovery. This case study shows that area-based management can work, if the protected area is large enough, in the right place, effectively manages key threats, impacts are removed rather than displaced to other areas and no new threats are added (*e.g.* marine mining, tidal energy generation, pollution).

(SOURCE: Slooten, E. 2013. Effectiveness of area-based management in reducing bycatch of the New Zealand dolphin. *Endang. Spec. Res.* 20: 121-130.)

Habitat degradation

General

OCEAN ACIDIFICATION IS DISSOLVING PLANKTONIC SNAILS OFF US WEST COAST

The acidity of shelf waters off the US west coast has reached a level at which the shells of more than 50% of the tiny free-swimming marine snails known as pteropods are severely corroded. This value is estimated to be twice that of the pre-industrial era and is expected to triple by 2050. Pteropods, as zooplankton, are at the base of the food chain and are consumed by fish and by baleen whales. This provides yet another example of how pollution (especially carbon dioxide emissions) can affect the larger marine environment and cetaceans by affecting their food chain.

(SOURCES Bednarsek, N., Feely, R.A., Reum, J.C.P., Peterson, B., Menkel, J., Alin, S.R., and Hables, B. 2014. *Proc. Roy. Soc. B* 281: 20140123, *http://dx.doi.org/10.1098/rspb.2014.013*; News. 2014. *Mar. Pollut. Bull.* 83: 7.)

BOTTLENOSE DOLPHINS LEAVING DOUBTFUL SOUND

The bottlenose dolphin population in Doubtful Sound, New Zealand, has dramatically increased the amount of time it spends outside the Sound. Capture-recapture modelling, based on photo-identification data, demonstrated a dramatic decline in capture probability within the Sound between 2005-09 and 2010-11. Potential reasons for this change in distribution include changes in food availability, tourism pressure and freshwater input from a hydro power scheme.

(SOURCE: Henderson, S.D., Dawson, S.M., Rayment, W.J. and Currey, R.J.C. 2013. Missing in action? Are the resident dolphins of Doubtful Sound becoming less resident? *Endang. Spec. Res.* 20: 99-107.)

RADIOACTIVE PLUME FROM FUKUSHIMA CROSSES THE PACIFIC

The radioactivity discharged into the northwest Pacific from the 2011 nuclear reactor accident at Fukushima in Japan has now crossed the Pacific and reached North American waters. The signal arrived 1,500km west of British Columbia in 2013 and reached the Canadian continental shelf in February 2014. Although the radioactivity levels do not pose an immediate threat to marine life, including cetaceans, or human health, they demonstrate three important points: (1) This single accident doubled the fallout background values from the atmospheric nuclear bomb tests in the 1950s; (2) this single accident is a long-term pollution issue; values are expected to increase until 2016 before they return to earlier background levels by 2021; and (3) pollution events can have ocean-wide implications, calling for international efforts and cooperation to tackle marine pollution issues more globally.

(SOURCE: Smith, J.N., Brown, R.M., Williams, W.J., Robert, M., Nelson, R. and Moran, S.B. 2015. Arrival of the Fukushima radioactivity plume in North American continental waters. *PNAS* 112: 1,310-1,315.)

INCREASED EUTROPHICATION OF CHINA'S COASTAL SEAS

Eutrophication has become one the most devastating forms of marine pollution. Through oxygen depletion it can lead to the collapse of entire ecosystems, and worldwide more than 400 eutrophication-related so-called 'dead zones' have been identified. Between 1970 and 2000, the amounts of the dissolved nutrients nitrogen and phosphorus released into the Bohai Gulf, Yellow Sea and South China Sea have increased 2-5 times. A further increase of 30-200% is expected by 2050. This poses a serious threat of other eutrophication-related symptoms as well; the authors predict an increased risk of harmful algal blooms in all three coastal seas. They call for better sewage treatment and more efficient agricultural practices to counter this trend.

(SOURCE: Strokal, M., Yang, H., Thang, Y., Kroeze, C., Li, L., Luan, S., Wang, H., Yang, S., and Zhang, Y 2014. Increasing eutrophication in the coastal seas of China from 1970 to 2050. *Mar. Pollut. Bull.* 85: 123-140.)

Fisheries interactions

DOLPHIN BYCATCH PERVASIVE IN AN AUSTRALIAN TRAWL FISHERY

Data from skippers' logbooks and independent observers were used to assess common bottlenose dolphin bycatch patterns between 2003 and 2009 in the Pilbara trawl fishery, Western Australia. Both datasets indicated that dolphins were caught in all fishery areas, across all depths and throughout the year. Observer reported bycatch rates (12.6 dolphins/1,000 trawls) were about double those reported by skippers (6.5 dolphins/1,000 trawls). One trawl vessel caught significantly more dolphins than three other boats assessed. The lowest bycatch rates were between 00:00hrs and 05:59hrs and bycatch was reduced 45% in nets with bycatch reduction devices (BRDs) after their introduction. These results indicated that differences among vessels (or skippers' trawling techniques) and dolphin behaviour influenced dolphin bycatch rates more than location or time of year; thus, spatial or seasonal adjustments to trawling effort would be unlikely to significantly reduce dolphin bycatch. Modified BRDs, with top-opening escape hatches from which dolphins might escape to the surface, may be a more effective means of further reducing dolphin bycatch.

(SOURCE: Allen, S.J., Tyne, J.A., Kobryn, H.T., Bejder, L., Pollock, K.H., and Loneragan, N.R. 2014. Patterns of dolphin bycatch in a north-western Australian trawl fishery. *PLoS ONE* 9: e93178. doi:10.1371/journal.pone.0093178.)

SPERM WHALE BYCATCH IN US PACIFIC WATERS EXCEEDS SUSTAINABLE LEVELS

Bycatch of sperm whales in the California swordfish drift gillnet fishery has been documented since the observer program started in 1990. The fishery was observed from 1990 through 2012, with a total of 8,365 drift gillnet sets observed. Ten sperm whales were entangled during six different observed sets, yielding a bycatch rate of about 1.1 sperm whales per 1,000 observed sets. All of the entanglements occurred during October through December in waters deeper than 1,500m, in proximity to steep continental shelf bathymetry. Recent bycatch of sperm whales in this fishery has exceeded allowable potential biological removal levels set under the US Marine Mammal Protection Act.

(SOURCE: Carretta, J.V., Oleson, E., Weller, D.W., Lang, A.R., Forney, K.A., Baker, J., Hanson, B., Martien, K., Muto, M.M., Lowry, M.S., Barlow, J., Lynch, D., Carswell, L., Brownell, R.L., Mattila, D.K., and Hill, M.C. 2013. US Pacific Marine Mammal Stock Assessments: 2012. NOAA Technical Memorandum, NMFS-SWFSC-504.)

FISHING INTERACTIONS CONTINUE TO THREATEN MAUI'S DOLPHIN

Maui's dolphin is a subspecies of Hector's dolphin and current population estimates indicate that only about 55 Maui's dolphins over 1 year of age remain. A risk assessment workshop attributed 95.5% of human-induced mortalities to commercial, recreational, customary or illegal fishing-related activities combined, and the remaining 4.5% to non-fishing-related threats. There is high confidence that total human-induced mortality is higher than the population can sustain. Population projections indicate a 95.7% likelihood that the population will decline if threats remain at current levels (*i.e.* at the time of the workshop and prior to the introduction of interim measures).

(SOURCE: Currey, R.J.C., Boren, L.J., Sharp, B.R., and Peterson, D. 2012. *A Risk Assessment of Threats to Maui's Dolphins*. Ministry for Primary Industries and Department of Conservation, Wellington. 51 pp., available at *http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/maui-tmp/mauis-dolphin-risk-assessment.pdf*.)

'RECREATIONAL' GILLNETTING STILL A THREAT TO HECTOR'S DOLPHINS

T-POD acoustic data-loggers were moored in outer, mid and inner Akaroa Harbour to quantify variation in habitat utilisation by Hector's dolphins over the course of a year, to determine if they use the inner harbour where 'recreational' (non-commercial) gillnetting is allowed for eight months of the year (April-September). T-POD data showed a much higher level of use of the inner harbour in austral winter than was expected, indicating that the current compromise allowing gillnetting in this area poses genuine risk of entanglement.

(SOURCE: Dawson, S.M., Fletcher, D. and Slooten E. 2013. Habitat use and conservation of an endangered dolphin. *Endang, Spec. Res.* 21: 45-54.)

MORE THAN HALF OF NEW ZEALAND'S FISHING EFFORT IS NOT REPORTED

New Zealand's reported marine fisheries data are incomplete due to the lack of reporting significant numbers of landings in commercial fisheries, fish that are discarded and fish that are taken by recreational and traditional fishers. This analysis reconstructed total catches in New Zealand waters from reported catches for the period 1950-2010. A baseline was constructed using publically available official catch data. Added to this baseline were data from stock assessment reports, peer-reviewed literature, grey literature, data obtained under the Official Information Act, and data from a wide range of industry experts and personnel. The reconstructed total catch was about 2.9 times greater than the 14 million tonnes reported to the FAO on behalf of New Zealand for that period. Unreported commercial catch and discards accounted for the bulk of the difference. While some estimates of unreported catches and discards are included in stock assessment reports, the lack of comprehensive and transparent reporting has implications

for the quota management system and for the management of fisheries impacts on cetaceans, including direct impacts (e.g. bycatch) and indirect impacts (*e.g.* reduction of prey availability for cetaceans).

(SOURCE: Simmons, G., Bremner, G., Stringer, C., Torkington, B., Teh, L., Zylich, K., Zeller, D., Pauly, D. and Whittaker, H. 2015. Preliminary reconstruction of marine fisheries catches for New Zealand, 1950-2010. Working paper #2015-87, University of British Columbia Fisheries Centre.)

INDO-PACIFIC HUMPBACKED DOLPHINS INTERACT WITH FISHERIES IN EASTERN TAIWAN STRAIT

In eastern Taiwan Strait, there is substantial overlap between Indo-Pacific humpbacked dolphins and several kinds of fishing gear known to cause dolphin mortality. Large numbers of fishing vessels operated from ports within dolphin habitat, with an average of 32 fishing craft per km observed along a 200km stretch. More than 30% of the fewer than 100 dolphins in this population exhibited injuries caused by fishing gear. Three individuals were photographed with fishing gear attached to their bodies and one dolphin was found dead with fresh injuries caused by fishing gear. In order to ensure population recovery, mortalities due to human causes should be reduced to below one individual every seven years. Trammel nets, other gillnets and trawling pose the greatest threat and occur throughout the dolphins' habitat. Other fishing methods are available; using the most selective, sustainable fishing methods will benefit not only dolphins but also seabirds and fish stocks, meaning the fishing industry that depends on these stocks will also benefit.

(SOURCE: Slooten, E., Wang, J.Y., Dungan, S.Z., Forney, K.A., Hung, S.K., Jefferson, T.A., Riehl, K.N., Rojas-Bracho, L., Ross, P.S., Wee, A., Winkler, R., Yang, S.C. and Chen, C.A. 2013. Impacts of fisheries on the critically endangered humpback dolphin, *Sousa chinensis*, population in the eastern Taiwan Strait. *Endang. Spec. Res.* 22: 99-114.)

Marine debris

MICROPLASTICS ARE ABUNDANT IN NORTHEAST PACIFIC WATERS

Microplastics have been identified as posing a risk to marine organisms, including cetaceans. This risk involves the particles themselves, the substances they contain, and the toxic chemicals that adhere to their surfaces. This study revealed between 8 and 9,200 particles/m³ in Canadian waters, with values being lower offshore and increasing 6- to 27-fold closer to shore. Some microplastics apparently originated locally from land-based sources, while others appeared to be accumulated by oceanographic conditions. The authors argue for heightened scrutiny given the widespread contamination of the northeast Pacific and the oncoming debris from the 2011 Tohoku tsunami.

(SOURCE: Desforges, J.-P.W., Galbraith, M., Dangerfield, N, and Ross, P.S. 2014. Widespread distribution of microplastics in subsurface seawater in the NE Pacific Ocean. *Mar. Pollut. Bull*. 79: 94-99.)

PRESENCE OF LARGE 'GARBAGE PATCH' CONFIRMED IN THE SOUTH PACIFIC

A 4,489km-long transect through the South Pacific subtropical gyre (SPSG) revealed an average of nearly 27,000 plastic particles per kilometre. The amount of plastics on the surface increased toward the centre of the gyre, verifying the presence of a 'garbage patch' in the southern hemisphere. The highest value near the centre of the predicted accumulation zone was nearly 400,000 particles per kilometre. These values are still below those reported from the North Pacific subtropical gyre (NPSG), but underline the pervasive, large-scale threat that marine debris poses to the marine environment and its inhabitants.

(SOURCE: Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., Hafner, J., Zellers, A., and Rifman, S. 2013. Plastic pollution in the South Pacific subtropical gyre. *Mar. Pollut. Bull.* 68: 71-76.)

MARINE DEBRIS A MAJOR FACTOR AFFECTING THE COASTAL ECOSYSTEM IN SOUTH KOREA

Experts in South Korea, along with local participants working through an open access website, identified 21 marine species affected by marine debris between 2010 and 2012. This included a finless porpoise. Ten types of marine debris were recorded as causing impacts. Recreational fishing gear, especially fish hooks, affected wildlife most frequently. The authors call for South Korea to prioritize recreational fishing activities in the management of marine debris.

(SOURCE: Hong, S., Lee, J., Jang, Y.C., Kim, Y.J., Kim, H.J., Han, D., Hong, S.H., Kang, D., and Shim, W.J. 2013. Impacts of marine debris on wild animals in the coastal area of Korea. *Mar. Pollut. Bull.* 66: 117-124.)

AMOUNT OF PLASTIC MARINE DEBRIS IN EAST ASIAN SEAS PREDICTED TO INCREASE DRAMATICALLY

Anthropogenic litter in the marine environment (marine debris, beach litter) is a worldwide problem that has been especially highlighted by the so-called 'Great Pacific Garbage Patch,' trapped in the central north Pacific Ocean by major oceanic currents (gyres). Over the next 10 years, the amount of plastic litter reaching beaches in East Asian marginal seas (Yellow Sea, East China Sea, Japan Sea) is predicted to increase dramatically, with some beaches potentially experiencing a 250-fold increase in the amount of debris washed ashore. This trend is expected to continue even if inputs are reduced. In South Korea, an attempt was made to determine the economic costs. A marine debris pollution event on Geoje Island in 2011, attributed to heavy rainfall and flooding, washed debris into the sea via the Nakdong River. This event coincided with the summer vacation season and reduced the number of tourists here by 37%, leading to an estimated tourism revenue loss of US$37 million. Overall, the Pacific Ocean has a major marine debris problem, which affects all marine organisms that spend time at the sea surface.

(SOURCES: Kako, S., Isobe, A., Kataoka, T., and Hinata, H. 2014. A decadal prediction of the quantity of plastic marine debris littered on beaches of the East Asian marginal seas. *Mar. Pollut. Bull.* 81: 174-184; Jang, Y.C., Hong, S., Lee, J., Lee, M.J., and Shim, W.J. 2014. Estimation of lost tourism revenue in Geoje Island from the 2011 marine debris pollution event in South Korea. *Mar. Pollut. Bull.* 81: 49-54.)

RIVERS TRANSPORT LARGE AMOUNTS OF LITTER TO THE OCEAN AND BEACHES OF THE SOUTHEAST PACIFIC

A study of four rivers in Chile showed that the litter composition of each river reflects the human influences along its course. Riverine litter was deposited on both sides of the river mouths but tended to be more abundant on beaches north of the inflows, pointing to the influence of the prevailing water currents. The most abundant items on beaches were plastic, followed by polystyrene and manufactured wood. Such 'persistent buoyant' litter travels the farthest. More abundant litter and more distinct patterns occur during the rainy season, when more litter is washed into the ocean. Marine debris has multiple ecological impacts, including entanglement and ingestion by cetaceans.

(SOURCE: Rech, S., Macaya-Caquilpan, V., Pantoja, J.F., Rivadeneira, M.M., Jofre Madariaga, D., and Thiel, M. 2014. Rivers as a source of marine litter - a study from the SE Pacific. *Mar. Pollut. Bull.* 82: 66-75.)

Ship strikes

SHIP COLLISIONS WITH BRYDE'S WHALES IN HAURAKI GULF, NEW ZEALAND, MUST BE REDUCED

Ship strikes are the main cause of mortality for one of the few known resident populations of Bryde's whales in the world. In those whales in which the cause of death could be determined (just under half), 83% were attributed to ship strikes, with an average of two whales per year suffering lethal injuries. This rate of collision-related mortality might not be sustainable for the local population. Tag data showed

that the whales spent more than 90% of their time between the surface and a depth of 12m, within the range of the draught of ships entering Auckland Harbour. Based on the broad distribution of whales in the Gulf and other considerations, rerouting vessel traffic, visual detection and acoustic monitoring were all considered to be ineffective measures to reduce ship strikes. The authors suggested that reducing vessel speed to 10 knots (current speeds often in excess of 20 knots) would reduce the risk of whale death from ship strikes to 25%. This and other recommendations were incorporated into a Large Whale Warning System (LWWS), whose success was critically evaluated: although most ships passed clear of a reported whale location, only few notably changed course, so that more information must be gathered to better understand how and whether the communication between vessels and the LWWS is functioning properly. Year-round mandatory speed restrictions have never been implemented anywhere by the International Maritime Organization (IMO) and may take several years to be implemented here.

(SOURCE: Constantine, R., Aguilar Soro, N., and Johnson, M. 2012. Sharing the waters: minimising ship collisions with Bryde's whales in Hauraki Gulf. *Research Progress Report*, 22pp.; Constantine, R., Johnson, M., Riekkola, L., Jervis, S., Kozmian-Ledward, L., Dennis, T., Torres, L.G., and Aguilar de Soto, N. 2015. Mitigation of vessel-strike mortality of endangered Bryde's whales in the Hauraki Gulf, New Zealand. *Biol. Conserv.* 186: 149-157; Riekkola, L. and Constantine, R. 2014. An assessment of the Large Whale Reporting System December 2012 - November 2013. *LWWS Report.* 32 pp.)

INCREASING SHIP STRIKES OF HUMPBACK WHALES IN HAWAIIAN ISLANDS

Records for the Hawaiian Islands going back 37 years were examined for evidence of vessel collisions with humpback whales. From 1975-2011, 68 whale collisions were reported (59 witnessed collisions and nine whale injuries consistent with collision). None of these collisions appeared to have been lethal. Over 63% involved calves and sub-adults, suggesting younger animals may be more susceptible to ship strikes. Collision rates are increasing, which the authors suggest is due to increasing whale abundance, although moderate-sized (7.9m to 19.8m) vessels have also increased - the category most involved in ship strikes, accounting for two-thirds of incidents.

(SOURCE: Lammers, M.O., Pack, A.A., Lyman, E.G. and Espiritu, L. 2013. Trends in collisions between vessels and North Pacific humpback whales (*Megaptera novaeangliae*) in Hawaiian waters (1975-2011). *J. Cet. Res. Manage.* 13: 73-80.)

BLUE WHALES INTERACT WITH SHIPPING AND MINING OPERATIONS

Blue whale distribution around New Zealand is poorly understood. Their survival depends on the ability to reliably encounter large aggregations of euphausiid prey. Therefore, documenting and protecting blue whale foraging grounds are fundamental to their recovery. Evidence suggests that the South Taranaki Bight, between the North and South Islands of New Zealand, is used as a foraging ground for a common euphausiid prey that aggregates due to a nearby coastal upwelling system. Blue whale distribution was compared with ship traffic density and the distribution of seabed mining activities, revealing close proximity between whales and these potential threats. The author calls for a greater understanding of blue whale habitat use patterns to manage human activities effectively. While a proposal for sand mining here was declined by the New Zealand Environmental Protection Agency, this area already has several oil and gas platforms and a busy shipping lane.

(SOURCE: Torres, L.G. 2013. Evidence for an unrecognised blue whale foraging ground in New Zealand. *NZ J. Mar. Freshwat. Res.* 47: 235-248.)

Chemical pollution

MERCURY LEVELS EXPECTED TO RISE IN PACIFIC OCEAN FISH IN COMING DECADES

Methyl mercury is the toxic form of mercury. Inorganic mercury is transformed into methyl mercury by bacteria. This study found that up to 80% of this toxic form found in deep-feeding north Pacific fish is produced in the ocean (at 50-400m depth) by bacteria clinging to sinking particles. North Pacific fisheries are downwind from rapidly industrializing China and India, which rely on coal-burning power plants, a major source of mercury pollution. Mercury may travel thousands of miles before being 'rained-out' into the ocean. Levels are expected to increase in coming decades and perhaps even to double by mid-century. Mercury also bioaccumulates, with highest values in top predators such as cetaceans. Combined with expanding Oxygen Minimum Zones (OMZs) in the Pacific (and elsewhere), this poses a threat to north Pacific fisheries, the world's most important source of marine protein.

(SOURCES: Blum, J.D., Popp, B.N., Drazen, J.C., Choy, C.A., and Johnson, M.W. 2014. Methylmercury production below the mixed layer in the North Pacific Ocean. *Nat. Geosci.* 6 doi:10.1038/NGEO1918; NEWS: *Mar. Pollut. Bull*. 75: 4.)

HIGH LEVELS OF PERSISTENT ORGANIC POLLUTANTS IN YELLOW SEA MINKE WHALES

This study examining the PCB, OCP and PBDE concentrations in 32 marine species inhabiting the Yellow Sea revealed that the pelagic food chain is an important biomagnification pathway for many of these compounds. Muscle tissues of bycaught minke whales had higher concentrations of all contaminants than those found in the other species. The Yellow Sea is a major feeding and breeding ground for fish and an important habitat of minke whales in the northwest Pacific. This is one of dozens of recent publications on elevated concentrations of pollutants in Chinese and Korean waters.

(SOURCE: Byun, G.-H., Moon, H.-B., Choi, J.-H., Hwang, J., and Kang, C.-K. 2013. Biomagnification of persistent chlorinated and brominated contaminants in food web components of the Yellow Sea. *Mar. Pollut. Bull.* 73: 210-219.)

MERCURY LEVELS IN PACIFIC ALBACORE AND BIGEYE TUNA INDICATE INCREASING INPUTS INTO THE PACIFIC

Large predatory fish are often used as indicators of mercury contamination because they bioaccumulate some of the highest (and therefore human-health-relevant) heavy metal concentrations through the food chain. The samples collected in this study from the western and central Pacific showed high enough levels based on FAO/WHO's 'tolerable weekly intake levels' to limit consumption by humans. The values in this and other studies in the 21st century revealed that muscle mercury concentrations for these species are higher than values from 1983. This trend points to an increased input of mercury into the Pacific Ocean. This is also relevant for predatory cetaceans at the top of the food chain.

(SOURCE: Chen, C.-Y., Lai, C.-C., Chen, K.-S., Hsu, C.-C., Hung, C.-C., and Chen, M.-H. 2014. Total and organic mercury concentrations in the muscles of Pacific albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*). *Mar. Pollut. Bull.* 85: 606-612.)

DDE LEVELS IN GULF OF CALIFORNIA LONG-BEAKED COMMON DOLPHINS

DDT levels were measured in long-beaked common dolphins (n=16) in the Gulf of California. While DDD and DDT levels were generally below detection levels, DDE concentrations averaged 16 $\mu g.g^{-1}$ lipid weight (max.: 87.3 $\mu g.g^{-1}$ lipid weight in a juvenile female). This provides baseline contamination data for a little-studied species and location.

(SOURCE: Gallo-Reynoso. J.P., Malek, T.B., García-Hernández. J., Vázquez-Moreno. L., and Segura-García, I. 2015. Concentrations of DDE in blubber biopsies of free-ranging long-beaked common dolphins (*Delphinus capensis*) in the Gulf of California. *Bull. Environ. Contam. Toxic.* 94: 6-11.)

PLASTIC FROM THE NORTH PACIFIC IDENTIFIED AS A SOURCE OF PERSISTENT ORGANIC POLLUTANTS IN FISH AND BIRDS

There is a growing concern about food web contamination due to plastic waste. PCBs, OCPs and PBDEs were detected in all samples of juvenile yellowtail fish caught in the North Pacific Subtropical Convergence Zone (NPCG). Synthetic items were found in the stomachs of 10% of the fish. This is the first evidence of the bioaccumulation of PCBs, DDTs and other chlorinated pesticides, PBDEs and NP in fish from the NPCG. NP is produced in large quantities in the US and Japan to manufacture detergents and as an antioxidant and stabilizer in many plastics. The authors attribute the fish contamination with NP, and possibly with other compounds, to plastic debris. In another study, PBDEs were found in short-tailed shearwaters in the north Pacific Ocean. The same compounds were detected in plastic found in the stomachs of the birds. These studies demonstrate that marine debris-derived chemicals are present in marine organisms.

(SOURCES: Gassel, M., Harwani, S., Park, J.-S., and Jahn, A. 2013. Detection of nonylphenyol and persistent organic pollutants in fish from the North Pacific Central Gyre. *Mar. Pollut. Bull.* 73: 231-242; Tanaka, K., Takada, H., Yamashita, R., Mizukawa, K., Fukuwaka, M, and Watanuki, Y. 2013. Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. *Mar. Pollut. Bull.* 69: 219-222.)

PERSISTENT ORGANIC POLLUTANTS IN INDO-PACIFIC HUMPBACKED DOLPHINS

Of 11 persistent organic pollutants (POPs) examined in various tissues of stranded Indo-Pacific humpbacked dolphins in Hong Kong waters, ∑DDTs, ∑HCHs and mirex were generally higher than those found in cetaceans from other geographic regions. Unprecedented amounts of POPs have been released into this estuary over the last three decades. The levels of POPs in the testes of one male suggested an increasing risk of infertility. This species, classified as 'threatened' by the IUCN, consumes many of the same fish species as the local human population, making this investigation important for risk assessments and the protection of human health, as well as dolphin health.

(SOURCE: Gui, D., Yu, R., He, X., Tu, Q., and Wu, Y. 2014. Tissue distribution and fate of persistent organic pollutants in Indo-Pacific humpback dolphins from the Pearl River estuary, China. *Mar. Pollut. Bull.* 86: 266-273.)

TOXIC PETROLEUM COMPOUNDS CONCENTRATED IN ZOOPLANKTON IN EAST CHINA SEA

The most toxic petroleum hydrocarbon compounds are polycyclic aromatic hydrocarbons (PAHs). They have been classified as primary pollutants by the US EPA due to their carcinogenicity, toxicity and mutagenicity. The Changjiang (Yangtze) River transports thousands of tons of pollutants, including PAHs, into the East China Sea, a marginal sea of the Pacific Ocean. PAHs were highly concentrated in zooplankton along salinity fronts. This sea has high values of primary productivity and therefore supports many key fisheries stocks. The authors suggest that PAH-contaminated zooplankton may pose increased risk due to biomagnification in the marine food web. This underlines how compromising organisms at the base of the food chain can potentially affect top predators, including cetaceans.

(SOURCE: Hung, C.-C., Ko, F.-C., Gong, G.-C., Chen, K.-S., Wu, J.-M., Chiang, H.L., Peng, S.-C., and Santschi, P.H. 2014. Increased zooplankton PAH concentrations across hydrographic fronts in the East China Sea. *Mar. Pollut. Bull.* 83: 248-257.)

PBDE LEVELS IN TAIWANESE SPOTTED DOLPHINS

PBDEs are a type of contaminant found in flame retardants, plastics, circuit boards and other products. Pantropical spotted dolphins (n=8) stranded on the coast of Taiwan were analysed for PBDEs; levels ranged up to 0.443 $\mu g.g^{-1}$ lipid weight. Levels were correlated with body length and thus may bioaccumulate, with highest levels in blubber and males having significantly higher levels than females. The authors conclude that '*PBDEs should be considered an increasing pollution problem in the Asia-Pacific region, which may be of great concern in the future*'.

(SOURCE: Ko, F. C., We, N.Y. and Chou, L.S. 2014. Bioaccumulation of persistent organic pollutants in stranded cetaceans from Taiwan coastal waters. *J. Hazard. Mat.* 277: 127-133.)

HIGH HEAVY METAL LEVELS IN CERTAIN WESTERN PACIFIC OCEAN CETACEANS

A study on the feeding ecology of seven cetacean species in the western Pacific Ocean (based on stranded or bycaught individuals) revealed extremely high levels of arsenic (AS) and cadmium (CD) in the livers and kidneys two toothed whale species, Fraser's dolphins and Risso's dolphins. This threat is prey-derived, whereby Fraser's dolphins feed on hatchetfishes and Risso's dolphins on squid. The authors assume a health threat and call for investigating AS and CD levels in these prey organisms to better understand the food chain pathways of these heavy metals.

(SOURCE: Liu, J.-Y., Chou, L.-S., and Chen, M.-H. 2015. Investigation of the trophic level and niche partitioning of 7 cetacean species by stable isotopes, and cadmium and arsenic tissue concentrations in the western Pacific Ocean. *Mar. Pollut. Bull.* 93: 270-277.)

HIGH LEVELS OF CONTAMINANTS IN NEWLY DESCRIBED DOLPHIN SPECIES

The Burrunan dolphin is a newly described species from southeastern Australia. Contaminant levels were measured in live animals (collected via biopsies; n=20) and stranded animals (n=10). ΣPCB levels in stranded animals ranged from 258.80-8055 µg.g-1 wet weight. Mean mercury levels in the liver of stranded animals (n=6) were 420 µg.g-1 wet weight. Comparing mercury levels in the blubber of live and stranded animals showed stranded animals had mercury levels three times higher (mean 3.64, up to 7.4 µg.g-1 wet weight in blubber), although levels in live animals were also high (mean 1.32, up to 4.4 µg.g-1 wet weight in blubber). The region of Australia these animals inhabit has considerable industrial activity, including gold mining - a known source of mercury pollution. These high contaminant levels are a cause of concern for this new species.

(SOURCE: Monk, A., Charlton-Robb, K., Buddhadasa, S., and Thompson, R.M. 2014. Comparison of mercury contamination in live and dead dolphins from a newly described species, *Tursiops australis. PLoS ONE* 9: e104887.)

HIGH DDT CONTENT IN SEAFOOD IN EAST CHINA SEA

The OCP contents were examined in 13 types of seafood in four Chinese counties bordering the East China Sea. This area is influenced by the Yangtze and Qiantang rivers; the Yangtze River estuary is the largest agricultural production base in China. Sixteen OCPs were detected, whereby the combined DDT content was the highest, making up 32-89% of the total OCP content. DDT has been banned in many parts of the world. This analysis showed that some of the DDT stems from historical usage, but that there are possible fresh inputs in two of the four areas investigated. DDT is also still used as an additive in antifouling paints for fishing ships, and three DDT-based antifouling paint manufacturers are located here. High contents in fish point to potentially high contents in other top predators such as cetaceans, of which 16 species have been recorded in the East China Sea.

(SOURCE: Wang, J., Yu, X., and Fang, L. 2014. Organochlorine pesticide content and distribution in coastal seafoods in Zhoushan, Zhejiang Province. *Mar. Pollut. Bull.* 80: 288-292.)

HEAVY METAL POLLUTION IN COASTAL WATERS OF SOUTH CHINA

The authors review over 90 publications on heavy metal concentrations in South China. The levels were closely associated with the degree of local industrialization, with some areas being severely contaminated. The seafood safety limits were exceeded in several cases, such as for molluscs in Hong Kong or seafood from Lingdingyang (molluscs: 51-fold higher than the standard), as well as Guangxi and Hainan provinces. Due to bioaccumulation, this poses a risk to marine organisms higher up the food chain, such as cetaceans. Indeed, heavy metals (mercury) consumed in seafood are the only type of marine pollution that has definitively caused human mortalities (i.e. 'Minamata disease'). The authors call for more stringent environmental protection measures and better public awareness.

(SOURCE: Wang, S.-L., Xu, X.-R., Sun, Y.-X., Liu, J.-L., and Li, H.-B. 2014. Heavy metal pollution in coastal areas of South China: A review. *Mar. Pollut. Bull*. 76: 7-15.)

Disease and mortality events

Disease

TOXOPLASMOSIS IDENTIFIED AS A FACTOR IN THE DECLINE OF ENDANGERED HECTOR'S DOLPHINS AND CRITICALLY ENDANGERED MAUI'S DOLPHINS

The death of 7 of 28 examined Hector's dolphins was attributed to an atypical strain of toxoplasmosis. This included 2 of 3 critically endangered Maui's dolphins, a subspecies of Hector's dolphin. This study provides first evidence that infectious disease could be important in the population decline and potential extinction of this endemic New Zealand species (see Currey *et al*. under 'Habitat degradation'). Toxoplasmosis can also impact behaviour and promote dolphin foetus mortality. Although it has typically been considered a secondary disease of immunosuppressed dolphins, the authors pointed to the possibility that this strain could be highly pathogenic and emphasised that this source of mortality is currently not being considered in threat management plans (focusing on fisheries bycatch) for this species. This underlines the difficulty in incorporating the cumulative effects of multiple concurrent threats to cetaceans.

(SOURCE: Roe, W.D., Howe, L., Baker, E.J., Burrows, L. Hunter, S.A. 2013. An atypical genotype of *Toxoplasma gondii* as a cause of mortality in Hector's dolphins (*Cephalorhynchus hectori*). *Veter. Parasit. 192*: 67-74.)

Oil spills

PROGRESS IN IMPROVING INFORMATION ON AND RESPONSE TO OIL SPILLS IN THE EASTERN PACIFIC

Risk zones for oil spill impacts were determined for the 23 coastal provinces of Thailand. Four zone categories (from low to very high risk) were determined, in part based on seabird, sea turtle, dugong and cetacean populations. This analysis yielded risk maps that could help improve regulations related to shipping. In another effort, the IMO teamed up with IPIECA to launch a new global initiative program designed to improve oil spill preparedness and response capabilities in southeast Asia. This program was initiated to address '*the increased level of oil spill risk due to higher levels of shipping traffic, and increased exploration and production activities across the region*'. A third study presented an improved prediction system for oil spills in the Yellow Sea, prompted by the *HV Hebei Spirit* accident in 2007, which resulted in the largest oil spill ever recorded in the Yellow Sea.

(SOURCES: Singkran, N. Classifying risk zones by the impacts of oil spills in the coastal waters of Thailand. *Mar. Pollut. Bull.* 70: 24-43; NEWS. *Mar. Pollut. Bull.* 70: 3; Kim, C.-S., Cho, Y.-K., Choi, B.-JH., Jung, K.T., and You, S.H. 2013. Improving a prediction system for oil spills in the Yellow Sea: Effect of tides on subtidal flow. *Mar. Pollut. Bull.* 68:85-92.)

Harmful algal blooms (HABs)

HIGH STRANDING MORTALITIES IN PERU ATTRIBUTED LARGELY TO TOXIC ALGAL BLOOMS

In 2014, 1132 small cetaceans and 13 whales stranded in Peru, mostly between Lambayeque and Piura. The peak stranding events occurred in January and February (904 mortalities). The species most affected was the long-beaked common dolphin, but at least seven other species were recorded, including Bryde's whales and humpback whales. This report notes unusual oceanographic conditions and cites toxic algae along these coasts during those two months as the probable cause of these unusually high mortalities. It also mentions repeated closures of a bay due to biotoxins in scallop banks. Additionally, 22 animals showed fishing net marks and mutilated body parts for consumption or bait. Of the 13 baleen whales, four died due to entanglement and one due to ship strike. The report notes the severe deficiency in the control of artisanal and large vessels, as well as marine traffic especially during the migration season of humpback whales.

(SOURCE: IMARPE (Instituto del Mar del Peru). 2014. Cetacean unusual mortality event 2014. 7pp.)

LARGE INCREASE IN ANTHROPOGENIC NITROGEN IN THE NORTH PACIFIC

Transport of nitrogen from the atmosphere to the open ocean has more than doubled globally over the past 100 years. The increase in nitrogen deposition has been particularly high in the north Pacific due to increasing human populations and industrial growth in Asia. The authors note that '*The possible impacts of this anthropogenic perturbation on the open-ocean nitrogen cycle are numerous*', including altering patterns of primary productivity, altering phytoplankton composition in the Pacific and '*in the long term, the structure of the ecosystem'*. The authors warn that this increase in nitrogen levels in the ocean could '*constitute another example of a global-scale alteration of the Earth system*'.

(SOURCE: Kim, I.N., Lee, K., Gruber, N., Karl, D.M., Bullister, J.L., Yang, S., and Kim, T.W. 2014. Increasing anthropogenic nitrogen in the North Pacific Ocean. *Science* 346: 1,102-1,106.)

TOXIC RED TIDES ON THE INCREASE IN CHINESE WATERS

Red tides typically involve blooms of specific planktonic organisms that discolour the water and emit toxic substances, often associated with fish kills. This long-term study revealed that 172 red tide events occurred around the Yangtze River Estuary between 1972 and 2009. The frequency of red tide outbreaks increased significantly after the year 2000, with often more than 10 events per year. Importantly, large outbreaks (exceeding 1,000km^2) became much more common after 2000. The authors report that these have caused great harm to offshore and coastal economies and to human health. Red tides are increasingly being associated with coastal pollution and affect the entire food chain, therefore also posing a threat to cetaceans.

(SOURCE: Liu, J.Z., Zheng, B., Cai, W., Kin, K., and Tang, J. 2013. Temporal and spatial distribution of red tide outbreaks in the Yangtze River Estuary and adjacent waters, China. *Mar. Pollut. Bull.* 73: 213-221.)

Noise impacts

DOLPHIN MOTHER-CALF PAIRS ARE MORE SENSITIVE TO TOURISM

The effects of tour boats and a research boat on the group structure and vocal behaviour of bottlenose dolphins were

quantified in Doubtful Sound, New Zealand. Groups with mother-calf pairs were significantly less cohesive and coordinated when tour boats were audible. They were more vocal when boats were close and while moving away, presumably to re-establish group structure. Furthermore, groups with calves increased their whistle rates when tour boats were travelling faster, while groups without calves became quieter. Dolphins also responded to boat noise with alterations in whistle frequency and duration. These findings indicate that boat noise affects communication, and groups with calves are particularly sensitive to boat presence and noise. Group structure and whistle parameters were also affected by the research boat, highlighting the importance of accounting for observer effects in studies of tourism impacts. The particular sensitivity of groups with calves to boats has important implications for the management of impacts on this population due to its endangered status and history of low calf survival.

(SOURCE: Guerra, M.G., Dawson, S.M., Brough, T.E. and Rayment, W.J. 2014. Effects of boats on the surface and acoustic behaviour of an endangered population of bottlenose dolphins. *Endang. Spec. Res.* 24: 221-236.)

ATYPICAL MASS STRANDING OF BEAKED WHALES COINCIDENT WITH NAVAL EXERCISE OFF GUAM

On 23 March 2015, three beaked whales stranded simultaneously but in different locations along the southern coast of Guam. It was confirmed that a joint US-Japanese naval exercise incorporating sonar use and anti-submarine activities, involving eight ships, was being conducted in nearby waters during 23-27 March.

(SOURCE: *http://www.kuam.com/story/28628542/2015/03/27/sonar-was-being-tested-when-whales-were-beached*.)

POPULATION OF BOTTLENOSE DOLPHINS IN NEW ZEALAND IS IN DECLINE

Concern has been raised about disturbance by boat traffic (tourism-related and otherwise) on the small population of bottlenose dolphins in the Bay of Islands, New Zealand. There was a 7.5% annual decline in the population between 1997 and 2006, probably due to emigration/displacement or mortality. The calving rate increased between 1997-99 and 2003-05, from 0.13 to 0.25 (*i.e.* one calf every four years), but this is still lower than for other studied populations. Calf mortality rates were higher than rates reported elsewhere. A combination of population decline, high calf mortality rates and low recruitment gives a poor prognosis for this population's viability. Chronic disturbance may be having a population-level effect. The authors conclude that '*management should focus on minimizing sources of anthropogenic disturbance* [i.e. boat traffic] *and enforcing compliance with current legislation*'.

(SOURCE: Tezanos-Pinto, G., Constantine, R., Mourão, F., Berghan, J. and Baker, C.S. 2015. High calf mortality in bottlenose dolphins in the Bay of Islands, New Zealand - a local unit in decline. *Mar. Mamm. Sci.* 31: 540-559.)

GLOBAL

General

EXTINCTION HOTSPOT LOCATIONS DETERMINED BY ANALYSING THE PALEONTOLOGICAL RECORD

The paleontological record (for the past 23 million years) was investigated to examine patterns of extinction for marine species. Six major marine taxonomic groups (bivalves, gastropods, scleractinian corals, echinoids, sharks, and mammals) were analysed due to their occurrence in the fossil record. The extinction risk was higher in tropical ecosystems. Mammals had the highest extinction risk and the extinction rates were highest in the Indo-Pacific, tropical south Pacific, and east Asia, followed by the North Atlantic, Indian Ocean and sub-Antarctic islands. These regions of high intrinsic extinction rates are currently facing strong impacts from anthropogenic activities, raising further concern regarding the extinction of marine mammals here.

(SOURCE: Finnegan, S., Anderson, S.C., Harnik, P.G., Simpson, C., Tittensor, D.P., Byrnes, J.E., Finkel, Z.V., Lindberg, D.R., Liow, L.H., Lockwood, R., Lotze, H.K., McClain, C.R., McGuire, J.L., O'Dea, A. and Pandolfi, J.M. 2015. Paleontological baselines for evaluating extinction risk in the modern oceans. *Science* 348: 567-570.)

FIRST EVIDENCE THAT MARINE PROTECTED AREAS WORK FOR MARINE MAMMALS

The survival rate of a Hector's dolphin population increased after a marine mammal sanctuary was established to reduce gillnet mortality. Photo-identification surveys catalogued 462 individuals. Survival rates modelled before and after the sanctuary was created showed there was a 90% probability that survival improved after implementing the sanctuary, with estimates of mean survival probability increasing by 5.4%. This improvement in survival corresponds to a 6% increase in mean annual population growth. Clearly, MPAs can be effective for marine mammals. Estimating demographic parameters in marine mammals requires many years of data to achieve sufficient precision to detect biologically meaningful change. Therefore, MPAs should be established with a commitment to long-term monitoring.

(SOURCE: Gormley, A.M., Slooten, E., Dawson, S.M., Barker, R.J., Rayment, W., du Fresne, S. and Bräger, S. 2012. First evidence that marine protected areas can work for marine mammals. *J. Appl. Ecol.* 49: 474-480.)

PATTERNS OF MARINE SPECIES LOSS IN THE OCEANS

The authors argue that marine defaunation started much later in marine systems than terrestrial and freshwater systems. Despite this, humans have decreased the abundance of both large (*e.g.* baleen whales) and small (*e.g.* anchovies) marine species. Although marine ecosystems have fared slightly better than terrestrial ecosystems, with fewer marine extinctions - at least extinctions that are known - anthropogenic impacts on marine animals are increasing. The authors warn that the current rates of marine species loss '*may be the prelude to a major extinction pulse… as the footprint of human ocean use widens*'. They recommend a system of MPAs and careful management of connecting ocean corridors. They note that '*current trends in ocean use suggest that habitat destruction is likely to become an increasingly dominant threat to ocean wildlife over the next 150 years*'.

(SOURCE: McCauley, D.J., Pinksy, M., Palumbi, S.R., Estes, J.A., Joyce, F.H. and Warner, R.R. 2015. Marine defaunation: animal loss in the global ocean. *Science* 347: 247, DOI: 10.1126/science.1255641.)

KEY RESEARCH QUESTIONS OF GLOBAL IMPORTANCE FOR CETACEAN CONSERVATION

A workshop at the 18th Biennial Conference on the Biology of Marine Mammals developed a list of urgent research questions, whose lack of answers are obstructing cetacean conservation. Examples of these research questions include:

- How do we better monitor cetaceans, human activities (e.g. industry, fisheries and tourism) and their interactions?
- What can be done to further engage industry and support communities (including indigenous societies) to develop and undertake cetacean-sustainable activities?
- How will current and predicted environmental changes (including climate change and anthropogenic pollution) affect cetacean ranges, habitat use, health, including through changes in the distributions of human activities (e.g. increase in Arctic shipping and drilling)?
- At what point do sub-lethal impacts compromise the viability of a cetacean population?

- How do we quantify multiple, cumulative, and synergistic impacts? To what degree are cetaceans able to habituate, cope, tolerate, or adapt? Does removing certain stressors increase resilience to those that remain?

The questions provide a road map for conservation research necessary to help manage and protect cetaceans.

(SOURCE: Parsons, E.C.M., Baulch, S., Bechshoft, T., Bellazzi, G., Bouchet, P., Cosentino, A.M., Godard-Codding, C.A.J., Gulland, F., Hoffmann-Kuhnt, M., Hoyt, E., Livermore, S., MacLeod, C.D., Matrai, E., Munger, L., Ochiai, M., Peyman, A., Recalde-Salas, A., Regnery, R., Rojas-Bracho, L., Salgado-Kent, C.P., Slooten, E., Wang, J.Y., Wilson, S.C., Wright, A.J, Young, S., Zwamborn, E. and Sutherland, W.J. 2015. Key research questions of global importance for cetacean conservation. *Endang. Spec. Res.* 27: 113-118.)

KEY RESEARCH QUESTIONS OF GLOBAL IMPORTANCE FOR MARINE SPECIES CONSERVATION

A workshop at the 3rd International Marine Conservation Congress developed a list of urgent research questions that would aid marine conservation globally. Some examples of these research questions include:

Climate change

- What attributes of species (e.g. tropical or temperate, sessile or motile) make them particularly sensitive to stressors attributable to climate change?

Disease

- Which strategies can be used to mitigate and manage the effects of the spread of existing and emergence of new marine pathogens?

Noise

- To what extent and in which ways does anthropogenic noise affect marine fauna at the population level, particularly species that depend heavily upon sound, and how do impacts accrue over time and space?

Shipping

- How can the negative impacts of shipping on marine species and ecosystems (e.g. disturbance to sensitive habitat areas, output of CO_2 and black carbon, underwater noise, and the release of other pollutants during construction and operations) be reduced and public awareness of such impacts be elevated?

Chemical pollution and marine debris

- How should novel and emerging marine contaminants be regulated even if their impacts and conservation implications are not fully understood?

Bycatch

- How can the impacts of bycatch from legal and illegal, unreported, and unregulated (IUU) fisheries be reduced to a level that will allow the reversal of declining trends of affected species?

Cumulative impacts

- What are the best ways to estimate, evaluate, and manage cumulative impacts and multiple anthropogenic stressors in the marine environment?

(SOURCE: Parsons, E.C.M., Favaro, B., Draheim, M., McCarthy, J.B., Aguirre, A.A., Bauer, A.L., Blight, L.K., Cigliano, J.A., Coleman, M.A., Côté, I.M., Fletcher, S., Foley, M.M., Jefferson, R., Jones, M.C., Kelaher, B.P., Lundquist, C.J., Nelson, A., Patterson, K., Walsh, L., Wright, A.J. and Sutherland, W.J. 2014. 71 important questions for the conservation of marine biodiversity. *Conserv. Biol.* 28: 1,206-1,214.)

WHALES HELP SHAPE MARINE ECOSYSTEMS

Whales once played a significant role in shaping marine ecosystems due to their large populations and high energy demands; the authors refer to them as 'ecosystem engineers'. These roles included - beyond being important predators and prey - promoting plankton growth by moving nutrients from depth to the surface (where plankton grows) and from feeding areas to calving areas. Moreover, whales shift carbon to the deep sea when they die and their carcasses serve as a habitat for many specialized invertebrates. The decline in overall whale numbers (by 66-90%) from commercial whaling probably altered the structure and function of the oceans. The authors conclude that, as whale populations increase, many of these structures and functions may be restored.

(SOURCES: Roman, J., Estes, J.A., Morisette, L., Smith, C., Costa, D., McCarthy, J., Nation, J.B., Nicol, S., Pershing, A., and Smetacek, V. 2014. Whales as ecosystem engineers. *Fron. Ecol. Environ* 12: 377-385; News. *Mar. Pollut. Bull.* 85: 4.)

RISK OF EXTINCTION FOR MARINE ORGANISMS AS HIGH AS FOR TERRESTRIAL SPECIES

It has long been thought that human activities have had less impact in the marine than in the terrestrial environment. This is in part because only 19-24 of 850 recorded extinctions involved marine species. A new study of global extinction risk, however, reveals that this is a misconception, partly due to the different proportion of species that have been assessed by the IUCN. Correcting for this disproportion and focusing on species for which sufficient taxonomic data and conservation assessments are available shows that one in every four or five marine species is at a heightened risk of extinction. This is the same value as for land-living plants and animals.

(SOURCES: Webb, T.J. and Mindel, B.L. 2015. Global patterns of extinction risk in marine and non-marine systems. *Curr. Biol.* 25: 506-511; NEWS: *Mar. Pollut. Bull.* 92:7.)

POLLUTION AND OCEAN ACIDIFICATION

On one hand, pollutants and eutrophication promote ocean acidification. On the other, ocean acidification increases the toxicity of heavy metals and reduces the degradation of organic pollutants. This paper reflects a wider attempt to understand how various threats can act synergistically, *i.e.* can multiply the impacts of individual threats beyond a mere additive accumulation of threats. This information is relevant to cetaceans because increasing the bioavailability of heavy metals and other pollutants would mean higher concentrations in their tissues, and strengthened acidification would lead to a decline of various shell-producing plankton species at the base of their food web.

(SOURCE: Zeng, X., Chen, Xijuan and Zhuang, J. 2015. The positive relationship between ocean acidification and pollution. *Mar. Pollut. Bull.* 91: 14-21.)

Habitat degradation

General

AN EVALUATION OF THE ENVIRONMENTAL IMPACTS OF DREDGING ON MARINE MAMMALS

A review on the environmental impacts of dredging discussed the wide impacts this activity can have on the marine environment and marine mammals. While dredging vessels are slow, and thus make collisions with marine mammals unlikely, they produce broadband noise, mostly below 1kHz. This has the potential to cause behavioural changes and mask communication calls, especially in baleen whales. For example, backhoe dredgers produce noise (bandwidth 3 Hz-20kHz) at a source level of 179 dB re 1µPa @1m. Dredging produces sediment plumes, which may not physically affect cetaceans but could affect planktonic and benthic species. It could also affect important habitats such as sea grass beds by smothering them with sediment. Dredging can also liberate sequestered contaminants into the marine environment and cause short-term increases in nutrient availability. The great variability in dredging equipment implies variable impacts, which may also vary depending on the site being dredged.

The authors conclude that the impacts on cetaceans are '*most likely to be masking and short-term behavioural alterations and changes to prey availability*'.

(SOURCE: Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A. and Thomsen, F. 2014. A review of impacts of marine dredging activities on marine mammals. *ICES J. Mar. Sci.* 72: 328-340.)

Marine debris

FIRST STUDY TO SHOW MICROPLASTICS IN A BALEEN WHALE

Although macroplastics have often been documented in the digestive tracts of whales, this is the first report of ingested microplastics. The intestines of a humpback whale stranded in the Netherlands contained several polymer types, including polyethylene, polypropylene, polyvinylchloride and nylon in varying particle shapes (sheets, fragments and threads). The specific effects of microplastics in cetaceans have not yet been studied, but the larger surface-to-volume ratio compared to macroplastics and the leaching of chemicals from plastics, as reported in other marine organisms, calls for better reporting of microplastic occurrence in whales and further research into potential impacts.

(SOURCE: Besseling, E., Foekema, E.M., Van Franeker, J.A., Leopold, M.F., Kühn, S., Bravo Rebolledo, E.L., Heße, E., Mielke, L., IJzer, J., Kamminga, P., and Koelmans, A.A. 2015. Microplastic in a macro filter feeder: humpback whale *Megaptera novaeangliae*. *Mar. Pollut. Bull.,* in press, *http://dx.doi.org/10.1016/j.marpolbul.2015.04.007*.)

PLASTIC MARINE DEBRIS REMAINS A GROWING ISSUE

Numerous recent publications underline the increasing recognition of the threat that plastic debris poses in the marine environment. An overview of the impact of debris on marine life (Gall and Thompson) reports that 340 papers have been published on encounters between organisms and marine debris, involving 693 species. At least 17% of the species were listed as threatened or near threatened. One editorial (Moore) outlines the history of the problem and provides a 9-point list of issues that need to be clarified, including an initial report of efforts to recycle stranded marine debris. Another paper (Gonzalez Carman *et al.*) presents a range of legal and institutional tools, along with a framework and practical suggestions, to mitigate the effect of plastic pollution on marine species, using Argentina as an example. The entanglement and ingestion threat posed to cetaceans is outlined in detail in Baulch and Perry (2014) (see SC/65b/E01).

(SOURCES: Gall, S.C. and Thompson, R.C. 2015. The impact of debris on marine life. *Mar. Pollut. Bull.* 92: 170-179; Gonzalez Carman, V., Machain, N., and Campagna, C. 2015. Legal and institutional tools to mitigate plastic pollution affecting marine species: Argentina as a case study. *Mar. Pollut. Bull.* 92: 125-133; Moore, C.J. 2015. How much plastic is in the ocean? You tell me! *Mar. Pollut. Bull.* 92: 1-3.)

MARINE PLASTIC DEBRIS COULD INCREASE TENFOLD BY 2025

The total amount of plastic waste produced by 192 coastal countries was calculated for the year 2010 to be 275 million metric tons. Of this, an estimated 4.8 to 12.7 million metric tons went into the ocean. The quality of waste treatment and population size of the respective country were the two major factors determining how much waste entered the oceans to become plastic marine debris. The researchers warned that '*without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025*'.

(SOURCE: Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., and Law, K.L. 2015. Plastic waste inputs from land into the ocean. *Science* 347: 768- 771.)

RESEARCH PRIORITIES FOR ADDRESS THE PROBLEM OF MARINE DEBRIS

A group of experts on the impacts of debris on marine species developed a list of urgent research questions to address the problem of marine plastics. Marine plastics are a major component of marine debris and have been highlighted as a substantive threat for cetaceans. Some examples of these research questions include:

- What are the impacts of plastic pollution on the physical condition of key marine habitats?
- What are the impacts of plastic pollution on trophic linkages?
- What are the species-level impacts of plastic pollution, and can they be quantified?
- What are the population-level impacts of plastic pollution, and can they be quantified?
- What are the impacts of wildlife entanglement?
- What, and where, are the main sources of plastic pollution entering the marine environment?
- What are the alternatives to plastic?

(SOURCE: Vegter, A.C., Barletta, M., Beck, C., Borrero, J., Burton, H., Campbell, M.L., Eriksen, M., Eriksson, C., Estrades, A., Gilardi, K., Hardesty, B.D., Ivar do Sul, J.A., Lavers, J.L., Lazar, B., Lebreton, L., Nichols, W.J., Ribic, C.A., Ryan, P.G., Schuyler, Q.A., Smith, S.D.A., Takada, H., Townsend, K.A., Wabnitz, C.C.C., Wilcox, C., Young, L., and Hamann, M. 2014. Global research priorities to mitigate plastic pollution impacts on marine wildlife. *Endang. Spec. Res.* 25: 225-247.)

Chemical pollution

POLLUTANT LEVELS IN DOLPHIN POPULATION CAN VARY BY LAND USE AND WATERSHED

A study investigating contaminant levels in dolphins found major differences in burdens between dolphins inhabiting two adjacent watersheds. A population in a developed watershed exhibited higher PCBs and PBDEs levels than one inhabiting a watershed with predominant wetland. Thus, there can be major differences in contaminant signatures at the watershed level, and land-use patterns in watersheds can affect contaminant levels in dolphin populations.

(SOURCE: Adams, J., Speakman, T., Zolman, E., Mitchum, E., Bossart, G., and Fair, P. 2014. The relationship between land use and emerging and legacy contaminants in an apex predator, the bottlenose dolphin (*Tursiops truncatus*), from two adjacent estuarine watersheds. *Environ. Res.* 135: 346-353.)

LONG-TERM CONCENTRATIONS OF ORGANIC CONTAMINANTS IN MARINE MAMMALS SHOW MIXED TRENDS

Marine mammals bioaccumulate certain pollutants to high concentrations over their lifetimes, especially organic contaminants that are lipophilic. A worldwide analysis of the literature from 2008 to 2014 showed both upward and downward trends depending on the substance. Thus, some contaminants whose use has been regulated and restricted showed decreased amounts in tissues (e.g. organochlorine pesticides, PBDE, HBCD, butyltins). The trends for perfluorinated compounds are more mixed. For PCBs, whose use has been widely controlled since the 1980s, an earlier downward trend appears to have stalled; their concentrations in harbour porpoise in the UK, for example, remain at toxicologically significant levels. This raises concerns for killer whales and bottlenose dolphins, for example, due to their larger size and greater bioaccumulation potential. The authors caution that restrictions on certain brominated flame retardants mean that the use of other brominated, chlorinated and phosphorus flame retardants will increase. Moreover, new compounds - with currently unknown potential impact - are still being detected in marine mammal tissues. Finally, some 'legacy' organic pollutants such as DDT continue to exert effects, calling for further efforts to reduce their inputs.

(SOURCE: Law, R.J. 2014. An overview of time trends in organic contaminant concentrations in marine mammals: Going up or down? *Mar. Pollut. Bull.* 82: 7-10.)

THE MOVEMENT OF MERCURY THROUGH THE OCEANS AND ANTHROPOGENIC INPUTS

A three-dimensional model simulated the movement of mercury through water and ocean systems, atmosphere, rivers, and oceans. Examining a time when anthropogenic activities had major impacts (e.g. during the 15th century), the model indicated that mercury remains in the water for an average of 2,000 years before becoming embedded in sediment. The model predicted that mercury levels in the deep north Pacific '*are a factor of 2-3 higher than in the deep north Atlantic Ocean*', because the movement of oceanic waters transfer mercury from the north Atlantic to the north Pacific. Anthropogenic inputs of mercury result in levels 5-6 times higher than predicted natural levels.

(SOURCE: Zhang, Y., Jaeglé, L., and Thompson, L. 2014. Natural biogeochemical cycle of mercury in a global three-dimensional ocean tracer model. *Glob. Geochem. Cycles* 28: 553-70.)

Disease and mortality events

Oil spills

ECOSYSTEM IMPACTS OF THE *DEEPWATER HORIZON* OIL SPILL

The *Deepwater Horizon* oil spill introduced over 518 million litres of oil into the Gulf of Mexico marine ecosystem. A wide range of impacts have been reported, including greater marsh erosion (due to an increase in 'oil-eating' bacteria and root damage); fewer acrobat ants and marsh periwinkles; increased mortality rates and slower growth in eastern oyster larvae; and fewer chicks and nests built by seaside sparrows. Gulf killifish showed genetic evidence of exposure to toxic chemicals, although population numbers did not change, while thousands of brown pelicans died (again, no change in population numbers). Paradoxically, shrimp populations increased in oiled areas. Oil sank to the sea floor over more than 3,200km^2, an area roughly the size of Rhode Island. Near the wellhead, patches of coral were apparently killed or damaged by the oil. The diversity of benthic invertebrates decreased up to 17km from the centre of the spill. Impacts on dolphin health in Barataria Bay, Louisiana, were reported in SC/65b/E01. An analysis of stranding patterns during the unusual mortality event (UME) found the highest values ever recorded in Louisiana in 2010-11, with high levels in 2011 for both Mississippi and Alabama. Stranding rates on the coast of Florida and Texas were not elevated during this period. Mortalities were clustered with this UME, with increased strandings in northern Louisiana and Mississippi (Mar-May 2010); Barataria Bay, Louisiana (Aug 2010-Dec 2011); Mississippi and Alabama (2011); and multiple locations around the Gulf of Mexico in early 2013. The total ecosystem impact of the spill still needs to be ascertained, but was extensive. Note that the Gulf is also the world's largest eutrophication-related 'dead zone', underlining the cumulative threats of multiple sources of pollution.

(SOURCES: Cornwall, W. 2015. Five years after the *Deepwater Horizon* disaster, scars linger. *Science* 348: 22-29; Schwacke, L.H., Smith, C.R., Townsend, F.I., Wells, R.S., Hart, L.B., Balmer, B.C., Collier, T.K., De Guise, S., Fry, M.M., Guillette, Jr., L.J., Lamb, S.V., Lane, S.M., McFee, W.E., Place, N.J., Tumlin, M.C., Ylitalo, G.M., Zolman, E.S., and Rowles, T.K. 2014. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the *Deepwater Horizon* oil spill. *Environ. Sci. Tech.* 48: 93-103; Venn-Watson, S., Garrison, L., Litz, J., Fougeres, E., Mase, B., Rappucci, G., Stratton, E., Carmichael, R., Odell, D., Shannon, D., Shippee, S., Smith, S., Staggs, L.,Tumlin, M., Whitehead, H., and Rowles, T. 2015. Demographic clusters identified within the Northern Gulf of Mexico common bottlenose dolphin (*Tursiops truncates*) [sic] unusual mortality event: January 2010-June 2013. *PLOS One*: DOI: 10.1371/journal.pone.0117248.)

COMPARISON OF THE GULF OF MEXICO MORTALITY EVENT TO PAST MORTALITY EVENTS

A study compared the number of dolphin strandings in the Gulf of Mexico UME to past mortality events. As of September 2014, more than 1000 mortalities had been reported (versus a maximum of 344 in a 1990 mortality event), and the event had lasted more than 48 months, compared to the previous longest event of 17 months (average UME event length = 6 months). Previous UMEs had been attributed to morbillivirus or brevetoxin exposure. Although this UME began before the *Deepwater Horizon* oil spill, the latter has been implicated in the former's persistence.

(SOURCE: Litz, J., Baran, M., Bowen-Stevens, S., Carmichael, R., Colegrove, K., Garrison, L.P., Fire, S.E., Fougeres, E.M., Hardy, R. Holmes, S., Jones, W., Mase-Guthrie, B.E., Odell, D.K., Rosel, P.E., Saliki, J.T., Shannon, D.K., Shippee, S.F., Smith, S.M., Stratton, E.M., Tumlin, M.C., Whitehead, H.R., Worthy, G.A.J., and Rowles, T.K. 2014. Review of historical unusual mortality events (UMEs) in the Gulf of Mexico (1990-2009): providing context for the multi-year northern Gulf of Mexico cetacean UME declared in 2010. *Disease Aq. Org.* 112: 161-175.)

Climate change

GLOBAL ATMOSPHERIC CARBON DIOXIDE LEVELS REACH 400PPM - HIGHEST LEVELS IN HUMAN HISTORY

In February 2015, atmospheric carbon dioxide levels reached 400 ppm, the highest level recorded in human history. Levels have not been so high for at least 2 million years (23 million years according to other estimates). The levels were reported from 40 sampling sites at remote locations. Since the pre-industrial era, the atmospheric carbon dioxide level has risen by approximately 120 ppm, with half of that that rise occurring from 1980 onwards.

(SOURCE: Biello, D. 2015. CO2 levels for February eclipsed prehistoric highs. *Scient. Amer.*, March 5, *http://www.scientificamerican.com/article/co2-levels-for-february-eclipsed-prehistoric-highs*; NOAA. 2015. Trends in atmospheric carbon dioxide, *http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html*; Franks, P.J., Royer, D.L., Beerling, D.J., Van de Water, P.K., Cantrill, D.J., Barbour, M.M., and Berry, J.A. 2014. New constraints on atmospheric CO_2 concentration for the Phanerozoic. *Geophys. Res. Lett* 41: 4,685-4,694.)

GLOBAL WARMING AND ANOXIC EVENTS

While warming of ocean waters and ocean acidification have been widely discussed as two climate change impacts, ocean deoxygenation has gained less attention. Since the 1960s, the number of anoxic zones in coastal waters has doubled. Open ocean deoxygenation has also occurred, exacerbated by stratification of ocean waters due to warming and changing patterns of ocean circulation. In particular there has been an extensive oxygen decline in the northeast Pacific in the tropical and subtropical oceans over the last 50 years. Excessive nutrient levels that lead to coastal anoxic events also worsen oceanic hypoxia by '*increasing surface-layer production that ultimately fuels microbial respiration at depth*'. Intensified wind-driven upwelling, which is one effect of global warming, is also bringing low oxygen and low pH waters from the deep ocean to coastal regions, again exacerbating coastal anoxic events. This is having particular impact on the west coast of the US, coasts of Mexico and the Bay of Bengal. A second study examined existing 'dead zones' and predicted warming in these locations. The authors found that 94% of anoxic zones would likely experience at least a 2°C temperature increase by 2100. Various climate variables, including temperature, ocean acidification, sea-level rise, precipitation, wind, and storm patterns, will affect dead zones. Many of these factors are expected to work synergistically and promote hypoxia.

(SOURCES: Levin, L.A. and Breitburg, D.L. 2015. Linking coasts and seas to address ocean deoxygenation. *Nat. Clim. Change* 5: 401-403; Altieri, A.H. and Gedan, K.B. 2014. Climate change and dead zones. *Glob. Change Biol.* 21: 1,395-1,406.)

THE PROJECTED DECREASE IN AEROSOL LEVELS WILL GREATLY EXACERBATE ARCTIC WARMING

Aerosols play a part in modifying climate change, possibly reducing the effect of greenhouse-gas-induced warming by 1.3-2.2°C. This cooling effect is particularly prominent in the Arctic. Without this aerosol-linked cooling, the Arctic would be even warmer. Aerosol emissions are projected to decrease in coming decades. If greenhouse gas emissions continue as they are, the net effect will be an 8.3°C rise in Arctic temperatures by 2100. The authors warn that unless greenhouse gases are reduced drastically, Arctic warming will be more severe than expected.

(SOURCE: Najafi, M.R., Zwiers, F.W., and Gillett, N.P. 2015. Attribution of Arctic temperature change to greenhouse-gas and aerosol influences. *Nat. Clim. Change* 5: 246-249.)

LOSS OF ANTARCTIC ICE IS ACCELERATING AND IRREVERSIBLE

Floating ice sheets around Antarctica hold back ice on the land, like a fence (i.e. buttressing). If this sea ice is lost, land ice flows into the sea, adding to oceanic water volume and thus sea level. Eighteen years of satellite data revealed that average ice-shelf volume change accelerated from the decade 1994-2003 to the decade 2003-12. Ice losses in the western Antarctic increased by approximately 70% over the past decade, and gains in eastern Antarctic ice shelves have now ceased. An 18% loss of thickness occurred for some ice shelves in the Amundsen and Bellingshausen regions in less than two decades. The authors state that *'If the present climate forcing is sustained, we expect a drastic reduction in volume of the rapidly thinning ice shelves at decadal to century time scales, resulting in grounding-line retreat and potential ice-shelf collapse. Both of these processes further accelerate the loss of buttressing, with consequent increase of grounded-ice discharge and sea-level rise*'. A study in the Amundsen Sea Embayment of West Antarctica examined ice loss using four different methods. From 1992-2013, the ice mass loss was 83±5 Gt/yr, with the rate accelerating at 6.1±0.7 Gt/yr, but between 2003-11, the mass loss was 102±10 Gt/yr with an acceleration of 15.7±4.0 Gt/yr. Thus the rate of ice loss was not only accelerating, but the rate of acceleration was increasing. The authors conclude that '*The comprehensive record, evaluated from multiple techniques, of mass loss in West Antarctica, produced here shows a tripling in mass loss in recent years*'. In eastern Antarctica the situation is also pessimistic. Surveys over the Totten glacier (90x22 miles) found two undersea troughs beneath the ice shelf, allowing warm, saline deep water to flow under the glacier and exacerbate the rate of melting and glacier flow. The Totten glacier holds back a catchment of ice that, if it were to flow into the sea, would on its own create a 3.5m rise in sea level. The glacier is currently losing 150km^3 of ice each year. A fourth study modelled ice loss patterns in the Antarctic assuming that carbon dioxide levels were returned to pre-industrial levels. The pattern of warming and heat uptake by Southern Ocean waters initially causes a slight recovery of ice extent, but then convection brings stored heat to the surface and causes '*a substantial loss of sea ice*'. This lost ice does not recover even after 150 years at atmospheric carbon dioxide concentrations reduced to pre-industrial levels.

(SOURCES: Paolo, F.S., Fricker, H.A. and Padman, L. 2015. Volume loss from Antarctic ice shelves is accelerating. *Science* 348: 327-331; Sutterley, T.C., Velicogna, I., Rignot, E., Jeremie Mouginot, J., Flament, T., van den Broeke, M.R., vanWessem, J.M. and Reijmer, C.H. 2014. Mass loss of the Amundsen Sea Embayment of West Antarctica from four independent techniques. *Geophys. Res. Lett* 41: 8,421-8,428; Greenbaum, J.S., Blankenship, D.D., Young, D.A., Richter, T.G., Roberts, J.L., Aitken, A.R.A., Legresy, B., Schroeder, D.M., Warner, R.C., van Ommen, T.D., and Siegert, M.J. 2015. Ocean access to a cavity beneath Totten Glacier in East Antarctica. *Nat. Geosci.* 8: 294-298; Ridley, J.K. and Hewitt, H.T. 2014. A mechanism for lack of sea ice reversibility in the Southern Ocean. *Geophys. Res. Lett* 41: 8,404-8,410.)

ANTARCTIC ICE SHEETS MORE VULNERABLE THAN PREVIOUSLY THOUGHT

A three-dimensional modelling exercise has found that Antarctica's ice sheets may be more vulnerable to warming than previously thought. There are two new ways by which ice sheets might collapse: meltwater and rain can drain into crevasses in the ice, leading to vertical fractures, and/or the top of the sheets can break apart, leading to sheet collapse. The West Antarctic Ice Sheet could collapse much faster than previously predicted (in decades rather than centuries).

(SOURCE: Pollard, D., DeConto R.M. and Alley R.B. 2015. Potential Antarctic Ice Sheet retreat driven by hydrofracturing and ice cliff failure. *Earth Planet. Sci. Lett.* 412: 112-121.)

ARCTIC SEA ICE IS WARMING FROM BELOW - AN EFFECT THAT WILL INCREASE AS ICE IS LOST

Water temperatures measured at different depths and areas across the Arctic Ocean indicated that heat rose more quickly from areas above uneven areas of the seabed versus flatter seafloor. This rising of heat from certain locations could warm Arctic sea ice more quickly and result in even greater sea ice loss than expected. Shrinking Arctic sea ice would promote mixing, these warm water mixing hotspots would increase, and further melting would occur.

(SOURCE: Rippeth, T.P., Lincoln, B.J., Lenn, Y.-D., Mattias Green, J.A., Sundfjord, A. and Bacon, S. 2015. Tide-mediated warming of Arctic halocline by Atlantic heat fluxes over rough topography. *Nat. Geosci.* 8: 191-194.)

WIND PATTERNS AND WARM WATER UPWELLING EXACERBATE ICE SHELF LOSS IN ANTARCTICA

Hydrographic ocean data collected since 1975 show that, over the past 40 years, Circumpolar Deep Water (CDW) has warmed in all sectors around Antarctica. As a result, water flowing under Antarctic ice shelves has warmed in recent decades. Winds at the continental shelf break may also add to this process. This warm water is effectively melting the underside of ice sheets, undermining them and causing them to break up. In parts of Antarctica where warming and ice loss are occurring, CDW slopes upward to the shelf break, possibly as the result of wind-induced upwelling. In the Ross and Weddell Seas, where there is less shelf warming, CDW flows downwards, again possibly due to wind patterns. Thus, Antarctic winds can play a major role in promoting ice loss. Increased atmospheric warming and ozone depletion will probably intensify these winds. Future changes in wind patterns could, moreover, also subject the Ross and Weddell Seas to warm-water upwelling. The authors note that marine megafauna may have already experienced these warmer waters, notably in the Bellingshausen and Amundsen Seas, concluding that this warming will '*lead to irreversible retreat of a portion of the West Antarctic Ice Sheet, which will have an impact on global sea level*'.

(SOURCE: Schmidtko, S., Heywood, K.J., Thompson, A.F., Aoki, S. 2014. Multidecadal warming of Antarctic waters. *Nature* 346: 1,227-1,231.)

UNPRECEDENTED RATES OF CLIMATE CHANGE REPORTED

One of the concerns about observed climate change is its rapid rate and how that reduces the ability of ecosystems and human societies to adapt. The strong rate of increase was confirmed in a study that found that trends in greenhouse-gas and aerosol emissions are causing rates of change that '*are unprecedented for at least the past 1,000 years*'. In particular, regional rates of change in Europe, North America and the Arctic are higher than the global average. The authors caution that '*the world is now entering a regime where background rates of climate change will be well above historical averages until at least*

mid-century' and '*The accelerated rates of change noted here mean that impacts related to rates of change will intensify over the coming decades*'.

(SOURCE: Smith, S.J., Edmonds, J., Hartin, C.A., Mundra, A. and Calvin, K. 2015. Near-term acceleration in the rate of temperature change. *Nat. Clim. Change* 5: 333-336.)

EXTINCTION RISK FROM CLIMATE CHANGE

A model estimating extinction rates from climate change predicted that the amount of climate change that has already occurred will ultimately cause 2.8% of species to go extinct. The international policy target of limiting global warming at present to 2°C will lead to 5.2% of species going extinct. However, current estimates predict that this policy target will be greatly exceeded. A 3°C level of warming will lead to 8.5% of species going extinct, and if the current 'business-as-usual' level of emissions is not reduced, it will lead to a 4.3°C rise and a 16% extinction rate. Extinction risks were highest in South America, Australia, and New Zealand and did not vary by taxonomic group. The author states '*Extinction risks from climate change are expected not only to increase but to accelerate for every degree rise in global temperatures. The signal of climate change-induced extinctions will become increasingly apparent if we do not act now to limit future climate change*'.

(SOURCE: Urban, M.C. 2015. Accelerating extinction risk from climate change. *Science* 348: 571-573.)

LOSS OF ARCTIC SNOWPACK AND RECORD LOW LEVEL OF WINTER SEA ICE

Spring snow depth in the Arctic was measured between 2009 and 2013 by airborne radar surveys and ground-truthed with surface measurements. These data were compared to 1954-91 data from Soviet ice stations. Snow thickness had decreased by 37% in the western Arctic and by 56% in the Beaufort and Chukchi Seas. The lack of snow was considered to be due to later formation of Arctic sea ice, which reduces snow accumulation. As sea ice starts forming later each autumn, there is less time for snow to accumulate before winter sets in. In a second report, the National Snow and Ice Data Center wrote that the Arctic winter sea ice extent in February 2015 was the lowest since satellite measurements of the Arctic began in the 1970s: 50,200 miles^2 less than the previous record low in 2011.

(SOURCES: Webster, M.A., Rigor, I.G., Nghiem, S.V., Kurtz, N.T., Farrell, S.L., Perovich, D.K., and Sturm, M. 2014. Interdecadal changes in snow depth on Arctic sea ice. *J. Geophys. Res.: Oceans* 119: 5,395-5,406; Mooney, C. 2015. Arctic sea ice hit new low, data shows. *Wash. Post,* 20 March 2015: A3.)

Noise impacts

RESPONSES OF DOLPHINS TO MID-FREQUENCY NAVAL SONAR

Responses of dolphins to mid-frequency active (MFA) sonar were recorded in the Southern California Bight from 2004 through 2008. Fifteen groups of common dolphins (five short-beaked, ten *Delphinus* sp.), nine Pacific white-sided dolphin groups, and two bottlenose dolphin groups displayed responses, including cessation or changes in vocalization rates, changes in behavioural state or direction of travel. Interestingly, 46% of groups not exposed to sonar also changed their behaviour, whereas 43% of focal groups exposed to sonar did not. Vocalisation intensity began to increase at peak sound pressure levels of 113.6 dB re: 1 µPa; behavioural changed began at values of 121.3 dB re: 1µPa. Vocalizations began to cease at peak sound pressure levels of 123 dB re: 1µPa (or 107-117 dB rms re: 1µPa). The authors note a caveat: '*it is possible that more subtle behavioural responses occurred that were not recorded, and so this analysis could have underestimated the level of response*'. They suggested that '*lack of response in some cases may indicate a tolerance of or habituation to MFA sonar by local populations*', although they note that some responses occurred at lower received levels and some animals might be more sensitive to sonar. Behavioural responses by dolphins could occur when '*the MFA sonar source could be up to or greater than 100km away*'. The authors also note that '*at sonar received levels over about 147 dB Peak re: 1 µPa, dolphins were no longer present; this could indicate some avoidance of the area and would represent an additional behavioural response*'.

(SOURCE: Henderson, E.E., Smith, M.H., Gassmann, M., Wiggins, S.M., Douglas, A.B. and Hildebrand, J.A. 2014. Delphinid behavioral responses to incidental mid-frequency active sonar. *J. Acoust. Soc. Amer.* 136: 2003-2014.)

BAIRD'S BEAKED WHALE RESPONSES TO SIMULATED SONAR AT LOW RECEIVED LEVELS

A controlled exposure to simulated mid-frequency active sonar (at 3.5-4 kHz) was conducted on a tagged Baird's beaked whale - the first time the response of this species has been recorded. Within three minutes of sonar exposure onset, the tagged whale increased its swim speed and body movement and showed '*unusual dive behavior for each of its next three dives*'. The animal responded at a received level of 127 dB re: 1µPa. The researchers conclude that for Baird's beaked whales there is '*evidence of avoidance responses at relatively low received levels compared to those for many other species*'.

(SOURCE: Stimpert. A.K., Deruiter, S.L., Southall, B.L., Moretti, D.J., Falcone, E.A., Goldbogen, J.A., Friedlaender, A., Schorr, G.S, and Calambokidis, J. 2014. Acoustic and foraging behavior of a Baird's beaked whale, *Berardius bairdii*, exposed to simulated sonar. *Scient. Rep.* 4(7031). 8pp.)

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GLOSSARY OF TERMS

Aerosol: A suspension of solid or liquid particles in a gas; includes both the particles and the suspending gas, which is usually air.

Anoxia: Absence of oxygen.

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

Bioaccumulation: When a pollutant increases in concentration from the environment to the first and subsequent organisms in a food chain. Pollutant levels in top predators are highest.

Bioavailability: Quantity or fraction of an ingested dose that is absorbed.
Biomagnification: Increase in concentration of a pollutant within an organism compared to background levels in its diet.
Bivalve: A class of marine and freshwater molluscs that have laterally compressed bodies enclosed by a shell consisting of two hinged parts.
Brevetoxin: A class of dangerous neurotoxins produced during blooms (red tides) of certain algae.
Butyltins: A class of toxic chemicals commonly used in anti-fouling paints on ship hulls (as tributyltin or dibutyltin, a break-down product of tributyltin).
Capture-recapture modelling: Also called mark-recapture. A method of estimating a population's size by capturing, marking and releasing a sample of that population and then later recapturing another sample and counting the number of marked individuals within the sample.
Carcinogenicity: Ability or tendency to produce cancer.
Data logger: An electronic device that records data over time or across locations.
dB: Decibel - a logarithmic measure of sound pressure level.
DDD: The organochlorine dichlorodiphenyldichloroethane, a breakdown product of the pesticide DDT.
DDE: The organochlorine dichlorodiphenyldichloroethylene, a breakdown product of the pesticide DDT.
DDT: The organochlorine pesticide dichlorodiphenyltrichloroethane, which tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.
Dead zone: Areas of hypoxia and eutrophication.
Defaunation: The loss of wildlife from ecological communities.
Echinoids: Seastars and sea urchins.
Euphausiid: Of the family Euphausiidae, to which krill belong (may also include the single species found in the family Bentheuphausiidae).
Eutrophication: Input of nutrients into an aquatic system, typically associated with excessive plant growth and oxygen depletion.
FAO: Food and Agriculture Organisation of the UN.
Gastropods: Snails
Gyre: Large system of rotating ocean currents.
HBCD: Hexabromocyclododecane, a brominated flame retardant.
HCH: Hexachlorocyclohexane, a polyhalogenated compound.
Hypoxia: Low levels of dissolved oxygen.
Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1,000 Hertz).
IMO: International Maritime Organisation.
IPIECA: The global oil and gas industry association for environmental and social issues.
IUCN: International Union for Conservation of Nature.
Lipid weight: A basis of measurement whereby concentrations of a substance are compared to the lipid (fat) content of a material.
Lipophilic: Capable of dissolving in lipids (fats); having an affinity for lipids.
Marginal sea: A smaller sea on the boundary of a larger one.
µPa: Micropascal, a unit of pressure.
Microplastics: Plastic particles 0.3-5mm in diameter, often the result of larger plastic pieces breaking down over time.
Minamata disease: A group of physical and physiological symptoms arising from mercury poisoning.
Mirex: A synthetic organochlorine insecticide, typically used against ants.
MPA: Marine Protected Area.
Mutagenicity: Ability or capability of producing genetic mutations.
NP: Nonylphenol, a group of organic compounds typically used in manufacturing, among other things, antioxidants, lubricating oil additives, and detergents.
OCP: Organochlorine pesticide.
OMZ: Oxygen minimum zone.
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.
PCB: Polychlorinated biphenyls.
PBDE: Polybrominated dipheyl ether.
Pelagic: Of or related to the open ocean.
Perfluorinated compounds: A class of environmentally persistent molecules with fluorine atoms attached, used in many industrial applications including fire-fighting foams, pesticides and surface coatings.
Phytoplankton: Free-floating marine plants (versus zooplankton - free-floating marine animals).
Polyethylene, polypropylene, polyvinyl chloride: Plastics.
POPs: Persistent organic pollutants, organic compounds that are resistant to degradation and thus persist in the environment.
ppm: Parts per million
Pteropod: Specialised free-swimming pelagic sea snails and sea slugs.
Scleractinian corals: Stony corals or hard corals.
Stratification: Layering that occurs in most sedimentary rocks and in those igneous rocks formed at the earth's surface.
T-PODs: **T**iming **PO**rpoise **D**etector, an electronic device to record cetacean echolocation clicks.
Trammel nets: Gill nets with three layers of netting tied together on a common floatline and common leadline, used to catch a wide variety of fishes.
Wet weight: A basis of measurement whereby concentrations of a substance are calculated without the water being removed.
WHO: World Health Organisation.
Zooplankton: Free-floating marine animals.

Species glossary

Baird's beaked whale	*Berardius bairdii*
Blue whale	*Balaenoptera musculus*
Bryde's whale	*Balaenoptera edeni*
Bowhead whale	*Balaena mysticetus*
Burrunan dolphin	*Tursiops australis*
Common bottlenose dolphins	*Tursiops truncatus*
Finless porpoise	*Neophocaena phocaenoides*
Fraser's dolphin	*Lagenodelphis hosei*
Harbour porpoise	*Phocoena phocoena*
Hector's dolphin	*Cephalorhynchus hectori*
Humpback whale	*Megaptera novaeangliae*
Indo-Pacific humpbacked dolphin	*Sousa chinensis*
Killer whale	*Orcinus orca*
Long-beaked common dolphin	*Delphinus capensis*
Maui's dolphin	*Cephalorhynchus hectori maui*
Minke whale	*Balaenoptera acutorostrata*
Narwhal	*Monodon monoceros*
Pacific white-sided dolphin	*Lagenorhynchus* obliquidens
Pantropical spotted dolphins	*Stenella attenuata*
Risso's dolphin	*Grampus griseus*
Short-beaked common dolphin	*Delphinus delphis*
Sperm whale	*Physeter macrocephalus*
Acrobat ant	*Crematogaster pilosa*
Brown pelican	*Pelecanus occidenatlis*
Eastern oyster	*Crassostrea virginica*
Gulf killifish	*Fundulus grandis*
Hatchetfishes	*Polyipnus* spp.
Marsh periwinkle	*Littoraria irrorata*
Seaside sparrow	*Ammodramus maritimus*
Short-tailed shearwaters	*Puffinus tenuirostris*
Yellowtail fish	*Seriola lalandi*