

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2014

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INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 and 1998-5, directed the Scientific Committee (SC) to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 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 (SC/55/E7) 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 2014 SOCER focuses on the **Atlantic Ocean**, summarising key papers and articles published from ca. 2012 through 2014 to date.

ATLANTIC OCEAN

General

World's first large marine ecosystem legal framework

One trend in improving the state of the oceans is attempting to incorporate ever larger regions into conservation and management schemes. Angola, Namibia and South Africa have signed the Benguela Current Convention, which aims to promote the conservation and sustainable use of the Benguela Current Large Marine Ecosystem, one of the richest ecosystems on earth. This Southern Atlantic cold-water current flows northward along the west coast of Africa. This cross-national agreement was supported by the United Nations Development Programme and the Global Environment Facility. Such large-scale approaches have the potential to provide the greatest benefits, including for highly migratory species such as cetaceans.

(SOURCE: News. 2013. *Mar. Pollut. Bull.* 71: 3)

Dredging operations linked for the first time to behavioural changes in a dolphin population

This study is the first to conclusively link dredging operations to a measurable behavioural response in a marine predator. The bottlenose dolphin population along the north-eastern coast of Scotland has experienced a range expansion, whereby Aberdeen Harbour has progressively become a foraging area. Nonetheless, higher intensities of dredging have caused the dolphins to spend less time in the harbour, even though there was already a high baseline level of anthropogenic disturbance there. As opposed to the habituation to some other stressors, the lack of any change in tolerance to dredging might be explained by the irregular nature of the disturbance. Currently 1481 dredging vessels are operating worldwide, a capacity increase of 75% since 2000: this reflects the need to accommodate rising levels of shipping and offshore energy exploitation in cetacean management.

(SOURCE: Pirota, E., *et al.* 2013. Dredging displaces bottlenose dolphins from an urbanised foraging patch. *Mar. Pollut. Bull.* 74: 396-402)

Link between decreasing prey, decreasing body condition and decreasing reproductive rate in baleen whales

An analysis on the effect of linkages between prey availability, body condition and reproductive rates was conducted for North Atlantic fin whales. As prey abundance declined, blubber thickness declined, and pregnancy rates in breeding age females similarly declined, suggesting a link between food availability and reproductive rate. This study has important repercussions for the impacts of a variety of stressors such as a prey decline due to overfishing, climate change or pollution, or disruption of feeding behaviour by disturbance from noise-producing activities or boat traffic, which could ultimately lead to a decline in reproductive rates and therefore effect the recovery of baleen whale populations. This study gives important evidence to a link that had been previously been postulated.

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(SOURCE: Williams, R., *et al.* 2013. Evidence for density-dependent changes in body condition and pregnancy rate of North Atlantic fin whales over four decades of varying environmental conditions. *ICES J Mar. Sci.* 70: 1273-1280)

Habitat degradation

General

Water quality in European waters assessed by remote sensing

Determining water quality is important for marine ecosystems, their inhabitants, and the human population. In Europe, the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) have been approved, the goal being to achieve a 'good' surface water status by 2015. This study used satellite imagery to develop a tool to better estimate the sea surface chlorophyll-*a* within coastal waters of Spain from 2005-2010. This approach helped estimate this parameter with a frequency 40 times higher when compared to field sampling and revealed that the water body showed a high quality status. The authors consider this to be a powerful tool to efficiently evaluate waters within the EEZs of European countries.

(SOURCE: Novoa, S., *et al.* 2012. Water quality assessment using satellite-derived chlorophyll-*a* within the European directives, in the southeastern Bay of Biscay. *Mar. Pollut. Bull.* 64: 739-750)

Decreased harbour porpoise abundance around wind farm shows slight recovery over time

The Nysted Offshore Wind Farm was built in the Danish western Baltic Sea in 2001, and at the time was the largest offshore wind farm in the world, with 72 2.3MW turbines. The impact of the wind farm on harbour porpoises was investigated by examining distribution via acoustic monitoring over a 10-year period. Researchers found that the "results show that [harbour porpoise] echolocation activity declined in Nysted Offshore Wind Farm after the baseline in 2001–2...and has not fully recovered yet", but the impact of the wind farm on porpoises "is gradually diminishing", with an increase in numbers, from 11% of the baseline level immediately after construction to 29% of the baseline 10 years later, which they attribute to habituation, reduced fishing effort in the wind farm area, and possibly an artificial reef effect of the turbine platforms.

(SOURCE: Teilmann, J. and Carstensen, J. 2012. Negative long term effects on harbour porpoises from a large scale offshore wind farm in the Baltic – evidence of slow recovery. *Environ. Res. Ltrs.* 7: doi:10.1088/1748-9326/7/4/045101)

Fisheries interactions

Bottlenose dolphins interact with fishery gear in Florida

Most of the fishery-related bottlenose dolphin strandings in Florida involved hook and line gear (as opposed to trap pot gear and fishing nets). Total fishery gear cases increased over time (1997-2009). Adult male individuals had a greater number of interactions than expected, related to their higher tendency to engage in unnatural foraging behaviours such as depredation and scavenging. These behaviours are probably reinforced due to the overlap between popular recreational fishing spots and prime feeding habitat for dolphins. Such studies are crucial for improving conservation and management efforts.

(SOURCE: Adimey, N.M., *et al.* 2014. Fishery gear interactions from stranded bottlenose dolphins, Florida manatees and sea turtles in Florida, U.S.A. *Mar. Pollut. Bull.* 80: in press. <http://dx.doi.org/10.1016/j.marpolbul.2014.02.008>)

Marine Debris

Microplastics abundant in the Atlantic

Microplastics represent marine debris at the smallest scale, either the degradation products of large plastic items or the small 'plastic pellets' that provide the raw material for producing plastic items. An examination of 125 beaches on three islands in the North Atlantic Canary current revealed enormous concentrations, reaching 100g of plastic per litre of sediment. These beaches are in highly protected natural areas, demonstrating that this material is brought from distant coasts and the open ocean. All microplastics on shorelines spent time in coastal and open water habitats, and evidence is mounting that these particles and the toxic compounds that adhere to them are taken up by marine organisms, including those at the top of the food chain such as cetaceans.

(SOURCE: Baztan, J., *et al.* 2014. Protected areas in the Atlantic facing the hazards of micro-plastic pollution: First diagnosis of three islands in the Canary Current. *Mar. Pollut. Bull.* 80: 302-311)

Computer-generated mapping tools improve removal of derelict fishing gear

Lost and discarded fishing gear poses a threat to marine habitats and their inhabitants, including cetaceans. Removal of such gear has become a major management issue. In Biscayne National Park, Florida, lobster trap debris 'hot spot' maps were created that combine remotely sensed data on habitat type and depth with previous locations of debris collection. This GIS-based approach effectively reduced the search area by 95%. An expanded system incorporating water currents, locations of known fishing effort and distance from port could further improve such efforts and would be a promising approach elsewhere where the relationship between fishing effort, debris occurrence and entanglement risk have been established.

(SOURCE: Martens, J. and Huntington, B.E. 2012. Creating a GIS-based model of marine debris "hot spots" to improve efficiency of a lobster trap debris removal program. *Mar. Pollut. Bull.* 64: 949-955)

Riverine input of litter into the North Sea: case study Thames River

The input of litter into the sea by rivers is considered to be a major source of marine debris. The Port Authority of London, for example removes about 250 tons of debris and rubbish each year from the Thames – a major input route into the North Sea – using purpose-built vessels and special debris collectors. This study deployed various types of bottom nets to collect submerged debris. Most was plastic and amounts were highest near sewage treatment works. Many items were sanitary products not designed to be disposed via lavatories, calling for a change in consumer behaviour and for applying pressure on manufacturers of such products to improve their biodegradability. The results underline that, beyond visible debris floating on the surface, consideration must also be given to submerged items reaching the sea via rivers.

(SOURCE: Morritt, D., Stefanoudis, P.V., Pearce, D., Crimmen, O.A., and Clark, P.F. 2014. Plastic in the Thames: A river runs through it. *Mar. Pollut. Bull.* 78: 196-200)

South Atlantic Ocean 'garbage patch' detected

Plastic and other marine debris have been recognized as a severe marine pollution problem, and the IWC has recently highlighted the ingestion and entanglement threat posed to cetaceans by marine litter. This study demonstrated that floating debris is accumulating along the margins of the South Atlantic Gyre as far south as 34-35°S. Almost all the litter (97%) was composed of plastic, and in most cases litter far outnumbered floating seaweeds. The author speculate there are even higher densities of litter in the core of the gyre.

(SOURCE: Ryan, P.G. 2014. Litter survey detects the South Atlantic 'garbage patch'. *Mar. Pollut. Bull.* 79: 220-224)

Ship strikes

Rules to reduce collisions with right whales along US Atlantic coast to be made permanent

The US National Oceanic and Atmospheric Administration (NOAA) has taken steps to permanently implement the temporary rules (expiration date December 2013) governing ship traffic in areas containing North Atlantic right whales along the Atlantic coast of the United States. The rules specify reduced speeds (10 knots or less) of vessels longer than 65 feet during certain times of the year between Maine and Florida. These rules have significantly reduced collisions between ships and whales since 2008. Compliance has been good, although three large commercial vessels were fined for violations in late 2011. The 450 right whales in the Northwest Atlantic are among the most endangered animals in the world.

(SOURCE: News. 2013. *Mar. Pollut. Bull.* 72: 4-5; News. 2012. *Mar. Pollut. Bull.* 64: 460)

Chemical pollution

Perfluorinated compounds in bottlenose dolphins

Perfluorinated compounds (PFCs) are used as surface coatings and are a focus of interest in pollution studies due to their persistence, bioaccumulation and global distribution. The blood plasma of bottlenose dolphin populations from two US southeast Atlantic sites was examined. Dolphins from the Charleston, South Carolina, site had some of the highest PFC levels reported in marine mammals (same order of magnitude as occupationally exposed humans). Importantly, the highest values were found in juveniles (significantly higher than in adult males and females). Such high levels during rapid growth and development may involve greater health risks and are probably due to PFC transfer from the mother by milk and by prey consumed during early years. This class of pollutants is known to contain endocrine disruptors, tumour promoters and immunosuppressors.

(SOURCE: Fair, P.A., *et al.* 2012. Assessment of perfluorinated compounds (PFCs) in plasma of bottlenose dolphins from two southeast US estuarine areas: Relationship with age, sex and geographic locations. *Mar. Pollut. Bull.* 64: 66-74)

High persistent organic pollutant levels in East Atlantic common dolphins

Blubber samples were analysed for POPs from 42 female short-beaked common dolphins that were taken as bycatch between 1992 and 2006 by fisheries operating off the southwest coast of the U.K. At least 1000 common dolphins are taken as bycatch each year here. Seventy-two percent of the examined individuals had PCB concentrations above an established toxicity threshold (17 mg kg⁻¹ lipid weight), and the dolphins from UK waters “represented the upper end of the concentrations reported” in the literature. These elevated PCB levels are a cause for concern regarding potential risk of death due to infectious diseases. The levels are expected to be even higher in males, which cannot offload such contaminants to their offspring as breeding females do.

(SOURCE: Law, R.J., *et al.* 2013. Organochlorine pesticides and chlorobiphenyls in the blubber of bycaught female common dolphins from England and Wales from 1992-2006. *Mar. Pollut. Bull.* 69 (1-2): 238-242)

Ban of tributyltin has proven to be effective in UK waters

Tributyltin (TBT) is a toxic compound used as an additive to antifouling paints for boat hulls. After EU and IMO initiatives, it was banned in 2003 (with complete prohibition on ship hulls phased in through 2008 due to painting intervals). This study shows that 1) the TBT concentrations have declined in harbour porpoises and 2) the percentage of porpoises in which TBT was detected has declined (from 100% in the 1990s to 4.3% in 2009). The authors conclude that “the ban has proven to be effective in reducing inputs to the seas from vessels”. Similar trends have been documented in other ‘legacy’ pollutants such as organochlorine pesticides and certain flame retardants, but not for PCBs (due to continuing diffuse inputs and the large reservoir already present in the environment).

(SOURCE: Law, R.J., *et al.* 2012. Butyltin compounds in liver of harbour porpoises (*Phocoena phocoena*) from the UK prior to and following the ban on the use of tributyltin in antifouling paints (1992-2005 and 2009). *Mar. Pollut. Bull.* 64: 2576-2580)

DDT levels declining

The analysis of the pesticide DDT and its breakdown products (DDD and DDE) in thousands of bivalve samples taken from coastal water of the United States revealed that average concentrations were declining along both the West and East Coast. The highest values in Atlantic waters were in Delaware and the Hudson/Raritan Estuary; in the Gulf of Mexico in Alabama and northwestern Florida. Values are declining with an environmental half-life between 10 and 14 years and are expected to drop to below 10% of today’s concentrations by 2050. This indicates that this pollutant is slowly disappearing from environments where no new production or inputs occur. Unfortunately, the use of this pesticide is not banned worldwide. This pollutant is subject to bioaccumulation and is therefore found in relatively high amounts in top marine predators such as cetaceans.

(SOURCE: Sericano, J.L., Wade, T.L., Sweet, S.T., Ramirez, J., and Lauenstein, G.G. 2014. Temporal trends and spatial distribution of DDT in bivalves from the coastal marine environments of the continental United States, 1986-2009. *Mar. Pollut. Bull.* 80: in press. <http://dx.doi.org/10.1016/j.marpolbul.2013.12.049>)

Disease and mortality events

General

Cause of death in one-third of stranded cetaceans on the Canary Islands is anthropogenic

An examination of 233 stranded cetaceans from 19 species in the Canary Islands, Northeast Atlantic, revealed that the cause of death in one-third of the cases was anthropogenic. The most common causes of death were fishery interactions (bycatch), ship collisions (particularly in sperm whales), atypical mass strandings linked to naval exercises (beaked whales), ingestion or entrapment by marine debris, and anthropogenic-related pathology. The most important non-anthropogenic causes of death were starvation and a range of infectious and non-infectious diseases. This highlights the many threats facing cetaceans and provides valuable input for cetacean conservation and management efforts here.

(SOURCE: Arbelo, M., *et al.* 2013. Pathology and causes of death of stranded cetaceans in the Canary Islands (1999-2005). *Dis. Aquat. Org.* 103: 87-99, doi: 10.3354/dao02558)

Oil spills

Deepwater Horizon spill impacts dolphin health

Bottlenose dolphins in Barataria Bay, Louisiana, are showing several disease conditions that are uncommon and consistent with petroleum hydrocarbon exposure. This bay in the Gulf of Mexico received heavy and prolonged oiling related to the *Deepwater Horizon* incident. The 29 dolphins examined showed evidence of adrenal toxicity and were five times more likely to have moderate to severe lung disease. Almost half of the animals were given a guarded or worse prognosis, with 17% of these not expected to survive. A comparable but unexposed population in Sarasota Bay, Florida, showed a significantly lower prevalence and severity of symptoms. Mortalities in Barataria Bay are considered to be part of an ongoing Unusual Mortality Event (UME) covering the northern Gulf of Mexico and encompassing 1051 cetacean strandings since early November 2013.

(SOURCE: Schwacke, L.H., *et al.* 2014. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the *Deepwater Horizon* oil spill. *Environ. Sci. Tech.* 48: 93-103)

Disease

Novel morbillivirus in South Atlantic dolphin

Although major morbillivirus outbreaks and mortalities have been reported in cetaceans from the Northern Hemisphere, only one fatal case, in a bottlenose dolphin, has been reported in the Southern Hemisphere (southwest Pacific Ocean). This is the first reported case in the South Atlantic, affecting the coastal and estuarine Guiana dolphin. The stranded female calf contained a novel strain of morbillivirus. Accordingly, morbillivirus infection is extant in Guiana dolphins in Brazil and dolphin calves are susceptible.

(SOURCE: Groch, K.R., *et al.* 2014. Novel cetacean morbillivirus in Guiana dolphin, Brazil. *Emerg. Infect. Dis.* 20: 511-513)

Brucella infection found in harbour porpoise stranded on Belgian coast

The bacterium *Brucella ceti* was found in a stranded adult female harbour porpoise on the Belgian coast. The necropsy revealed the bacterium in multiple organs, a recent pregnancy and the possibility of a spontaneous abortion. *Brucella* is known to cause abortions in terrestrial animals and could therefore also affect reproduction in cetaceans. The results also point to potential vertical and horizontal transmission to new-borns. The authors also emphasize the health risk posed to humans of contracting this disease by handling infected cetaceans in the framework of, *e.g.*, strandings, bycatches, rehabilitation centres.

(SOURCE: Jauniaux, T.P., *et al.* 2010. *Brucella ceti* infection in harbor porpoise (*Phocoena phocoena*). *Emerging Infectious Diseases* 16: 1966-1968)

Morbillivirus in an Atlantic dolphin closely related to virus in Mediterranean dolphins

A morbillivirus detected in a live-stranded juvenile bottlenose dolphin in the Canary Islands, eastern North Atlantic Ocean, is nearly identical to the morbillivirus reported in striped dolphins in the Mediterranean Sea. This supports the hypothesis that transmission occurs between species and shows that the dolphin populations in the Mediterranean and Atlantic are in contact through the Strait of Gibraltar. This information could help clarify the infectious source(s) of the die-off of bottlenose dolphins along the East Coast of the United States in 2013.

(SOURCE: Sierra, E., *et al.* 2014. Fatal systemic morbillivirus infection in bottlenose dolphin, Canary Islands, Spain. *Emerg. Infect. Dis.* 20 (2) <http://dx.doi.org/10.3201/eid2002.131463doi>)

Climate change

Possible impacts of climate change for UK waters

Temperatures in UK waters show an overall upward trend. Changes in primary production are expected throughout UK waters, with southern waters becoming 10% more productive (*e.g.*, the English Channel) and northern regions (*e.g.*, central and northern North Sea) becoming 20% less productive. Shifts of cetacean species have been reported, with various species of dolphins (including white-beaked dolphins, Atlantic white-sided dolphins, short-beaked common dolphins and striped dolphins) moving northwards, and novel stranding of warmer water species being reported for the first time (such as Blainville's beaked whale), suggesting a temperature-change-linked shift for a variety of cetacean species.

(SOURCE: Marine Climate Change Impacts Partnership. 2014. *Report Card 2013*. Marine Climate Change Impacts Partnership. In: Evans, P.G.H. and Bjørge, A. 2013. Impacts of climate change on marine mammals. Marine Climate Change Impacts Partnership: Science Review. Available from: http://www.mccip.org.uk/media/13291/2013arc_backingpapers_15_marm.pdf)

Reduction of ocean circulation in North Atlantic could lead to cooling

Although the Marine Climate Change Impacts Partnership described warming of the waters in the North Atlantic, another study determined that the Atlantic Meridional Overturning Circulation (AMOC) decreased 10-15% since 2004. This study analysed data from floating sensor arrays in the North Atlantic over an eight-year period. If the AMOC is strong, more heat is transferred into the surface waters of the North Atlantic; if weak, less heat is transferred. It was also suggested that the AMOC may have actually declined by 20% or more. Although climate change is likely a factor in weakening ocean circulation, it was suggested that the change is more dramatic than would be expected by climate change alone and that other factors may be involved.

(SOURCE: Robson, J., Hodson, D., Hawkins, E. and Sutton, R. 2014. Atlantic overturning in decline? *Nature Geoscience* 7: 2-3; Smeed, D.A. *et al.* 2013. Observed decline of the Atlantic Meridional Overturning Circulation 2004 to 2012. *Ocean Sci.* 10: 1619-1645)

Noise impacts

Canary Islands: No mass strandings since sonar ban

The Canary Islands have been a hotspot for mass strandings, particularly of beaked whales. These strandings have been attributed to naval exercises, specifically those involving high-intensity sonar. No mass strandings have been reported since the Spanish government imposed a moratorium on naval exercises in these waters in 2004. This demonstrates that prompt political action can result in remarkable conservation success for whales and dolphins.

(SOURCE: Fernandez, A., Arbelo, M., and Martin, V. 2013. No mass strandings since sonar ban. *Nature, Corres.* 497: 317)

Substantial disturbance of German harbour porpoise stock possible during wind farm construction

Aerial surveys in the German North Sea investigated harbour porpoise abundance and seasonal changes in distribution. Porpoises moved into German waters in the spring, became more abundant in the early part of the summer and then apparently move out of German waters in the autumn. The surveys found that there were specific areas where porpoises aggregated, or 'hotspots', in the spring and summer. This distribution was compared with proposed and existing sites for wind farms. The authors proposed that wind farm licences should not be granted for one of the hotspot areas (Sylt Outer Reef) and construction should not occur during the spring for a second (Borkum Reef Ground). Assuming that porpoises were disturbed within 20km of a construction site, it was estimated that as much as "39% of the harbour porpoise stock in the German EEZ could be affected during construction".

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

Military exercises responsible for common dolphin mass stranding in Southwest England

On 9 June 2008, short-beaked common dolphins mass-stranded in Falmouth Bay, Cornwall; at least 26 died. They were well fed, had no signs of algal toxin exposure and had low pollutant levels in tissues. However, five animals had microscopic haemorrhages in the ear. Several potential causes of the stranding were excluded, including "infectious disease, gas/fat embolism, boat strike, bycatch, predator attack, foraging unusually close to shore, chemical or algal toxin exposure, abnormal weather/climatic conditions, and high-intensity acoustic inputs from seismic airgun arrays or natural sources (*e.g.*, earthquakes)." There was, however, a naval exercise on the morning of the mass stranding. The authors suggested that the initial naval exercise drove the pelagic dolphins into the enclosed waters of Falmouth Bay, and then subsequent helicopter activity caused them to strand. The authors concluded "naval activity to be the most probable cause of the Falmouth Bay [mass stranding event]".

(SOURCE: Jepson, P.D., *et al.* 2013. What caused the UK's largest common dolphin (*Delphinus delphis*) mass stranding event? *PLoS ONE* 8(4): e60953. doi:10.1371/journal.pone.0060953)

Acoustic behavioural responses of bottlenose dolphins to shipping in the Sado Estuary, Portugal

The Sado Estuary, Portugal, has a particularly high level of boat traffic. The group size and acoustic and visual behaviour of common bottlenose dolphins resident in this area was monitored and correlated with the presence or

absence of vessels within a 1km radius of dolphin groups. Overall, mean call rates decreased significantly in the presence of boats. Production of creaks (fast click trains) was significantly lower in the presence of ferry boats. Significant differences in dolphin whistle minimum, maximum, and start frequencies were also observed, suggesting vessel traffic is having an impact on communication within this small dolphin population.

(SOURCE: Luís, A.R., Couchinho, M.N. and Santos, M.E. 2014. Changes in the acoustic behavior of resident bottlenose dolphins near operating vessels. *Mar. Mamm. Sci.* in press)

New attempt to tackle underwater noise in a coastal North Atlantic case study

Underwater noise levels have been increasing worldwide and are a recognized threat for cetaceans. This study characterized the noise levels at two sites in Moray Firth, Scotland, an important marine mammal habitat (Special Area of Conservation). It established a pre-development baseline and presented ship noise monitoring methods. These relied partially on shore-based time-lapse footage and on the ship-tracking Automatic Identification System (AIS). By tying the results to EU Marine Strategy Framework Directive indicators, this study shows a way forward in how international regulations can best address the anthropogenic noise issue.

(SOURCE: Merchant, N.D., Pirota, E., Barton, T.R., and Thompson, P.M. 2014. Monitoring ship noise to assess the impact of coastal developments on marine animals. *Mar. Pollut. Bull.* 78: 85-95)

Killer whale response thresholds to sonar lower than predicted by US Navy mitigation measures

Killer whale groups in Norway were exposed to experimentally-controlled military sonar at 1-2 kHz and 6-7 kHz, with the source level increasing and the sonar source in increasing proximity, to determine the threshold at which behavioural changes occurred. Responses occurred between 94 and 164 dB re 1 μ Pa SPL. These response thresholds did not seem to be influenced by sonar frequency or prior exposure to sonar. The mean response threshold was 142 ± 15 dB (SD) re 1 μ Pa SPL. The researchers concluded that the “dose-response functions indicate that some killer whales started to avoid sonar at received [sound levels] below thresholds assumed by the U.S. Navy”. Moreover, the “predicted extent of habitat over which avoidance reactions occur...was large enough to raise concerns about biological consequences to the whales”.

(SOURCE: Miller, P.J.O. *et al.* 2014. Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. *J. Acoust. Soc. Amer.* 135: 975)

Decrease in killer whale abundance linked to naval sonar when prey abundance is low

Monitoring with visual and passive acoustic surveys was conducted before, during and after a naval exercise in Norway and the effect noted on killer whales. Although the main factor that affected killer whale presence was the availability of herring (the whales' main prey species), when herring presence was low, naval sonar activity had a negative impact on killer whale presence.

(SOURCE: Sanna Kuningas, S., Kvadsheim, P.H., Lam, F.P.A. and Miller, P.J.O. 2013. Killer whale presence in relation to naval sonar activity and prey abundance in northern Norway. *ICES J. Mar. Sci.* 70:1287-1293)

GLOBAL

General

Whale-watching disturbance estimated to cause substantial decreases in whale energy intake

Considerable effort is being made to answer how short-term behavioural disturbance in marine mammals, including cetaceans, translates into impacts at the population level. The authors analysed interactions of northern minke whales with whale-watching vessels, combined with a stepwise modelling approach, to estimate energy budgets and the loss of energy intake because normal foraging and diving behaviour ceases or is altered. Whale-watching vessel presence resulted in an estimated overall decrease in energy intake of 42%, due to a decrease in feeding behaviour.

(SOURCE: Christiansen, F., Rasmussen, M.H. and Lusseau, D. 2013. Inferring activity budgets in wild animals to estimate the consequences of disturbances. *Behav. Ecol.* 24: 1415-1425)

Habitat degradation and hunting of large species associated with mammal extinction risk

A review of IUCN Red Listed mammal species to determine what common factors were associated with endangerment determined that “large and widely distributed mammals are affected by combinations of direct exploitation and threats associated with increasing landscape modification that go from logging to intense human land-use.” On the other hand, “small, narrowly distributed species are affected by intensifying levels of landscape

modification but are not directly exploited.” Unsurprisingly the most endangered species were exposed to the greatest number of threats and it was suggested that “extinction risk is associated with the accumulation of external threats.” Habitat loss and degradation were strongly associated with mammal extinction risk, and for large, widely distributed species (*e.g.*, cetaceans), hunting was an additional factor that increased extinction risk.

(SOURCE: González-Suárez, M. and Revilla, E. 2014. Generalized drivers in the mammalian endangerment process. *PLoS ONE* 9(2): e90292. doi:10.1371/journal.pone.0090292)

Yangtze finless porpoise population rapidly declining

The most recent survey conducted in 2012 in the Yangtze River and two adjoining lakes in China showed that the population of this endangered species – the only freshwater finless porpoise in the world – has declined to a mere 1000 individuals. Compared with the 2006 survey, this represents an unsustainable 13.7% rate of annual decline. The species is projected to become extinct as early as 2025. This decline is attributed to human disturbance such as increasing shipping traffic and newly discovered illegal fishing practices, including traps that could affect the porpoises. This trend could be exacerbated by the drastic shrinking of many Yangtze River Basin lakes: from 1950 to 2010, the central and lower reaches of the Yangtze lost approximately two-thirds of their lakes due to increased land reclamation for agriculture and industrial development. Moreover, 32 individuals were found dead in early 2012 in Dongting and Poyang lakes, from electro-fishing, boat propellers, food shortages and poison. The recent extinction of the baiji in the same waters is a wake-up call to take immediate and urgent action. The reputation and reason for existence of national and international cetacean conservation and management organizations, including the IWC, is at stake – as is the conscience and responsibility of humankind toward nature in general.

(SOURCES: News. 2013. *Mar. Pollut. Bull.* 71: 3; News. 2012. *Mar. Pollut. Bull.* 64: 460; News. 2012. *Mar. Pollut. Bull.* 64: 1081)

Vast quantities of dumped military ordnance pose an increasing threat

European countries have dumped more than 1 million tons of munitions in the Irish Sea, 168,000 tons in Danish waters, and 300,000 tons in the North Sea. After World War II, the US and European countries dumped another 300,000 tons of conventional and chemical munitions into the sea. An estimated 150 individual dump sites spread from Iceland to Gibraltar. In the US, more than 400 dump sites are located in the Pacific, Atlantic and Gulf of Mexico. The integrity of this military ordnance, especially of incendiary and chemical weapons, has been compromised after decades in seawater. With our increasing use of the ocean bed for fishing, sand and gravel extraction, offshore oil and wind energy production, diving and so on – coupled with the further deterioration and leakage of toxic substances – this material poses an increasing threat to marine and human life.

(SOURCE: Morton, B. 2013. Bombs away! *Mar. Pollut. Bull.* 73: 1-2)

The global state of the oceans

A special issue of *Marine Pollution Bulletin* was devoted to a synthesis of two workshops held by the International Programme on the State of the Ocean (IPSO; www.stateoftheocean.org) in partnership with the International Union for Conservation of Nature (IUCN; www.iucn.org). The verdict: “[H]uman activities have led to intense multiple stressors acting together in many marine ecosystems. Most notably these are arising from overexploitation of biotic resources, climate change effects forming the so-called ‘deadly trio’ (ocean warming, acidification and hypoxia/anoxia) and pollution.” The authors call for a “rapid adoption of a holistic approach to sustainable management of all activities that impinge on marine ecosystems.” With regard to marine fisheries, several solutions are presented, including addressing the weaknesses and gaps in ocean governance via United Nations General Assembly resolutions. The most ambitious and promising approach is a structural overhaul of the system. This would include creating a new global infrastructure to coordinate, ensure consistency and accountability, and supervise, sanction and enforce. One step would be to create a U.N. Department for Oceans and Law of the Sea, and to negotiate a new agreement under UNCLOS to protect and preserve marine life in areas beyond national jurisdictions.

(SOURCE: Rogers, A.D. (ed.) 2013. The global state of the ocean: interactions between stresses, impacts and some potential solutions. Synthesis papers from the International Programme on the State of the Ocean 2011 and 2012 workshops. *Mar. Pollut. Bull.* 74: 491-551)

Habitat degradation

General

Pollution with faecal pathogens increasing in coastal waters

Much of the world's human population and our domesticated animals live along coastlines. Parasites, bacteria and viruses that are shed in the faeces of humans and animals enter coastal waters through sewage, storm-drains and as run-off. This is making contamination of coastal waters with terrestrially-derived faecal pathogens a chronic and increasingly global pollution problem. This threat is expected to increase as natural coastal habitats become degraded or replaced by human infrastructure. Climate change is also expected to exacerbate this problem, calling for reducing our 'faecal footprint'. This type of contamination has adverse effects on marine wildlife, including marine mammals.

(SOURCE: Shapiro, K. 2012. Climate and coastal habitat change: A recipe for a dirtier ocean. *Mar. Pollut. Bull.* 64: 1079-1080)

Marine Debris

Marine debris: pervasive in the sea and dominating the literature on marine pollution

Marine debris is such an intensifying threat that it is coming to dominate the publications in the field of marine pollution. A review of the literature as it pertains to cetaceans reveals that ingestion of debris has been documented in 48 (56% of) species. Rates of ingestion peaked at 31% in some populations. Debris-induced mortality rates of up to 22% of stranded animals were documented. Plastic constituted most of the debris ingested. There is a high prevalence of debris interactions, and the authors call upon cetacean stranding networks to collect and publish such data on a species level.

(SOURCE: Baulch, S. and Perry, C. 2014. Evaluating the impacts of marine debris on cetaceans. *Mar. Pollut. Bull.* 80: in press. <http://dx.doi.org/10.1016/j.marpolbul.2013.12.050>)

New approaches to detecting lost fishing gear

Derelict fishing gear (DFG) poses a threat to marine ecosystems (and safe navigation). It is a key item in the cetacean entanglement problem and requires a multi-disciplinary approach. A special journal issue was devoted to the early, at-sea detection of such gear, the goal being pre-emptive removal. Three disciplines are addressed: oceanography, remote sensing and marine debris. The main conclusions drawn in these disciplines are that 1) DFG concentrations can be modelled, substantially reducing the search area and improving at-sea detection efficiency; 2) the only known attempt to use unmanned aircraft systems, whose instruments can detect DFG poorly visible to the human eye, proved to be unsuccessful but provided information for future attempts; and 3) marine debris removal is much less costly than the long-term impacts of ghost fishing.

(SOURCE: McElwee, L., Morishige, C. and Donohue, M. (eds.) 2012. At-sea detection of derelict fishing gear. *Mar. Pollut. Bull.* 65: 1-75)

Ship strikes

New method to help detect ship strikes as the cause of death in cetaceans

Recording the number of cetacean deaths due to non-natural causes is an important task at the IWC, and ship strikes are a key recognized threat. Examinations of 13 stranded cetaceans with sharp trauma from ship strikes showed that muscle samples from elsewhere on the carcass (*i.e.*, not at the injury site) also revealed a series of relevant microscopic changes. This histopathological approach provides additional criteria to help determine ship strikes as the cause of death in animals that are in an advanced stage of decomposition or where access to the entire animal is limited.

(SOURCE: Sierra, E., *et al.* 2014. Histopathological muscle findings may be essential for a definitive diagnosis of suspected sharp trauma associated with ship strikes in stranded cetaceans. *PLoS One* 9 (2): 1-8: e88780)

Chemical pollution

Sperm whales used to indicate global lead pollution

Heavy metals, including lead, are a key marine pollutant. Sperm whales were used as an indicator species to assess oceanic lead pollution globally. They are suitable because they are distributed worldwide, long-lived and positioned at the end of the food chain, where higher concentrations are expected due to bioaccumulation. Three hundred and thirty-seven (337) skin biopsies were collected from animals around the world, including 35 from the Atlantic. Lead

concentrations in skin reflect recent exposure because the half-life of lead in soft tissues is only a few weeks or months. This was the first global toxicological dataset for lead in a marine mammal and confirmed that lead is widely distributed, with hotspots in some regions (*e.g.*, Papua New Guinea, Bahamas, Australia). The authors expect lead concentrations in other organs to be higher than that found in skin.

(SOURCE: Savery, L.C., *et al.* 2014. Global assessment of oceanic lead pollution using sperm whales (*Physeter macrocephalus*) as an indicator species. *Mar. Pollut. Bull.* 79: 236-244)

Whale earplug reveals lifetime history of contaminant exposure

In a new approach, an earplug taken from a blue whale killed by a ship strike off Santa Barbara, California, revealed information about the lifetime profiles (*i.e.*, from birth to death) of exposure to organic contaminants (pesticides and flame retardants) and mercury. There was a transfer of contaminants to this whale from its mother early in life and two distinct pulses of mercury contamination. The recognition that earplugs chronologically archive pollutant and hormone levels provides a new approach to measuring environmental stress. In this case, hormone levels revealed a doubling of stress over the animal's lifetime and enabled determination of the time to sexual maturity. Combined with similar studies on earplugs of museum samples, this increases the feasibility of accurately assessing anthropogenic impacts on scales ranging from an individual whale to the marine ecosystem.

(SOURCE: Trumble, S.J., Robinson, E.M., Berman-Kowalewski, M., Potter, C.W., and Usenko, S. 2013. Blue whale earplug reveals lifetime contaminant exposure and hormone profiles. *PNAS* 110: 16922-16926)

Disease and mortality events

Direct exploitation

Human consumption of cetaceans

Based on 900 sources of information, the authors of this study determined that people from at least 114 countries have consumed one or more of at least 87 marine mammal species. These include less well-known species such as the pygmy beaked whale, South Asian river dolphin, narwhal, Chilean dolphin, long-finned pilot whale and Burmeister's porpoise. Overall the historical review reveals an increase in the exploitation of small cetaceans, particularly coastal and estuarine species. Many are caught in conjunction with fishing activities, whereby 'non-targeted-deliberate' acquisition is cause for serious concern. A greater understanding of the underlying motivations is required to design and implement more effective conservation measures, especially because most takes are in countries with little or no assessment of marine mammal populations.

(SOURCE: News. 2012. *Mar. Pollut. Bull.* 64: 459-461; Robards, M.D. and Reeves, R.R. 2011. The global extent of marine mammal consumption by humans: 1970-2009. *Biol. Conserv.* 144: 2770-2786)

Stress

The sublethal effects of capture

A review of marine bycatch papers determined that there were many possible sublethal effects of capture (*i.e.*, bycatch), even if animals are released alive. These include physiological disturbance, behavioural impairment, injury, reflex impairment, and effects on reproduction (such as miscarriages in dolphins), feeding, and growth for animals that survived a fisheries interaction. Some of these sublethal impacts could be short-term (*e.g.*, acute stress response) or could be long-term or even delayed sublethal outcomes (*e.g.*, reduction in growth or reproduction) and are thus "directly fitness-relevant and could have had population-level effects." The authors called for more research into the effects of capture stress on reproduction in particular. They note that to date the sublethal effects of bycatch have mostly been ignored, but they could have major conservation and management repercussions. This could certainly be the case for cetaceans that were captured either accidentally (in active and ghost fishing gear) or deliberately (for research purposes).

(SOURCE: Wilson, S.M., Raby, G.D., Burnett, N.J., Hinch, S.G. and Cooke, S.J. 2014. Looking beyond the mortality of bycatch: sublethal effects of incidental capture on marine animals. *Biological Conservation* 171: 61-72)

Climate change

Climate change predictions for the oceans

The most recent 2014 International Panel for Climate Change (IPCC) report deals with foreseen effects of climate change and allocates a level of confidence to the predictions therein. Many of the predictions are related to the ocean environment. The authors note that "Responding to climate-related risks involves decision-making in a changing

world, with continuing uncertainty about the severity and timing of climate change”, cautioning policy makers that decisions need to be made urgently even when many scientific factors remain uncertain.

(SOURCE: Field, F.B. *et al.* 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. International Panel on Climate Change, Geneva)

Upwelling ceased in Weddell Sea polynya due to climate change

The Weddell Sea polynya, an area of open water the size of New Zealand, is formed by relatively warm salty water being pushed to the surface when passing over a ridge. It keeps the Weddell Sea ice free. Normally, after emitting heat, this upwelling water sinks to become a major source of Antarctic bottom water, and this movement is a major contribution to oceanic circulation. However, the polynya has recently been covered by a layer of low-density freshwater from melting glaciers and increased precipitation. The cessation of this upwelling has reduced the transport of heat, salt and ocean water towards Antarctica, and will greatly impact ocean circulation as well as Antarctic productivity, a major habitat for Southern Hemisphere cetaceans.

(SOURCE: de Lavergne, C., Palter, J.B., Galbraith, E.D., Bernardello, R. and Marinov, I. 2014. Cessation of deep convection in the open Southern Ocean under anthropogenic climate change *Nat. Clim. Change* doi:10.1038/nclimate2132)

Noise impacts

Seismic survey playbacks lead to abnormal development in larvae

The impacts of underwater noise on cetaceans continues to be investigated, but noise impacts on prey and keystone species are less well understood. Recordings of seismic survey pulses were played back to scallop larvae (a component of zooplankton). Larvae exposed to these pulses exhibited significant developmental delays and half (46%) developed body abnormalities. The larvae were exposed to received levels of 160 dB re 1 μ Pa (rms). Accordingly, considering the source levels of seismic survey arrays, the zone of impact for such larvae could be “over hundreds of km-squared assuming spherical spreading of sound” around a seismic survey source. This study suggests that the impact of seismic surveys could extend to ecosystem productivity and larger components of marine ecosystems other than just cetaceans.

(SOURCE: Aguilar De Soto, N. *et al.* 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. *Scient. Reps* 3: 2831; doi:10.1038/srep02831)

Cuvier’s beaked whales respond to mid-frequency naval sonar at levels much lower than assumed

Two tagged Cuvier’s beaked whales were exposed to playbacks of mid-frequency active naval sonar. The sound source started at 160dB re 1 μ Pa when whales were 3.4-9.5 km away, and the source was “ramped up” by 3dB every 25 seconds to 210dB re 1 μ Pa. The whales began to respond at received levels of 89 dB re 1 μ Pa (rms) by ceasing to beat their tail flukes. One animal stopped echolocating, ceased foraging, and swam rapidly away from the source at a received level of 98 dB re 1 μ Pa (rms). The avoidance response lasted for 1.6 hours. The other whale initiated a similar response at a received level of 127 dB re 1 μ Pa (rms), and this response lasted for 1.7 hours, with an unusually deep dive profile lasting 7.6 hours after exposure. The authors noted that “current US management practices assume that significant behavior disruption almost never occurs at exposure levels this low”; therefore, significant impacts to beaked whales could occur at levels lower than previously thought, making current US mitigation guidelines for mid-frequency active sonar ineffective at preventing impacts to whales.

(SOURCE: DeRuiter, S.L., *et al.* 2013. First direct measurements of behavioural responses by Cuvier’s beaked whales to mid-frequency active sonar. *Biol. Lett.* 9(4): 20130223)

Seismic surveys can alter the behaviour of fish and invertebrates

Air guns used in seismic surveys are a major source of anthropogenic noise and are known to affect cetaceans. Experiments involving two species of schooling fish (trevally and pink snapper) and southern reef squid revealed that fish and invertebrates also react to this type of noise. The fish, for example, moved to the bottom and swam faster in more tight groups. The squid showed similar behaviour: alarm responses and changes in swimming patterns and vertical position. Accordingly, consideration should be given not only to the direct effect of air guns on cetaceans, but also indirect effects on their potential prey. The corresponding mitigation techniques need to be developed before beginning a seismic survey.

(SOURCE: Fewtrell, J.L. and McCauley, R.D. 2012. Impact of air gun noise on the behaviour of marine fish and squid. *Mar. Pollut. Bull.* 64: 984-993)

First study to show that baleen whales react to sonar noise

Tagged blue whales in the Southern California Bight showed behavioural responses to mid-frequency (1-10 kHz) sonar sound. Although the sound levels produced in the experiments were orders of magnitude below some military systems, the blue whales responded by stopping feeding, increasing swimming speed, and travelling away from the sound source. This is the first study to show that baleen whales respond to this type of mid-frequency sound, which is known to cause mass strandings of deep-diving toothed whales.

(SOURCE: Goldbogen, J.A., *et al.* 2013. [Blue whales respond to simulated mid-frequency military sonar](http://dx.doi.org/10.1098/rsbl.2013.022378). *Proc. Roy. Soc. B*.280: 20130657. <http://dx.doi.org/10.1098/rsbl.2013.022378>)

International Maritime Organization issues new guidelines for shipping noise

The International Maritime Organization (IMO) recently adopted guidelines to reduce underwater noise from commercial ships – the impact of such noise on cetaceans was a major motivation for these guidelines. Although these guidelines are voluntary, their development is a major step forward in recognising and mitigating underwater noise produced by shipping. They: recognise that shipping noise can have short- and long-term impacts on marine species, especially on cetaceans and other marine mammals; call for monitoring and measurement of shipping noise; note analytical models that could be used to determine effective quieting measures; provide guidance for designing quieter ships; provide further guidance for reducing noise emissions from existing ships, especially by minimising cavitation from ship propellers; and provide advice on shipboard operations that could minimise shipping noise production, *e.g.*, polishing ship propellers to smooth the surface and remove fouling organisms.

(SOURCE: International Maritime Organization's Code on Noise Levels on Board Ships, 2014 edition, available for purchase at <http://www.imo.org/Publications/Documents/Newsletters%20and%20Mailers/Mailers/I817E.PDF>)

How to tell if bubble lesions in stranded cetaceans are from sonar/decompression or decomposition

Gas bubble lesions and emboli have been identified as signs of possible sonar exposure or rapid decompression (*e.g.*, being brought to the surface rapidly after being caught in deep-water nets) in cetacean carcasses. However, it is difficult to tell whether bubbles seen in the tissues of stranded carcasses are from decomposition or emboli/decompression. A review of bubble presence found more gas bubbles in tissues of animals that had rapidly decompressed (due to bycatch) compared to stranded animals. Another analysis of gas in bubbles of test animals found that emboli- and decompression-associated bubbles have similar gas compositions (70-80% nitrogen and 20-30% carbon dioxide). Moreover, bubbles associated with decomposition contain hydrogen, which could be used as an indicator of decomposition-associated bubbles. These are useful diagnostic tools for detecting sources of cetacean mortality from anthropogenic activities.

(SOURCE: de Quirós, Y.B., *et al.* 2013. Differentiation at autopsy between in vivo gas embolism and putrefaction using gas composition analysis. *Inter. J. Legal Med.* 127: 437–445; de Quirós, Y.B., *et al.* 2013. Compositional discrimination of decompression and decomposition gas bubbles in bycaught seals and dolphins. *PLoS ONE* 8(12): e83994. doi:10.1371/journal.pone.0083994)

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Appendix 1

GLOSSARY

Species glossary

Atlantic white-sided dolphin	<i>Lagenorhynchus acutus</i>
Baiji	<i>Lepotes vexillifer</i>
Blue whale	<i>Balaenoptera musculus</i>
Blainville's beaked whale	<i>Mesoplodon densirostris</i>
Burmeister's porpoise	<i>Phocoena spinipinnis</i>
Chilean dolphin	<i>Cephalorhynchus eutropia</i>
Common bottlenose dolphin	<i>Tursiops truncatus</i>
Common dolphin (short-beaked)	<i>Delphinus delphis</i>
Cuvier's beaked whale	<i>Ziphius cavirostris</i>
Guiana dolphin	<i>Sotalia guianensis</i>
Fin whale	<i>Balaenoptera physalus</i>
Finless porpoise	<i>Neophocaena phocaenoides</i>
Harbour porpoise	<i>Phocoena phocoena</i>
Killer whale	<i>Orcinus orca</i>
Long-finned pilot whale	<i>Globicephala melas</i>
Minke whale (northern)	<i>Balaenoptera acutorostrata</i>
North Atlantic right whale	<i>Eubalaena glacialis</i>
Pygmy beaked whale	<i>Mesoplodon peruvianus</i>
South Asian river dolphin	<i>Platanista gangetica</i>
Sperm whale	<i>Physeter macrocephalus</i>
Striped dolphin	<i>Stenella coeruleoalba</i>
White-beaked dolphin	<i>Lagenorhynchus albirostris</i>
Pink snapper	<i>Pagrus auratus</i>
Trevally	<i>Pseudocaranx dentex</i>
Southern reef squid	<i>Sepioteuthis australis</i>

Glossary of terms

AIS: Automatic Identification System.

AMOC: The Atlantic Meridional Overturning Circulation, a major current in the Atlantic Ocean, characterized by a northward flow of warm, salty water in the upper layers of the Atlantic, and a southward flow of colder water in the deep Atlantic.

Anoxia: Absence of oxygen.

Bioaccumulation: When a pollutant increases in concentration from the environment to the first and subsequent organisms in a food chain.

Bivalve: A class of marine and freshwater molluscs that have laterally compressed bodies enclosed by a shell consisting of two hinged parts.

Chlorophyll-a: A specific form of chlorophyll used in photosynthesis, which absorbs most energy from violet-blue and orange-red light. This photosynthetic pigment is essential for photosynthesis in some marine phytoplankton.

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.

Depredation: In ecology, when animals feed on anthropogenically available resources, such as dolphins taking fish on lines or elephants eating crops.

EEZ: Exclusive Economic Zone.

Emboli: Plural of embolus, which is any detached, traveling mass (solid, liquid, or gaseous) in blood vessels that is carried by circulation. Emboli are capable of clogging arteries at a site distant from their point of origin.

Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1000 Hertz).

Hypoxia: Low levels or supply of oxygen.

Indicator species: Species that can provide information on ecological changes and give early warning signals regarding ecosystem processes due to their sensitive reactions to them. They can also be called sentinel species.

IMO: International Maritime Organization.

IPCC: International Panel on Climate Change.

Keystone species: A species with a disproportionately large effect on its ecosystem relative to its abundance.

Lipid weight: A basis of measurement whereby concentrations of a substance are compared to the lipid (fat) content of a material.

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.

Morbillivirus: A family of viruses that are typically highly infectious and pathogenic – the family includes measles, dog distemper and dolphin morbillivirus. A number of mass mortality events have been associated with viruses from this family.

MW: Megawatt.

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 (209 different forms that contain differing numbers of chlorine atoms arranged in various positions on the aromatic rings) are industrial organochlorines that were manufactured to be used in electrical transformers and other applications. These man-made chemicals do not occur naturally and all traces reflect pollution.

PFCs: 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.

POPs: Persistent organic pollutants, organic compounds that are resistant to degradation and thus persist in the environment.

Primary production: The synthesis of organic compounds from atmospheric or aqueous carbon dioxide, forming the foundation of any food web.

rms: Root-mean-square. A measurement of sound pressure.

SD: Standard deviation.

SPL: Sound pressure level. A measure of the intensity of sound, in decibels.

South Atlantic Gyre: The subtropical gyre in the South Atlantic Ocean. In the southern portion of the gyre, northwesterly (or southeastward-flowing) winds drive eastward-flowing currents that are difficult to distinguish from the northern boundary of the Antarctic Circumpolar Current. Like other oceanic gyres, it collects vast amounts of floating debris.

TBT: Tributyltin. A toxic chemical commonly used in anti-fouling paints on ship hulls.

Trap pot gear: Submerged, three-dimensional wire or wood devices that permit fishery species to enter, but make escape extremely difficult or impossible.

UNCLOS: United Nations Convention on the Law of the Sea.