Appendix 5

BUDGET

Agenda	Purpose	Justification	Requested budget (£)	Minimum budget (£)
12.1	Pre-meeting of the Cetacean Emerging and Resurging Diseases (CERD)	(1) Summarise available information on cetacean pathogens, biotoxins and diseases so that disease agents, data gaps and geographic hotspots can be identified; and (2) organise a review of cetacean skin diseases with specific emphasis on the issues in South America (See Appendix 2).	7700	2000
12.2	Pollution 2000+ II phase	Scoping meeting to consider validation and critical assessment of biopsy techniques with application to large whale species as selected for study during Phase II, Develop a modelling/risk assessment framework for pollutants in cetaceans (see Appendix 3)	5000	5000
12.6.1	Climate change workshop	Scoping meeting to (1) identifying experts who can provide concise reviews of climate change impacts on cetacean habitats, and (2) identifying scientists with long-term datasets that can be analysed for effects of the anticipated change so to bring advice related to cetacean conservation and the aims of the IWC and (3) specific scope and goals of the workshop (See Appendix 4).	6000	6000

Appendix 6

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2007

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

INTRODUCTION

A prototype of the State of the Cetacean Environment Report (SOCER) was submitted to the International Whaling Commission Scientific Committee (SC) in 2000 in response to several resolutions from the Commission, including Resolutions 1997-7 and 1998-5, which directed the SC to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 welcomed the concept of the SOCER at the 52nd Annual Meeting in Adelaide, Australia, and “request[ed] the annual submission of this report to the Commission”. The first full SOCER (SC/55/E7) was submitted in 2003 and focused on the Mediterranean and Black Seas and the Atlantic Ocean. Subsequent SOCERs focused on the Pacific Ocean, the polar seas, and the Indian Ocean, each also including a Global section, addressing information that applies generally to cetacean environments. SC/59/E3 (SOCER 2007) again focuses on the Mediterranean and Black Seas (2007 thus marks the beginning of a new cycle of regional coverage), summarising key papers and articles that have been published from 2004 through 2007 to date.

LITERATURE ANALYSIS:

At SC/57, the Chair of the Scientific Committee requested the SOCER editors to determine what percentage of the cetacean literature was devoted to topics specifically related to habitat threats and conservation issues, versus topics addressing basic biology, ecology, and evolution. To perform this analysis, the editors used a literature database maintained by David Janiger of the Natural History Museum of Los Angeles County (NHMLAC)[1]. For the year 2006, it contained 1501 document records from over 300 peer-reviewed journals, books, theses, and technical reports[2], covering all aspects of marine mammal biology, evolution, ecology, habitats, conservation, and policy. We believe this is a reasonably inclusive database of marine mammal literature (see SC/58/E1 for additional background).

All document records from the NHMLAC database that were specifically focused on pinnipeds or other marine animals or were focused on aspects of marine organisms, habitats or ecosystems that were not directly relevant to cetaceans were deleted. The remaining 655 records[3] were then classified as follows:

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Janiger searches every week for at least 35 keywords in *Zoological Records*, *Biological Abstracts*, and *Current Contents.* Once a month he also checks the leading publishers’ websites for the same keywords.

[2] See Appendix 2, SC/58/E1, for a full list of the peer-reviewed publications in the NHMLAC database (some books, all theses, and all technical reports were omitted from this list, but were included in the analysis). Most documents included in the analysis were subject to some level of peer review, but a small number were not necessarily peer-reviewed; *e.g.*, they appeared in a publication’s ‘news’ section. There were several abstracts (from conferences or other sources – no full papers available) included in the NHMLAC database in 2006; none of these was included in the analysis. Full-paper proceedings, however, were included.

[3] The full list of document records is available on request from the editors.

- B ('basic biology'): Primarily focused on basic biology (*e.g.*, evolution, behaviour, physiology, anatomy, or taxonomy), ecology (*e.g*., distribution, habitat preference, habitat partitioning, or stock structure), or research techniques
- C ('conservation'): Primarily focused on environmental threats, conservation, management, or policy

When a study presented basic biological or ecological information on a species and included a discussion on management implications only as a 'general framework' consideration, then it was typically categorised as 'basic biology.' If, however, management or conservation implications were the primary motivation for undertaking a study (even if including basic aspects of cetacean biology or ecology, *e.g.*, most studies on hearing), then the paper was generally categorised as 'conservation.'

Of the 655 document records examined for this analysis, 56.3% (n = 369) were focused on basic biology and 43.7% (n = 286) on conservation. This is almost certainly an underestimate of the number of studies in the database that were undertaken to inform management or conservation policies related to cetaceans, given the criteria noted above for categorising papers. The proportion of the database categorized as 'conservation' papers remained constant from 2005 to 2006. The total number of papers addressing cetacean issues increased, but this was most likely attributable to an expanded search effort by the NHMLAC database manager rather than an absolute increase in papers published.

Over the last decade, scientific research in the field of marine sciences has undergone a paradigm shift. In response to a deteriorating environment, research efforts have increasingly focused on topics related to describing, preserving, restoring and managing damaged systems and their inhabitants. This goes hand in hand with an increased urgency for collecting the relevant data, which is also reflected in the allocation of funds for conservation-oriented projects and programmes. Based on the statistics presented here, in which almost half of all publications on cetacean biology and ecology have a direct conservation focus, this process is occurring in the field of cetacean research as well. Accordingly, the IWC is accurately reflecting the current trend in scientific endeavour by dealing with environmental and conservation matters.

MEDITERRANEAN AND BLACK SEAS

Habitat protection/degradation

General

HABITAT DEGRADATION AND CETACEANS IN THE ADRIATIC

The short-beaked common dolphin (*Delphinus delphis*) and common bottlenose dolphin (*Tursiops truncatus*) are the two most abundant cetacean species in the Adriatic Sea; historically the former was believed to be most abundant. However, common dolphins were severely depleted by culling in the 19th and first half of the 20th century, and sightings are now relatively rare. Severe habitat degradation, including anoxic events and algal blooms as a result of eutrophication and prey depletion as a result of overfishing, most likely prevented recovery. Bottlenose dolphins are now more frequently encountered than common dolphins, as they were probably less frequently targeted by culls due to their larger size and behaviour (*e.g*., lack of bow-riding, longer dives); genetic data, however, show that the population has been highly fragmented. Other cited factors threatening the Adriatic dolphin populations include chemical contaminants such as PCBs and conflicts with fishermen. This paper highlights "*the imperative of avoiding culling, deliberate killings and other takes for cetacean species that are exposed to a wide array of environmental threats*" and underlines that recovering Adriatic cetaceans will require improving habitat quality.

(SOURCE: Bearzi, G., Holcer, D. and Notarbartolo di Sciara, G. 2004. The role of historical dolphin takes and habitat degradation in shaping the present status of northern Adriatic cetaceans. *Aquat. Conserv.* 14: 363-379)

MEDITERRANEAN BIODIVERSITY AFFECTED BY INVASIVE ALIENS

More than 500 alien species have been identified in the Mediterranean Sea. This has been related to sudden declines in the abundance, and even local extirpations, of native species, concurrent with proliferation of aliens. The influx of alien species involves both unintended introductions and migration from the Red Sea through the Suez Canal. The result is reduced genetic diversity as well as loss of functions, processes and habitat structure, which increase the risk of decline and extinction. Based on a range of organisms from algae to fish, the author demonstrates that all levels of the ecosystem are affected and that a real threat to the balance of marine coastal diversity exists.

(SOURCE: Galil B.S. 2007. Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. *Mar. Pollut. Bull.* 55: 314-322)

Fisheries Interactions

CONTINUED DECLINE OF COMMON DOLPHINS RELATED TO OVERFISHING OF PREY

The short-beaked common dolphin was once one of the most common cetacean species in the Mediterranean Sea. The 2000-2010 IUCN Cetacean Action Plan noted a dramatic decline in population in the central and eastern Mediterranean. This population was classified as Endangered on the IUCN Red List of Threatened Animals in 2003, and was included on Appendix I of the Convention on the Conservation of Migratory Species (Bonn Convention, CMS) in 2005. A recent study around the Island of Kalamos, Greece, suggests that overfishing of prey, in combination with unsustainable levels of bycatch in fishing gear, is the main cause of this decline. Purse seine nets, in particular, seem to be responsible for the local overexploitation of fish species that are important prey for common dolphins, tuna and swordfish. Despite all expressions of concern, recommendations, strategic planning and scientific background produced (*e.g*., ACCOBAMS Conservation Plan for Mediterranean Common Dolphins, 2004), no relevant action has been taken to date that would result in common dolphin recovery around Kalamos or in the Mediterranean at large

(SOURCES: Bearzi, G., Politi, E., Agazzi, S., and Azzellino, A. 2006. Prey depletion caused by overfishing and the decline of marine megafauna in eastern Ionian Sea coastal waters (central Mediterranean). *Biol. Conserv.* 127(4):373-382; Bearzi, G., Politi, E., Agazzi, S., Bruno, S., Costa, M., and Bonizzoni, S. 2005. Occurrence and present status of coastal dolphins (*Delphinus delphis* and *Tursiops truncatus*) in the eastern Ionian Sea. *Aquat. Conserv.: Mar. Freshwater Ecosyst.* 15:243-257; Bearzi, G., Notarbartolo di Sciara, G., Reeves, R.R., Cañadas, A., and Frantzis, A. 2004. *Conservation Plan for Short-Beaked Common Dolphins in the Mediterranean Sea.* ACCOBAMS, Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area. 90 pp.)

SIGNIFICANT LEVELS OF GILLNET BYCATCH ESTIMATED FOR SARDINIA, ITALY

Fishermen interviews and boat-based surveys were used to estimate the impacts of gillnets on bottlenose dolphins off the coast of Sardinia, Italy. On nearly 69% of fishing days, dolphins caused damage to nets. The entanglement and mortality rate was conservatively estimated to be 1.47 animal/year (0.98 immature and 0.49 adult). Although the rate of sightings and animal distribution did not change when gillnets were present, the length of time animals spent in an area and their proportion of feeding activity increased in response to net placement. The author noted that the "*extent of the estimated bycatch is worrisome in terms of the ability of bottlenose dolphins off Sardinia to sustain such an annual loss*".

(SOURCE: Díaz López, B. 2006. Interactions between Mediterranean bottlenose dolphins (*Tursiops truncatus*) and gillnets off Sardinia, Italy. *ICES J. Mar. Sci.* 63: 946-951)

FISH FARMS ALTER DISTRIBUTION AND CAUSE ENTANGLEMENT OF BOTTLENOSE DOLPHINS

On the northeast coast of Sardinia, Italy, a finfish aquaculture site changed the spatial and temporal distribution of bottlenose dolphins. The dolphins were attracted to the facility, apparently feeding on wild fish aggregating near the site, as well as on fish within the facility and dead discarded fish. This is described as a 'sponge effect' for bottlenose dolphin groups that originally did not exploit the area. Because bottlenose dolphins from various regions show a similar social structure, this study provides the best evidence to date that fish farms alter the ranges of small cetaceans. In addition, three dolphin mortalities occurred in anti-predator nets over a 15-month survey period. The entanglement rate (2.4 dolphins per year), could be a substantial source of dolphin mortality for a relatively small population (34 animals identified to date), and the authors suggest reviewing the use of anti-predator nets and possibly using acoustic devices to deter dolphins. Predation on farmed fish may also lead to conflicts between humans and dolphins.

(SOURCE: Díaz López, B. and Bernal Shirai, J.A. 2007. Bottlenose dolphin (*Tursiops truncatus*) presence and incidental capture in a marine fish farm on the north-eastern coast of Sardinia (Italy). *J. Mar. Biol. Assoc. UK* 87: 113-117; Díaz López, B. 2006. Bottlenose dolphin (*Tursiops truncatus*) predation on a marine fish farm: some underwater observations. *Aquat. Mamm.* 32: 305-310; Díaz López B., Marini L., and Polo F. 2005. The impact of a fish farm on a bottlenose dolphin population in the Mediterranean Sea. *Thalassas* 21(2): 65-70)

CETACEAN MORTALITIES AND FISHERIES

Fishing gear in the Mediterranean causes direct mortality of cetaceans, the most significant issue being fishing bycatch. Although driftnet fisheries are the largest concern, a wide variety of interactions involve almost every kind of major fishing gear. Although ICCAT provisions and the EU completely ban the use of driftnets, an important international fleet was still operating in Mediterranean waters in 2004. The bycatch of one fleet, for example, included common dolphin, striped dolphin (*Stenella coeruleoalba*), bottlenose dolphin, pilot whale (*Globicephala* sp.), sperm whale (*Physeter macrocephalus*), fin whale (*Balaenoptera physalus*) and minke whale (*Balaenoptera acutorostrata)*, with mortalities of the first two species amounting to 3647 dolphins (split evenly between the two species) in the Alborán Sea and a further 13,358 in the Strait of Gibraltar and adjacent Atlantic waters.

(SOURCE: Tudela S. 2004. Ecosystem effects of fishing in the Mediterranean: An analysis of the major threats of fishing gear and practices to biodiversity and marine habitats. General Fisheries Commission for the Mediterranean. Studies and Reviews, No. 74, FAO)

Marine Debris

BEAKED WHALE KILLED BY PLASTIC DEBRIS INGESTION

A beaked whale that stranded on the Croatian shore of the Adriatic in 2002 was necropsied and the cause of death was determined to be a digestive blockage caused by the ingestion of four plastic bags. The animal had been seen swimming in shallow waters for one month and may have ingested the plastic in these waters. This is "*the first case of death of Cuvier's beaked whale in the Mediterranean, i.e., Adriatic Sea, caused by ingestion of plastic bags*…"

(SOURCE: Gomerčić, H., Gomerčić, M.D., Gomerčić, T., Lucić, H., Dalebout, M., Galov, A., Škrtić, D., Ćurković, S., Vuković, S. and Huber, D. 2006. Biological aspects of Cuvier's beaked whale (*Ziphius cavirostris*) recorded in the Croatian part of the Adriatic Sea. *Eur. J. Wildl. Res.* 52: 182-187)

Marine Protected Areas

CETACEAN CONSERVATION ACTION PLAN PRODUCED FOR LIBYA

The human population along Libya's coast has increased and is predicted to double in the next three decades. This is associated with increasing waste (most of it poorly treated or untreated), with widespread dumping of sewage and building debris at sea, and coastal discharges of detergents and chemicals. Moreover, Libya is a major oil producer. Oil spills have occurred near offshore oil operations, terminals, refineries and as the result of ballast discharges; the El-Bouri oil field alone spilled an estimated 2,770 m^3 of oil in a 25-month period. Oil and gas exploration is accompanied by seismic surveys and high-intensity sounds. These environmental threats are compounded by fisheries-related problems: cetacean bycatch occurs, as do illegal culls by fishermen. Environmentally damaging and illegal fishing methods include the use of nets prone to entangling cetaceans, explosives and chemicals to catch fish. The government issues considerable subsidies to local fishermen, which has considerably increased fishing effort and fishery/cetacean interactions. Suggested conservation actions include awareness raising and local capacity building. The plan specifies setting up a stranding network, analysing strandings for contaminants, and training local scientists to collect samples and conduct ecotoxicological analyses. The establishment of marine protected areas was suggested to safeguard habitat quality and prevent degradation, as well as prevent noise pollution and disturbance. It was also emphasised that cetaceans should be included in the environmental impact assessments of development projects.

(SOURCE: Bearzi, G. 2006. *Action Plan for the Conservation of Cetaceans in Libya*. Regional Activity Centre for Specially Protected Areas (RAC/SPA). Libya's Environment General Authority and Marine Biology Research Center. 50pp)

ESTABLISHMENT OF A MARINE PROTECTED AREA FOR BOTTLENOSE DOLPHINS IN CROATIA

Part of the sea in the Cres and Lošinj Archipelago, in the Northern Adriatic Sea, has been granted preventive protection status for a three year period as a Special Marine Reserve by regulation of the Republic of Croatia based on the proposal and data of Blue World Institute. The reserve totals 526 km^2 (between 14.17°E and 14.40°E and 44.78°N and 45.70°N) and is the largest marine protected area in the Adriatic. This area is identified as critical habitat for the resident common bottlenose dolphin population (about 100 animals), which has been monitored for 20 years by the Adriatic Dolphin Project. It will also serve to protect the loggerhead sea turtle (*Caretta caretta*) and *Posidonia* seagrass, along with 152 species of marine flora and 303 species of marine invertebrates.

(SOURCE: Regulation UP/I-612-07/06-33/676, 532-08-02-1/5-06-1 (26 July 2006) of the Ministry of Culture of the Republic of Croatia, as communicated by D. Holcer, Croatian Natural History Museum)

Ship Strikes

FIN WHALES AT RISK FROM SHIP STRIKES

An extensive review of ship collision records for the relatively isolated population of fin whales in the Mediterranean Sea from 1972 to 2005 revealed that 50 out of 297 carcasses (16.8%) were killed by boats. The minimum mean annual fatal collision rate increased from 1 whale/year to 1.7 whale/year during the 1970s-1990s. Most fatal strike events (85%) were reported in or adjacent to the Pelagos Sanctuary (Ligurian Sea), characterized by high levels of traffic and whale concentrations. The reported rates are unusually high for baleen whales. The high likelihood of unreported fatal strikes, combined with other anthropogenic threats, suggests an urgent need for a comprehensive, basin-wide conservation strategy, including ship strike mitigation requirements, amongst them real-time monitoring of whale presence and distribution in order to re-locate ferry routes to areas of lower cetacean density, as well as reducing ship speed in high cetacean density areas.

(SOURCE: Panigada, S., Pesante, G., Zanardelli, M., Capoulade, F., Gannier, A., and Weinrich, M.T. 2006. Mediterranean fin whales at risk from fatal ship strikes. *Mar. Pollut. Bull.*, 52:1287-1298; ACCOBAMS. 2006. *Report of the Joint ACCOBAMS/Pelagos Workshop on Large Whale Ship Strikes in the Mediterranean Sea*. M. Weinrich, S. Panigada, and C. Guinet (eds.). Monaco, 14-15 Nov. 2005. 35 pp.)

SPAIN TAKES MEASURES TO REDUCE BOAT COLLISIONS WITH SPERM WHALES AND PROMOTE CONSERVATION

The Spanish Ministry of Environment and the Navy Hydrographical Institute have taken measures to reduce ship strikes with sperm whales in the Strait of Gibraltar (36º 00,6' N - 5º 28,8' W; 35º 55,2' N - 5º 27,0' W; 35º 51,6' N - 5º 38,4' W; 35º 57,0' N - 5º 40,2' W). A security zone has been indicated on nautical charts and a 'Notice to Mariners' has been issued (reduced speed and navigate with particular caution). An additional effort has been made by the Ministry of Agriculture, Fisheries and Food and the Navy Hydrographical Institute to reposition the Traffic Separation Scheme off Cabo de Gata, Almeria. This measure in the Special Area of Conservation (SAC) involved communicating the repositioning to the International Maritime Organization (IMO), publishing a 'Notice to Mariners', and altering international nautical charts.

(SOURCE: Spanish Ministry of Environment, Ministry of Agriculture, Fisheries and Food, Navy Hydrographical Institute, as communicated by Scientific Committee member S. Lens)

Chemical pollution

DECREASE IN ORGANIC POLLUTANTS IN BOTTLENOSE DOLPHINS

Temporal changes of contaminant levels (HCB, PCBs and total DDT) in bottlenose dolphins from the Spanish coast were analysed from tissues samples collected between 1978 and 2002. Although levels of contaminants were relatively high compared to other regions, pollutant levels had decreased significantly over this 25-year period. The ratio of DDE to total DDT increased, *i.e*., more metabolised/degraded forms of DDT were becoming prevalent. This was interpreted as a lack of inputs of these pollutants into the Mediterranean, and as "*a decline in the pollutant loads of the* [Mediterranean] *ecosystem as a whole*".

(SOURCE: Borrell, A. and Aguilar, A. 2007. Organochlorine concentrations declined during 1987-2002 in western Mediterranean top predators. *Chemosphere* 66: 347-352)

A POSSIBLE BIOMARKER FOR POLLUTANTS IN CETACEANS

Biopsy samples from fin whales and striped, bottlenose and short-beaked common dolphins from the Mediterranean were used to investigate possible biomarkers for endocrine disrupting organic pollutants. Increasing levels of organochlorine endocrine disruptors were correlated with the enzyme BPMO, indicating that evidence of BPMO induction could be such a biomarker. The PCB levels in Mediterranean dolphins were similar to those in St Lawrence estuary beluga whales – a population for which pollution may be having population level impacts. However, contaminant levels (and BPMO activity) in the Mediterranean fin whales were considerably lower. The researchers concluded that "[t]*his research represents a warning signal of the potential reproductive alterations in marine top predators and suggests the need for continuous monitoring to avoid reductions in population and biodiversity in the Mediterranean Sea*".

(SOURCE: Fossi, M.C., Casini, S. and Marsali, L. 2006. Endocrine disrupters in Mediterranean top marine predators. *Environ. Sci. Pollut. Res.*13: 204-207)

MEDITERRANEAN BOTTLENOSE DOLPHINS HAVE HIGHER MERCURY LEVELS THAN ATLANTIC INDIVIDUALS

Mediterranean bottlenose dolphins displayed mercury (Hg) levels that were five times higher than those of Atlantic dolphins. As expected, the concentrations increased with age. The high values were attributed to diet, with the Mediterranean prey exhibiting the highest Hg levels. This is a consequence of the Hg enrichment in Mediterranean food webs, both due to natural causes (mercury-containing ores, volcanic activity) and waste discharges. No such relationship was observed for Hg in Mediterranean versus Atlantic striped dolphins, or for cadmium (Cd) in either species, which was attributed to different diets.

Maximum contaminant level

Liver (µg.g^{-1} wet weight) Hg: 204

(SOURCE: Lahaye, V., Bustamante, P., Dabin, W., Van Canneyt, O., Dhermain, F., Cesarini, C., Pierce, G.J. and Caurant, F. 2006. New insights from age determination on toxic element accumulation in striped and bottlenose dolphins from Atlantic and Mediterranean waters. *Mar. Pollut. Bull*. 52: 1219-1230)

HIGH LEVELS OF PERFLUORINATED CONTAMINANTS IN BLACK SEA PORPOISES

Black Sea harbour porpoises were examined for toxic perfluorinated compounds. PFOS was the major perfluorinated contaminant found, and compounds were higher in liver and kidney tissues than blubber, muscle or brain tissue. A foetus had the highest level of kidney contamination load (and one of the highest in the brain). The conclusion was that elevated levels of perfluorinated compounds in Black Sea porpoise tissues "*might pose a threat to this population*".

Maximum values

PFOS (ng.g^{-1} wet weight) liver: 1790; kidney: 1371; brain: 100

(SOURCE: Van De Vijver, K.I., Holsbeek, L., Das, K., Blust, R., Joiris, C. and De Coen, W. 2007. Occurrence of perfluorooctane sulfonate and other perfluorinated alkylated substances in harbor porpoises from the Black Sea. *Environ. Sci. Technol*. 41: 315-320)

Disease and mortality events

Harmful Algal Blooms (HABs)

Harmful Algal Blooms are an emerging problem in the Mediterranean

Harmful Algal Blooms (HABs) have a wide range of effects, including fish mortalities and impacts on human health (from skin irritations to poisoning after consumption of exposed shellfish). They have also been implicated in cetacean deaths. They are therefore considered one of the major problems that coastal countries face. Before the 1980s, HABs were considered rare events in the Mediterranean. Certain habitat modifications such as nutrient enrichment and reduced water exchange rates can promote HABs. Large harbours, for example, foster habitat conditions for such events in the Mediterranean. Harbours are also subjected to high traffic of commercial vessels, which are known to play a role as reservoirs (via ballast water) for the resting cysts of the harmful phytoplankton species and thus in spreading these species.

(SOURCE: Masó M. and Garcés E. 2006. Harmful microalgae blooms (HAB); problematic and conditions that induce them. *Mar. Pollut. Bull.* 53: 620-630)

Stranding

STRANDING OF LONG-FINNED PILOT WHALES IN SPAIN ASSOCIATED WITH MORBILLIVIRUS

Five long-finned pilot whales (*Globicephala melas*) stranded over the course of one month in southeast Spain and were diagnosed with morbillivirus infection based on characteristic histopathological lesions. A PCR-based assay detected viral RNA in fresh tissues. After a major morbillivirus-related die-off in 1991, which involved Mediterranean striped dolphins, this stranding indicates a broader level of infection in Mediterranean cetaceans.

(SOURCE: Research conducted by the Department of Animal Medicine and Surgery, the Department of Veterinary Pathology of the Veterinary Faculty of the University of Murcia and by the Valdeolmos Laboratory INIA-CISA Madrid Spain, as communicated by A. Bayón, DVM PhD, Director Veterinario, Centro de Recuperación de Fauna Silvestre 'El Valle', Dirección General del Medio Natural, Consejería de Industria y Medio Ambiente, Región de Murcia, Spain)

STRANDINGS OF THREE CETACEAN SPECIES IN THE BLACK SEA

From late March to early July 2006, individuals of all three Black Sea cetacean subspecies (the Black Sea harbour porpoise [*P. phocoena relicta*], Black Sea short-beaked common dolphin [*D. delphis ponticus*], and Black Sea common bottlenose dolphin [*T. truncatus ponticus*]) stranded along the coast of the Black Sea. At least five countries were affected: Bulgaria, Georgia, Turkey, Romania and Ukraine (where over 200 strandings were recorded). Harbour porpoises were found most often. Some individuals showed signs of entanglement, while some live-stranded. Fisheries interactions were therefore not the single cause of the Black Sea cetacean die-off in 2006.

(SOURCE: Radu G., Popov K., Mikhailov K. and Birkun A., Jr. 2006. Cetacean mass-stranding in Bulgaria caused by fishing ... however other mortality causes are at work in the wider Black Sea. *FINS* (the newsletter of ACCOBAMS), Vol. 3, No. 1: 32; Birkun A., Jr. 2006. Live strandings in the Black Sea region. Presentation at the Live Stranding and Cetacean Rescue Workshop (Monaco, 3-4 November 2006), 4 pp. (unpubl. document); Krivokhizhin S.V. and Birkun A.A., Jr. 2004. Reference points for the evaluation of normal level of cetacean strandings on the Black Sea coast of Crimea. Pp. 294-297 in: *Marine Mammals of the Holarctic*. Moscow, 609 pp.)

Noise impacts

Sonar

ATYPICAL MASS STRANDING OF CUVIER'S BEAKED WHALE IN SPAIN

Veterinary pathologists from Las Palmas University's Unit of Cetacean Research (Veterinary Pathology Unit, Institute for Animal Health, Veterinary School) in the Canary Islands conducted a pathological study of four Cuvier's beaked whales (*Ziphius cavirostris*) that mass stranded on the coast of Almeria, southern Spain, on 26 January 2006. The two males and two females were in good body (nutritive) condition. All four showed a 'Gas and Fat Embolic Syndrome', as previously described in 'atypical' beaked whale mass strandings associated spatially and temporally with military naval exercises involving mid-frequency active sonar. A group of NATO warships was in the area where the whales stranded.

(SOURCE: Communicated by A. Fernández, DVM, PhD, ECVP, Veterinary Histology and Pathology Institute for Animal Health and Food Security (IUSA), Veterinary School, University of Las Palmas de Gran Canaria, Spain)

CUVIER'S BEAKED WHALE STRANDINGS IN THE MEDITERRANEAN

The Mediterranean has records of Cuvier's beaked whale strandings going back to 1803. Records of atypical mass strandings were highlighted: three occurred in 1963 and 2001, four in 1997 and one each in 1966, 1974, 1987, 1992, 1993, 1996, 1999 and 2000. Three mass standings are known to have occurred while military vessels were present, and two single strandings occurred in the presence of military vessels. One mass stranding was directly linked to naval activities. Stranding hotspots included the Ligurian Sea (on the northern Italian coast and the north of Corsica), southeast Italy and western Greece. A next stage would be to determine how many of these stranding events were associated with anthropogenic noise.

(SOURCE: Podesta, M., D'Amico, A., Pavan, G., Drougas, A., Komnenou, A. and Portunato, N. 2006. A review of Cuvier's beaked whale strandings in the Mediterranean Sea. *J. Cet. Res. Manage.* 7: 251-261)

General

A CRITIQUE OF CETACEAN CONSERVATION PROGRESS

In an editorial, Giovanni Bearzi discusses cetacean conservation in the Mediterranean. A variety of workshops and meetings yielded an Action Plan for the region's cetaceans, but Bearzi points out that large action plans have a substantial 'laundry list' of recommendations that are numerous and expensive, exceeding funds available. Moreover, implementing many of the actions would involve major policy changes that will be politically resisted by socioeconomic interests (*e.g.*, the fishing industry). Bearzi warns that much effort is spent producing substantial documents that are not translated into action. He also notes that even though conservation action may result in, for example, marine protected areas, there is little follow-up to assess whether species are actually benefiting from the designation. Many protected areas may be "*just one more paper park*". He states "[a] *dispassionate look at the Mediterranean reveals that most or all of the big threats are present and at least some are probably getting worse* [since the advent of ACCOBAMS]". He warns that "'*decision makers' are rarely serious about doing conservation that may result in unpopular action, no matter how thick the pile of scientific articles, workshop recommendations, and action plans on their desks*" and emphasised the importance of public awareness and public pressure in changing policy towards conservation. These concerns also apply to cetacean conservation efforts elsewhere.

(Bearzi, G. 2007. Marine conservation on paper. *Conserv. Biol.* 21: 1-3)

SPAIN INITIATES PROJECT TO MONITOR BOTTLENOSE DOLPHINS AND HARBOUR PORPOISES

Based on a 2002 report by the Spanish Environment Ministry that highlighted the Alborán Sea as an area of special interest for the conservation of cetaceans, the Spanish Cetacean Society (SEC) has initiated a 4-year project (within the framework of L'Instrument Financier pour l'Environnement (LIFE)-Nature program of the European Commission), known as 'Conservation of Cetaceans and Turtles in Murcia and Andalusia'. It will examine the health, distribution and abundances of bottlenose dolphins and harbour porpoises – both in Annex II of the European Union's Habitats Directive. This project will develop its actions at three levels – monitoring, managing and divulgation (stakeholder implication) – in the Alborán Sea and its contiguous waters of the Gulf of Cádiz and the Gulf of Vera. This will contribute to the construction of the NATURA 2000 network of Europe's most valuable natural sites.

(SOURCE: http://www.cetaceos.com/life/index.htm, as communicated by Scientific Committee member S. Lens)

IUCN STATUS REVIEW OF CETACEANS IN MEDITERRANEAN AND BLACK SEA

A comprehensive review was conducted of cetaceans in the Mediterranean and Black Sea as part of a workshop held on 5-6 March 2006. Several species and populations were highlighted as threatened. The Strait of Gibraltar subpopulation of killer whales (*Orcinus orca*) is critically endangered (IUCN) and there is current evidence for decline. There was also evidence for decline in the endangered Mediterranean sperm whale, striped dolphin, short-beaked common dolphin and Black Sea harbour porpoise subpopulations and subspecies, respectively. There was insufficient information to assess whether Mediterranean or Black Sea common bottlenose dolphins or Black Sea short-beaked common dolphins were currently declining. The status of fin whales could also not be assessed. Key threats affecting Mediterranean cetaceans included pelagic drift nets which, although banned by the European Union in 1992, were still being utilised by Moroccan, Italian and French vessels. Purse seine nets, longlines and bottom trawling have also caused cetacean bycatch. High-speed ferry collisions were another source of mortality, and concerns were expressed over noise impacts, in particular sound from military activities, seismic surveys, dynamite fishing and dense shipping traffic. Unregulated whalewatching and pollution (*e.g.,* trace elements, organochlorine pollutants, and marine debris) were also highlighted. Culls of Strait of Gibraltar killer whales were reported due to high levels of interaction between these whales and bluefin tuna longline fisheries. Other threats to these killer whales included prey (bluefin tuna) depletion and wind farm construction. In the Black Sea, high levels of historic takes (an estimated 4 to 5 million cetaceans) have severely depleted cetacean populations, and anthropogenic activities are preventing recovery of, and further depleting, some species. Prey depletion due to overfishing, hypoxic events, and bycatch are key threats. In 1982, a gas platform explosion killed 2000 already depleted Black Sea harbour porpoises; live captures, in particular of common bottlenose dolphins (at least 92 bottlenose dolphins were taken between 1990 and 1999) for dolphinaria in Eastern Europe, the Middle East, Southeast Asia and South America have further depleted these populations.

(SOURCE: Reeves, R. and Notarbartolo di Sciara, G. (eds.) 2006. *The Status and Distribution of Cetaceans in the Black Sea and Mediterranean Sea.* IUCN Centre for Mediterranean Cooperation, Málaga, Spain. 137pp.)

GLOBAL

Habitat protection/degradation

General

HABITAT DEGRADATION AND MAJOR DECLINES IN SPECIES IN ESTUARIES AND COASTAL SEAS

After reconstructing the historical state of 12 important estuary systems and coastal areas, this study concluded that water quality had been degraded, invasive species introduced, more than 65% of the areas with seagrass beds and wetland habitat had been destroyed, and more than 90% of 'important species' had been lost. Degradation had accelerated in the past 150 years. The researchers stated that "*among mammals, fish and invertebrates, we see sequential depletion of the most valued and largest species and subsequent replacement with smaller and less valuable ones*". Despite conservation efforts in the 20th century, only 2% of species have shown substantial recovery (and 12% partial recovery); "[l]*arge whales, sirenia, and sea turtles, however, remain at low levels*". "*Exploitation stands out as the causative agent for 95% of species depletions and 96% of extinctions"* in the coastal and estuarine ecosystems studied. The other factors noted were pollution, disease, and disturbance. Synergistic effects were emphasised: "*In 49% of species depletions and 42% of extinctions, multiple human impacts were involved, commonly exploitation and habitat loss*". When species have recovered, typically conservation efforts have reduced or ended exploitation and simultaneously reduced one or more synergistic factors (such as pollution). The estuaries studied included important cetacean habitats such as the Bay of Fundy, the Baltic Sea, Moreton Bay, Galveston Bay and the St Lawrence Estuary.

(SOURCE: Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Peterson, C.H. and Jackson, J.B.C. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312: 1806-1809)

LOSS OF MARINE BIODIVERSITY IMPACTING WATER QUALITY, FOOD SECURITY AND ECOSYSTEM STABILITY

An analysis of how biodiversity loss affected marine systems showed that "*the rate of fisheries collapses…has been accelerating over time*" and "*despite large increases in global fishing effort, cumulative yields across all species…had declined by 13%...since passing a maximum in 1994*". Fisheries collapses were more common in species-poor ecosystems. Marine reserves and fisheries closures increased species richness by 23%, which in turn boosted productivity that translated into a 400% increase in catch per unit effort. Ecosystem stability where marine reserves were established also increased. It was concluded that as biodiversity decreased "*rates of* [fisheries] *resource collapse increased*" exponentially, with a corresponding decrease in the ability for systems to recover. Decreasing biodiversity was also coupled with an exponential decrease in water quality. The researchers concluded that "[b]*y restoring marine biodiversity through sustainable fisheries management, pollution control, maintenance of essential habitats, and creation of marine reserves, we can invest in the productivity and reliability of goods and services that the ocean supplies to humanity. Our analyses suggest that business as usual would foreshadow serious threats to global food security, coastal water quality, and ecosystem stability, affecting current and future generations*".

(SOURCE: Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F., Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J. and Watson, R. 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science* 314: 787-790)

Fisheries Interactions

REMOVAL OF TOP PREDATORS CAN START TROPHIC CASCADES

Eleven shark species consume other, lower trophic level elasmobranch species. Over the past 35 years, abundance of these species has decreased, primarily due to fishing. As a result of reduced predation, lower trophic level species flourished, which in turn led to increased predation on commercially important shellfish stocks (*i.e*., a trophic cascade), to such an extent that a 100-year-old shellfish fishery collapsed. The researchers propose that "*top-down effects must be widely expected whenever entire functional groups of predators are depressed, as can occur with industrial fisheries*". This result contradicts the hypothesis that predator removal will increase commercially important stocks. The study also illustrates the importance of apex predators (such as cetaceans) to the integrity of marine ecosystems and the vital importance of considering "*indirect species interactions*".

(SOURCE: Myers, R.A., Baum, J.K., Shepherd, T.D., Powers, S.P. and Peterson, C.H. 2007. Cascading effects of the loss of apex predatory sharks from a coastal ecosystem. *Science* 315: 1846-1850)

REMOVAL OF TOP PREDATORS CAN DESTABILIZE ECOSYSTEMS

Diverse ecosystems seem to have more stable food webs. An analysis of food web stability investigated the impacts of top level predators. Food webs are more stable if top predators can respond rapidly to utilize a new food source, allowing a declining food source to recover. In addition, the presence of food web 'channels' that have slow or fast rates of turnover (*e.g*., birth rates, death rates, or energy efficiency leads to rapid or slow turnover in biomass in the food web) are also important to food web stability. The authors noted that "*removal of high-order consumers…ought to destabilize these systems*". They state that "*the same traits that we identify as critical ecosystem structures are currently being undermined by human activities. For example…losses of top predators and, in cases where food-web dynamics have been documented, diversity has abruptly and dramatically declined*". They then add that "*it seems that human actions are not only reducing the diversity of our natural ecosystems, but more importantly are probably eroding the very structures that confer stability to food webs in nature*".

(SOURCE: Rooney, N., McGann, K., Gellner, G. and Moore, J.C. 2006. Structural asymmetry and the stability of diverse food webs. *Nature* 442: 265-269)

Marine Protected Areas

CONNECTIVITY BETWEEN MARINE PROTECTED AREAS AND LIFE HISTORY EFFECTS

'Connectivity' between marine protected areas (MPAs) is important for their success, and factors such as habitat fragmentation and over-fishing reduce this connectivity. If conservation is only at a 'local' level (*i.e*., little connectivity), exploitation pressure outside a protected area can decrease dispersal, increase habitat fragmentation, and reduce the genetic diversity of species within the protected area "*because dispersal distance is likely genetically correlated to…development and size at maturation, the effects of MPAs on life-history evolution could be synergistic"*. Measurement of shifts in life history (such as age or size at maturation) could be used as indicators of MPA success and connectivity (or lack thereof). Studies into this issue could be used to create networks of MPAs "*perhaps of various sizes and spacings…designed to maintain ecosystem function*". This may be relevant to some IWC sanctuary deliberations, in particular considering the downward shift in age and size at sexual maturity observed in Antarctic minke whales (*B. bonaerensis*) in the Southern Ocean Sanctuary.

(SOURCE: Dawson, M.N., Grosberg, R.K. and Botsford, L.W. 2006. Connectivity in marine protected areas. *Science* 313: 43-44 [Letter to Science])

Solar Radiation/Ozone Layer

ULTRAVIOLET RADIATION HAS SIGNIFICANT IMPACTS ON MARINE SPECIES GROWTH AND SURVIVAL

Ultraviolet B radiation (UVB) is normally filtered to a great extent by the ozone layer, but its intensity has increased due to ozone depletion, particularly at the poles. This review discovered that impacts of UVB radiation varied widely and there was no discernable pattern between taxonomic groups, or correlation with size of organism, although embryos were more susceptible. Generally, however, UVB had large, significant and negative impacts on the growth and survival of marine biota. The reviewers noted that "[a]*t the community level, differences in susceptibility to environmental stressors may vary between organisms, leading to unforeseen interactions between stressors on the community as a whole*". Possible synergistic effects between pollutants and UVB radiation on marine species were emphasised. The results illustrate that UVB radiation and ozone depletion could negatively impact marine ecosystems, particularly in polar regions, which are major cetacean habitats.

(SOURCE: Bancroft, B.A, Baker, N.J. and Blaustein, A.R. 2007. Effect of UVB radiation on marine and freshwater organisms: a synthesis through meta analysis. *Ecol. Lett.* 10: 332-345)

Whalewatching Impacts

WHALEWATCHING VESSELS IMPACT BOTTLENOSE DOLPHINS

Two papers from long-term research on Indo-Pacific bottlenose dolphins (*T. aduncus*) in Shark Bay, Australia, investigated the impacts of whalewatching vessels. Two areas were compared: high and low vessel traffic areas (impact vs. control sites respectively), which were 17 km apart and had different dolphin populations. A land-based survey on experimental boat approaches to dolphins noted significant changes in their behaviour. Groups became more compact, swimming direction became more erratic, and there were higher rates of change in group membership. *"Dolphins at the control site had stronger and longer-lasting responses than those at the impact site*". This initially suggested habituation of impact-site dolphins and fewer impacts on this population. However, the observed individuals may have been less sensitive animals (meaning the most sensitive animals had left the area after dolphin watching began), because the second paper indicated a shift in distribution. Long-term dolphin abundance was monitored at both sites. In the impact site, one dolphin-watching company began operations, which did not affect abundance or distribution. However, a second operation resulted in a significant decrease in dolphin abundance (a 15% decline). At the undisturbed control site, abundance slightly increased (by 8.5%). Thus there was a significant effect on a dolphin population despite the relatively low density of whale-watching vessels (*i.e*., only two). The authors note that such whale-watching impacts could be particularly damaging for threatened cetaceans: *"*[a] *similar decline would be devastating for small, closed, resident, or endangered cetacean populations".*

(SOURCES: Bejder, L., Samuels, A., Whitehead, H. and Gales N. 2006. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Anim. Behav.* 72: 1149-1158; Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J., Flaherty, C. and Kürtzen, M. 2006. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conserv.Biol.*20: 1791–1798).

Chemical pollution

TOXICITY OF HEAVY METALS IS NOT SIMPLY CORRELATED TO TEMPERATURE

Because the rates of many biological activities increase with temperature, the toxicity of chemical contaminants may increase from polar to temperate to tropical regions. However, this was not the case for four heavy metals (Cu, Cd, Zn, Pb) tested on marine invertebrates. Although the sensitivity to heavy metals does differ between the major geographic regions, the pattern is not predictable. Thus, toxicity data from one region (for example, from temperate regions, for which the most data are available) do not necessarily ensure adequate environmental protection for another region.

(SOURCE: Chapman P. M., McDonald B.G., Kickham P.E., and McKinnon S. 2006. Global geographic differences in marine metals toxicity. *Mar. Pollut. Bull.* 52: 1081-1084)

BROMINATED ORGANIC CONTAMINANTS FOUND IN WHALE OIL FROM 1920S

Archived whale oil, collected in 1921, had detectable levels of certain halogenated compounds, which suggests that these compounds may be produced naturally in the marine environment. The contaminant levels were compared to those in blubber from a fin whale stranded on the east coast of the United States in 2004. Organic halogenated compounds such as MeO-PBDE, MPBs and DMBP were found in the historical sample, albeit at levels that were an order of magnitude lower than in the stranded fin whale. Other commercially produced chemicals of toxicological concern, including DDE, PCBs, and a brominated flame retardant, were absent in the whale oil but present in the whale blubber, suggesting no natural production at any significant level of these contaminants. The presence of certain brominated compounds in the archived whale oil suggests that cetaceans and other marine life may have evolved biochemical processes to cope with at least some kinds of contaminants.

Maximum contaminant levels

Whale oil (µg.g^{-1} lipid weight) 6MeO-BDE-47: 0.09; ΣMBp-HBr5: 0.07; 2' MeO-BDE-68:0.03; DDE: not detected; PCB (CB-154): not detected; BDE-47: not detected.

Blubber (µg.g^{-1} lipid weight) 6MeO-BDE-47: 0.2; ΣMBp-HBr5: 0.94; 2' MeO-BDE-68: 0.2; DDE: 3.2; PCB (CB-154): 1.1; BDE-47: 0.4)

(SOURCE: Teuten, E.L. and Reddy, C.M. 2007. Halogenated organic compounds in archived whale oil: A pre-industrial record. *Environ. Pollut*. 145: 668-671)

Disease and mortality events

Harmful Algal Blooms (HABs)

ALGAL BLOOM TOXIN CAUSES REPRODUCTIVE FAILURE AND MORTALITY IN MARINE MAMMALS

In 1998 and 2002, algal blooms occurred immediately before California sea lion breeding seasons, and during these periods a total of 209 pregnant sea lions stranded. Symptoms ranged from head waving to seizures and coma. Reproductive failure was reported in these animals, either as the result of spontaneous abortion, premature birth or death of the female. Of these stranded animals, 108 animals died after aborting or giving birth. Domoic acid, an algal bloom toxin, was detected in a variety of body fluids, including urine (of both mother and foetus), amniotic fluid and gastric juices. The study demonstrated that domoic acid in the mother's blood can pass across the placenta. Substances can pass over the blood/brain barrier more easily in foetal animals and, although the domoic acid level is lower in the foetus than the mother, it may have more potential to cause neurological damage. Cetaceans have been exposed to HABs and their reproductive success and survival are also potentially at risk.

(SOURCE: Brodie, E.C., Gulland, F.M.D., Greig, D.J., Hunter, M., Jaakola, J., St. Leger, J., Leighfield, T.A., Van Dolah, F.M. 2006. Domoic acid causes reproductive failure in California sea lions (*Zalophus californianus*). *Mar. Mamm. Sci* 22: 700-707)

METHOD TO DETECT ALGAL TOXINS IN DOLPHIN STRANDINGS

Placing a blood spot to dry on a cellulose card for later analysis is a sampling method used when collection and storage of whole blood is not possible. A new study has shown that dolphin blood collected using this method can be analysed for brevetoxin (an algal bloom toxin). This means that in the future samples can easily be collected from stranded cetaceans by both researchers and stranding program volunteers, and shipped quickly and simply. This will simplify determining the prevalence of high levels of algal toxins and the extent to which they cause cetacean mortalities.

(SOURCE: Maucher, J.M., Briggs, L., Podmore, C. and Ramsdell, J.S. 2007. Optimization of blood collection card method/enzyme-linked immunoassay for monitoring exposure of bottlenose dolphin to brevetoxin-producing red tides. *Environ. Sci. Technol.* 41: 563-567)

Ship Strikes

SHIP STRIKE MORTALITY OF WHALES INCREASES WITH SPEED – 100% MORTALITY AT 15 KNOTS

In vessel collisions with whales, the likelihood of a whale suffering mortality is almost 100% when a vessel is travelling at 15 knots. As speed decreases, the likelihood of mortality likewise decreases, with a 50% likelihood of mortality at 11.8 knots, and 17% at 8 knots. Only 11% of vessels in the northwest Atlantic travel at speeds of 9 knots or less (and only 6.2% at 7 knots or less); if collisions were to occur, mortality would probably be high. Therefore, to reduce mortality rates in species frequently hit by ships (particularly right whales [*Eubalaena glacialis*], but also other large whale species), speed restrictions in certain areas may be appropriate.

(SOURCE: Vanderlaan, A.S.M. and Taggart, C.T. 2006. Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Mar. Mamm. Sci.* 23: 144-156)

Stress and Disease

STRESS MAY INCREASE PORPOISE DISEASE SUSCEPTIBILITY

In harbour porpoises, cytokine activity – an indicator of immune system responses – differed between animals captured in the wild and those in a captive facility. The former showed increases in cytokine and also cortisol, a known stress indicator. The results were "*suggestive of stress-induced modulation of the immune responses in accidentally caught animals*", *i.e*., increased susceptibility to disease as a result of 'stress'. Stress can suppress the immune system, and the "*stress impact of accidentally-caught animals could have severe consequences for these animals*". Thus, even when released, bycaught animals may have increased post-release mortality. The authors warned that other potential sources of stress, such as exposure to noise or shipping, might also affect porpoises' susceptibility to disease.

(SOURCE: Fonfara, S., Siebert. U., Pramge, A. and Colijn, F. 2007. The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). *J. Mar. Biol. Assoc.UK* 87: 905-911)

Climate change

LARGE SPECIES LESS ABLE TO ADAPT TO CLIMATE CHANGE

This short review of evidence for rapid adaptation to climate change in vertebrates and invertebrates found that genetic shifts in many animal populations have already occurred as the result of global warming. From the patterns of such adaptation, it was concluded that "[s]*mall animals with short life cycles and large populations will probably adapt*" whereas "*populations of many large animals with longer life cycles and smaller population sizes will decline in population size or be replaced*…" As cetaceans are amongst the largest and most long-lived species, their ability to adapt and survive climate change would likely be low.

(SOURCE: Bradshaw, W.E. and Holzapfel, C.M. 2006. Evolutionary response to rapid climate change. *Science* 312: 1477-1478)

CLIMATE CHANGE CAN REDUCE PHYTOPLANKTON PRODUCTIVITY

A study on phytoplankton productivity in surface waters and temperature suggests a major impact on marine ecosystems – reduced oceanic productivity as a result of climate change. A decade of analysis of satellite images shows declining productivity in warming surface areas of the ocean. Increasing surface water temperatures may be causing stratification and restricting the refreshment of nutrients, thereby reducing phytoplankton productivity. "*The observed reductions in ocean productivity during the recent post-1999 warming period provide insight on how future climate change can alter marine food webs*" and "*such changes will inevitably alter…fishery yields, and dominant basin scale biological regimes.*" Moreover, an "*influx of freshwater…will contribute to reduced mixing*" and thus could reduce productivity. Another recent study has documented a large increase in freshwater inputs into the Arctic: as the result of global warming-induced sea ice and glacier melting, increasing river discharges, and changing precipitation patterns, an additional 37,000 km³ of freshwater have been added to the Arctic Ocean (15,000 and 2,000 from sea ice and glacier melting, respectively) between 1965 and 2000, with a peak in recent years. Until recently, ice melt has played only a minor role in adding freshwater, but "*rising temperatures will undoubtedly amplify that contribution in potentially dramatic ways*". This emphasizes the major effects climate change could have in reducing phytoplankton productivity and thus on food webs, marine ecosystems and, ultimately, cetaceans.

(SOURCES: Doney, S.C. (2006) Plankton in a warmer world. *Nature* 444: 695-696; Behenfeld, M.J., O'Malley, R.T., Siegel, D.A., McClain, C.R., Sarimiento, J.L., Feldman, G.C., Milligan, A.J., Falkowski, P.G., Letelier, R.M. and Boss, E.S. (2006) Climate-driven trends in contemporary ocean productivity. *Nature* 444: 752-755; Peterson, B.J., McClelland, J., Curry, R., Holmes, R.M., Walsh, J.E. and Aagaard, K. 2006. Trajectory shifts in the Arctic and Sub-Arctic freshwater cycle. *Science* 313: 1061-1066)

BOTTOM-UP ECOSYSTEM IMPACTS ON TOP PREDATORS AND IMPLICATIONS OF CLIMATE CHANGE

Sand eels are an important prey species for many marine vertebrates in the North Atlantic, including several species of seabirds and northern minke whales. In recent years commercial fish landings of sand eels have more than halved and the seabirds dependent upon sand eels have suffered breeding failures. An ecological investigation examined whether this sand eel decline was related to predation and fisheries (*i.e*., top-down control) or food abundance (*i.e*., bottom-up control). A stronger link was discovered between food abundance and sand eel biomass and, in turn, seabird breeding productivity. One seabird species was impacted more by adult sand eel abundance than biomass per se. As climate has a major impact on zooplankton abundance, the conclusion was that "*climate driven changes in plankton communities can affect top predators*". Moreover, "*top down control from human fisheries, may also affect ecosystems strongly" and "[t]he simultaneous pressures of climate change and fisheries is difficult to predict, but there is little doubt that…marine top predators will be exposed to dramatic changes in the coming decades*". This study has implications also for whale species, in particular northern minke whales.

(SOURCE: Frederiksen, M., Edwards, M., Richardson, A.J., Halliday, N.C. and Wanless, S. 2006. From plankton to top predators: bottom-up control of a marine food web across four trophic levels. *J. Animal Ecol.* 75: 1259-1268)

IMPACTS OF CLIMATE CHANGE ON MARINE MAMMALS

Two reviews on climate change and cetaceans discussed the possibility of direct impacts, including distribution shifts and range expansions or contractions. This may be particularly problematic for species with restricted ranges, *e.g*., river dolphins, the vaquita (*Phocoena sinus*), or polar species. Temperature changes may also affect cetacean physiology. Indirect impacts include: "*the effects of climate change on prey availability affecting the distribution, abundance and migration, community structure, susceptibility to disease and contaminants, reproductive success and, ultimately, the survival of marine mammal species*". Predators and competitors may also change. Changes in salinity levels, pH, rainfall and coastal runoff were also discussed, including decreases in some species of plankton but perhaps increases in others – including more harmful algal blooms. One review noted that "[m]*management and conservation measures need to take into account the potential changes in species' range by creating protected areas for the remaining and predicted habitat*" and that protected areas may have to be dynamic to take into account shifting boundaries, rather than being fixed and immovable. This review also emphasised the potential for synergy with other impacts such as pollution, which may increase the effects of climate change.

(SOURCES: Learmouth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and Robinson, R.A. 2006. Potential effects of climate change on marine mammals. *Oceanogr. Mar. Biol. Ann. Rev.* 44: 431-464; Simmonds, M.P. and Isaac, S.J. 2007. The impacts of climate change on marine mammals: Early signs of significant problems. *Oryx* 41: 19-26)

INTERNATIONAL PANEL OF CLIMATE CHANGE STATES THAT CLIMATE CHANGE IS REAL AND WILL LIKELY CAUSE SUBSTANTIAL ENVIRONMENTAL CHANGES

"*Warming of the climate system is unequivocal"* and "[m]*ost of the observed increase in globally averaged temperatures is very likely due to the observed increase in anthropogenic greenhouse gas concentrations*". The past 12 years (1995-2006) have been the warmest recorded since 1850. Ocean temperature has increased as far down as 3 km as a result of absorbing 80% of the additional heat added to the global climate system. This added heat has resulted in sea level rises (1.8±0.5 mm/year, 1960-2003; 3.1±0.7 mm/year, 2003-2006; a total rise of 17 cm over the 20th century). It is "*very likely*" that ice melting in Greenland and Antarctica has added to this rise. Predicted sea level rises by 2090-2099 (compared to 1980-99) will be from 0.18 m to 0.59 m. Average ocean surface temperatures are likely to increase from 1.8 to 4°C. In some warming projections "*Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century*". Due to ice melting and increased precipitation, more freshwater has entered into this region and reduced salinities. Salinities in equatorial and tropical waters have conversely increased. Other effects such as changing wind patterns, droughts, heat waves and increased frequency and power of tropical cyclones have also been observed in the North Atlantic. "*For the next two decades a warming of about 0.2°C per decade is predicted*". In addition, ocean acidification has been reported (a 0.1 decrease in pH since pre-industrial times) due to increased levels of dissolved carbon dioxide, with a pH reduction of 0.14 to 0.35 units predicted by the end of the 21st century – heavily impacting coral reefs and calcareous phytoplankton. The IPCC also notes that "*it is very likely that* [thermohaline circulation] *in the Atlantic Ocean will slow down during the 21st century*" by up to 25%, which could have major impacts in Atlantic ecosystems. Finally, warming and sea level rise "*would continue for centuries due to timescales associated with climate processes and feedbacks, even if greenhouse gases were to be stabilized*". Thus, climate change is causing, and will result in, further major and long-term changes in the ocean environment.

(SOURCE: IPCC. 2007. *Climate Change 2007: the Physical Science Basis. Summary for Policy Makers.* International Panel on Climate Change, Geneva, Switzerland. 18pp.)

Noise impacts

Cetacean Hearing

VARIATION IN DOLPHIN HEARING SENSITIVITY – IMPLICATIONS FOR NOISE IMPACT PREDICTIONS

The hearing abilities of 47 captive dolphins (aged 4 to 47 years) were measured using auditory evoked potentials via suction cup sensors attached to the lower jaw. Hearing varied greatly, with sensitivity decreasing as animals aged, more so in males than females; most dolphins older than 27 had some hearing loss, with two animals showing signs of profound deafness. A genetic component to hearing ability was suggested; additionally, certain antibiotic treatments may affect hearing abilities of some cetaceans. These results suggest that hearing data gathered from males or older dolphins, from animals that have been treated with antibiotics, or in studies sampling small numbers of individuals may underestimate noise impacts on dolphin populations.

(SOURCE: Houser, D.S. and Finneran, J.J. 2006. Variation in the hearing sensitivity of a dolphin population determined through the use of evoked potential audiometry. *J. Acoust. Soc. Amer.* 120: 4090-4099)

Mitigation

SOME MITIGATION MEASURES FOR REDUCING NOISE IMPACTS ON MARINE MAMMALS INEFFECTIVE OR UNTESTED

To reduce impacts of noise on cetaceans, various agencies have introduced mitigation measures, such as exclusion zones and pre-operation surveys. A review of these measures, however, indicates that for deep-diving beaked whales, the likelihood of observers actually sighting an animal in the zone of acoustic impact is less than one in ten, indicating that this approach is ineffective. Moreover, the effectiveness of several other measures (such as 'ramping up' or increasing the intensity of noise production, the idea being that sensitive animals will move away) has not been scientifically assessed for any species. We also lack information on whether noise exposure can have population-level impacts because of the timeframes (years or even decades) needed for data acquisition and because many cetacean populations have not been assessed prior to strandings. Finally, current risk assessments are hindered because the mechanism by which sound causes strandings in beaked whales or the sound level at which such effects occur is unknown.

(SOURCE: Barlow, J. and Gisiner, R. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *J. Cet. Res. Manage.* 7: 239-249)

Seismic Surveys

AIRGUNS TRANSMIT HIGHER FREQUENCIES, AND HIGH SOUND PRESSURE LEVELS AT GREATER DISTANCES, THAN PREVIOUSLY THOUGHT

Tagged sperm whales exposed to seismic airguns have affected our current thinking of sound and its potential effects on cetaceans. Standard models of geometrical spreading of sound did not match up with the actual transmissions in the field. Sound levels decreased between 5 km and 9 km from the sound source, but then increased between 9 km and 13 km. Received levels "*can be just as high at12 km as they are at 2 km*". Sound echoing from the seabed or reflecting from the sea surface (secondary arrivals) created "*higher received levels at 5-12.6 km than at ranges closer to the seismic sources*". Thus, "*if pulses with received levels in the range of 140-165 dB re. 1 μPa…are found to have negative effects on sperm whales…then animals in the Gulf of Mexico could be impacted at ranges of more than 10 km from seismic survey vessels, well beyond ranges predicted by [modelling] and beyond where visual observers on the source vessel can monitor effectively*". This casts doubt on previous assumptions that whales would move horizontally away from survey vessels: indeed, they might move vertically or even approach a vessel to avoid high sound levels. Accordingly, impacts could occur farther from the sound source than previously predicted by models. Also, higher levels of high frequency sound were received by the whales than expected. Although airguns predominantly produce sound below 250 Hz, significant sound energy was received at the surface above 500 Hz. The high frequency sound appears to be transferred and filtered, travelling along near the surface in stratified waters. This means that "*even animals with poor low-frequency hearing (for example, dolphins and other small odontocetes) could potentially detect and be affected by* [seismic surveys]". Also, although sperm whales may pass through a layer of higher frequencies when surfacing, "*some species, such as pelagic dolphins, will likely be more exposed to the high frequency components, because they spend time travelling and socializing near the surface*". Thus, seismic surveys could affect high-frequency sensitive species (*e.g*., odontocetes) more than previously thought. Finally, in terms of exposure levels, sperm whales received sound levels of up to 162 dB (re 1 μPa (pp)) when between 4 and 12 km from the seismic survey vessel.

(SOURCE: Madsen, P.T., Johnson, M., Miller, P.J.O., Aguilar Soto, N., Lynch, J. and Tyack, P. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *J. Acoust. Soc. Amer.* 120: 2366-2379; DeRuiter, S.L., Tyack, P.L., Lin, Y.-T., Newhall, A.E., Lynch, J.F. and Miller, P.J.O. 2006. Modelling acoustic propagation of airgun array pulses recorded on tagged sperm whales (*Physeter macrocephalus*). *J. Acoust. Soc. Amer.* 120: 4100-4114)

SEISMIC SURVEY INTENSITY CORRELATED WITH REDUCED CETACEAN DIVERSITY

Cetacean diversity off the coast of Brazil dropped from 1994 to 2004, with a conspicuous decrease in 2000-2001. A proposed cause was an increase in seismic surveys there; significantly more surveys were conducted in 2000-2001 than in previous or subsequent years. There was a significant correlation between increasing numbers of seismic surveys and decreasing whale diversity. Other oceanographic parameters – temperature, salinity and density – showed no relationship to the decline. The authors suggested that non-resident, transient or more mobile species may be displaced from Brazilian waters during seismic surveys.

(SOURCE: Parente, C.L., de Araújo, J.P. and de Araújo, M.E. 2007. Diversity of cetaceans as a tool in monitoring environmental impacts of seismic surveys. *Biota. Neotrop.* 7: 1-7)

Shipping

REACTION OF A BEAKED WHALE TO SHIPPING NOISE

A tagged Cuvier's beaked whale changed its behaviour when a ship passed overhead, *i.e*., "*elevated received noise levels…from a passing ship coincided with an unusual foraging dive*". During the dive the animal received broadband sound at 136 dB re 1 μPa, at a minimum of 700 m from the vessel. Levels of received mid-frequency sound were 117 dB re 1 μPa when the ship passed (as opposed to a background mean of 93 dB re 1 μPa during other dives). During this disturbed dive, the whale increased its click-sound level by 15 dB, perhaps to offset acoustic masking effects of the ship. The disturbed dive was also shorter than other dives (42 minutes versus 57 minutes), less time was spent vocalising and the number of buzzes (sound associated with catching prey) was lower. The authors considered that this led to *"a reduction in foraging efficiency of more than 50% for this dive as compared to the other dives".* Although this whale may have been habituated to shipping noise, its reaction demonstrated that such animals *"may not habituate to the elevated noise levels from such a close approach".* This was the first observation of an effect from shipping traffic on beaked whales. Frequent disturbances of this nature (50% lower foraging efficiency) could have a biologically significant impact.

(SOURCE: Aguilar Soto, N., Johnson, M., Madsen, P.T., Tyack, P.L., Bocconcelli, A., and Borsani. J.F. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Mar. Mamm. Sci.* 22: 690-699)

Sonar

BEAKED WHALE DIVING SUGGESTS SONAR-INDUCED STRANDINGS RESULT FROM BEHAVIOURAL CHANGE

Fat emboli and lesions suggestive of 'the bends' have been detected in beaked whales that have stranded coincident with sonar-using activities. These lesions may reflect supersaturated levels of nitrogen in the blood stream. Tagged Cuvier's and Blainville's beaked whales had average foraging dive depths that "*were deeper…and longer…than reported for any other air breathing species*". The whales ascended to the surface slowly and silently, and there was a long interval (more than one hour) between deep dives. Deep dives were followed by a series of shallow dives without foraging. The nature of these shallow dives makes it unlikely that they are for 'recompression' (as human scuba divers sometimes do in emergencies to equilibrate dissolved gases in the blood). The researchers "*infer that* [beaked whale] *natural diving behavior is inconsistent with known problems of acute nitrogen supersaturation and embolism*" and that "*decompression problems are more likely to result from an abnormal behavioural response to sonar*", *i.e*., "*repeated dives shallower than the depth of lung collapse* [~100 m]".

(SOURCES: Tyack, P.L., Johnson, M., Aguilar Soto, N., Starless, A. and Madsen, P.T. 2006. Extreme diving of beaked whales. *J. Expert. Biol.* 209: 4238-4253; Rommel, S.A., Costidas, A.M., Fernandez, A., Jepson, P.D., Pabst, D.A., McLellan, W.W., Houser, D.S., Cranford, T.W. Van Helden, A.L., Allen, D.M. and Barros, N.B. 2006. Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding. *J. Cet. Res. Manage.* 7:189-209)

A SERIES OF UNUSUAL STRANDINGS IN TAIWAN

Several unusual stranding events in Taiwan in 2004 and 2005 co-occurred with military activities. In February 2004, a joint US/Philippines military exercise began in waters 100 miles south of Taiwan. The day after the exercise began at least nine short-finned pilot whales (*G. macrorhynchus*) stranded on the southeast coast of Taiwan. A week later, a ginkgo-toothed beaked whale (*M. ginkgodens*) stranded on the southwest coast. The latter had internal injuries suggestive of acoustic or impulsive-induced trauma. A striped dolphin stranded two days later. The exercise ended in early March and on the same day a mass stranding of short-finned pilot whales occurred in neighbouring China, followed by another stranding three days later. Before 2004, there had been only two confirmed strandings of short-finned pilot whales in Taiwan. In February the following year, two mass stranding events of live pygmy killer whales (*Feresa attenuata*) in southwest coastal areas occurred, along with a milling event wherein another group entered a shallow coastal harbour. Two Risso's dolphins (*Grampus griseus*) also stranded. Examined animals displayed signs of acoustic trauma. Between 19 July and 13 August 2005, there were 22 strandings events involving several species (including dwarf sperm whale [*K. simus*], pantropical spotted dolphin [*S. attenuata*], striped dolphin and Blainville's and Longman's beaked whales [*Indopacetus pacificus*]); 25 animals were reported for (mostly) the northern coast of Taiwan. During July, a naval exercise was being conducted by the Chinese military in the East China Sea, and in August, a joint Japanese/ US navy exercise took place. This is the greatest rate of cetacean strandings ever recorded in Taiwan, including strandings of rarely found species such as striped dolphins. Interestingly, many of the strandings were deep diving pelagic species. Moreover, five of six examined carcasses had 'bubbles' in tissues, a symptom associated with sonar-induced mortality. Other possible sources of underwater noise or possible stranding-inducing factors were investigated (typhoons, underwater earthquakes and seismic surveys), but could not account for the unusual pattern of strandings. Navy sonar and/or live ammunition exercises were considered to be plausible causes for many of the stranding events: the ginkgo-toothed whale showed evidence of acoustic trauma at a time when military exercises were being conducted. Carcasses need to be thoroughly examined to determine likely causes of death.

(SOURCE: Wang, J.Y. and Yang, S.-C. 2006. Unusual cetacean stranding events of Taiwan in 2004 and 2005. *J. Cet. Res. Manage.* 8: 283-292)

General

IMPORTANT ENVIRONMENTAL QUESTIONS ASKED BY POLICY MAKERS

In the United Kingdom, 100 key conservation and environmental questions were identified that policy makers urgently need answered. Many were related to the marine environment and similar to questions asked by members of the IWC Scientific Committee (SC) and Commissioners.

Habitat degradation:

"*What measure of habitat condition should we use to measure habitat change*…?"

"*How long does seabed take to recover from disturbances such as dredging, wind-farm construction and oil and gas extraction*?"

Fisheries and ecosystem effects:

"*What are the direct (catch) and indirect (food supplementation by discards, prey depletion) impacts of commercial fishing on cetaceans and seabirds*?"

Pollutants, both synthetic and biological:

"*What impact does plastic-derived litter have on the marine environment*?"

"*What are the ecological impacts of faecal matter, pesticides and undigested food flows from aquaculture*?"

Protected areas:

"*How large should marine protected areas be…?"*

"*What will be the impact of marine protected areas on wide ranging migratory species…?*"

Climate change:

"*How will acidification of surface water from rising CO_2 concentrations affect planktonic productivity and other marine organisms*?"

"*Which species are likely to be the best indicators of the effects of climate change on natural communities*?"

"*Which habitats and species might we lose completely…because of climate change*?"

"*What time lags can be expected between climate change and ecological change*?"

"*How can climate change interact with other ecological pressures (e.g., invasive species and habitat fragmentation) to create synergistic effects*?"

"*How well suited is the current…protected area system for conserving biodiversity in the face of climate change, and how can it be enhanced in light of this*?"

"*How will changes to oceanographic conditions as the result of climate change affect marine ecosystems?"*

(SOURCE: Sutherland, W.J., Armstrong-Brown, S., Armsworth, P.R., Brereton, T., Brickland, J., Campbell, C.D., Chamberlain, D.E., Cooke, A.I., Dulvy, N.K., Dusic, N.R., Fitton, M. Freckleton, R.P., Godfray, H.C.J., Grout, N., Harvey, H.J., Hedley, C., Hopkins, J.J., Kift, N.B., Kirby, J., Kunin, W.E., MacDonald, D.W., Marker, B., Naura, M., Neale, A.R., Oliver, T., Osborn, D., Pullin, A.S., Shardlow, M.E.A., Showler, D.A., Smith, P.L., Smithers, R.J., Solandt, J-L., Spencer, J., Spray, C.J., Thomas, C.D., Thompson, J., Webb, S.E., Yalden, D.W., and Watkinson, A.R. 2006. The identification of 100 ecological questions of high policy relevance in the UK. *J. Appl. Ecol.* 43: 617-627)

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Appendix 1

GLOSSARY

SPECIES GLOSSARY

Antarctic minke whale	*Balaenoptera bonaerensis*
Beluga whale	*Delphinapterus leucas*
Blainville's beaked whale	*Mesoplodon densirostris*
Bowhead whale	*Balaena mysticetus*
Common bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Common minke whale	*Balaenoptera acutorostrata*
Cuvier's beaked whale	*Ziphius cavirostris*
Dwarf sperm whale	*Kogia sima*
Fin whale	*Balaenoptera physalus*
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*
Harbour porpoise	*Phocoena phocoena*
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*
Killer whale	*Orcinus orca*
Long-finned pilot whale	*Globicephala melas*
Longman's beaked whale	*Indopacetus pacificus*
North Atlantic right whale	*Eubalaena glacialis*
Pantropical spotted dolphin	*Stenella attenuata*
Pygmy killer whale	*Feresa attenuata*
Risso's dolphin	*Grampus griseus*
Short-finned pilot whale	*Globicephala macrorhynchus*
Sperm whale	*Physeter macrocephalus*
Spinner dolphin	*Stenella longirostris*
Striped dolphin	*Stenella coeruleoalba*
Vaquita	*Phocoena sinus*
California sea lion	*Zalophus californianus*
Loggerhead sea turtle	*Caretta caretta*
Bluefin tuna	*Thunnus thynnus*
Herring	*Clupea harengus*
Sand eel	*Ammodytes* spp.
Swordfish	*Xiphias gladius*
Tuna	*Thunnus* spp.

Element glossary

Cd	cadmium
Cu	copper
Hg	mercury
Pb	lead
Zn	zinc

Glossary of terms

Acoustic fats: Lipids in the lower jaw of toothed cetaceans, which receive and carry sound to the inner ear.

Aquaculture: Finfish or shellfish farming.

Aphotic zone: The region of the ocean where light does not penetrate.

Atypical mass stranding: A stranding of two or more animals, not a mother-calf pair, that occurs over an extended geographical area (in a relatively short period of time) instead of in a single location.

BDE-47: 2,2',4,4' tetrabromodiphenyl, a brominated flame retardant.

Bends (the): Potentially fatal human disorder (typically affecting scuba divers), also known as caisson disease or decompression sickness, caused by rapid release of nitrogen bubbles in tissues.

Biomarkers: A biological indicator, *e.g.,* blood chemical levels, of health status or pollutant level.

Biota: All living things in an ecosystem.

BPMO: Benzo(α)pyrene monoxigenase, an enzyme that metabolizes organic contaminants.

Brevetoxin: A class of dangerous neurotoxins produced during blooms (red tides) of certain algae.

Broadband: Capable of transmitting a wide range of frequencies.

Brominated: Containing the element bromine.

Congener: A term in chemistry that refers to one of many variants or configurations of a common chemical structure.

Cortisol: A hormone produced by the adrenal gland, involved in the stress response.

Cytokine: A type of protein in an organism's cells that is released as part of the immune response and whose action is similar to hormones.

dB: Decibel – a logarithmic measure of sound pressure level

DDE: The organochlorine dichlorodiphenyldichloroethylene, a product of the breakdown of DDT.

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

Diatom: Common type of phytoplankton, a one-celled alga encased in a silica cell wall. The species *Pseudo-nitzschia australis* produces domoic acid, which poisons mammals, causing paralysis and reproductive failure.

DMBP - Dimethyl bipyrrole

Domoic acid: See diatom.

Dry weight: Dry weight, as opposed to wet weight, is a basis of measurement whereby concentrations of a substance are compared with dry content (*i.e.,* all water is removed) of a material.

Elasmobranch: Sharks and rays.

Endocrine system: A system of ductless glands producing hormones that control and moderate metabolic processes in the body.

Endocrine disrupter: Any outside substance (chemical) that interferes with an organism's endocrine system.

Eutrophication: Input of nutrients into an aquatic system, typically associated with excessive plant growth and oxygen depletion.

Fluorinated: Containing the element fluorine.

HAB: Harmful algal bloom. Population explosion of certain phytoplankton species (algae) that produce toxic substances that can harm higher levels of the marine food chain and humans who consume contaminated seafood.

Halogenated: A compound with a halogen atom (*e.g.*, chlorine, bromine, iodine) attached.

HCB: Hexachlorobenzene, an environmentally persistent organochlorine pesticide.

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

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

Masking: A phenomenon wherein the frequency and intensity of ambient noise covers up or 'masks' a biologically important signal, making it undetectable by a receiver.

MeO-PBDE – Methoxylated polybrominated diphenyl ether.

µg: Microgram.

Milling event: When a group of cetaceans enters shallow water and begins to circle continually or move about haphazardly in a tightly packed group, with an occasional member breaking away and swimming toward the beach.

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.

MPBs – Methyl bipyrroles

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.

Ozone: O_3, a molecule naturally occurring in the upper atmosphere that filters ultraviolet radiation.

Pathogen: A disease-causing agent (*e.g.,* bacterium, virus).

PBDE: Polybrominated diphenyl ether, a brominated flame retardant.

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. PCB (CB-154) is 2,2',4,4',5,5'- hexachlorobiphenyl, one of the most prevalent PCB congeners.

Perfluorinated compounds: A class of environmentally persistent molecules with fluorine atoms attached, used in many industrial applications including fire-fighting foams, pesticides and surface coatings. See PFOS.

PFOS: Perfluorooctane sulfonate.

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

Purse seine: A large net used to encircle fish in open water, the bottom of which is then drawn together to enclose the fish.

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

Supersaturation: The state of a solution with more dissolved material than the solvent can normally hold.

Trophic cascade: Occurs when predators in a food chain suppress the abundance of their prey, thereby reducing predation pressure on the next lower trophic level. If a top predator is reduced or removed, a trophic cascade begins when its prey increases, suppressing the normal abundance of the next trophic level down.

Trophic level: Each level in a food chain, including decomposers, producers (photo- and chemo-synthesizers), and consumers.

Wet weight: See dry weight.