Appendix 2

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2005

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INTRODUCTION

The first edition 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 submission of the first SOCER at the 52nd Annual Meeting in Adelaide, Australia, and "request[ed] the annual submission of this report to the Commission". Previous SOCERs have focused on the Atlantic Ocean, the Mediterranean Sea, and the Pacific Ocean. SC/57/E8 (SOCER 2005) focuses on the Arctic and Southern Ocean (polar) regions, summarising key papers and articles that have been published in 2003, 2004, and to date in 2005.

ARCTIC

Habitat protection/degradation

Arctic ozone decimated by solar storms

Satellite data showed that a record discharge of charged particles from the sun in October and November 2003 destroyed large amounts of ozone. Electrons from the sun ionized nitrogen, which in turn formed nitrogen oxides with CFC-like effects, destroying an estimated 60% of the ozone above the Arctic during spring 2004. Ozone levels remained low until July 2004.

(SOURCE: Randall, C.E., Harvey, V.L., Manney, G.L., Orsolini, Y., Codrescu, M., Sioris, C., Brohede, S., Haley, C.S., Gordley, L.L., Zawodny, J.M., and Russell, J.M. 2005. Stratospheric effects of energetic particle precipitation in 2003–2004. *Geophys. Res. Lett.* 32: L05802, doi:10.1029/ 2004GL022003)

Chemical pollution

Radioactive contamination of the Arctic Ocean

One of the latest Arctic Ocean surveys by the Swedish Polar Secretariat examined the concentrations of iodine-129 from the Norwegian coast to the North Pole. This radioactive component of nuclear fuel waste is released from nuclear processing facilities at La Hague, France, and Sellafield, UK. The study reveals a two-fold increase in the upper 1000 m since 1996 and predicts another doubling in the Arctic Ocean between 2001 and 2006. This demonstrates that radioactive contaminants, as with other pollutants produced in temperate zones, make their way to and become concentrated in ecologically sensitive waters of polar regions.

(SOURCE: Alfimov V., Aldahan A., Possnert G., and Winsor P. 2004. Anthropogenic iodine-129 in seawater along a transect from the Norwegian coastal current to the North Pole. *Mar. Poll. Bull*. 49: 1097-1104)

Factors influencing bioaccumulation of persistent organic pollutants in Arctic food webs

The Arctic ecosystem has a number of unique attributes, including long food chains, reduced diversity of species, similar food webs across the entire region, and limited influence from pollution point sources. Organochlorine concentrations and bioaccumulation in Arctic marine biota are influenced by lipid content, body size, age, gender, reproduction, habitat use, migration, biotransformation, seasonal changes in habitat conditions, feeding ecology, and trophic position. Diet or trophic level is the dominant factor influencing organochlorine concentrations and dynamics in seabirds and marine mammals, although biotransformation can significantly influence contaminants such as hexachlorocyclohexane isomers. Although models developed to assess organochlorine dynamics in aquatic food webs have included biological variables (*e.g.*, lipid content, feeding rate, diet composition, growth rate), these models are all highly simplified. This reduces the biological validity of the models and may be particularly problematic in a highly seasonal environment, such as the Arctic.

(SOURCE: Borga, K., Fisk, A.T., Hoekstra, P.F., and Muir, D.C.G. 2004. Biological and chemical factors of importance in the bioaccumulation and trophic transfer of persistent organochlorine contaminants in arctic marine food webs. *Environ. Toxicol. Chem.* 23(10):2367-85

Levels of contaminants in Arctic cetaceans

The organochlorine levels in 75 harbour porpoises from Greenland were generally found to be low. However, some harbour porpoises in northern Norway, some resident killer whales and all transient killer whales in Alaska, and some long-finned pilot whales in the Faeroes display levels of PCBs that have induced immunosuppression and reproductive failure in other mammalian species. Reproduction in fish-eating marine mammals such as minke whales, belugas, narwhals, long-finned pilot whales and harbour porpoises may be affected as the result of consuming PCB-contaminated fish. Killer whales consuming contaminated marine mammals may exhibit PCB-related reproductive abnormalities. Contaminant levels (especially PCBs, DDT and dioxin-like substances) in cetacean prey species (fish and molluscs) should be considered and monitored when managing and issuing guidelines to protect marine species.

Maximum contaminant levels

Mature male harbour porpoises from Nuuk, Greenland (ng.g^{-1} lipid weight) HCB: 300; ΣDDT: 5780; ΣPCB: 3750

(SOURCES: Borrell, A., Aguilar, A., Lockyer, C., Heide-Jorgensen, M.P. and Jensen, J. 2004. Organochlorine residues in harbour porpoises from southwest Greenland. *Environ. Pollut.* 128: 381-391; De Wit, C., Fish, A., Hobbs, K., Muir, O., Gabrielsen, G., Kallenborn, R., Krahn, M.M., Norstrom, R. and Skaare, J. 2004. *AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic.* Arctic Monitoring and Assessment Program, Oslo Norway)

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Contamination trends in West Greenland narwhals

A total of 150 narwhals harvested in subsistence hunts were analysed for organochlorine and heavy metal contamination. Cadmium, selenium and mercury levels increased in animals during the first 3 to 4 years of life, after which no trend was observed. Females tended to have higher heavy metal contaminant loads than males. Females showed decreases in organochlorine levels for their first 8-10 years of life, but levels increased after 10 years of age. Male organochlorine levels increased in the first few years; levels tended to be stable after that. Levels of organochlorines in western Greenland were considered to be similar to animals in the Canadian Arctic, but half of the levels recorded in East Greenland and Svalbard.

Maximum contaminant levels

Mean narwhal liver values ($ng.g^{-1}$ wet weight) Cd: 39900; Hg: 16300; Se: 12000; Zn: 40000

Mean narwhal (7 yr. old males) blubber values ($ng.g^{-1}$ lipid weight) HCB: 1001; ΣHCH: 219; ΣCBH: 2376; ΣDDT: 4964; ΣPCB: 2160; ΣTOX: 5955

(SOURCE: Dietz, R., Riget, F., Hobson, K.A., Heide-Jørgensen, M.P., Møller, P. Cleeman, M. de Boer, J. and Glasius, M. 2004. Regional and inter annual patterns of heavy metals, organochlorines and stable isotopes in narwhals (*Monodon monoceros*) from West Greenland. *Sci. Total Environ.* 331: 83-105)

Recent increases in air-borne heavy metal pollution

A study on atmosphere-borne trace element contaminants in the Arctic troposphere determined that anthropogenic heavy metals such as lead, zinc and copper, as well as sea salt-associated sodium and magnesium, were highest in the winter and lowest in the summer. Elements carried in soil dust (aluminium, barium, calcium, iron and manganese) peak briefly in spring (April-May; due to long-range atmospheric transport of dust from Eurasian deserts) and in the autumn (September-October; due to locally windblown dust and soil). There were no long-term trends in sodium, manganese and calcium concentrations, but levels of soil-associated aluminium, iron and titanium have tended to decrease after 1995. Although there was a decrease in atmospheric lead, zinc, nickel and copper in the 1980s, this stabilised and levels started to increase after 1995. In a comparison of atmospheric contamination in Arctic regions, trace element levels in the eastern Russian Arctic were on average three to four times higher than levels recorded in Barrow, Alaska, and Alert, Canada, supporting a Eurasian source of atmospheric trace element pollution in the Arctic.

(SOURCE: Gong, S.L. and Barrie, L.A. 2005. Trends of heavy metal components in the Arctic aerosols and their relationship to the emissions in the Northern Hemisphere. *Sci. Total. Environ.* 342: 175-183)

Research into link between atmosphere and aquatic environment required

Most persistent organic pollutants (POPs) are transported to the Arctic by the atmosphere. The transport mechanisms involved are complicated, with trends and patterns in the Canadian Arctic probably differing from those in the European/eastern Arctic. The role of snow and ice – and the transfer of contaminants via river-ice to sea-ice and subsequent transport across the Arctic – distinguish the processes here from those in temperate regions. The roles of snow, ice and wind conditions in the fate of contaminants are still poorly understood and research is needed to shed light on the link between the atmosphere (the source) and the aquatic environment.

(SOURCE: Halsall, C.J. 2004. Investigating the occurrence of persistent organic pollutants (POPs) in the Arctic: their atmospheric behaviour and interaction with the seasonal snow pack. *Environ. Pollut.* 128: 163-175)

First record of polychlorinated naphthalenes (PCNs) in marine mammals in the Canadian Arctic

Polychlorinated naphthalenes (PCNs) are a group of 75 compounds manufactured as complex technical mixtures with past industrial applications. Samples of beluga blubber collected from subsistence hunts from Baffin Island, Canada, were analysed for polychlorinated naphthalenes (PCNs). Levels of toxic coplanar PCBs were also determined. Although concentrations of PCNs were less than 1% of the coplanar PCBs, they contributed to 11% of the toxicity (TEQ) of the sample. This is the first study to record this toxic class of anthropogenic compound in Arctic marine mammals.

Maximum contaminant levels

ΣPCN ($pg.g^{-1}$ lipid weight): 383; ΣCoplPCB ($ng.g^{-1}$ lipid weight): 317

(SOURCE: Helm, P.A., Bidleman, T.F., Stern, G.A. and Koczanski, K. 2002. Polychlorinated naphthalenes and coplanar biphenyls in beluga whales (*Delphinapterus leucas*) and ringed seal (*Phoca hispida*) from the eastern Canadian Arctic. *Environ. Pollut.* 119: 69-78)

High levels of polychlorinated naphthalenes (PCNs) in the Norwegian Arctic

The deposition and accumulation of persistent organic pollutants (POPs) in the Arctic snow pack are important steps in their transfer from the atmosphere to the marine environment. The levels of polychlorinated naphthalenes (PCNs) in the Norwegian Arctic greatly exceeded those in the Canadian Arctic and were within the upper ranges of the eastern Arctic Ocean. Snow densities had a considerable effect in explaining variation in the concentrations, with denser, aged snow having lower values. The high levels of PCNs, coupled with their dioxin-like toxicity, warrant further investigation into the fate of these chemicals in the Arctic.

(SOURCE: Herbert, B.M.J., Halsall, C.J., Villa, S., Fitzpatrick, L., Jones, K.C., Lee, R.G.M. and Kallenborn, R. 2005. Polychlorinated naphthalenes in air and snow in the Norwegian Arctic: a local source or an Eastern Arctic phenomenon? *Sci. Total Environ.*: in press)

Pollutants potentially differentiate Arctic minke whale stocks

The levels of persistent organochlorines (OCs) in the blubber of 155 minke whales from 7 management regions (IWC 'small areas') in the European Arctic revealed a general increase from west to east. Minke whales from the Barents Sea, for example, had significantly higher levels of OCs than those from several other regions, including the North Sea. The distinction of the western Greenland minkes from other IWC-defined stocks in northern European waters agrees with findings from genetic and other studies. On the other hand, the general similarity in mean levels of PCBs, DDT and others suggest that the whales are quite mobile and may feed in multiple areas. The distinct differences in certain OC compounds illustrate the potential of pollutant levels in helping to distinguish whale stocks.

Maximum contaminant levels

Arctic minke whale ($ng.g^{-1}$ lipid weight) HCB: 544; ΣCHL: 2110; ΣDDT: 6280; ΣHCH: 497; ΣPCB: 22800

(SOURCE: Hobbs, K.E., Muir, D.C.G., Born, E.W. Dietz, R., Haug, T., Metcalfe, T., Metcalfe, C. and Øien, N. 2003. Levels and patterns of persistent organochlorines in minke whale (*Balaenoptera acutorostrata*) stocks from the North Atlantic and European Arctic. *Environ. Pollut.* 121: 239-252)

Relatively low levels of organochlorines in Alaskan bowheads, higher levels in belugas

Bowhead whale tissues and uncooked maktak (skin and blubber) were collected during subsistence hunts at Barrow, Alaska from 1997 to 1999. Concentrations of organochlorines in these tissues were low compared to other marine mammals, due to the lower trophic status of this species. There were no statistical differences in contaminant levels between most tissues, although HCH was higher in heart and diaphragm tissues. Organochlorine levels were also analysed in samples from bowhead and beluga whales collected during subsistence hunts in 1999 and 2000. Levels of contamination in beluga whales were greater than in bowhead whales, which was attributed to belugas occupying a higher trophic level. When compared to contaminant levels in prey species, contaminant levels in beluga blubber were greater by a factor of up to 46.5 times (this maximum was for DDE – for PCBs, the factor was 24.4; for DDT, 23.0; for chlordane, 13.5; for chlorobenzene, 4.3; and for HCH, 3.7).

Maximum contaminant levels

Blubber ($ng.g^{-1}$ wet weight) HCB: 273; ΣCHL: 701; ΣDDT: 1925; ΣHCH: 763; ΣPCB: 1305

Mean contaminant levels

Beluga ($ng.g^{-1}$ lipid weight) ΣClBz: 330; ΣHCH: 224; ΣCHL: 1320; ΣDDT: 1979; ΣPCB: 3305

Bowhead ($ng.g^{-1}$ lipid weight) ΣClBz: 196; ΣHCH: 282; ΣCHL: 1260; ΣDDT: 437; ΣPCB: 541

(SOURCE: Hoekstra, P.F. O'Hara, T.M., Backus, S.M., Hanns C., and Muir, D.C.G. 2005. Concentrations of persistent organochlorine contaminants in bowhead whale tissues and other biota from northern Alaska: implications for human exposure from a subsistence diet. *Environ. Res.*: in press; Hoekstra, P.F., O'Hara, T.M., Fisk, A.T., Borgå, K., Solomon, K.R. and Muir D.C.G. 2003. Trophic transfer of persistent organochlorine contaminants (OCs) within an Arctic marine food web from the southern Beaufort-Chukchi Seas near Barrow, Alaska. *Environ. Pollut.* 124: 497-507)

Organochlorines concentrated along an Arctic marine food web

The biomagnification of persistent organochlorine contaminants (OCs) along the Arctic marine food web is promoted by the efficient transfer of lipids and the nutritional demands of higher level mammalian predators. The concentration of certain OCs increased along a food web in the Southern Beaufort-Chukchi Seas and was significantly higher in cetaceans, such as the bowhead and beluga whales, than in fish. The values were consistent with those reported from the Canadian Arctic and temperate food webs, but not with those from the Barents and White Seas. This suggests that the variability is due to differences in contaminant exposure, underlining the importance of examining pollution exposure and risks on a regional basis.

(SOURCE: Hoekstra, P.F., O'Hara, T.M., Fisk, A.T., Borga, K., Solomon, K.R. and Muir, D.C.G. 2003. Trophic transfer of persistent organochlorine contaminants (OCs) within an Arctic marine food web from the southern Beaufort-Chukchi Seas. *Environ. Pollut.* 124: 509-522)

Global atmospheric patterns necessary to explain transport of pollutants to Arctic

Several classes of persistent organic pollutants (POPs) were examined in the air at Canadian and Russian Arctic sites between 1992 and 2001. One site showed a decline of organochlorines (OCs) and particulate polycyclic aromatic hydrocarbons (PAHs); the latter was attributed to the collapse of industrial activity in the former Soviet Union between 1991 and 1995. A seasonality of concentrations, with recurring elevated levels in spring, was recorded. The air concentrations were influenced by two climate variation patterns, the North Atlantic Oscillation (NAO) and the Pacific North American (PNA) pattern. In the future, planetary atmospheric patterns must be taken into account in the global prediction and modelling of POPs.

(SOURCE: Hung, H., Blanchard, P., Halsall, C.J., Bidleman, T.F., Stern, G.A., Fellin, P., Muir, D.C.G., Barrie, L.A., Jantunen, L.M., Helm, P.A. and Konoplev, A. 2005. Temporal and spatial variabilities of atmospheric polychlorinated biphenyls (PCBs), organochlorine (OC) pesticides and polycyclic aromatic hydrocarbons (PAHs) in the Canadian Arctic: Results from a decade of monitoring. *Sci. Total Environ.*: in press)

Exponential increase of flame retardants in Canadian beluga whales

The levels of polybrominated diphenyl ethers (PBDEs), used in flame retardants, showed a significant exponential increase between 1988 and 1999 in beluga whales from the St. Lawrence Estuary in Canada. Although the levels are still below those reported for other marine mammals, these belugas doubled their blubber concentration every 3 years. These are among the fastest rates of increase measured in wildlife. This accumulation was recorded in both males and females, and ongoing strong uptake apparently masks the elimination by females via milk to suckling calves. In a population that has declined to 1000 individuals, *i.e.*, by about 80-90% of its estimated size in 1885, these developments warrant continued close monitoring.

(SOURCE: Lebeuf, M., Goutex, B., Measures, L. and Trottier, S. 2004. Levels and temporal trends (1988-1999) of polybromilated diphenyl ethers in beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Canada. *Environ. Sci. Technol.* 38: 2971-2977)

Persistent organochlorine pesticides in the Arctic

The Arctic has become a sink for various anthropogenic compounds such as persistent organochlorine (OCs), largely after long-range transport from temperate environments. Using HCH as an example, this study reveals that the pathways of different forms of HCH to the Arctic differ; for example, α-HCH is transported via the atmosphere and β-HCH via ocean currents. While α-HCH concentrations in beluga whales from Cumberland Sound are decreasing, β-HCH concentrations are increasing. Bowhead whales exhibit a reversal in their blubber α/β-HCH ratios as they migrate and feed annually between the Bering and the Beaufort Sea. These differences underline the complexity of chemical pollution in the Arctic and the need for detailed research to provide adequate databases.

(SOURCE: Li, Y.F. and MacDonald, R.W. 2005. Sources and pathways of selected organochlorine pesticides to the Arctic and the effect of pathway divergence on HCH trends in biota: a review. *Sci. Total Environ.* 342: 87-106)

Modelling the transport of PCBs to the Arctic

This study selected four of the more than 200 different forms of PCBs for a modelling approach. Contamination of the Arctic takes place from two sources, northwest Europe and America (30% and 19%, respectively), but at different seasons. American sources penetrate the Arctic in May, European sources in January, in line with the annual atmospheric circulation patterns in the Arctic. Interestingly, the model considers sea ice coverage: melting snow and ice passes contaminants into the aquatic environment. Thus, warmer temperatures associated with climate change could accelerate the input of PCBs into Arctic marine food chains.

(SOURCE: Malanichev, A., Mantseva, E., Shatalov, V., Strukov, B. and Vulykh, N. 2004. Numerical evaluation of the PCBs transport over the Northern Hemisphere. *Environ. Pollut.* 128: 279-289)

New class of persistent contaminants in the Arctic food chain

A new class of persistent fluorinated contaminants, in particular perfluoroctane sulfonate (PFOS), has been detected for the first time in a wide range of animals in the Canadian Arctic, from fish and common loons to polar bears and ringed seals. PFOS levels were more substantial in polar bears than PCB levels. Mammals feeding at higher trophic levels had higher concentrations. Future studies should examine the toxicities of this novel group of compounds. Their detection in seals suggests that Arctic cetaceans also have these contaminants in their tissues.

Maximum contaminant levels

PFOS ($ng.g^{-1}$) polar bears >4000; ringed seals 37

(SOURCE: Martin, J.W., Southwick, M.M., Braune, B.M., Hoekstra, P.F., Muir, D.C.G. and Mabury, S.A. 2004. Identification of long-chain perfluorinated acids in biota from the Canadian Arctic. *Environ. Sci. Technol.* 38: 373-380)

Review of pollutant trends in Greenland

A study that reviewed and compared organic and inorganic contaminant data from Greenland determined that mercury levels tended to be greater in marine biota from east Greenland, whilst cadmium levels were greatest in western Greenland. Although there were not enough data to analyse long-term temporal trends in cetaceans, generally ringed seals have increasing levels of mercury, but decreasing levels of cadmium, contamination since the 1980s. Typically, marine species also had greater PCB, DDT and HCH concentrations in eastern, compared to western, Greenland. PCB levels in polar bears in east Greenland have decreased substantially in the last decade, as have HCH levels in seals generally, but DDT levels in seals have increased in western Greenland. Similar trends may be likely in other marine mammals such as cetaceans.

(SOURCE: Riget, F., Dietz, R., Vorkamp, K., Johansen, P. and Muir, D. 2004. Levels of spatial and temporal trends of contaminants in Greenland biota: an updated review. *Sci. Total Environ.* 331: 29-52)

Naturally occurring organohalogens in bowhead and beluga whales

Four halogenated dimethyl bipyrroles (HDBPs), which are possibly naturally occurring, were evaluated in marine mammal blubber from a variety of species, including Arctic beluga and bowhead whales. Levels of pollutants in Alaskan belugas were higher than in animals from Canada, which in turn were higher than concentrations in Svalbard. Higher levels were deemed to be the result of being closer to a North Pacific source of these contaminants. Levels in bowhead whales in the Beaufort Sea were considerably lower.

Maximum contaminant levels

ΣHDBP ($ng.g^{-1}$ lipid weight) beluga, Alaska: 99.2; Canada: 54.4; Svalbard: 6.1; bowhead: 1.8

(SOURCE: Tittlemier, S., Borrell, A., Duffe, J., Duignan, P.J., Fair, P., Hall, A., Hoekstra, P., Kovacs, K.M., Krahn, M.M., Lebeuf, M., Lydersen, C., Muir, D., O'Hara, T., Olsson, M., Pranschke, J., Ross, P., Siebert, U., Stern, G., Tanabe, S. and Norstrom, R. 2002. Global distribution of halogenated dimethyl bipyrroles in marine mammal blubber. *Arch. Environ. Contam. Toxicol.* 43: 244 – 255)

Long chain perfluorinated acids found in beluga whales and narwhals

Samples of beluga whale and narwhal liver from animals harvested in subsistence hunts in Nunavut, Canada, were analysed for polyfluorinated contaminants: all fluorinated compounds investigated were found in these cetacean tissues. Samples of other biota from different trophic levels were also analysed; it was determined that PFOS biomagnifies, with approximately a threefold increase in contamination with increasing trophic level. This, therefore, adds another anthropogenic contaminant of concern that should be evaluated in Arctic cetaceans.

Maximum contaminant levels

Beluga ($ng.g^{-1}$ wet weight) PFOS: 15.8; PFOA: 2.8; N-EtPFOSA: 11.7; PFOSA: 48.4

Narwhal ($ng.g^{-1}$ wet weight) PFOS: 17.7; PFOA: 1.1; N-EtPFOSA: 6.9; PFOSA: 10.9

(SOURCE: Tomy, G.T., Budakowski, W., Halldorson, T., Helm, P.A., Stern, G.A., Friesen, K., Pepper, K., Tittlemier, S.A. and Fisk, A.T. 2004. Fluorinated organic compounds in an eastern Arctic marine food web. *Environ. Sci. Technol.* 38*:* 6475-6481)

Europe and Asia greatest contributors to Arctic HCH contamination

Researchers modelling the transport of α–HCH from temperate regions where the contaminant was produced to the Arctic determined that Europe and greater Asia (including China and southeast Asia) had the greatest impact on α–HCH in the Arctic, with high levels of emission of this contaminant in Asia and moderate levels of emission in Europe, but greater transferability of the contaminant in the latter region into the Arctic.

(SOURCE: Toose, L., Woodfine, D.G., MacLeod, M., Mackay, D. and Gouin, J. 2004. BETR-World: a geographically explicit model of chemical fate: application to transport of α–HCH to the Arctic. *Environ. Pollut.* 128: 223-240)

Immunotoxic and hormone-disrupting PBDEs in Arctic cetaceans

Although levels were deemed to be relatively low, a study on polybrominated diphenylether (PBDE) contamination (primarily from brominated fire retardants) in Arctic marine mammals from Svalbard noted that beluga whales do display contamination by this chemical group despite being in a 'pristine' environment. Levels of these contaminants were higher than levels recorded in the Canadian Arctic (nine times higher in the case of contaminated juveniles). Belugas had higher contaminant loads than ringed seals feeding on similar prey, possibly due to an inability to metabolise these compounds. As PBDEs were seen to bioaccumulate in a similar fashion to PCBs and are known to have immunotoxic and endocrine-disrupting effects, and as they continue to be produced and used in increasing amounts, they will no doubt pose an increasing environmental threat for the Arctic and its wildlife.

Maximum contaminant levels

ΣPBDE ($ng.g^{-1}$ lipid weight) beluga calf: 279; beluga juvenile: 314

(SOURCE: Wolkers, H., Van Bavel, B., Derocher, A.E., Wiig, Ø., Kovacs, K.M., Lydersen, C., and Lindström, G. 2004. Congener-specific accumulation and food chain transfer of polybrominated diphenyl ethers in two Arctic food chains. *Environ. Sci. Technol.* 38: 1667-1674)

Disease and mortality events

Immune system of Arctic cetaceans impaired by PCBs

This study supports the theory that organochlorines (OCs), particularly polychlorinated biphenyls (PCBs), are increasingly a cofactor in the deaths of marine mammals. Examinations of the blood of beluga whales (and bottlenose dolphins) revealed that non-coplanar PCBs suppressed the immune response of cells, *i.e.*, their ability to digest extracellular molecules in a process known as phagocytosis. The results imply that wild populations of these cetaceans may be at risk of succumbing to normally non-threatening diseases because their immune systems may be compromised due to environmental contaminant exposure.

(SOURCE: Levin, M., Morsey, B., Mori, C. and De Guise, S. 2004. Specific non-coplanar PCB-mediated modulation of bottlenose dolphin and beluga whale phagocytosis upon in vitro exposure. *J. Toxicol. Environ. Health, Part A,* 67: 1517-1535)

Climate change

Arctic warming heralds global impacts

The Arctic is now experiencing some of the most rapid and severe climate change on earth. Over the next 100 years, climate change is expected to accelerate, contributing to many physical and ecological changes, some of which have already begun. Sea ice reduction, sea level rise, increased storms, and (at least temporarily) more productive marine fisheries may result in unpredictable changes in marine fauna distribution and population trends. The exact impact these significant and wide-ranging environmental changes will have on Arctic cetacean populations is unknown and may be less than for terrestrial and ice-dependent species, but food webs involving cetaceans will almost certainly be disrupted in various ways.

(SOURCE: ACIA. 2004. *Impacts of a Warming Arctic: Arctic Climate Impact Assessment*. Cambridge University Press, http://www.acia.uaf.edu)

High levels of warming and ice melting in the Arctic

According to satellite data, a high rate of warming has occurred over the Arctic region in the last two decades. Temperatures have increased 0.54^{o}C per decade over sea ice, 0.85 ^{o}C over Greenland, and 0.79 ^{o}C over North America, but there has been only a 0.14 ^{o}C decrease in temperature over Eurasia. Previous data based on satellite imagery underestimated the degree of warming by half. Due to changes in stratospheric temperature, ozone levels in the Arctic are also decreasing by approximately 1% a year. In addition, the region of melting ice on the Greenland ice sheet has increased by 17% between 1992 and 2002. Snow cover has also decreased in the Northern Hemisphere, at a rate of 2.6% per decade, and 15% of the Arctic tundra has been lost since the 1970s (an area three times the size of California). As 14% of the world's carbon is stored in the Arctic, reductions in permafrost, and the resulting release of stored greenhouse gases such as carbon dioxide and methane, are a cause for concern. With respect to cetaceans, the high rates of sea ice loss are particularly relevant – a 9.2% decrease in perennial sea ice per decade. It is also suggested that the upper water layers of the Arctic Ocean are 10% less saline than in the 1970s, the result of ice melting and increased river flows.

(SOURCE: Comiso, J.C. and Parkinson, C.L. 2004. Satellite-observed changes in the Arctic. *Phys. Today* 57:38-44)

Scientists to use submarine to investigate Greenland ice sheet

To investigate the underside of Greenland ice sheets and advance research on patterns of ice sheet melting and contributions to sea level rise, scientists are planning to use an automated submarine. This novel technique will hopefully address and clarify some of the issues involved in sea ice melting in the Arctic.

(SOURCE: Haag, A. 2004. Greenland ice sheet to get an underhand inspection. *Nature* 430: 955)

Greenland glacier rapidly increasing discharge

Scientists monitoring the flow of the Jakobshavn Isbræ glacier noticed an increase in flow from 5,700 m.yr^{-1} in 1992, to 9,400 m.yr^{-1} in 2000, to 12,600 m.yr^{-1} in 2003. Since 1997 the glacier has been thinning at a rate up to 15 m.yr^{-1}. This increased flow of glacier ice, and hence additional water, into the coastal waters of Greenland has implications for oceanographic conditions and may hasten sea level rises. The researchers note that the flow of the Jakobshavn Isbræ glacier has contributed to about 4% of the 20th century sea level rise, so its increased flow could have significant effects. The researchers also note the rapidity with which flow rate has increased.

(SOURCE: Joughin, I., Abdalati, W. and Fahnestock, M. 2004. Large fluctuations in speed on Greenland's Jakobshavn Isbræ glacier. *Science* 432: 608-610)

Arctic sea ice trends may impact narwhal

An analysis of narwhal habitat use in conjunction with data on sea ice trends was conducted to investigate possible impacts of global warming on narwhals. In particular the limited number of leads and cracks in ice in winter, in conjunction with localized decreasing trends in open water and high site fidelity, suggest that narwhals are very vulnerable to sea ice changes, including greater risks of sea ice entrapments. Researchers note that "[e]stimates of sustainable levels of exploitation should also include the risks of sudden large-scale mortalities on the wintering grounds".

(SOURCE: Laidre, K. and Heide-Jørgensen, M.P. 2005. Arctic sea ice trends and narwhal vulnerability. *Biol. Conserv.* 121: 509-517)

The Bering Sea is getting warmer

Starting in 1996, spring has consistently come earlier in the Bering Sea, and since 1976 there have been warmer summers. Air temperature records from St Paul Island also indicate air temperatures were warmer in the region in the last two decades, and the 20th century was warmer than the 19th century. The mean number of days during which there was more than 5% ice cover in the Bering Sea after 1 January has decreased from 130 days (1971 to 1976) to 67 days (1977 to 1989). The presence of sea ice is related to phytoplankton growth – when there is ice present after mid-March, phytoplankton blooms earlier (due to ice-phytoplankton associations); when no ice is present, phytoplankton blooms in May or June. A late bloom means more prey is available to pelagic species, but an early bloom favours benthic species as dying plankton falls to the seabed. This would be expected to cause a shift in the Bering Sea ecosystem and it was suggested that recent increases in pelagic walleye pollock and decreases in bottom-living Pacific cod are linked to these phytoplankton, and hence climatic changes. The data suggest that there is a climate-influenced shift and alteration in the Bering Sea ecosystem that could ultimately affect Arctic cetaceans.

(SOURCE: Overland, J.E. and Stabeno, P.J. 2004. Is the climate of the Bering Sea warming and affecting the ecosystem? *Eos* 85(33): 309-316)

Retreating glaciers in Alaska may cause increase in earthquakes

Researchers discovered decreases in average ice thickness of 1-5 m *per annum* in south central Alaska between 1995 and 2000. The losses of ice resulted in movements of underlying land and horizontal deformation of up to 4 cm *per annum*, in response to the loss of the overlying weight. The land deformation was such that changes in positions of specific sites could be measured by GPS. During the 20th century, this region has experienced losses in ice thickness of up to 1 km. It was also suggested that increasing seismic activity in the region is linked to the thinning ice cover. Both a decrease in ice and the potential for increased seismic activity may affect cetacean habitats, and in the case of earthquakes may cause increased exposure to tsunamis and to high source levels of noise.

(SOURCE: Sauber, J.M. and Molina, B.F. 2004. Glacier ice fluctuations and fault instability in tectonically active southern Alaska. *Global Planet.Change* 42: 279-293)

Global warming may cause Arctic ozone hole

Scientists argue that climatic changes resulting from global warming led to an unusually cold Arctic winter in 2004. Also greenhouse gases are believed to lead to colder temperatures in the stratosphere as more heat is locked near the surface, and less escapes to warm the upper atmosphere. This cold temperature is believed to have led to increases in cold temperature clouds (which form at temperatures <-80°C), upon whose surface CFC compounds can adhere, destroying ozone molecules. In some areas of the Arctic more than half of the atmospheric ozone molecules have been destroyed. Ozone loss in the Arctic is less severe than in the colder Antarctic, but researchers predict that an Arctic ozone hole could develop in the next two decades.

(SOURCE: Schiermeier, Q. 2005. Arctic trends scrutinized as chilly winter destroys ozone. *Science* 435: 6)

Arctic sea ice coverage at record low in 2002

Arctic sea ice extent and area in September 2002 reached their lowest levels recorded since 1978. These conditions likely resulted from anomalous warm southerly winds in spring and persistent low pressure and high temperatures over the Arctic Ocean in summer.

(SOURCE: Serreze, M.C., Maslanik, J.A., Scambos, T.A., Fetterer, F., Stroeve, J., Knowles, K., Fowler, C., Drobot, S., Barry, R.G., and Haran, T.M. 2003. A record minimum Arctic sea ice extent and area in 2002. *Geophys. Res. Lett.* 30:1110, doi:10.1029/2002GL016406)

Increased freshwater flow into the Arctic

Researchers have reported an increase in freshwater discharge in the Arctic of 1800 km^3 per year. The discharges increased threefold in the last 30 years of the 20th century. By comparing the discharge increases in a model that did, and a model that did not, incorporate greenhouse gas levels, researchers determined this increase in water discharge was definitely linked to greenhouse gas levels and global warming. Via their models, the researchers estimate the discharges will continue to increase until the year 2020. Although freshwater discharges will increase in both hemispheres, rates are higher, due to high levels of warming, in the Arctic. This additional input of freshwater could have major impacts on oceanic circulatory systems, such as the shut down of Thermohaline Circulation in the Atlantic, which in turn could have major impacts on not just the world's marine ecosystems, but also the global climate.

(SOURCE: Wu, P., Wood, R. and Stott P. 2005. Human influence on increasing Arctic river discharges. *Geophys. Res. Lett.* 32*:* L02703; Stocker, T.F. and Raible, C.C. 2005. Water cycle shifts gear. *Nature* 434: 830-833)

SOUTHERN OCEAN

Habitat protection/degradation

Premature halt in recovery of marine mammals may be due to damaged ecosystems

Antarctic fur seals numbers, after a previously high period of growth, are now stabilising (reaching carrying capacity), despite numbers being an order of magnitude lower than pre-exploitation levels. The authors suggest that "the near-extinction of parts of various components of the [Antarctic] ecosystem" and population stabilisations are a response to extensive exploitation of marine resources in the Antarctic region. The results of this study imply that lack of recovery in some cetacean populations is due to ecosystem degradation.

(SOURCE: Hucke-Gaete, R., Osman, L.P., Moreno, C.A. and Torres, D. 2004. Examining natural population growth from near extinction: the case of the Antarctic fur seal at the South Shetlands, Antarctica. *Polar Biol.* 27: 304-311)

Sewage pollution around Antarctic research stations

Sewage is not always treated efficiently at some Antarctic bases, and pathogens entering the marine environment "have the potential to infect and cause disease, or become part of the gut flora of local sea mammal and bird populations". A sewage treatment facility was installed at Rothera Research Station, a British base on Adelaide Island. As a result of the facility, the sewage plume (and extent of faecal bacteria) in coastal waters was reduced from over 800m, to less than 50m. Sewage treatment facilities are currently only present at a few Antarctic research bases and the author suggests that more should introduce such facilities to reduce human impacts on the otherwise pristine environment.

(SOURCE: Hughes, K.A. 2004. Reducing sewage pollution in the Antarctic marine environment using a sewage treatment plant. *Mar. Poll. Bull.* 49: 850-853)

IUCN Resolution calls for Antarctic marine protected areas

The 3rd IUCN Congress passed a resolution on Antarctica and the Southern Ocean that called for:

- All parties to the Antarctic treaty and CCAMLR to develop a network of protected areas with urgency being given to marine habitats, and particularly to provide protection to the Ross Sea with marine protected/special management areas;
- All parties to the Antarctic treaty to introduce an Antarctic tourism management scheme;
- CCAMLR members to develop and strengthen the precautionary management regime for krill to minimise the impact of krill fishing;
- The IUCN Director General to provide resources to actively support the establishment of Antarctic protected areas, to develop liability rules and procedures for environmental damage taking place in the Antarctic Treaty area and to ensure that cumulative environmental impacts are taken into account in decision making;
- The IUCN Director General to promote ways to enforce existing measures that manage and protect the Antarctic ecosystem;
- The IUCN Director General to assist in raising public awareness of Antarctic environmental issues.

(SOURCE: IUCN 2004. CGR3. RES029-REV1. *Antarctica and the Southern Ocean*. 3rd IUCN Congress, 17-25 November 2004, Bangkok, Thailand)

Exotic species in the Southern Ocean

The introduction of non-indigenous species is a problem in many of the world's oceans and has been identified as a potential threat to Antarctic waters. The examination of vessels travelling between Hobart, Tasmania, and the Southern Ocean revealed the presence of known invasive species among the fouling communities that established themselves on the ships' hulls while at port over winter. The study shows that the global spread of invasive marine species is likely to exert an increasing influence on the biota of the Southern Ocean.

(SOURCE: Lewis, P.N., Hewitt, C.L., Riddle, M., and McMinn, A. 2003. Marine introductions in the Southern ocean: an unrecognized hazard to biodiversity. *Mar. Poll. Bull*. 46: 213-223)

Large ozone hole over Antarctic

The Antarctic ozone 'hole' in 2003 was the second largest ever observed (10.9 million square miles versus 11.5 million square miles in 2000). Chlorine- and bromine-containing compounds from human activity are considered to be the primary cause of ozone depletion. These ozone-depleting chemicals will remain active in the stratosphere for several decades despite international protocols that have greatly reduced their production and release. Prolonged exposure to ultraviolet B rays, which ozone normally blocks, has been linked to adverse biological effects on plants and animals; for example, on the plankton communities that form the base of the marine food chain in the Southern Ocean.

(SOURCE: Marine Pollution Bulletin News. 2003. *Mar. Poll. Bull*. 46: 1363)

Ultraviolet radiation damages Antarctic marine microbes

Researchers from the Australian Antarctic Division (AAD) have shown that ultraviolet B radiation (UVBR), beyond impacting phytoplankton, can damage or kill other microbes such as protozoa, bacteria and viruses. Thus, exposure to UVBR due to depletion of ozone in the stratosphere can change the marine microbial community. This impacts the abundance, size structure, palatability and nutritional quality of food within the food web in Antarctic waters.

(SOURCE: Marine Pollution Bulletin News. 2004. *Mar. Poll. Bull*. 49: 373)

Southern Ocean fishing pirates

Illegal fishing has taken a toll on certain fish populations in Antarctic and sub-Antarctic waters. Pirates are now being targeted by the Australian Government, which has committed nearly AU$90 million over 2 years to improve patrolling in the Southern Ocean and is seeking to secure an agreement with member nations of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). A publicly available, so-called 'ship-of-shame' register has been proposed to allow countries to identify vessels known to be engaged in illegal fishing activities.

(SOURCE: Marine Pollution Bulletin News. 2004. *Mar. Poll. Bull*. 49: 884)

Chemical pollution

Increasing levels of persistent organic pollutants in Antarctic organisms

Levels of persistent organic pollutants continue to increase in the Antarctic due to global redistribution and recent uses in the southern hemisphere. Top predators – Weddell seals and southern elephant seals – biomagnified persistent organic pollutants 30-160 fold relative to their krill prey. Future biomonitoring should include a range of mammal species due to the different ecology and metabolic abilities of each species.

(SOURCE: Goerke, H., Weber, K., Bornemann, H., Ramdohr, S., and Plotz, J.2004. Increasing levels and biomagnification of persistent organic pollutants (POPs) in Antarctic biota. *Mar. Poll. Bull.* 48: 295-302)

Banning TBT versus invasive species: an environmental quandary

As a result of the discovery of high levels of TBT in Antarctic sediments (see Negri *et al.* 2004 below), it has been proposed that TBT anti-fouling paints be banned for Antarctic vessels. However, concerns have also been raised about the possible introduction of invasive species on hulls without anti-fouling treatments, particularly as Antarctic vessels suffer hull abrasion from sea ice. The authors note that there may be particular problems with vessels transiting in other regions of the world and then visiting Antarctica or sub-Antarctic islands briefly (such as re-supply vessels and tourism-related vessels).

(SOURCE: Lewis, P.N., Riddle, M.J. and Hewitt, C.L. 2004. Management of exogenous threats to Antarctica and the sub-Antarctic Islands: balancing risks from TBT and non-indigenous marine organisms. *Mar. Poll. Bull.* 49: 999-1005)

Mercury in the Southern Ocean marine food chain

Antarctic marine biota is generally believed to have relatively low levels of anthropogenic contaminants. Although mantle tissue from deepwater-dwelling warty squid from the Southern Ocean had relatively low levels of mercury, levels in Patagonian toothfish from Macquarie Island were relatively high. Considering that the fish analysed were juveniles and that mercury bioaccumulates, levels in adult fish could be even higher. Mercury levels in some fish were higher than some recommended human health limits. Elevated mercury levels in such fish species is a cause for concern for marine mammals that may be ingesting contaminated species.

Maximum contaminant levels

Mercury ($ng.g^{-1}$): 590

(SOURCE: McArthur, T., Butler, E.C.V. and Jackson, G.D. 2003. Mercury in the marine food chain in the Southern Ocean at Macquarie Island: an analysis of a top predator, Patagonian toothfish (*Dissostichus eleginoides*) and a mid-trophic species, the warty squid (*Moroteuthis ingens*). *Polar Biol.* 27: 1-5.

Status of organochlorines in the atmosphere of the Southern Ocean

Organochlorine (OC) levels measured during a Brazilian Antarctic Expedition in 1995 were compared with earlier data. Both HCH levels and DDT levels were 10 times lower than the previous data of 1987; in the case of DDT, this indicated that any new inputs of DDT have not reached the southwest Atlantic sector of the Antarctic region. Atmospheric PCB levels showed no significant temporal trend and have apparently not decreased rapidly in the last decades.

(SOURCE: Montone, R.C., Taniguchi, S., Boian, C., and Weber, R.R. 2005. PCBs and chlorinated pesticides (DDTs, HCHs and HCB) in the atmosphere of the southwest Atlantic and Antarctic oceans. *Mar. Poll. Bull.*: in press)

High levels of TBT in Antarctic marine sediments

Nearshore sediment samples were analysed for butyltin (BT) contaminations in the Ross Sea, Antarctica. Tributyltin (TBT) was the predominant contaminant, with levels at some sites considered to be high. The source of BTs could be anti-fouling paints abraded from the surface of ice-breaking ships or from the hulls of grounded vessels (see Lewis *et al.* 2004 above). This is the first time this pollutant, which has been linked to contaminant health risk concerns in cetaceans, has been recorded in the Antarctic.

Maximum contaminant levels

Total butyltin (ng $Sn.g^{-1}$ dry weight): 2290

(SOURCE: Negri, A.P., Hales, L.T., Battershill, C. Wolff, C. and Webster, N.S. 2004. TBT contamination identified in Antarctic marine sediments. *Mar. Poll. Bull*. 48: 1142-1144)

Some organochlorines at equilibrium, others increasing

Between 1987 and 1996, most persistent organic pollutant (POP) levels showed significant increases in benthos-feeding and fish-feeding fish, while they remained nearly constant or increased less in a krill feeder. Hence, the former species represent indicator species for changing POP levels in Antarctica. By comparison with trends in the northern hemisphere, global distribution of HCB appears to be more uniform. Changing levels of other POPs reflect global redistribution and increasing transfer to Southern Ocean waters, probably due to recent usage in the southern hemisphere and climate change.

Ratios (1996/1987) of average concentrations

PCB 138: 0.7; PCB 180: 1.7; PCB 153: 1.8; HCB: 0.8; p,p'-DDE: 2.0; nonachlor III: 2.9; trans-nonachlor: 3.3; mirex: 6.7.

(SOURCE: Weber, K and Goerke, H. 2003. Persistent organic pollutants (POPs) in Antarctic fish: levels, patterns, changes. *Chemosphere* 53: 667-678)

Chemical contamination around Antarctic bases

Several studies examined contaminant levels around Antarctic bases held by New Zealand, Brazil, and Australia. Several areas had been contaminated by minor fuel spills, and elevated levels of silver, cadmium, lead, vanadium, boron, molybdenum, nickel, copper, cobalt, phosphate, manganese, magnesium, tin, iron and zinc were found in soils and sediments near the bases. Sources included paints, sewage, and contaminant-laced melt water. These studies show the potential for local contamination of the polar environment around Antarctic bases and how this contamination could affect coastal marine species and coastal marine habitats.

(SOURCES: Webster, J., Webster, K., Nelson, P. and Waterhouse, E. 2003. The behaviour of residual contaminants at a former station site, Antarctica. *Environ. Pollut*. 123: 163-179; Santos, I.R., Silva-Filho, E.V., Shaefer, C.E.G.R., Albuquerque-Filho, M.R. and Campos, L.S. 2005. Heavy metal contamination in coastal sediments and soils near the Brazilian Antarctic Station, King George Island. *Mar. Poll. Bull*. 50: 185-194; Stark, J.S., Snape, I., Riddle, M.J. and Stark, S.C. 2004. Constraints on spatial variability in soft-sediment communities affected by contamination from an Antarctic waste disposal site. *Mar. Poll. Bull.* 50: 276-290; and Cunningham, L., Snape, I., Stark, J.S. and Riddle, M.J. 2005. Benthic diatom community response to environmental variables and metal concentrations in a contaminated bay adjacent to Casey Station, Antarctica. *Mar. Poll. Bull*. 50: 264-275)

Climate change

Massive decrease in krill levels may be due to global warming

Researchers compared Antarctic krill records gathered by nine countries, encompassing data from 12,000 net hauls collected during the period 1926-2003. The results showed an 80% decrease in krill abundance in the last 30 years. The researchers link the decline to loss of winter sea ice (under which krill over-winter) and also global warming. Such a massive reduction in krill stocks has significant implications for Antarctic cetaceans for whom kill is a major prey species. If global warming causes the loss of fast-ice in winter, depletion of the whales' prey base will increase.

(SOURCE: Atkinson, A., Siegel, V., Pakhomov, E., and Rothery, P. 2004. Long-term decline in krill stock and increase in salps within the Southern Ocean. *Nature* 432: 100-103)

Coastal Antarctic glaciers shrinking at an alarming rate

A new survey showed that nearly 90% of the 244 glaciers on the Antarctic Peninsula analysed in the study are losing snow and ice faster than they are being replaced. Researchers from the British-Antarctic and U.S. Geological Surveys compared 2,000 aerial photos of the glaciers taken in the 1940s against 100 recent satellite images. They discovered that the glaciers had grown until the middle of the 20th century, stabilized in the 1960s, and began retreating in the 1970s. The researchers noted that retreat of these glaciers has been rapidly accelerating. One prime example is the Sjogren Glacier, whose edge has moved inland by more than 13 km since 1993. Those glaciers that have not retreated (32) have been relatively few in number, and their advance has only been very limited (an average of 300 m), with the total glacial shrinkage overwhelming these small advances. The researchers primarily blame global warming for this ice retreat, but also note that other oceanographic and meteorological factors may contribute.

(SOURCE: Cook, A.J., Fox, A.J., Vaughan, D.G. and Ferrigno, J.G. 2005. Retreating glacier fronts on the Antarctic Peninsula over the past half-century. *Science* 308: 541-544)

East Antarctic ice sheet growing; west Antarctic ice sheet thinning

Satellite images have shown that the East Antarctic ice sheet has been growing in thickness by 1.8 cm per year (between 1992 and 2003), possibly due to increased precipitation resulting from global warming. The increase in ice thickness is estimated to be enough to reduce the rise of sea level by 0.012 cm per year. In contrast, the West Antarctic ice sheet is becoming thinner by 0.9 cm per year.

(SOURCE: Davis, C.H., Li, Y., McConnell, J.R., Frey, M.M. and Hanna E. 2005. Snowfall-driven growth in East Antarctic ice sheet mitigates recent sea-level rise. *Science*: in press)

Faster flow rate and thinner glaciers in Amundsen Sea

Researchers have confirmed that glaciers flowing into the Amundsen Sea have become progressively thinner over the past 15 years. The speed of glacier flow has also increased. For Pine Island Glacier, this increase in flow extends more than 100 km inland, and the rate of flow has increased by 3.5% between April 2001 and early 2003. Warmer water melting the underside of the glacier may be partially causing the increased flow, as well as the disintegration of restraining ice sheets. Currently glaciers are discharging 250 cubic km of ice *per annum* into the Amundsen Sea, a volume 60% greater than is replaced. These processes are contributing more than 10% to the global annual sea-level rise and contributing to oceanographic changes in the Southern Ocean.

(SOURCE: Kerr, R.A. A bit of icy Antarctica is sliding toward the sea. *Science* 305: 1897; Thomas, R., Rignot, E., Casassa, G., Kanagaratnam, P., Acuña, C., Akins, T., Brecher, H., Frederick, E., Gogineni, P., Krabill, W., Manizade, S., Ramamoorthy, H., Rivera, A., Russell, R., Sonntag, J., Swift, R., Yungel, J. and Zwally, J. 2004. Accelerated sea-level rise from West Antarctica. *Science* 306: 255-258)

Glacier flow into the Southern Ocean increases after ice shelf collapse

Satellite images of the now-collapsed section of the Larsen B Ice Shelf show that the speed of glaciers emptying into ocean waters has increased from two to six times between January 2000 and February 2003. Decreases in glacier height were also recorded in satellite images after the collapse of the ice shelf: a 38 m decrease for one glacier. The study indicates that the ice shelf plays an important role in holding back glaciers; with the break-up of the ice shelf, glaciers and the water they contain are flowing more rapidly into the sea. This has implications for not only decreased water salinity in the region, but also an increase in oceanic water volume, which could ultimately lead to sea level rises.

(SOURCE: Scambos, T.A., Bohlander, J.A., Shuman, C.A. and Skvarca P. 2004. Glacier acceleration and thinning after ice shelf collapse in the Larsen B embayment, Antarctica. *Geophys. Res. Lett.* 31: L18402)

General

Managing Antarctic tourism

Two Antarctic Treaty Consultative Meetings (ATCM) in 2004 aired concerns about increasing and unregulated tourism in Antarctica. Over the past decade, tourist vessels here have increased from 12 to 47, with a corresponding dramatic increase in ship-based tourists. Visitors increasingly prefer closer looks on cruise ships and smaller ice-strengthened vessels. The 45 Antarctic Treaty nations are interested in developing an agreed and coordinated approach to managing tourism, and an Antarctic tourism industry accreditation scheme is being proposed. Continued, unregulated growth poses a threat to Antarctica's wilderness and wildlife, which includes cetaceans. This would also have implications for future whale-watching operations here.

(SOURCE: Marine Pollution Bulletin News. 2004. *Mar. Poll. Bull*. 49: 5; *Mar. Poll. Bull.* 49: 884)

POLAR REGIONS

Habitat protection/degradation

Polar ecosystems may be more vulnerable

A review on the environmental problems in polar environments notes that "[e]xtinction of a link in the food chain would be more serious in polar than in other regions, because lower diversity and simpler food chains could mean that elimination of just a single species could have serious structural and functional consequences for food webs". Due to the large areas over which polar ecosystems extend, immigration or replacement from other regions in the ecosystem may help mitigate against loss of one part of the food chain. However, a counter-argument states that the "process will…be slowed by the regions' tendency for brooding and direct development of young".

(SOURCE: Chapman, P.M. and Riddle. M.J. 2005. Toxic effects of contaminants in polar marine environments. *Environ. Sci. Technol.*39: 200A–207A)

Concerns expressed about future of polar ecosystems

Two researchers for the British Antarctic Survey evaluated threats to polar ecosystems and predicted their possible states by 2025. Although in terms of pollution some polar areas are relatively pristine, there are local problem areas; for example, sites of radioactive dumping and metal processing in the Russian Arctic and organic pollutants associated with military installations and oil installations. Also, ecosystems of both polar areas have been highly disturbed by fishing. Greatest concern was expressed about climate change, particularly reductions in sea ice extent and duration. For Antarctica, although climate change was an issue, more concern was expressed about harvesting of living marine resources. The researchers stated that in both polar areas "the capacity of marine ecosystems to withstand the cumulative impact of a number of pressures, including climate change, pollution and overexploitation, acting synergistically is of greatest concern".

(SOURCE: Clarke, A. and Harris, C.M. 2003. Polar marine ecosystems: major threats and future change. *Environ. Conserv.* 30: 1-25)

Polar ecosystem models suggest quick losses and slow recoveries of baleen whales

A Bering Sea ecosystem model predicted that increases in baleen whales might reduce the abundance of Alaska pollock, cephalopods and deep-water fish (through competition for zooplankton), but most other fish groups would not be affected. Total removal of baleen whales caused less than a 10% increase in fish biomass after 100 years. Conversely, reduction in prey species would cause a quick reduction in mammal numbers, which would be slow to recover, even if prey stocks increased. An Antarctic ecosystem model simulated 20th century whaling by removing 10% of baleen whales *per annum* (from 1900 to 1950), followed by 50 years of no whaling. At the end of this 'moratorium', whales had only recovered to 10% of their original (pre-whaling) biomass. The model also simulated the effects on whale stocks of 'culling' other megafauna – only removals of myctophid fish had a major effect (40% increase in whale biomass), although this had a negative impact on seal and penguin populations. The authors concluded that "environmental effects (which were not modelled) [may] play an important role in influencing the dynamics of marine ecosystems" and "populations of large whales are easily reduced to low numbers, but take a long, long time to recover".

(SOURCE: Trites, A.W., Coombs, A.P. and Bredesen, E.L. 2004. Whales, whaling and ecosystem change in the Antarctic and eastern Bering Sea: insights from ecosystem models. *CIESM Mongr.* 25: 85-139)

Chemical pollution

Polar marine ecotoxicology: a lack of information

Ecotoxicology is "the study of the fate and effects of chemical and physical agents in natural ecosystems". A series of articles has underlined that there is a lack of data on the toxic effects of such substances on local species in polar regions. Only a few articles are available and many are contained in difficult-to-obtain documents and reports, often restricted to the effects of oil contamination. This recognition is important because the information available from non-polar organisms and habitats may not be applicable to the polar regions. Such knowledge would be crucial for assessing critical doses, instigating appropriate management changes, and mitigating exposure.

(SOURCE: Chapman, P.M. and Riddle, M.J. 2003. Missing and needed: polar marine ecotoxicology. *Mar. Poll. Bull.* 46: 927-928; 2004. Correspondence: *Mar. Poll. Bull*. 49: 603-607)

Pollution issues in polar environments – the need for toxicity, ecological and environmental data

A review noted that polar species have several characteristics that may make them more susceptible to pollutant impacts: relatively long life spans and a tendency toward gigantism (which causes a lower surface-area-to-volume ratio and thus relatively slower rate of contaminant uptake). At the low temperatures typical of polar regions, metabolic rates are also often slower and thus contaminants may accumulate in tissues more slowly. But polar organisms also have high lipid contents for energy storage, thus increasing the risk of lipophilic contaminant uptake. Their lower energy usage may also mean there is less energy available for pollutant detoxification. As species may have longer development times, they may also be exposed for longer periods to contaminants during the vulnerable juvenile period. It was also noted that stressors such as ultraviolet B radiation might work synergistically to intensify pollutant effects. Finally, experimental studies have demonstrated that polar invertebrates may have different sensitivities to contaminants than temperate species, thus making extrapolations of toxicity from temperate species difficult. It is pointed out that much polar contaminant research deals with a simple recording of contaminant values rather than interpreting these values and determining their effects on species and ecosystems. The reviewers conclude, "[t]o adequately address these challenges, we need to undertake more basic research on the ecology of polar marine environments…[to] understand how toxicity is modified under the peculiar conditions characteristic of polar regions".

(SOURCE: Chapman, P.M. and Riddle, M.J. 2005. Toxic effects of contaminants in polar marine environments. *Environ. Sci. Technol*.39: 200A–207A)

Climate change

Warning about increased rates of ice sheet disintegration

A review of global warming impacts notes that many climatic change models do not consider increased melting and disintegration of Greenland and Antarctic ice sheets, yet predict up to an 88 cm increase in sea level in the next century due to thermal expansion of water. However, this may be an underestimation. Approximately 5-10% of the planet's trapped heat went into melting ice in the 20th century, with most of the century's 10-20 cm increase in sea level arising from thermal expansion. However, it is possible that, as the atmosphere becomes moister, energy will be more efficiently transported to the polar regions and, as ice streams accelerate, more floating ice will be rafted to warmer waters to melt. The review also highlights the potential for air pollution (particularly 'soot') to hasten melting by decreasing the reflectance, and increasing the absorbance, of heat radiation by water crystals. Glacier melt and ice disintegration could proceed rapidly and, once past a critical point, it would "be impossible to avoid substantial ice sheet disintegration". Global warming in excess of 1°C could trigger a runaway melting of the world's ice sheets. Sea level rise and ice sheet changes are important issues for cetaceans, as these could cause major changes in cetacean critical habitat, and critical habitat of prey species, particularly in polar regions.

(SOURCE: Hansen, J. 2005. A slippery slope: how much global warming constitutes "dangerous anthropogenic interference"? *Clim. Change* 68: 269-279)

Model suggests ice cap melting may not contribute much to sea level rise

A modelling exercise predicted that, due to increased precipitation, sea levels may change by the end of the 21st century from a decrease of 19 cm to an increase of 5 cm when considering the Antarctic ice sheet and from a 2 cm decrease to a 9 cm increase when considering the Greenland ice sheet. The total estimated sea level change due to both regions ranged from a 12 cm decrease to a 5 cm increase. The authors considered thermal expansion of sea water and melting of alpine glaciers as the major sources of sea level rise in the 21st century. However, the researchers note that post-21st century contributions from melting ice sheets could be greater if global warming were to continue.

(SOURCE: Huybrechts, P., Gregory, J., Janssens, I. and Wild, M. 2004. Modelling Antarctic and Greenland volume changes during the 20th and 21st centuries forced by GCM time slice integrations. *Glob. Planet. Change* 42: 83-105)

GLOBAL

Habitat protection/degradation

Floating oceanic plastic debris is widespread

A survey of floating plastic marine debris in the Southern, Atlantic and Arctic Oceans noted such debris in all regions, with rates of 0-10 items/km^2, and 3 items/km^2 even in the Southern Ocean. North of the polar zone, and around the Falkland Islands, densities of debris had increased. In a comparison with a survey conducted ten years earlier in the south-west Atlantic and Southern Oceans, rates of debris encountered were the same. The widespread nature of marine debris, even in 'pristine' environments, is a cause for concern – such debris is known to entangle, or be ingested by, cetaceans. The researchers also point to marine debris as a probable vector of invasive species.

(SOURCE: Barnes, D.K.A. and Milner, P. 2005. Drifting plastic and its consequences for sessile organism dispersal in the Atlantic Ocean. *Mar. Biol.* 146: 815-825)

Reducing whale numbers impacts deep sea species

Researchers have discovered that whale carcasses falling to the deep sea bed can potentially support communities of deep sea organisms for decades. Up to 185 species have so far been identified per large whale skeleton, and at least 32 species are unique to these fallen whale carcasses. However, researchers have expressed concern that past commercial whaling has reduced the number of 'whale falls' and has impacted these deep sea species. Models investigating the impact of reduced whale falls predict that 40% of the North Atlantic whale fall-dependent species have already gone extinct. These results significantly broaden the ecosystem impact that whaling, and decreases in whale numbers, can have.

(SOURCE: Ferber, D. 2005. Whaling endangers more than whales. *Science* 307: 1190-1191)

Fish population collapse and why populations do not recover

An analysis of 230 fish populations showed an 83% reduction from known historic levels. Researchers point out that 'known historic levels' often underestimates true historic population sizes as removals and anthropogenic impacts on stocks may precede known data sets. Few reduced populations have shown recovery even 15 years after the population collapsed, with reductions in fishing pressure being insufficient to promote recovery. Problems that prevent recovery include:

- slow response by managers to address depletion;
- inability to reduce anthropogenic removals/mortality to zero (*e.g.*, by-catch continues);
- public/user-group perceptions that are unsupported by science that delay or alter the nature of the managerial response;
- the allee effect (small population sizes lead to proportionally increased rates of predation, reduced mating success and reduced fertility);
- reduced numbers of adults increasing inter-specific competition and predation of juveniles;
- reduced abundance of top predators causing a shift in ecosystems that may impact recovery;
- selective harvesting, where the largest most successful animals are targeted whereas animals with lower fitness stay in the population.

The impacts of inappropriate fisheries management are illustrated by the Canadian stock of Atlantic cod, where within 30 years the stock declined by 99.9% in some areas. The issues covered in this paper are relevant to cetacean species that are dependent on over-fished prey populations.

(SOURCE: Hutchings, J.A. and Reynolds, J.D. 2004. Marine fish population collapses: consequences for recovery and extinction risk. *Biosci.* 54: 297-309)

IUCN Resolution calls for management of unsustainable marine fisheries and harvests

At the 3rd IUCN Congress, a resolution on sustainable management of the High Seas was passed that called for:

- Members to implement the FAO Code of Conduct for Responsible Fishing and to enforce measures from several international agreements to ensure sustainable use of High Seas marine resources;
- The development of new international mechanisms (via UNCLOS) for the governance, management, protection and restoration of marine biodiversity and productivity in the High Seas;
- The taking of immediate action to eliminate illegal, unreported and unregulated fishing;
- An upgrading of regional fisheries management organisations to adopt procedures that take into account ecosystem-based, precautionary approaches to minimise impacts on marine ecosystems;
- Investigation into ways to enforce actions on flag states that fail to control domestically registered vessels;
- Establish a global network of marine protected areas beyond national jurisdictions and to develop scientific and legal bases for their establishment, by 2012;
- Support of scientific research into high seas biodiversity and ecological processes to ensure the sustainability of human activities.

(SOURCE: IUCN 2004. CGR3. RES057-REV1. *Conservation and Sustainable Management of High Seas Biodiversity*. 3rd IUCN Congress, 17-25 November 2004, Bangkok, Thailand)

Millennium Assessment 2005 report highlights unsustainable use of marine ecosystems

At the request of the UN Secretary-General, the Millennium Ecosystem Assessment (MA) was carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. The findings of the MA's report, published in March 2005, include:

- The global rate of extinctions in the last century may be up to 1,000 times higher than historical extinction rates calculated from the fossil record;
- Coastal habitat change and overexploitation of marine ecosystems are qualified as having had a very high – and increasing – impact on biodiversity over the last century;
- Capture fisheries are operating well beyond sustainable levels to supply current, much less future, demands;
- Fish biomass targeted in fisheries has decreased by 90-99% of pre-industrial biomass available;
- Industrial fishing fleets have shifted to fishing farther offshore and in deeper water to meet global demand;
- Approximately 35% of the world's mangrove areas – representing an important habitat for tropical cetacean prey – has been lost in the 20th century;
- Models indicate that total input of nitrogen to coastal ecosystems in developing countries will increase by 10-20% by 2030, which will contribute to toxic algal blooms and the formation of oxygen-depleted 'dead zones'.

The report advocates the establishment of marine protected areas and no-take zones.

(SOURCE: Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC, http://www.millenniumassessment.org/en/products.aspx)

Tsunami damage extensive throughout Indian Ocean

Early surveys of coral reefs after a massive tsunami hit on 26 December 2004 show damage that was highly variable, with some areas in far better shape than expected, while others were completely decimated. In the Similan Islands of Thailand, only 15% of the area's coral was severely damaged, while other Thai reefs were "stripped to bare rock". Satellite images of habitat damage in Aceh, Indonesia, give an indication of the wide-scale coastal damage. Specific marine and coastal habitat impacts include destruction of mangroves, damage to fringing coastal coral reefs, and probable degradation of the Pulau Weh Marine Reserve (3,900 ha) and Kepulauan Banyak Marine Recreation Area (227,500 ha). In several areas coastal morphology has changed, with the creation of new lagoons and the enlargements of estuary deltas. Large volumes of soil and debris entering the marine environment are likely to cause degradation of coastal habitats, including those of coastal cetaceans. At least one Indo-Pacific humpback dolphin was washed inshore by the tsunami; the dolphin was swept into a lagoon in Khao Lak, Thailand, where local authorities and fishermen trapped it with nets and transported it to the sea by truck. The IUCN notes that ecological effects are likely to be severe, although varied, with the pelagic environment likely to be less affected. The tsunami struck ecosystems that in many cases were already stressed by unsustainable resource use, such as over-fishing and habitat destruction. Areas with healthier ecosystems (*i.e.,* intact mangroves) have been less affected. Management actions that strengthen ecosystem health and resilience are essential to aid and speed up recovery and to protect against future tsunamis and earthquakes.

(SOURCE: Pennisi, E. 2005. Powerful tsunami's impact on coral reefs was hit and miss. *Science* 307: 657; Parish, F. and Lee, D. 2005. Preliminary information on impacts of the 26th December 2004 tsunami on selected coastal ecosystems in Aceh Province, Indonesia. Global Environment Centre, Malaysia, http://www.gecnet.info; IUCN Statement. 2005. Indian Ocean tsunami: early observations of effects on marine environments. Gland, Switzerland, 5 January; Reuters, Rare dolphin saved from Thai lagoon. 5 January 2005, http://www.msnbc.msn.com/id/6780685)

Meeting on ocean acidification

Since the industrial revolution, the pH of the world's oceans has dropped by 0.1 due to increased carbonic acid levels (created by dissolving carbon dioxide). Concerns have been raised that pH levels could drop by 0.5 by 2100, increasing the acidity of the oceans. In August 2004, scientists met in the UK to develop a research plan to investigate this issue, while simultaneously the Royal Society announced that they will be launching an inquiry into the possible ecosystem effects of this increase in acidity. There is concern that increases in acidity could seriously deplete coral and calcareous plankton, which in turn could disrupt oceanic ecosystems and cetacean prey species.

(SOURCE: Schiermeier, Q. 2004. Researchers seek to turn the tide on problem of acid seas. *Nature* 430: 820)

An approach to identifying vulnerable marine areas

A new approach to marine protected areas emphasises 'sensitivity' (the degree to which marine features respond to stresses) and 'vulnerability' (the probability that a feature will be exposed to a stress to which it is sensitive). The paper uses two whale groups to test their proposed approach, using exposure to noise (via boat traffic and oil production) as the stressor against which the cetaceans are to be protected. Plotting the probability of encountering a stressor against the distribution of the cetaceans, the study determined key marine areas in which the whales would be vulnerable. Humpback whales were predicted to be more vulnerable to small boat traffic, ferry routes and oil production, but they and other balaenopterid whales were both vulnerable to shipping lanes. This paper introduces a potentially useful method for highlighting areas where habitat degradation or environmental threats are greatest and where cetaceans should receive greater protection.

(SOURCE: Zacharias, M.A. and Gregr, E.J. 2005. Sensitivity and vulnerability in marine environments: an approach to identifying vulnerable marine areas. *Cons. Biol*. 19: 86-97)

Chemical pollution

Negative effects of contaminants on fertility and reproductive systems

A review on environmental contaminants described impacts on reproductive systems by pollutants, including organic and trace element pollutants, but also metabolic by-products from female contraceptives. The authors state "the developmental consequences of environmentally mediated DNA damage to sperm include impaired embryonic development and the induction of abnormalities in the offspring such as childhood or testicular cancer". Several contaminants that have been detected in cetacean tissues (*e.g*., PAHs and dioxins) are known to have impacts on fertility and to produce reproductive abnormalities. The effects of possible oestrogen-mimicking chemicals such as DDT, furans, dieldrin and other organochlorines were also highlighted, but the scale and mechanism of these effects were unclear.

(SOURCE: Aitken, R.J., Koopman, P. and Lewis, S.E.M. 2004. Seeds of concern. *Nature* 432: 48-52)

Biomarkers of contamination studied with non-lethal methods

Effective non-lethal techniques to study the effects of toxic pollutants on marine mammals have been developed in recent years. One such technique is currently being investigated using marine mammal cell lines to test for biomarkers for the highly toxic dioxin class of chemicals. Another is the induction of the cytochrome P450 1A1 enzyme (CYP1A1), which has frequently been used as a biomarker for PCB, dioxins, furans and PAHs in animal tissues, including marine mammals (notably beluga whales). CYP1A1 induction was effectively done from skin samples collected via biopsies of 50 sperm whales.

(SOURCE: Brenez, C., Gerkens, P., Mazzucchelli, G., Jauniaux, T., Eppe, G., De Pauw, E., and De Pauw-Gillet, M.C. 2004. A strategy to identify specific biomarkers related to the effects of a PCDD/F mixture on the immune system of marine mammals. *Talanta* 63: 1125-1230; Godard, C.A.J., Smolowitz, R.M., Wilson, J.Y., Payne, R.S. and Stegeman, J.J. 2004. Induction of cetacean cytochrome P450 1A1 by ß-naphthoflavone exposure of skin biopsy slices. *Toxicol. Sci.* 80: 268-275)

Baleen used to analyse heavy metal trends

Researchers analysing heavy metal levels in northern minke and bowhead whale tissues determined that baleen, particularly in museum specimens of animals, could be effectively used to monitor long-term mercury trends in baleen whale species.

(SOURCE: Hobson, K.A., Riget, F.F., Outridge, P.M., Dietz, R. and Born, E. 2004. Baleen as a biomonitor of mercury content and dietary history of North Atlantic minke whales (*Balaenoptera acutorostrata*): combining elemental and stable isotope approaches. *Sci. Total Environ.* 331: 69-82; Shao, Q., Wilson, M.D., Romanek, S.D. and Hobson, K.A. 2004. Time series analysis of elemental and isotopic data from biomineralized whale tissue. *Environ. Ecol. Stat.* 11: 323-337)

PCBs and DDE damage sperm

Slight negative effects were found by investigating PCB and *p,p'*-DDE levels in the blood of fishermen (consuming varying levels of contaminated fish) and comparing with sperm chromatin/DNA integrity. Thus, organic contaminants can cause infertility via sperm damage, which may have life history and population recovery implications for contaminated cetaceans.

(SOURCE: Rignell-Hydbom, A., Rylander, L., Giwercman, A., Jönsson, B.A.G., Lindh, C., Eleuteri, P., Rescia, M., Leter, G., Cordelli, E., Spano, M. and Hagmar, L. 2005. Exposure to PCNs and *p,p'*-DDE and human sperm chromatin integrity. *Environ. Health Perspec.* 113: 175-179)

Toxic brominated fire retardants (PBDEs) – as big a problem as PCBs

Polybrominated diphenyl ethers (PBDEs), commonly produced as fire retardants, but also found in plastics products, are structurally similar to PCBs. PBDE properties, similar to those of PCBs, can cause hormonal disruption (especially of thyroid hormones) and neurological and developmental abnormalities, and are also mutagenic and carcinogenic. PBDEs have also been discovered in a wide range of aquatic species, including cetaceans, although there appear to be hotspots around developing nations. However, unlike concentrations of PCBs, concentrations of PBDEs are increasing. It is argued that "PBDEs may surpass PCBs in a few decades to become the most prevalent organohalogen compound", making this class of chemicals a pollutant of concern.

(SOURCE: Tanabe, S. 2004. PBDEs, an emerging group of persistent pollutants. *Mar. Poll. Bull.* 49: 369-370)

Pollutants affect animal behaviour

The endocrine system-disrupting nature of many pollutants can also impact behaviour, particularly mating behaviour or rearing of young, both of which are controlled and moderated by sex hormones. Impacts on thyroid hormones may also affect levels of activity, which in turn may affect the ability to feed. Other behavioural changes in mammals that have been linked to pollutants include increased aggression and retarded learning. Thus, pollutants could have effects that are not directly physiological, but could reduce breeding success and increase mortality rates through behavioural changes. Behaviour could therefore be used as a non-invasive biomonitor for pollutant levels, emphasising the need for development in the new field of 'behavioural ecotoxicology'.

(SOURCE: Zala, Z.M. and Penn, D.J. 2004. Abnormal behaviours induced by chemical pollution: a review of the evidence and new challenges. *Anim. Behav.* 68: 649-664)

Disease and mortality events

Antibiotic resistant bacteria in the aquatic environment

A study on antibiotics in waters discharged from a sewage treatment plant in Brisbane, Australia, determined that three antibiotics could be detected up to 500 m from the discharge site. Moreover, bacteria in the treatment plant were resistant to all six of the antibiotics researchers tested. Bacteria collected from discharge waters displayed resistance to two of the antibiotics tested. The increasing prevalence of antibiotics and antibiotic-resistant pathogens in the aquatic environment therefore "pose[s] a potential threat to ecosystem functions and…human health".

(SOURCE: Costanzo, S.D., Murby, J. and Bates, J. 2005 Ecosystem response to antibiotics entering the aquatic environment. *Mar. Poll. Bull.* 51: 218-223)

A possible pollution-induced lymphoma in a bottlenose dolphin

A cancerous tumour (immunoblastic lymphoma) was discovered in a bottlenose dolphin stranded in the Canary Islands. The researchers investigating the case suggested contaminants in the tissues of the animal may have been associated with the tumour.

Maximum contaminant levels

ΣPCB (ng.g^{-1} wet weight): 10,970; ΣDDT (ng.g^{-1} wet weight): 15,592

(SOURCE: Jaber, J.R., Pérez, J., Carballo, M., Arbelo, M., Espinosa de Los Monteros, A., Herráez, P., Muñoz, J., Andrada, M., Rodríguez, F. and Fernández, A. 2005. Hepatosplenic large cell immunoblastic lymphoma in a bottlenose dolphin (*Tursiops truncatus*) with high levels of polychlorinated biphenyl congeners. *J. Comp. Path.* 132: 242-247)

Marine epidemics may be more widespread and harder to control

A review of epidemiology in the marine environment emphasised that terrestrial epidemiology may not be transferable to the marine environment. Species in marine ecosystems have more open populations, often with very widespread dispersal patterns, typically via copious volumes of eggs or larvae with adaptations for long-distance dispersal. These factors may make disease transmission more widespread and rapidly propagated. As colonial or modular organisms are more common in marine systems than terrestrial ones, lack of genetic diversity may lead to increased rates of infection. Methods for containing epidemics in terrestrial systems (*e.g.*, quarantine, vaccination, culls, movement restrictions) are generally not, or less, applicable to the marine environment. Several marine diseases in recent years have had terrestrial sources – transmitted to the marine environment by sewage, for example. However, dealing with epidemics in the marine environment requires the development of new epidemiological models and control strategies.

(SOURCE: McCallum, H.I., Kuris, A., Harvell, C.D., Lafferty, K.D., Smith, G.W. and Porter, J. 2004. Does terrestrial epidemiology apply to marine systems? *Trends Ecol. Evol.* 19(11): 585-591)

Blood chemistry values are not a good indicator for health trends

Using bottlenose dolphins as a potential indicator species, researchers developed a list of 19 blood parameters to use as indicators and indices of the 'health' of a population. Suggested blood parameters included alkaline phosphatase, creatine, blood urea and blood cell counts. However, the approach was hampered by inter-laboratory variability and lack of independence between some factors. Comparing stranding rates, losses of known animals, and losses of calves against the blood parameters, a slight positive correlation was obtained, but it was not significant. Although the health status of some individuals could be summarised by the factors, it was suggested that this approach would not be able to detect trends in population health and perhaps more sensitive or additional factors and indicators are required.

(SOURCE: Wells, R.S., Rhinehart, H.L., Hansen, L.J., Sweeny, J.C., Townsend, F.I., Stone, R., Casper, D.R., Scott, M.D., Hohn, A.A. and Rowles, T.K. 2004. Bottlenose dolphins as marine ecosystem sentinels: developing a health monitoring system. *EcoHealth* 1: 246-254)

Marine mammal cancer link with PCBs

An unusually high number of California sea lions stranded along the central California coast during the period 1993-2003 had cancerous tumours. When compared to sea lions that died from non-cancer-related causes, blubber levels of PCBs in these cancer-stricken animals were significantly higher. This association between blubber concentrations of PCBs and cancer in sea lions suggests that these contaminants may play a role in the development of this disease in marine mammals, including cetaceans.

Maximum contaminant levels

Blubber (ng.g^{-1} wet weight) ΣPCB: 64,000 (males), 39,000 (females); ΣDDT: 200,000 (males), 120,000 (females)

Median contaminant levels

Blubber (ng.g^{-1} wet weight) ΣPCB: 20,000 (males), 6100 (females); ΣDDT: 54,000 (males), 21,000 (females)

(SOURCE: Ylitalo G.M., Stein, J.E., Hom, T., Johnson, L.L., Tilbury, K.L., Hall, A.J., Rowles, T., Greig, D., Lowenstine, L.J. and Gulland, F.M.D. 2005. The role of organochlorines in cancer-associated mortality in California sea lions (*Zalophus californianus*). *Mar. Poll. Bull.* 50: 30-39)

Climate change

Gas eruptions may add to global warming and affect ecosystems

Recent discoveries of gas eruptions off the coast of Africa (which in one instance covered an area two-thirds the size of Belgium) has led to concerns about the role of these eruptions in exacerbating global warming. The gas eruptions are primarily the result of upwelling-fueled, very high rates of primary production, which lead to large seabed deposits of organic material. These in turn lead to increased bacterial activity and effervescing gases, including the greenhouse gas methane, which is the predominant product. Global warming may affect wind patterns, which in turn increase the rate of upwelling, which increases the nutrient supply for phytoplankton production. With the production of methane, greenhouse gases increase; this in turn increases the rate of upwelling and so on – a positive-feedback loop. The researchers note that there may be a biological remedy if plankton-eating fish, able to swim against currents, could consume and reduce the phytoplankton levels. The study documents another possible ecosystem-level impact of global warming, which in turn may contribute to global warming itself.

(SOURCE: Bakun, A. and Weeks, S.J. 2004. Greenhouse gas buildup, sardines, submarine eruptions and the possibility of abrupt degradation of intense marine upwelling ecosystems. *Ecology Letters* 7: 1015-1023)

Global warming affecting plankton levels and seasonality

Since 1935, plankton has been collected from devices attached to ocean-going freighters for research purposes. Using the large data set derived from this trawled plankton, it was determined that the abundance of plankton in the northeast Atlantic has shifted over the past 45 years, with increasing phytoplankton abundance in temperate and polar regions, due to warming of surface waters, and decreasing abundance in warmer regions. Moreover, the timing of the seasonal abundance of plankton has also shifted. These changes in phytoplankton abundance are already affecting components of the food web levels, and have been linked to the decline of fish species such as North Sea cod. These ecosystem changes resulting from global warming will have multiple effects on marine mammal stocks, and their prey species, globally.

(SOURCE: Edwards, M. and Richardson, A.J. 2004. Impact of climate change on marine pelagic phenology and trophic mismatch. *Science* 430: 881-884; Richardson, A.J. and Schoeman, D.S. 2004. Climate impact on plankton ecosystems in the Northeast Atlantic. *Science* 305: 1609-1612)

Satellite data confirms that global warming is occurring

Climatologists using data collected from deep oceanic waters and satellite imagery confirm that heat being absorbed by the planet (including by marine waters) exceeds heat radiated into space by 0.85 Watts/m^2 of the earth's surface, causing a net warming. The analysis predicts a 0.6^oC rise in temperature over the next century even if greenhouse gases are capped immediately, and likely sea level rise and further disintegration of polar ice sheets. One of the researchers stated in a newspaper interview that "[t]here can no longer be genuine doubt that human-made gases are the dominant cause of observed warming".

(SOURCES: Hansen, J., Nazarenko, L., Ruedy, R. Sato, M., Willis, J., Del Genio, A., Koch, D., Lacis, A., Lo, K., Menon, S., Novakov, T., Perlwitz, J., Russell, G., Schmidt, G.A. and Tausney, N. 2005. Earth's energy imbalance: confirmation and implications. *Science*: in press; Associated Press. 2005. Data from space, oceans validate global warming timeline. *Washington Post* 29 April 2005: A13)

Possible reduction in Thermohaline Circulation – a warning for massive changes in climate

The premise of the Hollywood movie 'The Day After Tomorrow' is that global warming leads to the cessation of Thermohaline Circulation (THC) in the North Atlantic, leading to decreased heat exchange from the ocean to the north Atlantic region, thus causing rapid decreases in temperature in the northern hemisphere. Scientists studying the flow of water over the Greenland-Scotland ridge warn that changes in water flows and salinities in this region are possibly indicative of a weakening of THC and that this issue urgently needs investigation.

(SOURCE: Hansen, B., Østerhus, S., Quadfasel, D. and Turrell, W. 2004. Already the day after tomorrow? *Science* 305: 953-954)

Scientists and policymakers agree on climate change strategies

A report issued by a 14-member independent panel of scientists and policymakers sought to find common ground between nations that have ratified the 1997 Kyoto Protocol and those that have not. Its recommendations include the following:

- A long-term objective should be established to prevent global average temperature from rising more than 2°C above the pre-industrial level;
- G8 governments should establish national standards to generate at least 25% of electricity from renewable energy sources by 2025;
- G8 governments should increase their spending on research, development, and demonstration of advanced technologies for energy-efficient and low- and zero-carbon energy supply two-fold or more by 2010, at the same time as adopting near-term strategies for the large-scale deployment of existing low- and no-carbon technologies;
- G8 governments should shift their agricultural subsidies from food crops to biofuels, while implementing appropriate safeguards to ensure sustainable farming methods are encouraged, culturally and ecologically sensitive land preserved, and biodiversity protected;
- Developed countries should honour existing commitments to provide greater financial and technical assistance to help vulnerable countries adapt to climate change and pursue the establishment of an international compensation fund to support disaster mitigation and preparedness.

(SOURCE: International Climate Change Taskforce. 2005. *Meeting the Climate Challenge: Recommendations of the International Climate Change Taskforce*. The Institute for Public Policy Research, London, http://www.americanprogress.org/climate)

Model confirms anthropogenic ocean warming occurring

Earlier research modelled the heating patterns of marine waters, assuming heat entrapment by greenhouse gases and compared these figures with recorded oceanic temperatures. The close match in the results confirms previous models predicting ocean warming as the result of anthropogenic activities, but with greater statistical confidence (>95%).

(SOURCE: Kerr, R.A. 2005. Ocean warming model again points to human touch. *Science* 307: 1190)

Climatic oscillations affect cetacean group sizes

An investigation on climatic factors and cetacean behaviour looked at group size in killer whales in Johnstone Strait, British Columbia, Canada, and in bottlenose dolphins in the Moray Firth, Scotland. The study examined patterns of Pacific and Atlantic salmon abundance, in relation to climatic oscillations, and in turn to cetacean group sizes. The cetaceans tended to occur in smaller groups when salmonids were less abundant, which in turn was linked to climatic oscillations. The study shows that the behavioural ecology of cetaceans may be affected by climate change.

(SOURCE: Lusseau, D., Williams, R., Wilson, B., Grellier, K., Barton, T.R., Hammond, P.S. and Thompson, P.M. 2004. Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic bottlenose dolphins. *Ecol. Lett.* 7: 1068-1076)

Climate change affecting cetacean distribution

From an analysis of stranding records in the UK, researchers noted that strandings of cold-water cetacean species have decreased and records of warm-water species have increased. This trend was also supported by survey data. These results are consistent with a northward shift of warm-water cetacean species, and raise concerns that cooler-water species, such as white-beaked dolphins, may be displaced or become extirpated in certain areas.

(SOURCE: MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmouth, J.A., Herman, J.S. and Reid, R.J. 2005. Climate change and the cetacean community of north-west Scotland. *Biol. Conserv.* 124: 477-483)

Temperature and sea level rises predicted to occur even if greenhouse gas production stabilised

Models were used to estimate probable increases in global temperatures and possible increases in sea level. In the 20th century there was an observed 0.6°C increase in global temperatures and a 10-20 cm sea level rise. If greenhouse gas production was immediately stabilised, global temperatures were still predicted to increase 0.4-0.6°C over the next century, with a concomitant 14-16 cm minimum increase in sea level. Temperature increase scenarios were 1.1-1.5°C, 1.9-2.6°C, and 2.2-3.5°C, depending on the model used. Likewise, sea level rises were predicted at 13-18 cm, 18-25 cm, and 19-30 cm. For the following century (2100-2200), it was predicted that the increase in temperature would slow: a 0.1-0.3°C over the century, but there would be a 12-21 cm sea level rise. A second study looked at the potential longer-term warming that would occur even if greenhouse gas composition was fixed at today's levels – greater than a 1°C increase in temperature by 2400 and 10 cm increase in sea level per century. The study also investigated the predicted effects of capping and stabilising current emission levels, and predicting their long term effects: 2-6°C total temperature increase by 2400, with sea levels rising at 25 cm per century. Therefore, without a decrease in greenhouse gases, temperature and sea level rises are predicted to be inevitable, with substantial changes even if emissions are controlled and remain at current levels.

(SOURCES: Meehl, G.A., Washington, W.M., Collins, W.D., Arblaster, J.M., Hu, A., Buja, L.E., Strand, W.G. and Teng, H. 2005. How much more global warming and sea level rise? *Science* 307: 1769-1772; Wigley, T.M.L. 2005. The climate change commitment. *Science* 307: 1766-1769)

More heat waves expected in the 21st century

Modelling the incidences of heat waves and atmospheric conditions showed that recent heat waves in Europe and North America coincided with an atmospheric circulation pattern that will intensify with increasing greenhouse gases. This will lead to more frequent, more intense and longer-lasting heat waves in parts of the world. The increasing heat waves could result in indirect impacts on cetaceans that dwell in temperature-sensitive habitats or have temperature-dependent distributions.

(SOURCE: Meehl, G.A. and Tebaldi, C. 2004. More intense, more frequent, and longer lasting heat waves in the 21st Century. S*cience* 305: 994-997)

Estimates of global warming double

Since 1991, the UN Intergovernmental Panel on Climate Change (IPCC) report has predicted a 1.5-4.5°C increase in average temperatures with every doubling of CO_2 levels. However, new results from computer models suggest that the temperature increase could go as high as 11°C. Researchers enlisted 95,000 people from 150 countries to download a general circulation model (GCM) and run it using the idle processing capacity on their personal computers. After analysing 2000 simulations, researchers discovered that when CO_2 concentration doubles from pre-industrial levels – as is expected to happen between 2050 and 2100 – the simulations predict a 1.9 to 11.5°C temperature rise.

(SOURCE: Pelley, J. 2005. Estimates of greenhouse warming double. *Environ. Sci. Tech.* 39: 190A)

Global warming changing fish distribution

A 1°C temperature increase has been witnessed in the North Sea between 1977 and 2001. Fisheries data indicate that this warming water over the past quarter of a century has pushed North Sea fish populations northwards and into deeper waters. The shift in distribution may hamper the recovery of depleted fish stocks in this area and disrupt the North Sea ecosystem. For example, it may introduce new predators or prey into the area. This paper demonstrates the impact of climate change on the distribution of fish stocks, and therefore cetacean prey, as well as how climate change contributes to the decline, or prevents the recovery, of fish stocks.

(SOURCE: Perry, A.L., Low, P.J., Ellis, J.R. and Reynolds, J.D. 2005. Climate change and distribution shifts in marine fishes. *Science*: in press)

Hottest summer in Europe result of human influence

Summer 2003 was possibly the hottest in Europe since 1500 AD. Researchers analysing recorded European temperature trends in conjunction with models on greenhouse accumulation in the atmosphere and other factors determined (with confidence >90%) that "human influence has at least doubled the risk of a heat wave". If high summer temperatures as observed in 2003 were to become more common, then it could have major impacts on species whose distribution is affected by temperature (such as many cetaceans).

(SOURCE: Stott, P.A., Stone, D.A. and Allen, M.R. 2004. Human contribution to the European heat wave of 2003. *Nature* 432: 610-614).

Noise impacts

ACCOBAMS passes resolution on noise

At the Second Meeting of the ACCOBAMS Contracting Parties, which was held between 9-12 November 2004, in Palma de Mallorca, Spain, a resolution was passed that urged all to "avoid the use of man made noise in habitat of vulnerable species and areas where marine mammals or endangered species may be concentrated" and for noise-producing activities to only proceed with "special caution" in areas where there may be beaked whales. The resolution also charged the ACCOBAMS Scientific Committee to develop "a common set of guidelines on conducting activities known to produce underwater sound with the potential to cause adverse effects on cetaceans", including military sonar, and also called for "extreme caution" when conducting noise-producing activities in the Mediterranean and Black Seas.

(SOURCE: ACCOBAMS. 2004. Resolution 2.16. *Assessment and impact assessment of man-made noise*. 2nd Meeting of the ACCOBAMS Contracting Parties, 9-12 November2004, Palma de Mallorca, Spain, http://www.accobams.mc/Accob/Wacco.nsf/0/491fb7e7d4267c0cc1256f7e004b4ec8/$FILE/E%20Res%202.16.pdf)

Vulnerable animals may not react to human disturbance

Recent research into the disturbance reactions of birds may have implications for the observation of noise-related effects on marine mammals. In an experiment in which turnstones were given supplementary levels of food (controls were not manipulated), these birds showed a greater response to human disturbance, including greater displacement as the result of anthropogenic activity. The implication is that animals that are better fed, or in better condition, can stop feeding sooner and move farther from habitats when disturbed than animals that are in marginal condition. The researchers point out the need to consider the animals that are at greatest risk, rather than the animals that show the greatest reaction, when evaluating human disturbance, *i.e.*, less response to anthropogenic activities does not necessarily mean less impact on animals. It may be more relevant to examine stress and resource use rather than behavioural responses as a measure of vulnerability.

(SOURCE: Beale, C.M. and Monaghan, P. 2004. Behavioural responses to human disturbance: a matter of choice? *Anim. Behav.* 68: 1065-1069)

Dolphin whistling rates increase when boats approach

In Sarasota, Florida, bottlenose dolphins were estimated to encounter a boat within 100 m every 6 minutes during the daytime. Animals produced signature whistles more frequently when a boat approached. It was suggested that these whistles reflect heightened arousal, or bring groups together. The study also noted that jet-driven watercraft were quieter than conventional boats, and idling and ploughing boats were quieter than planing boats.

(SOURCE: Buckstaff, K.C. 2004. Effects of watercraft noise on the acoustic behaviour of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Mar. Mamm. Sci.* 20: 709-725)

Exposure to noise caused retarded development in hearing centres of brain

A study investigating brain development in rats noted that animals reared in an environment where they were continuously exposed to moderate levels of noise displayed retarded development of auditory centres of the brain. The researchers note that if this were the case for humans, children reared in a noisy environment could exhibit hearing and linguistic difficulties. If a similar effect occurred in cetaceans, the increasing levels of anthropogenic background noise in the oceans could cause retardation in brain development for functions that are essential to cetacean survival.

(SOURCE: Chang, E.F. and Merzenich, M.M. 2003. Environmental noise retards auditory cortical development. *Science* 300: 498-502)

Beaked whale mass stranding linked to sonar in the Canary Islands

In July 2004, an 'atypical' mass stranding of four Cuvier's beaked whales occurred in the Canary Islands. There have been at least four mass strandings of beaked whales that have been associated with military exercises conducted near the Canary Islands (1985, 1986, 1987 and 2002). The 2004 mass stranding event coincided with the naval exercise 'Majestic Eagle', which was conducted 100 km to the north of the islands in the week prior to the beaked whale carcasses being discovered. Fat emboli, *i.e.*, lesions associated with decompression sickness that have been associated with sonar-linked strandings, were found in the tissues of three of the whales.

(SOURCE: Espinosa, A., Arbelo, M., Castro, P., Martín, V., Gallardo, T. and Fernández, A. 2005. New beaked whale mass stranding in Canary Islands associated with naval military excercises (Majestic Eagle 2004). In: *19th Annual Conference of the European Cetacean Society and Associated Workshops, 2-7April 2005, La Rochelle, France*, p. 95. European Cetacean Society, La Rochelle.; Fernández, A., Mendez, M., Sierra, E., Godinho, A., Herráez, P., Espinosa De Los Monteros, A., Rodríguez, F. and Arbelo, M. 2005. New gas and fat embolic pathology in beaked whales stranded in the Canary Islands. In: *19th Annual Conference of the European Cetacean Society and Associated Workshops, 2-7April 2005, La Rochelle, France*, p. 95. European Cetacean Society, La Rochelle)

European Parliament Resolution on noise and sonar

On 28 October 2004, the European Parliament passed a resolution that called on the Commission and Member States to:

- "adopt a moratorium on the deployment of high-intensity active naval sonars until a global assessment of their cumulative environmental impact on marine mammals, fish and other marine life has been completed";
- "immediately restrict the use of high-intensity active naval sonars in waters falling under their jurisdiction";
- "monitor and investigate in a transparent manner mass strandings and deaths of marine mammals in EU waters that are associated with the use of intense anthropogenic noise";
- "conduct a study of the potential impact on the marine environment of the deployment of high-intensity active naval sonars and to provide an assessment, on the basis of information from the Member States, of the impact of current practices in European waters";
- "set up a Multinational Task Force to develop international agreements regulating noise levels in the world's oceans, with a view to regulating and limiting the adverse impact of anthropogenic sonars on marine mammals and fish".

Also the European Parliament stated it "[c]onsiders that any measures to introduce common standards and cooperation in the defence industry field must exclude and actively seek alternatives to technologies which are likely to cause unnecessary and serious damage to the environment and other Community interests, such as, in this case, fisheries".

(SOURCE: European Parliament resolution on the environmental effects of high-intensity active naval sonars [B6-0089/2004]), http://www.animalwelfare.com/whales/news/EU%20Sonar%20Resolution% 2010-2004.pdf)

IUCN Resolution calls for reduction and regulation of underwater noise

At the 3rd IUCN Congress, a resolution on underwater noise was passed that called for:

- The IUCN Director General and IUCN members to identify and implement measures to reduce anthropogenic noise in the world's oceans;
- Members to conduct further research on the effects of anthropogenic underwater noise on marine wildlife and how to mitigate these effects;
- Members to recognise that conservation measures should not be postponed due to a lack of full scientific certainty;
- The World Commission on Protected Areas (WCPA) to consider anthropogenic noise when working on the designation and management of marine protected areas;
- The Commission on Environmental Law (CEL) to make recommendations on the international regulation of underwater noise;
- The development of alternative technologies to reduce marine noise impacts;
- Restricting the use of military sonar to low-risk areas and work towards regulation of its use.

(SOURCE: IUCN 2004. CGR3. RES053-REV1. *Undersea Noise Pollution*. 3rd IUCN Congress, 17-25 November 2004, Bangkok, Thailand)

Cetacean 'milling event' in Hawaii linked to military activities

At 0730hrs on 3 July 2004, approximately 200 melon-headed whales were found milling in shallow water in Hanalei Bay, Kauai, Hawaii. Coincident with this event, the US Navy, along with Japanese vessels, was conducting manoeuvres, with active sonar in use, in waters near the island. One whale eventually stranded. This is the first record of this species coming inshore coincident with the use of military sonar.

(SOURCE: Kaufman, M. 2004. Sonar used before whales hit shore. *Washington Post* 31 August 2004: A3)

Multi-species mass stranding in North Carolina linked to military activities

Between 15 and 16 January 2005, 31 short-finned pilot whales, one common minke whale, and two pygmy sperm whales stranded in the Outer Banks area, North Carolina. Coincident with the stranding, six US Navy vessels were operating off Norfolk, Virginia. Although the US Navy stated "no Navy ships were using active sonar within a 50 nautical miles radius" of the area, one naval vessel did use sonar for seven minutes about 90 nautical miles southeast of the stranding area. The US Navy is currently considering locating a sonar testing range in the waters off North Carolina. This is yet another multi-species cetacean stranding event that has been linked to military sonar use.

(SOURCE: Kaufman, M. 2005. Whale stranding in N.C. followed Navy sonar use. *Washington Post* 28 January 2005: A3)

Riverine Irrawaddy dolphins show greater reactions to boat traffic

Coastal and riverine Irrawaddy dolphins decreased surfacing in reaction to the presence of boats. This reaction was more pronounced in riverine animals. While coastal animals only demonstrated reactions to speedboats, riverine animals also showed reactions to motorised canoes and tug boats. Distances at which reactions were caused were also greater for riverine animals (250-300 m) than coastal animals (50 m). Concern was expressed that boat traffic may be a particular problem for riverine dolphins.

(SOURCE: Kreb, D. and Rahadi, K.D. 2004. Living under an aquatic freeway: effects of boats on Irawaddy dolphins (*Orcaella brevirostris*) in a coastal and riverine environment in Indonesia. *Aquat. Mamm.* 30: 363-375.)

Acoustic harassment devices produce high source levels and cetacean-used frequencies in field

Acoustic harassment devices (AHDs or seal scrammers) have been highlighted as a source of anthropogenic sound that may disturb or displace cetaceans, particularly harbour porpoises. A recent study evaluated the source levels of three common varieties of AHDs within an open water setting. Peak source levels ranged up to 193 dB re 1 µPa with mid to high frequency (1.8 kHz – 103 kHz) components. The frequencies used in these devices coincide with frequencies used by many cetacean species and at levels that would be likely to cause at least behavioural disturbance and possibly habitat displacement. This emphasises that users of AHDs should consider the unintended impact of these devices on cetaceans.

(SOURCE: Lepper, P.A., Turner, V.L.G., Goodson, A.D. and Black, K.D. 2004. Source levels and spectra emitted by three commercial aquaculture anti-predation devices. In *Proceedings of the Seventh European Conference on Underwater Acoustics, ECUA 2004, Delft, The Netherlands, 5-8 July, 2004)*

Seismic surveys implicated in giant squid deaths

Concerns have been raised that high rates of giant squid strandings on the northern coast of Spain, adjacent to the Bay of Biscay, may be linked to seismic surveys. Nine giant squid have stranded in this area coincident with seismic surveys, five within a 10-day period in 2001 and four within one week in 2003. All the squid showed evidenced of acoustic trauma, and some with other internal tissue damage. This finding is particularly relevant to cetaceans, as large squid are important prey species of sperm and beaked whales. In addition, the Bay of Biscay is one of the most important habitats for cetaceans in southern Europe, especially beaked whale species.

(SOURCE: MacKenzie, D. 2004. Seismic surveys may kill giant squid. *New Sci.* 184(2467): 15)

Sperm whales show signs of decompression sickness

Examination of sperm whale bones collected over a 111-year time span showed routine osteonecrosis, increasing with age, a symptom in humans of decompression sickness (the 'bends'). This indicates that sperm whales are neither anatomically nor physiologically immune to the effects of deep diving. The authors suggest that recent reports of decompression-like sickness in another deep-diving taxon (beaked whales) in the presence of anthropogenic sound sources could therefore be a result of the animals' decompression sickness-avoidance behaviour being overridden by extended periods at the surface to escape the noise.

(SOURCE: Moore, M.J. and Early, G.A. 2004. Cumulative sperm whale bone damage and the bends. *Science* 306: 2215)

Biologically significant effects of noise: recommendations

To address concerns about marine mammal populations and ocean noise, the report of the US National Research Council's Committee on Characterizing Biologically Significant Marine Mammal Behavior made several recommendations, including:

- Developing a centralized database of marine mammal sightings and the mammals' responses to anthropogenic sound. Surveys should use standardised formats to allow comparison of data, and include track lines, with all data entered into the database to be assessed for quality;
- Developing a conceptual model to assess the impacts of acoustic activities on marine mammals, with an appropriate sensitivity analysis of the model to identify data needed and to focus research on acquiring the required data;
- The use of glucocorticoid and other blood hormone levels to assess stress in marine mammals, and to investigate the effect of age, sex and condition differences. The use of faecal samples to assess stress levels was recommended;
- Analysing in detail cetacean populations for which there are long-term data sets and develop a set of both individual-based and demographic models;
- Develop a practical process though which acoustic activities can be assessed to determine whether there will be an adverse effect on marine mammals, which should ideally be precautionary, capable of reassessing risk estimates as data improve, consider the cumulative effect of multiple low-level effects, and be composed of a few easy-to-estimate parameters;
- A better process to fully consider cumulative impacts and total mortality/losses from all sources.

(SOURCE: National Research Council. 2005. *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects.* National Academies Press, Washington, D.C.)

Offshore windfarms could have significant noise impacts

A study funded by the Crown Estate (a UK statutory authority) investigated the possible effects on cetaceans and marine fish from noise and vibrations of offshore windfarms. The study report determined that there would be significant effects during construction, notably during pile-driving. Disturbance reactions (avoidance) would be likely to a distance of several kilometres and severe acoustic trauma was possible within 100 m of a site.

(SOURCE: Nedwell, J. and Howell, D. 2004. *A review of offshore windfarm related underwater noises*. Report 544 R 0308. Subacoustec, Southampton; Nedwell, J., Langworthy, J., and Howell, D. 2003. *Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore windfarms and comparison with background noise*. Report 544 R 0424. Subacoustec, Southampton)

Mass strandings in the Galápagos – a possible link to noise

A review of cetacean strandings and discovered remains on the Galápagos Islands documented two Cuvier's beaked whale and two short-finned pilot whale mass strandings. Remains of multiple individuals found in the same location also suggest that there have been mass strandings of false killer whales, pantropical spotted dolphins, common bottlenose dolphins and additional mass strandings of pilot whales. One of the beaked whale strandings occurred on 11 April 2000 and was coincident with seismic surveys being conducted by the *Maurice Ewing* research vessel, although the vessel was 270 nautical miles away from the stranding location. The authors postulated that other mass strandings on the Galápagos may be linked to anthropogenic noise, as well as other anthropogenic causes.

(SOURCE: Palacios, D.M., Salazar, S.K. and Day, D. 2005. Cetacean remains and strandings in the Galápagos Islands, 1923-2003. *Latin. Amer. J. Aquat. Mamm.* 3: 127-150)

Pollutant (TBT) may cause hearing loss

Concentrations of TBT have been linked to hearing-inhibiting effects in the inner ear of mammals. Researchers have shown particular concern for the implications for cetaceans: "Notably, this observation identifies a new environmental threat for marine mammals by TBT, which is known to accumulate in the food chain". TBT contamination has been highlighted as being an issue for concern in cetaceans, and hearing loss associated with this pollutant could have impacts with respect to whales detecting shipping traffic, the cumulative impact of noise in the oceans and ultimately biologically significant effects on the ability of cetaceans to communicate and detect prey.

(SOURCE: Song, L., Seeger, A. and Santos-Sacchi, J. 2005. On membrane motor activity and chloride flux in the outer hair cell: lessons learned from the environmental toxin Tributyltin. *Biophys. J.* 88: 2350-2362)

Shipping noise symposium report

The first international symposium on 'Shipping Noise and Marine Mammals' was held on 18-19 May 2004 in Arlington, Virginia, U.S.A. This meeting brought together representatives of various ocean industries, academia and other research organizations, government and military personnel, and non-governmental organizations to address, for the first time, the issue of shipping noise and its impact and influence on the marine environment. The main purpose of the meeting was to initiate discussion on what information is available and needed concerning sounds produced by large ships and other vessels and their potential impacts on marine mammals. The issue will only become more urgent – the world's shipping fleet continues to increase in size (number and overall tonnage) and an approximate doubling in the number of large vessels is expected in the next two or three decades. While the relative contribution of sounds from various vessel types to overall ambient noise and their possible impacts on marine life remain largely unknown, quieting technologies do exist and are being further developed by the military and industry. At the conclusion of the meeting, a steering committee was formed to plan a proposed follow-on symposium.

(SOURCE: National Oceanic and Atmospheric Administration. 2005. *Shipping Noise and Marine Mammals: A Forum for Science, Management and Technology*. Final report of the National Oceanic and Atmospheric Administration, Washington. D.C.)

Seismic survey noise travels farther in shallow water

Modelling of the sound propagation of seismic airgun noise predicted noise levels of 160dB re 1µPa at 9 km from a 20-gun array (6.5 km for a 10-gun array). For 180 dB the range was just below one kilometre (0.95 km for a 20-gun array; 0.83 km for a 10-gun array). When field measurements were made in deeper water (>300 m), however, 160dB was measured at approximately 2.5 km, whereas in shallow water, 160dB was received at greater distances than predicted (at least 12 km from the array). This paper illustrates the potential noise levels produced from a research vessel conducting seismic surveys, and illustrates the importance of in-field verification of noise levels, and how these may differ substantially from those estimated by predictive models.

(SOURCE: Tolstoy, M., Diebold, J.B., Webb, S.C., Bohnenstiehl, D.R., Chapp, E., Holmes, R.C. and Rawson, M. 2004. Broadband calibration of R/V Ewing seismic sources. *Geophys. Res. Lett.* 31: L14310)

Mass stranding in Florida linked to military activities

At the beginning of March 2005, nearly 80 rough-toothed dolphins stranded in the Florida Keys. The mass stranding was coincident with a US Navy submarine exercise in the area. The submarine in question was said to be using two types of active sonar. This is yet another stranding event coincident with a military exercise, involving a pelagic cetacean species not previously observed to strand coincident with acoustic activity.

(SOURCE: Washington Post. 2005. Dolphin troubles may be related to sonar. *Washington Post* 11 March 2005: C12)

General

Nations agree to reduce rate of biodiversity loss by 2010

In April 2002, the 188 parties to the Convention on Biological Diversity agreed to reduce the rate of biodiversity loss significantly by 2010. This commitment was endorsed by the World Summit on Sustainable Development later that year. Measuring progress toward this goal poses a significant challenge. A Red List Index has been proposed to measure changes in overall extinction risk for all species, worldwide, in an entire class of organisms. It has both fine ecological resolution and the ability to represent comprehensive geographical regions. The cost is a lack of the sharp temporal resolution achieved by habitat, population and trophic indices. Other indicators of biodiversity, such as water quality and population trends, will also be measured in an effort to mark progress. Ultimately, urgent investment of resources is needed to ensure the goal is met.

(SOURCE: Brooks, T. and Kennedy, E. 2004. Biodiversity barometers. *Nature* 431: 1046)

Record mortality in endangered North Atlantic right whales

Since February 2004, at least seven right whales have been found dead along the U.S. east coast. The vast majority of these mortalities are anthropogenic and represent more than 2% the population, which is already in decline. The deaths are as follows:

- 3 February 2004: A pregnant female and her near-term calf were killed by a ship and found floating east of Virginia Beach, Virginia along their migratory corridor;
- 7 February 2004: A young calf was found dead of undetermined causes in the southeastern U.S. calving ground;
- 17 November 2004: A U.S. Naval vessel struck a pregnant female; her body and that of her near-term female calf were found on 24 November off the coast of Virginia;
- 9 December 2004: The body of a dead right whale was reported floating off Nantucket Island in Massachusetts. Bad weather prevented researchers from retrieving the body and no cause of death was determined;
- 10 January 2005: The body of a female right whale was seen floating off Nantucket Island. Bad weather prevented researchers from retrieving her body and no cause of death could be determined, nor could it be determined whether this mother of six previous calves was pregnant;
- 25 January 2005: The body of a female and her near-term calf were found in the calving ground off the coast of Georgia. This was her first calf and the strain of the pregnancy caused the scars from a previous anthropogenic injury to re-open, resulting in her death and that of her calf;
- 4 March 2005: The body of an adult right whale was found on an island off the coast of Virginia. The death resulted from a serious injury consequent to the animal's entanglement in fishing gear. Identity of the animal is pending.

(SOURCE: Sharon B. Young, The Humane Society of the United States, SOCER form submission, from unpublished data from the U.S. National Marine Fisheries Service and news reports)

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GLOSSARY

Species glossary

Beluga whale	*Delphinapterus leucas*	Mediterranean monk seal	*Monachus monachus*
Bowhead whale	*Balaena mysticetus*	Polar bear	*Ursus maritimus*
Cuvier's beaked whale	*Ziphius cavirostris*	Ringed seal	*Phoca hispida*
Common bottlenose dolphin	*Tursiops truncatus*	Southern elephant seal	*Mirounga leonina*
False killer whale	*Pseudorca crassidens*	Weddell seal	*Leptychotes weddelli*
Harbour porpoise	*Phocoena phocoena*		
Humpback whale	*Megaptera novaeangliae*	Rat	*Rattus norvegicus*
Indo-Pacific humpback dolphin	*Sousa chinensis*		
Irrawaddy dolphin	*Orcaella brevirostris*	Turnstone	*Arenaria interpres*
Killer whale	*Orcinus orca*		
Long-finned pilot whale	*Globicephala melas*	Alaska pollock	*Theragra chalcogramma*
Melon headed whale	*Peponocephala electra*	Arctic cod	*Boreogadus saida*
Minke whale	*Balaenoptera acutorostrata*	Atlantic cod	*Gadus morhua*
Narwhal	*Monodon monoceros*	Atlantic salmon	*Salmo salar*
North Atlantic right whale	*Eubalaena glacialis*	Giant squid	*Architeuthis* spp.
Northern minke whale	*Balaenoptera acutorostrata*	Pacific cod	*Gadus macrocephalus*
Pantropical spotted dolphin	*Stenella attenuata*	Pacific salmon	
Pygmy sperm whale	*Kogia breviceps*	Chinook	*Oncorhynchus tshawytscha*
Rough-toothed dolphin	*Steno bredanensis*	Sockeye	*Oncorhynchus nerka*
Short-finned pilot whale	*Globicephala macrorhynchus*	Coho	*Oncorhynchus kisutch*
Sperm whale	*Physeter macrocephalus*	Pink	*Oncorhynchus gorbuscha*
White-beaked dolphin	*Lagenorhynchus albirostris*	Chum	*Oncorhynchus keta*
		Patagonian toothfish	*Dissostichus eleginoides*
Antarctic fur seal	*Arctocephalus gazella*	Walleye pollock	*Theragra chalcogramma*
California sea lion	*Zalophus californianus*	Warty squid	*Moroteuthis ingens*
Harbour seal	*Phoca vitulina*		
Hawaiian monk seal	*Monachus schauinslandi*	Krill	*Euphausia superba*

Element glossary

Ag	silver	N	nitrogen
Al	aluminium	K	potassium
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Cd	cadmium	Mo	molybdenum
Co	cobalt	Ni	nickel
Cr	chromium	Pb	lead
Cu	copper	Se	selenium
Fe	iron	Sn	tin
Hg	mercury	V	vanadium

Glossary of terms

ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area.

Acoustic harassment devices: Also known as AHDs or seal scrammers. These are devices that produce high intensity sound and are designed to displace marine mammals such as seals from areas such as fish farms.

Aquaculture: Finfish or shellfish farming

Anti-fouling paint: Paint used to prevent accumulation of marine organisms, such as barnacles, on ship hulls. Repulsing chemicals such as butyltin are used to prevent organisms from settling.

Atypical mass stranding: A stranding involving more than two beaked whales that strand more or less simultaneously in time, but in locations separated by at least a kilometre or more.

Benthic: Referring to the ocean bottom.

Bioaccumulation: Increase in concentration of a contaminant in an organism's tissues (*e.g.,* blubber) over time, compared to the concentration of the contaminant in the environment.

Biomagnification: Increase in concentration of a contaminant from one link in a food chain to another.

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

Biopsy: Removal of tissue or cells from the living body for non-lethal examination or study, especially for diagnostic purposes.

Biota: All living things in an ecosystem.

Brominated: Containing the element bromine.

Butyltin: An organic compound containing tin that has toxic properties to marine life, used in anti-fouling paints on ship hulls.

Carcinogenic: Capable of causing cancer.

CFC: Chlorofluorocarbons.

Chlordane: An organochlorine pesticide.

CO_2: Carbon dioxide, a major 'greenhouse' gas.

dB: Decibel – a measure of sound pressure level.

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

DDT: The organochlorine pesticide dichlorodiphenyltrichloro-ethane, which tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.

Dioxin: A class of extremely toxic organochlorines, generally produced as a waste or by-product.

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.

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

Epidemic: The outbreak of a pathogen- or parasite-caused disease in a population that increases rapidly, reaches a peak then declines. The term epizootic is used for non-human animals.

Epidemiology: The study of disease epidemics (c.f.)

Exogenous: Derived or existing externally.

Fluorinated: Containing the element fluorine.

HCB: Hexachlorobenzene, an environmentally persistent organochlorine pesticide.

HCH: Hexochlorocyclohexane, an environmentally persistent organochlorine pesticide.

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

Immunosuppression: The suppression of the immune system or response, resulting in a greater susceptibility to disease.

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

Lipophilic: A reference to compounds that dissolve easily in lipid (*i.e.,* dissolve and accumulate in fat cells).

Mutagenic: Capable of causing genetic mutations.

Myctophid: Of the family Myctophidae, a taxon of deep sea fishes comprising the lanternfish.

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.

Osteonecrosis: Death of bone tissue.

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

PAHs: Polycyclic aromatic hydrocarbons.

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

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.

Pelagic: Referring to open water, free-swimming marine species.

Perfluorinated organochemicals (PFOs): A class of toxic organic molecules with fluorine atoms attached (also called perfluorinated compounds), including perfluoroalkyl carboxylates (PFCAs) and perfluoro-octane sulfonate (PFOS).

Phagocytosis: A cell's ability to digest (remove) extracellular molecules.

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

Polychlorinated naphthalenes: A group of chemicals containing 1 to 8 chlorine atoms bound to the naphthalene di-benzene ring, structurally similar to PCBs.

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

TEQ: Toxic Equivalent. The overall toxicity or environmental threat posed by a set of closely related pollutants.

Thermohaline Circulation: The deepwater circulation of the oceans, which is primarily caused by differences in density (which are in turn dependent on salinity and temperature) between water bodies of different regions. This circulation system is important in distributing heat energy around the world.

Trophic level: Each level of consumption in a food chain.

Watt: A measure of electrical energy.

Wet weight: See dry weight.

Zoonotic: Animal disease that is capable of infecting and causing disease in humans.