

Marine Science Review - 174

Marine mammals



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A. Recent articles – no abstract available

El-Zein, R.A., Hastings-Smith, D.A., Ammenheuser, M.M., Treinen-Moslen, M., Gulland, F.M., and Ward, J.B. **Evaluation of two different biomarkers for use in the assessment of toxic chemical exposure in California sea lions (*Zalophus californianus*).** *Marine Pollution Bulletin* 52(1): 108-113, 2006.

Bradshaw, C.J.A., Evans, K., and Hindell, M.A. **Mass cetacean strandings - a plea for empiricism.** *Conservation Biology* 20(2): 584-586, 2006.

Dalton, R. **More whale strandings are linked to sonar.** *Nature* 440(7084): 593, 2006.

Laist, D.W. and Shaw, C. **Preliminary evidence that boat speed restrictions reduce deaths of Florida manatees.** *Marine Mammal Science* 22(2): 472-479, 2006.

Towell, R.G., Ream, R.R., and York, A.E. **Decline in northern fur seal (*Callorhinus ursinus*) pup production on the Pribilof Islands.** *Marine Mammal Science* 22(2): 486-491, 2006.

B. Recent publications available online

Southall, B.L., Braun, R., Gulland, F.M.D., Heard, A.D., Baird, R.W., Wilkin, S.M., and Rowles, T.K. 2006. **Hawaiian melon-headed whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004.** NOAA Technical Memorandum NMFS-OPR-31. 73pp.

Available at: http://www.nmfs.noaa.gov/pr/pdfs/health/stranding_melonheadedwhales_final_report.pdf

Notes: While causation of this stranding event may never be unequivocally determined, the authors consider the Navy's active sonar transmissions of July 2-3, 2004, a plausible, if not likely, contributing factor in what may have been a confluence of events. This conclusion is based on: (1) the evidently anomalous nature of the stranding; (2) its close spatiotemporal correlation with wide-scale, sustained use of sonar systems previously associated with stranding of deepdiving marine mammals; (3) the directed movement of two groups of transmitting vessels toward the southeast and southwest coast of Kaua'i; (4) the results of acoustic propagation modeling and an analysis of possible animal transit times to the Bay; and (5) the absence of any other compelling causative explanation. The initiation and persistence of this event may have resulted from an interaction of biological and physical factors. The biological factors may have included the presence of an apparently uncommon, deep-diving cetacean species (and possibly an offshore, non-resident group), social interactions among the animals before or after they entered the Bay, and/or unknown predator or prey conditions. The physical factors may have included the presence of nearby deep water, multiple vessels transiting in a directed manner while transmitting active sonar over a sustained period, the presence of surface sound ducting conditions, and/or intermittent and random human interactions while the animals were in the Bay.

C. Recent articles with abstracts

Hamilton, P.K. and Marx, M.K. **Skin lesions on North Atlantic right whales: categories, prevalence and change in occurrence in the 1990s.** *Diseases of Aquatic Organisms* 68(1): 71-82, 2005.

Notes: North Atlantic right whales *Eubalaena glacialis* experienced decreased reproduction and body condition in the 1990s, causing concern about the overall health of this critically endangered population. Images from a detailed photo-identification catalog of right whales were analyzed for the presence of skin lesions. Lesions were categorized as white lesions or blister lesions and each of those categories were further divided based on lesion morphology and location. Of 439 whales photo-analyzed between 1980 and 2002, white lesions were detected on 227 ind. (51.7%) and blister lesions were found on 76 ind. (17.3%). The majority of white lesions (72.8%) were detected in the Bay of Fundy where their prevalence increased dramatically during the 1990s (peaking at 40 and 41% of all identified whales in 1997 and 1999, respectively). A correlation between whale density and white lesions in the Bay of Fundy suggested that this lesion type may have been the result of a contagious agent, though the data on mother/calf pairs did not indicate transmission from mother to calf. Blister lesions appeared at low levels throughout the population over the study period. Neither lesion category was more prevalent on males or females, nor were there any differences between adults and juveniles. One white lesion type appeared exclusively on whales that had been entangled, and whose subsequent survival was in most cases questionable. This is the first detailed analysis of skin lesions in this species. Only 1 tissue sample has been previously obtained from a lesion, and thus the histology and etiology of these lesions remain unknown. Further work is needed to explore the role of disease and environmental variables in lesion prevalence.

Kastelein, R.A., Jennings, N., Verboom, W.C., deHaan, D., and Schooneman, N.M. **Differences in the response of a striped dolphin (*Stenella coeruleoalba*) and a harbour porpoise (*Phocoena phocoena*) to an acoustic alarm.** *Marine Environmental Research* 61(3): 363-378, 2006.

Notes: Small cetacean bycatch in gillnet fisheries may be reduced by deterring odontocetes from nets acoustically. However, different odontocete species may respond differently to acoustic signals from alarms. Therefore, in this study a striped dolphin and a harbour porpoise were subjected simultaneously to sounds produced by the XP-10 experimental acoustic alarm. The alarm produced 0.3 s tonal signals randomly selected from a set of 16 with fundamental frequencies between 9 and 15 kHz, with a constant pulse interval of 4.0 s (duty cycle 8%) and a Source Level range of 133-163 dB re 1 mPa (rms). The effect of the alarm was judged by comparing the animals' respiration rate and position relative to the alarm during test periods with those during baseline periods. As in a previous study on two porpoises with the same alarm, the porpoise in the present study reacted strongly to the alarm by swimming away from it and increasing his respiration rate. The striped dolphin, however, showed no reaction to the active alarm. Based on harbour porpoise audiograms and the specific audiogram of the striped dolphin in the present study, and the low background noise levels during the experiment, both animals must have heard the alarm signals clearly. This study indicates that cetacean species are not equally sensitive to human-made noise disturbance. Therefore, source levels of acoustic alarms should be adapted to the species they are supposed to deter. In addition, alarms should be tested on each odontocete species for which they are intended to reduce bycatch.

Mori, C., Morsey, B., Levin, M., Nambiar, P.R., and DeGuise, S. **Immunomodulatory effects of in vitro exposure to organochlorines on T-cell proliferation in marine mammals and mice.** *Journal of Toxicology and Environmental Health Part A* 69(4): 283-302, 2006.

Notes: Marine mammals bioaccumulate various environmental contaminants such as organochlorines (OCs), which biomagnify via the food web. While the immunomodulatory effects of individual OCs have been studied, the effects of mixtures are not well understood. The immunomodulatory effects of polychlorinated biphenyl (PCB) 138, 153, 169, and 180 as well as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and all possible mixtures were examined in marine mammals and mice. Lymphocyte proliferation was significantly modulated by OCs in all species tested, mostly by non-coplanar PCBs, as shown using regression analyses. Correlation analyses showed significant correlations (interpreted as additive effects) between OCs in

mice, killer whales, and Steller sea lions. Nonadditive synergistic and antagonistic interactions between OCs were detected in most of the species tested. Toxic equivalency (TEQ) values used for OC toxicity assessment failed to predict the immunomodulatory effects measured in mice and marine mammals. The commonly used mouse model failed to predict immunomodulatory effects in other species. Clustering data suggested that phylogeny does not predict toxicity of OCs. Overall, our data suggest the presence of species-specific sensitivities to different mixtures, in which OCs interactions may be complex and that may exert their effects through dioxinlike or dioxin-independent pathways. Lastly, lymphocyte proliferation, an important part of adaptive immunity, was significantly modulated in mice and marine mammals, suggesting the possibility of increased susceptibility to diseases. These findings will be useful to better characterize the risk associated with OC exposure and possibly lead to new conservation and management strategies.

Vianna, J.A., Bonde, R.K., Caballero, S., Giraldo, J.P., Lima, R.P., Clark, A., Marmontel, M., Morales-Vela, B., DeSouza, M.J., Parr, L., Rodriguez-Lopez, M.A., Mignucci-Giannoni, A.A., Powell, J.A., and Santos, F.R. **Phylogeography, phylogeny and hybridization in trichechid sirenians: implications for manatee conservation.** *Molecular Ecology* 15(2): 433-447, 2006.

Notes: The three living species of manatees, West Indian (*Trichechus manatus*), Amazonian (*Trichechus inunguis*) and West African (*Trichechus senegalensis*), are distributed across the shallow tropical and subtropical waters of America and the western coast of Africa. We have sequenced the mitochondrial DNA control region in 330 *Trichechus* to compare their phylogeographic patterns. In *T. manatus* we observed a marked population structure with the identification of three haplotype clusters showing a distinct spatial distribution. A geographic barrier represented by the continuity of the Lesser Antilles to Trinidad Island, near the mouth of the Orinoco River in Venezuela, appears to have restricted the gene flow historically in *T. manatus*. However, for *T. inunguis* we observed a single expanding population cluster, with a high diversity of very closely related haplotypes. A marked geographic population structure is likely present in *T. senegalensis* with at least two distinct clusters. Phylogenetic analyses with the mtDNA cytochrome b gene suggest a clade of the marine *Trichechus* species, with *T. inunguis* as the most basal trichechid. This is in agreement with previous morphological analyses. Mitochondrial DNA, autosomal microsatellites and cytogenetic analyses revealed the presence of hybrids between the *T. manatus* and *T. inunguis* species at the mouth of the Amazon River in Brazil, extending to the Guyanas and probably as far as the mouth of the Orinoco River. Future conservation strategies should consider the distinct population structure of manatee species, as well as the historical barriers to gene flow and the likely occurrence of interspecific hybridization.

McKinney, M.A., De Guise, S., Martineau, D., Beland, P., Arukwe, A., and Letcher, R.J. **Biotransformation of polybrominated diphenyl ethers and polychlorinated biphenyls in beluga whale (*Delphinapterus leucas*) and rat mammalian model using an in vitro hepatic microsomal assay.** *Aquatic Toxicology* 77(1): 87-97, 2006.

Notes: Although polychlorinated biphenyls (PCBs) and polybrominated diphenyl ether (PBDE) flame retardants are important organic contaminants in the tissues of marine mammals, including those species from the Arctic, there is exceedingly little direct evidence on congener-specific biotransformation. We determined and compared the in vitro metabolism of environmentally relevant PCB (4,4'-di-CB 15, 2,3',5-tri-CB26, 2,4,5-tri-CB31, 2,2',5,5'-tetra-CB52, 3,3',4,4-tetra-CB77, 2,2',4,5,5'-penta-CB101, 2,3,3',4,4-penta-CB105 and 2,3',4,4',5-penta-CB118), and PBDE (4,4'-di-BDE15, 2,4,4'-tri-BDE28, 2,2',4,4'-tetra-BDE47, 2,2',4,5'-tetra-BDE49, 2,2',4,4',5-penta-BDE99, 2,2',4,4',6-penta-BDE100, 2,2',4,4',5,5'-hexa-BDE153, 2,2',4,4',5,6'-hexa-BDE154 and 2,2',3,4,4',5,6'-hepta-BDE183) congeners using hepatic microsomes of a beluga whale (*Delphinapterus leucas*) from the Arviat (western Hudson Bay) area of the Canadian Arctic. Ortho-meta bromine-unsubstituted BDE15, BDE28 and BDE47 were significantly metabolized (100%, 11% and 5% depleted, respectively) by beluga, whereas control rat microsomes (from pooled male Wistar Han rats) metabolized BDE28, BDE49, BDE99 and BDE154 (13%, 44%, 11% and 17% depleted, respectively). CB15 and CB77 (putative CYP1A substrates) were more rapidly metabolized (100% and 93% depleted, respectively) by male beluga than CB26 and CB31 (CYP1A/CYP2B-like) (25% and 29% depleted, respectively), which were more rapidly metabolized than CB52 (CYP2B-like) (13% depleted). Higher chlorinated CB101 and CB105 showed no depletion. Rat control microsomes metabolized CB15 to a lesser extent (32% depleted) than beluga, but much more rapidly transformed CB52 (51% depleted, respectively). Within the 90 min in vitro assay time frame, the preference was towards metabolism of ortho-meta unsubstituted congeners (for both PCBs and PBDEs) in beluga whale, whereas for rat controls, meta-para unsubstituted congeners also substantially metabolized. For both beluga whale and rat, metabolic rates were inversely associated with the degree of halogenation. For the rapidly biotransformed CB15 and BDE15, water-soluble OH-metabolites were detected after incubation. These results indicate that CYP-mediated oxidative hepatic biotransformation is a metabolic pathway in the toxicokinetics of both PCB and PBDE congeners in beluga whales

and in the rat model. This may suggest that the formation of potentially toxic oxidative PCB and PBDE products (metabolites), in addition to the parent pollutants, may be contributing to contaminant-related stress effects on the health of beluga whale.

Cooper, L.W., Ashjian, C.J., Smith, S.L., Codispoti, L.A., Grebmeier, J.M., Campbell, R.G., and Sherr, E.B. **Rapid seasonal sea-ice retreat in the Arctic could be affecting Pacific walrus (*Odobenus rosmarus divergens*) recruitment.** *Aquatic Mammals* 32(1): 98-102, 2006.

Notes: Under conditions of rapid sea-ice retreat and dissolution, we observed at least nine Pacific walrus calves separated from adult females in waters as deep as 3,000 m in July and August 2004 in the Canada Basin of the Arctic Ocean. Given limited sea surface visibility from the ship, we surmise that many additional calves may have been separated in the overall study area. These conditions appear to have been related to the transport of unusually warm (7° C) Bering Sea water into this area north of Alaska. Walruses invest considerable maternal resources while caring for calves on seasonally ice-covered continental shelves for periods of up to 2 y or more and only rarely separate from their young. Therefore, these observations indicate that the Pacific walrus population may be ill-adapted to rapid seasonal sea-ice retreat off Arctic continental shelves.

Leaper, R., Cooke, J., Trathan, P., Reid, K., Rowntree, V., and Payne, R. **Global climate drives southern right whale (*Eubalaena australis*) population dynamics.** *Biology Letters* 2(2): 289-292, 2006.

Notes: Sea surface temperature (SST) time-series from the southwest Atlantic and the El Niño 4 region in the western Pacific were compared to an index of annual calving success of the southern right whale (*Eubalaena australis*) breeding in Argentina. There was a strong relationship between right whale calving output and SST anomalies at South Georgia in the autumn of the previous year and also with mean El Niño 4 SST anomalies delayed by 6 years. These results extend similar observations from other krill predators and show clear linkages between global climate signals and the biological processes affecting whale population dynamics.

Andersen, G., Foreld, S., Skaare, J.U., Jenssen, B.M., Lydersen, C., and Kovacs, K.M. **Levels of toxaphene congeners in white whales (*Delphinapterus leucas*) from Svalbard, Norway.** *The Science of the Total Environment* 357(1-3): 128-137, 2006.

Notes: This study reports concentrations of three pesticide toxaphene congeners (CHBs; CHB-26, -50 and -62) from the blubber of ten adult, male white whales (*Delphinapterus leucas*) from Svalbard, Norway. The CHB congeners that occurred at the highest levels in the blubber of the white whales were, as expected, CHB-26 (4636 +/- 1992 (SD) ng/g l.w.) and CHB-50 (6579 +/- 2214 ng/g l.w.); CHB-62 (232 +/- 231 ng/g l.w.) was also present, but at much lower concentrations. The mean level of the sum of the three CHBs (SCHBs= 11,447 +/- 4208 ng/g l.w.) in this study is more than twice the mean concentrations of the well-known organochlorine (OC) pollutants SDDT's (sum of pp'-DDT, pp'-DDE, pp'-DDD) and SPCBs (sum of 27 PCB congeners) previously reported from the same individual white whales. The concentrations of CHBs in white whales from Svalbard are at the high end of the range for concentrations of these compounds compared to other Arctic white whale populations. Additionally, the contribution of CHBs to the overall OC burden is larger in white whales from Svalbard compared with their counterparts from other areas in the Arctic. Male white whales from Svalbard have several orders of magnitude higher concentrations of SCHBs compared to seals and polar bears (*Ursus maritimus*) from the same area. The high levels of CHBs in these whales, and their dominance in the OC pattern, suggests that white whales in Svalbard are exposed to high levels of this group of contaminants. Further studies are needed to investigate possible effects of CHBs and other OC contaminants on the white whale population in Svalbard.

Jemison, L.A., Pendleton, G.W., Wilson, C.A., and Sniall, R.J. **Long-term trends in harbor seal numbers at Tugidak Island and Nanvak Bay, Alaska.** *Marine Mammal Science* 22(2): 339-360, 2006.

Notes: We conducted land-based counts of harbor seals (*Phoca vitulina richardii*) and collected related environmental data at Tugidak Island (Gulf of Alaska, 1994-2000) and Nanvak Bay (Bristol Bay, 1990-2000) to estimate population trends and

identify factors influencing counts. At Tugidak Island, the seal population declined substantially during molting from 1976 through the 1980s, stabilized in the early 1990s, and increased at a moderate rate (3.47%/yr, CI: 1.0%-5.8%) from 1994 to 2000. Pups and all seals ashore during pupping increased at higher annual rates of 5.4% (CI: 2.2%-8.8%) and 8.3% (CI: 4.5%-12.3%) from 1994 to 2000 at Tugidak Island. At Nanvak Bay seals declined in abundance between 1975 and 1990 but increased during the 1990s at 9.27%/yr (CI: 7.2%-11.3%) during pupping and 2.1%/yr (CI: 0.6%- 3.6%) during molting. Date and time-of-day were significant covariates in all analyses. Factors that led to declines at Tugidak Island and Nanvak Bay have seemingly abated sufficiently such that these populations are currently increasing, though still greatly reduced from the 1970s. Index sites are useful adjuncts to aerial surveys, providing survey-related information not always available from aerial counts, which is useful in survey design and data analysis.

Hennen, D. **Associations between the Alaska Steller sea lion decline and commercial fisheries.** *Ecological Applications* 16(2): 704-717, 2006.

Notes: The Steller sea lion (SSL) population in Alaska was listed as threatened under the Endangered Species Act in 1990. At that time, several procedural restrictions were placed on the commercial fisheries of the region in an effort to reduce the potential for human-induced mortality on sea lions. Several years have elapsed since these restrictions were put into place, and questions about their efficacy remain. In an effort to determine whether or not fisheries management measures have helped the SSL population to recover, estimates of the fishing activity of the Bering Sea/Gulf of Alaska commercial fisheries in the vicinity of individual SSL rookeries and SSL population trends at those rookeries were made using data from the National Marine Fisheries Service (NMFS) Fisheries Observer Program and Steller Sea Lion Adult Count Database. Fisheries data from 1976-2000 were analyzed in relation to SSL population counts from 1956-2001 at 32 rookeries from the endangered western stock. Linear regression on the principal components of the fisheries data show that a positive correlation exists between several metrics of historical fishing activity and the SSL population decline. The relationship is less consistent after 1991, supporting a hypothesis that management measures around some of the rookeries have been effective in moderating the localized effects of fishing activity on SSL.

Rosing-Asvid, A. **The influence of climate variability on polar bear (*Ursus maritimus*) and ringed seal (*Pusa hispida*) population dynamics.** *Canadian Journal of Zoology* 84(3): 357-364, 2006.

Notes: Unusually high polar bear (*Ursus maritimus* Phipps, 1774) predation on ringed seal (*Pusa hispida* (Schreber, 1775)) pups and increased survival of polar bear cubs during mild springs is documented in published articles. Strong predation on newborn ringed seal pups in early spring, however, is likely to lower the overall energy intake of polar bears if ringed seal pups are their main food, because the energetic value of ringed seal pups increases 7-8 times during the 6 week lactation period. So although hunting success in early spring increases cub survival during the period after den emergence when they are most vulnerable, it is likely to increase the number of starving bears later in the season. This negative-feedback effect of strong spring predation will not occur in areas where other seal species are abundant during summer, and polar bears in such areas are likely to exhibit population growth during periods with milder springs, at least until the ringed seal population has been depleted. Long time series of population estimates that can be used to test this hypothesis do not exist, but it is strongly supported by catch statistics for polar bears and ringed seals from east Greenland.

Chilvers, B.L., Wilkinson, I.S., Duignan, P.J., and Gemmill, N.J. **Diving to extremes: are New Zealand sea lions (*Phocarctos hookeri*) pushing their limits in a marginal habitat?** *Journal of Zoology* 269(2): 233-240, 2006.

Notes: When studying diving behaviour, it is important to know whether a species is operating at or close to its maximum physiological capacity, because if it is, it will be less capable of compensating for normal environmental or human-induced fluctuations in its environment. New Zealand (NZ) sea lions *Phocarctos hookeri* are among the world's rarest pinnipeds with a restricted distribution and abundance to the most southerly limit of their known range, NZ's sub- Antarctic. Female NZ sea lions are the deepest and longest diving of the otariids, foraging further from their breeding rookeries than any other sea lion. In this study, the diving behaviours of 18 female NZ sea lions from Enderby Island, Auckland Islands, were recorded during early lactation over two austral summers, 2003 and 2004. While at sea, sea lions dived almost continuously, spending on average 52.7% of their time submerged (> 6 m). The mean dive depth (+/- SE) for all dives was 129.5 +/- 5.3 m (range 94.6

+/- 1.1 to 178.9 +/- 1.6 m). The mean duration of dives was 4.0 +/- 0.1 min with an average of 40 +/- 2.9% of all dive times spent in the deepest 85% of the dive. Although there was high variation in diving behaviour among individuals, overall, animals were found to be diving beyond their estimated aerobic dive limits on 68% of all dives. Given that female NZ sea lions have a high percentage of dives that are beyond their theoretical aerobic limits, we ask whether this represents a miscalculation in aerobic limits, is it a species highly adapted to carry an anaerobic load or a species that is physically stretched to their limits? A species that is presumably under physiological stress just to maintain its current low static population numbers is also likely to be more susceptible to external impacts and this needs consideration for their management.

Gonzalez-Suarez, M., McCluney, K.E., Aurioles, D., and Gerber, L.R. **Incorporating uncertainty in spatial structure for viability predictions: a case study of California sea lions (*Zalophus californianus californianus*).** *Animal Conservation* 9(2): 219-227, 2006.

Notes: In recent years, population viability analysis has become a popular tool to assess the relative risk of extinction among populations. Viability estimates for spatially structured populations require movement data that are often unavailable. In this paper, a diffusion approximation model was used to explore the effects of different spatial scenarios resulting from assumptions about movement rates. Census data for 13 breeding islands occupied by California sea lions *Zalophus californianus californianus* in the Gulf of California were used to explore three potential scenarios: unlimited movement between sites (panmictic population), limited movement (several clusters of populations) and no movement between islands (isolated islands). Predicted viability estimates were different for each scenario, but contrary to expectations, the mean extinction risk estimates were generally lowest when movement was unlimited (panmictic scenario). However, despite an extensive dataset, the confidence of the viability predictions for each scenario was low. In some cases, uncertainty in predictions within a scenario was greater than differences between scenarios. Therefore, it is recommended that in situations where movement rates and spatial structure are unknown, extinction risk estimates should reflect both the confidence intervals for each risk estimate and the uncertainty resulting from different spatial scenarios. This study also provides the first estimate of population viability (considering spatial structure) for California sea lions in the Gulf of California and an evaluation of population status based on the IUCN criteria for species listing.

Slooten, E., Dawson, S., Rayment, W., and Childerhouse, S. **A new abundance estimate for Maui's dolphin: What does it mean for managing this critically endangered species?** *Biological Conservation* 128(4): 576-581, 2006.

Notes: Hector's dolphin *Cephalorhynchus hectori* is found only in New Zealand waters. We carried out a population survey of the North Island subspecies *Cephalorhynchus hectori maui*, also known as Maui's dolphin. The total population size estimate is 111 individuals (95% confidence interval = 48-252). The small population size confirms its critically endangered IUCN status. A sustainable level of human-caused mortality for this population would be 0.16 (one dolphin every 6.4 years). This essentially means that fisheries bycatch, and where possible other human impacts, need to be eliminated to allow population recovery. A protected area has been created to reduce the threat from entanglement in fishing gear. Gillnet fishing is prohibited along a 210 nautical mile stretch of coastline. The main concerns are that gillnet fishing is still allowed inside harbours and trawling continues inside the protected area.

Parra, G.J., Corkeron, P.J., and Marsh, H. **Population sizes, site fidelity and residence patterns of Australian snubfin and Indo-Pacific humpback dolphins: Implications for conservation.** *Biological Conservation* 129(2): 167-180, 2006.

Notes: Very little is known about the ecology of snubfin *Orcaella heinsobni* and Indo-Pacific humpback dolphins *Sousa chinensis* in Australian waters. We used photo-identification data collected between 1999 and 2002 in Cleveland Bay, northeast Queensland, to estimate abundance, site fidelity and residence patterns of these species in order to make recommendations for their effective conservation and management. Our abundance estimates indicate that less than a hundred individuals of each species inhabit this coastal area. Even with relatively unbiased and precise abundance estimates population trends will be extremely difficult to detect in less than three years unless changes in population size are very high (> 20% p.a.). Though both species are not permanent residents in Cleveland Bay, they both used the area regularly from year to year following a model of emigration and reimmigration. Individuals of both species spend periods of days to a month or more in coastal waters of Cleveland Bay before leaving, and periods of over a month outside the study area before entering the bay again. Because of

their small population sizes and movement patterns, snubfin and humpback dolphins are particularly vulnerable to local extinction. Our results illustrate that: (1) detection of population trends should not be a necessary criterion for enacting conservation measures of both species in this region, and (2) efforts to maintain viable populations of both species in Cleveland Bay must include management strategies that integrate anthropogenic activities in surrounding areas.

Herrera, G.E. and Hoagland, P. **Commercial whaling, tourism, and boycotts: An economic perspective.** *Marine Policy* 30(3): 261-269, 2006.

Notes: Commercial whaling is highly contentious, angering animal rights groups and conservation organizations, who threaten boycotts. Proponents of whaling argue that many whale stocks are plentiful enough to support sustainable harvests. In terms of economic efficiency, a nation's decision to engage in whaling depends on rents from the whaling industry, ecological and market linkages, and the potential for boycotts. We analyze the tradeoffs involved in a nation's decision to engage in whaling, whale-watching, and fishing. Scenarios exist in which whaling is economically rational. Indeed, sometimes it makes economic sense to subsidize whaling. In other circumstances, market pressures make commercial whaling inefficient.

Heazle, M. **Lessons in precaution: The International Whaling Commission experience with precautionary management.** *Marine Policy* 30(5): 496-509, 2006.

Notes: The precautionary principle (PP) only represents a *new* approach to managing uncertainty in so far that it requires *proponents* of an activity or substance to provide evidence that the activity/substance is *harmless*, as opposed to the more traditional "trial and error" approach that has instead placed the burden of proof that something is *harmful* on its *opponents*. This article critiques the PP as a policy making tool for managing uncertainty, focusing on the epistemological problems it raises, before then using the International Whaling Commission's experience with precautionary approaches to wildlife management to demonstrate the principle's limits and weaknesses when applied in a highly politicised policymaking environment. The article concludes that while the PP offers some benefits for managing uncertainty, its vagueness and openness to broad interpretation can also result in its application creating, rather than limiting, risks and uncertainty.

Doucette, G.J., Cembella, A.D., Martin, J.L., Michaud, J., Cole, T.V.N., and Rolland, R.M. **Paralytic shellfish poisoning (PSP) toxins in North Atlantic right whales *Eubalaena glacialis* and their zooplankton prey in the Bay of Fundy, Canada.** *Marine Ecology Progress Series* 306: 303-313, 2006.

Notes: Intensive study of the highly endangered western North Atlantic right whale *Eubalaena glacialis* over the past 25 yr has yielded evidence of reproductive dysfunction and compromised health, particularly in the late 1990s. Among the factors identified as potentially contributing to this phenomenon, exposure to marine biotoxins associated with harmful algal blooms has received little consideration. We assessed the occurrence of paralytic shellfish poisoning (PSP) toxins (saxitoxin [STX] analogues) in *E. glacialis* and in the co-occurring zooplankton assemblage dominated by *Calanus finmarchicus*, the primary food for this whale species in the North Atlantic. Samples of *E. glacialis* feces collected during August/September 2001 from at least 11 different whales in the Bay of Fundy, Canada, tested positive for PSP toxins using a receptor binding assay and were also quantified by high-performance liquid chromatography with fluorescence detection, indicating concentrations as high as 0.5 μg STX equivalents g^{-1} of feces. Zooplankton samples collected in the Bay of Fundy during the same period contained similar levels of PSP toxins by weight using both methods. Additional data from the Bay of Fundy revealed the presence of PSP toxin-producing dinoflagellates, *Alexandrium* spp., immediately before and during the sampling period. Associated PSP toxin levels in shellfish from nearby Cheney Passage, New Brunswick, exceeded regulatory limits over the same time frame. These findings provide direct evidence for the occurrence of PSP toxins in *E. glacialis* and suggest that trophic transfer of marine algal toxins is a factor contributing to the failure of the endangered North Atlantic right whale population to recover.

Crocker, D.E., Costa, D.P., LeBoeuf, B.J., Webb, P.M., and Houser, D.S. **Impact of El Nino on the foraging behavior of female northern elephant seals.** *Marine Ecology Progress Series* 309: 1-10, 2006.

Notes: Our aim was to examine the foraging behavior of northern elephant seals *Mirounga angustirostris* during the 1997-98 El Nino and compare it to foraging in others years. Given their deep diving and spatial distribution, their immediate response to a severe El Nino was expected to give insight into the timing, scale and magnitude of El Nino Southern Oscillation impacts on a large marine predator. Time-depth records and Argos-linked satellite tracks were obtained from adult females departing on post-breeding foraging migrations from 1990 to 1999, including females foraging during the 1998 El Nino. Rates of mass gain and trip duration were recorded for females from 1983 to 1999. Movement tracks of females in 1998 were similar to those observed in non-El Nino years. Rate of mass gain at sea was 0.29 ± 0.36 kg d⁻¹ in 1998, the lowest measured since 1983. Marked declines in the mass gain rate of females were noted in severe El Nino years, but not in moderate El Nino years. Females increase spring foraging trip duration to compensate for decreases in foraging success. In 1998, the frequency distribution and temporal pattern of dive shapes suggested reduced residence time in prey patches and increased travel time between patches and these parameters showed a strong relationship with rates of mass gain. Our data confirm that the immediate ecological impact of the 1997-98 El Nino was not limited to the near-shore coastal margin, but extended far out into the North Pacific Ocean.

Madsen, P.T., Wahlberg, M., Tougaard, J., Lucke, K., and Tyack, P. **Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs.** *Marine Ecology Progress Series* 309: 279-295, 2006.

Notes: The demand for renewable energy has led to construction of offshore wind farms with high-power turbines, and many more wind farms are being planned for the shallow waters of the world's marine habitats. The growth of offshore wind farms has raised concerns about their impact on the marine environment. Marine mammals use sound for foraging, orientation and communication and are therefore possibly susceptible to negative effects of man-made noise generated from constructing and operating large offshore wind turbines. This paper reviews the existing literature and assesses zones of impact from different noise-generating activities in conjunction with wind farms on 4 representative shallow-water species of marine mammals. Construction involves many types of activities that can generate high sound pressure levels, and pile-driving seems to be the noisiest of all. Both the literature and modeling show that pile-driving and other activities that generate intense impulses during construction are likely to disrupt the behavior of marine mammals at ranges of many kilometers, and that these activities have the potential to induce hearing impairment at close range. The reported noise levels from operating wind turbines are low, and are unlikely to impair hearing in marine mammals. The impact zones for marine mammals from operating wind turbines depend on the low-frequency hearing-abilities of the species in question, on sound-propagation conditions, and on the presence of other noise sources such as shipping. The noise impact on marine mammals is more severe during the construction of wind farms than during their operation.

Mizroch, S.A. and Rice, D.W. **Have North Pacific killer whales switched prey species in response to depletion of the great whale populations?** *Marine Ecology Progress Series* 310: 235-246, 2006.

Notes: Springer et al. (2003; Proc Natl Acad Sci USA 100:12223-12228) hypothesized that populations of seals, sea lions and sea otters in the northern North Pacific Ocean and Bering Sea declined because of increased predation by killer whales, in what they termed a 'sequential megafaunal collapse'. They hypothesized that the killer whales had been dependent on large whales for food, and that their increased predation on the smaller marine mammals was directly due to the depletion of great whale populations as a result of post-World War II industrial whaling. The maps presented by Springer et al. (2003) masked the development and precipitous decline of post-World War II industrial whaling. Our analysis shows that north of 50°N, whaling developed slowly from 1948 to 1951, expanded steadily from 1952 to 1962, and increased very sharply from 1963 to 1967. By 1968, there was near total drop-off in catches north of 50°N as the whaling fleets moved south. Because of the extraordinary whale biomass removals in the mid-1960s, any whaling-related prey shifting should have started by 1968, not the mid-1970s as they suggested. We also present data that refute their assumption that North Pacific killer whales depended on large whales as prey either prior to or concurrent with the whaling era. During the years of the development and pulse of whaling (i.e. prior to 1968), less than 3 % of the mammal-eating killer whales were observed to have large whale remains in their stomachs. Killer whales attack healthy, adult large whales only rarely, and such attacks are usually unsuccessful. Neither minke nor gray whales were depleted by post-World War II industrial whaling, and they have always been available as prey for North Pacific killer whales.

Lea, M.A., Guinet, C., Cherel, Y., Duhamel, G., Dubroca, L., Pruvost, P., and Hindell, M. **Impacts of climatic anomalies on provisioning strategies of a Southern Ocean predator.** *Marine Ecology Progress Series* 310: 77-94, 2006.

Notes: The large temporal and spatial variability in marine productivity encountered by marine predators may negatively influence breeding success. The Antarctic fur seal *Arctocephalus gazella* (AFS), a marine predator in the Southern Ocean (SO) ecosystem with a circumpolar distribution, exhibits a short, 4 mo lactation coinciding with increased summer marine productivity. The diet of AFS, and the distance to significant and productive oceanographic features, such as the Antarctic Polar Frontal Zone (PFZ), varies considerably between populations. We studied the foraging activity, foraging efficiency and the pup provisioning strategies of lactating AFS at a key breeding site in the southern Indian Ocean, the Kerguelen Archipelago. Foraging parameters were examined in relation to interannual variability in oceanographic conditions and prey availability in the PFZ over 3 consecutive breeding seasons (1998 to 2000). The location of foraging zones, diving activity, diet and foraging efficiency varied significantly between years, concurrently with annual changes in sea-surface temperature (SST) and prey availability. The strongest recorded El Nino Southern Oscillation event in 1997-1998 coincided with anomalously warm waters in the vicinity of the Archipelago. Deeper diving by females, reduced maternal and pup body condition, and minimal pup growth rates and low catch per unit effort of the primary prey species, lanternfishes (Myctophidae) were all recorded in this period. Maternal size was positively related to the growth performance of pups only in this period, indicating the importance of age/size and/or experience in mediating environmental fluctuations. Foraging efficiency over a foraging cycle and variability in mean provisioning rates (trip duration), were identified as proxies of prey availability within the foraging range of seals, emphasising the effectiveness of the use of AFS foraging behaviour as an indicator of both food and oceanographic variability and climatic anomalies. The increasing frequency of anomalously warm SST events in sectors of the SO, however, may elicit specific behavioural responses from 'central place foragers' (i.e. species that return to breeding sites to feed their young) to avoid sustained poor body condition of females and their weaned offspring.

Leduc, R.G., Dizon, A.E., Burdin, A.M., Blokhin, S.A., George, J.C., and Brownell, R.L. **Genetic analyses (mtDNA and microsatellites) of Okhotsk and Bering/Chukchi/Beaufort Seas populations of bowhead whales.** *Journal of Cetacean Research and Management* 7(2): 107-112, 2005.

Notes: Both North Pacific populations of bowhead whales (*Balaena mysticetus*) underwent heavy exploitation by commercial whalers in the 19th century, but their reduction in numbers was unequal and their contemporary population sizes differ by an order of magnitude. To investigate the genetic divergence of the different populations, tissue samples of bowhead whales representing the Okhotsk Sea (OS) population (25 samples) and the Bering/Chukchi/Beaufort Seas (BCBS) population (29 samples) were used to generate mtDNA control region sequences and genotypes for three microsatellite loci. There were 20 haplotypes represented in the contemporary BCBS samples and four in the OS samples, three of which were shared with the BCBS samples. The BCBS samples had a much greater haplotypic diversity (0.93) than the OS samples (0.61). Analyses of both types of data revealed significant genetic differences between the two populations, indicating that the populations represent discrete gene pools.

Cox, T.M. and et al. **Understanding the impacts of anthropogenic sound on beaked whales.** *Journal of Cetacean Research and Management* 7(3): 177-187, 2006.

Notes: This review considers the effect of anthropogenic sound on beaked whales. Two major conclusions are presented: (1) gas-bubble disease, induced in supersaturated tissue by a behavioural response to acoustic exposure, is a plausible pathologic mechanism for the morbidity and mortality seen in cetaceans associated with sonar exposure and merits further investigation; and (2) current monitoring and mitigation methods for beaked whales are ineffective for detecting these animals and protecting them from adverse sound exposure. In addition, four major research priorities, needed to address information gaps on the impacts of sound on beaked whales, are identified: (1) controlled exposure experiments to assess beaked whale responses to known sound stimuli; (2) investigation of physiology, anatomy, pathobiology and behaviour of beaked whales; (3) assessment of baseline diving behaviour and physiology of beaked whales; and (4) a retrospective review of beaked whale strandings.

Rommel, S.A., Costidis, A.M., Fernández, A., Jepson, P.D., Pabst, D.A., McLellan, W.A., Houser, D.S., Cranford, T.W., van Helden, A.L., Allen, D.M., and Barros, N.B. **Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding.** *Journal of Cetacean Research and Management* 7(3): 189-209, 2006.

Notes: A number of mass strandings of beaked whales have in recent decades been temporally and spatially coincident with military activities involving the use of midrange sonar. The social behaviour of beaked whales is poorly known, it can be inferred from strandings and some evidence of at-sea sightings. It is believed that some beaked whale species have social organisation at some scale; however most strandings are of individuals, suggesting that they spend at least some part of their life alone. Thus, the occurrence of unusual mass strandings of beaked whales is of particular importance. In contrast to some earlier reports, the most deleterious effect that sonar may have on beaked whales may not be trauma to the auditory system as a direct result of ensonification. Evidence now suggests that the most serious effect is the evolution of gas bubbles in tissues, driven by behaviourally altered dive profiles (e.g. extended surface intervals) or directly from ensonification. It has been predicted that the tissues of beaked whales are supersaturated with nitrogen gas on ascent due to the characteristics of their deep-diving behaviour. The lesions observed in beaked whales that mass stranded in the Canary Islands in 2002 are consistent with, but not diagnostic of, decompression sickness. These lesions included gas and fat emboli and diffuse multiorgan haemorrhage. This review describes what is known about beaked whale anatomy and physiology and discusses mechanisms that may have led to beaked whale mass strandings that were induced by anthropogenic sonar. Beaked whale morphology is illustrated using Cuvier's beaked whale as the subject of the review. As so little is known about the anatomy and physiology of beaked whales, the morphologies of a relatively well-studied delphinid, the bottlenose dolphin and a well-studied terrestrial mammal, the domestic dog are heavily drawn on.

MacLeod, C.D. and D'Amico, A. **A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise.** *Journal of Cetacean Research and Management* 7(3): 211-221, 2006.

Notes: Little is known about the ecology and behaviour of species within the family Ziphiidae. In this paper, five aspects of beaked whale ecology and behaviour are reviewed in relation to possible anthropogenic impacts upon them: social structure; life history; foraging/diving ecology; form and function of beaked whale sounds; and habitat characteristics. Differences in social structure within and between species may affect how anthropogenic activities affect local populations. Life history parameters may likewise vary within and between species and may influence the extent of and ability to recovery from population level impacts. Foraging and diving ecology determine where beaked whales spend most of their time and therefore, where in the water column they are most likely to encounter anthropogenic activities. The form and function of beaked whale sounds may be important in determining whether and how beaked whales are affected by anthropogenic noise. Finally, habitat characteristics determine whether beaked whales are likely to occur in a specific area where anthropogenic activities are to be undertaken and may also determine exactly how beaked whales are affected by it within a local area. To help fill the gaps in our knowledge of beaked whale behaviour and ecology, available opportunities for data collection must be maximised. This includes greater levels of co-operation between research groups to build up large datasets, the use of platforms of opportunity to study beaked whales in areas where little research has previously been undertaken and maximising the amount of information that can be learned from each possible source of data, such as stranded animals, through co-ordinated national and international research programmes.

Barlow, J. and Gisiner, R. **Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales.** *Journal of Cetacean Research and Management* 7(3): 239-249, 2006.

Notes: Certain anthropogenic sounds are widely believed to cause strandings of beaked whales, but their impacts on beaked whale populations are not known and methods for mitigating their effects are largely untested. The sound sources that have been coincident with beaked whale strandings are military, mid-frequency sonar (2-10kHz) and airgun arrays, both of which are used widely throughout the world for defence and geophysical exploration, respectively and for which alternative technologies are not readily available. Avoidance of beaked whale habitats is superficially a straightforward means of reducing the potential effects, but beaked whales are widely distributed and can be found in virtually all deep-water marine habitats that are free of ice. Some areas of high beaked whale abundance have been identified, but the geographic distribution is poorly known for most species. Beaked whales are both visually and acoustically difficult to detect. Commonly used mitigation measures (e.g. 'ramp-up' and 'detection-modification-avoidance') have not been assessed for their effectiveness. Surveys to detect population-level impacts would likely require many years of regular monitoring and for most areas where beaked whale

strandings have occurred, there are no pre-exposure estimates of population sizes. Risk assessment models can be used to estimate the sound levels to which beaked whales might be exposed under a variety of scenarios, however, the lack of information on the causal mechanism for sound-related beaked whale strandings makes it difficult to identify exposure levels that would warrant mitigative actions. Controlled exposure experiments which measure the behavioural responses of animals to fully characterised sound sources, may hold the greatest potential for understanding the behavioural responses of beaked whales to sound and for designing mitigation methods to avoid future impacts.

Podesta, M., D'Amico, A., Pavan, G., Drougas, A., Komnenou, A., and Portunato, N. **A review of Cuvier's beaked whale strandings in the Mediterranean Sea.** *Journal of Cetacean Research and Management* 7(3): 251-261, 2006.

Notes: Cuvier's beaked whale (*Ziphius cavirostris*) is the only species of beaked whale commonly found in the Mediterranean Sea, a deep, semi-enclosed basin. Beaked whales are generally an offshore family often found in association with the canyons and steep escarpments common to the area. Much of the current knowledge of this species has been derived from strandings data. Historically, strandings data for the Mediterranean Sea has been collected by individual researchers and more recently, over the last two decades, by national strandings networks. We reviewed strandings data collected by strandings networks from Italy, Greece, Spain and France. Additionally, we compiled strandings information gleaned from the literature, personal communications, regional newspapers and the world wide web from countries that border the Mediterranean Sea. While this review is certainly not exhaustive, it has allowed the creation of an extensive geo-referenced basin wide database using a geographic information system (GIS) of over 300 stranding events. The acquired data permit documentation of the number of mass stranding events, allow general observations about distribution and chronology of stranding events dating back to 1803 and enables evaluation of strandings based on several different criteria. The first recorded mass stranding event was in 1963 off Genova, Italy. Analysis shows that specific geographic stranding areas can be identified, even though the level of effort undertaken in the different countries may vary.

Barlow, J., Ferguson, M.C., Perrin, W.F., Ballance, L., Gerrodette, T., Joyce, G., MacLeod, C.D., Mullin, K., Palka, D.L., and Waring, G. **Abundance and densities of beaked and bottlenose whales (family Ziphiidae).** *Journal of Cetacean Research and Management* 7(3): 263-270, 2006.

Notes: Estimating the abundance and density of beaked whales is more difficult than for most other cetacean species. Consequently few estimates appear in the published literature. Field identification is problematic, especially for the smaller species, and visual detection rates decrease dramatically with Beaufort sea state; prior experience is very important to an observer's ability to detect beaked whales. Passive acoustics may hold future promise for detecting beaked whales from their vocalisations, especially for the larger species. Most published estimates of abundance or density are based on visual line-transect studies that found narrower effective strip widths and lower trackline detection probabilities for beaked whales than for most other cetaceans. Published density estimates range from 0.4-44 whales per 1,000km² for small beaked whales and up to 68 whales per 1,000km² for large beaked whales. Mark-recapture methods based on photo-identification have been used to estimate abundance in a few cases in limited geographical areas. Focused research is needed to improve beaked whale abundance and density estimates worldwide.