Marine Science Review – 192
Pollution

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In this review:

A. Recent articles – no abstract available

Stamper, M.A., Whitaker, B.R., and Schofield, T.D. **Case study: Morbidity in a pygmy sperm whale *Kogia breviceps* due to ocean-borne plastic.** *Marine Mammal Science* 22(3): 719-722, 2006.

Mallory, M.L., Roberston, J., and Moenting, A. **Marine plastic debris in northern fulmars from Davis Strait, Nunavut, Canada.** *Marine Pollution Bulletin* 52(7): 813-815, 2006.

B. Recent publications available online

Greenpeace. 2006. **Plastic Debris in the World's Oceans.** Greenpeace International, Amsterdam. 43pp.

Available at: http://oceans.greenpeace.org/raw/content/en/documents-reports/plastic_ocean_report.pdf

Notes: This report draws together scientific research on the distribution of marine debris in the world's oceans and its impacts on wildlife. The information is sourced largely from papers that have been published on this subject between 1990 and 2005. Finally it addresses workable solutions to help curb this threat to the marine environment.

C. Recent articles with abstracts

Bayen, S., Obbard, J.P., and Thomas, G.O. **Chlorinated paraffins: A review of analysis and environmental occurrence.** *Environment International* 32(7): 915-929, 2006.

Notes: Chlorinated paraffins (CPs), as technical mixtures of polychlorinated alkanes (PCAs), are ubiquitous in the environment. CPs tend to behave in a similar way to persistent organic pollutants (POPs), leading several countries to impose regulations on the use of CPs. In this article, we review the literature on the properties of CPs, the current analytical tools available to determine CPs in various types of environmental matrices, and concentrations found in the environment. In particular, concentrations of CPs in environmental compartments including air, water, sediments, biota, human food products and human tissues are summarized. Priorities for future research are: improvements in analytical methodologies (reducing the complexity of the analysis, producing reference materials and performing interlaboratory studies); determining background levels of chlorinated paraffins in the environment and human populations (this question should be answered using quality assured analytical tools allowing the intercomparison of data); and investigating the sources of CPs to the environment and to humans.

Loureiro, M.L., Ribas, A., Lopez, E., and Ojea, E. **Estimated costs and admissible claims linked to the Prestige oil spill.** *Ecological Economics* 59(1): 48-63, 2006.

Notes: The current case study presents an evaluation of the societal costs caused by the Prestige oil spill. We conclude that the economic magnitude of the catastrophe caused by the Prestige oil spill is rather significant. Short-term losses in all affected economic sectors, cleaning and recovery costs, and all environmental losses accountable at this point, add to a lower bound estimate of €770.58 million (prices in 2001 currency), excluding all other financial and future possible losses. Such important losses justify future studies that assess potential costs and benefits derived from the application of preventive measures and other contingency plans.

Lohmann, R., Jurado, E., Dachs, J., Lohmann, U., and Jones, K.C. **Quantifying the importance of the atmospheric sink for polychlorinated dioxins and furans relative to other global loss processes.** *Journal of Geophysical Research* 111(D21): art. D21303, 2006.

Notes: Previous attempts to establish global mass balances for polychlorinated dioxins and furans (PCDD/Fs) have focused on the terrestrial sink, thereby neglecting deposition to the oceans and atmospheric losses. In this study, the atmospheric sink of polychlorinated dioxins and furans (PCDD/Fs) was calculated on the basis of their presence in soils. OH radical ([OH]) depletion reactions compete with atmospheric deposition fluxes for the fate of atmospheric PCDD/Fs. Three different steady state scenarios were considered: scenario A was a one-box atmosphere with globally averaged [OH], temperature (T), atmospheric lifetime (t_{life}), and a constant gas-particle partitioning (Φ); in scenario B, [OH], T, and Φ were averaged in a multibox atmosphere, with a constant t_{life}; and in scenario C, t_{life} was varied. In scenario A the strength of the atmospheric sink was 2400-2800 kg/yr; in scenario B it was ~2100 kg/yr; in scenario C, it was ~1,800 kg/yr (t_{life} = 5.4 days) to ~2,800 kg/yr (t_{life} = 14 days). The majority of the atmospheric sink was due to the depletion of Cl_4DFs (1300-1400 kg/yr), followed by Cl_4DDs (360-380 kg/yr) and Cl_5DFs (230-240 kg/yr). On a global scale, major sinks for PCDD/Fs are the deposition to terrestrial soils and the oceans. For Cl_{6-8}DDs, deposition to soils outweighs depletion reactions in the atmosphere and ocean uptake. The more volatile Cl_{4-5}DD/Fs, however, are true "multimedia" compounds, with their estimated atmospheric sink being roughly as important as the terrestrial sink (in the case of Cl_5DD/Fs) or outweighing it (e.g., Cl_4DD/Fs).

Choong, A.M.F., Teo, S.L. M., Leow, J.L., Koh, H.L., and Ho, P.C.L. **A preliminary ecotoxicity study of pharmaceuticals in the marine environment.** *Journal of Toxicology and Environmental Health Part A* 69(21): 1959-1970, 2006.

Notes: Environmental fates and effects of pharmaceuticals in the aquatic environment have been the focus of recent research in environmental ecotoxicology. Worldwide studies of common over-the-counter pharmaceuticals have reported detectable levels in the aquatic environment, but there are few studies examining impacts on marine habitats. These drugs can affect the functions of various vertebrates and invertebrates. The stability of two pharmaceuticals, cyclizine (CYC) and prochlorperazine (PCZ), in seawater was examined under light and dark conditions, as well as the toxicity of these compounds to larvae of the barnacle *Balanus amphitrite*, which is a cosmopolitan marine organism found in most of the world's oceans. CYC was very stable under all the tested conditions. On the other hand, PCZ degraded in light but not in the dark, and was more stable in seawater than fresh water. For the barnacle larvae, the LC50 of prochlorperazine was 0.93 μ/ml and the LC50 for CYC was approximately 0.04 μg/ml.

Lokke, S. **The precautionary principle and chemicals regulation - Past achievements and future possibilities.** *Environmental Science and Pollution Research* 13(5): 342-349, 2006.

Notes: Background, Aim and Scope. The paper investigates the development of the institutional basis for the present modes of chemicals regulation and management, with special attention to interrelations with the precautionary principle. Main Features. The paper elucidates on how the precautionary principle has been shaped in relation to chemicals regulation and management since Carson's Silent Spring (years before the principle was confirmed as a policy-principle in German and European legislation. Furthermore, it is examined how the precautionary principle interacted with the development of the present chemicals regulatory regime, in a complex interplay within the OECD and Member Countries. The present modes of precaution in the new EU chemical legislation - REACH - are investigated with respect to the precautionary principle, and

tested against two contemporary problems; brominated flame retardants and endocrine disrupting substances. Results. The analysis demonstrates the changing character of the integration of the precautionary principle. The main tendencies are from implicit to more explicit precaution and from a closed expert-orientation towards a more deliberative approach to scientific knowledge and uncertainty. The results demonstrate that the precautionary principle is manifest in both the design of the testing strategy and in policy provisions. In particular, the substitution of hazardous substances with less hazardous is important. Discussion. Despite explicit attention to the precautionary principle, is the present reformulation of the European Chemicals policy in danger of falling into loop-holes that equal problems related to the present regulation of existing chemicals? 'Precaution' has been reduced virtually to an abstract concept that is more or less devoid of practical meaning in the regulatory process. Conclusions. It is concluded that the role of the precautionary principle in chemicals regulation will require continued scrutiny in the future shaping of the REACH strategy. Perspectives. Continued development of robust and precaution-based chemicals regulation will have to involve both new data-generation strategies and new forms of political decision-making, with special attention given to transparency and deliberative policymaking.

Lee, D.I., Cho, H.S., and Jeong, S.B. **Distribution characteristics of marine litter on the sea bed of the East China Sea and the South Sea of Korea.** *Estuarine, Coastal and Shelf Science* 70(1-2): 187-194, 2006.

Notes: The types, quantities, and distribution of marine litter found on the sea bed of the East China Sea and the South Sea of Korea are surveyed. Surveys were evaluated using bottom trawl nets during 1996-2005 cruises. Mean distribution densities were high in coastal seas, especially in the South Sea of Korea offshore from Yeosu, with 109.8 kg km^{-2}, and low in the East China Sea, with densities of 30.6 kg km^{-2}. Fishing gear, such as pots, nets, octopus jars, and fishing lines, accounted for about 42-72% and 37-62% of litter items in the East China Sea and the South Sea of Korea, respectively, whereas the contributions of rubber, vinyl, metal, plastic, glass, wood, and clothing were below 30% mainly. Rope and drum composition fluctuated greatly, between 54% and 0%. Eel and net pots dominated the marine debris of the South Sea of Korea, and some vinyl, plastics, and fishing gear made in Korea, China, and Japan were collected in abundance in the East China Sea. Fishing gear was probably discarded into the sea, deliberately or inadvertently, by fishing operations. A comprehensive joint approach by Korea, China, and Japan is needed for the continuous monitoring of input sources, the actual conditions, and the behavior of marine litter for protection against litter pollution and fisheries resource management in this area.

Danis, B., Debacker, V., Miranda, C.T., and Dubois, P. **Levels and effects of PCDD/Fs and co-PCBs in sediments, mussels, and sea stars of the intertidal zone in the southern North Sea and the English Channel.** *Ecotoxicology and Environmental Safety* 65(2): 188-200, 2006.

Notes: There is considerable concern regarding dioxin-like compounds (DLCs) in the marine environment. These ubiquitous contaminants are highly resistant to degradation, highly accumulated by marine organisms, and extremely toxic. Concentrations of DLCs, including 7 polychlorodibenzo-*p*-dioxins, 10 polychlorodibenzofurans, and 4 coplanar polychlorinated biphenyls, were determined in sediments, mussels (*Mytilus edulis*), and sea stars (*Asterias rubens*) from five intertidal stations distributed along the Belgian coast and the English Channel. The induction of a biomarker, cytochrome P450 immunopositive protein (CYP1A IPP), was also measured in sea star pyloric caeca. Although no significant differences were found between the considered stations, DLC levels were found to be relatively high in biota, especially when the toxicity of these compounds is considered. Particular concern arises from TEQ values determined in mussels from all locations. Sea stars were found to be more discriminant between the stations. CYP1A IPP induction was found to be significantly related to DLC levels measured in sea stars and allowed significant discrimination between the considered stations.

O'Connor, T.P. and Lauenstein, G.G. **Trends in chemical concentrations in mussels and oysters collected along the US coast: Update to 2003.** *Marine Environmental Research* 62(4): 261-285, 2006.

Notes: With data from the annual analyses of mussels and oysters collected in 1986-1993 from sites located throughout the coastal United States [O'Connor, T.P., 1996. Trends in chemical concentrations in mussels and oysters collected along the US coast from 1986 to 1993. Mar. Environ. Res. 41, 183-200] showed decreasing trends, on a national scale, for chemicals whose use has been banned or has greatly decreased and that concentrations of most other chemicals were neither increasing nor decreasing. With data through 2003 those conclusions still apply. National median concentrations of synthetic organic

chemicals and cadmium continue to decrease. The added data show that concentrations of lindane and high molecular weight PAHs are also decreasing on a national scale. For metals other than cadmium and zinc (in mussels), the added data reveal trends at more sites than in 1993 but no additional national trends. However, the longer time series has revealed several local and regional trends.

Pacyna, E.G., Pacyna, J.M., Fudala, J., Strzelecka-Jastrzab, E., Hlawiczka, S., and Panasiuk, D. **Mercury emissions to the atmosphere from anthropogenic sources in Europe in 2000 and their scenarios until 2020.** *The Science of the Total Environment* 370(1): 147-156, 2006.

Notes: The paper reviews the current state of knowledge regarding European emissions of mercury and presents estimates of European emissions of mercury to the atmosphere from anthropogenic sources for the year 2000. This information was then used as a basis for Hg emission scenario development until the year 2020. Combustion of coal in powerplants and residential heat furnaces generates about half of the European emissions being 239 tonnes. The coal combustion is followed by the production of caustic soda with the use of the Hg cell process (17%). Major points of mercury emission generation in the mercury cell process include: by-product hydrogen stream, end box ventilation air, and cell room ventilation air. This technology is now being changed to other caustic soda production technologies and further reduction of Hg emissions is expected in this connection. The third category on the list of the largest Hg emitters in Europe is cement production (about 13%). The largest emissions were estimated for Russia (the European part of the country), contributing with about 27% to the European emissions, followed by Poland, Germany, Spain, Ukraine, France, Italy and the United Kingdom. Most of these countries use coal as a major source of energy in order to meet the electricity and heat demands. In general, countries in the Central and Eastern Europe generated the main part of the European emissions in 2000. Emission reductions between 20% and 80% of the 2000 emission amounts can be obtained by the year 2020, as estimated by various scenarios.

Kucklick, J.R., Krahn, M.M., Becker, P.R., Porter, B.J., Schantz, M.M., York, G.S., O'Hara, T.M., and Wise, S.A. **Persistent organic pollutants in Alaskan ringed seal (*Phoca hispida*) and walrus (*Odobenus rosmarus*) blubber.** *Journal of Environmental Monitoring* 8(8): 848-854, 2006.

Notes: Since 1987, the Alaska Marine Mammal Tissue Archival Project (AMMTAP) has collected tissues from 18 marine mammal species. Specimens are archived in the National Institute of Standards and Technology's National Biomonitoring Specimen Bank (NIST-NBSB). AMMTAP has collected blubber, liver and/or kidney specimens from a number of ringed seals (*Phoca hispida*) from the areas near Nome and Barrow, Alaska and walruses (*Odobenus rosmarus*) from several locations in the Bering Sea. Thirty-three ringed seal and 15 walrus blubber samples from the NIST-NBSB were analyzed for persistent organic pollutants (POPs). The compounds determined included PCBs (28 congeners or congener groups), DDT and related compounds, hexachlorobenzene (HCB), hexachlorocyclohexane isomers (HCHs), chlordanes, dieldrin, and mirex. POP concentrations in ringed seal blubber were significantly higher in Barrow than in Nome when statistically accounting for the interaction of age and gender; HCB, however, was not statistically different between the two locations. Unlike males, POP concentrations and age were not significantly correlated in females probably as a result of lactational loss. POP concentrations in walrus blubber were lower than in ringed seal blubber for ΣPCBs, chlordanes, and HCHs, but higher for dieldrin and mirex. POP concentrations in ringed seals and walrus from Alaska provide further evidence that the western Arctic tends to have lower or similar POP concentrations compared to the eastern Canadian Arctic.

Riget, F., Vorkamp, K., Dietz, R., and Rastogi, S.C. **Temporal trend studies on polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) in ringed seals from East Greenland.** *Journal of Environmental Monitoring* 8(10): 1000-1005, 2006.

Notes: The concentrations of polybrominated diphenyl ethers (PBDEs) 17, 28, 47, 49, 66, 85, 99, 100, 153, 154, and 183 were determined in ringed seal blubber from central East Greenland collected in 1986, 1994, 1999 and during the period 2001 to 2004. The trend of PBDEs was compared with the trends of polychlorinated biphenyls (PCBs) 28, 31, 52, 101, 105, 118, 138, 153, 156, and 180 during the same period. The levels of SPBDE in East Greenland ringed seals ranged from 21.8 ng g^{-1} lipid weight (lw) in 1986 to 39.3 ng g^{-1} lw in 2001 and are among the highest observed in ringed seal from the Arctic. The dominating congeners were BDE-47 (75.4%) and BDE-99 (9.7%). The concentrations of PBDEs and PCBs increased with

the age of the seals, and therefore only young seals (≤ 4 years old) were included in the temporal trend analyses. No significant trend ($p > 0.14$) was observed in SPBDE or the congeners BDE 28, 47 and, 99 during the period while SPCB decreased significantly ($p = 0.004$) over the period from 1986 to 2004 with an estimated annual rate of 4.3%.

Pacyna, E.G., Pacyna, J.M., Steenhuisen, F., and Wilson, S. **Global anthropogenic mercury emission inventory for 2000.** *Atmospheric Environment* 40(22): 4048-4063, 2006.

Notes: The paper reviews the current state of knowledge regarding global emissions of mercury and presents a new inventory of global emissions of mercury to the atmosphere from anthropogenic sources for the year 2000. The largest emissions of Hg to the global atmosphere occur from combustion of fossil fuels, mainly coal in utility, industrial, and residential boilers. As much as two-thirds of the total emission of ca. 2190 ton of Hg emitted from all anthropogenic sources worldwide in 2000 came from combustion of fossil fuels. Emissions of Hg from coal combustion are between one and two orders of magnitude higher than emissions from oil combustion, depending on the country. Various industrial processes account for additional 30% of Hg emissions from anthropogenic sources worldwide in 2000. Major contribution to emissions from this source category comes from gold production using Hg technology. The Asian countries contributed about 54% to the global Hg emission from anthropogenic sources in 2000, followed by Africa (18%) and Europe, including the European part of Russia (11%). China heads the list of the 10 countries with highest Hg emissions from anthropogenic activities. With more than 600 ton of Hg, China contributes about 28% to the global emissions of mercury. It is expected that future changes of Hg emissions from anthropogenic sources worldwide until the year 2020 should be within ± 20% of the current estimates, although this assessment should be treated with great caution. Emission estimates for various continents presented in this paper were used to prepare global emission maps. These maps are presented in a companion paper (Wilson et al., 2005. Spatial distribution of global anthropogenic mercury atmospheric emissions. Atmospheric Environment, in this issue).

Wurl, O., Potter, J.R., Durville, C., and Obbard, J.P. **Polybrominated diphenyl ethers (PBDEs) over the open Indian Ocean.** *Atmospheric Environment* 40(29): 5558-5565, 2006.

Notes: Atmospheric concentrations of polybrominated diphenyl ethers (PBDEs), a group of industrial chemicals widely used as flame retardants were measured over the Indian Ocean and represent the first comprehensive data of atmospheric contaminations of PBDEs over the open ocean. Air back trajectory analysis shows that PBDEs have great potential for long-range atmospheric transport to remote regions of the world. In this report, we show that PBDE concentrations (mean 2.5 pg m^{-3}) over the open Indian Ocean are in a similar range to those reported for remote land-based locations in the 3 more industrialized northern hemisphere. Concentrations along the coastline of Java, Indonesia, were as high as 15 pg m^{-3}. Overall, data suggests that PBDEs are now ubiquitous in their global atmospheric distribution.

Sormo, E.G., Salmer, M.P., Jenssen, B.M., Hop, H., Baek, K., Kovacs, K.M., Lydersen, C., Falk-Petersen, S., Gabrielsen, G.W., Lie, E., and Skaare, J.U. **Biomagnification of polybrominated diphenyl ether and hexabromocyclododecane flame retardants in the polar bear food chain in Svalbard, Norway.** *Environmental Toxicology and Chemistry* 25(9): 2502-2511, 2006.

Notes: Concentrations of brominated flame retardants (BFRs), including polybrominated diphenylethers (PBDEs) and hexabromocyclododecane (HBCD), were investigated in an arctic marine food chain consisting of four invertebrate species: polar cod (*Boreogadus saida*), ringed seals (*Pusa hispida*), and polar bears (*Ursus maritimus*). The most abundant BFR, brominated diphenyl ether (BDE)-47, was found in detectable concentrations even in zooplankton, the lowest trophic level examined in this study. Most of the investigated BFRs biomagnified as function of tropic level in the food chain. A noticeable exception occurred at the highest trophic level, the polar bear, in which only BDE-153 was found to increase from its main prey, the ringed seal, indicating that polar bears appear to be able to metabolize and biodegrade most BFRs. In contrast, lower-brominated PBDEs, particularly BDE-47, showed clear signs of bioaccumulation in zooplankton, polar cod, and ringed seals. We suggest that this discrepancy in the fate of BFRs among the different species may be related to greater induction of oxidative detoxification activities in the polar bear. Absorption and debromination rates may be more important for bioaccumulation rates of BFRs in zooplankton, polar cod, and ringed seals. Lipid weight-based concentrations (LWCs) and whole body-based concentrations (WBCs) of BFRs were used to assess biomagnification factors (BMFs). Whole-body

concentrations gave the most realistic BMFs, as BMFs derived from LWCs seem to be confounded by the large variability in lipid content of tissues from the investigated species. This study demonstrates that PBDEs and HBCD have reached measurable concentrations even in the lower trophic levels (invertebrates and fish) in the Arctic and biomagnifies in the polar bear food chain.

Tierney, K.B., Ross, P.S., Jarrard, H.E., Delaney, K.R., and Kennedy, C.J. **Changes in juvenile coho salmon electro-olfactogram during and after short-term exposure to current-use pesticides.** *Environmental Toxicology and Chemistry* 25(10): 2809-2817, 2006.

Notes: For anadromous salmonids, olfaction is a critical sense, enabling return migration. In recent years, several pesticides have been identified that interfere with salmonid olfaction at concentrations in the μg/L range; thus, they may pose a risk to species longevity. In the present study, we investigated the acute effects of five agricultural pesticides on juvenile coho salmon (*Oncorhynchus kisutch*) olfaction using the electro-olfactogram (EOG), a measure of odorant-evoked field potentials. Electro-olfactogram responses to the odorant L-serine were measured during and following a 30-min exposure of the left olfactory rosette to chlorothalonil, endosulfan, glyphosate acid, iodocarb (IPBC), trifluralin, and 2,4-dichlorophenoxyacetic acid. With the relatively insoluble pesticides endosulfan and trifluralin, decreases in EOG amplitude were only apparent at relatively high concentrations (100 and 300 μg/L, respectively) following 20 min of exposure and were absent for chlorothalonil (1 mg/L). With the water-soluble herbicide glyphosate, significant EOG reductions occurred within 10 min of exposure to 1 mg/L and more rapidly with higher concentrations. Recovery of EOG post-glyphosate exposure was concentration-dependent, and complete recovery was not observed with some concentrations at 60 min postexposure. Dichlorophenoxyacetic acid only affected EOG at high concentration (100 μg/L), where it eliminated EOG within 2 min of exposure. With IPBC, EOG was decreased at 25 min of exposure to 1 mg/L; higher concentrations caused decreases to occur more rapidly. Excluding IPBC and glyphosate, all EOG reductions occurred at concentrations greater than the current Canadian water-quality guidelines and reported 96-h lethality values. Our results show that olfactory neurons can be impaired rapidly by some current-use pesticides, even at exposures in the low-μg/L range.

Rodriguez-Navarro, A.B., Romanek, C.S., Alvarez-Lloret, P., and Gaines, K.F. **Effect of *in ovo* exposure to PCBs and Hg on Clapper Rail bone mineral chemistry from a contaminated salt marsh in coastal Georgia.** *Environmental Science and Technology* 40(16): 4936-4942, 2006.

Notes: The effect of Hg and PCBs (Aroclor 1268) on bone characteristics was investigated in a population of Clapper Rails (*Rallus longirostris*) inhabiting contaminated and unimpacted estuarine marsh systems in coastal Georgia. Exposure to contaminants did not affect the length or weight of leg bones, but it significantly altered the chemical composition of the bone. Specifically, bone in the contaminated site had a higher Ca to P, and lower carbonate and acid phosphate content. These characteristics are typical of more mature bone mineral and indicate that toxicants have accelerated bone maturation. FTIR spectroscopy data revealed a dose dependent change in the crystallinity of bone mineral, and the relative proportion of specific PO4 groups in different molecular environments in the bone, with toxicants loads. These changes are most probably related to a hormonal alteration of the rate of bone remodelation induced by exposure to toxicant loads.

Steffen, C., Borga, K., Skaare, J.U., and Bustnes, J.O. **The occurrence of organochlorines in marine avian top predators along a latitudinal gradient.** *Environmental Science and Technology* 40(16): 5139-5146, 2006.

Notes: The aim of this study was to determine the role of cold condensation and fractionation on the occurrence of organochlorine contaminants (OCs) in avian marine top predators along a latitudinal gradient. We measured 24 polychlorinated biphenyl (PCB) congeners and six pesticide OCs in blood of great black-backed gulls (*Larus marinus*) from the Norwegian Coast (58°N - 70°N) and glaucous gulls (*Larus hyperboreus*) from Bjornoya in the Norwegian Arctic (74°N). Glaucous gulls had up to 3 times higher SOC concentrations compared to the great black-backed gulls, and a OC pattern dominated largely by persistent and low volatile compounds such as highly chlorinated PCBs and metabolites such as oxychlordane. This was not consistent with cold condensation and fractionation theory, but probably related to diet and elevated biomagnification. Among great black-backed gulls, however, there were indications of both cold condensation and fractionation. Higher and lower chlorinated PCBs had highest absolute concentrations in the south and in the north,

respectively, except for one location at an intermediate latitude, where concentrations of most OCs exceeded all other locations. In terms of proportional contribution to SOC (pattern), relatively volatile OCs such as HCB, oxychlordane and tri- to penta- PCB congeners were more important at northern latitudes, while hexa- to nona-PCBs made up a larger proportion of SOC in the south. The results thus showed that differences in global distribution of compounds with different physicochemical properties could be detected in avian top predators such as large gulls, even if biomagnification and biotransformation influence both the absolute concentrations and the patterns of OCs.

Tierney, K.B., Taylor, A.L., Ross, P.S., and Kennedy, C.J. **The alarm reaction of coho salmon parr is impaired by the carbamate fungicide IPBC.** *Aquatic Toxicology* 79(2): 149-157, 2006.

Notes: To determine whether the carbarnate fungicide IPBC alters the olfactory-mediated behavioral and physiologic alarm responses of coho salmon parr (*Oncorhynchus kisutch*), groups of coho were exposed to skin extract (an alarm pheromone source) under a variety of conditions. In the 3 min following skin extract exposure, freezing behavior was significantly increased under darkness (IR lighting) but not ambient lighting (25.3 ± 2.6% and 7.5 ± 5.7%, respectively; D calculated as: [(time (s) after/time (s) before) - 1] x 100%), and so IR was used for further experiments. Physiologically, following skin extract exposure, plasma cortisol concentration was increased at 0.5 h (58.1 ± 14.6 ng/ml versus 4.32 ± 1.31 ng/ml, exposed versus control), hematocrit (Hct) was increased at 2 h (50.4 ± 1.0% versus 41.7 ± 1.6%), and leucocrit (Lct) was decreased at 0.5 and 2 h (0.534 ± 0.114 and 0.13 ± 0.01% versus 1.23 ± 0.20%). After 0.5 h exposures to 0, 1, 10 and 100 µg/l IPBC and skin extract, the time spent dashing (> 5 cm/s) increased significantly (323 ± 118%) in the first minute after skin extract exposure, but was absent in IPBC-exposed coho. Freezing behavior increased after skin extract exposure with control and 1 µg/l IPBC exposures (11.0 ± 3.0% and 17.7 ± 11.0%, respectively), but was absent after 10 µg/l and decreased after 100 µg/l IPBC. Physiologically, Hct and plasma lactate concentration were significantly increased above controls after 1 µg/l IPBC exposure (Hct: 45.7 ± 1.6% versus 34.0 ± 1.6%, lactate: 12.8 ± 1.2 mM versus 3.30 ± 1.2 mM). After 10 µg/l exposure, IPBC alone elicited a stress response similar to skin extract. However in the 100 µg/l treatment group the stress parameters were not different from controls. These findings suggest that the behavioral and physiologic alarm responses of juvenile salmonids may be impaired by acute exposure to ≥ 1 µg/l IPBC.

Lannig, G., Flores, J.F., and Sokolova, I.M. **Temperature-dependent stress response in oysters, *Crassostrea virginica*: Pollution reduces temperature tolerance in oysters.** *Aquatic Toxicology* 79(3): 278-287, 2006.

Notes: Combined effects of temperature and a toxic metal, cadmium (Cd), on energy metabolism were studied in a model marine bivalve, the eastern oyster *Crassostrea virginica*, acclimated at 20, 24 and 28ºC and exposed to 50 mg l^{-1} of Cd. Both increasing temperature and Cd exposure led to a rise in standard metabolic rates, and combined stressors appeared to override the capability for aerobic energy production resulting in impaired stress tolerance. Oysters exposed to elevated temperature but not Cd showed no significant change in condition, survival rate and lipid peroxidation, whereas those exposed to both Cd and temperature stress suffered high mortality accompanied by low condition index and elevated lipid peroxidation. Furthermore, RNA/DNA ratios indicative of protein synthesis rate, and levels of glutathione, which is involved in metal detoxification, increased in Cd-exposed oysters at 20ºC but not at 28ºC. Implications of the synergism between elevated temperatures and cadmium stress on energy metabolism of oysters are discussed in the light of the potential effects of climate change on oyster populations in polluted areas.

Bangsgaard, K., Madsen, S.S., and Korsgaard, B. **Effect of waterborne exposure to 4-*tert*-octylphenol and 17 b-estradiol on smoltification and downstream migration in Atlantic salmon, *Salmo salar*.** *Aquatic Toxicology* 80(1): 23-32, 2006.

Notes: Groups of Atlantic salmon parr (November, Exp. 1) or pre-smolts (March, Exp. 2) were exposed to estradiol-17b (E2 conc.: nominal 500 ng l^{-1}/actual 8-16 ng l^{-1}) and two doses of *tert*-octylphenol (OP: nominal 25 mg l^{-1}/actual 4.5-6.5 mg l^{-1} and OP: nominal 100 mg l^{-1}/actual 10-30 mg l^{-1}) for 26 days in fresh water, and the effects on physiological and behavioural aspects of parr-smolt transformation were investigated. Vitellogenesis was induced by all treatments, as indicated by elevated levels of plasma vitellogenin (Vtg) and hepatosomatic index. Elevated Vtg levels were still found in OP-100 and E2-treated fish 4-5 months after cessation of treatment, indicating a slow clearance of Vtg from circulation. Smolting was compromised by E2 and OP-100 treatment as judged by reduced gill Na^+, K-ATPase activity and impaired ability to regulate plasma

osmolality and muscle water content in 24-h sea water (SW) challenge tests during the period of smolting. Downstream migratory behaviour was monitored from late April to July (Exp. 2) by implanting passive integrated transponder tags into subgroups of treated and control smolts and placing them in a stream raceway. Irrespective of treatment, nocturnal downstream movement was initiated in all groups on April 23, switching to diurnal movement in late May. Average swimming speed was estimated to be higher than current speed, indicating active migration. E2 and OP-100 fish migrated at lower frequency than control fish, suggesting a reduced migratory drive. The data suggests that waterborne exposure of salmon to xenoestrogens reduce both physiological and behavioural components of smoltification, even when exposure occurs several months prior to smolting.

Guillette, L.G. **Endocrine disrupting contaminants--beyond the dogma.** *Environmental Health Perspectives* 114(Supplement 1): 9-12, 2006.

Notes: Descriptions of endocrine disruption have largely been associated with wildlife and driven by observations documenting estrogenic, androgenic, antiandrogenic, and antithyroid actions. These actions, in response to exposure to ecologically relevant concentrations of various environmental contaminants, have now been established in numerous vertebrate species. However, many potential mechanisms and endocrine actions have not been studied. For example, the DDT [1,1,1-trichloro-2,2-bis(*p*-chlorophenyl) ethane] metabolite, *p,p´*-DDE [1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene] is known to disrupt prostaglandin synthesis in the uterus of birds, providing part of the explanation for DDT-induced egg shell thinning. Few studies have examined prostaglandin synthesis as a target for endocrine disruption, yet these hormones are active in reproduction, immune responses, and cardiovascular physiology. Future studies must broaden the basic science approach to endocrine disruption, thereby expanding the mechanisms and endocrine end points examined. This goal should be accomplished even if the primary influence and funding continue to emphasize a narrower approach based on regulatory needs. Without this broader approach, research into endocrine disruption will become dominated by a narrow dogma, focusing on a few end points and mechanisms.

Horiguchi, T., Kojima, M., Hamada, F., Kajikawa, A., Shiraishi, H., Morita, M., and Shimizu, M. **Impact of tributyltin and triphenyltin on ivory shell (*Babylonia japonica*) populations.** *Environmental Health Perspectives* 114(Supplement 1): 13-19, 2006.

Notes: We histopathologically examined gonads and chemically determined organotin compounds in tissues of the ivory shell, *Babylonia japonica*. Imposex (a superimposition of male-type genital organs on females) occurred in approximately 80-90% of *B. japonica* specimens that we examined, with the penis and vas deferens both well developed. No oviduct blockage by vas deferens formation was observed. Ovarian spermatogenesis and suppressed ovarian maturation were observed in the females that exhibited imposex, although no histopathological abnormalities were found in males. Tissue distributions of organotin compounds [tributyltin (TBT), triphenyltin (TPhT), and their metabolites] were different for butyltins and phenyltins; a remarkably high accumulation of TBT was observed in the ctenidium, osphradium, and heart, whereas high concentrations of TPhT were detected in the ovary and digestive gland. More than one-third of TBT accumulated in the digestive glands of both males and females, followed by the testis, ctenidium, muscle, and heart tissues in males and in the muscle, ovary, ctenidium, and head tissues (including the central nervous system ganglia) in females. In both males and females, more than half of total TPhT accumulated in the digestive glands, followed by the gonads. The next highest values were in the muscle, ctenidium, and heart tissues in males and in the muscle, oviduct, and head tissues in females. Both TBT and TPhT concentrations in the gonads were positively correlated with penis length in females. Our findings strongly suggest that reproductive failure in adult females accompanied by imposex, possibly induced by TBT and TPhT from antifouling paints, may have caused the marked decline of *B. japonica* populations in Japan.

Hagger, J.A., Depledge, M.H., Oehlmann, J., Jobling, S., and Galloway, T.S. **Is there a causal association between genotoxicity and the imposex effect?** *Environmental Health Perspectives* 114(Supplement 1): 20-26, 2006.

Notes: There is a growing body of evidence that indicates common environmental pollutants are capable of disrupting reproductive and developmental processes by interfering with the actions of endogenous hormones. Many reports of endocrine disruption describe changes in the normal development of organs and tissues that are consistent with genetic

damage, and recent studies confirm that many chemicals classified to have hormone-modulating effects also possess carcinogenic and mutagenic potential. To date, however, there have been no conclusive examples linking genetic damage with perturbation of endocrine function and adverse effects *in vivo*. Here, we provide the first evidence of DNA damage associated with the development of imposex (the masculinization of female gastropods considered to be the result of alterations to endocrine-mediated pathways) in the dog-whelk *Nucella lapillus*. Animals (n = 257) that displayed various stages of tributyltin (TBT) -induced imposex were collected from sites in southwest England, and their imposex status was determined by physical examination. Linear regression analysis revealed a very strong relationship (correlation coefficient of 0.935, $p < 0.0001$) between the degree of imposex and the extent of DNA damage (micronucleus formation) in hemocytes. Moreover, histological examination of a larger number of dog-whelks collected from sites throughout Europe confirmed the presence of hyperplastic growths, primarily on the vas deferens and penis in both TBT-exposed male snails and in females that exhibited imposex. A strong association was found between TBT body burden and the prevalence of abnormal growths, thereby providing compelling evidence to support the hypothesis that environmental chemicals that affect reproductive processes do so partly through DNA damage pathways.

Gee, D. **Late lessons from early warnings: Toward realism and precaution with endocrine-disrupting substances.** *Environmental Health Perspectives* 114(Supplement 1): 152-160, 2006.

Notes: The histories of selected public and environmental hazards, from the first scientifically based early warnings about potential harm to the subsequent precautionary and preventive measures, have been reviewed by the European Environment Agency. This article relates the "late lessons" from these early warnings to the current debates on the application of the precautionary principle to the hazards posed by endocrine-disrupting substances (EDSs). Here, I summarize some of the definitional and interpretative issues that arise. These issues include the contingent nature of knowledge; the definitions of precaution, prevention, risk, uncertainty, and ignorance; the use of differential levels of proof; and the nature and main direction of the methodological and cultural biases within the environmental health sciences. It is argued that scientific methods need to reflect better the realities of multicausality, mixtures, timing of dose, and system dynamics, which characterize the exposures and impacts of EDSs. This improved science could provide a more robust basis for the wider and wise use of the precautionary principle in the assessment and management of the threats posed by EDSs. The evaluation of such scientific evidence requires assessments that also account for multicausal reality. Two of the often used, and sometimes misused, Bradford Hill "criteria," consistency and temporality, are critically reviewed in light of multicausality, thereby illustrating the need to review all of the criteria in light of 40 years of progress in science and policymaking.

Boren, L.J., Morrissey, M., Muller, C.G., and Gemmell, N.J. **Entanglement of New Zealand fur seals in man-made debris at Kaikoura, New Zealand.** *Marine Pollution Bulletin* 52(4): 442-446, 2006.

Notes: New Zealand fur seals in the Kaikoura region breed near a town with expanding tourist and fishing industries and commonly come ashore entangled in nets and plastic debris. However, the rate at which entanglement occurs was previously unknown. A decade of Department of Conservation seal callout data was analysed to determine the level of entanglement in the region and the most common debris type. Monitoring of adult female fur seals released from entanglement provided information on the potential for serious wounds to heal and survivorship of released individuals. Entanglement rates of pinnipeds in Kaikoura are some of the highest reported worldwide (average range: 0.6-2.8%) with green trawl net (42%), and plastic strapping tape (31%) together contributing the most to debris types. Nearly half of the reported entangled seals are successfully released (43%) and post-release monitoring shows that with appropriate intervention the chance of an individual surviving even with a significant entanglement wound is high. Our study demonstrates that while entanglement in the region is high, a successful intervention protocol may help reduce the potential for entanglement-related mortality in the region.

Ng, K.L. and Obbard, J.P. **Prevalence of microplastics in Singapore's coastal marine environment.** *Marine Pollution Bulletin* 52(7): 761-767, 2006.

Notes: Microplastics have been recently identified as marine pollutants of significant concern due to their persistence, ubiquity and potential to act as vectors for the transfer and exposure of persistent organic pollutants to marine organisms. This study documents, for the first time, the presence and abundance of microplastics (> 1.6 mm) in Singapore's coastal environment. An

optimized sampling protocol for the collection and analysis of microplastics was developed, and beach sediments and seawater (surface microlayer and subsurface layer) samples were collected from nine different locations around the coastline. Low density microplastics were separated from sediments by flotation and polymer types were identified using Fourier transform infrared (FTIR) spectrometry. Synthetic polymer microplastics identified in beach sediments included polyethylene, polypropylene, polystyrene, nylon, polyvinyl alcohol and acrylonitrile butadiene styrene. Microplastics were detected in samples from four out of seven beach environments, with the greatest quantity found in sediments from two popular beaches in the eastern part of Singapore. Polyethylene, polypropylene and polystyrene microplastics were also found in the surface microlayer (50-60 mm) and subsurface layer (1 m) of coastal waters. The presence of microplastics in sediments and seawater is likely due to on-going waste disposal practices from industries and recreational activities, and discharge from shipping.

Lucas, Z. and MacGregor, C. **Characterization and source of oil contamination on the beaches and seabird corpses, Sable Island, Nova Scotia, 1996-2005.** *Marine Pollution Bulletin* 52(7): 778-789, 2006.

Notes: During April 1996-May 2005, 2343 oiled seabird corpses were recorded in beach surveys conducted on Sable Island, Nova Scotia. One hundred eighty-three samples of oil were collected from the beaches and from the feathers of bird corpses. Gas chromatographic (GC/FID) analysis was used to identify generic oil type and likely marine source. During this period, at least 74 marine oil discharge events were probably responsible for beached pelagic tar and contamination of seabird corpses found on Sable Island, of which 77.0% were crude oils, 14.9% were fuel oils, and 8.1% were bilge oil mixtures. While fuel and bilge oils may be discharged by all vessel and platform types, crude oil discharges are associated with tanker operations. This study demonstrates that oiling of the sea from tankers remains a serious wildlife issue in the Northwest Atlantic.

Zamora-Ley, I.M., Gardinali, P.R., and Jochem, F.J. **Assessing the effects of Irgarol 1051 on marine phytoplankton populations in Key Largo Harbor, Florida.** *Marine Pollution Bulletin* 52(8): 935-941, 2006.

Notes: The antifouling boosting agent Irgarol 1051 is a strong inhibitor of the photosystem II (PSII) with high efficiency/toxicity towards algae. However, because some phytoplankton species are more sensitive to Irgarol than others, its persistent release into the environment could result in adverse changes in the phytoplankton community structure at heavily impacted sites such as marinas. Continuous monitoring in the Florida Keys showed Irgarol concentrations of up to 635 ng L^{-1} in the canal system leading to Key Largo Harbor Marina (KLH) with a sharp decrease in concentration at stations offshore from the mouth of the canal. Preliminary phytoplankton community assessments from surface water samples collected in KLH between February and August 2004 showed changes in several phytoplankton species in concordance with the increase of the herbicide concentrations. Typical responses include an increase in the abundance of eukaryotes and *Cryptomonas* sp. as Irgarol concentrations increase.

Ofiara, D.D. and Seneca, J.J. **Biological effects and subsequent economic effects and losses from marine pollution and degradations in marine environments: Implications from the literature.** *Marine Pollution Bulletin* 52(8): 844-864, 2006.

Notes: This paper serves as the missing piece in a more fuller understanding about economic losses from marine pollution, and demonstrates what losses have been estimated in the literature. Biological effects from marine pollution are linked with resulting economic effects and losses. The merging of these two areas is usually absent in studies of marine pollution losses. The literature has examined several effects due to marine pollution: damages due to harvest closures-restrictions, damages from consumption of unsafe seafood, damages due to decreased recreational activity, and damages related to waterfront real estate adjacent to contaminated water. Overall, marine pollution can and has resulted in sizable economic effects and losses. On the basis of the literature there is adequate justification for public policy actions to curb marine pollution, require inspection of seafood for toxic substances, and preserve marine water quality and sensitive marine environments.

Myer, J.H., Gunthorpe, L., Allinson, G., and Duda, S. **Effects of antifouling biocides to the germination and growth of the marine macroalga, *Hormosira banksii* (Turner) Desicaine.** *Marine Pollution Bulletin* 52(9): 1048-1055, 2006.

Notes: The International Maritime Organisation's (IMO) ban on the use of tributyltin in antifouling paints has inevitability increased the use of old fashioned antifoulants and/or the development of new paints containing 'booster biocides'. These newer paints are intended to be environmentally less harmful, however the broader environmental effects of these 'booster biocides' are poorly known. Germination and growth inhibition tests using the marine macroalga, *Hormosira banksii* (Turner) Desicame were conducted to evaluate the toxicity of four new antifouling biocides in relation to tributyltin-oxide (TBTO). Each of the biocides significantly inhibited germination and growth of *Hormosira banksii* spores. Toxicity was in increasing order: diuron < zineb < seanine 211 < zinc pyrithione < TBTO. However, the lack of knowledge on partitioning in the environment makes it difficult to make a full assessment on whether the four biocides tested offer an advantage over organotin paints in terms of environmental impact.

Kajiwara, N., Kunisue, T., Kamikawa, S., Ochi, Y., Yano, S., and Tanabe, S. **Organohalogen and organotin compounds in killer whales mass-stranded in the Shiretoko Peninsula, Hokkaido, Japan.** *Marine Pollution Bulletin* 52(9): 1066-1076, 2006.

Notes: Blubber and liver samples were obtained for analysis of wide ranges of contaminants from killer whales (*Orcinus orca*) which were locked away in drifting sea ice on the coast of Rausu, the Shiretoko Peninsula in Eastern Hokkaido, Japan in February 2005. Among the organohalogen compounds analyzed, DDTs were the predominant contaminants with concentrations ranging from 28 to 220 μg/g on a lipid-weight basis followed by PCBs and other organochlorine pesticides. PBDEs levels were two or three orders of magnitude lower than those of PCBs and DDTs. 2,3,7,8-tetrachlorodibenzo-*p*-dioxin toxic equivalents (TEQs) derived by WHO mammal-TEF in killer whales were in the range of 110-440 pgTEQ/g. Mono-*ortho* coplanar PCBs contributed to 75-98% of total TEQs, indicating coplanar PCBs are significant contaminants for risk assessment in this species. The fact that hepatic residue levels of butyltins (from 13 to 770 ng/g wet weight) were much higher than those of phenyltins may be reflecting extensive use of tributyltin as antifouling paint.

Hofmeyr, G.J.G., Bester, M.N., Kirkman, S.P., Lydersen, C., and Kovacs, K.M. **Entanglement of Antarctic fur seals at Bouvetoya, Southern Ocean.** *Marine Pollution Bulletin* 52(9): 1077-1080, 2006.

Notes: Entanglements of Antarctic fur seals *Arctocephalus gazella* were recorded during four summers from 1996 to 2002 at the subantarctic island, Bouvetoya. Rates of entanglement varied between 0.024% and 0.059%. These rates are low for a pinniped population and might be because of the geographic isolation of the haulout site. An apparent decrease in the levels of entanglement over the course of the study was likely due, at least in part, to the removal of entanglements by observers. At least two-thirds of entangling materials were generated by fishery sources. Since there is no known local source of anthropogenic marine pollution, seals become entangled either in waters distant from the island, or when materials drift into local waters. Significantly more subadults were found entangled than expected from the postulated population age class distribution.
