

Marine Science Review – 173

Pollution



In this review:

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A. Recent publications available online

Ditz, D. 2006. **Cloudy Skies, Chance of Sun: A Forecast for U.S. Reform of Chemicals Policy.** Center for International Environmental Law, Washington, DC. 6pp.

Available at: http://www.ciel.org/Publications/Cloudy_Skies_9May06.pdf

Notes: As Europe prepares for REACH, the sweeping new regulation on chemical manufacturers, importers, and users, some Americans are asking whether similar reforms are needed in the United States. The political climate is not heartening for passing environmental legislation, especially something as ambitious as comprehensive reform of chemical regulation. But change is in the air. State and local governments are enacting laws to eliminate dangerous substances. New leaders are emerging as advocates for environmental health protection. U.S. businesses are re-evaluating the materials that they make, use, and market. The process of U.S. chemical policy reform has begun.

Walker, B. 2006. **Killing Them Softly ... Health Effects in Arctic Wildlife Linked to Chemical Exposures.** WWF International Arctic Programme and WWF-DetoX. 28pp.

Available at: http://assets.panda.org/downloads/arctic_wildlife_health_effects_report_1___23_may.pdf

Notes: This report focuses on what is known about actual health problems in arctic mammals and birds linked to chemical exposures though acknowledges that science is still far from fully understanding how chemicals impact the health of wild animals in their natural environments. The report notes that: 1. free-ranging animals are exposed to many threats that can affect their health, including combined exposures of many different chemicals; 2. these chemical mixtures make it difficult to differentiate the health effect from one particular chemical from another; and 3. research is also complicated by the fact that basic information on normal metabolism or immune function is almost non-existent for many wild animals. It reviews the main effects – disturbances of the hormone and immune systems, vitamin A levels, and bone mineral density – that have been studied in arctic wildlife thus far, and concludes that the greatest concern is that contaminant mixtures may interact with other natural stressors in the Arctic, (e.g. climate change, habitat loss, reduced food supply) resulting in wildlife having reduced ability to successfully deal with every day challenges, (e.g. harsh winters, hibernation, feeding, nesting predation) leading to reduced reproductive capacity, increased likelihood of disease or even death, and population declines.

B. Recent articles with abstracts

Breitholtz, M., Ruden, C., Hansson, S.O., and Bengtsson, B.E. **Ten challenges for improved ecotoxicological testing in environmental risk assessment.** *Ecotoxicology and Environmental Safety* 63(2): 324-335, 2006.

Notes: New regulations, in particular the new European chemicals legislation (REACH), will increase the demands on environmental risk assessment (ERA). The requirements on efficient ecotoxicological testing systems are summarized, and 10 major issues for the improvement of ERA practices are discussed, namely: (1) the choice of representative test species, (2) the development of test systems that are relevant for ecosystems in different parts of the world, (3) the inclusion of sensitive life stages in test systems, (4) the inclusion of endpoints on genetic variation in populations, (5) using mechanistic understanding of toxic effects to develop more informative and efficient test systems, (6) studying disruption in invertebrate endocrine mechanisms, that may differ radically from those we know from vertebrates, (7) developing standardized methodologies for testing of poorly water-soluble substances, (8) taking ethical considerations into account, in particular by reducing the use of vertebrates in ecotoxicological tests, (9) using a systematic (statistical) approach in combination with mechanistic knowledge to combine tests efficiently into testing systems, and (10) developing ERA so that it provides the information needed for precautionary decision-making.

Ferrier, R.C., D'Arcy, B.J., MacDonald, J., and Aitken, M. **Diffuse pollution - What is the nature of the problem?** *Water and Environment Journal* 19(4): 361-366, 2005.

Notes: This paper considers recent developments in the understanding of diffuse pollution, its generation, transport and impacts. The relative importance of diffuse sources to total pollutant loading must be identified in order to develop appropriate strategies for management. Research has indicated that individual diffuse pollutants respond differently to changing flow conditions and that there is a widespread misconception that higher flows are associated with lower pollutant concentrations. Evidence is presented to highlight this discrepancy and a rationale for load assessment is presented. The implications of this for monitoring within the context of the EU Water Framework Directive are discussed as are the implications for the mitigation of diffuse pollution.

Schmidt, K., Steinberg, C.E.W., Staaks, G.B.O., and Pflugmacher, S. **Influence of a xenobiotic mixture (PCB and TBT) compared to single substances on swimming behavior or reproduction of *Daphnia magna*.** *Acta Hydrochimica et Hydrobiologica* 33(4): 287-300, 2005.

Notes: Aroclor 1254, a technical PCB mixture (polychlorinated biphenyls) and TBT (tributyltin-chloride) are environmental pollutants that cause a broad spectrum of acute toxic and chronic effects in aquatic animals. In this paper, the sensitivity of *Daphnia magna* to chronic exposure to mixed xenobiotics was evaluated under laboratory conditions. The results show that xenobiotic mixtures (50% each of the single compounds) were more toxic than individual xenobiotics alone. By measuring behavioral parameters of animals, it becomes evident that exposure to single xenobiotics significantly affects daphnids: exposure led finally to a rapid decrease in mean swimming activity and also caused changes in preferred swimming depth, with daphnids preferring the upper layers of aquaria. The mixture altered the swimming behavior even more strongly compared to the group stressed by single chemicals. Finally, all daphnids sank to the bottom of the aquaria, still alive, but inactive at the end of the exposure period. In addition, we investigated the reproductive capacity (number of newborn per female and day). PCB did not affect the number of newborn significantly, TBT-stress led to an evidently decreased number of young daphnids and the xenobiotic mixture decreased reproduction even more. In conclusion, we found significant effects of the single compounds as well as approximately additive (swimming behavior) and synergistic (reproduction) effects of the chemical mixture on daphnids indicating the possibility of dramatic ecological consequences of the occurrence of mixed xenobiotic substances in the aquatic environment.

Paerl, H.W. **Assessing and managing nutrient-enhanced eutrophication in estuarine and coastal waters: Interactive effects of human and climatic perturbations.** *Ecological Engineering* 26(1): 40-54, 2006.

Notes: Estuaries are among the most productive, resourceful, and dynamic aquatic ecosystems on Earth. Their productive nature is linked to the fact that they process much of the world's riverine and coastal watershed discharge. These watersheds support more than 75% of the human population and are sites of large increases in nutrient loading associated with urban and agricultural expansion. Increased nutrient loading has led to accelerated primary production, or eutrophication; symptoms include increased algal bloom activity (including harmful taxa), accumulation of organic matter, and excessive oxygen consumption (hypoxia and anoxia). While nutrient-enhanced eutrophication is a "driver" of hypoxia and anoxia, physical-

chemical alterations due to climatic events, such as stormwater discharge, flooding, droughts, stagnancy, and elevated temperatures are also involved. The complex interactions of anthropogenic and climatic factors determine the magnitude, duration, and aerial extent of productivity, algal blooms, hypoxia, and anoxia. Using the eutrophic Neuse River Estuary (NRE), North Carolina, USA, as a case study, the physical-chemical mechanisms controlling algal bloom and hypoxia dynamics were examined. Because primary production in the NRE and many other estuaries is largely nitrogen (N) limited, emphasis has been placed on reducing N inputs. Both the amounts and chemical forms of N play roles in determining the composition and extent of phytoplankton blooms that supply the bulk of the organic carbon fueling hypoxia. Biomass from bloom organisms that are readily grazed will be readily transferred up the planktonic and benthic food chain, while toxic or inedible blooms frequently promote sedimentary C flux, microbial mineralization, and hence may exacerbate hypoxia potential. From a watershed perspective, nutrient input reductions are the main options for reducing eutrophication. Being able to distinguish the individual and cumulative effects of physical, chemical and biotic controls of phytoplankton productivity and composition is key to understanding, predicting, and ultimately managing eutrophication. Long-term collaborative (university, state, federal) monitoring, experimental assessments, and modeling of eutrophication dynamics over appropriate spatial and temporal scales is essential for developing realistic, ecologically sound, and cost-effective nutrient management strategies for estuarine and coastal ecosystems impacted by both anthropogenic and climatic perturbations.

Ying, G.G. **Fate, behavior and effects of surfactants and their degradation products in the environment.** *Environment International* 32(3): 417-431, 2006.

Notes: Surfactants are widely used in household and industrial products. After use, surfactants as well as their products are mainly discharged into sewage treatment plants and then dispersed into the environment through effluent discharge into surface waters and sludge disposal on lands. Surfactants have different behavior and fate in the environment. Nonionic and cationic surfactants had much higher sorption on soil and sediment than anionic surfactants such as LAS. Most surfactants can be degraded by microbes in the environment although some surfactants such as LAS and DTDMAC as well as alkylphenols may be persistent under anaerobic conditions. LAS were found to degrade in sludge amended soils with a half-lives of 7 to 33 days. Most surfactants are not acutely toxic to organisms at environmental concentrations and aquatic chronic toxicity of surfactants occurred at concentrations usually greater than 0.1 mg/L. However, alkylphenols have shown to be capable of inducing the production of vitellogenin in male fish at a concentration as low as 5 mg/L. More toxicity data are needed to assess the effects on terrestrial organisms such as plants.

Walker, J.B., Houseman, J., Seddon, L., McMullen, E., Tofflemire, K., Mills, C., Corriveau, A., Weber, J.P., LeBlanc, A., Walker, M., Donaldson, S.G., and Van Oostdam, J. **Maternal and umbilical cord blood levels of mercury, lead, cadmium, and essential trace elements in Arctic Canada.** *Environmental Research* 100(3): 295-318, 2006.

Notes: Maternal and umbilical cord blood levels of mercury (Hg), lead (Pb), cadmium (Cd), and the trace elements copper (Cu), zinc (Zn), and selenium (Se) are reported for Inuit, Dene/Metis, Caucasian, and other nonaboriginal participants from Arctic Canada. This is the first human tissue monitoring program covering the entire Northwest Territories and Nunavut for multiple contaminants and establishes a baseline upon which future comparisons can be made. Results for chlorinated organic pesticides and PCBs for these participants have been reported elsewhere. Between May 1994 and June 1999, 523 women volunteered to participate by giving their written informed consent, resulting in the collection of 386 maternal blood samples, 407 cord samples, and 351 cord:maternal paired samples. Geometric mean (GM) maternal total mercury (THg) concentrations ranged from 0.87 $\mu\text{g/L}$ (SD = 1.95) in the Caucasian group of participants ($n = 134$) to 3.51 $\mu\text{g/L}$ (SD = 8.30) in the Inuit group ($n = 146$). The GM of the Inuit group was 2.6-fold higher than that of the Dene/Metis group (1.35 $\mu\text{g/L}$ SD = 1.60, $n = 92$) and significantly higher than those of all other groups ($P < 0.0001$). Of Inuit women participants, 3% ($n = 4$) were within Health Canada's level of concern range (20-99 $\mu\text{g/L}$) for methylmercury (MeHg) exposure. Of Inuit and Dene/Metis cord samples, 56% ($n = 95$) and 5% ($n = 4$), respectively, exceeded 5.8 mg/L MeHg. The revised US Environmental Protection Agency lower benchmark dose. GM maternal Pb was significantly higher in Dene/Metis (30.9 mg/L or 3.1 mg/dL ; SD = 29.1 mg/L) and Inuit (31.6 mg/L , SD = 38.3) participants compared with the Caucasian group (20.6 mg/L ; SD = 17.9) ($P < 0.0001$). Half of all participants were smokers. GM blood Cd in moderate smokers (1-8 cigarettes/day) and in heavy smokers (>8 cigarettes/day) was 7.4-fold higher and 12.5-fold higher, respectively, than in nonsmokers. The high percentage of smokers among Inuit (77%) and Dene/Metis (48%) participants highlights the need for ongoing public health action directed at tobacco prevention, reduction, and cessation for women of reproductive age. Pb and THg were detected in more than 95% of all cord blood samples, with GMs of 21 mg/L and 2.7 mg/L , respectively, and Cd

was detected in 26% of all cord samples. With a GM of 0.08 mg/L. Cord:maternal ratios from paired samples ranged from 0.44 to 4.5 for THg, from 0.5 to 10.3 for MeHg, and 0.1 to 9.0 for Pb. On average, levels of THg, MeHg, and Zn were significantly higher in cord blood than in maternal blood ($P < 0.0001$), whereas maternal Cd, Pb, Se, and Cu levels were significantly higher than those in cord blood ($P < 0.0001$). There was no significant relationship between methylmercury and selenium for the range of MeHg exposures in this study. Ongoing monitoring of populations at risk and traditional food species, as well as continued international efforts to reduce anthropogenic sources of mercury, are recommended.

Scott, A.P., Katsiadaki, I., Witthames, P.R., Hylland, K., Davies, I.M., McIntosh, A.D., and Thain, J. **Vitellogenin in the blood plasma of male cod (*Gadus morhua*): A sign of oestrogenic endocrine disruption in the open sea?** *Marine Environmental Research* 61(2): 149-170, 2006.

Notes: An ELISA for cod vitellogenin (VTG) has been set up using cod lipovitellin for plate coating and standardisation. The assay has been applied to plasma samples collected from male and female cod caught in three distinct areas around the UK, three areas off the Norwegian coast and also to cod reared initially at an aquaculture site and subsequently maintained at a research station. The aim of the study was to determine whether there were any signs of oestrogenic endocrine disruption in a fish species living offshore. VTG induction was found in male cod caught in the North Sea, the Shetland Box area, in Oslofjord and also in cultivated fish. There was a strong relationship between concentrations of VTG and fish size. There was no evidence that the presence of VTG in the plasma of males is a natural part of their life cycle. On the other hand, the size of fish at which these elevated VTG concentrations appear (ca. 5 kg) is about the size that cod change from feeding primarily on benthic invertebrates to mainly other fish, both benthic and pelagic. The possibility is suggested that large cod pick up oestrogenic endocrine disruptors through the food chain.

Vogelbein, W.K. and Unger, M.A. **Liver carcinogenesis in a non-migratory fish: The association with polycyclic aromatic hydrocarbon exposure.** *Bulletin of the European Association of Fish Pathologists* 26(1): 11-20, 2006.

Notes: Field and laboratory studies indicate a strong positive association between exposure to chemical pollutants in aquatic environments and development of neoplasia in fishes. This brief communication reviews some of the more important North American and European studies that have been conducted on this relationship. We then review work conducted on a small non-migratory estuarine cyprinodontid teleost fish, the mummichog (*Fundulus heteroclitus*) in the industrialized Elizabeth River, Virginia USA. Histopathological surveys of mummichogs from variously degraded habitats indicate an association between PAH exposure and development of neoplasia. We have observed non-neoplastic lesions, preneoplasms and hepatic, biliary, exocrine pancreatic and vascular neoplasms in mummichogs inhabiting Virginia and Maryland estuaries. These lesions track a sediment PAH gradient with highest prevalence occurring in fish from PAH-contaminated sites in the industrialized portions of the Elizabeth River, Virginia. Liver metabolizing enzyme profiles typical of those observed in carcinogen-challenged laboratory rodents (e.g., depressed phase I enzymes, elevated phase II enzymes, elevated p-glycoprotein) provided additional support of a chemical etiology for the neoplasms occurring in these fish. Long-term laboratory exposure of mummichogs to creosote-contaminated sediments resulted in development of altered hepatocellular foci and hepatic neoplasms. Biomarkers of fish exposure and effects (e.g., CYP1A induction, bile FAC's, DNA adducts, liver histopathology) are presently used in the Puget Sound, Washington USA and Elizabeth River, Virginia USA to track long-term environmental recovery following habitat remediation.

Vasseur, P. and Cossu-Leguille, C. **Linking molecular interactions to consequent effects of persistent organic pollutants (POPs) upon populations.** *Chemosphere* 62(7): 1033-1042, 2006.

Notes: There is great concern about the potential adverse effects of persistent organic pollutants (POPs) on wildlife. Threats come from toxic chemicals with long half lives in the environment that were released worldwide on a large scale in the past at a time when little was known of their potential effects on the environment. Although the Stockholm Convention (2001) initially targeted 12 POP chemicals -- organochlorinated compounds -- for the reduction/elimination of releases, the problem can be extended to persistent toxic substances more generally. Therefore, identifying early biomarkers for possible toxic effects to populations in the long term is a challenge for ecotoxicologists. Regional decline in fish, bird and/or invertebrate populations resulting from exposure to POPs, such as DDT (dichlorodiphenyltrichloroethane), PCBs (polychlorinated

biphenyls), PCDD (polychlorinated dibenzo-p-dioxins), and TBT (tributyltin) could be related to some biochemical, endocrine and physiological effects in individuals. Examples of known mechanisms of POP ecotoxicity will be illustrated in the first part. The next parts will be devoted to (i) data gaps and limitations to extrapolation from lower to higher levels of biological organization, (ii) confusing factors in field studies and the combined effects of persistent toxic pollutants and (iii) recommendations for the design and interpretation of experimental studies.

Papush, L. and Danielsson, A. **Silicon in the marine environment: Dissolved silica trends.** *Estuarine, Coastal and Shelf Science* 67(1-2): 53-66, 2006.

Notes: Dissolved silica (DSi) is an important nutrient for primary production. During the last decades, negative trends in DSi concentrations have been observed in coastal areas globally, with implications for the marine ecosystem. This tendency is mainly attributed to two processes: decrease in river loadings (as a result of water regulation and building of dams) and eutrophication in the coastal zone, with subsequent silica depletion. One such area affected by both an intensive water regulation and eutrophication is the Baltic Sea. The present study focused on the pelagic DSi trends in different parts of the Baltic Sea for the last three decades. It was found that there are decreasing trends for most of areas and water depths ranging between -0.05 and -1.2 mmol Si l⁻¹ yr⁻¹. The trends are levelling out during the last decade. Since the riverine load of dissolved silica has not changed at a corresponding rate during the time period, the decrement is assumed to be mainly a result of the ongoing eutrophication within the marine water body. This assumption was strengthened by the increasing trends of inorganic nitrogen and phosphorus.

Webb, M.A.H., Feist, G.W., Fitzpatrick, M.S., Foster, E.P., Schreck, C.B., Plumlee, M., Wong, C., and Gundersen, D.T. **Mercury concentrations in gonad, liver, and muscle of white sturgeon *Acipenser transmontanus* in the lower Columbia River.** *Archives of Environmental Contamination and Toxicology* 50(3): 443-451, 2006.

Notes: This study determined the partitioning of total mercury in liver, gonad, and cheek muscle of white sturgeon (*Acipenser transmontanus*) in the lower Columbia River. The relationship between tissue mercury concentrations and various physiologic parameters was assessed. White sturgeon were captured in commercial fisheries in the estuary and Bonneville, The Dalles, and John Day Reservoirs. Condition factor (CF), relative weight (W-r), and gonadosomatic index (GSI) were determined for each fish (n = 57). Gonadal tissue was examined histologically to determine sex and stage of maturity. Liver (n = 49), gonad (n = 49), and cheek muscle (n = 57) were analyzed for total mercury using cold-vapor atomic fluorescence spectrophotometry. Tissue protein concentrations were measured by ultraviolet-visible spectroscopy. Plasma was analyzed for testosterone (T), 11-ketotestosterone (KT), and 17 β -estradiol (E2) using radioimmunoassay. Mean tissue mercury concentrations were higher in muscle compared with liver and gonad at all sampling locations, except Bonneville Reservoir where mean liver mercury content was the highest tissue concentration observed in the study. Significant negative correlations between plasma androgens (T and KT) and muscle mercury content and plasma E2 and liver mercury content were found. A significant positive linear relationship between white sturgeon age and liver mercury concentrations was evident. Significant negative correlations between CF and relative weight and gonad and liver mercury content were found. In addition, immature male sturgeon with increased gonad mercury content had decreased GSIs. These results suggest that mercury, in the form of methylmercury, may have an effect on the reproductive potential of white sturgeon.

Shoji, J., Masuda, R., Yamashita, Y., and Tanaka, M. **Effect of low dissolved oxygen concentrations on behavior and predation rates on red sea bream *Pagrus major* larvae by the jellyfish *Aurelia aurita* and by juvenile Spanish mackerel *Scomberomorus niphonius*.** *Marine Biology* 147(4): 863-868, 2005.

Notes: A shift in outcomes of predator-prey interactions in plankton community may occur at sublethal dissolved oxygen concentrations that commonly occur in coastal waters. Laboratory experiments were conducted to investigate how a decline in dissolved oxygen concentration alters the predation rate on fish larvae by two estuarine predators. Behavior and consumption of larval fish by moon jellyfish *Aurelia aurita* (103.1 \pm 12.4 mm in bell diameter) and by a juvenile piscivore, Spanish mackerel *Scomberomorus niphonius* (30.1 \pm 2.1 mm in standard length: SL), were observed under four oxygen concentration treatments (1, 2 and 4 mg l⁻¹ and air-saturated: 5.8 mg l⁻¹). Larvae of a coastal marine fish species, red sea bream *Pagrus major* (7.21 \pm 0.52 mm SL), were used as prey for the experiment. Bell contraction rate of the jellyfish did not vary among

the oxygen concentrations tested, indicating a tolerance to low oxygen concentration. Gill ventilation rate of the Spanish mackerel increased and swimming speed decreased as the oxygen concentration decreased, indicating that oxygen concentrations $\leq 4 \text{ mg l}^{-1}$ are physiologically stressful for this species. The number of larvae consumed in 15 min. by jellyfish increased whereas those consumed by Spanish mackerel decreased with the decrease in oxygen concentration. Low oxygen concentrations that are commonly observed in coastal waters of Japan during summer have the potential to increase the relative importance of jellyfish as predator of fish larvae and to change the importance of alternative trophic pathways in estuarine ecosystems.

Shoji, J., Masuda, R., Yamashita, Y., and Tanaka, M. **Predation on fish larvae by moon jellyfish *Aurelia aurita* under low dissolved oxygen concentrations.** *Fisheries Science* 71(4): 748-753, 2005.

Notes: Laboratory experiments were conducted to test the hypothesis that low dissolved oxygen concentrations have the potential to enhance the predation rate on fish larvae by moon jellyfish *Aurelia aurita* which is increasing in abundance in the coastal waters of Japan. Larvae of the red sea bream *Pagrus major* in four size classes (2.9, 4.1, 6.2 and 8.6 mm in standard length) were used as prey in a short-term predation experiment. No change in the bell contraction rate of the jellyfish (mean bell diameter, $100.4 \pm 10.2 \text{ mm}$) was observed at the oxygen concentrations tested (1, 2 and 4 mg/L, and air-saturated, 5.5-6.0 mg/L), suggesting a strong tolerance to a decline in the oxygen concentration. More than 80% of the 2.5 and 4.1-mm size-class larvae were predated on by the jellyfish at all oxygen concentrations during the 15-min trials in 10-L tanks. The 6.2 and 8.6-mm size-class larvae were able to escape from the jellyfish apparently due to their developed swimming ability at the two higher dissolved oxygen concentrations. There was an increase in predation on larvae of these two size classes at the two lower dissolved oxygen concentrations. Predation by moon jellyfish on fish larvae can be more intense at low dissolved oxygen concentrations that commonly occur in the coastal waters of Japan.

Grove, M. and Breitburg, D.L. **Growth and reproduction of gelatinous zooplankton exposed to low dissolved oxygen.** *Marine Ecology Progress Series* 301: 185-198, 2005.

Notes: The lobate ctenophore *Mnemiopsis leidyi* and the scyphomedusan jellyfish *Chrysaora quinquecirrha* are seasonally important consumers in the food web of Western Atlantic and Gulf of Mexico estuaries, including Chesapeake Bay. The abundance and importance of these gelatinous species may be increasing as a result of anthropogenic alteration of these systems, particularly the increasing severity and extent of low dissolved oxygen. Ctenophores and jellyfish are more tolerant of hypoxia than co-occurring finfish, and can sustain high feeding rates in hypoxic waters. We examined the effects of hypoxia exposure on *M. leidyi* and *C. quinquecirrha* growth rates and *M. leidyi* reproduction over 4 d periods in 1 m^3 mesocosms at a range of natural prey densities. Both small (0.2 to 2.0 ml biovolume) and larger (8.0 to 17.6 ml biovolume) ctenophores had significantly reduced growth at oxygen levels of 1.5 and 2.5 mg l^{-1} as compared to air-saturated water, especially at high prey densities. Egg production by large ctenophores was also significantly reduced by exposure to low dissolved oxygen concentrations. In contrast, *C. quinquecirrha* growth rates were unaffected by low dissolved oxygen concentrations tested. These results are counter-intuitive as *M. leidyi* preferentially utilizes moderately hypoxic bottom waters in the field, while *C. quinquecirrha* avoids such waters. Our findings suggest that hypoxia may differentially affect population growth of these dominant gelatinous species.

Richmond, C., Marcus, N.H., Sedlacek, C., Miller, G.A., and Oppert, C. **Hypoxia and seasonal temperature: Short-term effects and long-term implications for *Acartia tonsa* dana.** *Journal of Experimental Marine Biology and Ecology* 328(2): 177-196, 2006.

Notes: Far more attention has been given to the short-term lethal impacts of reduced dissolved oxygen on commercially important fish and crabs than to the long-term sublethal impacts on these same species, or on lower trophic levels. This study demonstrates that chronic, sublethal effects of hypoxia on the copepod *Acartia tonsa*, a critical component of many pelagic coastal food webs, can lead to significant decreases in population growth. The results of laboratory experiments conducted at 15°C (winter) and 25°C (summer), under conditions of normoxia (controls), sublethal hypoxia (1.5 ml l^{-1}) and lethal hypoxia (0.7 ml l^{-1}) show that egg production female⁻¹ day⁻¹ was significantly lower at 0.7 ml l^{-1} compared to controls at both temperatures, while egg production female⁻¹ day⁻¹ was significantly lower at 1.5 ml l^{-1} compared to controls in both

summer experiments and in one of the two winter experiments. Survival was significantly decreased in the 0.7 ml l(-1) treatment compared to controls and the 1.5 ml l(-1) treatment. Copepods developed more slowly and matured at smaller adult body sizes at both temperatures under both lethal and sublethal hypoxia compared to normoxia. Under summer temperatures, egg production was reduced by hypoxia exposure on two counts: (1) exposure to hypoxia during development resulted in smaller adults, which translated into lower egg production, and (2) egg production was still significantly lower in hypoxia treatments compared to controls even when differences in body size were taken into account. While copepods collected in winter and exposed to winter temperatures and hypoxia also matured at smaller body sizes than copepods exposed to normoxia, egg production in winter was almost entirely attributable to this reduction in body size. These results suggest that coastal hypoxia may have a significantly greater impact in the summer months, when copepod populations are most abundant and growing at their most rapid rate of the year. With the anticipated increases in global temperatures, hypoxia may have even greater impacts on pelagic food webs.

Hjorth, M., Dahllof, I., and Forbes, V.E. **Effects on the function of three trophic levels in marine plankton communities under stress from the antifouling compound zinc pyrithione.** *Aquatic Toxicology* 77(1): 105-115, 2006.

Notes: This study aimed to investigate functional responses of natural marine planktonic communities to stress from the antifouling compound zinc pyrithione (ZPT). Isotope labelling techniques (C-14) were applied to study bacterial incorporation of leucine, photosynthetic activity of phytoplankton and grazing of labelled prey by zooplankton communities for 6 days after exposures to nominal concentrations of 0, 5, 25, 50 nM ZPT in a mesocosm experiment in Isefjord, Denmark. Significant direct effects were visible on chlorophyll *a* concentrations, which decreased in all exposed communities, to between 48 and 36% of control concentrations on Day 3, 1 day after the last exposure. Phytoplankton activities were also significantly affected on Day 3 with activities between 9 and 26% of control levels, as was zooplankton activities in the 25 and 50 nM exposures. In the 50 nM exposure the total community zooplankton activity was reduced to 25 +/- 4%, and per individual to 46 +/- 11% of control levels. Bacterial communities showed positive indirect effects with high activities (up to 183 +/- 40%) due to higher amounts of available substrate from algal death. Pollution induced community tolerance analyses performed on phytoplankton and bacterial communities at the end of the experiment indicated a development of increased tolerance for phytoplankton in the 50 nM exposed communities, whereas there were no changes in tolerance in the bacterial communities. Multivariate analysis of the integrated functional response by the plankton communities revealed a significant difference ($p < 0.05$) between exposed communities compared to controls in the first 3 days after last exposure and in the end of the experiment. The study provides evidence of diverse effects on the functions of marine plankton communities under stress from a pollutant. Direct effects lead to cascading indirect effects throughout the community, eventually causing different developments. Continuous exposure to ZPT could lead to severe long-term effects, causing more permanent changes in structure and function than observed here. The study demonstrates that it is possible to assess the functional effects of a stressor in a complex mesocosm and to determine effects in a complex plankton community, which were not predictable from laboratory studies.

Martin-Skilton, R., Lavado, R., Thibaut, R., Minier, C., and Porte, C. **Evidence of endocrine alteration in the red mullet, *Mullus barbatus* from the NW Mediterranean.** *Environmental Pollution* 141(1): 60-68, 2006.

Notes: Red mullet (*Mullus barbatus*) were collected from different sampling sites (NW Mediterranean) in spring and autumn, with the aim of assessing potential alterations of the endocrine system. Alkylphenols were measured in fish bile as an indicator of estrogenic exposure. Key enzymatic activities involved in both synthesis (ovarian 17 beta-hydroxysteroid dehydrogenases and P450 aromatase) and metabolism of steroids were assessed together with histological alterations of the gonads. During the spring sampling, delayed gamete maturation, intersexuality, fibrosis, and depressed ovarian P450 aromatase activity were observed in organisms from the most polluted sites. During the autumn sampling, those effects were less evident, indicating that fish might be more susceptible to endocrine disrupting chemicals during the reproductive period. Nonetheless, enhanced glucuronidation of testosterone and estradiol was observed. Overall, this work provides first evidences of significant alterations in the endocrine system of red mullet from highly impacted areas in the NW Mediterranean.

Downs, C.A., Fauth, J.E., Wetzel, D., Hallock, P., Halas, J.F., Halas, J.C., Curry, R., and Woodley, C.M. **Investigating coral reef degradation at Alina's reef in the Florida Keys: Cellular physiology of white grunt (*Haemulon plumieri*) as a**

biological indicator. *Environmental Forensics* 7(1): 15-32, 2006.

Notes: Coral reefs in the Florida Keys are severely degraded with a reported 38% loss between 1996 and 2000, yet the causes of these devastating declines remain largely unknown. Our long-term studies in the Upper Keys and Biscayne National Park indicate acute stress events affecting physiological condition in species representing different trophic levels in the reef community, one of which was white grunt (*Haemulon plumieri*; Lacepede, 1801). We initiated a preliminary investigation describing cellular physiological stress effects and the possible causes of these stress events using cellular diagnostic profiling coupled with a cursory body-load contaminant chemistry analysis. The cellular biomarker profiles from fish taken from Alina's Reef indicated a toxic response profile that was suggestive of a suicide reaction of the cytochrome P450 2-class as a result of an interaction with a xenobiotic that adversely affects heme metabolism. Elevated levels of damaged porphyrin products were also found in fish from Alina's Reef. Liver loads of anthropogenic contaminants (e.g., pesticides, PCBs) were measured and provided further evidence for possible causative agents. Evaluation and synthesis of each type of data were used to establish a biological effect, develop a mechanism of pathogenicity, and build a profile for possible causative agent(s).

Braune, B.M. and Malone, B.J. **Organochlorines and mercury in waterfowl harvested in Canada.** *Environmental Monitoring and Assessment* 114(1-3): 331-359, 2006.

Notes: Samples of breast muscle from 32 species of waterfowl collected from 123 sites across Canada were analyzed for chlorobenzenes (CBz), chlordane-related compounds (CHL), hexachlorocyclohexanes (HCH), DDT, mirex, dieldrin, PCBs and mercury. SDDT, S CBz and SPCB were the compounds most frequently found above trace levels. SHCH and SMirex were detected the least often. Mercury was detected in all of the mergansers, over 50% of dabbling, bay and sea ducks, and in less than 2% of the geese analysed. The highest levels of contaminants were generally found in birds feeding at higher trophic levels such as sea ducks and mergansers. With the exception of a few samples of mergansers and long-tailed ducks from eastern Canada, which contained SPCB concentrations of 1.0 - 2.4 mg kg⁻¹, SPCB levels were less than 1 mg kg⁻¹ wet weight. Only one merganser from eastern Canada had a SDDT concentration (2.6 mg kg⁻¹ ww) which was greater than 1 mg kg⁻¹ ww. The highest SCHL (0.10 mg kg⁻¹ ww) was also found in mergansers from eastern Canada. Levels of total mercury in breast muscle were either low (< 1 mg kg⁻¹ ww) or below detection limits with the exception of a few samples of mergansers from eastern Canada which contained mercury concentrations of 1.0 - 1.5 mg kg⁻¹ ww. Health Canada determined that the organochlorine and mercury levels found in samples of breast muscle of ducks and geese analysed in this study did not pose a health hazard to human consumers and therefore these waterfowl were safe to eat.

Glibert, P.M., Harrison, J., Heil, C., and Seitzinger, S. **Escalating worldwide use of urea - a global change contributing to coastal eutrophication.** *Biogeochemistry* 77(3): 441-463, 2006.

Notes: While the global increase in the use of nitrogen-based fertilizers has been well recognized, another change in fertilizer usage has simultaneously occurred: a shift toward urea-based products. Worldwide use of urea has increased more than 100-fold in the past 4 decades and now constitutes > 50% of global nitrogenous fertilizer usage. Global urea usage extends beyond agricultural applications; urea is also used extensively in animal feeds and in manufacturing processes. This change has occurred to satisfy the world's need for food and more efficient agriculture. Long thought to be retained in soils, new data are suggestive of significant overland transport of urea to sensitive coastal waters. Urea concentrations in coastal and estuarine waters can be substantially elevated and can represent a large fraction of the total dissolved organic nitrogen pool. Urea is used as a nitrogen substrate by many coastal phytoplankton and is increasingly found to be important in the nitrogenous nutrition of some harmful algal bloom (HAB) species. The global increase from 1970 to 2000 in documented incidences of paralytic shellfish poisoning, caused by several HAB species, is similar to the global increase in urea use over the same 3 decades. The trend toward global urea use is expected to continue, with the potential for increasing pollution of sensitive coastal waters around the world.

Eddy, F.B. **Ammonia in estuaries and effects on fish.** *Journal of Fish Biology* 67(6): 1495-1513, 2005.

Notes: This review aims to explore the biological responses of fish in estuaries to increased levels of environmental ammonia. Results from laboratory and field studies on responses of fish to varying salinity and to increased ammonia will be evaluated,

although studies which examine responses to ammonia, in relation to varying salinity, pH and temperature together are rare. In a survey of British estuaries the continuous measurement of total ammonia showed values that ranged from background levels increasing up to $\approx 10 \text{ mg N l}^{-1}$ although higher values have been noted sporadically. In outer estuaries pH values tended to stabilize towards sea water values (e.g. $\approx \text{pH } 8$). Upper reaches of estuaries are influenced by the quality of their fresh waters sources which can show a wide range of pH and water quality values depending on geological, climatic and pollution conditions. In general the ammonia toxicity (96 h LC50) to marine species (e.g. $0.09\text{--}3.35 \text{ mg l}^{-1} \text{ NH}_3$) appears to be roughly similar to freshwater species (e.g. $0.068\text{--}2.0 \text{ mg l}^{-1} \text{ NH}_3$). Ammonia toxicity is related to differences between species and pH rather than to the comparatively minor influences of salinity and temperature. In the marine environment the toxicity of ionized ammonia (NH_4^+) should be considered. The water quality standard for freshwater salmonids of $21 \text{ mg l}^{-1} \text{ NH}_3\text{-N}$ was considered to be protective for most marine fish and estuarine fish although the influence of cyclical changes in pH, salinity and temperature were not considered. During ammonia exposures, whether chronic or episodic, estuarine fish may be most at risk as larvae or juveniles, at elevated temperatures, if salinity is near the seawater value and if the pH value of the water is decreased. They are also likely to be at risk from ammonia intoxication in waters of low salinity, high pH and high ammonia levels. These conditions are likely to promote ammonia transfer from the environment into the fish, both as ionized and unionized ammonia, as well as promoting ammonia retention by the fish. Fish are more likely to be prone to ammonia toxicity if they are not feeding, are stressed and if they are active and swimming. Episodic or cycling exposures should also be considered in relation to the rate at which the animal is able to accumulate and excrete ammonia and the physiological processes involved in the transfer of ammonia. In the complex environment of an estuary, evaluation of ammonia as a pollutant will involve field and laboratory experiments to determine the responses of fish to ammonia as salinity and temperature vary over a period of time. It will also be necessary to evaluate the responses of a variety of species including estuarine residents and migrants.

Dodds, W.K. **Nutrients and the "dead zone": the link between nutrient ratios and dissolved oxygen in the northern Gulf of Mexico.** *Frontiers in Ecology and Environment* 4(4): 211-217, 2006.

Notes: The "dead zone", an area with reduced concentrations of dissolved oxygen, forms every year off the mouth of the Mississippi River in the northern Gulf of Mexico. Some marine animals are stressed or killed by the hypoxic conditions, with negative consequences for this large and economically important marine fishery. In the past, the dead zone has been linked to nitrogen (N) input from the Mississippi River, but recent analyses suggest that phosphorus (P) also plays a role. It has therefore been proposed that controlling both the N and P entering the Gulf may be required to minimize hypoxia. However, the use of elemental ratios (stoichiometric analysis) of dissolved inorganic nutrients to reach this conclusion is scientifically tenuous. Stoichiometric analyses of total N and P and the results of several nutrient enrichment growth bioassays also suggest the importance of both N and P, but offer less evidence for a P effect, providing a stronger scientific basis for management.

Beard, J. **DDT and human health.** *The Science of the Total Environment* 355(1-3): 78-89, 2006.

Notes: 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane (DDT) was the first widely used synthetic pesticide and is extremely persistent in both the environment and the human body. The introduction of DDT revolutionised agricultural production and has been credited with the elimination of malaria from the United States and Europe. However, DDT is also known to have had major environmental consequences and has been associated with dramatic declines in many animal populations. Although DDT use has generally been restricted since the early 1970s, exposure to the pesticide remains widespread. In developed countries, slow elimination from the body means a large proportion of the population still have detectable levels of DDT, or its metabolite DDE, in their serum or adipose tissue. In developing countries, the pesticide continues to be used for vector control and a significant proportion of breast-fed babies has daily intakes above recommended levels. This review considers the epidemiological evidence for possible adverse effects of human exposure to DDT. Much of this research is weakened by methodological flaws. However, recent methods in breast cancer research using nested studies in cohorts with stored biological samples have allowed a more rigorous assessment of a putative role for DDT in disease aetiology. While DDT does not appear to play a causative role in breast cancer development, there is suggestive evidence for a role in the aetiology of other conditions such as pancreatic cancer, neuropsychological dysfunction, and reproductive outcomes. Research into these and other conditions would benefit from the same rigorous approaches used in breast cancer research. Until further high quality evidence is available, it is still too early, even 60 years after the introduction of this once ubiquitous chemical, to pass judgement on the role of DDT in a number of common diseases.

Danis, B., Wantier, P., Flammang, R., Pernet, P., Chambost-Manciet, Y., Coteur, G., Warnau, M., and Dubois, P.
Bioaccumulation and effects of PCBs and heavy metals in sea stars (*Asterias rubens*, L.) from the North Sea: A small scale perspective. *The Science of the Total Environment* 356(1-3): 275-289, 2006.

Notes: Sea stars (*Asterias rubens* L.) were collected in different stations distributed in the Southern Bight of the North Sea. Concentrations of four heavy metals and six PCB congeners were measured in two body compartments (body wall and pyloric caeca). In order to assess the potential harm of these contaminants, two biochemical parameters were measured in sea stars, viz. reactive oxygen species (ROS) production by amoebocytes and cytochrome P450 immunopositive protein (CYP1A IPP) induction in pyloric caeca. Sea stars from stations located in the plume of the Scheldt river showed the highest contamination levels. Other stations, similarly located, displayed lower levels. No simple relationship could be established between ROS production by sea star amoebocytes and contaminant levels measured in sea star tissues. CYP1A IPP induction displayed more contrasted responses, and highly significant regressions were found between PCB concentrations measured in pyloric caeca and CYP1A IPP. Both biological parameters were found to vary significantly over the study area. On the whole, data indicated that contamination levels and subsequent effects in sea stars were comparable to those described in previous large-scale studies, but that working at a smaller scale highlighted the existence of patterns of contamination which can blur general trends due to major contamination sources like contaminated rivers.

Dietz, R., Riget, F., Born, E.W., Sonne, C., Grandjean, P., Kirkegaard, M., Olsen, M.T., Asmund, G., Renzoni, A., Baagoe, H., and Andreasen, C. **Trends in mercury in hair of Greenlandic polar bears (*Ursus maritimus*) during 1892-2001.** *Environmental Science and Technology* 40(4): 1120-1125, 2006.

Notes: Mercury concentrations in hair from 397 Greenland polar bears (*Ursus maritimus*) sampled between 1892 and 2001 were analyzed for temporal trends. In East Greenland the concentrations showed a significant ($p < 0.0001$, $n = 27$) increase of 3.1%/year in the period 1892-1973. In Northwest Greenland, a similar ($p < 0.0001$, $n = 69$) increase of 2.1%/year was found, which continued until 1991, when the most recent samples were obtained. In East Greenland, a significant ($p = 0.009$, $n = 322$) decrease of 0.8%/year was observed after 1973. Two Northwest Greenland samples from 1300 A.D. had a mean value of 0.52 mg/kg of dry weight, which can be considered as a baseline level. The Hg concentration during 1985-1991 from Northwest Greenland (mean value of 7.45 mg/kg of dry weight) was more than 14-fold higher than the assumed baseline level from 1300 A.D. from the same region (i.e., about 93% anthropogenic). Although a decrease was found in East Greenland after 1973, the concentration is still ca. 11 fold higher than the baseline level (i.e., about 90% anthropogenic).

Smithwick, M., Norstrom, R.J., Mabury, S.A., Solomon, K., Evans, T.J., Stirling, I., Taylor, M.K., and Muir, D.C.G.
Temporal trends of perfluoroalkyl contaminants in polar bears (*Ursus maritimus*) from two locations in the North American Arctic, 1972-2002. *Environmental Science and Technology* 40(4): 1139-1143, 2006.

Notes: Perfluoroalkyl substances are globally distributed anthropogenic contaminants. Their production and use have increased dramatically from the early 1980s. While many recent publications have reported concentrations of perfluorooctane sulfonate (PFOS) and other perfluoroalkyl acids (PFAs) in biotic and abiotic samples, only limited work has addressed temporal trends. In this study we analyzed archived polar bear (*Ursus maritimus*) liver tissue samples from two geographic locations in the North American Arctic, collected from 1972 to 2002. The eastern group, taken from the vicinity of northern Baffin Island, Canada, comprised 31 samples, and the western group, from the vicinity of Barrow, Alaska, comprised 27 samples. Samples were analyzed for perfluorocarboxylic acids (PFCAs) from carbon chain length C8 to C15, perfluorohexane sulfonate, PFOS, the neutral precursor perfluorooctane sulfonamide (PFOSA), as well as 8:2 and 10:2 fluorotelomer acids and their α,β unsaturated acid counterparts. Concentrations of PFOS and PFCAs with carbon chain lengths from C9 to C11 showed an exponential increase between 1972 and 2002 at both locations. Doubling times ranged from 3.6 \pm 0.9 years for perfluorononanoic acid in the eastern group to 13.1 \pm 4.0 years for PFOS in the western group. PFOSA showed decreasing concentrations over time at both locations, while the remaining PFAs showed no significant trends or were not detected in any sample. The doubling time for PFOS was similar to the doubling time of production of perfluorooctylsulfonate-fluoride-based products during the 1990s.

Law, R.J., Bersuder, P., Allchin, C.R., and Barry, J. **Levels of the flame retardants hexabromocyclododecane and tetrabromobisphenol A in the blubber of harbor porpoises (*Phocoena phocoena*) stranded or bycaught in the UK, with evidence for an increase in HBCD concentrations in recent years.** *Environmental Science and Technology* 40(7): 2177-2183, 2006.

Notes: Within the U.K. Marine Mammals Stranding Program, analysis of brominated flame retardants began in 1999. Initially, the focus of attention was the brominated diphenyl ethers. Since the withdrawal of the pentamix and octamix polybrominated diphenyl ether (PBDE) formulations from the EU market prior to August 2004, two other high-volume products, hexabromocyclododecane (HBCD) and tetrabromobisphenol A (TBBP-A), have been included. We report the concentrations of these compounds in the blubber of harbor porpoises (*Phocoena phocoena*) stranded or dying due to physical trauma in the U.K. during the period 1994-2003. Analysis was undertaken using LC/MS method on a diastereoisomer basis. Eighty-five samples were analyzed for HBCD, and 68 of these for TBBP-A. *a*-HBCD dominated over the other isomers and was detected in all samples analyzed at concentrations ranging from 10 to 19 200 mg kg⁻¹ wet weight. The maximum concentration was about double that reported in earlier U.K. studies. TBBP-A was detected in only 18 samples and at much lower concentrations, from 6 to 35 mg kg⁻¹ wet weight. Investigation of possible time trends indicated a sharp increase in HBCD concentrations from about 2001 onward, which was not confounded by age (length), sex, nutritional status, or location. This may be a result of changing patterns of use of HBCD following limitations on the production and use of two PBDE formulations within the EU and will feed ongoing risk assessment activities.
