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Marine Science Review – 204

Marine pollution

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In this review:

A. Recent articles – no abstract available
B. Recent articles with abstracts

A. Recent articles – no abstract available

Peck, A.M. and Hornbuckle, K.C. **Environmental sources, occurrence, and effects of synthetic musk fragrances.** *Journal of Environmental Monitoring* 8(9): 874-879, 2006.

Ramu, K., Kajiwara, N., Mochizuki, H., Miyasaka, H., Asante, K.A., Takahashi, S., Ota, S., Yeh, H.M., Nishida, S., and Tanabe, S. **Occurrence of organochlorine pesticides, polychlorinated biphenyls and polybrominated diphenyl ethers in deep-sea fishes from the Sulu Sea.** *Marine Pollution Bulletin* 52(12): 1827-1832, 2006.

B. Recent articles with abstracts

Walker, T.R., Grant, J., and Archambault, M.C. **Accumulation of marine debris on an intertidal beach in an urban park (Halifax Harbour, Nova Scotia).** *Water Quality Resources Journal of Canada* 41(3): 256-262, 2006.

Notes: This study evaluated monthly accumulation rates and types of marine debris washed ashore at a recreational beach in Point Pleasant Park, Halifax Harbour, between April and September 2005. Black Rock Beach is 70 m long and a total of 2129 marine debris items were collected and sorted, representing a mean accumulation rate of 355 (+/- 68 SE) items month^{-1}. The total weight of debris items was only 10.8 kg (mean 2 kg +/- 0.4 SE), however eighty-six percent of this debris was plastic material. The types of litter found included: tampon applicators, condoms (i.e., sewage-related debris [SRD]); plastic fast food packaging, confectionary wrappers, Styrofoam fragments, plastic bottles and caps, items of clothing, soft drink cans, cigarettes and cigarette holders (i.e., recreational or land-based debris); packing bands, nylon rope and nets (i.e., shipping- or fishing-related debris). These items were generated by recreational use of the park (52%), sewage disposal (14%) and from shipping and fishing activities (7%). It is suggested that a significant reduction in marine debris at recreational beaches may arise by improving public awareness of the environmental and aesthetic impacts of marine litter and future improvements to the municipal sewage disposal system.

Besada, V., Gonzalez, J.J., and Schultze, F. **Mercury, cadmium, lead, arsenic, copper and zinc concentrations in albacore, yellowfin tuna and bigeye tuna from the Atlantic Ocean.** *Ciencias Marinas* 32(2B): 439-445, 2006.

Notes: The concentrations of Hg, Cd, Pb, As, Cu and Zn were determined in 67 tuna samples from the Atlantic Ocean in order to determine the concentrations present in different species and to evaluate possible risks for human health as a consequence of the consumption of these products. The maximum permissible levels of Hg, Cd and Pb in foodstuffs are established by Commission Regulations (EC) 466/2001 and 78/2005. The species studied were albacore (*Thunnus alalunga*), yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*). These three species showed differences in the metal concentrations analyzed. The maximum Hg concentrations obtained in albacore and yellowfin tuna samples were well below the limit established for human consumption (1.0 mg kg^{-1} wet weight), but some bigeye tuna individuals exceeded this limit. In the case of the other regulated metals, the values were well below the limit. For these three species, Hg concentrations

increased as the size of the individuals increased, but there was no clear relationship between concentrations and sizes for the rest of the elements studied.

Mortensen, A.S. and Arukwe, A. **The persistent DDT metabolite, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene, alters thyroid hormone-dependent genes, hepatic cytochrome P4503A, and pregnane X receptor gene expressions in Atlantic salmon (*Salmo salar*) parr.** *Environmental Toxicology and Chemistry* 25(6): 1607-1615, 2006.

Notes: The present study investigated the effects of 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (DDE) on the thyroid and steroid-metabolizing system in Atlantic salmon (*Salmo salar*) parr. Fish were exposed to waterborne DDE and thyroxine (T_4), both singly and in combination, for 5 d. Thyroid-stimulating hormone (TSHb), T_4 deiodinase (T4ORD), thyroid receptors (TRa and TRb), and insulin-like growth factor type 1 receptor (IGF-1R) were analyzed using quantitative (real-time) polymerase chain reaction in liver, brain, and kidney, whereas cytochrome P4503A (CYP3A) and pregnane X receptor (PXR) mRNA levels were analyzed only in the liver. Exposure to DDE and T_4, both singly and in combination, inhibited TSHb expression in the brain. The DDE induced TSHb in the liver, and T_4 inhibited TSHb in the liver and kidney, both singly and in combination with DDE. The DDT-metabolite DDE induced T4ORD expression in the kidney and liver, and combined exposure with T_4 inhibited T4ORD expression in the brain, kidney, and liver. The IGF-1R and TRa expressions were induced by DDE and T_4 singly in the brain, whereas combined exposure with both compounds did not affect IGF-1R and TRd transcript levels. Whereas T_4 inhibited TRb expression in the liver, exposure to DDE, both singly and in combination with T_4, induced TRb transcript levels in the liver. Exposure to T_4 and DDE, both singly and in combination, resulted in a parallel pattern of CYP3A and PXR mRNA induction in the liver. These results indicate that DDE alters thyroid hormone-dependent genes and hepatic CYP3A and PXR levels. The hepatic modulation of CYP3A and PXR transcript levels by DDE represents a novel aspect of DDE toxicity that, to our knowledge, has not been demonstrated previously in fish. Therefore, the present study demonstrates some possible physiological and endocrine consequences from exposure to endocrine-disrupting chemicals for salmon parr during smoltification.

Aumento, F., Cristaldi, M., and Zucchetti, M. **Nuclear powered submarines as hazards to the marine environment.** *Fresenius Environmental Bulletin* 15(9A): 1068-1075, 2006.

Notes: Hundreds of nuclear-powered submarines (NPS) have been manufactured since 1953; some 160 are still in operation. Decommissioning NPS is a major, delicate and costly task. There have been many incidents with NPS during their 50 years operational period: Most of these emergencies resulted in serious radiological and ecological consequences. In the Mediterranean, the effects of marine pollution due to NPS have been under recent investigation following the October 2003 accident to the US nuclear submarine Hartford in Sardinia (Italy). Preliminary studies indicated that no apparent environmental release had taken place as a direct result of the accident. However, further analyses detected traces of Pu-239 in several of the algal species, indicative of anthropogenic pollutants. Furthermore, several samples showed concentrations of radially distributed alpha tracks (forming "hot spots") emanating from micron-sized point sources. The concentrated, extremely localized occurrence of these nuclides cannot be explained in terms of left-over worldwide nuclear pollution. A local source seems more plausible. Our ongoing sampling programme has revealed that: some of the high alpha/hot spot levels measured in February 2004 have decreased markedly during subsequent months, others have decreased only slightly, and others still have remained unchanged: a clear indication that different nuclides are present. We are now analyzing 2005 samples.

Handler, N.B., Payran, A., Higgins, C.P., Luthy, R.G., and Boehm, A.B. **Human development is linked to multiple water body impairments along the California coast.** *Estuaries and Coasts* 29(5): 860-870, 2006.

Notes: To elucidate relationships between land cover and water quality along the central California coast, we collected monthly samples from 14 coastal waterway outlets representing various degrees of human development. Sites were distributed between three salinity categories, freshwater, estuarine, and marine, to better understand land cover-water quality relationships across a range of coastal aquatic ecosystems. Samples were analyzed for fecal indicator bacteria (FIB), dissolved nutrients, stable nitrogen isotopes in particulate organic matter, and chlorophyll *a* (chl *a*). Sediment samples from 11 sites were analyzed for the concentration of the anthropogenic organic contaminant perfluorooctane sulfonate and its precursors (SPFOS). While

the data indicated impairment by nutrient, microbial, and organic contaminants at both agricultural and urban sites, the percentage of agricultural land cover was the most robust indicator of impairment, showing significant correlations ($p < 0.05$) to FIB, nutrient, chl *a*, and SPFOS levels. FIB densities were strongly influenced by salinity and were highest at sites dominated by agriculture and urbanization. Nutrient levels and chl *a* correlated to both agricultural and urban land use metrics as well. Positive correlations among FIB, nutrients, chl *a*, and SPFOS suggest a synergy between microbial, nutrient, and organic pollution. The results emphasize the importance of land management in protecting coastal water bodies and human health, and identify nutrient, microbial, and organic pollution as prevalent problems in coastal California water bodies.

Chesman, B.S. and Langston, W.J. **Intersex in the clam *Scrobicularia plana*: a sign of endocrine disruption in estuaries?** *Biology Letters* 2(3): 420-422, 2006.

Notes: The phenomenon of endocrine disruption is currently a source of growing concern. Feminization of male fish in UK rivers has been shown to occur extensively and has been linked with exposure to endocrine-disrupting compounds present in the environment. Much less is known of the extent and scale of endocrine disruption in estuarine and marine ecosystems, particularly in invertebrates. We present evidence that intersex, in the form of ovotestis, is occurring in the common estuarine bivalve *Scrobicularia plana*, which is considered to be inherently gonochoristic. We report varying degrees in the severity of ovotestis in male *S. plana*, and have adopted and developed a grading method to assess the extent of this intersex condition. These findings indicate that *S. plana* offers potential for widespread screening and investigation of endocrine disruption, helping to focus remediatory strategy.

Bellas, J. **Comparative toxicity of alternative antifouling biocides on embryos larvae of marine invertebrates.** *The Science of the Total Environment* 367(2-3): 573-585, 2006.

Notes: This study evaluates the impact of commonly used "booster" biocides (chlorothalonil, Sea-Nine 211, dichlofluanid, tolylfluanid and Irgarol 1051) on early developmental stages of marine invertebrates of commercial and ecological relevance. Toxicity tests were conducted with embryos and larvae of the bivalve *Mytilus edulis*, the sea-urchin *Paracentrotus lividus* and the ascidian *Ciona intestinalis*. Toxicity was quantified in terms of the EC50 (median effective concentration) and EC_{10} reducing embryogenesis success, larval growth and larval settlement by 50% and 10% respectively. The EC_{10} and EC_{50} for chlorothalonil ranged from 2 to 108 and from 25 to 159 nM; for Sea-Nine 211 values were 6-204 and 38-372 nM; for dichlofluanid effective concentrations were 95-830 and 244-4311 nM; tolylfluanid yielded values between 99-631 and 213-2839 nM; and Irgarol 1051 was the least toxic compound showing values from 3145 to > 25 600 and from 6076 to > 25 600 nM. Those biocides may be ranked in the following order from highest to lowest toxicity to embryos and larvae of *M. edulis*, *P. lividus* and *C. intestinalis*: chlorothalonil > Sea-Nine 211 > dichlofluanid = tolylfluanid > Irgarol 1051. The registered effective concentrations were compared to worst-case environmental concentrations reported in literature in order to evaluate the risk posed by these biocides to those invertebrate species. Our data support that chlorothalonil, Sea-Nine 211 and dichlofluanid predicted levels in marinas represent a threat to *M. edulis*, *P. lividus* and *C. intestinalis* populations, whilst Irgarol 1051 showed no toxic effects on the biological responses tested here at worst-case environmental concentrations.

Sarmah, A.K., Meyer, M.T., and Boxall, A.B.A. **A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment.** *Chemosphere* 65(5): 725-759, 2006.

Notes: Veterinary antibiotics (VAs) are widely used in many countries worldwide to treat disease and protect the health of animals. They are also incorporated into animal feed to improve growth rate and feed efficiency. As antibiotics are poorly adsorbed in the gut of the animals, the majority is excreted unchanged in faeces and urine. Given that land application of animal waste as a supplement to fertilizer is often a common practice in many countries, there is a growing international concern about the potential impact of antibiotic residues on the environment. Frequent use of antibiotics has also raised concerns about increased antibiotic resistance of microorganisms. We have attempted in this paper to summarize the latest information available in the literature on the use, sales, exposure pathways, environmental occurrence, fate and effects of veterinary antibiotics in animal agriculture. The review has focused on four important groups of antibiotics (tylosin, tetracycline, sulfonamides and, to a lesser extent, bacitracin) giving a background on their chemical nature, fate processes, occurrence, and effects on plants, soil organisms and bacterial community. Recognising the importance and the growing

debate, the issue of antibiotic resistance due to the frequent use of antibiotics in food-producing animals is also briefly covered. The final section highlights some unresolved questions and presents a way forward on issues requiring urgent attention.

Davies, K. **Strategies for eliminating and reducing persistent bioaccumulative toxic substances: Common approaches, emerging trends, and level of success.** *Journal of Environmental Health* 69(5): 9-15, 2006.

Notes: This paper reviews nine of the best-known strategies for eliminating and reducing substances in the category known as "persistent bioaccumulative toxic substances" (PBTSs). The nine strategies are as follows: 1) Ontario's Candidate Substances List for Bans and Phase-outs. (1992), 2) Canada's ARET Program (1994), 3) Canada's Toxic Substances Management Policy (1995), 4) the Commission for Environmental Cooperation's Sound Management of Chemicals Initiative (1995), 5) the Great Lakes Binational Toxics Strategy (199), 6) the U.S. Environmental Protection Agency's (U.S. EPAs) draft National PBT Strategy (1998), 7) U.S. ERNs Waste Minimization Program (1998), 8) the U.N. Stockholm Convention on Persistent Organic Pollutants (2001), and 9) Washington State's Rule on Persistent Bioaccumulative Toxins (2006). The review describes the commonalities among the strategies, including their goals and principles, design approaches, and other common elements, It also discusses several emerging trends, such as the increasing importance of economic considerations, human health information, and nonregulatory management approaches. The paper concludes with a discussion of how effective the strategies have been at achieving their goals of elimination and reduction of persistent bioaccumulative toxic substances.

Cherkasov, A.A., Overton, R.A., Sokolov, E.P., and Sokolova, I.M. **Temperature-dependent effects of cadmium and purine nucleotides on mitochondrial aconitase from a marine ectotherm, *Crassostrea virginica*: a role of temperature in oxidative stress and allosteric enzyme regulation.** *Journal of Experimental Biology* 210(1): 46-55, 2007.

Notes: Temperature and heavy metals such as cadmium (Cd) are important environmental stressors that can strongly affect mitochondrial function of marine poikilotherms. In this study, we investigated the combined effects of temperature (20°C and 30°C) and Cd stress on production of reactive oxygen species (ROS) and oxidative stress in a marine poikilotherm *Crassostrea virginica* (the eastern oyster) using mitochondrial aconitase as a sensitive biomarker of oxidative damage. We also assessed potential involvement of mitochondrial uncoupling proteins (UCPs) in antioxidant protection in oyster mitochondria using purine nucleotides (GDP, ATP and ADP) as specific inhibitors, and free fatty acids as stimulators, of UCPs. Our results show that exposure to Cd results in elevated ROS production and oxidative damage as indicated by aconitase inactivation which is particularly pronounced at elevated temperature. Unexpectedly, oyster mitochondrial aconitase was inhibited by physiologically relevant levels of ATP (IC50=1.93 and 3.04 μmol l^{-1} at 20°C and 30°C, respectively), suggesting that allosteric regulation of aconitase by this nucleotide may be involved in regulation of the tricarboxylic acid flux in oysters. Aconitase was less sensitive to ATP inhibition at 30°C than at 20°C, consistent with the elevated metabolic flux at higher temperatures. ADP and GDP also inhibited mitochondrial aconitase but at the levels well above the physiological concentrations of these nucleotides (6-11 μmol l^{-1}). Our study shows expression of at least three UCP isoforms in *C. virginica* gill tissues but provides no indication that UCPs protect mitochondrial aconitase from oxidative inactivation in oysters. Overall, the results of this study indicate that temperature stress exaggerates toxicity of Cd leading to elevated oxidative stress in mitochondria, which may have important implications for survival of poikilotherms in polluted environments during seasonal warming and/or global climate change, and suggest a novel temperature-dependent mechanism of allosteric regulation of TCA flux in oyster mitochondria.

Karapanagiotii, HR. K. and Klontza, I. **Investigating the properties of plastic resin pellets found in the coastal areas of Lesvos Island.** *Global NEST Journal* 9(1): 71-76, 2007.

Notes: Plastic pellets (small granules, 1-5 millimeters in diameter) are widely distributed in the ocean and coastal zones all over the world. They are an industrial raw material for the plastic industry and are unintentionally released to the environment both during manufacturing and transport. These pellets are highly persistent and because of their hydrophobic nature they have being identified as carriers of toxic chemicals in the marine environment. Several marine organisms accumulate plastic particles in their stomach. A positive correlation between the mass of ingested plastic and PCBs in fat tissues has been documented. Also, plastic pellets are proposed as indicators of organic pollution in the sea. However, the sorption mechanisms of organic contaminants onto plastic pellets are not yet well understood. For this reason we collected such pellets from various beaches in

Lesvos island. Since this material is highly heterogeneous we also obtained, from plastic manufacturers, virgin pellets made from polyethylene and polypropylene. Phenanthrene was used as the model sorbate. It is a compound with high toxicity and abundance in the environment and relatively easy to use in the laboratory. Also, there are many publications dealing with phenanthrene sorption onto different materials and our results are easily compared with previous research. Batch experiments were performed to determine the sorption kinetics of the pellets. Factors under investigation included pellet material, degree of pellet erosion, and sorption kinetic behavior. All of the five beaches in Lesvos island investigated had plastic pellets on the sand surface. All of these plastic pellets were eroded and 2/3 of them had similar appearance to virgin polyethylene pellets obtained from plastic manufacturers. Pellet color is not indicative of erosion that will lead to varying sorption kinetic behavior. Pellet density could not be used to identify pellets sampled from the beach. Apparent sorption coefficient increases with time for all pellets investigated. Thus, sorption into plastic pellets is limited by diffusion in the polymer phase. 2/3 of the plastic eroded pellets demonstrate sorption kinetics similar to virgin polyethylene pellets after 38 days.

DeLorenzo, M.E. and Serrano, L. **Mixture toxicity of the antifouling compound Irgarol to the marine phytoplankton species *Dunaliella tertiolecta*.** *Journal of Environmental Science and Health Part B - Pesticides, Food Contaminants and Agricultural Wastes* 41(8): 1349-1360, 2006.

Notes: This study examined the toxicity of Irgarol, individually and in binary mixtures with three other pesticides (the fungicide chlorothalonil, and the herbicides atrazine and 2,4-D), to the marine phytoplankton species *Dunaliella tertiolecta*. Standard 96-h static algal bioassays were used to determine pesticide effects on population growth rate. Irgarol significantly inhibited *D. tertiolecta* growth rate at concentrations ≥ 0.27 mg/L. Irgarol was significantly more toxic to *D. tertiolecta* than the other pesticides tested (Irgarol 96 h EC_{50} = 0.7 mg/L; chlorothalonil 96 h EC_{50} = 64 mg/L; atrazine 96 h EC_{50} = 69 mg/L; 2,4-D 96 h EC_{50} = 45,000 mg/L). Irgarol in mixture with chlorothalonil exhibited synergistic toxicity to *D. tertiolecta*, with the mixture being approximately 1.5 times more toxic than the individual compounds. Irgarol and atrazine, both triazine herbicides, were additive in mixture. The toxicity threshold of 2,4-D was much greater than typical environmental levels and would not be expected to influence Irgarol toxicity. Based on these interactions, overlap of certain pesticide applications in the coastal zone may increase the toxicological risk to resident phytoplankton populations.

Beiras, R. and Saco-Alvarez, L. **Toxicity of seawater and sand affected by the Prestige fuel-oil spill using bivalve and sea urchin embryogenesis bioassays.** *Water Air and Soil Pollution* 177(1-4): 457-466, 2006.

Notes: An evaluation of the toxicity of seawater and sand sampled from an area of the Galician coast (NW Iberian Peninsula), highly impacted by the Prestige fuel-oil spill, was attempted by using marine invertebrate embryogenesis bioassays with bivalves and sea urchins. Water samples were frozen and toxicity testing was delayed until the reproductive season of the sea urchins. Sand samples were elutriated and tested within 13 d from sampling, using bivalves from commercial stocks. Sand elutriates were non toxic for embryos despite visual presence of small tar balls. In contrast, seawater from the most impacted site was highly toxic during the first days after the spill, with complete inhibition of embryogenesis even after 4-fold dilution. In a lower degree toxicity persisted for two months in light-exposed coastal water. These findings stress the impact to water column organisms of the less conspicuous and frequently overlooked water-accommodated fraction, rather than the more visible oil slick.

Moore, M.N. **Do nanoparticles present ecotoxicological risks for the health of the aquatic environment?** *Environment International* 32(8): 967-976, 2006.

Notes: Nanotechnology is a major innovative scientific and economic growth area, which may present a variety of hazards for environmental and human health. The surface properties and very small size of nanoparticles and nanotubes provide surfaces that may bind and transport toxic chemical pollutants, as well as possibly being toxic in their own right by generating reactive radicals. There is a wealth of evidence for the harmful effects of nanoscale combustion-derived particulates (ultrafines), which when inhaled can cause a number of pulmonary pathologies in mammals and humans. However, release of manufactured nanoparticles into the aquatic environment is largely an unknown. This review addresses the possible hazards associated with nanomaterials and harmful effects that may result from exposure of aquatic animals to nanoparticles. Possible natioparticle association with naturally occurring colloids and particles is considered together with how this could affect their bioavailability

and uptake into cells and organisms. Uptake by endocytotic routes are identified as probable major mechanisms of entry into cells; potentially leading to various types of toxic cell injury. The higher level consequences for damage to animal health, ecological risk and possible food chain risks for humans are also considered based on known behaviours and toxicities for inhaled and ingested nanoparticles in the terrestrial environment. It is concluded that a precautionary approach is required with individual evaluation of new nanomaterials for risk to the health of the environment. Although current toxicity testing protocols should be generally applicable to identify harmful effects associated with nanoparticles, research into new methods is required to address the special properties of nanomaterials.

Mattson, G. **MARPOL 73/78 and Annex I: An assessment of its effectiveness.** *Journal of International Wildlife Law and Policy* 9(2): 175-194, 2006.

Notes: Oil pollution poses a major threat to marine species and the environment. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the governing international treaty regarding the elimination of oil spills from tankers on the world's oceans. This paper focuses on a discussion of the tanker incidents which have brought about MARPOL 73/78's current inspection, monitoring, and enforcement provisions, and Annex I's implementation of the double-hull amendments. These treaty sections will be assessed for their effectiveness and what sections, if any, warrant improvement or require further assessment by the International Maritime Organization (IMO) and MARPOL 73/78.

Karlsson, J., Breitholtz, M., and Eklund, B. **A practical ranking system to compare toxicity of anti-fouling paints.** *Marine Pollution Bulletin* 52(12): 1661-1667, 2006.

Notes: The toxicity of a number of new anti-fouling paints, claimed to function by physical means and not by leakage of toxic substances, have been tested on two common organisms in the Baltic Sea, i.e., the red macroalga *Ceramium tenuicorne* and the copepod *Nitocra spinipes*. In order to compare the toxicity between the paints a ranking system was developed based on the EC_{50-} and LC_{50-} values. The results showed a wide span in toxicity with the most toxic paints ranked 160 times more toxic than the ones ranked least toxic. Also, TBT, irgarol and diuron, which have been used as active ingredients in traditional anti-fouling paints, were used to evaluate the sensitivity of the two test organisms. The results showed that the test organisms were equally sensitive to the substances as similar organisms in earlier studies. In conclusion, the ranking system presented in this study permits ranking and comparison of total toxicity of complex mixtures.

Hylland, K. **Biological effects in the management of chemicals in the marine environment.** *Marine Pollution Bulletin* 53(10-12): 614-619, 2006.

Notes: Coastal ecosystems are impacted by many stressors, of which chemicals are possibly not the most important. Chemicals differ from most other stressors such as eutrophication and hypersedimentation in the time scale -- effects from the latter act on the scale of weeks or months, whereas effects from chemicals may take years to manifest themselves in population or community changes. There are four different approaches available to manage chemicals in marine ecosystems: target contaminant levels, target individual effects, target community impacts (biodiversity) and finally, target processes. These four differ in the analytical methods available and the analyst's ability to separate effects from chemicals from other environmental factors and natural variation. There is, furthermore, a need to develop a framework to integrate biological effects methods with risk assessment methodology. Such integration will improve the basis for risk-based assessment of chemicals. A problematic issue relevant to all aspects of environmental management are the interactions between chemicals, and between chemicals and eutrophication or sedimentation. There is a clear need for more knowledge about such interactions.

Downs, C. and Downs, A. **Preliminary examination of short-term cellular toxicological responses of the coral *Madracis mirabilis* to acute Irgarol 1051 exposure.** *Archives of Environmental Contamination and Toxicology* 52(1): 47-57, 2007.

Notes: Irgarol 1051 is an *s*-triazine herbicide formulated with Cu2O in antifouling paints. Recent studies have shown that Irgarol 1051 inhibits coral photosynthesis at environmentally relevant concentrations, consistent with its mode of action as a photosystem II inhibitor. Related toxicologic effects of this herbicide on coral cellular physiology have not yet been investigated. We used cellular diagnostics to measure changes in 18 toxicologic cellular parameters in endosymbiotic algal (dinoflagellate) and cnidarian (host) fractions of the common branching coral *Madracis mirabilis* associated with *in vivo* 8- and 24-hour exposures to a nominal initial Irgarol 1051 concentration of 10 mg L^{-1}. Responses measured were (1) xenobiotic response, which includes total and dinoflagellate multixenobiotic resistance (MXR), cnidarian cytochrome (CYP) P450-3 and P450-6 classes, cnidarian, and dinoflagellate glutathione-s-transferase (GST); (b) oxidative damage and response, which includes cnidarian and dinoflagellate Cu/Zn and Mn superoxide dismutase (SOD), cnidarian and dinoflagellate glutathione peroxidase (GPx), cnidarian catalase, and total protein carbonyl); (3) metabolic homeostasis, which includes chloroplast and invertebrate small heat-shock proteins (sHsp), cnidarian protoporphyrinogen oxidase IX (PPO), cnidarian ferrochelatase, and cnidarian heme oxygenase; and (4) protein metabolic condition, which includes cnidarian and dinoflagellate heat shock proteins (hsp70 and hsp60), total ubiquitin, and cnidarian ubiquitin ligase. Acute responses to Irgarol 1051 exposure included significant increases in total and dinoflagellate MXR, dinoflagellate Cu/Zn SOD, dinoflagellate chloroplast sHsp, and cnidarian PPO. Irgarol 1051 exposure resulted in decreases in cnidarian GPx, cnidarian ferrochelatase, cnidarian catalase, and cnidarian CYP 450-3 and -6 classes. Related implications of Irgarol 1051 exposure to coral cellular condition are discussed.

Bouilly, K., Bonnard, M., Gagnaire, B., Renault, T., and Lapegue, S. **Impact of diuron on aneuploidy and hemocyte parameters in Pacific oyster, *Crassostrea giga*s.** *Archives of Environmental Contamination and Toxicology* 52(1): 58-63, 2007.

Notes: Diuron is a substituted urea herbicide used for agricultural and nonagricultural weed control. Its widespread use and relatively slow breakdown led us to analyze its influence on aneuploidy level (lowered chromosome number in a percentage of somatic cells) and hemocyte parameters in Pacific oysters, *Crassostrea gigas*. Adult oysters were subjected to two diuron concentrations (300 ng L^{-1} and 3 mg L^{-1}) for 11 weeks. Significantly higher aneuploidy level was observed in diuron-treated oysters compared with the control. Furthermore, the observed impact on aneuploidy persisted to the next generation as offspring exhibited significantly higher aneuploidy levels when their parents had been exposed to diuron. Significant increases in hemocyte parameters (cell mortality, phagocytosis, granulocyte percentage, reactive oxygen species, and lysosome presence) of the adults were also observed after 4 weeks of diuron exposure. The effects observed on oyster aneuploidy level and hemocyte parameters could have serious environmental and practical consequences.

Olivier, A., Leduc, H.C., Roh, E., Harvey, M.C., and Brown, G.E. **Impaired detection of chemical alarm cues by juvenile wild Atlantic salmon (*Salmo salar*) in a weakly acidic environment.** *Canadian Journal of Fisheries and Aquatic Sciences* 63(10): 2356-2363, 2006.

Notes: Many prey fishes rely on damage-released chemical alarm cues to detect and avoid predators. The ability to use these cues has been shown to confer considerable survival benefits to individuals. While several laboratory studies and a single field study have demonstrated that an ambient pH of 6.0 impairs fishes in their ability to detect these alarm cues, no study had yet compared the response to alarm cue exposures across populations residing in multiple streams of a different acidity level. In our study, we conducted live behavioural observations in five nursery streams, ranging in pH from 5.71 to 7.49 on two age classes (young of the year and parr) of wild juvenile Atlantic salmon (*Salmo salar*). We aimed to assess if the detection of these chemical alarm cues was constantly dependant on the ambient pH or if variations in the detection occurred among populations of the different streams regardless of the ambient acidity level. Our results demonstrated that salmon present in any acidic stream did not respond to alarm cues, while those in neutral streams exhibited typical alarm responses.

Meador, J.P., Sommers, F.C., Ylitalo, G.M., and Sloan, C.A. **Altered growth and related physiological responses in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs).** *Canadian Journal of Fisheries and Aquatic Sciences* 63(10): 2364-2376, 2006.

Notes: A dietary feeding study with polycyclic aromatic hydrocarbons (PAHs) was conducted with juvenile Chinook salmon (*Oncorhynchus tshawytscha*) to mimic exposure from urban estuaries during their transition from freshwater to seawater. A significant reduction in mean fish dry weight was observed only for the highest doses; however, analysis of variance (ANOVA)

using standard deviations and examination of the cumulative frequency plots revealed high variability among all treatments. The skewed fish weight distribution revealed a large number of small fish in several treatments compared with control fish. Analyses of whole-body lipids and several parameters in blood plasma related to growth and metabolism indicated alterations for most treatments. These results and trends in growth, plasma chemistry, and lipids as a consequence of PAH exposure were similar to those in fish exhibiting starvation, which we have termed "toxicant-induced starvation". Based on these results, we conclude that PAHs are toxic to salmonids at this life stage and the reduction in biomass and lipid stores observed here would have the potential to cause increased mortality for individuals during their first winter.

Jenssen, B.M. **Endocrine-disrupting chemicals and climate change: A worst-case combination for arctic marine mammals and seabirds?** *Environmental Health Perspectives* 114(Suppl. 1): 76-80, 2006.

Notes: The effects of global change on biodiversity and ecosystem functioning encompass multiple complex dynamic processes. Climate change and exposure to endocrine-disrupting chemicals (EDCs) are currently regarded as two of the most serious anthropogenic threats to biodiversity and ecosystems. We should, therefore, be especially concerned about the possible effects of EDCs on the ability of Arctic marine mammals and seabirds to adapt to environmental alterations caused by climate change. Relationships between various organochlorine compounds, necessary such as polychlorinated biphenyls, dichlorophenyldichloroethylene, hexachloro-benzene, and oxychlordane, and hormones in Arctic mammals and seabirds imply that these chemicals pose a threat to endocrine systems of these animals. The most pronounced relationships have been reported with the thyroid hormone system, but effects are also seen in sex steroid hormones and cortisol. Even though behavioral and morphological effects of persistent organic pollutants are consistent with endocrine disruption, no direct evidence exists for such relationships. Because different endocrine systems are important for enabling animals to respond adequately to environmental stress, EDCs may interfere with adaptations to increased stress situations. Such interacting effects are likely related to adaptive responses regulated by the thyroid, sex steroid, and glucocorticosteroid systems.

Cox, C. and Surgan, M. **Unidentified inert ingredients in pesticides: Implications for human and environmental health.** *Environmental Health Perspectives* 114(12): 1803-1806, 2006.

Notes: BACKGROUND: By statute or regulation in the United States and elsewhere, pesticide ingredients are divided into two categories: active and inert (sometimes referred to as other ingredients, adjuvants, or coformulants). Despite their name, inert ingredients may be biologically or chemically active and are labeled inert only because of their function in the formulated product. Most of the tests required to register a pesticide are performed with the active ingredient alone, not the fall pesticide formulation. Inert ingredients are generally not identified on product labels and are often claimed to be confidential business information. OBJECTIVES: In this commentary, we describe the shortcomings of the current procedures for assessing the hazards of pesticide formulations and demonstrate that inert ingredients can increase the toxicity of and potential exposure to pesticide formulations. DISCUSSION: Inert ingredients can increase the ability of pesticide formulations to affect significant toxicologic end points, including developmental neurotoxicity, genotoxicity, and disruption of hormone function. They can also increase exposure by increasing dermal absorption, decreasing the efficacy of protective clothing, and increasing environmental mobility and persistence. Inert ingredients can increase the phytotoxicity of pesticide formulations as well as the toxicity to Fish, amphibians, and microorganisms. CONCLUSIONS: Pesticide registration should require fall assessment of formulations. Evaluations of pesticides under the National Environmental Policy Act, the Endangered Species Act, and similar statutes should include impact assessment of formulations. Environmental monitoring for pesticides should include inert ingredients. To enable independent research and risk assessment, inert ingredients should be identified on product labels.

Shaw, S.D., Brenner, D., Berger, M.L., Carpenter, D.O., Hong, C.S., and Kannan, K. **PCBs, PCDD/Fs, and organochlorine pesticides in farmed Atlantic salmon from Maine, eastern Canada, and Norway, and wild salmon from Alaska.** *Environmental Science and Technology* 40(17): 5347-5354, 2006.

Notes: Farmed Atlantic salmon (*Salmo salar*) from Maine and eastern Canada, wild Alaskan Chinook salmon (*Oncorhynchus tshawytscha*), and organically farmed Norwegian salmon samples were analyzed for the presence of polychlorinated biphenyls (PCBs), dioxin-like PCBs, polychlorinated dibenzopdioxins (PCDDs), dibenzo-p-furans (PCDFs), and chlorinated pesticides. PCDD and PCDF congeners were not detected in > 80% of the samples analyzed. Total PCB concentrations (7.2-29.5 ng/g,

wet weight, ww) in the farmed salmon were significantly higher than those in the wild Alaskan Chinook samples (3.9-8.1 ng/g, ww). Concentrations of PCBs, WHO PCB TEQs, and chlorinated pesticides varied significantly by region. PCB and WHO PCB TEQ concentrations in farmed salmon from eastern Canada were lower than those reported in samples collected two years earlier, possibly reflecting recent industry efforts to lower contaminant concentrations in feed. Organically farmed Norwegian salmon had the highest concentrations of PCBs (mean: 27 ng/g, ww) and WHO PCB TEQs (2.85 pg/g, ww); their TEQ values are in the higher range of those reported in farmed salmon from around the world. Removal of skin from salmon fillets resulted in highly variable reductions of lipids and contaminants, and in some skin-off samples, contaminant levels were higher, suggesting that skin removal does not protect the consumer from health risks associated with consumption of farmed salmon.

Muir, D.C.G. and Howard, P.H. **Are there other persistent organic pollutants? A challenge for environmental chemists.** *Environmental Science and Technology* 40(23): 7157-7166, 2006.

Notes: The past 5 years have seen some major successes in terms of global measurement and regulation of persistent, bioaccumulative, and toxic (PB&T) chemicals and persistent organic pollutants (POPs). The Stockholm Convention, a global agreement on POPs, came into force in 2004. There has been a major expansion of measurements and risk assessments of new chemical contaminants in the global environment, particularly brominated diphenyl ethers and perfluorinated alkyl acids. However, the list of chemicals measured represents only a small fraction of the approximately 30,000 chemicals widely used in commerce (> 1 t/y). The vast majority of existing and new chemical substances in commerce are not monitored in environmental media. Assessment and screening of thousands of existing chemicals in commerce in the United States, Europe, and Canada have yielded lists of potentially persistent and bioaccumulative chemicals. Here we review recent screening and categorization studies of chemicals in commerce and address the question of whether there is now sufficient information to permit a broader array of chemicals to be determined in environmental matrices. For example, Environment Canada's recent categorization of the Domestic (existing) Substances list, using a wide array of quantitative structure activity relationships for PB&T characteristics, has identified about 5.5% of 11,317 substances as meeting P & B criteria. Using data from the Environment Canada categorization, we have listed, for discussion purposes, 30 chemicals with high predicted bioconcentration and low rate of biodegradation and 28 with long range atmospheric transport potential based on predicted atmospheric oxidation half-lives > 2 days and log air-water partition coefficients ≥ 5 and ≤ 1. These chemicals are a diverse group including halogenated organics, cyclic siloxanes, and substituted aromatics. Some of these chemicals and their transformation products may be candidates for future environmental monitoring. However, to improve these predictions data on emissions from end use are needed to refine environmental fate predictions, and analytical methods may need to be developed.

Tao, L., Kannan, K., Kajiwara, N., Costa, M.M., Fillmann, G., Takahashi, S., and Tanabe, S. **Perfluorooctanesulfonate and related fluorochemicals in albatrosses, elephant seals, penguins, and Polar Skuas from the Southern Ocean.** *Environmental Science and Technology* 40(24): 7642-7648, 2006.

Notes: Perfluorinated chemicals (PFCs) have been used as surfactants in industrial and commercial products for over 50 years. Earlier studies of the geographical distribution of PFCs focused primarily on the Northern Hemisphere, while little attention was paid to the Southern Hemisphere. In this study, livers from eight species of albatrosses, blood from elephant seal, and blood and eggs from penguins and polar skua collected from the Southern Ocean and the Antarctic during 1995 - 2005 were analyzed for 10 PFCs. In addition, for comparison with the Southern Ocean samples, we analyzed liver, sera, and eggs from two species of albatrosses from Midway Atoll in the North Pacific Ocean. Perfluorooctanesulfonate (PFOS) and perfluorooctanoic acid (PFOA) were found in livers of albatrosses from the Southern Ocean. PFOS was the major contaminant, although the concentrations were < 5 ng/g, wet wt, in 92% of the albatross livers analyzed. PFOA was detected in 30% of the albatross livers, with a concentration range of < 0.6 - 2.45 ng/g, wet wt. Other PFCs, including long-chain perfluorocarboxylates (PFCAs), were below the limits of quantitation in livers of albatrosses from the Southern Ocean. In liver, sera, and eggs of albatrosses from the North Pacific Ocean, long-chain PFCAs (perfluorononanoate, perfluorodecanoate, perfluoroundecanoate, and perfluorododecanoate) were found at concentrations similar to those of PFOS and PFOA. The mean concentration of PFOS in livers of Laysan albatrosses from the North Pacific Ocean (5.1 ng/g, wet wt) was higher than that in several species of albatrosses from the Southern Ocean (2.2 ng/g, wet wt). Species-specific differences in the concentrations of PFOS were noted among Southern Ocean albatrosses, whereas geographical differences in PFOS concentrations among the Indian Ocean, South Pacific Ocean, and South Atlantic Ocean were insignificant. Concentrations of

PFOS and PFOA were, respectively, 2- and 17-fold higher in liver than in sera of Laysan albatrosses. PFOS was found in the blood of elephant seals from Antarctica at concentrations ranging from < 0.08 to 3.52 ng/mL. PFOS was found in eggs (2.1 - 3.1 ng/g) and blood (< 0.24 - 1.4 ng/mL) of polar skuas but was not detected in penguins from Antarctica. Our study documents the existence of low but detectable levels of PFOS and PFOA in Southern Hemisphere fauna, suggesting distribution of these compounds on a global scale.

Butt, C.M., Muir, D.C.G., Stirling, I., Kwan, M., and Mabury, S.A. **Rapid response of arctic ringed seals to changes in perfluoroalkyl production.** *Environmental Science and Technology* 41(1): 42-49, 2007.

Notes: Temporal trends in perfluoroalkyl compounds (PFCs) were investigated in liver samples from two ringed seal (*Phoca hispida*) populations in the Canadian Arctic, Arviat (Western Hudson Bay) (1992, 1998, 2004, 2005) and Resolute Bay (Lancaster Sound) (1972, 1993, 2000, 2004, 2005). PFCs analyzed included C_7-C_{15} perfluorinated carboxylates (PFCAs) and their suspected precursors, the 8:2 and 10:2 fluorotelomer saturated and unsaturated carboxylates (FTCAs, FTUCAs), C_4, C_6, C_8, C_{10} sulfonates, and perfluorooctane sulfonamide (PFOSA). Liver samples were homogenized, liquid-liquid extracted with methyl tert-butyl ether, cleaned up using hexafluoropropanol, and analyzed by liquid chromatography with negative electrospray tandem mass spectrometry (LC-MS/MS). C_9-C_{15} PFCAs showed statistically significant increasing concentrations during 1992-2005 and during 1993-2005 at Arviat and Resolute Bay, respectively. Doubling times ranged from 19.4 to 15.8 years for perfluorododecanoate (PFDoA) to 10.0-7.7 years for perfluorononanoate (PFNA) at Arviat and Resolute Bay but were shorter when excluding the 2005 samples. Conversely, perfluorooctane sulfonate (PFOS) and PFOSA concentrations showed maximum concentrations during 1998 and 2000 at Arviat and Resolute Bay, with statistically significant decreases from 2000 to 2005. In the case of Arviat, two consecutive decreases were measured from 1998 to 2003 and from 2003 to 2005. PFOS disappearance half-lives for seals at Arviat and Resolute Bay were 3.2 and 4.6 years. These results indicate that the ringed seals and their food web are rapidly responding to the phase out of perfluorooctane sulfonyl fluoride based compounds by 3M in 2001. Further, the relatively short doubling times of the PFCAs and PFOS disappearance half-lives support the hypothesis of atmospheric transport as the main transport mechanism of PFCs to the arctic environment.

Brian, J.V., Harris, C.A., Scholze, M., Kortenkamp, A., Booy, P., Lamoree, M., Pojana, G., Jonkers, N., Marcomini, A., and Smupter, J.P. **Evidence of estrogenic mixture effects on the reproductive performance of fish.** *Environmental Science and Technology* 41(1): 337-344, 2007.

Notes: Recent research into the effects of mixtures of estrogenic chemicals has revealed the capacity for similarly acting chemicals to act in combination, according to the principles of concentration addition. This means that, collectively, they may pose a significant environmental risk, even when each component is present at a low and individually ineffective concentration. The aim of this study was to investigate the ecological significance of mixture effects at low-effect concentrations by assessing the combined effect of estrogenic chemicals on the reproductive performance of fish. Pairs of fathead minnows were exposed to five estrogenic chemicals. Endpoints analyzed included fecundity, the expression of male secondary sexual characteristics, somatic indices, and vitellogenin induction. In the first phase of the study, a concentration-response analysis was performed to investigate the relative sensitivity of these endpoints. In the second phase, mixture effects at low-effect concentrations were explored by exposing fish to each of the mixture components, individually and in combination. Data from these experiments provide evidence of mixture effects on fitness and fecundity, demonstrating the capacity for chemicals to act together to affect reproductive performance, even when each component is present below the threshold of detectable effects. This has important implications for hazard assessment and contributes to our understanding of mixture effects at increasing levels of biological complexity.

Booth, A.M., Sutton, P.A., Lewis, C.A., Lewis, A.C., Scarlett, A., Chau, W., Widdows, J., and Rowland, S.J. **Unresolved complex mixtures of aromatic hydrocarbons: Thousands of overlooked persistent, bioaccumulative, and toxic contaminants in mussels.** *Environmental Science and Technology* 41(2): 457-464, 2007.

Notes: Comprehensive two-dimensional gas chromatography-time-of-flight-mass-spectrometry can be used to resolve and identify individual petroleum-derived hydrocarbons in unresolved complex mixtures (UCMs), such as those accumulated by mussels (*Mytilus edulis*). Mussels exhibiting a range of scope for growth values were collected from sites around the UK coast.

Tissue extracts from mussels exhibiting impaired health contained large amounts of aromatic hydrocarbon UCMs compared to the extracts from healthy mussels. The UCMs (up to 125 μg g^{-1} dry tissue) contained thousands of previously unidentified branched alkyl homologues of known aromatic hydrocarbons such as branched alkylbenzenes (BABs), tetralins (BATs), and indanes and indenes (BINs). The toxicity of few such alkyl branched compounds has been investigated previously, but here we show that a commercial mixture of BABs (C_{12}-C_{14}) is toxic to mussels in laboratory tests (11-57 μg g^{-1} dry tissue), reducing feeding rate by up to 40% in 72 h. Thus, some, if not all aromatic UCMs, apparently comprise potent mixtures of persistent, bioaccumulative and toxic compounds which have been overlooked previously.
