May 2007

Marine Science Review – 217

Pollution

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In this review:

A. Recent articles – no abstract available

Quakenbush, L.T. **Polybrominated diphenyl ether compounds in ringed, bearded, spotted, and ribbon seals from the Alaskan Bering Sea.** *Marine Pollution Bulletin* 54(2): 232-236, 2007.

Boehm, P.D., Neff, J.M., and Page, D.S. **Assessment of polycyclic aromatic hydrocarbon exposure in the waters of Prince William Sound after the Exxon Valdez oil spill: 1989-2005.** *Marine Pollution Bulletin* 54(3): 339-356, 2007.

B. Recent articles with abstracts

Levin, M., Morsey, B., and DeGuise, S. **Modulation of the respiratory burst by organochlorine mixtures in marine mammals, humans, and mice.** *Journal of Toxicology and Environmental Health Part A* 70(1): 73-83, 2007.

Notes: The effects of organochlorines (OC) on the immune systems of marine mammals and humans are poorly understood. One important innate immune function of peripheral blood neutrophils and monocytes is the respiratory burst, which generates reactive oxygen species (ROS) used to kill engulfed microorganisms. The present study characterized the immunomodulatory potential for mixtures of OCs, compared to that of individual OCs, on the respiratory burst in several marine mammals, humans, and B6C3F1 mice. The effects of three non-coplanar polychlorinated biphenyls (PCBs) (138, 153, 180), one coplanar PCB (169), and 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and all possible mixtures were tested upon in vitro exposure for 1 h, and their effects on the generation of a respiratory burst were measured by flow cytometry. The final concentration for each congener, alone or in a mixture, was 5 ppm for PCBs and 0.05 ppb for TCDD. Both significant enhancement and suppression of the respiratory burst occurred in all species tested, but the pattern was different between species and cell types (neutrophils vs. monocytes). Both coplanar and non-coplanar OCs were involved in the modulation of the respiratory burst. Regression analysis was not able to elucidate which OCs were involved in modulating the responses, highlighting the difficulty of developing models to predict the immunotoxic effects attributed to OC mixtures. The traditional mouse model and toxic equivalency (TEQ) approach both failed to consistently predict the toxicity of OCs in all species tested, questioning their applicability in the risk assessment process for all species. Elucidating the relative sensitivities to the immunomodulatory effects of OC mixtures between different species may have important implications for risk assessment as well as conservation and management strategies.

Rotllant, G., Abad, E., Sarda, F., Abalos, M., Company, J.B., and Rivera, J. **Dioxin compounds in the deep-sea rose shrimp *Aristeus antennatus* (Risso, 1816) throughout the Mediterranean Sea.** *Deep Sea Research Part I, Oceanographic Research* 53(12): 1895-1906, 2006.

Notes: Polychlorodibenzo-p-dioxins (PCDDs) and polychlorodibenzofurans (PCDFs) are among the more toxic anthropogenic contaminants. They are fat-soluble and accumulate in animal tissues. Exposure to PCDD/Fs can cause several endocrine, reproductive and developmental problems in animals, including human beings. Several studies have demonstrated

that fish and invertebrates living in association with sediments are exposed to and accumulate contaminants, but to date there have been no studies of PCDD/Fs contamination in deep-sea regions. Specimens of *Aristeus antennatus* (Risso, 1816) were collected from depths of 600-2500 m at different points in the Mediterranean Sea, from the western basin off the coast of Barcelona to the central basin off the Peloponnesian Peninsula, with otter trawl gear. Amounts of PCDD/Fs were measured in different animal tissues by high resolution gas chromatography coupled to high resolution mass spectrometry (HRGC-HRMS). This is the first study to report the presence of PCDD/Fs in deep-sea organisms dwelling at depths below 600 m. *A. antennatus* presented levels of PCDD/Fs of the same order of magnitude, or slightly higher, as those found in shallow-water species (*Melicertus kerathurus*) with respect to land-generated contamination. This highlights the widespread distribution of these pollutants and the potential threat posed to the biodiversity of fragile and vulnerable ecosystems such as the deep-sea. PCDD/F levels detected in the edible parts (muscle) of the commercial shrimp *A. antennatus* were clearly below the toxic limit value established by European legislation. Levels followed the trend muscle < ovary < hepatopancreas, according to the lipid content of the organs in question. The specific profile of toxic PCDD/F congeners in the studied Penaeid shrimp specimens was characterized mainly by octachlorodibenzo-p-dioxin (OCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF) and 2,3,4,7,8-pentachlorodibenzofuran (PeCDF) congeners. Moreover, non 2,3,7,8-substituted congeners bioaccumulated in this species, as observed in shallow-water crustaceans. PCDD/Fs were found in the shrimp *A. antennatus* throughout the Mediterranean Sea. Total PCDD/Fs burdens were higher in shrimps caught in the western Mediterranean than in those caught at eastern Mediterranean sites. There was a tendency for higher levels of PCDD/F contamination in samples obtained from deeper (2500 m) than from shallower sites (600 m).

Scheuhammer, A.M., Meyer, M.W., Sandheinrich, M.B., and Murray, M.W. **Effects of environmental methylmercury on the health of wild birds, mammals, and fish.** *Ambio* 36(1): 12-19, 2007.

Notes: Wild piscivorous fish, mammals, and birds may be at risk for elevated dietary methylmercury intake and toxicity. In controlled feeding studies, the consumption of diets that contained Hg (as methylmercury) at environmentally realistic concentrations resulted in a range of toxic effects in fish, birds, and mammals, including behavioral, neurochemical, hormonal, and reproductive changes. Limited field-based studies, especially with certain wild piscivorous bird species, e.g., the common loon, corroborated laboratory-based results, demonstrating significant relations between methylmercury exposure and various indicators of methylmercury toxicity, including reproductive impairment. Potential population effects in fish and wildlife resulting from dietary methylmercury exposure are expected to vary as a function of species life history, as well as regional differences in fish-Hg concentrations, which, in turn, are influenced by differences in Hg deposition and environmental methylation rates. However, population modeling suggests that reductions in Hg emissions could have substantial benefits for some common loon populations that are currently experiencing elevated methylmercury exposure. Predicted benefits would be mediated primarily through improved hatching success and development of hatchlings to maturity as Hg concentrations in prey fish decline. Other piscivorous species may also benefit from decreased Hg exposure but have not been as extensively studied as the common loon.

Vetter, W., von der Recke, R., Herzke, D., and Nygard, T. **Natural and man-made organobromine compounds in marine biota from Central Norway.** *Environment International* 33(1): 17-26, 2007.

Notes: Brominated organic pollutants were found in selected samples of mollusk tissue, fish liver, as well as in the eggs and livers of shag from three sites in Central Norway. More than 80 organobromines were identified owing to the defined isotope ratio acquired by GC/ECNI-MS. However, only a few peaks could be assigned to anthropogenic brominated flame retardants (polybrominated diphenyl ethers). Most of the organobromine compounds detected were unknown or halogenated natural products. The known halogenated natural products MHC-1 and TBA were abundant in all samples and usually between equally abundant, and up to 50 fold more concentrated than the major polybrominated diphenyl ether congener BDE 47. The halogenated natural products BC-2 (2-MeO-BDE 68) and BC-3 (6'-MeO-BDE 47), were on level with BDE 100 which was the second most abundant BDE congener in many samples. The previously identified natural polybrominated hexahydroxanthene derivatives (PBHDs) were detected for the first time in bird eggs. Being major contaminants in bird eggs, PBHDs were only present at low levels in bird liver from nestlings originating from the same clutch. Such differences were detected for several other major contaminants. One unknown tetrabromo compound particularly abundant in mussels from Munkholmen was studied by GC/MS and the molecular ion was detected at m/z 446. The abundance of the most important unknown compounds did not correlate with BDEs and they most likely represent halogenated natural products. This study supports that halogenated natural products have to be treated as serious contaminants of marine coastal waters. Our data

suggest that their abundance is highest in habitats along the shoreline. Thorough examination of these compounds in environmental samples is an important task.

Surís-Regueiro, J.C., Garza-Gil, M.D., and Varela-Lafuente, M.M. **The *Prestige* oil spill and its economic impact on the Galician fishing sector.** *Disasters* 31(2): 201-215, 2007.

Notes: The sinking of the *Prestige* oil tanker on 18 November 2002 off the coast of Galicia, Spain, had important economic, environmental and social ramifcations. The aim of this paper is to carry out an initial analysis of the costs related to a halt in fishing activities in Galicia between November 2002 and December 2003. This involves three different steps: an assessment of the cost of the preventative and palliative measures introduced by Spanish public administrations (compensation for affected fishermen and shellfish fisherman); an indirect evaluation of the implications of the disaster (via a study of data on production); and a direct appraisal of the economic impact of the event (reduction in income), using questionnaires completed by a representative sample of fishermen and shellfish fisherman. The results obtained from these three methods of estimating losses are compatible. By December 2003, losses to the Galician fishing sector stood at an estimated EUR 76 million.

Arrhenius, Å., Backhaus, T., Grönvall, F., Junghans, M., Scholze, M., and Blanck, H. **Effects of three antifouling agents on algal communities and algal reproduction: Mixture toxicity studies with TBT, Irgarol, and Sea-Nine.** *Archives of Environmental Contamination and Toxicology* 50(3): 335-345, 2006.

Notes: The toxicity of three antifoulants (Sea-Nine, Irgarol, and TBT) was determined individually and in mixtures in two tests with microalgae. Effects on periphyton community photosynthesis and reproduction of the unicellular green algae *Scenedesmus vacuolatus* were investigated. The tested antifoulants were highly toxic in both tests. Observed mixture toxicities were compared with predictions derived from two concepts: Independent Action (IA), assumed to be more relevant for the tested mixtures that were composed of dissimilarly acting substances, and Concentration Addition (CA), regarded as a reasonable worst-case approach in predictive mixture hazard assessment. Despite the corresponding mechanistic basis, IA failed to provide accurate predictions of the observed mixture toxicities. Results show the same pattern in both assays. Mixture effects at high concentrations were slightly overestimated and effects at low concentrations were slightly underestimated. Maximum observed deviations between observed and IA-predicted concentrations amount to a factor of 4. The suggested worst-case approach using CA was protective only in effect regions above 20%. Nevertheless, the application of any concept that accounts for possible mixture effects is more realistic than the present chemical-by-chemical assessment.

Lin, B., Lin, C.-Y., and Jong, T.-C. **Investigation of strategies to improve the recycling effectiveness of waste oil from fishing vessels.** *Marine Policy* 31(4): 415-420, 2007.

Notes: The marine ecological environment and fishery resources can be severely polluted or destroyed by waste oil from fishing vessels if they are emitted directly into the ocean without any proper pre-treatment process. International conventions such as MARPOL 73/78 regulate waste-oil emissions and require the installation of a waste oil-water separator only for ocean-going ships of over 400 gross tons. Hence, these international conventions are not applicable to most fishing ships due to their low gross tonnages. In addition, space on most fishing vessels is too limited to allow waste-oil storage tanks or a waste oil-water separator to comply with international maritime regulations. Because a significant amount of waste oil is produced by fishing vessels around the world every day, effective strategies or measures are needed to prevent this waste oil from polluting the marine environment. This study thus investigates strategies and measures for improving the effectiveness of waste-oil collection from fishing vessels. This study found that existing procedures for the collection and treatment of waste lubricating oil on land could be applied to the management of waste oil and bilge water from fishing vessels. Sufficient oil-water separators and storage facilities for the collection of waste oil should be placed at each fishing port and shipyard. Fishermen should then be required to deliver their waste oil to these storage facilities, from where it can be transported to legal recycling companies for further treatment. In addition, fishing harbor authorities should bear definitive responsibility for monitoring the illegal dumping of waste oil and for checking the waste-oil record books of fishing vessels. Each maritime country should enforce relevant laws and regulations to reduce the emission of waste oil from fishing vessels into the ocean.

Pollock, M.S., Clarke, L.M.J., and Dubé, M.G. **The effects of hypoxia on fishes: from ecological relevance to physiological effects.** *Environmental Reviews* 15(1): 1-14, 2007.

Notes: Hypoxia is an ever increasing threat to aquatic systems. While fluctuating levels of dissolved oxygen (DO) can be a natural phenomenon, hypoxia caused by eutrophication and organic pollution is now considered to be amongst the most pressing and critical water pollution problems in the world, particularly in densely populated regions. The effects of low DO on fishes are an area of great concern and thriving study. Researchers have examined the effects of low DO on fishes from the cellular to community level. The purpose of the current paper is to review the effects of low DO on complex fish behaviour, community and fish physiology. Our review will also highlight studies in which DO is known to interact with a known contaminant. Throughout the paper we will highlight areas in need of future research such as chronic exposure, interactive effects of DO and contaminants, an increased understanding of how hypoxia affects communities of organisms, and finally a need for an increase in freshwater studies.

Donner, S.D. **Surf or turf: A shift from feed to food cultivation could reduce nutrient flux to the Gulf of Mexico.** *Global Environmental Change - Human and Policy Dimensions* 17(1): 105-113, 2007.

Notes: The extensive use of nitrogen fertilizer on the central U.S. croplands contributes to nitrogen loading by the Mississippi River and the development of seasonal hypoxia in the Gulf of Mexico. The majority of grains cultivated on central U.S. croplands are used as animal feed, rather than directly as human food. In this study, the IBIS-THMB nitrogen modeling system is used to demonstrate how a shift away from meat production from Mississippi Basin crops could reduce total land and fertilizer demands by over 50%, without any change in total production of human food protein. The change would return nitrate-nitrogen export by the Mississippi River to levels at which the Gulf of Mexico "dead zone" has been small or non-existent. An analysis of future land use scenarios and other mitigation proposals, including the construction of riparian wetlands, indicates that a reduced focus on beef production may need to be a part of nitrogen management policy in the Mississippi Basin.

Donner, S.D. and Scavia, D. **How climate controls the flux of nitrogen by the Mississippi River and the development of hypoxia in the Gulf of Mexico.** *Limnology and Oceanography* 52(2): 856-861, 2007.

Notes: The intensification of agriculture in the central U.S. is commonly cited as the primary cause of the increase in nitrogen (N) flux by the Mississippi River since the 1950s and the development of seasonal bottom-water hypoxia in the northern Gulf of Mexico. Over the past two decades, however, agricultural land use and land cover have remained relatively constant. With high N inputs each year, climate variability could now be controlling the variability in N leaching from land and transport through the river system. In this study, we examine how precipitation in specific regions of the central U.S. affects the nitrate-N flux by the Mississippi River and the extent of hypoxia in the Gulf of Mexico. Precipitation amounts across the Corn Belt in the previous November-December and in March-April-May are together a strong predictor ($r^2 = 0.68$) of the spring nitrate flux by the Mississippi. A hypoxia model shows that the year-to-year variability in central U.S. climate must be considered in developing nutrient management policy. During a wet year, an N reduction of 50-60% -- close to twice the recommended target -- is required to meet the goal of reducing the hypoxia zone to less than 5,000 km^2 in size. A higher reduction goal is particularly important considering the expected changes in climate in the coming decades.

Burkholder, J., Libra, B., Weyer, P., Heathcote, S., Kolpin, D., Thorne, P.S., and Wichman, M. **Impacts of waste from concentrated animal feeding operations on water quality.** *Environmental Health Perspectives* 115(2): 308-312, 2007.

Notes: Waste from agricultural livestock operations has been a long-standing concern with respect to contamination of water resources, particularly in terms of nutrient pollution. However, the recent growth of concentrated animal feeding operations (CAFOs) presents a greater risk to water quality because of both the increased volume of waste and to contaminants that may be present (e.g., antibiotics and other veterinary drugs) that may have both environmental and public health importance. Based on available data, generally accepted livestock waste management practices do not adequately or effectively protect water resources from contamination with excessive nutrients, microbial pathogens, and pharmaceuticals present in the waste.

Impacts on surface water sources and wildlife have been documented in many agricultural areas in the United States. Potential impacts on human and environmental health from long-term inadvertent exposure to water contaminated with pharmaceuticals and other compounds are a growing public concern. This work-group, which is part of the Conference on Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards - Searching for Solutions, identified needs for rigorous ecosystem monitoring in the vicinity of CAFOs and for improved characterization of major toxicants affecting the environment and human health. Last, there is a need to promote and enforce best practices to minimize inputs of nutrients and toxicants from CAFOs into freshwater and marine ecosystems.

Inoue, S., Oshima, Y., Usuki, H., Hamaguchi, M., Hanamura, Y., Kai, N., Shimasaki, Y., and Honjo, T. **Effect of tributyltin on veliger larvae of the Manila clam, *Ruditapes philippinarum*.** *Chemosphere* 66(7): 1353-1357, 2007.

Notes: We investigated the effects of waterborne and maternal exposure to tributyltin (TBT) on veliger larvae of the Manila clam, *Ruditapes philippinarum*. In a waterborne exposure test, veliger larvae (D-larvae stage: 24 h after fertilization) were exposed to TBT at measured concentrations of < 0.01 (control), 0.055, 0.130, 0.340, and 0.600 μg/l for 13 d. The percentage of normal veliger larvae (the ratio of normal veliger larvae to all larvae) decreased significantly in all TBT treatment groups compared with that in the control group. In a maternal exposure test, 100 clams were exposed to TBT at measured concentrations of < 0.01 (control), 0.061, and 0.310 μg/l at 20-22ºC for 3 weeks, and the percentage of normal veliger larvae assessed for 13 d. No maternal effects on veliger larvae from TBT were observed in TBT treatment groups as compared with the control group. These results demonstrate that waterborne TBT affects Manila clam veliger larvae, and indicates that TBT may have reduced Manila clam populations by preventing the development and survival of veliger larvae.

Francioni, E., Wagener, A.D., Scofield, A.D., Depledge, M.H., Cavalier, B., Sette, C.B., Carvalhosa, L., Lozinsky, C., and Mariath, R. **Polycyclic aromatic hydrocarbon in inter-tidal mussel *Perna perna*: Space-time observations, source investigation and genotoxicity.** *The Science of the Total Environment* 372(2-3): 515-531, 2007.

Notes: The investigation aimed primarily at understanding the PAH record in inter-tidal mussel tissues and evaluating the bivalve performance as a bioindicator for oil contamination. The species *Perna perna* was used as test organism since it is abundantly distributed in coastal areas of the Americas, Africa and elsewhere. The study was carried out in Guanabara Bay and comprised two observation phases: phase one included seasonal sampling in 8 sites, whereas in phase two 4 sites were examined over 4 years. Among the 35 determined PAH (60-90 μg kg^{-1} up to 4000-6000 μg kg^{-1}) alkylated homologues predominated by more than 80%. The PAH profile in inter-tidal mussels is largely petrogenic with high contribution of dibenzothiophenes (DBT) and phenanthrenes (Ph). The prevailing petrogenic fingerprint, confirmed by diagnostic ratios, is linked to the properties of the intertidal habitat, which favors exposure to oil films. C2DBT/C2Ph and C3DBT/C3Ph ratios, however, show a wide range of values uncorrelated to specific oils. Micronucleus frequencies are significantly related to PAH concentrations, especially to those of alkylated homologues. Genotoxic expression appears at concentrations as low as 300 μg kg^{-1} S35 PAH.

Johnson, L.L., Ylitalo, G.M., Sloan, C.A., Anulacion, B.F., Kagley, A.N., Arkoosh, M.R., Lundrigan, T.A., Larson, K., Siipola, M., and Collier, T.K. **Persistent organic pollutants in outmigrant juvenile chinook salmon from the Lower Columbia Estuary, USA.** *The Science of the Total Environment* 374(2-3): 342-366, 2007.

Notes: Although chemical contaminants are recognized as a potential factor contributing to the salmon declines in the Pacific Northwest, United States, information on contaminant concentrations in threatened and endangered salmon from the Columbia Estuary is limited. In this study we monitored exposure to several persistent organic pollutants [polycyclic aromatic hydrocarbons (PAHs), polychlorinated bipheryls (PCBs), dichlorodiphenyltrichloroethanes (DDTs) and other organochlorine pesticides] in outmigrant juvenile fall chinook salmon (*Oncorhynchus tschawytscha*) in the Lower Columbia River, and evaluated the potential for adverse effects on salmon and the estuarine food web. Contaminants were measured in whole bodies and stomach contents of subyearling to yearling chinook collected in 2001 and 2002 from sites near the confluence of the Columbia and Willamette Rivers, Longview, and within the lower Estuary. The contaminants detected at highest concentrations in salmon whole bodies were PCBs and DDTs. Average concentrations of PCBs in salmon from the sampling sites ranged from 1300 to 14,000 ng/g lipid, in some cases exceeding the recently estimated threshold for adverse health

effects in juvenile salmonids of 2400 ng/g lipid. Average DDT concentrations ranged from 1800 to 27,000 ng/g lipid. These levels are among the highest measured in juvenile salmon from Pacific Northwest estuaries to date. Concentrations of PCBs and DDTs in salmon whole bodies showed no clear spatial gradient from the Willamette/Columbia Confluence to the mouth of the Columbia, but tended to be higher in larger fish and older fish, suggesting a correlation with estuarine residence time. PCBs, DDTs, and PAHs were all found in salmon stomach contents, indicating that prey is a source of exposure. Hatchery feed may have contributed to contaminant body burdens in those fish that were of hatchery origin. Contaminant body burdens in salmon were poorly correlated with contaminant concentrations previously measured in local bed sediments, suggesting that pelagic as well as benthic sources are important in determining salmon exposure.

Labenia, J.S., Baldwin, D.H., French, B.L., Davis, J.W., and Scholz, N.L. **Behavioral impairment and increased predation mortality in cutthroat trout exposed to carbaryl.** *Marine Ecology Progress Series* 329: 1-11, 2006.

Notes: Willapa Bay is a coastal estuary in Washington State that provides seasonal rearing habitat for anadromous cutthroat trout *Oncorhynchus clarki clarki*. Cutthroat trout forage throughout the estuary in the summer months when carbaryl, a carbamate insecticide, is applied to oyster beds via aerial spraying and other application methods to control burrowing shrimp populations. The insecticide interferes with normal nervous system function in trout via the inhibition of acetylcholinesterase, an enzyme that regulates neurotransmitter-mediated signaling at synapses. In the present study, we show that the olfactory system of trout is unresponsive to carbaryl, and that trout do not avoid seawater containing the pesticide at environmentally representative concentrations. Short-term (6 h) carbaryl exposures significantly reduced acetylcholinesterase activity in both brain and muscle in a dose-dependent manner. Enzyme activity gradually recovered over 42 h following carbaryl exposure (6 h at 500 $\mu g\ l^{-1}$). In tests of swimming performance, trout were unable to orient to directional flow and swim effectively at exposure concentrations $\geq$ 750 $\mu g\ l^{-1}$. Finally, we determined rates of predation by lingcod *Ophiodon elongatus* on carbaryl-exposed and unexposed trout. Exposed animals were consumed by predators at significantly higher rates at concentrations $\geq$ 500 $\mu g\ l^{-1}$. We conclude that cutthroat trout are unlikely to avoid carbaryl-contaminated seawater, and that estuarine applications are likely to cause neurobehavioral impairments in trout that may increase individual mortality due to predation.

Markey, K.L., Baird, A. H., Humphrey, C., and Negri, A.P. **Insecticides and a fungicide affect multiple coral life stages.** *Marine Ecology Progress Series* 330: 127-137, 2007.

Notes: Coral reefs are under threat from land-based agricultural pollutants on a global scale. The vulnerability of early life stages of corals is of particular concern. Here, we compared the sensitivity of gametes, larvae and adult branches of the broadcast-spawning coral *Acropora millepora* (Ehrenberg) to a number of common pollutants, including 4 classes of insecticides -- 2 organophosphates (chlorpyrifos, profenofos), an organochlorine (endosulfan), a carbamate (carbaryl) and a pyrethroid (permethrin) -- and a fungicide (2-methoxyethylmercuric chloride, MEMC). Fertilisation of gametes was not affected by any of the insecticides at concentrations up to 30 $\mu g\ l^{-1}$. In contrast, settlement and metamorphosis were reduced by between 50 and 100% following 18 h exposure to very low concentrations (0.3 to 1.0 $\mu g\ l^{-1}$) of each insecticide class. The insecticides had few visible effects on adult branches following 96 h exposure to a concentration of 10 $\mu g\ l^{-1}$, with the exception of profenofos, which caused polyp retraction, bleaching (i.e. algal symbiont densities were reduced) and a slight reduction in photosynthetic efficiency of the algal symbionts. The fungicide MEMC affected all life-history stages: both fertilisation and metamorphosis were inhibited at 1.0 $\mu g\ l^{-1}$, and polyps became withdrawn and photosynthetic efficiency was slightly reduced at 1.0 $\mu g\ l^{-1}$. At 10 $\mu g\ l^{-1}$ MEMC, branches bleached and some host tissue died. This high susceptibility of coral larvae to pesticides at concentrations around their detection limit highlights the critical need to assess toxicity against all life-history stages of keystone organisms: to focus on mature individuals may underestimate species sensitivity.

Riget, F., Dietz, R., Born, E.W., Sonne, C., and Hobson, K.A. **Temporal trends of mercury in marine biota of west and northwest Greenland.** *Marine Pollution Bulletin* 54(1): 72-80, 2007.

Notes: Temporal trends in mercury concentrations ([Hg]) during the last two to three decades were determined in liver of shorthorn sculpin, ringed seal and Atlantic walrus from northwest Greenland (NWG, 77°N) and in liver of shorthorn sculpin and ringed seal from central west Greenland (CWG, 69°N) during the last decade. Stable-nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) isotope values were determined in muscle of ringed seals to provide insight into potential trophic level changes through time.

Log-linear regressions on annual median [Hg] did not reveal any temporal trend in shorthorn sculpin from CWG and NWG and walrus from NWG. In ringed seals from NWG, an increase in [Hg] of 7.8% per year was observed. When based on $\delta^{15}N$-adjusted [Hg] this rate increased to 8.5% but was still non-significant. In ringed seal from CWG no trend was found in [Hg] during the period 1994-2004. However, during the last part of the period (1999-2004) the [Hg] increased significantly. Including tissue $\delta^{15}N$ values as a covariate had a marked effect on these results. The annual changes in $\delta^{15}N$-adjusted [Hg] was estimated to -5.0% for the whole period and 2.2% during the last 5 years compared to -1.3% and 12.4%, respectively, for the non-adjusted [Hg].

Carpenter, A. **The Bonn Agreement Aerial Surveillance programme: Trends in North Sea oil pollution 1986-2004.** *Marine Pollution Bulletin* 54(2): 149-163, 2007.

Notes: This paper examines the use of aerial surveillance activities conducted in the North Sea region of Europe since 1986 to assess trends in levels of oil inputs into the marine environment, both across the whole region and within the waters of the different coastal states. It makes use of data collected under the aegis of the 1969 Bonn Agreement through its Annual Reports on Aerial Surveillance and examines developments in surveillance methods and technology which have led to improvements in the detection of oil spills, even during the hours of darkness. The paper then examines country specific data for the eight North Sea contracting parties to the Agreement to assess trends in oil spills in the region.

Tollefsen, K.E., Harman, C., Smith, A., and Thomas, K.V. **Estrogen receptor (ER) agonists and androgen receptor (AR) antagonists in effluents from Norwegian North Sea oil production platforms.** *Marine Pollution Bulletin* 54(3): 277-283, 2007.

Notes: The in vitro estrogen receptor (ER) agonist and androgen receptor (AR) antagonist potencies of offshore produced water effluents collected from the Norwegian Sector were determined using recombinant yeast estrogen and androgen screens. Solid phase extraction (SPE) concentrates of the effluents showed E2 agonist activities similar to those previously reported for the United Kingdom (UK) Continental Shelf (< 0.1-4 ng E2 L^{-1}). No activity was detected in the filtered oil droplets suggesting that produced water ER activity is primarily associated with the dissolved phase. Targeted analysis for methyl- to nonyl-substituted alkylphenol isomers show the occurrence of known ER agonists in the analysed samples. For the first time, AR antagonists were detected in both the dissolved and oil associated phase at concentrations of between 20 and 8000 μg of flutamide equivalents L^{-1}. The identity of the AR antagonists is unknown, however this represents a significant input into the marine environment of unknown compounds that exert a known biological effect. It is recommended that further analysis using techniques such as bioassay-directed analysis is performed to identify the compounds/ groups of compounds that are responsible in order to improve the assessment of the risk posed by produced water discharges to the marine environment.

Oehlmann, J., Di Benedetto, P., Tillmann, M., Duft, M., Oetken, M., and Schulte-Oehlmann, U. **Endocrine disruption in prosobranch molluscs: evidence and ecological relevance.** *Ecotoxicology* 16(1): 29-43, 2007.

Notes: Prosobranch snails represent almost 50% of all recent molluscs, are ubiquitously distributed, play important roles in various ecosystems and exhibit a variety of reproductive modes and life-cycle-strategies. Many of them attain life spans of several years, which in combination with their limited ability to metabolize organic chemicals, may contribute to the fact that prosobranchs constitute one of the most endangered taxonomic groups in aquatic ecosystems. Although it is not yet known to what extent endocrine disrupting chemicals (EDCs) contribute to this situation, the case of tributyltin (TBT) and its population-level impact on prosobranchs demonstrates the general susceptibility of these invertebrates. The existing evidence for comparable population-level effects in prosobranch snails by other androgens, antiandrogens, and estrogens is critically reviewed. The example of TBT demonstrates the difficulty to prove an endocrine mode of action for a given chemical. Although it is generally accepted that TBT causes imposex and intersex in prosobranch snails as a result of endocrine disruption, the detailed biochemical mechanism is still a matter of debate. The strengths and weaknesses of the five competing hypotheses are discussed, together with previously unpublished data. Finally, the ecological relevance of EDC effects on the population and community level and the application of prosobranchs for the assessment of EDCs are addressed.

Sugni, M., Mozzi, D., Barbaglio, A., Bonasoro, F., and Carnevali, M.D.C. **Endocrine disrupting compounds and echinoderms: new ecotoxicological sentinels for the marine ecosystem.** *Ecotoxicology* 16(1): 95-108, 2007.

Notes: Echinoderms are valuable test species in marine ecotoxicology and offer a wide range of biological processes appropriate for this approach. In spite of this potential, available data in literature are still rather limited, particularly with regard to the possible effects of endocrine disrupter compounds (EDCs). This review presents echinoderms as useful models for ecotoxicological tests and gives a brief overview of the most significant results obtained in recent years, particularly in the context of the COMPRENDO EU project. In this research project two different aspects of echinoderm physiology, plausibly regulated by humoral mechanisms, were investigated: reproductive biology and regenerative development. Selected EDCs suspected for their androgenic or antiandrogenic action were tested at low concentrations. The results obtained so far showed that different parameters such as regenerative growth, histological pattern, egg diameter and gonad maturation were affected by the exposure to the selected compounds. These results substantiate that reproductive and regenerative phenomena of echinoderms can be considered valuable alternative models for studies on EDCs and confirm that these compounds interfere with fundamental physiological processes, including growth, development and reproductive competence.

LeBlanc, G.A. **Crustacean endocrine toxicology: a review.** *Ecotoxicology* 16(1): 61-81, 2007.

Notes: Crustaceans are major constituents to aquatic ecosystems that provide a variety of ecological and economic services. Individual crustacean species are adept at occupying diverse niches and their success, in part, stems from neuro-endocrine signaling cascades that regulate physiology in response to environmental and internal cues. Peptide hormones are major signal transducers in crustaceans. The crustacean hyperglycemic hormone family of peptides regulates various aspects of growth, reproduction, and metabolism. These peptides may function as the terminal hormone to regulate some physiological activities or may function as intermediates in a signaling cascade. Ecdysteroids and terpenoids are two major classes of terminal signaling molecules in these cascades. Hormones from these two classes function independently or in concert to regulate various processes. Ecdysteroid signaling is subject to toxicological disruption through disturbances in ecdysteroid synthesis or binding of toxicants to the ecdysteroid receptor. Methyl farnesoate is the major terpenoid hormone of crustaceans and also is susceptible to disruption by environmental chemicals. However, the methyl farnesoate signaling pathway is poorly understood and only limited mechanistic confirmation for disruption of this endocrine signaling pathway exists. Disruption of the ecdysteroid/terpenoid signaling pathways in crustaceans has been associated with aberrations in growth, metamorphosis, reproductive maturation, sex determination, and sex differentiation. Population studies have revealed disruptions in crustacean growth, molting, sexual development, and recruitment that are indicative of environmental endocrine disruption. However, environmental factors other than pollution (i.e., temperature, parasitism) also can elicit these effects and definitive causal relationships between endocrine disruption in field populations of crustaceans and chemical pollution is generally lacking.

Short, J.W., Irvine, G.V., Mann, D.H., Maselko, J.M., Pella, J.J., Lindeberg, M.R., Payne, J.R., Driskell, W.B., and Rice, S.D. **Slightly weathered Exxon Valdez oil persists in Gulf of Alaska beach sediments after 16 years.** *Environmental Science and Technology* 41(4): 1245-1250, 2007.

Notes: Oil stranded by the 1989 Exxon Valdez spill has persisted in subsurface sediments of exposed shores for 16 years. With annualized loss rates declining from ~ 68% yr(-1) prior to 1992 to similar to 4% yr(-1) after 2001, weathering processes are retarded in both sediments and residual emulsified oil ("oil mousse"), and retention of toxic polycyclic aromatic hydrocarbons is prolonged. The *n*-alkanes, typically very readily oxidized by microbes, instead remain abundant in many stranded emulsified oil samples from the Gulf of Alaska. They are less abundant in Prince William Sound samples, where stranded oil was less viscous. Our results indicate that, at some locations, remaining subsurface oil may persist for decades with little change.

Poulain, A.J., Garcia, E., Amyot, M., Campbell, P.G.C., Raofie, F., and Ariya, P.A. **Biological and chemical redox transformations of mercury in fresh and salt waters of the high arctic during spring and summer.** *Environmental Science and Technology* 41(6): 1883-1888, 2007.

Notes: It is well-established that atmospheric deposition transports Hg to Arctic regions, but the postdepositional dynamics of Hg that can alter its impact on Arctic food chains are less understood. Through a series of in situ experiments, we investigated the redox transformations of Hg in coastal and inland aquatic systems. During spring and summer, Hg reduction in streams and pond waters decreased across a 4-fold increase in salinity. This alteration of Hg reduction due to chloride was counterbalanced by the presence of particles, which favored the conversion of oxidized Hg to its elemental form. In saline waters, biogenic organic materials, produced by algae, were able to promote oxidation of Hg(0) even under dark conditions. Overall these results point to the vulnerability of marine/coastal Arctic systems to Hg, compared to inland systems, with oxidation processes enhancing Hg residence times and thus increasing its potential to enter the food chain.

Nakata, H., Sasaki, H., Takemura, A., Yoshioka, M., Tanabe, S., and Kannan, K. **Bioaccumulation, temporal trend, and geographical distribution of synthetic musks in the marine environment.** *Environmental Science and Technology* 41(7): 2216-2222, 2007.

Notes: Bioaccumulation of synthetic musks in a marine food chain was investigated by analyzing marine organisms at various trophic levels, including lugworm, clam, crustacean, fish, marine mammal, and bird samples collected from tidal flat and shallow water areas of the Ariake Sea, Japan. Two of the polycyclic musks, HHCB and AHTN, were the dominant compounds found in most of the samples analyzed, whereas nitro musks were not detected in any of the organisms, suggesting greater usage of polycyclic musks relative to the nitro musks in Japan. The highest concentrations of HHCB were detected in clams (258-2730 ng/g lipid wt.), whereas HHCB concentrations in mallard and black-headed gull were low, and comparable with concentrations in fish and crab. These results are in contrast to the bioaccumulation pattern of polychlorinated biphenyls for which a positive correlation between the concentration and the trophic status of organisms was found. Such a difference in the bioaccumulation is probably due to the metabolism and elimination of HHCB in higher trophic organisms. Temporal trends in concentrations of synthetic musks were examined by analyzing tissues of marine mammals from Japanese coastal waters collected during 1977-2005. HHCB concentrations in marine mammals have shown significant increase since the early 1990s, suggesting a continuous input of this compound into the marine environment. Comparison of the time trend for HHCB with those for PCBs and PBDEs suggested that the rates of increase in HHCB concentrations were higher than the other classes of pollutants. To examine the geographical distribution of HHCB, we have analyzed tissues of fish, marine mammals, and birds collected from several locations. Synthetic musks were not detected in a sperm whale (pelagic species) from Japanese coastal water and in eggs of south polar skua from Antarctica. While the number of samples analyzed is limited, these results imply a lack of long-range transportation potential of synthetic musks in the environment.

Alvarez, M.D., Murphy, C.A., Rose, K.A., McCarthy, I.D., and Fuiman, L.A. **Maternal body burdens of methylmercury impair survival skills of offspring in Atlantic croaker (*Micropogonias undulatus*).** *Aquatic Toxicology* 80(4): 329-337, 2006.

Notes: Methylmercury (MeHg), the organic form of mercury, bioaccumulates easily through the food chain. Fish in high trophic levels can accumulate substantial levels of MeHg and transfer it to their developing eggs. Here, the effects of maternally derived MeHg on the planktonic larval stage of Atlantic croaker were investigated. Adult Atlantic croaker were fed MeHg-contaminated food at three levels: 0, 0.05, and 0.1 mg kg^{-1} day^{-1} for 1 month. Fish were then induced to spawn and MeHg levels in the eggs were measured (0.04-4.6 ng g^{-1}). Behavioral performance of exposed and control larvae was measured at four developmental stages: end of yolk absorption (yolk), end of oil absorption (oil), and 4 and 11 days after oil absorption (oil + 4 and oil + 11). Behaviors analyzed included survival skills related to foraging and predator evasion: routine behavior (rate of travel, active swimming speed, net-to-gross displacement ratio, and activity) and startle response to a visual and a vibratory stimulus (responsiveness, reactive distance, response distance, response duration, average response speed, and maximum response speed). Maternally transferred MeHg induced concentration-dependent effects on survival skills. Statistical and simulation models applied to predict the ecological consequences of the behavioral effects suggested that maternal transfer of MeHg may substantially lower survival of planktonic stage larvae compared to unexposed larvae. These results also imply that larvae of top predatory fish species, such as blue marlin, may suffer mortality through maternal transfer of MeHg.

Cebrian, E. and Uriz, M.J. **Contrasting effects of heavy metals and hydrocarbons on larval settlement and juvenile survival in sponges.** *Aquatic Toxicology* 81(2): 137-143, 2007.

Notes: Metals and polycyclic aromatic hydrocarbons (PAHs) contaminate sediments and waters of coastal areas threatening early stages of invertebrate development. Effects on these stages may largely determine the decline and even disappearance of invertebrate populations in polluted environments. Our study aimed to determine the possible influence of metals (Cu and Cd) and PAHs on larval settlement and consecutive survival of two widespread sponges of the Mediterranean: *Crambe crambe* and *Scopalina lophyropoda*. Larvae of both species were exposed to Cu and Cd for a short period during 1 week, and settlement and following (6 months) survival of juvenile were monitored. Short exposures to copper and cadmium at the concentrations used did not affect *C. crambe* settlement compared with SW control, and no effect on consecutive survival of juveniles was observed. In contrast, short pulses of copper and cadmium at the concentrations used enhanced *Scopalina lophyropoda* settlement and did not affect the consecutive survival of juveniles with respect to SW controls. Furthermore, experiments designed to assess the effects of short exposures to PAHs and the combined effect of contamination by Cu2+ and PAHs on larval settlement, were conduced during 10 days on *C. crambe* larvae. Hydrocarbons, differently than copper and cadmium, inhibited the settlement of sponge larvae to a certain extent. The synergetic negative effect of copper and hydrocarbons on *C. crambe* settlers may cause a decline of populations in areas with both sources of contamination. The present study provides the only available data on toxicity of copper, cadmium and hydrocarbon toxicants on sponge larval settlement.

Meier, S., Andersen, T.E., Norberg, B., Thorsen, A., Taranger, G.L., Kjesbu, O.S., Dale, R., Morton, H.C., Klungsoyr, J., and Svardal, A. **Effects of alkylphenols on the reproductive system of Atlantic cod (*Gadus morhua*).** *Aquatic Toxicology* 81(2): 207-218, 2007.

Notes: Produced water, a by-product of offshore oil production, contains significant amounts of alkylhenols (APs). Many studies have shown that APs cause endocrine disruption in marine organisms, but relatively little is currently known about their long-term effects on the biology of pelagic fish. Here, we describe in detail the effects of APs on the reproductive potential of first-time spawning Atlantic cod (*Gadus morhua*). Cod were fed with feed paste containing four APs (4-tert-butylphenol, 4-n-pentylphenol, 4-n-hexylphenol and 4-n-heptylphenol), at a range of concentrations, for either 1 or 5 weeks. AP-exposed fish were compared to unexposed fish and to fish fed paste containing natural estrogen (17 ß-estradiol). Our results showed that in female fish AP exposure impaired oocyte development, with an increase in the amount of spermatogonia and a reduction in the amount of spermatozoa present. Taken together these results suggest that APs released into the sea via produced water may have a negative influence on the overall reproductive fitness of cod populations.

Lerner, D.T., Bjornsson, B.T., and McCormick, S.D. **Effects of aqueous exposure to polychlorinated biphenyls (Aroclor 1254) on physiology and behavior of smolt development of Atlantic salmon.** *Aquatic Toxicology* 81(3): 329-336, 2007.

Notes: Polychlorinated biphenyls (PCBs) area widespread aquatic contaminant and are present in both wild and hatchery raised Atlantic salmon, *Salmo salar*. The possible sub-lethal alterations in smolt physiology and behavior due to PCB exposure of salmon have not been widely examined. In this study, we examined the effects of the PCB mixture Aroclor 1254 on survival and smolt development of Atlantic salmon. In separate experiments, fish were exposed as yolk-sac larvae of as juveniles just prior to the parr-smolt transformation in April to 1 $\mu g\ l^{-1}$ (PCB-1) or 10 $\mu g\ l^{-1}$ (PCB-10) aqueous Aroclor 1254 (A1254), or vehicle for 21 days. After exposure, yolk-sac larvae were reared at ambient conditions for 1 year, until the peak of smolting the following May. Juveniles were sampled immediately after exposure. Both groups were assessed for behavioral, osmoregulatory, and endocrine disruption of smolt development at the peak of smolting. PCB-1 and PCB-10 treated yolk-sac larvae exhibited significant increases in the rate of opercular movement after 14 and 21 days of exposure. At the peak of smolting, prior exposure as yolk-sac larvae to PCB-1 did not affect behavior, while PCB-10 dramatically decreased volitional preference for seawater. Neither concentration of A1254 had long-term effects on the osmoregulatory or endocrine parameters measured in animals exposed as yolk-sac larvae. Juvenile fish exposed to PCB-1 or PCB-10 during smolting exhibited a dose-dependent reduction in preference for seawater. Fish treated with the higher dose of A1254 also exhibited a 50% decrease in gill Na+,K+-ATPase activity and a 10% decrease in plasma chloride levels in freshwater. In addition, plasma triihodothyronine was reduced 35-50% and plasma cortisol 58% in response to exposure to either concentration: whereas plasma thyroxine, growth hormone, and insulin-like growth factor I levels were unaffected. These results indicate that the effects of exposure to A1254 may vary according to developmental stage. Exposure to A1254 in the freshwater environment can inhibit preparatory adaptations that occur during smolting, thereby reducing marine survival and sustainability of salmon populations.