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Marine Science Review – 246

Pollution

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In this review:

O/A denotes an open access article or journal

A. Recent articles – no abstract available

Iqbal, J., Portier, R.J., and Gisclair, D. **Aspects of petrochemical pollution in coastal Louisiana, USA.** *Marine Pollution Bulletin* 54(6): 792-797, 2007.

B. Recent articles with abstracts

Collado-Vides, L., Caccia, V.G., Boyer, J.N., and Fourqurean, J.W. **Tropical seagrass-associated macroalgae distributions and trends relative to water quality.** *Estuarine, Coastal and Shelf Science* 73(3-4): 680-694, 2007.

Notes: Tropical coastal marine ecosystems including mangroves, seagrass beds and coral reef communities are undergoing intense degradation in response to natural and human disturbances, therefore, understanding the causes and mechanisms present challenges for scientist and managers. In order to protect our marine resources, determining the effects of nutrient loads on these coastal systems has become a key management goal. Data from monitoring programs were used to detect trends of macroalgae abundances and develop correlations with nutrient availability, as well as forecast potential responses of the communities monitored. Using eight years of data (1996-2003) from complementary but independent monitoring programs in seagrass beds and water quality of the Florida Keys National Marine Sanctuary (FKNMS), we: (1) described the distribution and abundance of macroalgae groups; (2) analyzed the status and spatiotemporal trends of macroalgae groups; and (3) explored the connection between water quality and the macroalgae distribution in the FKNMS. In the seagrass beds of the FKNMS calcareous green algae were the dominant macroalgae group followed by the red group; brown and calcareous red algae were present but in lower abundance. Spatiotemporal patterns of the macroalgae groups were analyzed with a non-linear regression model of the abundance data. For the period of record, all macroalgae groups increased in abundance (Ab_i) at most sites, with calcareous green algae increasing the most. Calcareous green algae and red algae exhibited seasonal pattern with peak abundances (Φ_i) mainly in summer for calcareous green and mainly in winter for red. Macroalgae Ab_i and long-term trend (m_i) were correlated in a distinctive way with water quality parameters. Both the Ab_i and m_i of calcareous green algae had positive correlations with NO_3^-, NO_2^-, total nitrogen (TN) and total organic carbon (TOC). Red algae Ab_i had a positive correlation with NO_2^-, TN, total phosphorus and TOC, and the m_i in red algae was positively correlated with N:P. In contrast brown and calcareous red algae Ab_i had negative correlations with N:P. These results suggest that calcareous green algae and red algae are responding mainly to increases in N availability, a process that is happening in inshore sites. A combination of spatially variable factors such as local current patterns, nutrient sources, and habitat characteristics result in a complex array of the macroalgae community in the seagrass beds of the FKNMS.

Martinez-Ribes, L., Basterretxea, G., Palmer, M., and Tintore, J. **Origin and abundance of beach debris in the Balearic Islands.** *Scientia Marina* 71(2): 305-314, 2007. **O/A**

Notes: The abundance, nature and possible sources of litter on 32 beaches on the Balearic Islands (Mediterranean Sea) were investigated in 2005. Mean summer abundances in the Balearics reached approximately 36 items m^{-1}, with a corresponding weight of 32±25 g m^{-1}, which is comparable to the results of other studies in the Mediterranean. Multivariate analyses (principal component analysis and redundancy analysis) confirmed strong similarities between islands and a statistically significant seasonal evolution of litter composition and abundance. In summer (the high tourist season), debris contamination expressed as item abundance was double that in the low season and showed a heterogeneous nature associated with beach use. Cigarette butts were the most abundant item, accounting for up to 46% of the objects observed in the high tourist season. In contrast, plastics related to personal hygiene/medical items were predominant in wintertime (67%) and natural wood was the most important debris by weight (75%). In both seasons, litter characteristics suggested a strong relationship with local land-based origins. While beach users were the main source of summer debris, low tourist season litter was primarily attributed to drainage and outfall systems.

Kelly, B.C., Ikonomou, M.G., Blair, J.D., Morin, A.E., and Gobas, F.A.P.C. **Food web-specific biomagnification of persistent organic pollutants.** *Science* 317(5835): 236-239, 2007.

Notes: Substances that accumulate to hazardous levels in living organisms pose environmental and human-health risks, which governments seek to reduce or eliminate. Regulatory authorities identify bioaccumulative substances as hydrophobic, fat-soluble chemicals having high octanol- water partition coefficients (K_{OW}) (≥ 100,000). Here we show that poorly metabolizable, moderately hydrophobic substances with a K_{OW} between 100 and 100,000, which do not biomagnify (that is, increase in chemical concentration in organisms with increasing trophic level) in aquatic food webs, can biomagnify to a high degree in food webs containing air-breathing animals (including humans) because of their high octanol-air partition coefficient (K_{OA}) and corresponding low rate of respiratory elimination to air. These low K_{OW} - high K_{OA} chemicals, representing a third of organic chemicals in commercial use, constitute an unidentified class of potentially bioaccumulative substances that require regulatory assessment to prevent possible ecosystem and human-health consequences

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Fulweiler, R.W., Nixon, S.W., Buckley, B.A., and Granger, S.L. **Reversal of the net dinitrogen gas flux in coastal marine sediments.** *Nature* 448(7150): 180-182, 2007.

Notes: The flux of nitrogen from land and atmosphere to estuaries and the coastal ocean has increased substantially in recent decades. The observed increase in nitrogen loading is caused by population growth, urbanization, expanding water and sewer infrastructure, fossil fuel combustion and synthetic fertilizer consumption. Most of the nitrogen is removed by denitrification in the sediments of estuaries and the continental shelf, leading to a reduction in both cultural eutrophication and nitrogen pollution of the open ocean. Nitrogen fixation, however, is thought to be a negligible process in sub-tidal heterotrophic marine systems. Here we report sediment core data from Narragansett Bay, USA, which demonstrate that heterotrophic marine sediments can switch from being a net sink to being a net source of nitrogen. Mesocosm and core incubation experiments, together with a historic data set of mean annual chlorophyll production, support the idea that a climate-induced decrease in primary production has led to a decrease in organic matter deposition to the benthos and the observed reversal of the net sediment nitrogen flux. Our results suggest that some estuaries may no longer remove nitrogen from the water column. Instead, nitrogen could be exported to the continental shelf and the open ocean and could shift the effect of anthropogenic nitrogen loading beyond the immediate coastal zone.

Lurling, M. and Scheffer, M. **Info-disruption: pollution and the transfer of chemical information between organisms.** *Trends in Ecology and Evolution* 22(7): 374-379, 2007.

Notes: Many organisms use subtle chemical cues not only to find partners and food, but also to sense the presence of natural enemies and to avoid predation. As we discuss here, an increasing number of studies now show that low, non-toxic concentrations of chemicals, ranging from heavy metals and pesticides to seemingly harmless substances such as surfactants, can disrupt the transfer of chemical information, inducing maladaptive responses in both the signaller and the receiver. Similar

to endocrine disruptors, these 'info disruptors' form a new class of chemical threats, which could have far-reaching implications for ecosystem functioning and conservation management.

Robinson, C.D., Brown, E., Craft, J.A., Davies, I.M., Megginson, C., Miller, C., and Moffat, C.F. **Bioindicators and reproductive effects of prolonged 17 β-oestradiol exposure in a marine fish, the sand goby (*Pomatoschistus minutus*).** *Aquatic Toxicology* 81(4): 397-408, 2007.

Notes: The effects of 17 β-oestradiol (E2) on mortality, growth rates, sexual maturation, hepatic vitellogenin (VTG) mRNA expression and reproductive success were investigated during an 8-month, water-borne exposure of a marine fish, the sand goby (*Poinatoschistus minutus*). Indicators of oestrogenic exposure were investigated as predictors of population-level reproductive success. E2 exposure concentrations were < 5 (below limit of detection), 16 ± 3, 97 ± 20 and 669 ± 151 ng l^{-1} (bootstrap means and standard errors). The carrier solvent (< 20 μl^{-1} propan-2-ol) significantly reduced the rate of egg production compared to untreated fish, but did not significantly affect male VTG mRNA expression, brood size, or the other studied parameters. Fish exposed to 16 ng l^{-1} E2 showed few adverse effects compared with solvent only-exposed fish. Exposure to 97 ng l^{-1} E2 significantly inhibited male sexual maturation, induced male VTG mRNA expression and delayed spawning. The 97 ng l^{-1} E2 exposed population also produced fertile eggs at a significantly slower rate than solvent controls; however, brood size, fertility and overall reproductive success were not significantly affected. Exposure to 669 ng l^{-1} E2 significantly increased mortality, adversely affected haematological parameters and caused an almost total lack of reproductive activity, with both sexes failing to mature. Reproductive failure following exposure to 669 ng l^{-1} E2 was evident in both sexes when crossed with untreated animals. This work indicates that marine fish are similarly as sensitive to oestrogenic exposure as freshwater fish, that exposure biomarkers such as VTG are more sensitive to exposure than are reproductive effects, and that the use of carrier solvents in long-term reproductive studies should be avoided.

Hjermann, D.O., Melsom, A., Dingsor, G.E., Durant, J.M., Eikeset, A.M., Roed, L.P., Ottersen, G., Storvik, G., and Stenseth, N.C. **Fish and oil in the Lofoten-Barents Sea system: synoptic review of the effect of oil spills on fish populations.** *Marine Ecology Progress Series* 339: 283-299, 2007.

Notes: The Lofoten-Barents Sea area, which contains some of the most valuable fish stocks of the Atlantic Ocean, is being considered for offshore oil production. We review the effects of a hypothetical oil spill on fishes in this area, with a focus on effects on the egg and larval stage of the 3 dominating fish stocks: NE Arctic cod *Gadus morhua*, Barents Sea capelin *Mallotus villosus*, and Norwegian spring-spawning herring *Clupea harengus*. In particular, we emphasise that the long-term population impact of an oil spill depends on ecological and oceanographic factors, some of which have been poorly explored. Among these are (1) effects of the physical state of the ocean, especially mesoscale circulation features, on the advection of oil and fish larvae, (2) effects of the spatial distribution of spawners, (3) effects of harvesting on stock structure and length of the spawning season, (4) effects of natural mortality and species interactions subsequent to an oil spill, and (5) chronic sublethal effects from persistent oil residues.

Arslan, O.C. and Parlak, H. **Embryotoxic effects of nonylphenol and octylphenol in sea urchin *Arbacia lixula*.** *Ecotoxicology* 16(6): 439-444, 2007.

Notes: Nonylphenol (NP) and octylphenol (OP), both of which are biodegradation products of alkylphenols, are widely used in industrial applications and in some domestic products. These chemicals are found widely in surface water and aquatic sediments. We have carried out a comparative embryotoxicity analysis of the effects of increasing concentrations of NP (seven concentrations ranging from 0.937 to 18.74 μg/l) and OP (six concentrations ranging from 5 to 160 μg/l) on embryos of the sea urchin *Arbacia lixula*. The indicators evaluated were larval malformations, developmental arrest and embryonic/larval mortality. The results revealed that low concentrations of these chemicals (NP, OP) generally caused malformations in the skeletal system. High concentrations (18.74 μg NP/l, 160 μg OP/l) were found to inhibit the growth of embryos in the early life stages by preventing mitosis. We conclude that NP and OP present a major risk to the normal development of *A. lixula* at the low concentrations that have been recorded in the environment. These chemicals are therefore most likely to represent an ecological hazard at the population level given the cumulative effects of other environmental pollutants.

Philippart, C.J.M., Beukema, J.J., Cadee, G.C., Dekker, R., Goedhart, P.W., vanIperen, J.M., Leopold, M.F., and Herman, P.M.J. **Impacts of nutrient reduction on coastal communities.** *Ecosystems* 10(1): 95-118, 2007.

Notes: Eutrophication due to high anthropogenic nutrient loading has greatly impacted ecological processes in marine coastal waters and, therefore, much effort has been put into reducing nitrogen and phosphorus discharges into European and North-American waters. Nutrient enrichment usually resulted in increase of biomass and production of phytoplankton and microphytobenthos, often coinciding with shifts in species composition within the primary producer community. Consequences of increasing eutrophication for higher trophic levels are still being disputed, and even less is known about the consequences of nutrient reduction on coastal food webs. Here, we present 30-year concurrent field observations on phytoplankton, macrozoobenthos and estuarine birds in the Dutch Wadden Sea, which has been subject to decades of nutrient enrichment and subsequent nutrient reduction. We demonstrate that long-term variations in limiting nutrients (phosphate and silicon) were weakly correlated with biomass and more strongly with community structures of phytoplankton, macrozoobenthos and estuarine birds. Although we cannot conclusively determine if, and if so to what extent, nutrient enrichment and subsequent nutrient reduction actually contributed to the concurrent trends in these communities, it appears likely that part of the variance in the studied coastal communities is related to changes in nutrient loads. Our results imply that nutrient reduction measures should not ignore the potential consequences for policies aimed at bird conservation and exploitation of marine living resources.

Lerner, D.T., Bjornsson, B.T., and McCormick, S.D. **Larval exposure to 4-nonylphenol and 17ß-estradiol affects physiological and behavioral development of seawater adaptation in Atlantic salmon smolts.** *Environmental Science and Technology* 41(12): 4479-4485, 2007.

Notes: Population declines of anadromous salmonids are attributed to anthropogenic disturbances including dams, commercial and recreational fisheries, and pollutants, such as estrogenic compounds. Nonylphenol (NP), a xenoestrogen, is widespread in the aquatic environment due to its use in agricultural, industrial, and household products. We exposed Atlantic salmon yolk-sac larvae to waterborne 10 or 100 μg L^{-1} NP (NP-L or NP-H, respectively), 2 μg L^{-1} 17ß-estradiol (E_2), or vehicle, for 21 days to investigate their effects on smolt physiology and behavior 1 year later. NP-H caused approximately 50% mortality during exposure, 30 days after exposure, and 60 days after exposure. Mortality rates of NP-L and E_2 fish were not affected until 60 days after treatment, when they were 4-fold greater than those of controls. Treatment with NP-L or E_2 as yolk-sac larvae decreased gill sodium-potassium-activated adenosine triphosphatase (Na^+,K^+-ATPase) activity and seawater (SW) tolerance during smolt development, 1 year after exposure. Exposure to NP-L and E_2 resulted in a latency to enter SW and reduced preference for SW approximately 2- and 5-fold, respectively. NP-L-exposed fish had 20% lower plasma insulin-like growth factor I (IGF-I) levels and 35% lower plasma triiodothyronine (T_3). Plasma growth hormone and thyroxine (T_4) were unaffected. Exposure to E_2 did not affect plasma levels of IGF-I, GH, T_3, or T_4. Both treatment groups exhibited increased plasma cortisol and decreased osmoregulatory capacity in response to a handling stressor. These results suggest that early exposure to environmentally relevant concentrations of NP, and other estrogenic compounds, can cause direct and delayed mortalities and that this exposure can have long term, "organizational" effects on life-history events in salmonids.

Lerner, D.T., Bjornsson, B.T., and McCormick, S.D. **Aqueous exposure to 4-nonylphenol and 17ß-estradiol increases stress sensitivity and disrupts ion regulatory ability of juvenile Atlantic salmon.** *Environmental Toxicology and Chemistry* 26(7): 1433-1440, 2007.

Notes: Population declines of wild Atlantic salmon have been attributed to an array of anthropogenic disturbances, including dams, commercial and recreational fishing, habitat loss, and pollution. Environmental contaminants in particular can act as environmental stressors on fish, typically causing disruption of ion homeostasis due to their close association with the aquatic environment. To examine the effects of the xenoestrogen 4-nonylphenol (NP) or 17ß-estradiol (E_2) on stress sensitivity and ion regulation, we exposed juvenile Atlantic salmon continuously for 21 d to either 10 or 100 μg/L NP (NP-L or NP-H), 2 μg/E_2 (positive control), or vehicle control during the parr-smolt transformation in April. After treatment, fish were sampled in freshwater (FW), transferred to 30‰ seawater (SW) for 24 h, or subjected to a handling stress. Estradiol and NP-H increased plasma vitellogenin in mates and females, and E_2 increased gonadosomatic index only in males. In FW, E_2 reduced sodium potassium-activated adenosine triphosphatase activity as well as plasma levels of growth hormone, insulin-like growth

factor I, and triiodothyronine. Both E_2 and NP-H reduced plasma sodium in FW and increased plasma chloride in SW. Plasma cortisol levels pre- and poststressor were significantly elevated by all treatments relative to controls, but only E_2 increased plasma glucose before and after the stressor. These results indicate that exposure of anadromous salmonids to environmental estrogens heightens sensitivity to external stressors, impairs ion regulation in both FW and SW, and disrupts endocrine pathways critical for smolt development.

Fisher, L.S., Mays, P.A., and Wylie, C.L. **An overview of nitrogen critical loads for policy makers, stakeholders, and industries in the United States.** *Water Air and Soil Pollution* 179(1-4): 3-18, 2007.

Notes: Critical load values are calculated to determine ecosystem responses to deposition in a given area; these values may act as a tool to identify sensitive ecosystems in further need of protection. This overview provides an introduction to nitrogen critical loads for policy makers and parties involved in managing nitrogen deposition including electric utility generators, transportation managers and automobile manufacturers, and large-scale agricultural operators in the United States. It examines the use of the critical loads concept in European nations for establishing policy guidelines, current research on nitrogen critical loads in the U.S., and the development of nitrogen critical loads modeling and mapping.

Harris, R.C. *et al.* **Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition.** *Proceedings of the National Academy of Sciences [USA]* 104(42): 16586-16591, 2007. **O/A**

Notes: Methylmercury contamination of fisheries from centuries of industrial atmospheric emissions negatively impacts humans and wildlife worldwide. The response of fish methylmercury concentrations to changes in mercury deposition has been difficult to establish because sediments/soils contain large pools of historical contamination, and many factors in addition to deposition affect fish mercury. To test directly the response of fish contamination to changing mercury deposition, we conducted a whole-ecosystem experiment, increasing the mercury load to a lake and its watershed by the addition of enriched stable mercury isotopes. The isotopes allowed us to distinguish between experimentally applied mercury and mercury already present in the ecosystem and to examine bioaccumulation of mercury deposited to different parts of the watershed. Fish methylmercury concentrations responded rapidly to changes in mercury deposition over the first 3 years of study. Essentially all of the increase in fish methylmercury concentrations came from mercury deposited directly to the lake surface. In contrast, <1% of the mercury isotope deposited to the watershed was exported to the lake. Steady state was not reached within 3 years. Lake mercury isotope concentrations were still rising in lake biota, and watershed mercury isotope exports to the lake were increasing slowly. Therefore, we predict that mercury emissions reductions will yield rapid (years) reductions in fish methylmercury concentrations and will yield concomitant reductions in risk. However, a full response will be delayed by the gradual export of mercury stored in watersheds. The rate of response will vary among lakes depending on the relative surface areas of water and watershed.

Zhang, W.J. and Zhang, X.Y. **A forecast analysis on fertilizers consumption worldwide.** *Environmental Monitoring and Assessment* 133(1-3): 427-434, 2007.

Notes: This study aimed to make a review and forecast on fertilizers consumption worldwide in order to provide basal data for the decision-making of fertilizers production and for the environmental impact assessment of fertilizers application. It was found that fertilizers consumption was dependent on human population and the increase of fertilizers consumption was mainly resulted from expansion of human population. The univariate linear model, $y=a+rx(t)$, where y is the fertilizers consumption, x(t) is the total human population at year t, r is the annual fertilizers consumption per capita, was used to fit historical data of fertilizers consumption, and the forecasts during 2010 to 2030 were given in detail. Model analysis showed that world's per capita annual consumption of total fertilizers, nitrogenous fertilizers, phosphate fertilizers, and potash fertilizers, were 34.6, 24.4, 6.6, and 3.7 kg, respectively. Per capita annual consumption of total fertilizers for Asia, Africa, Caribbean, Oceania, North & Central America, Europe, and South America were 38.8, 5.9, 6.8, 114.0, 62.9, -0.9, and 43.6 kg, respectively. Compared to the current level, the world's total fertilizers consumption would reach 226,150,381 Mt by 2030, an increase of 32.1% against current level. Worldwide consumption of nitrogenous fertilizers, phosphate fertilizers, and potash fertilizers would reach 141,800,601, 50,961,129, and 33,388,650 Mt by 2030, increasing 37.5, 25.8, and 21.2% based on current levels. Consumption of total, nitrogenous, phosphate, and potash fertilizers in Asia and Africa would increase 54 to 55% and

40 to 60% by 2030, respectively. Total fertilizers consumption in North & Central America would see an increase of 39.4% by 2030, and in South America and Oceania it would increase by 30.9 and 64.7%, respectively. By 2030, Caribbean's consumption for total fertilizers would increase 2.8%. Europe's total fertilizers consumption was forecast to continuously decline and would have a decrease of 2.4% by 2030. Annual relative growths of consumption of total fertilizers, nitrogenous fertilizers, phosphate fertilizers, and potash fertilizers for the world, Africa, Asia, and South America were forecast to decrease in the forecast period. For North & Central America, annual relative growths of consumption of total fertilizers and nitrogenous fertilizers would decrease and the others would increase annually by 2030. Annual relative growths of consumption of total fertilizers, phosphate fertilizers, and potash fertilizers for Oceania were forecast to rise annually by 2030. Europe's annual relative growths of consumption of total fertilizers and potash fertilizers would decrease in the future.

Arslan, O.C., Parlak, H., Oral, R., and Katalay, S. **The effects of nonylphenol and octylphenol on embryonic development of sea urchin (*Paracentrotus lividus*).** *Archives of Environmental Contamination and Toxicology* 53(2): 214-219, 2007.

Notes: In this study, embryotoxic and genotoxic effects of nonylphenol (NP) and octylphenol (OP), which are the derivates of alkylphenol (APs), were evaluated using the gametes and embryos of the sea urchin *Paracentrotus lividus*. The sperm and eggs of sea urchins were exposed to increasing concentrations of NP (0.937-18.74 μg/L) and OP (5-160 μg/L) under static conditions. The endpoints were sperm fertilization success, quantitative and morphologic changes in mitotic activity, larval malformations, developmental arrest, and embryonic/larval mortality. A dose-response-related reduction (approximately 20%) was observed in fertilization success and significant increases in the number of larvae with skeleton malformations at the pluteus stage of the contaminated sperms. The spermiotoxic and embryotoxic concentrations were determined as 0.937 μg/L for NP and 4.685 μg/L for OP for this species. The embryotoxicity of NP and OP is concentration dependent, and significant growth reduction at the early life stages and an increase in larval malformations as skeleton deformities at the pluteus stage were observed. Cytogenetic analysis of embryos showed a decreasing curve in mitotic indexes (number of mitosis per embryo) with increasing concentrations of NP and OP. It can be concluded that NP and OP adversely affect the reproduction and embryonic developmental stages of the *P. lividus* and this is of great ecological importance because of the hazard at the population level.

Thomas, P., Rahman, Md. S., Khan, I.A., and Kummer, J.A. **Widespread endocrine disruption and reproductive impairment in an estuarine fish population exposed to seasonal hypoxia.** *Proceedings of the Royal Society of London [B]* 274(1626): 2693-2701, 2007.

Notes: The long-term effects on marine fish populations of the recent increase worldwide in the incidence of coastal hypoxia are unknown. Here we show that chronic environmental exposure of Atlantic croaker (*Micropogonias undulatus*) to hypoxia in a Florida estuary caused marked suppression of ovarian and testicular growth which was accompanied by endocrine disruption. Laboratory hypoxia studies showed that the endocrine disruption was associated with impairment of reproductive neuroendocrine function and decreases in hypothalamic serotonin (5-HT) content and the activity of the 5-HT biosynthetic enzyme, tryptophan hydroxylase. Pharmacological restoration of hypothalamic 5-HT levels also restored neuroendocrine function, indicating that the stimulatory serotonergic neuroendocrine pathway is a major site of hypoxia-induced inhibition. Inhibition of tryptophan hydroxylase activity to downregulate reproductive activity could have evolved as an adaptive mechanism to survive periodic hypoxia, but in view of the recent increased incidence of coastal hypoxia could become maladaptive and potentially affect fish population abundance and threaten valuable fishery resources.

Lau, C., Anitole, K., Hodes, C., Lai, D., Pfahles-Hutchens, A., and Seed, J. **Perfluoroalkyl acids: A review of monitoring and toxicological findings.** *Toxicological Sciences* 99(2): 366-394, 2007.

Notes: In recent years, human and wildlife monitoring studies have identified perfluoroalkyl acids (PFAA) worldwide. This has led to efforts to better understand the hazards that may be inherent in these compounds, as well as the global distribution of the PFAAs. Much attention has focused on understanding the toxicology of the two most widely known PFAAs, perfluorooctanoic acid, and perfluorooctane sulfate. More recently, research was extended to other PFAAs. There has been substantial progress in understanding additional aspects of the toxicology of these compounds, particularly related to the

developmental toxicity, immunotoxicity, hepatotoxicity, and the potential modes of action. This review provides an overview of the recent advances in the toxicology and mode of action for PFAAs, and of the monitoring data now available for the environment, wildlife, and humans. Several avenues of research are proposed that would further our understanding of this class of compounds.

Scarlett, A., Galloway, T.S., and Rowland, S.J. **Chronic toxicity of unresolved complex mixtures (UCM) of hydrocarbons in marine sediments.** *Journal of Soils and Sediments* 7(4): 200-206, 2007.

Notes: *Background, Aim and Scope*. Unresolved complex mixtures (UCM) of hydrocarbons, containing many thousands of compounds which cannot be resolved by conventional gas chromatography (GC), are common contaminants of sediments but little is known of their potential to affect sediment-dwelling organisms. Evidence exists for reduced health status in mussels, arising from aqueous exposure to aromatic UCM components acting through a narcotic mode of action. However, UCM contaminants in sediments may not be sufficiently bioavailable to elicit toxic effects. The aim of our study was therefore to measure the sublethal effects of chronic exposure to model UCM-dominated oils at environmentally realistic concentrations and compare this to effects produced by a UCM containing weathered crude oil. A further aim was to determine which, if any, fractions of the oils were responsible for any observed toxicity. *Materials and Methods*. Whole oils were spiked into estuarine sediment to give nominal concentrations of 500 μg g^{-1} dry weight. Juveniles of the estuarine amphipod *Corophium volutator* were exposed to the contaminated sediment for 35 days and their survival, growth rate and reproductive success quantified. Using an effect-directed fractionation approach, the oils were fractionated into aliphatic and two aromatic fractions by open column chromatography and their toxicity assessed by further chronic exposures using juvenile *C. volutator*. *Results*. The growth rates of amphipods were reduced following exposure to the oils although this was only statistically significant for the weathered oil; reproductive success was reduced by all oil exposures. Sediment spiked with UCM fractions also caused reduced growth and reproduction but no particular fraction was found to be responsible for the observed toxicity. Survivorship was not affected by any oil or fraction. *Discussion*. The study showed that chronic exposure to sediments contaminated by UCM-dominated oils could have population level effects on amphipods. The observed effects could not be explained by hydrocarbons resolved by conventional GC and effects were similar for both UCM-dominated and weathered oils. All of the fractions appeared to contribute to the observed effects; this is in contrast to previous research which had shown that an aliphatic UCM did not cause adverse effects in mussels. Conclusions. To our knowledge, this is the first study to demonstrate population-level effects arising from exposure to sediments contaminated by realistic environmental concentrations of UCM hydrocarbons. The results are consistent with many compounds, at very low individual concentrations, contributing towards the overall observed toxicity. *Recommendations*. Risk assessments of contaminated sediments should take into account the contribution towards the potential for toxic effects from UCM hydrocarbons. Studies into sediment contamination should report both aliphatic and aromatic UCM concentrations to aid risk assessments.

Scott, A.P., Sanders, M., Stentiford, G.D., Reese, R.A., and Katsiadaki, I. **Evidence for estrogenic endocrine disruption in an offshore flatfish, the dab (*Limanda limanda* L.).** *Marine Environmental Research* 64(2): 128-148, 2007.

Notes: Dab (*Limanda limanda*) caught in UK offshore waters show evidence of being exposed to estrogenic endocrine disrupters at a relatively low level. Two of 449 males caught between June and July 2005 had markedly elevated levels of vitellogenin (VTG; 21 and 750 μg/ml, and the remainder ranged from < 0.01 to 8.6 μg/ml. Omitting the two outliers, there was a very significant positive relationship with the mass of individual males (a feature noted in previous studies on cod). Mean VTG concentrations in males differed significantly between sites. The site with the highest mean (1.6 μg/ml) was North East of the Dogger Bank and the site with the lowest (0.04 μg/ml) was in Cardigan Bay. Mean VTG concentrations in all North Sea fish were significantly higher than English Channel and Irish Sea fish, but this difference disappeared when fish mass was taken into account. VTG concentrations showed no relationship to water depth, stage of sexual maturity or age of the males. Sixty selected male plasmas were assayed for 17 β-estradiol but only two had measurable amounts (assay limit 0.04 ng/ml). Despite being the start of summer, the gonads of many of the males and females (especially those caught in the North Sea) showed signs of sexual maturity (presence of sperm in males and vitellogenic eggs in females). Many females had high VTG concentrations (up to 14 mg/ml) and 78 out of 80 had measurable concentrations of 17 β-estradiol. The cause of elevated VTG levels in male dab is unknown. As seen in cod, the presence of affected males does not appear to be linked to proximity to land or to known point sources of endocrine disrupters. However, our data, showing that larger fish are more likely to have elevated VTG concentrations, suggests a gradual accumulation by marine fish, probably through feeding, of persistent (probably relatively weak) estrogenic compounds.

Gao, Y., Kennish, M.J., and Flynn, A.M. **Atmospheric nitrogen deposition to the New Jersey coastal waters and its implications.** *Ecological Applications* 17(5): S31-S41, 2007. **O/A**

Notes: In situ measurements of atmospheric NO_3^- and NH_4^+ at Sandy Hook on the northern New Jersey (USA) coast and at Tuckerton on the southern New Jersey coast reveal significant temporal and spatial variations of these inorganic N constituents. The mean concentration of NO_3^- in precipitation was higher at Sandy Hook (44.6 µmol/L) than at Tuckerton (29.1 µmol/L). The mean concentration of NH_4^+ in precipitation exhibited a similar pattern, being higher at Sandy Hook (26.3 µmol/L) than at Tuckerton (18.3 µmol/L). Aerosol NO_3^- and NH_4^+ concentrations at Sandy Hook were also higher than those at Tuckerton. On an annual basis, the total atmospheric deposition of NO_3^- was estimated to be 51.1 mmol m^{-2} yr^{-1} at Sandy Hook and 32.9 mmol m^{-2} yr^{-1} at Tuckerton. For NH_4^+, the total atmospheric deposition was 32.8 mmol m^{-2} yr^{-1} at Sandy Hook and 20.3 mmol m^{-2} yr^{-1} at Tuckerton. Wet deposition accounted for up to 89% of the total NO_3^- deposition and 76-91% of the total NH_4^+ deposition on the New Jersey coast. By comparison, NO_3^- and NH_4^+ concentrations are relatively low in estuarine waters of New Jersey. The annual mean NO_3^- concentrations recorded in surface waters of the Mullica River-Great Bay Estuary near the Tuckerton atmospheric site during the 2002-2004 period were as follows: 12.1 µmol/L for the upper estuary, 4.5 µmol/L for the mid-estuary, 2.5 µmol/L for the lower estuary, and 1.2 µmol/L for the bay inlet area. The annual mean NH_4^+ concentrations in these waters were as follows: 1.5 µmol/L for the upper estuary, 3.8 µmol/L for the mid-estuary, 3.8 µmol/L for the lower estuary, and 2.4 µmol/L for the bay inlet area. In the Barnegat Bay-Little Egg Harbor Estuary, the mean concentrations of NO_3^- plus NO_2^- were < 4 µmol/L. In this system, atmospheric deposition accounts for ~ 39% of the total N load. These results suggest that atmospheric deposition appears to be an important pathway of new N inputs to New Jersey coastal waters and a potentially significant N enrichment source for biotic production.

Wazniak, C.E., Hall, M.R., Carruthers, T.J.B., Sturgis, B., Dennison, W.C., and Orth, R.J. **Linking water quality to living resources in a mid-Atlantic lagoon system, USA.** *Ecological Applications* 17(5): S64-S78, 2007. **O/A**

Notes: The mid-Atlantic coastal bays are shallow coastal lagoons, separated from the Atlantic Ocean by barrier sand islands with oceanic exchanges restricted to narrow inlets. The relatively poor flushing of these lagoon systems makes them susceptible to eutrophication resulting from anthropogenic nutrient loadings. An intensive water quality and seagrass monitoring program was initiated to track ecological changes in the Maryland and Virginia coastal bays. The purpose of this study was to analyze existing monitoring data to determine status and trends in eutrophication and to determine any associations between water quality and living resources. Analysis of monitoring program data revealed several trends: (1) decadal decreases in nutrient and chlorophyll concentrations, followed by recently increasing trends; (2) decadal increases in seagrass coverage, followed by a recent period of no change; (3) blooms of macroalgae and brown tide microalgae; and (4) exceedance of water quality thresholds: chlorophyll *a* (15 µg/L), total nitrogen (0.65 mg/L or 46 µmol/L), total phosphorus (0.037 mg/L or 1.2 µmol/L), and dissolved oxygen (5 mg/L) in many areas within the Maryland coastal bays. The water quality thresholds were based on habitat requirements for living resources (seagrass and fish) and used to calculate a water quality index, which was used to compare the bay segments. Strong gradients in water quality were correlated to changes in seagrass coverage between segments. These factors indicate that these coastal bays are in a state of transition, with a suite of metrics indicating degrading conditions. Continued monitoring and intensified management will be required to avert exacerbation of the observed eutrophication trends. Coastal lagoons worldwide are experiencing similar degrading trends due to increasing human pressures, and assessing status and trends relative to biologically relevant thresholds can assist in determining monitoring and management priorities and goals.

Paerl, H.W., Valdes-Weaver, L.M., Joyner, A.R., and Winkelmann, V. **Phytoplankton indicators of ecological change in the eutrophying Pamlico Sound system, North Carolina.** *Ecological Applications* 17(5): S88-S101, 2007. **O/A**

Notes: Nutrient enrichment and eutrophication of estuarine and coastal waters are accelerating, and there is a need to develop rapidly detectable and quantifiable indicators of these changes. Coastal systems are also impacted by climatic perturbations, including droughts, storms, and floods, the frequencies of which may be increasing. Phytoplankton are excellent indicators of ecological change. They are relatively easy to detect, identify, and quantify; they conduct a large share of primary production; and they are sensitive to diverse environmental stressors. In this study, phytoplankton total biomass, as chlorophyll *a*, and

group-specific chemotaxonomic indicators (including chlorophylls and carotenoids) were used to characterize community responses to human (nutrient) and climatic (hydrologic) perturbations in the Neuse River Estuary-Pamlico Sound, North Carolina, USA. This estuarine-coastal continuum is experiencing anthropogenic nutrient enrichment and, since 1996, a rise in hurricane frequency. Freshwater input and flushing strongly interacted with supplies of the limiting nutrient nitrogen (N) to determine the location, magnitude, and composition of phytoplankton biomass along this continuum. Elevated flow (high flushing) following hurricanes favored dominance by the fast-growing chlorophytes and cryptophytes. Diatoms tended to dominate under moderate flow, while dinoflagellates and cyanobacteria increased in dominance when low flow prevailed in winter/spring and summer/fall, respectively. Depending on seasonal hydrologic cycles and episodic (hurricane) conditions, phytoplankton community structure differed substantially. These changes impact eutrophication, food web, biogeochernical (e.g., hypoxia), and habitat conditions in this and other coastal ecosystems currently experiencing changes in nutrient inputs and climatic events. Phytoplankton-based indicators are adaptable to unattended monitoring platforms (e.g., ferries) that can be coupled to remote sensing and modeling efforts, in order to evaluate and help manage ecological change at ecosystem and regional scales

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Rabalais, N.N., Turner, R.E., Sen Gupta, B.K., Platon, E., and Parsons, M.L. **Sediments tell the history of eutrophication and hypoxia in the Northern Gulf of Mexico.** *Ecological Applications* 17(5): S129-S143, 2007. **O/A**

Notes: We examined a suite of paleoindicators in ^{210}Pb-dated sediment cores to determine the historical course of primary production, eutrophication, and oxygen stress in the coastal ocean adjacent to the plumes of the Mississippi and Atchafalaya rivers. The assumption that hypoxia is a natural feature of the coastal ecosystem in the northern Gulf of Mexico influenced by the discharge of the Mississippi River system is not supported by paleoindicators in accumulated sediments. There is a propensity for the ecosystem to develop hypoxia because of the high discharge of the Mississippi River and physical dynamics on the continental shelf that support stratification. However, paleoindicators of eutrophication and oxygen conditions record recent anthropogenic influences. The evidence for increased carbon production and accumulation comes from diatoms and their remnants, marine-origin carbon in the sediments, and phytoplankton pigments. Surrogates for oxygen condition, including mineral, isotopic, microfossil, and phytoplankton pigment indicators, indicate worsening oxygen stress. The changes are more apparent in areas of present chronic hypoxia and are coincident with the increasing nitrogen loads from the Mississippi River system beginning in the 1950s. Longer-term shifts in offshore ecology parallel landscape changes within the watershed in the last two centuries. The temporal shifts in this coastal ecosystem parallel the time sequence of similarly eutrophied coastal waters globally and coincide nicely with sediment analyses from other locations.

Davoodi, F. and Claireaux, G. **Effects of exposure to petroleum hydrocarbons upon the metabolism of the common sole *Solea solea*.** *Marine Pollution Bulletin* 54(7): 928-934, 2007.

Notes: On December 12th, 1999, the oil tanker Erika sank off the southern coast of Brittany (France), releasing 20 000-30 000 tons of heavy oil in the open sea. Among the affected coastal habitats were important nurseries for numerous flatfish species and particularly for the common sole, *Solea solea*. To investigate the potential impact of the spill on this economically significant resource, we employed Fry's concept of metabolic scope for activity to assess the deleterious effect of fuel exposure on the functional integrity of juvenile sole. Fish were captured from uncontaminated areas and experimentally exposed to contamination conditions mimicking those encountered during the weeks that followed the Erika spill. Using respirometry techniques we measured basal and active metabolic rates, and calculated aerobic metabolic scope, in control and fuel-exposed sole. We then compared the ability of control and fuel-exposed sole to face an episode of reduced oxygen availability. We found that whereas basal metabolic rate was not altered in fuel-exposed fish, active metabolic rate (-27%), and therefore aerobic metabolic scope, were impacted. These changes in metabolic scope were viewed as indicating changes in fishes' ability to face environmental contingencies. Finally the ability of sole to face an episode of reduced oxygen availability was found to be significantly altered following fuel exposure as indicated by a 65% increase in the critical oxygen level. It is concluded that fuel-exposed sole are functionally impaired and less able to face environmental challenges. The link between these results and the recently reported fall in the abundance of the year class that suffered the Erika oil spill is discussed.

Culbertson, J.B., Valiela, I., Peacock, E.E., Reddy, C.M., Carter, A., and Van der Kruik, R. **Long-term biological effects of petroleum residues on fiddler crabs in salt marshes.** *Marine Pollution Bulletin* 54(7): 955-962, 2007.

Notes: In September 1969, the Florida barge spilled 700,000 L of No. 2 fuel oil into the salt marsh sediments of Wild Harbor (Buzzards Bay, MA). Today the aboveground environment appears unaffected, but a substantial amount of moderately degraded petroleum still remains 8-20 cm below the surface. The salt marsh fiddler crabs, *Uca pugnax*, burrow into the sediments at depths of 5-25 cm, and are chronically exposed to the spilled oil. Behavioral studies conducted with *U. pugnax* from Wild Harbor and a control site, Great Sippewissett marsh, found that crabs exposed to the oil avoided burrowing into oiled layers, suffered delayed escape responses, lowered feeding rates, and achieved lower densities. The oil residues are therefore biologically active and affect *U. pugnax* populations. Our results add new knowledge about long-term consequences of spilled oil, a dimension that should be included when assessing oil-impacted areas and developing management plans designed to restore, rehabilitate, or replace impacted areas.

Rios, L.M., Moore, C., and Jones, P.R. **Persistent organic pollutants carried by synthetic polymers in the ocean environment.** *Marine Pollution Bulletin* 54(8): 1230-1237, 2007.

Notes: Thermoplastic resin pellets are melted and formed into an enormous number of inexpensive consumer goods, many of which are discarded after a relatively short period of use, dropped haphazardly onto watersheds and then make their way to the ocean where some get ingested by marine life. In 2003 and 2004 pre-production thermoplastic resin pellets and post-consumer plastic fragments were collected and analyzed for contamination for persistent organic pollutants (POPs). Samples were taken from the North Pacific Gyre, and selected sites in California, Hawaii, and from Guadalupe Island, Mexico. The total concentration of PCBs ranged from 27 to 980 ng/g; DDTs from 22 to 7100 ng/g and PAHs from 39 to 1200 ng/g, and aliphatic hydrocarbons from 1.1 to 8600 μg/g. Analytical methods were developed to extract, concentrate and identify POPs that may have accumulated on plastic fragments and plastic pellets. The results of this study confirm that plastic debris is a trap for POPs.

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do Sul, J.A.I. and Costa, M.F. **Marine debris review for Latin America and the Wider Caribbean Region: From the 1970s until now, and where do we go from here?** *Marine Pollution Bulletin* 54(8): 1087-1104, 2007.

Notes: The available literature on marine debris from Latin America and the Wider Caribbean Region was collected and linked, reviewing their methodologies and principal results (quantities, composition and spatial-temporal patterns). The study region comprises 52 coastal countries of which only 14 had registers of works on marine debris. A total of 70 works were available and 69 had their full contents accessed. Brazil dominated the available literature with 70% of the documents. Beaches were the most studied environment, and plastics the prevalent form of contamination in the whole region. The exposure of marine biota (species, type of contact, consequences) was highlighted. The studied region, although still little exploited by this sort of research, shows the same contamination patterns observed worldwide. We also contacted 40 researchers in the area, collecting scientific contributions, opinions and suggestions for improvement of this research field. Further advances and new (urgently needed) lines of research are also discussed.
