Marine Science Review – 191

Human health and pollution

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In this review:

A. Recent articles with abstracts

Fryer, M., Collins, C.D., Ferrier, H., Colvile, R.N., and Nieuwenhuijsen, M.J. **Human exposure modelling for chemical risk assessment: a review of current approaches and research and policy implications.** *Environmental Science and Policy* 9(3): 261-274, 2006.

Notes: A wide variety of exposure models are currently employed for health risk assessments. Individual models have been developed to meet the chemical exposure assessment needs of government, industry and academia. These existing exposure models can be broadly categorised according to the following types of exposure source: environmental, dietary, consumer product, occupational, and aggregate and cumulative. Aggregate exposure models consider multiple exposure pathways, while cumulative models consider multiple chemicals. In this paper each of these basic types of exposure model are briefly described, along with any inherent strengths or weaknesses, with the UK as a case study. Examples are given of specific exposure models that are currently used, or that have the potential for future use, and key differences in modelling approaches adopted are discussed. The use of exposure models is currently fragmentary in nature. Specific organisations with exposure assessment responsibilities tend to use a limited range of models. The modelling techniques adopted in current exposure models have evolved along distinct lines for the various types of source. In fact different organisations may be using different models for very similar exposure assessment situations. This lack of consistency between exposure modelling practices can make understanding the exposure assessment process more complex, can lead to inconsistency between organisations in how critical modelling issues are addressed (e.g. variability and uncertainty), and has the potential to communicate mixed messages to the general public. Further work should be conducted to integrate the various approaches and models, where possible and regulatory remits allow, to get a coherent and consistent exposure modelling process. We recommend the development of an overall framework for exposure and risk assessment with common approaches and methodology, a screening tool for exposure assessment, collection of better input data, probabilistic modelling, validation of model input and output and a closer working relationship between scientists and policy makers and staff from different government departments. A much increased effort is required in the UK to address these issues. The result will be a more robust, transparent, valid and more comparable exposure and risk assessment process.

Rawn, D.F.K., Forsyth, D.S., Ryan, J.J., Breakell, K., Verigin, V., Nicolidakis, H., Hayward, S., Laffey, P., and Conacher, H.B.S. **PCB, PCDD and PCDF residues in fin and non-fin fish products from the Canadian retail market 2002.** *The Science of the Total Environment* 359(1-3): 101-110, 2006.

Notes: Fish products (n = 129) available on the Canadian retail market were collected and analyzed for levels of PCBs, PCDDs and PCDFs during the spring of 2002. The collection included samples from eight fish groups (Arctic char, crab, mussels, oysters, salmon, shrimp, tilapia, trout) from the wild and those raised on fish farms, as available. Sample collection included both domestic and imported fish products, however, no significant difference in residue levels was observed between these groups of fish products. Salmon samples were found to contain the highest concentration of ΣPCBs (geometric mean 12.9 ng/g wet weight), while crab samples had greatest ΣPCDD/F levels (geometric mean 0.002 ng/g wet weight). The geometric mean of the total toxic equivalents (WHO-TEQ) ranged from 0.06 pg WHO-TEQ/g whole weight in farmed shrimp to 1.1 pg WHO-TEQ/g whole weight in farmed salmon samples. PCB 153, 138, 118 and 101 were the dominant congeners observed in fish product samples studied, while 1,2,3,7,8- pentachlorodibenzodioxin and 2,3,7,8-tetrachloro-dibenzofuran contributed the most to total PCDD and PCDF loadings. Lipid content was positively correlated to SPCB levels;

however, no relationship between lipid content and ΣPCDD/F concentrations was established. ΣPCB levels were below the Canadian guideline value for PCBs in fish and fish products (2000 ng/g). Similarly, 2,3,7,8-TCDD levels in all fish products were below the Canadian guideline value (0.020 ng/g).

Isosaari, P., Hallikainen, A., Kiviranta, H., Vuorinen, P.J., Parmanne, R., Koistinen, J., and Vartiainen, T. **Polychlorinated dibenzo-p-dioxins, dibenzofurans, biphenyls, naphthalenes and polybrominated diphenyl ethers in the edible fish caught from the Baltic Sea and lakes in Finland.** *Environmental Pollution* 141(2): 213-225, 2006.

Notes: A total of 156 fish composite samples were collected from five areas of the Baltic Sea and from three lakes and analysed for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs) and polybrominated diphenyl ethers (PBDEs). The European Union's maximum permissible level for PCDD/Fs, 4 pg WHO-TEQ/g fresh weight (fw), was exceeded in salmon, river lamprey and Baltic herring. In other species from the Baltic Sea, the 90th percentile was 3.42 pg WHO-PCDD/F-TEQ/g fw. In the lake fish, the concentrations of PCDD/Fs, PCBs and PCNs were only 29-46% of those in the same species caught from the Baltic Sea, whereas the concentrations of PBDEs in the lake fish were as high as in the Baltic Sea fish. Dioxin-like PCBs contributed to the total dioxin-like toxicity of PCBs and PCDD/Fs by 49 ± 12% in all the analysed samples.

Garritano, S., Pinto, B., Calderisi, M., Cirillo, T., Amodio-Cocchieri, R., and Reali, D. **Estrogen-like activity of seafood related to environmental chemical contaminants.** *Environmental Health: A Global Access Science Source* 5: art. 9, 2006.

Notes: **Background:** A wide variety of environmental pollutants occur in surface waters, including estuarine and marine waters. Many of these contaminants are recognised as endocrine disrupting chemicals (EDCs) which can adversely affect the male and female reproductive system by binding the estrogen receptor and exhibiting hormone-like activities. In this study the estrogenic activity of extracts of edible marine organisms for human consumption from the Mediterranean Sea was assayed. **Methods:** Marine organisms were collected in two different areas of the Mediterranean Sea. The estrogenic activity of tissues was assessed using an *in vitro* yeast reporter gene assay (*S. cerevisiae* RMY 326 ER-ERE). Concentrations of polychlorinated biphenyls (PCBs) (congeners 28, 52, 101, 118, 138, 153, 180) in fish tissue was also evaluated. **Results:** Thirty-eight percent of extracts showed a hormone-like activity higher than 10% of the activity elicited by 10 nM 17b-estradiol (E2) used as control. Total PCB concentrations ranged from 0.002 up to 1.785 ng/g wet weight. Chemical analyses detected different levels of contamination among the species collected in the two areas, with the ones collected in the Adriatic Sea showing concentrations significantly higher than those collected in the Tyrrhenian Sea ($p < 0.01$). **Conclusion:** The more frequent combination of chemicals in the samples that showed higher estrogenic activity was PCB 28, PCB 101, PCB 153, PCB 180. The content of PCBs and estrogenic activity did not reveal any significant correlation.

Luebke, R.W., Chen, D.H., Dietert, R., Yang, Y., and Luster, M.I. **Immune system maturity and sensitivity to chemical exposure.** *Journal of Toxicology and Environmental Health Part A* 69(9): 811-825, 2006.

Notes: It is well established that human diseases associated with abnormal immune function, including some common infectious diseases and asthma, are considerably more prevalent at younger ages. The immune system continues to mature after birth, and functional immaturity accounts for much of the increased susceptibility in the young. Although not established absolutely, it is generally believed that development constitutes a period of increased immune system susceptibility to xenobiotics, since adverse effects may occur at lower doses and/or immunomodulation may be more persistent, thus increasing the relative risk of xenobiotic exposure to the immunologically immature organism. Data from published reports were compared to determine whether age and developmental stage at exposure influence the immunotoxic effects of diethylstilbestrol (DES), diazepam (DZP), lead (Pb), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and tributyltin oxide (TBTO). These compounds were chosen for comparison based on the fact that each had been studied fairly extensively, resulting in a significant number of peer-reviewed publications. Based on lowest-observed-adverse-effect level (LOAEL) values for all five compounds, the developing immune system was found to be at greater risk than that of the adult, either because lower doses induced immunotoxicity, adverse effects were more persistent, or adverse effects were reported following developmental, but not adult, exposure.

Levenson, C.W. and Axelrad, D.M. **Too much of a good thing? Update on fish consumption and mercury exposure.** *Nutrition Reviews* 64(3): 139-145, 2006.

Notes: While there is a significant amount of data showing health benefits of increased fish consumption, there are conflicting reports about the cardiovascular risks of mercury in seafood. A recent long-term study attempted to resolve this controversy, providing an opportunity to balance recommendations from the US Environmental Protection Agency for mercury with those from the American Heart Association for fish consumption.

Mariussen, E. and Fonnum, F. **Neurochemical targets and behavioral effects of organohalogen compounds: An update.** *Critical Reviews in Toxicology* 36(3): 253-289, 2006.

Notes: Organohalogen compounds (OHCs) have been used and still are used extensively as pesticides, flame retardants, hydraulic fluids, and in other industrial applications. These compounds are stable, most often lipophilic, and may therefore easily biomagnify. Today these compounds are found distributed both in human tissue, including breast milk, and in wildlife animals. In the late 1960s and early 1970s, high levels of the polychlorinated biphenyls (PCBs) and the pesticide dichlorodiphenyl trichloroethane (DDT) were detected in the environment. In the 1970s it was discovered that PCBs and some chlorinated pesticides, such as lindane, have neurotoxic potentials after both acute and chronic exposure. Although the use of PCBs, DDT, and other halogenated pesticides has been reduced, and environmental levels of these compounds are slowly diminishing, other halogenated compounds with potential of toxic effects are being found in the environment. These include the brominated flame retardants, chlorinated paraffins (PCAs), and perfluorinated compounds, whose levels are increasing. It is now established that several OHCs have neurobehavioral effects, indicating adverse effects on the central nervous system (CNS). For instance, several reports have shown that OHCs alter neurotransmitter functions in CNS and Ca2+ homeostatic processes, induce protein kinase C (PKC) and phospholipase A2 (PLA2) mobilization, and induce oxidative stress. In this review we summarize the findings of the neurobehavioral and neurochemical effects of some of the major OHCs with our main focus on the PCBs. Further, we try to elucidate, on the basis of available literature, the possible implications of these findings on human health.

Charnley, G. and Kimbrough, R.D. **Overview of exposure, toxicity, and risks to children from current levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin and related compounds in the USA.** *Food and Chemical Toxicology* 44(5): 601-615, 2006.

Notes: Studies of children indicate that exposure of the general population to low levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) does not result in any clinical evidence of disease, although accidental exposure to high levels either before or after birth have led to a number of developmental deficits. Breast-fed infants have higher exposures than formula-fed infants, but studies consistently find that breast-fed infants perform better on developmental neurologic tests than their formula-fed counterparts, supporting the well-recognized benefits of breast feeding. Children receive higher exposures to PCDD/Fs from food than adults on a body-weight basis but those exposures are below the World Health Organization's tolerable daily intake. Laboratory rodents appear to be at least an order of magnitude more sensitive than humans to the aryl hydrocarbon receptor-mediated effects of these substances, which makes them poor surrogates for predicting quantitative risks but makes them good models for establishing safe levels of human exposure by organizations mandated to protect public health. Any exposure limit for PCDD/Fs based on developmental toxicity in sensitive laboratory animals can be expected to be especially protective of human health, including the health of infants and children. Because body burdens and environmental levels continue to decline, it is unlikely that children alive today in the USA will experience exposures to PCDD/Fs that are injurious to their health.

Brown, F.R., Winkler, J., Visita, P., Dhaliwal, J., and Petreas, M. **Levels of PBDEs, PCDDs, PCDFs, and coplanar PCBs in edible fish from California coastal waters.** *Chemosphere* 64(2): 276-286, 2006.

Notes: The levels of polychlorinated dibenzo-dioxins (PCDDs), polychlorinated dibenzo-furans (PCDFs), coplanar polychlorinated biphenyls (coPCBs), and polybrominated diphenyl ethers (PBDEs) were measured in fish collected from San

Francisco Bay in 2000 and from the California coast in 2001. The samples were composites of only the edible portions of the fish (skin on, skin off, or whole body minus head and guts) of comparable size and from distinct geographical areas. Sixty-five composite samples were analyzed for PCDD/PCDF/coPCBs, and 43 composite samples were analyzed for PBDEs. For all fish of all species from all sampling areas, the mean concentration of the sum of BDEs 47, 99, 100, 153, and 154 was 302 ng/g lipid weight, with BDE 47 > 100 > 99 similar to 154 > 153. For all fish of all species from all sampling areas, the mean PCDD/PCDF International Toxic Equivalent (I-TEQ) was 33.1 pg/g lipid. For the three coPCBs (77, 126, 169), the mean I-TEQ for all fish of all species from all sampling areas was 109 pg/g lipid. The highest concentrations of both PCDD/PCDF/ coPCBs and PBDEs were found in the highly populated areas of San Francisco Bay, the Los Angeles area, and San Diego Bay.

Valdersnes, S., Kallenborn, R., and Sydnes, L.K. **Identification of several Tonalide(R) transformation products in the environment.** *International Journal of Environmental Analytical Chemistry* 86(7): 461-471, 2006.

Notes: Organic synthesis has been applied to detect potential Tonalide (AHTN) transformation products in a semi-quantitative way in environmental samples by using a well-established trace-analytical method, developed for the quantification of the parent compound AHTN. For the first time, indications for the presence of transformation products of the synthetic musk compound 1-(5,6,7,8-tetrahydro-3,5,5,6,8,8-hexamethyl-2-naphthalenyl) ethanone (1) (Tonalide (R), AHTN) have been found in the environment. Pure standards of the detected products were obtained by multistep syntheses from Tonalide (R). Two main derivatives, 3-acetyl-5,6,7,8-tetrahydro-5,5,7,8,8-pentamethyl-2-naphthalenecarbaldehyde (2) and (3-ethyl-5,6,7,8-tetrahydro-5,5,7,8,8-pentamethyl-2-naphthalenyl) methanol (4), and three minor products, (5,6,7,8-tetrahydro-3,5,5,6,8,8-hexamethyl-2-naphtalenyl) methanol (6), 5,6,7,8- tetrahydro-3,5,5,6,8,8-hexamethyl-2-naphtalenecarbaldehyde (7), and methyl-5,6,7,8-tetrahydro-3,5,5,6,8,8-hexamethyl-2-naphthalenecarboxylate (8), were identified in three human breast-milk samples and three fish samples. All samples contained one or several of these transformation products at a concentration range of around 10 pg g^{-1} wet weight.

Cahoon, L.B., Hales, J.C., Carey, E.S., Loucaides, S., Rowland, K.R., and Nearhoof, J.E. **Shellfishing closures in southwest Brunswick County, North Carolina: Septic tanks vs. storm-water runoff as fecal coliform sources.** *Journal of Coastal Research* 22(2): 319-327, 2006.

Notes: Large coastal areas have been closed to shellfishing by fecal coliform pollution. Sources of contamination include humans and animals, with conveyance by storm-water runoff an increasingly important problem in rapidly developing coastal areas. Estuarine waters in southwestern Brunswick County, North Carolina, have long been closed to shellfishing, but sources and modes of fecal contamination have been debated. Water-quality monitoring data allowed evaluation of storm-water runoff and malfunctioning septic systems as causes for closures. Fecal coliform concentrations did not respond to changes in salinity. Plots of fecal coliform concentrations vs. rainfall totals in the 48-hour period prior to sampling at 10 monitoring locations in shellfishing waters revealed no clear rainfall effect. There were no significant differences in fecal coliform concentrations between periods with no rainfall in the preceding 72 hours and 24- or 48-hour periods with any rainfall at 9 of 10 monitoring locations. Fecal coliform concentrations after the highest 48-hour rainfalls (> 1.5 ") were not significantly higher than the highest concentrations after dry periods. Thus, storm-water runoff alone could not account for fecal coliform contamination in these shellfishing waters. The highest fecal coliform concentrations at monitoring locations within the estuarine watersheds were associated with on-site human waste-treatment systems. Site inspections confirmed that some instances of high fecal coliform counts resulted from improperly performing septic systems. Densities of septic systems reached 20/ha, with many areas of high density having soils severely limited for septic-system suitability. Ditching and drainage systems in densely developed areas facilitated septage discharge to adjacent estuarine waters. Although storm water conveyed some of the total load of nonhuman fecal contaminants, it also conveyed fecal contaminants from poorly performing septic systems, which, under these circumstances, represent important sources of fecal contamination.

Fernandes, A.R., Rose, M., White, S., Mortimer, D.N., and Gem, M. **Dioxins and polychlorinated biphenyls (PCBs) in fish oil dietary supplements: Occurrence and human exposure in the UK.** *Food Additives and Contaminants* 23(9): 939-947, 2006.

Notes: Commercially available fish oil supplements sourced from retail outlets in the UK, as well as by mail order, were surveyed in 2000-02 for dioxin (PCDD/Fs) and polychlorinated biphenyl (PCB) content. Sampled products were representative of market share. The WHO-TEQ values for these products ranged from 0.18 to 8.4 ng kg^{-1} for ΣPCDD/F and from 1.1 to 41 ng kg(-1) for Σ dioxin-like PCBs. The results suggest a downward trend in the levels of dioxins in fish oil supplements over the last decade, since levels for similar products ranged from 0.3 to 10 ng kg^{-1} for ΣPCDD/F WHO-TEQ in 1996. Levels of ICES (International Council for the Exploration of the Seas) 7 PCBs in the current study ranged from 8.3 to 267 mg kg^{-1}. Subsequent to this survey, European Union legislation has been introduced that includes a maximum limit of 2 ng kg^{-1} WHO-TEQ for dioxins in fish oil products for human consumption. Twelve of the 33 products reported here would have exceeded this limit. Negotiations are in progress to incorporate dioxin-like PCBs into the European Union regulations. When manufacturer-recommended doses were applied to the observed levels, the estimated upper bound human exposure to dioxins and dioxin-like PCBs from dietary intake of these products ranged from 0.02 to 7.1 pg WHO-TEQ kg^{-1} body weight day^{-1} for adults and from 0.02 to 10 pg WHO-TEQ kg^{-1} body weight day^{-1} for schoolchildren. This level rises to 1.8-8.9 pg WHO-TEQ kg^{-1} body weight day^{-1} for adults and 1.4-14 pg WHO-TEQ kg^{-1} body weight day^{-1} for schoolchildren when combined with the average exposure from the whole diet in 1997. Again, subsequent to this survey, the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) revised the UK tolerable daily intake (TDI) for mixtures of dioxins and dioxin-like PCBs from 10 to 2 pg WHO-TEQ kg^{-1} body weight day^{-1}. This is in line with the tolerable weekly intake (TWI) of 14 pg WHO-TEQ kg^{-1} body weight set by the Scientific Committee on Food (SCF).

Lee, D.-H., Lee, I.-K., Song, K., Steffes, M., Toscano, W., Baker, B.A., and Jacobs, D.R. **A strong dose-response relation between serum concentrations of persistent organic pollutants and diabetes -- Results from the National Health and Examination Survey 1999-2002.** *Diabetes Care* 29(7): 1638-1644, 2006.

Notes: OBJECTIVE - Low-level exposure to some persistent organic pollutants (POPs) has recently become a focus because of their possible link with the risk of diabetes. RESEARCH DESIGN AND METHODS - Cross-sectional associations of the serum concentrations of POPs with diabetes prevalence were investigated in 2,016 adult participants in the National Health and Nutrition Examination Survey 1999-2002. Six POPs (2,2',4,4',5,5'-hexachlorobiphenyl, 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin, 1,2,3,4,6,7,8,9-octachlorodibenzo-*p*-dioxin, oxychlordane, *p,p*'-dichlorodiphenyltrichloroethane, and *trans*-nonachlor) were selected, because they were detectable in 80% of participants. RESULTS - Compared with subjects with serum concentrations below the limit of detection, after adjustment for age, sex, race and ethnicity, poverty income ratio, BMI, and waist circumference, diabetes prevalence was strongly positively associated with lipid-adjusted serum concentrations of all six POPs. When the participants were classified according to the sum of category numbers of the six POPs, adjusted odds ratios were 1.0, 14.0, 14.7, 38.3, and 37.7 (P for trend < 0.001). The association was consistent in stratified analyses and stronger in younger participants, Mexican Americans, and obese individuals. CONCLUSIONS - There were striking dose-response relations between serum concentrations of six selected POPs and the prevalence of diabetes. The strong graded association could offer a compelling challenge to future epidemiologic and toxicological research.

Haramoto, E., Katayama, H., Oguma, K., Koibuchi, Y., Furumai, H., and Ohgaki, S. **Effects of rainfall on the occurrence of human adenoviruses, total coliforms, and *Escherichia coli* in seawater.** *Water Science and Technology* 54(3): 225-230, 2006.

Notes: A two-month survey was conducted in order to evaluate the effects of rainfall on the fate of microorganisms in seawater in the Tokyo Bay, Japan. The seawater sample (1,000 mL) was applied to a method to concentrate virus, followed by a quantification of human adenoviruses using the real-time PCR. Total coliforms and *E. coli*, which were determined by the colony forming method, were detected in all 47 seawater samples, while human adenovinuses were detected in 38 (81%) of the samples. The concentration of tested microorganisms showed 1-2 log units increase after rainfall events, followed by the gradual decrease to the level before the rainfall within a few days.

Hastein, T., Hjeltnes, B., Lillehaug, A., Skare, J.U., Berntssen, M., and Lundebye, A.K. **Food safety hazards that occur during the production stage: challenges for fish farming and the fishing industry.** *Revue scientifique et technique de l'Office international des Epizooties* 25(2): 607-625, 2006.

Notes: Seafood derived from wild fish as well as farmed fish has always been an important source of protein in the human diet. On a global scale, fish and fish products are the most important source of protein and it is estimated that more than 30% of fish for human consumption comes from aquaculture. The first part of this paper outlines the hazards and challenges associated with handling fish during farming and capture. The authors describe infectious agents that cause disease in fish as well as humans, zoonotic agents, intoxications due to bacteria and allergies caused by the consumption of fish. Although only a few infectious agents in fish are able to infect humans, some exceptions exist that may result in fatalities. However, the greatest risk to human health is due to the consumption of raw or insufficiently processed fish and fish products. The second part of the paper considers environmental contaminants in seafood that may pose a risk to human health, such as medicinal products and residues associated with aquaculture, persistent lipophilic organic compounds and metals (methyl-mercury, organotin). The authors include an updated overview of the various factors associated with farmed and captured fish that may cause risks to human health after consumption. Moreover, they discuss the challenges (in the widest sense) associated with handling fish during capture and farming, as well as those encountered during processing.

Davies, K. **Economic costs of childhood diseases and disabilities attributable to environmental contaminants in Washington State, USA.** *EcoHealth* 3(2): 86-94, 2006.

Notes: This study estimates the economic costs associated with childhood diseases and disabilities attributable to environmental contaminants in Washington State, USA, including asthma, cancer, lead exposure, birth defects, and neurobehavioral disorders. The estimates are based on "cost of illness" models that include direct healthcare costs and indirect costs. The estimates are also based on an "environmentally attributable fraction" model which quantifies the proportions of each disease or disability that can reasonably be attributed to environmental contaminants. The study concludes that the annual cost of selected childhood diseases and disabilities attributable to environmental contaminants in Washington State is $1875 million in 2004 $, comprising $310.6 million in direct healthcare costs and $1565 million in indirect costs, and with a range of $1600-$2200 million a year. These estimates are consistent with other studies. Like the previous studies, a significant proportion of the estimated costs can be attributed to lead exposure. This estimate is equivalent to about 0.7% of the total Washington Gross State Product, and the estimated direct healthcare costs are equivalent to at least 0.2% of the total Washington State health expenditures. These costs could be lessened or prevented if exposures to environmental contaminants were reduced or eliminated. This study argues for the need for an ecosystem approach to human health in which the condition of the environment, in terms of exposures to environmental contaminants, must be addressed taking a systemic perspective.

Aguirre, A.A., Gardner, S.C., Marsh, J.C., Delgado, S.G., Limpus, C.J., and Nichols, W.J. **Hazards associated with the consumption of sea turtle meat and eggs: A review for health care workers and the general public.** *EcoHealth* 3(3): 141-153, 2006.

Notes: Sea turtle products (e.g., meat, adipose tissue, organs, blood, eggs) are common food items for many communities worldwide, despite national regulations in some countries prohibiting such consumption. However, there may be hazards associated with this consumption due to the presence of bacteria, parasites, biotoxins, and environmental contaminants. Reported health effects of consuming sea turtles infected with zoonotic pathogens include diarrhea, vomiting, and extreme dehydration, which occasionally have resulted in hospitalization and death. Levels of heavy metals and organochlorine compounds measured in sea turtle edible tissues exceed international food safety standards and could result in toxic effects including neurotoxicity, kidney disease, liver cancer, and developmental effects in fetuses and children. The health data presented in this review provide information to health care providers and the public concerning the potential hazards associated with sea turtle consumption. Based on past mortality statistics from turtle poisonings, nursing mothers and children should be particularly discouraged from consuming all sea turtle products. We recommend that individuals choose seafood items lower in the food chain that may have a lower contaminant load. Dissemination of this information via a public health campaign may simultaneously improve public health and enhance sea turtle conservation by reducing human consumption of these threatened and endangered species.

Roegge, C.S. and Schantz, S.L. **Motor function following developmental exposure to PCBs and/or MeHg.** *Neurotoxicology and Teratology* 28(2): 260-277, 2006.

Notes: Recent studies raise concern for combined exposure to polychlorinated biphenyls (PCBs) and methylmercury (MeHg), two environmental contaminants that are found in fish and seafood. Past accidental poisonings in humans show that exposure to high levels of either contaminant is associated with motor impairments, including alterations in cerebellar functions such as balance and coordination. Epidemiological studies of lower level exposures suggest some neuromotor impairment in exposed children, but the majority of these studies have focused on cognitive endpoints rather than examining a full-range of motor function. In particular, the cerebellum could be a sensitive target for combined PCB and MeHg toxicity. MeHg exposure during development damages the cerebellum along with cortical areas, and PCBs may also cause cerebellar damage via thyroid hormone disruption during development. In addition, in vitro studies report interactive effects of PCBs and MeHg on ryanodine-sensitive calcium signaling. Ryanodine receptors are found especially within the cerebellum, and alterations in calcium signaling within the cerebellum could impair long-term depression and subsequent motor learning. This article reviews the motor impairments reported in humans and laboratory animals following exposure to PCBs and/or MeHg during development. There is need for a better understanding of the interactive effects of PCBs and MeHg, especially in regard to motor function.

Debes, F., Budtz-Jørgensen, E., Weihe, P., White, R.F., and Grandjean, P. **Impact of prenatal methylmercury exposure on neurobehavioral function at age 14 years.** *Neurotoxicology and Teratology* 28(3): 363-375, 2006.

Notes: A cohort of 1022 consecutive singleton births was generated during 1987-1988 in the Faroe Islands, where increased methylmercury exposure occurs from traditional seafood diets that include pilot whale meat. The prenatal exposure level was determined from mercury analyses of cord blood, cord tissue, and maternal hair. At age 14 years, 878 of 1010 living cohort members underwent detailed neurobehavioral examination. Eighteen participants with neurological disorders were excluded. Blood and hair samples obtained from the participants were analyzed for mercury. The neuropsychological test battery was designed based on the same criteria as applied at the examination at age 7 years. Multiple regression analysis was carried out and included adjustment for confounders. Indicators of prenatal methylmercury exposure were significantly associated with deficits in finger tapping speed, reaction time on a continued performance task, and cued naming. Postnatal methylmercury exposure had no discernible effect. These findings are similar to those obtained at age 7 years, and the relative contribution of mercury exposure to the predictive power of the multiple regression models was also similar. An analysis of the test score difference between results at 7 and 14 years suggested that mercury-associated deficits had not changed between the two examinations. In structural equation model analyses, the neuropsychological tests were separated into five groups; methylmercury exposure was significantly associated with deficits in motor, attention, and verbal tests. These findings are supported by independent assessment of neurophysiological outcomes. The effects on brain function associated with prenatal methylmercury exposure therefore appear to be multi-focal and permanent.

Sheehan, D.M. **No-threshold dose-response curves for nongenotoxic chemicals: Findings and applications for risk assessment.** *Environmental Research* 100(1): 93-99, 2006.

Notes: We tested the hypothesis that no threshold exists when estradiol acts through the same mechanism as an active endogenous estrogen. A Michaelis-Menten (MM) equation accounting for response saturation, background effects, and endogenous estrogen level fit a turtle sex-reversal data set with no threshold and estimated the endogenous dose. Additionally, 31 diverse literature dose-response data sets were analyzed by adding a term for nonhormonal background; good fits were obtained but endogenous dose estimations were not significant due to low resolving power. No thresholds were observed. Data sets were plotted using a normalized MM equation: all 178 data points were accommodated on a single graph. Response rates from similar to 1% to > 95% were well fit. The findings contradict the threshold assumption and low-dose safety. Calculating risk and assuming additivity of effects from multiple chemicals acting through the same mechanism rather than assuming a safe dose for nonthresholded curves is appropriate.

Schecter, A., Birnbaum, L., Ryan, J.J., and Constable, J.D. **Dioxins: An overview.** *Environmental Research* 101(3): 419-428, 2006.

Notes: This review article summarizes what is known about human health following exposure to dioxins. It is meant primarily for health professionals but was also written with the general public in mind. The need for such an article became apparent to the authors following media inquiries at the time the then Ukraine presidential candidate Victor Yushchenko was deliberately poisoned with the most toxic dioxin, tetrachlorodibenzodioxin or TCDD.

Covaci, A., Gerecke, A.C., Law, R.J., Voorspoels, S., Kohler, M., Heeb, N.V., Leslie, H., Allchin, C.R., and deBoer, J. **Hexabromocyclododecanes (HBCDs) in the environment and humans: A review.** *Environmental Science and Technology* 40(12): 3679-3688, 2006.

Notes: Hexabromocyclododecanes (HBCDs) are brominated aliphatic cyclic hydrocarbons used as flame retardants in thermal insulation building materials, upholstery textiles, and electronics. As a result of their widespread use and their physical and chemical properties, HBCDs are now ubiquitous contaminants in the environment and humans. This review summarizes HBCD concentrations in several environmental compartments and analyzes these data in terms of point sources versus diffuse sources, biomagnification potential, stereoisomer profiles, time trends, and global distribution. Generally, higher concentrations were measured in samples (air, sediment, and fish) collected near point sources (plants producing or processing HBCDs), while lower concentrations were recorded in samples from locations with no obvious sources of HBCDs. High concentrations were measured in top predators, such as marine mammals and birds of prey (up to 9600 and 19 200 ng/g lipid weight, respectively), suggesting a biomagnification potential for HBCDs. Relatively low HBCD concentrations were reported in the few human studies conducted to date (median values varied between 0.35 and 1.1 ng/g lipid weight). HBCD levels in biota are increasing slowly and seem to reflect the local market demand. One important observation is the shift from the high percentage of the g-HBCD stereoisomer in the technical products to a dominance of the a-HBCD stereoisomer in biological samples. A combination of factors such as variations in solubility, partitioning behavior, uptake, and, possibly, selective metabolism of individual isomers may explain the observed changes in stereoisomer patterns. Recommendations for further work include research on how HBCDs are transferred from products into the environment upon production, use, and disposal. Time trends need to be analyzed more in detail, including HBCD stereoisomers, and more data on terrestrial organisms are needed, especially for humans. Whenever possible, HBCDs should be analyzed as individual stereoisomers in order to address their fate and effects.

Domingo, J.L., Bocio, A., Falco, G., and Llobet, J.M. **Exposure to PBDEs and PCDEs associated with the consumption of edible marine species.** *Environmental Science and Technology* 40(14): 4394-4399, 2006.

Notes: In the present study, the concentrations of PBDEs and PCDEs were determined in 14 edible marine species widely consumed by the population of Catalonia (Spain). The daily intake of PBDEs and PCDEs associated with this consumption was also determined. A total of 42 composite samples were analyzed by HRGC/HRMS. The highest PBDE levels (ng/kg wet weight) were found in salmon (2015) followed by mackerel, swordfish, and red mullet (1124, 978, and 769, respectively), while those of PCDEs (ng/kg wet weight) were detected in red mullet (7088) followed by sardine (1829), anchovy (1606), tuna (1292), and mackerel (1031). For a standard male adult, total PBDE and PCDE intakes through edible marine species were 20.8 and 39.4 ng/day, respectively. The highest contributions to these intakes (ng/day) corresponded to the consumption of tuna (5.7), salmon (3.6), and hake (3.5) for PBDEs, and tuna (13.1), hake (7.3), and sardine (6.9) for PCDEs. Although currently there is not evidence of the dioxin-like behavior of PBDEs, further research is necessary to assess if long-term exposure to PBDEs, mainly through the diet, may mean adverse effects to humans. With respect to PCDE congeners, to establish TEF values would be of great value to evaluate human health risks.

Given, S., Pendleton, L.H., and Boehm, A.B. **Regional public health cost estimates of contaminated coastal waters: A case study of gastroenteritis at southern California beaches.** *Environmental Science and Technology* 40(16): 4851-4858, 2006.

Notes: We present estimates of annual public health impacts, both illnesses and cost of illness, attributable to excess gastrointestinal illnesses caused by swimming in contaminated coastal waters at beaches in southern California. Beach-specific

enterococci densities are used as inputs to two epidemiological dose-response models to predict the risk of gastrointestinal illness at 28 beaches spanning 160 km of coastline in Los Angeles and Orange Counties. We use attendance data along with the health cost of gastrointestinal illness to estimate the number of illnesses among swimmers and their likely economic impact. We estimate that between 627,800 and 1,479,200 excess gastrointestinal illnesses occur at beaches in Los Angeles and Orange Counties each year. Using a conservative health cost of gastroenteritis, this corresponds to an annual economic loss of $21 or $51 million depending upon the underlying epidemiological model used (in year 2000 dollars). Results demonstrate that improving coastal water quality could result in a reduction of gastrointestinal illnesses locally and a concurrent savings in expenditures on related health care costs.

Giwercman, A., Rignell-Hydbom, A., Toft, G., Rylander, L., Hagmar, L., Lindh, C., Pedersen, H. S., Ludwicki, J.K., Lesovoy, V., Shvets, M., Spano, M., Manicardi, G.C., Bizzaro, D., Bonefeld-Jorgensen, E.C., and Bonde, J.P. **Reproductive hormone levels in men exposed to persistent organohalogen pollutants: A study of Inuit and three European cohorts.** *Environmental Health Perspectives* 114(9): 1348-1353, 2006.

Notes: OBJECTIVE: Persistent organohalogen pollutant (POP) exposure may have a negative impact on reproductive function. The objective of this study was to assess the impact of POP exposure on the male hypothalamo-pituitary-gonadal axis. PARTICIPANTS: Participants included 184 Swedish fishermen and spouses of pregnant women from Greenland (*n* = 258), Warsaw, Poland (*n* = 113), and Kharkiv, Ukraine (*n* = 194). EVALUATIONS/MEASUREMENTS: Serum levels of 2,2',4,4',5,5'-hexachlorobiphenyl (CB-153) and dichlorodiphenyl dichloroethene (p,p'-DDE) were determined in the four populations, showing different exposure patterns: Swedish fishermen, high CB-153/low p,p'-DDE; Greenland, high CB-153/high p,p'-DDE; Warsaw, low CB-153/moderate p,p'-DDE; Kharkiv, low CB-153/high p,p'-DDE. Serum was also analyzed for testosterone, estradiol sex hormone-binding globulin (SHBG), inhibin B, luteinizing hormone (LH), and follicle-stimulating hormone (FSH). Free testosterone levels were calculated based on testosterone and SHBG. RESULTS: We found significant center-to-center variations in the associations between exposure and the outcomes. The most pronounced effects were observed in Kharkiv, where statistically significant positive associations were found between the levels of both CB-153 and p,p'-DDE and SHBG, as well as LH. In Greenland, there was a positive association between CB-153 exposure and LH. In the pooled data set from all four centers, there was positive association between p,p'-DDE and FSH levels [b = 1.1 IU/L; 95% confidence interval (CI), 1.0-1.1 IU/L]. The association between CB-153 levels and SHBG was of borderline statistical significance (b = 0.90 nmol/ L; 95% CI, -0.04 to 1.9 nmol/L). CONCLUSIONS: Gonadotropin levels and SHBG seem to be affected by POP exposure, but the pattern of endocrine response is the subject of considerable geographic variation.

Weiss, B. and Bellinger, D.C. **Social ecology of children's vulnerability to environmental pollutants.** *Environmental Health Perspectives* 114(10): 1479-1485, 2006.

Notes: BACKGROUND: The outcomes of exposure to neurotoxic chemicals early in life depend on the properties of both the chemical and the host's environment. When our questions focus on the toxicant, the environmental properties tend to be regarded as marginal and designated as covariates or confounders. Such approaches blur the reality of how the early environment establishes enduring biologic substrates. OBJECTIVES: In this commentary, we describe another perspective, based on decades of biopsychological research on animals, that shows how the early, even prenatal, environment creates permanent changes in brain structure and chemistry and behavior. Aspects of the early environment-encompassing enrichment, deprivation, and maternal and neonatal stress-all help determine the functional responses later in life that derive from the biologic substrate imparted by that environment. Their effects then become biologically embedded. Human data, particularly those connected to economically disadvantaged populations, yield equivalent conclusions. DISCUSSION: In this commentary, we argue that treating such environmental conditions as confounders is equivalent to defining genetic differences as confounders, a tactic that laboratory research, such as that based on transgenic manipulations, clearly rejects. The implications extend from laboratory experiments that, implicitly, assume that the early environment can be standardized to risk assessments based on epidemiologic investigations. CONCLUSIONS: The biologic properties implanted by the early social environment should be regarded as crucial elements of the translation from laboratory research to human health and, in fact, should be incorporated into human health research. The methods for doing so are not clearly defined and present many challenges to investigators.

Schecter, A., Papke, O., Harris, T.R., Tung, K.C., Musumba, A., Olson, J., and Birnbaum, L. **Polybrominated diphenyl ether (PBDE) levels in an expanded market basket survey of US food and estimated PBDE dietary intake by age and sex.** *Environmental Health Perspectives* 114(10): 1515-1520, 2006.

Notes: OBJECTIVES: Our objectives in this study were to expand a previously reported U.S. market basket survey using a larger sample size and to estimate levels of PBDE intake from food for the U.S. general population by sex and age. METHODS: We measured concentrations of 13 polybrominated diphenyl ether (PBDE) congeners in food in 62 food samples. In addition, we estimated levels of PBDE intake from food for the U.S. general population by age (birth through >/= 60 years of age) and sex. RESULTS: In food samples, concentrations of total PBDEs varied from 7.9 pg/g (parts per trillion) in milk to 3,726 pg/g in canned sardines. Fish were highest in PBDEs (mean, 1,120 pg/g; median, 616 pg/g; range, 11.14-3,726 pg/g). This was followed by meat (mean, 383 pg/g; median, 190 pg/g; range, 39-1,426 pg/g) and dairy products (mean, 116 pg/g; median, 32.2 pg/g; range, 7.9-683 pg/g). However, using estimates for food consumption (excluding nursing infants), meat accounted for the highest U.S. dietary PBDE intake, followed by dairy and fish, with almost equal contributions. Adult females had lower dietary intake of PBDEs than did adult males, based on body weight. We estimated PBDE intake from food to be 307 ng/kg/day for nursing infants and from 2 ng/kg/day at 2-5 years of age for both males and females to 0.9 ng/kg/day in adult females. CONCLUSION: Dietary exposure alone does not appear to account for the very high body burdens measured. The indoor environment (dust, air) may play an important role in PBDE body burdens in addition to food.

Lanphear, B.A., Paulson, J., and Beirne, S. **Trials and tribulations of protecting children from environmental hazards.** *Environmental Health Perspectives* 114(10): 1609-1612, 2006.

Notes: Society is increasingly aware of the profound impact that the environment has on children's health. Not surprisingly, there is increasing public scrutiny about children's exposures to environmental hazards, especially for disadvantaged children. These trends underscore the ethical imperative to develop a framework to protect children from environmental hazards. Such a framework must include regulations to test new chemicals and other potential hazards before they are marketed, a strategy to conduct research necessary to protect children from persistent hazards that are widely dispersed in their environment, stronger regulatory mechanisms to eliminate human exposures to recognized or suspected toxicants, and guidelines about the ethical conduct of research and the role of experimental trials that test the efficacy and safety of interventions to prevent or ameliorate children's exposure to persistent toxicants or hazards that are widely dispersed in their environment.
