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Marine Science Review – 205

Human health

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In this review:

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

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Dewailly, É. and Knap, A. **Food from the oceans and human health: Balancing risks and benefits.** *Oceanography* 19(2): 84-93, 2006.

Dufour, A.P. and Wymer, L.J. **Microbes, monitoring, and human health.** *Oceanography* 19(2): 72-80, 2006.

B. Recent articles with abstracts

Mozaffarian, D. and Rimm, E.B. **Fish intake, contaminants, and human health: Evaluating the risks and the benefits.** *Journal of the American Medical Association* 296(15): 1885-1899, 2006.

Notes: *Context* Fish (finfish or shellfish) may have health benefits and also contain contaminants, resulting in confusion over the role of fish consumption in a healthy diet. *Evidence Acquisition* We searched MEDLINE, governmental reports, and meta-analyses, supplemented by hand reviews of references and direct investigator contacts, to identify reports published through April 2006 evaluating (1) intake of fish or fish oil and cardiovascular risk, (2) effects of methyl-mercury and fish oil on early neurodevelopment, (3) risks of methylmercury for cardiovascular and neurologic outcomes in adults, and (4) health risks of dioxins and polychlorinated biphenyls in fish. We concentrated on studies evaluating risk in humans, focusing on evidence, when available, from randomized trials and large prospective studies. When possible, meta-analyses were performed to characterize benefits and risks most precisely. *Evidence Synthesis* Modest consumption of fish (eg, 1-2 servings/wk), especially species higher in the n-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), reduces risk of coronary death by 36% (95% confidence interval, 20%-50%; $P<.001$) and total mortality by 17% (95% confidence interval, 0%-32%; $P=.046$) and may favorably affect other clinical outcomes. Intake of 250 mg/d of EPA and DHA appears sufficient for primary prevention. DHA appears beneficial for, and low-level methylmercury may adversely affect, early neurodevelopment. Women of childbearing age and nursing mothers should consume 2 seafood servings/wk, limiting intake of selected species. Health effects of low-level methylmercury in adults are not clearly established; methylmercury may modestly decrease the cardiovascular benefits of fish intake. A variety of seafood should be consumed; individuals with very high consumption (≥5 servings/wk) should limit intake of species highest in mercury levels. Levels of dioxins and polychlorinated biphenyls in fish are low, and potential carcinogenic and other effects are outweighed by potential benefits of fish intake and should have little impact on choices or consumption of seafood (women of childbearing age should consult regional advisories for locally caught freshwater fish). *Conclusions* For major health outcomes among adults, based on both the strength of the evidence and the potential magnitudes of effect, the benefits of fish intake exceed the potential risks. For women of childbearing age, benefits of modest fish intake, excepting a few selected species, also outweigh risks.

Schecter, A., Johnson-Welch, S., Tung, K.C., Harris, T.R., Papke, O., and Rosen, R. **Polybrominated diphenyl ether (PBDE) levels in livers of US human fetuses and newborns.** *Journal of Toxicology and Environmental Health Part A* 70(1): 1-6,

2007.

Notes: Polybrominated diphenyl ether (PBDE) brominated flame retardants have recently been found to contaminate humans in the United States and other countries. U.S. human breast milk and blood levels of PBDEs are presently the highest in the world. U.S. cord blood samples tested positive for PBDEs, but until now there have been no peer-reviewed published data concerning levels of PBDEs in human tissue prior to and immediately after birth. Liver tissues were obtained from 4 stillborn fetuses and 7 liveborn infants, ranging from 20.5 to 39 wk gestational age; only 2 of the liveborn infants lived longer than 4 h and none were formula-fed or nursed, so tissue levels reflect intrauterine PBDE intake only. All samples were contaminated with PBDEs. Levels varied from 4 to 98 ppb, lipid. The mean level was 23.1 and the median 15.2 ppb, lipid. PBDE levels did not increase with gestational age. These data document the transfer of PBDEs from maternal to fetal tissue. PBDE concentrations are somewhat lower than those reported in adult blood or breast milk. The health consequences of prenatal contamination are not clear at present.

Ritter, L., Goushleff, N.C.I., Arbuckle, T., Cole, D., and Raizenne, M. **Addressing the linkage between exposure to pesticides and human health effects - Research trends and priorities for research.** *Journal of Toxicology and Environmental Health Part B* 9(6): 441-456, 2006.

Notes: In recent years, there has been escalating concern over the possible association between exposure to pesticides and adverse human health effects by a number of non-governmental organizations, professional and public interest groups. Recognizing the need to document the scientific basis of these concerns as a foundation for initiating a research theme devoted to linkages between exposures to pesticides and human health effects, the Canadian Institutes of Health Research (CIHR) requested a summary of recent research trends that address these linkages. Experts across Canada in the field of pesticide regulation and research were invited to participate in the review. The review summarizes the limitations of past and current studies related to pesticides and human health effects research and makes suggestions for future research priorities and proposed study designs that will improve the assessment of pesticide exposure, the associated health risks, and improved methodology for regulatory decision making.

Yang, M.H., Park, M.S., and Lee, H.S. **Endocrine disrupting chemicals: Human exposure and health risks.** *Journal of Environmental Science and Health Part C - Environmental Carcinogenesis and Ecotoxicology Reviews* 24(2): 183-224, 2006.

Notes: Endocrine disrupting chemicals (EDCs) have been emphasized due to their threats in fertility, intelligence, and survival. For the last decade, many researchers have investigated EDC-health outcome. However, EDC responses in human were not clearly clarified through experimental and epidemiological data. Therefore, considering particular status of EDC endpoints, we suggest that one of the best ways to prevent unknown health risks from EDCs is to perform exposure monitoring or to do surveillance for EDC release into the environment. For this purpose, this review considers exposure status of EDCs, and EDC-related health risks, focusing on the mainly highlighted EDCs, such as dioxins/PCBs, DDT/DDE, bisphenol A, phthalates, alkylphenols, and phytoestrogens. We also reviewed tobacco, a mixed source of EDC-related endocrine disorders.

Li, Z., Dong, T., Pröschel, C., and Noble, M. **Chemically diverse toxicants converge on Fyn and c-Cbl to disrupt precursor cell function.** *PLoS Biology* 5(2): art. e35, 2007.

Notes: Identification of common mechanistic principles that shed light on the action of the many chemically diverse toxicants to which we are exposed is of central importance in understanding how toxicants disrupt normal cellular function and in developing more effective means of protecting against such effects. Of particular importance is identifying mechanisms operative at environmentally relevant toxicant exposure levels. Chemically diverse toxicants exhibit striking convergence, at environmentally relevant exposure levels, on pathway-specific disruption of receptor tyrosine kinase (RTK) signaling required for cell division in central nervous system (CNS) progenitor cells. Relatively small toxicant-induced increases in oxidative status are associated with Fyn kinase activation, leading to secondary activation of the c-Cbl ubiquitin ligase. Fyn/c-Cbl pathway activation by these pro-oxidative changes causes specific reductions, in vitro and in vivo, in levels of the c-Cbl target platelet-derived growth factor receptor-*a* and other c-Cbl targets, but not of the TrkC RTK (which is not a c-Cbl target).

Sequential Fyn and c-Cbl activation, with consequent pathway-specific suppression of RTK signaling, is induced by levels of methylmercury and lead that affect large segments of the population, as well as by paraquat, an organic herbicide. Our results identify a novel regulatory pathway of oxidant-mediated Fyn/c-Cbl activation as a shared mechanism of action of chemically diverse toxicants at environmentally relevant levels, and as a means by which increased oxidative status may disrupt mitogenic signaling. These results provide one of a small number of general mechanistic principles in toxicology, and the only such principle integrating toxicology, precursor cell biology, redox biology, and signaling pathway analysis in a predictive framework of broad potential relevance to the understanding of pro-oxidant-mediated disruption of normal development.

Fleming, L.E., Broad, K., Clement, A., Dewailly, E., Elmir, S., Knap, A., Pomponi, S.A., Smith, S., Gabriele, H.S., and Walsh, P. **Oceans and human health: Emerging public health risks in the marine environment.** *Marine Pollution Bulletin* 53(10-12): 545-560, 2006.

Notes: There has been an increasing recognition of the inter-relationship between human health and the oceans. Traditionally, the focus of research and concern has been on the impact of human activities on the oceans, particularly through anthropogenic pollution and the exploitation of marine resources. More recently, there has been recognition of the potential direct impact of the oceans on human health, both detrimental and beneficial. Areas identified include: global change, harmful algal blooms (HABs), microbial and chemical contamination of marine waters and seafood, and marine models and natural products from the seas. It is hoped that through the recognition of the inter-dependence of the health of both humans and the oceans, efforts will be made to restore and preserve the oceans.

Karouna-Renier, N.K., Snyder, R.A., Allison, J.G., Wagner, M.G., and Rao, K.R. **Accumulation of organic and inorganic contaminants in shellfish collected in estuarine waters near Pensacola, Florida: Contamination profiles and risks to human consumers.** *Environmental Pollution* 145(2): 474-488, 2007.

Notes: We conducted a screening level assessment of contaminants in blue crabs (*Callinectes sapidus*) and oysters (*Crassostrea virginica*) from bays and bayous in the Pensacola, FL area. Tissue samples were analyzed for 17 dioxins/furans, 12 dioxin-like PCB (DL-PCBs) congeners, mercury, and various metals. Contaminant levels were compared to screening values (SV) calculated using U.S. EPA recommendations for establishing consumption advisories. All sampling locations exceeded the SV (0.098 pg g^{-1}) for dioxins/furans/DL-PCBs, based on a Florida-specific consumption rate (46 g day^{-1}). Arsenic (inorganic), mercury, cadmium, and zinc levels exceeded SVs in samples from select locations, and with the exception of mercury, these locations were generally downstream of known contaminated areas. We also assessed potential human health risks from consumption of these species. Risks to human health were greatest from consumption of crab hepatopancreas, suggesting that consumption of hepatopancreas, whether directly or indirectly, from crabs collected anywhere in the Pensacola Bay region should be avoided.

Mergler, D., Anderson, H.A., Hing Man Chan, L., Mahaffey, K.R., Murray, M., Sakamoto, M., and Stern, A.H. **Methylmercury exposure and health effects in humans: A worldwide concern.** *Ambio* 36(1): 3-11, 2007.

Notes: The paper builds on existing literature, highlighting current understanding and identifying unresolved issues about MeHg exposure, health effects, and risk assessment, and concludes with a consensus statement. Methylmercury is a potent toxin, bioaccumulated and concentrated through the aquatic food chain, placing at risk people, throughout the globe and across the socioeconomic spectrum, who consume predatory fish or for whom fish is a dietary mainstay. Methylmercury developmental neurotoxicity has constituted the basis for risk assessments and public health policies. Despite gaps in our knowledge on new bioindicators of exposure, factors that influence MeHg uptake and toxicity, toxicokinetics, neurologic and cardiovascular effects in adult populations, and the nutritional benefits and risks from the large number of marine and freshwater fish and fish-eating species, the panel concluded that to preserve human health, all efforts need to be made to reduce and eliminate sources of exposure.

Swain, E.B., Jakus, P.M., Rice, G., Lupi, F., Maxson, P.A., Pacyna, J.M., Penn, A., Spiegel, S.J., and Veiga, M.M. **Socioeconomic consequences of mercury use and pollution.** *Ambio* 36(1): 45-61, 2007.

Notes: In the past, human activities often resulted in mercury releases to the biosphere with little consideration of undesirable consequences for the health of humans and wildlife. This paper outlines the pathways through which humans and wildlife are exposed to mercury. Fish consumption is the major route of exposure to methylmercury. Humans can also receive toxic doses of mercury through inhalation of elevated concentrations of gaseous elemental mercury. We propose that any effective strategy for reducing mercury exposures requires an examination of the complete life cycle of mercury. This paper examines the life cycle of mercury from a global perspective and then identifies several approaches to measuring the benefits of reducing mercury exposure, policy options for reducing Hg emissions, possible exposure reduction mechanisms, and issues associated with mercury risk assessment and communication for different populations.

Grandjean, P. and Landrigan, P. **Developmental neurotoxicity of industrial chemicals.** *The Lancet* 368(9553): 2167-2178, 2006.

Notes: Neurodevelopmental disorders such as autism, attention deficit disorder, mental retardation, and cerebral palsy are common, costly, and can cause lifelong disability. Their causes are mostly unknown. A few industrial chemicals (eg, lead, methylmercury, polychlorinated biphenyls [PCBs], arsenic, and toluene) are recognised causes of neurodevelopmental disorders and subclinical brain dysfunction. Exposure to these chemicals during early fetal development can cause brain injury at doses much lower than those affecting adult brain function. Recognition of these risks has led to evidence-based programmes of prevention, such as elimination of lead additives in petrol. Although these prevention campaigns are highly successful, most were initiated only after substantial delays. Another 200 chemicals are known to cause clinical neurotoxic effects in adults. Despite an absence of systematic testing, many additional chemicals have been shown to be neurotoxic in laboratory models. The toxic effects of such chemicals in the developing human brain are not known and they are not regulated to protect children. The two main impediments to prevention of neurodevelopmental deficits of chemical origin are the great gaps in testing chemicals for developmental neurotoxicity and the high level of proof required for regulation. New, precautionary approaches that recognise the unique vulnerability of the developing brain are needed for testing and control of chemicals.

Hibbeln, J.R., Davis, J.M., Steer, C., Emmett, P., Rogers, I., Williams, C., and Golding, J. **Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study.** *The Lancet* 369(9561): 578-585, 2007.

Notes: **Background** Seafood is the predominant source of omega-3 fatty acids, which are essential for optimum neural development. However, in the USA, women are advised to limit their seafood intake during pregnancy to 340 g per week. We used the Avon Longitudinal Study of Parents and Children (ALSPAC) to assess the possible benefits and hazards to a child's development of different levels of maternal seafood intake during pregnancy. **Methods** 11875 pregnant women completed a food frequency questionnaire assessing seafood consumption at 32 weeks' gestation. Multivariable logistic regression models including 28 potential confounders assessing social disadvantage, perinatal, and dietary items were used to compare developmental, behavioural, and cognitive outcomes of the children from age 6 months to 8 years in women consuming none, some (1-340 g per week), and >340 g per week. **Findings** After adjustment, maternal seafood intake during pregnancy of less than 340 g per week was associated with increased risk of their children being in the lowest quartile for verbal intelligence quotient (IQ) (no seafood consumption, odds ratio [OR] 1·48, 95% CI 1·16-1·90; some, 1·09, 0·92-1·29; overall trend, p=0·004), compared with mothers who consumed more than 340 g per week. Low maternal seafood intake was also associated with increased risk of suboptimum outcomes for prosocial behaviour, fine motor, communication, and social development scores. For each outcome measure, the lower the intake of seafood during pregnancy, the higher the risk of suboptimum developmental outcome. **Interpretation** Maternal seafood consumption of less than 340 g per week in pregnancy did not protect children from adverse outcomes; rather, we recorded beneficial effects on child development with maternal seafood intakes of more than 340 g per week, suggesting that advice to limit seafood consumption could actually be detrimental. These results show that risks from the loss of nutrients were greater than the risks of harm from exposure to trace contaminants in 340 g seafood eaten weekly.

Gomara, B., Herrero, L., and Gonzalez, M.J. **Survey of polybrominated diphenyl ether levels in Spanish commercial foodstuffs.** *Environmental Science and Technology* 40(24): 7541-7547, 2006.

Notes: Concentrations of 15 BDEs flame retardants have been determined in a large variety of food samples purchased in different markets across Spain. This is the first time that BDEs 184, 191, 196, and 197; impurities from BDEs formulations; and/or degradation products of BDE 209, have been detected in foodstuffs. Values ranged from < 0.01 to 2482 pg/g fresh weight. The highest total BDE concentrations were found in fish samples (median of 189, range of 24-880 pg/g f.w.), followed by oils (median of 119, range of 14.8-2958 pg/g f.w.), meats (median of 75.9, range of 6.82-2518 pg/g f.w.), shellfish (median of 75.7, range of 3.29-677 pg/g f.w.), eggs (median of 73.5, range of 12.8-557 pg/g f.w.), and dairy products (median of 66.1, range of 3.24-1588 pg/g f.w.). The total BDE values found in this study are consistent with research reported elsewhere. They are in the same range as those recently reported by other European and Asian studies and lower than those conducted in the U.S. BDE 47 was the predominant congener in fish, shellfish, dairy products (except butter), and meats, while BDE 209 was the predominant in oil and egg samples. The most remarkable findings in this study were the large contribution of the highest brominated BDEs (hepta- to deca-BDE), and principally BDE 209, to the total BDE concentration found in Spanish foods, except fish and shellfish, and the presence of BDE 184, 191, 196, and 197 in many of the samples. The calculated intake of 38.5 ng/day of BDEs was comparable to intake assessment from other UE countries.

Ikonomou, M.G., Higgs, D.A., Gibbs, M., Oakes, J., Skura, B., McKinley, S., Balfry, S.K., Jones, S., Withler, R., and Dubetz, C. **Flesh quality of market-size farmed and wild British Columbia salmon.** *Environmental Science and Technology* 41(2): 437-443, 2007.

Notes: This study compared the flesh quality of farmed and wild sources of British Columbia (BC) salmon with respect to concentrations of polychlorinated biphenyl compounds, polychlorinated dibenzodioxins/dibenzofurans and their associated toxic equivalents, total mercury (THg), methylmercury (MeHg), and selected fatty acids of known importance for human health viz., omega-3 (n-3) highly unsaturated fatty acids (n-3 HUFAs) and (n-6) fatty acids. Skinned fillets from known sources of farmed Atlantic, coho, and chinook salmon (n = 110) and wild coho, chinook, chum, sockeye, and pink salmon (n = 91) were examined. Atlantic salmon contained higher PCB concentrations (means, 28-38 ng/g) than farmed coho or chinook salmon, and levels in these latter species were similar to those in wild counterparts (means, 2.8-13.7 ng/g). PCB levels in Atlantic salmon flesh were, nevertheless, 53-71-fold less than the level of concern for human consumption of fish, i.e., 2000 ng/g as established by Health Canada and the U.S. Food and Drug Administration (US-FDA). Similarly, THg and MeHg levels in all samples were well below the Health Canada guideline (0.5 μg/g) and the US-FDA action level (1.0 μg/g). On average, THg in farmed salmon (0.021 μg/g) was similar to or lower than wild salmon (0.013-0.077 μg/g). Atlantic salmon were a richer source (mean, 2.34 g/100 g fillet) of n-3 HUFAs than the other farmed and wild sources of salmon examined (means, 0.39-1.17 g/100 g). The present findings support the recommended weekly consumption guidelines for oily fish species (includes all BC salmon sources) for cardio-protective benefits as made by the American Heart Association and the UK Food Standards Agency.

Gourmelon, M., Montet, M.P., Lozach, S., Le Mennec, C., Pommepuy, M., Beutin, L., and Vernozy-Rozand, C. **First isolation of Shiga toxin 1d producing *Escherichia coli* variant strains in shellfish from coastal areas in France.** *Journal of Applied Microbiology* 100(1): 85-97, 2006.

Notes: ***Aims***: This study was carried out to evaluate the presence of Shiga toxin-producing *Escherichia coli* (STEC) and *E.coli* O157:H7 in shellfish from French coastal environments. ***Methods and Results***: Shellfish were collected in six growing areas or natural beds (B category) and nonfarming areas (D category) from July 2002 to August 2004. PCR detection of *stx* genes was performed on homogenized whole shellfish and digestive gland tissues enrichments. STEC strains were detected by colony DNA hybridization using a *stx*-specific gene probe and *E.coli* O157 strains were additionally searched by immunomagnetic separation with O157-specific magnetic beads. *Stx* genes were detected in 40 of 144 (27·8%) sample enrichments from mussels, oysters or cockles, 32 of 130 enrichments (24·6%) were from B-category areas and eight of 14 (57·1%) from the D-category area. Five strains carrying *stx*1 or *stx*1*d* genes and one *stx* negative, *eae* and *ehxA* positive *E.coli* O157:H7 were isolated from six of 40 *stx*-positive enrichments. No relation was found between the total *E.coli* counts in shellfish and the presence of STEC strains in the samples. ***Conclusions***: The STEC strains of different serotypes and *stx* types are present in shellfish from French coastal environments. It is the first isolation of STEC *stx1d* strains in France.

Significance and Impact of the Study: Shellfish collected in coastal environments can serve as a vehicle for STEC transmission.

Kirby-Smith, W.W. and White, N.M. **Bacterial contamination associated with estuarine shoreline development.** *Journal of Applied Microbiology* 100(4): 648-657, 2006.

Notes: ***Aims***: To examine the relationships among increasing estuarine shellfish closings due to bacterial contamination, adjacent shoreline land uses and environmental variables. ***Methods and Results***: A 1 year study of faecal coliform bacterial contamination of a small estuary in central NC, USA was done relative to adjacent land uses. The area has experienced rapid growth in residential shoreline development including the installation of adjacent, separate docking facilities for larger boats, each <11 slips (pseudomarina) that appear to be a single marina (individual facilities of >10 slips). Six near-shore sites were selected [old developed shore (OD), undeveloped shore (UD), two pseudomarinas (P1, P2), newly developed shore (ND) and a real marina (RM)]. Five locations were spaced along the shore near each site. Paired Thursday/Monday samples were collected biweekly (summer) and monthly (other seasons). Results indicate that OD had the highest bacteria counts followed by ND, RM and P1 & P2. Three sites (OD, ND and RM) failed to meet NC shellfishing waters standards at all locations. At the pseudomarina sites 4 of 10 locations failed to meet shellfish standards while two locations at UD failed to meet these standards. There were no significant differences between paired Thursday/Monday samples. At three sites (OD, UD and P2) bacteria counts were positively correlated with increased water level due to wind tides. ***Conclusions***: Any type of estuarine shoreline development may result in closing of adjacent shellfishing waters. ND had bacterial counts second only to OD in spite of the retention of vegetated shoreline buffers and very new septic systems. As expected, the RM also failed to meet shellfish standards. Unexpectedly, only four of the 10 pseudomarina locations failed to meet the standards. Weekend boat use had no effect on bacterial counts. Surface runoff from rain and shoreline flooding from increased water levels increased bacterial counts, probably as a result of suspension of surface deposited faeces from wildlife and domestic animals. ***Significance and Impact of the Study***: Multiple docking facilities do not necessarily result in violations of shellfish water quality standards. However, the elevated bacterial counts observed along the newly developed shore suggest caution in approving the practice of allowing individual 'oyster gardening' off private piers if the oysters are intended for human consumption. The practice of automatic closure of shellfish waters around RMs was supported. Correlations of bacterial counts with time following significant rainfall suggests a sampling strategy to separate local sources of bacteria from more remote sources thus focusing limited remedial resources more effectively.

Whelan, J. and Rust, C. **Innovative dietary sources of N-3 fatty acids.** *Annual Review of Nutrition* 26: 75-103, 2006.

Notes: It is now established that dietary n-3 polyunsaturated fatty acids (PUFAs) are involved in health promotion and disease prevention, particularly those traditionally derived from marine sources (e.g., eicosapentaenoic acid and docosahexaenoic acid). A number of organizations have made specific recommendations for the general population to increase their intakes of these nutrients. In response to and along with these recommendations, n-3 PUFAs are being incorporated into nontraditional food sources because of advances in the technology to safely enrich/fortify our food supply. Fatty acid compositions of traditional oils (e.g., canola and soybean) are being genetically modified to deliver more highly concentrated sources of n-3 PUFA. The advent of algal sources of docosahexaenoic acid provides one of the few terrestrial sources of this fatty acid in a concentrated form. All of this is possible because of newer technologies (microencapsulation) and improved processing techniques that ensure stability and preserve the integrity of these unstable fatty acids.

Fritsche, K. **Fatty acids as modulators of the immune response.** *Annual Review of Nutrition* 26: 45-73, 2006.

Notes: Research describing fatty acids as modulators of inflammation and immune responses abounds. Many of these studies have focused on one particular group of fatty acids, omega-3. The data from animal studies have shown that these fatty acids can have powerful anti-inflammatory and immunomodulatory activities in a wide array of diseases (e.g., autoimmunity, arthritis, and infection). However, the evidence from human trials is more equivocal. In this review, a historical framework for understanding how and why fatty acids may affect the immune system is provided. Second, highlights of two recent landmark reports from the Agency for Healthcare Research and Quality are presented. These reports critically evaluate the evidence from human clinical trials of omega-3 fatty acids and rheumatoid arthritis, asthma, and a few other immune-mediated diseases.

Third, the data from human clinical trials investigating the impact of various bioactive fatty acids on ex vivo and in vivo immune response are reviewed. Limitations in experimental design and immune assays commonly used are discussed. The discordance between expectation and evidence in this field has been a disappointment. Recommendations for improving both animal-based and human studies are provided.

Akutsu, K., Tanaka, Y., and Hayakawa, K. **Occurrence of polybrominated diphenyl ethers and polychlorinated biphenyls in shark liver oil supplements.** *Food Additives and Contaminants* 23(12): 1323-1329, 2006.

Notes: Results are reported of a pilot survey of concentrations of polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) in shark liver oil supplements. Eleven brands of dietary supplements were analysed using an isotope dilution GC/MS method. Total concentrations of 10 PBDE congeners (BDE-28, -47, -49, -66, - 99, -100, -153, -154, -155 and -183) ranged from 0.1 to 53 ng g^{-1} oil weight and total concentrations of six PCB congeners (CB-28/31, - 52, -118, -153 and -180) in the samples ranged from 16 to 340 ng g^{-1} oil weight (undetected values are not included). Two brands of Japanese deep-sea shark liver oil contained the highest levels of PBDEs (49-53 ng g^{-1} oil weight) and PCBs (290-340 ng g^{-1} oil weight). These results indicate that PBDEs may have entered Japanese deep-sea waters.

Tittlemier, S.A., Van de Riet, J., Burns, G., Potter, R., Murphy, C., Rourke, W., Pearce, H., and Dufresne, G. **Analysis of veterinary drug residues in fish and shrimp composites collected during the Canadian Total Diet Study, 1993-2004.** *Food Additives and Contaminants* 24(1): 14-20, 2007.

Notes: Thirty shrimp, marine fish, freshwater fish, and canned fish composite samples collected and prepared as part of the Canadian Total Diet Study were analysed for 39 different veterinary drug residues. The analyses were undertaken to obtain baseline data that could be used to estimate the dietary exposure of Canadians to these residues. The most frequently observed residue was AOZ (four out of 30 samples), the metabolite of furazolidone, at a range of 0.50 to 2.0 ng g^{-1} wet weight. Other residues detected included enrofloxacin (three samples; 0.3-0.73 ng g^{-1}), leucomalachite green (three samples; 0.73-1.2 ng g^{-1}), oxolinic acid (two samples; 0.3- 4.3 ng g^{-1}), AMOZ (the metabolite of furaltadone; one sample; 0.40 ng g^{-1}), chloramphenicol (one sample; 0.40 ng g^{-1}), and SEM (the metabolite of nitrofurazone; one sample; 0.8 ng g^{-1}). The results of this survey indicate that Canadians are exposed to low ng g^{-1} concentrations of some banned and unapproved veterinary drug residues via the consumption of certain fish and shrimp.

Stewart, P.W., Sargent, D.M., Reihman, J., Gump, B.B., Lonky, E., Darvill, T., Hicks, H., and Pagano, J. **Response inhibition during differential reinforcement of low rates (DRL) schedules may be sensitive to low-level polychlorinated biphenyl, methylmercury, and lead exposure in children.** *Environmental Health Perspectives* 114(12): 1923-1929, 2006.

Notes: BACKGROUND: Animal studies have shown that exposure to common, low-level environmental contaminants [e.g., polychlorinated biphenyls (PCBs), lead] causes excessive and inappropriate responding on intermittent reinforcement schedules. The Differential Reinforcement of Low Rates task (DRL) has been shown to be especially sensitive to low-level PCB exposure in monkeys. OBJECTIVES: We investigated the relationships between prenatal PCB and postnatal Pb exposure performance on a DRL schedule in children. We predicted that a) prenatal PCB exposure would reduce interresponse times (IRTs) and reinforcements earned, and b) postnatal Pb exposure would reduce IRTs and reinforcements earned. METHODS: We tested 167 children on a DRL20 (20 sec) reinforcement schedule, and recorded IRTs and the number of reinforced responses across the session. We measured prenatal PCB exposure (cord blood), methylmercury (MeHg) (maternal hair), and postnatal Pb exposure (venous blood), and > 50 potentially confounding variables. RESULTS: Results indicated impaired performance in children exposed to PCBs, MeHg and Pb. Children prenatally exposed to PCBs responded excessively, with significantly lower IRTs and fewer reinforcers earned across the session. In addition, exposure to either MeHg or Pb predicted statistically significant impairments of a similar magnitude to those for PCBs, and the associated impairments of all three contaminants (PCB, MeHg, and Pb) were statistically independent of one another. CONCLUSIONS: These results, taken with animal literature, argue the high sensitivity of DRL performance to low-level PCB, MeHg, and Pb exposure. Future research should employ behavioral tasks in children, such as DRL, that have been demonstrably sensitive to low-level PCB, MeHg and Pb exposure in animals.

Xue, F., Holzman, C., Rahbar, M.H., Trosko, K., and Fischer, L. **Maternal fish consumption, mercury levels, and risk of preterm delivery.** *Environmental Health Perspectives* 115(1): 42-47, 2007.

Notes: BACKGROUND: Pregnant women receive mixed messages about fish consumption in pregnancy because unsaturated fatty acids and protein in fish are thought to be beneficial, but contaminants such as methylmercury may pose a hazard. METHODS: In the Pregnancy Outcomes and Community Health (POUCH) study, women were enrolled in the 15th to 27th week of pregnancy from 52 prenatal clinics in five Michigan communities. At enrollment, information was gathered on amount and category of fish consumed during the current pregnancy, and a hair sample was obtained. A segment of hair closest to the scalp, approximating exposure during pregnancy, was assessed for total mercury levels (70-90% methylmercury) in 1,024 POUCH cohort women. RESULTS: Mercury levels ranged from 0.01 to 2.50 μg/g (mean = 0.29 μg/g; median = 0.23 μg/g). Total fish consumption and consumption of canned fish, bought fish, and sport-caught fish were positively associated with mercury levels in hair. The greatest fish source for mercury exposure appeared to be canned fish. Compared with women delivering at term, women who delivered before 35 weeks' gestation were more likely to have hair mercury levels at or above the 90th percentile (≥ 0.55 μg/g), even after adjusting for maternal characteristics and fish consumption (adjusted odds ratio = 3.0; 95% confidence interval, 1.3-6.7). CONCLUSION: This is the first large, community-based study to examine risk of very preterm birth in relation to mercury levels among women with low to moderate exposure. Additional studies are needed to see whether these findings will be replicated in other settings.

Deutch, B., Dyerberg, J., Pedersen, H.S., Asmund, G., Moller, P., and Hansen, J.C. **Dietary composition and contaminants in north Greenland, in the 1970s and 2004.** *The Science of the Total Environment* 370(2-3): 372-381, 2006.

Notes: *Objectives*: The fatty acid composition and other nutrients in traditional Inuit food appear to provide some protection against diseases of affluent industrialized societies, such as cardiovascular diseases and type 2 diabetes. A transition towards increased amounts of imported food might increase the occurrence of these diseases among Inuit. However, since the 1970s it has become evident that the marine-based Inuit diet also contains high levels of potentially toxic lipophilic organic pollutants and heavy metals. Since these two opposing effects on health appear to be inseparable, the phenomenon has become known as "The Arctic Dilemma". However, both the fatty acid composition and the contaminant levels vary in Greenlandic food items. Thus, in theory, it is possible to compose a diet where the benefits outweigh the risks. Our objective was to compare traditional and modern meals in Greenland regarding dietary composition, content of n-3 fatty acids and contaminants. *Study design*: The present study was part of the Arctic Monitoring and Assessment Programme, AMAP, comparing the results of dietary composition and nutrients in 177 traditional meals collected in Uummannaq municipality, north Greenland in 1976 with 90 meals sampled in Uummannaq town in 2004 under similar conditions. Eleven pesticides, 14 PCB congeners, heavy metals, selenium, and fatty acids were analysed in meals and blood samples from the participants. Contaminant levels were compared between 1976 and 2004 after adjustment for n-3 fatty acids, indicating local food content. *Results*: Between the traditional meals collected 30 years ago and the meals from 2004, dramatic and significant changes have occurred in the dietary composition. The percentage of local food has decreased, and with it the intake of n-3 fatty acids. Calculated as daily intake, all but three contaminants had decreased significantly. However, this could be explained by the lower intake of local food. After adjustment for n-3 fatty acid content in the food, significant declines of concentration in the local food were evident only for PCBs and lead, whereas for mercury, DDTs, and chlordanes the levels were unchanged, and for hexachlorobenzene, mirex, and toxaphenes, the levels had increased significantly. *Conclusion*: The consumption of locally produced food has decreased in Greenland during the last 30 years and this has led to a reduction in the daily intake of contaminants. However, the concentrations of contaminants in local food items have not decreased, except for PCB and lead. Therefore, we recommend that the consumption of local products is not increased beyond the present level, until the level of contaminants is reduced to a safer level.

Burger, J. and Gochfeld, M. **Mercury in fish available in supermarkets in Illinois: Are there regional differences.** *The Science of the Total Environment* 367(2-3): 1010-1016, 2006.

Notes: Media coverage has made the public aware of both the benefits and the risks from eating self-caught fish, but information on contaminants in commercial fish is much more limited, especially on a local level. The U.S. Food and Drug

Administration website provides methylmercury data for a variety of fish, but for many species sample sizes are small and data are more than a decade old, whereas commercial fish sources are highly dynamic. A few state agencies are beginning to provide contaminant information for commercial fish, including canned tuna. We examined the mercury concentration of six types of fish purchased in supermarkets in Chicago, Illinois in 2005. We measured total mercury (methylmercury accounts for about 90% of the total mercury in fish). One key question was whether the concentrations of mercury in fish available locally were similar to those reported in other areas of the country and in the FDA U.S. National data base. Such information is critical for the public, especially pregnant women or those planning on pregnancy, making decisions about types and quantities of fish to consume. Some fish are available generally throughout the U.S., but others are more locally available, suggesting a need for site-specific information. This research was stakeholder driven, and reflected local interest in the safety of local fish. There were significant differences in mercury concentrations among the fish, ranging from a mean of 0.03 mg/g (ppm-wet weight) for salmon (*Salmo* spp.) to 1.41 ppm for swordfish (*Xiphias gladius*). Maximum values for three species of fish (orange roughy *Hoplostethus atlanticus*, swordfish, walleye *Sander vitreus*) were over 1 ppm (FDA action level), and all of the fish except salmon had some values above 0.5 ppm, the action level set by some states and countries. There were significant differences in mercury concentrations among three types of canned tuna (*Thunnus* spp): "gourmet tuna" had the least amount of mercury, and white tuna had the most. The mean concentrations reported in this study were generally similar to those reported by the FDA, but there were important differences: 1) although the mean mercury concentrations for orange roughy for the Chicago data was similar to the FDA data, the maximum concentration was higher; 2) the mean for the Chicago swordfish was higher than the FDA data (1.26 vs 0.97 ppm, methylmercury); 3) the maximum for tuna steaks was higher in the FDA data set; and, 4) mean values for grouper (*Epinephelus* spp.) were higher in the FDA data set than the Chicago data. Further, the FDA has virtually no data on walleye and none on "gourmet tuna". These conclusions suggest that there are enough variations between the local data (Chicago) and the FDA data to warrant periodic local monitoring of commercial fish to provide up-to-date information to consumers about mercury in the fish they eat.

Julshamn, K., Grosvik, B.E., Nedreaas, K., and Maage, A. **Mercury concentration in fillets of Greenland halibut (*Reinhardtius hippoglossoides*) caught in the Barents Sea in January 2006.** *The Science of the Total Environment* 372(1): 345-349, 2006.

Notes: In January 2006 it was reported that Greenland halibut (*Reinhardtius hippoglossoides*) caught in the Barents Sea contained mercury levels that exceeded the EU's upper limit of 0.5 mg/kg wet weight for this species. To further investigate this finding, the National Institute of Nutrition and Seafood Research (NIFES) in Norway recently undertook a study to quantify the levels of mercury in Greenland halibut caught in the same area of the Barents Sea. A total of 120 Greenland halibut were caught in this area between the 28th and the 30th of January 2006. The fish were immediately frozen and shipped to the laboratory; individual fish were coded, weighed, defrosted, filleted and skinned before their mercury content was determined. Analyses were carried out on 65 individuals of Greenland halibut weighing from 0.81 kg to 7.1 kg, and 40 fish weighing more than 3 kg. The lowest mercury concentration found in muscle tissue (skinless and boneless fillet) was 0.019 mg/kg wet weight, in a fish that weighed 0.81 kg. The highest mercury concentration measured in muscle tissue was 1.1 mg/kg wet weight, from a fish that weighed 4.2 kg. Of the 65 fish analysed, 15 individuals with weight exceeding 3 kg had mercury concentrations in their muscle tissue exceeded the EU's upper limit.
