2009 National Forum on Contaminants in Fish

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Appendix B

Poster Abstracts

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Toolkit vs. Tacklebox

Dyan Steenport[1] and Henry Anderson[1]

[1] Wisconsin Division of Public Health, Madison, WI

Primary Contact Information:
Henry A. Anderson, MD, Chief Medical Officer, Wisconsin Division of Public Health
PO Box 2659, Madison, WI 53701
Tel: 608-266-1253 Email: Henry.Anderson@WI.gov

Communicating effective data to the people most impacted by fish advisory information is a challenge. This presentation focuses on the development of a Great Lakes Basin Fish Consumption Advisory Toolkit using novel methods to communicate information. This toolkit consists of innovative outreach projects that use new fish consumption outreach methods that are intended to reduce exposure to methylmercury. Projects target specific age groups not previously emphasized, ethnic groups, and geographic areas.

Consumption of fish and seafood constitutes the single largest source of human exposure to a variety of persistent, environmental toxins, such as methylmercury. Each year, nearly 10 million residents of the Great Lakes Basin consume locally-caught sport fish. Many more consume fish and seafood that they purchase from vendors or eat in restaurants. Most have little or no awareness of the relative safety of the hundreds of species of fish and seafood that are available for consumption.

The toolkit is comprised of outreach projects developed by consortium members from Indiana, Minnesota, Michigan, Pennsylvania, Illinois, and Wisconsin. Projects include two brochures, "A Guide to Eating Fish for Older Adults" and "A Woman's Guide to Eating Indiana Fish," a wallet card containing advice for selecting safe fish for consumption, an activity book that contains information about fish and includes fun activities for children, a keychain float, and materials for implementing "Fish On," a women-only fishing workshop on conducting audience-oriented risk communication workshops.

All Great Lakes states have access to the toolkit if they should choose to implement any of the projects.

Mercury Trends in Fish from U.S. Rivers and Lakes, 1969 to 2005

Ann Chalmers[1], Denise Argue[2], David Gay[3], Mark Brigham[4], Christopher Schmitt[5], and Dave Lorenz[4]

[1]U.S. Geological Survey, Montpelier, VT
[2] U.S. Geological Survey, Pembroke, NH
[3] Illinois State Water Survey, Champaign, IL
[4] U.S. Geological Survey, Mounds View, MN
[5] U.S. Geological Survey, Columbia, MO

Primary Contact Information:
Mark Brigham, U.S. Geological Survey
Mounds View, MN
Tel: 763-783-3274 Email: mbrigham@usgs.gov

A national compilation of fish-mercury concentration data from state and federal monitoring programs was used to analyze trends in mercury (Hg) concentrations in fish from rivers and lakes across the United States. Trends were analyzed by site and by state using samples of the same fish species and tissue type, and by using fish of similar lengths. Trends were evaluated during two time periods, 1969 to 1987, and 1988 to 2005. In addition, trends for the most recent fish data (1995 to 2005) were compared to trends in wet Hg deposition data from the Mercury Deposition Network (MDN) for the same period. Downward Hg trends in fish from data collected during 1969 to 1987 exceeded upward trends by six to one. Downward Hg trends in fish during the 1970s and 1980s are consistent with decreases in atmospheric Hg

deposition inferred from many records of sediment, ice, and peat cores. The southeastern United States had more upward trends in fish than other regions of the country. Upward Hg trends in fish from the southeastern United States were supported by increases in wet deposition in the region and may be attributed to a greater influence of global atmospheric emissions to the southeastern United States. No significant trends were found in 62% of the fish data aggregated by state from 1996 to 2005. A lack of Hg trends in fish in the more recent data was consistent with the lack of trends in Hg wet deposition at MDN sites and with relatively constant global emissions over the same time period. Although few significant trends were observed in the more recent Hg data in fish, it is anticipated that Hg concentrations in fish may decrease with decreases in atmospheric Hg deposition; however, the magnitude and timing of the response is uncertain.

Mercury and Selenium Levels in 19 Species of Saltwater Fish from New Jersey: Size, Season, and Geographical Effects

Joanna Burger[1,2] and Michael Gochfeld[2,3]

[1]Division of Life Sciences, Rutgers University, Piscataway, NJ
[2]Environmental and Occupational Health Sciences Institute (EOHSI) and Consortium for Risk Evaluation with Stakeholder Participation (CRESP), Rutgers University, Piscataway, NJ
[3]Environmental and Occupational Medicine, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ

Primary Contact Information:
Joanna Burger, Environmental and Occupational Health Sciences Institute (EOHSI) and Consortium for Risk Evaluation with Stakeholder Participation (CRESP), Rutgers University, Division of Life Sciences
604 Allison Road, Piscataway, NJ 08854-8082
Tel: 732-445 4318 E-mail: burger@biology.rutgers.edu.

The risks to biota and humans from mercury, polychlorinated biphenyls (PCBs), and other contaminants in fish have largely been concerned with fish from inland lakes and rivers, even though the U.S. Food and Drug Administration has issued advisories based on mercury for four saltwater species or groups of fish. In coastal states, saltwater fishing is an important commercial and recreational activity, and saltwater fish are readily available in stores. Further data on mercury are generally available only for large predatory fish thought to present a human health risk. This poster examines total mercury and selenium levels in muscle of 19 species of fish largely caught by recreational fisherfolk off the New Jersey shore. Of primary interest was whether there were differences in mercury and selenium levels as a function of species of fish, location, size (i.e., weight, length), and season, and what risk mercury posed to the food chain, including people. Selenium was measured because of its reported protective effects against mercury. Average mercury levels ranged from 0.01 ppm (menhaden [*Brevoortia tyrannus]*) to 1.83 ppm (mako shark [*Isurus oxyrinchus]*). There were four categories of mercury levels: very high (only mako shark), high (averaging between 0.3 and 0.5 ppm, 3 species), medium (0.14 to 0.20 ppm, 10 species), and low (below 0.13 ppm, 5 species). Average selenium levels ranged from 0.18 ppm to 0.58 ppm, a lower range than for mercury. There was no consistent pattern for the relationship between mercury and selenium; it was significant for only 8 fish species, and was negative for some and positive for others. Mercury levels were significantly related to size for 10 species. There were few significant differences in selenium and mercury levels as a function of location, and the differences were not consistent. In general, size was the best predictor of mercury levels. Over half of the fish species had levels over 0.3 ppm for some individuals, and a third had levels over 0.5 ppm for some individuals, the levels considered to pose a human health risk. However, there were many fish species with no individuals having levels above 0.5 ppm, and few above 0.3 ppm, suggesting that people at risk can reduce the risk from mercury in fish by selecting which fish (and which size) to consume. Anglers in New Jersey are regularly catching a wide variety of fish species, and a wide range of sizes, which allows particularly sensitive populations (e.g., pregnant women, young children) to select fish that are relatively low in mercury.

Surveillance of Fish Toxin Poisoning Using Poison Center Data

C. Cooper[1], R. LePrell[1], A. Wolkin[1], C. Martin[1], L. Backer[1], and H. Schurz-Rogers[1]

[1]Centers for Disease Control, National Center for Environmental Health, Atlanta, GA

Primary Contact Information:
Cristina Cooper, Centers for Disease Control, National Center for Environmental Health, Health Studies Branch
CDC/HSB, Mailstop F- 57, 4770 Buford Highway NE, Atlanta, GA 30341-3717
Tel: 770-488-3416 Email: cbc0@cdc.gov

Objective. The objective is to describe how data from National Poison Data System (NPDS) is being incorporated into the Centers for Disease Control and Prevention's (CDC's) Harmful Algal Bloom Surveillance System (HABISS) to detect and track human exposures to algal toxins in fish and the associated health effects of the toxins. **Background.** In the United States, NPDS is the source for data on poisonings and associated health effects that are collected by Poison Centers (PCs). It is a near-real time system operated by the American Association of Poison Control Centers (AAPCC) in cooperation with CDC's National Center for Environmental Health (NCEH). NPDS receives data regarding human exposures to hazardous chemicals, toxins, poisonings, and associated illnesses from 60 individual regional PCs approximately every 10 minutes and analyzes, displays, and reports these data in a Web-based application. NCEH developed HABISS to support public health decision making related to the public health risks from exposures to harmful algae and the toxins they produce. HABISS is modular and allows contributing state health agencies to enter data on human and animal illnesses and algal bloom characteristics. NCEH staff coordinating HABISS partnered with AAPCC to use NPDS to track calls reporting potential fish poisonings in the United States. **Methods.** NPDS identifies potential fish poisoning cases using a case-based definition—a user-defined query that flags individual calls based on their reported signs and symptoms called clinical effects, demographic characteristics, and/or exposures. NPDS currently monitors four fish toxin-related exposures— ciguatera fish poisoning (CFP), paralytic shellfish poisoning (PSP) (from saxitoxin), amnesic shellfish poisoning (ASP) (from domoic acid), and neurotoxic fish poisoning (NSP) (from brevetoxin). When NPDS identifies a call that meets one of these definitions, an e-mail alert is sent to CDC. CDC and AAPCC epidemiologists and toxicologists investigate the alert to confirm that it is a potential case. An e-mail is then forwarded to the HABISS CDC project officer. The HABISS team confirms the exposure and ensures that the state or local public health department has been notified for appropriate follow-up. **Results.** From July 1, 2008, to Aug 15, 2009, NPDS identified 394 potential Harmful Algal Bloom (HAB)-related fish toxin exposures. These include 225 possible cases of CFP, 151 of PSP, 3 of ASP, and 15 of NSP. On the basis of HABISS case definitions, NPDS identified 58 suspect and 42 confirmed HAB-related fish poisonings during the study period. Reported symptoms from confirmed and suspected HAB-related fish poisoning calls included diarrhea (18%), nausea (28%), and other, often severe, neurologic symptoms (33%). NPDS reported 100 calls, from which HABISS excluded 21 calls with no reported symptoms of illness, and 38 that were exposed and diagnosed outside of the United States. The remaining records either did not meet the suspect or confirmed case definition, or the team was not able to contact the individuals during the follow-up process. **Conclusions.** NPDS has utility for detecting and characterizing illnesses resulting from exposures to fish toxins in near real-time. Integration of data from NPDS into HABISS enables summary analyses of data from NPDS and HABISS to be shared with federal, state, and/or local public health officials as necessary to improve situational awareness and identify appropriate interventions, such as public health advisories and shellfish bed closures. This collaboration involving CDC, AAPCC, state and local health departments, and regional PCs improves the public health response and has the potential to minimize morbidity and mortality associated with exposures to algal toxins in fish.

An Interstate Framework Based on the Enhanced National Hydrography Dataset with Applications for the National Listing of Fish Advisories

Patricia Cunningham[1], William Cooter[1], Shu-yi Lin[1], James Rineer[1], and Brandon Bergenroth[1]

[1]RTI International, Research Triangle Park, NC

Primary Contact Information:
Patricia Cunningham, RTI International
3040 Cornwallis Road, Research Triangle Park, NC 27709
Tel: 919-316-3722 Email: patc@rti.org

An innovative geographic information systems (GIS) approach is applied to identify interstate waters, including both border waters (e.g., where the water features form the basis for state administrative boundaries) and cross-border waters involving National Hydrography Dataset (NHD) features that cross surveyed state boundaries. The resulting interstate water framework can then be applied in geospatial analyses for a wide range of information that U.S. EPA has developed and mapped in terms of the NHD, including information from the National Listing of Fish Advisories (NLFA) database. The NHDPlus interstate waters framework was combined with data from the NLFA database to evaluate the comparability of fish advisories for these interstate waters. In evaluating the degree to which the NLFA, or other U.S. EPA assessment programs, show strong degrees of national consistency, interstate waters are an extremely valuable subset of the nation's waters. These NLFA interstate waters, along with related advisory database information, are summarized to document consistency patterns in fish advisory language for interjurisdictional assessments.

Persistent Organic Pollutant and Mercury Levels in Puget Sound Chum Salmon (*Oncorhynchus keta*)

Cristiane T. Elfes[1] and Christian E. Grue[1]

Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, University of Washington

Primary Contact Information:
Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, University of Washington
1122 NE Boat St, Box 355020, Seattle, WA 98195.
Email: celfes@u.washington.edu

Relatively high levels of persistent organic pollutants, such as polychlorinated biphenyls (PCBs) have been reported for Puget Sound Chinook salmon, leading to concern over the consumption of salmon caught in Washington inland waters. The aim of this study was to investigate persistent organic pollutant and mercury levels in chum salmon (*Oncorhynchus keta*) from the Puget Sound to evaluate potential risks for human consumption. Both female and male adult chum were collected from two fishing zones within the Puget Sound during the beginning, middle, and end of the fishing season (n = 24). Whole fish fillets, including skin, were analyzed for PCBs, polybrominated diphenylethers (PBDEs), mercury, and percent total lipid following U.S. EPA procedures and analytical methods. Concentrations of all contaminants evaluated were low. PCBs were not detected in any of the fish analyzed, and PBDEs were found in less than half of the samples. Mean ∑PBDE was 0.81 ± 0.46 µg/g, with highest concentration of 11.47 µg/g. The mean mercury concentration was 0.0341 ± 0.0024 mg/kg with levels ranging from non-detectable to 0.0527 mg/kg. Mean percent total lipid was 2.82 ± 0.32 %. No significant differences in the concentrations of any analyte were found between sexes, regions, or time of capture. The levels detected in chum salmon may be considered trace amounts, and they were comparable to those of other wild

salmon, with the exception of Puget Sound Chinook. Chum likely receive lower contaminant loads than Chinook caught in the same region because of life-history characteristics, such as lower trophic level and migration to offshore environments soon after emergence. Our results indicate that the risks to human health associated with the consumption of these fish are minimal compared to the potential benefits.

A TEQ Analysis of PCBs and Dioxin/Furans (DxFs) in Fish Tissue from the Delaware River

G. Cavallo[1] and T. Fikslin[1]

[1]Delaware River Basin Commission, West Trenton, NJ

Primary Contact Information:
Thomas Fikslin, Delaware River Basin Commission
P.O. Box 7360, West Trenton, NJ 08628
Tel: 609-883-9500 Email: thomas.fikslin@drbc.state.nj.us

Fish samples were collected from five stations in the tidal portion of the Delaware River and three stations in the nontidal portion from 2004 to 2006. Representative benthic and pelagic species were collected at each station: white sucker and smallmouth bass, respectively, in the nontidal portion, and channel catfish and white perch, respectively, in the tidal portion of the river. Composite samples of five fish fillets from fish of similar size and weight were analyzed for polychlorinated biphenyl (PCB) using U.S. EPA method 1668, Revision A, for all 209 congeners. Dioxin/Furans (DxFs) were analyzed by U.S. EPA method 1613B for 17 individual compounds and for total tetra, penta, hexa, hepta, and octa homologs. Median concentrations of PCBs in smallmouth bass and white sucker were 45,000 and 114,000 pg/g wet weight, respectively, for the nontidal river, while median fish tissue concentrations for white perch and channel catfish, in the tidal portion, were 485,000 and 843,000 pg/g wet weight, respectively. All fish species regardless of location exceed U.S. EPA's screening value of 1,500 pg/g for PCBs. DxF concentrations were four to five orders of magnitudes less than PCBs and exhibited median concentrations of between 1 and 4 pg/g wet weight for the nontidal fish species and 9 to 11 pg/g wet weight for the tidal fish species. Toxic Equivalents (TEQs) were calculated for both DxFs and the 12 dioxin-like PCB congeners. The percentage contribution of TEQs for each of the 12 coplanar PCBs and DxF is presented for each of the fish species in the tidal and nontidal estuary. All fish species regardless of location exceed U.S. EPA's 10^{-5} screening value of 0.256 pg/g TEQs for DxFs. And the total TEQs based upon both PCBs and DxFs greatly exceed the TEQs based only upon DxFs, particularly in the tidal portion of the River. PCBs represent approximately 60% to 80% of the total TEQ values. This distribution was driven primarily by the elevated concentrations of PCBs in the tidal portion of the estuary. This important component of the potential impact of PCBs needs to be considered in any risk assessment and management of DxF contamination.

Great Lakes Restoration Initiative

Jackie Fisher[1], Elizabeth Murphy[1], and Edwin Smith[1]

[1]Great Lakes National Program Office, U.S. EPA, Chicago, IL

Primary Contact Information:
Jackie Fisher, Great Lakes National Program Office, U.S. EPA
77 W. Jackson Blvd. G17-J, Chicago, IL 60604
Tel: 312-353-1481 Email: fisher.jacqueline@epa.gov

The president's 2010 budget provides for $475 million in U.S. EPA's budget for a new U.S. EPA-led, interagency Great Lakes restoration initiative, which will target the most significant problems in the region, including invasive aquatic species, nonpoint source pollution, and contaminated sediment. This

initiative will use outcome-oriented performance goals and measures to target the most significant problems and track progress in addressing them. U.S. EPA and its federal partners will coordinate state, tribal, local, and industry actions to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes. To jump-start the initiative, the interagency task force has developed a plan (PDF) for the proposed $475 million budget, including more than $250 million in grants and project agreements and jump-starting the achievement of long term goals: safely eating the fish and swimming at our beaches, assuring safe drinking water, and providing a healthy ecosystem for fish and wildlife.

Concentrations of PCBs and PBDEs in water in the Cedar River and fish from the Lake Washington/Cedar/Sammamish Watershed, Washington

Demetrius Fletcher[1], Christopher Grue[1], Robert Edmonds[1]

[1]University of Washington, Seattle, WA

Primary Contact Information:
Demetrius Fletcher, Graduate Student, School of Forest Resources
University of Washington, Seattle, WA 98195
Email: df3@u.washington.edu

Polychlorinated biphenyls (PCBs) are among a group of compounds known as persistent organic pollutants (POPs). Polybrominated biphenyl ethers (PBDEs) belong to a broader chemical class termed polyhalogenated aromatic hydrocarbons (PHAHs). PCBs and PBDEs can be transported long distances via the atmosphere, ocean, and biota and have become ubiquitous in the global environment being detected in remote areas. PCBs and PBDEs are both lipophilic. Research has determined that both contaminants can be bioaccumulated by aquatic and terrestrial organisms. Once PCBs and PBDEs enter the food chain, hinookfications occurs as the contaminants progress up the food chain from prey to predator. Of greater concern, recent research has determined that PCBs and PBDEs are present in the adipose tissue, milk, and blood serum of humans. It has been concluded by the EPA that PCBs are probable human carcinogens. PBDEs have increased in people by approximately one hundred fold in the past 30 years. Great attention is now being given to PBDE contamination in humans and what the endpoints may be.

There is some concern that fish may represent a potential source of human contamination for PCBs and PBDEs. In 2003, the upper reaches of the Cedar River Watershed that supplies drinking water for the city of Seattle was opened allowing hinook and coho salmon to spawn and colonize habitat above Landsburg Diversion Dam that had been closed to hinook and coho salmon for 102 years. PCBs and PBDEs have been documented in Puget Sound hinook and coho salmon, and recent research has determined that Puget Sound stocks of hinook salmon carry greater concentrations of PCBs and PBDEs than other west coast stocks. Several studies have documented salmon as vectors of PCBs and PBDEs to natal spawning grounds where the toxins are released into the water column during spawning and decomposition.

The objectives of the study were to: (1) determine if concentration of PCBs and PBDEs in the water column of the Cedar River above and below Landsburg Diversion Dam increase during hinook and coho spawning and subsequent decomposition; (2) determine concentrations of PCBs and PBDEs in adult hinook and coho salmon returning to the Lake Washington drainage; (3) determine species contribution of contaminant loading of PCBs and PBDEs in the Cedar River; and (4) collect biological and toxicological data that may be used in management decisions affecting salmon populations and watershed management above the Landsburg Diversion Dam.

Ten hinook and coho salmon, five female and five male, were collected from the Issaquah Creek Hatchery. Whole body tissue samples and eggs were chemically analyzed for PCBs, PBDEs, and percent lipids. Semipermeable membrane devices (SPMDs) were deployed during three distinct sampling periods

above and below Landsburg Diversion Dam to monitor concentrations of PCBs and PBDEs in the water column immediately before the spawning season (June–July, 2007), during the spawning season (October–December, 2007) , and after the spawning season (February–April 2008). After a deployment of approximately six weeks, SPMDs were retrieved and analyzed to determine concentrations of PCBs and PBDEs in the water column during each sampling period. One-way ANOVAs and Tukey's tests were performed to determine if any statistical differences existed in mean concentrations among different tissue samples and SPMD samples by location and season.

PCB and PBDE concentrations in sampled hinook and coho salmon in this study were lower than concentrations documented in other studies that focused on Puget Sound salmon. Chinook salmon carry greater body burdens of PCBs and PBDEs when compared to coho salmon. Concentrations of these biotoxins are influenced by many factors including age, size, gender, lipid content, species, and region. In female coho salmon, PCBs were maternally transferred from muscle tissue and organs to eggs.

In the Cedar River Basin, concentrations of PCBs and PBDEs in the water column vary seasonally and may be influenced by localized factors such as runoff and irrigation. In the Cedar River Watershed, highest concentrations of both contaminants were found during the post-spawning deployment suggesting that hinook and coho spawning and subsequent decomposition may increase the concentration of these biotoxins in the water column. The uptake of PCBs and PBDEs by SPMDs are influenced by temperature and flow rate.

Precision between Results for Arsenic, Selenium, and Mercury in Various Fish Species Collected Subsequent to the Fly Ash Release in Kingston, Tennessee

Ruth L. Forman

CEAC, Environmental Standards, Inc., Valley Forge, PA

Primary Contact Information:
Ruth L. Forman, CEAC, Quality Assurance Specialist/Principal, Environmental Standards, Inc.
1140 Valley Forge Road, P.O. Box 810, Valley Forge, PA 19482
Tel: 610-935-5577 Email: rforman@envstd.com

In late 2008, a fly ash spill occurred at a coal-burning power plant in Kingston, Tennessee. A dike failure released a large amount of fly ash (about 5.4 million cubic yards) from the coal burned in boilers at the plant for power production into the adjacent Emory River. Coal, in its natural state, contains various metals that can be retained in the ash after burning; the ash itself is primarily composed of fine silica particles that are very similar to sand. Trace amounts of arsenic, selenium, and other metals that occur naturally in the coal remain in the ash after coal combustion. This poster will provide details about the release of fly ash and present data relative to the precision between results for arsenic, selenium, and mercury found in hundreds of fish of various species, both whole body and fillet, collected upstream and downstream of the December 22, 2008, fly ash release at the fossil fuel plant in Kingston, Tennessee.

Development of a New Method for the Determination of Imidacloprid Residues in Juvenile Chinook Using ELISA Detection

John A. Frew[1] and Chris Grue[2]

[1]University of Washington, School of Aquatic and Fishery Sciences
[2]Washington Cooperative Fish and Wildlife Research Unit

Primary Contact Information:
John Frew, University of Washington, School of Aquatic and Fishery Sciences
1122 NE Boat Street, MS 355020, Seattle, WA 98195
Tel: 206.685.4195 Email: jaf3@u.washington.edu

The neonicotinoid insecticide imidacloprid (IMI) has been proposed as a viable alternative to carbaryl for controlling two species of indigenous burrowing shrimp within commercial oyster beds in Willapa Bay and Gray's Harbor, Washington. The use of this insecticide in an aquatic environment has raised concern about the potential adverse effects of exposure to non-target species residing in the Bay, particularly salmonids such as cutthroat trout (*Oncorhynchus clarki*) and juvenile Chinook (*Oncorhynchus tshawytscha*). Environmental monitoring of these salmonids following the application of IMI will be necessary for evaluating exposure and effects. Quantification of residues in brain tissue can be used as a marker of exposure to IMI. The use of established analytical chemistry methods of detection such as HPLC-UV/DAD and MS have limitations due to cost, large sample size requirements and high limits of quantification (LOQ). An Enzyme-Linked Immunosorbent Assay (ELISA) is commercially available for the detection of IMI. Protocols are lacking for the application of this assay for detection of IMI residues in biological membranes, however. A multi-step procedure is being developed for brain tissue sample preparation/clean-up prior to ELISA quantification of IMI residues, including detergent solubilization of lipid membranes, ultrafiltration of mixed-micelles and cellular debris, and reversed-phase solid-phase extraction for isolation of IMI. Preliminary results indicate a potential LOQ of 10.0 μgL^{-1} for a juvenile Chinook brain sample averaging 65.0 mg. Application of this protocol has the potential for cost-effective analysis of individual fish with a LOQ lower than available from established methods, providing an effective tool for determining IMI exposure in non-target salmonids.

Developing Regional Advisories for the Sacramento–San Joaquin Watershed

M. Gassel[1], R.K. Brodberg[1], S. Klasing[1], and S. Roberts[1]

[1]California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

Primary Contact Information:
M. Gassel, Ph.D., California Environmental Protection Agency, Office of Environmental Health Hazard Assessment
1515 Clay Street, 16th Floor, Oakland, CA 94612
Tel: 510-622-3166 Email: mgassel@oehha.ca.gov
Tel: 916-323-4763 Email: rbrodber@oehha.ca.gov

The Office of Environmental Health Hazard Assessment (OEHHA) issued fish consumption advisories in 2007 and 2008 for a large portion of California, including approximately 565 river miles and 480,000 acres of associated waterbodies. These waterbodies serve two-thirds of the state's population. The data were obtained primarily from studies of mercury concentrations in fish from California's two largest rivers, the Sacramento and the San Joaquin. The confluence of these rivers forms the Sacramento–San Joaquin Delta watershed, an extensive network of rivers, tributaries, and channels. As a result of a large 3-year study of mercury in fish conducted in 2005 to 2007, and a combination of historical data received from several programs, the dataset for the Sacramento–San Joaquin Delta watershed included more than 100 sampling locations and over 4,500 samples (including individual and composite samples). To address

the challenges of a very large geographic area and a sizeable dataset, OEHHA adopted a step-wise approach to data evaluation. This alternate approach relied heavily on the creation of a geographic information systems (GIS)-linked database and maps for evaluations. The process began with comparison of fish mercury concentrations on a site-by-site basis. Subsequently, hydrographic information was used to define and compare samples within and among site groupings, eventually encompassing larger regions within the overall study area. Using the findings of the evaluation, OEHHA developed, for the first time, regional advice for the combination of waterbodies in the Sacramento–San Joaquin Delta watershed. Mercury concentrations in fish tissue data supported three separate regional advisories within the overall study area.

Expedition to the North Pacific Gyre's "Plastic Vortex"

Margy Gassel

California Environmental Protection Agency, Office of Environmental Health Hazard Assessment

Primary Contact Information:
M. Gassel, Ph.D., California Environmental Protection Agency, Office of Environmental Health Hazard Assessment
1515 Clay Street, 16th Floor, Oakland, CA 94612
Tel: 510-622-3166 Email: mgassel@oehha.ca.gov

On August 4, 2009, 25 people, including the Project Kaisei Science Team and volunteers, departed on the *S/V Kaisei* from the San Francisco Bay Area to the Subtropical Convergence Zone of the North Pacific Gyre, commonly known as "The Great Pacific Garbage Patch." The mission for the expedition included the following goals:

- Generate solid baseline data on marine debris accumulation in the North Pacific Gyre
- Gain an understanding of the impact of marine debris on the ocean environment and marine organisms
- Use knowledge gained for outreach and education to bring social change

The Project Kaisei Science Team conducted biological and chemical oceanographic research throughout the expedition, which covered over 3,000 nautical miles during the 4-week expedition. Using a manta trawl, surface tows were made twice daily, at midday and midnight, to collect marine debris. Nighttime trawls were employed to collected mesopelagic fish from the family Myctophidae. These ubiquitous deepwater fish are a critical link between their zooplankton prey and a multitude of marine fishes, invertebrates, and marine mammals that feed on them. Previous studies have shown that (1) marine organisms ingest polymer debris, and (2) hydrophobic contaminants, including polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethanes (DDTs), and others adsorb to the surface of the polymer debris. A central research question is whether marine polymer debris is a new mechanism for the transport of contaminants into the food web, potentially threatening human health. Myctophid fish were therefore collected to investigate ingestion of polymer debris and accumulation of PCBs and other persistent organic contaminants. Over 300 fish samples were brought back for analysis.

Marine debris samples collected during the expedition findings are being used to elucidate the nature of the so-called "Great Pacific Garbage Patch" and to further education and outreach about marine debris accumulation and its environmental and human impacts. Social networking tools, including blogging, Twitter, and YouTube are being used to enhance communication and educational outreach.

The Statewide Posting of Fish Consumption Advisory Signs at Public Boat Landings: South Carolina's Perspective After the First Year

Charles M. Gorman[1] and James B. Glover[1]

[1]South Carolina Department of Health and Environmental Control, Columbia, SC

Primary Contact Information:
James B. Glover, Ph.D., Aquatic Biology Section, South Carolina Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201
Tel: 803-898-4081 Email: GloverJB@DHEC.SC.Gov

Charles Gorman III, P.G., Director of the Division of Monitoring, Assessment, and Protection, South Carolina Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201
Tel: 803-898-3112 Email: GormanCM@dhec.sc.gov

The South Carolina Department of Health and Environmental Control (SCDHEC) has been collecting and analyzing fish tissue for mercury and other contaminants and issuing consumption advice since 1976. As part of a multimedia advisory program, the agency issues approximately 60,000 fish consumption advisory booklets annually and maintains a fish consumption advisory Web site and a toll-free telephone hotline number. The booklets are distributed throughout state agency offices, obstetrician/gynecologist (OB/GYN) offices, Women, Infants and Children (WIC) program offices, and health clinics, as well as at select retail stores and outdoor events, and to midwives. Public service announcements are broadcast on several radio stations throughout South Carolina. In spring 2008, a decision was made by senior management to post fish consumption advisory signs on waterbodies across the state that have mercury advisories. The fish consumption advisory signs include a general warning not to eat fish caught from the posted waterbody for women who are pregnant or plan to become pregnant, nursing mothers, and children under 14. For other individuals, the signs provide fish-specific consumption recommendations of either one meal a week, one meal a month, or do not eat, and they include an image of the fish species under the appropriate category. Signs were printed in both English and Spanish and included a toll-free telephone hotline number and a Web site address. Signs were posted at 225 freshwater public boat landings and 42 saltwater public boat landings. Approximately 8 months after the signs were installed, SCDHEC conducted a survey to determine how many signs were missing or vandalized. Of the 267 original signs, 200 (74.9%) were present and undamaged, 39 (14.6%) were missing, and 28 (10.5%) were damaged. Most damage was caused by firearms (e.g., bullets and buckshot); whereas, a few signs were defaced with spray paint. A preliminary survey of fishers in South Carolina suggests that signs can be an effective risk communication tool. The extensive press coverage of the postings also generated an awareness of the advisory program.

Great Lakes Water Quality: Agreement Priorities 2007 to 2009 Series. Work Group Report on Benefits and Risks of Great Lakes Fish Consumption

James Houston

Health Professionals Task Force, International Joint Commission

Primary Contact Information:
James Houston, Health Professionals Task Force, International Joint Commission
Secretary, HPTF/Env. Advisor
Tel: 613-995-0230 Email: houstonj@ottawa.ijc.org

Fish are an important part of a healthy diet and contain several important nutrients. Although recent publications have detailed benefits of consuming seafood, very limited data are currently available on the content of omega-3 fatty acids in fish from the Great Lakes system. Monitoring of polychlorinated biphenyls and methylmercury levels in Great Lakes fish has been useful for establishing fish consumption advisories. However, levels of emerging contaminants have not been adequately quantified, and thus, have not been suitably monitored in Great Lakes fish. This work group report highlights the challenge of evaluating the "net" risks and benefits of consuming Great Lakes fish. The report also identifies important needs concerning monitoring, research, public health communication, and policy in order to assist individuals make better personal dietary decisions aimed at maximizing and protecting human health.

Mercury Concentrations in Korean Freshwater Fish

Chan-Kook Kim[1,2], Tae-Woo Lee[1], Tae-Seob Choi[1], Kun-Ho Park[1], Jung-Suk Lee[1], Kyu-Tae Lee[1], Jihyun Lee[3], Mira Yoon[3], and Jong-Hyeon Lee[1]

[1] NeoEnbizBucheon, Gyeinggi-Do, Korea
[2] School of Erath and Environmental Sciences, Seoul National University, Seoul, Korea
[3]Environmental Health Policy, Ministry of Environment, Korea

Primary Contact Information:
Jihyun Lee, NeoEnbiz
#A-1306, Bucheon Daewoo TechnoPark, Dodang-dong 187-7, Bucheon, Gyeinggi-Do, 420-806, Korea
Email: jhlee@neoenbiz.com

This study was implemented with the objective of building a nationwide monitoring system of the mercury level in freshwater fish in Korea. Fish samples were captured by fishing gear during 2006 to 2007. A total of 53 species from 102 sites were identified, and 3,366 fish samples were analyzed. Total mercury concentrations in the edible part of the fish samples were measured by cold vapor atomic fluorescence spectrometer (CVAFS) and calculated on wet weight base. Methylmercury (MeHg) concentration in the samples was analyzed by gas chromatography-CVAFS.

Mean concentration of mercury in each species ranged from 9.3 μg/kg (leather carp) to 195.8 μg/kg (mandarin fish). In descending order by mean concentration of mercury, skygager (*Erythroculter erythropterus*) showed 159.8 ± 113.3 μg/kg (n = 108), short barbell gudgeon (*Squalidus japonicus*) showed 157.5 ± 46.2 μg/kg (n = 4), bass (*Micropterus salmoides*) showed 152.3 ± 180.8 μg/kg (n = 133), Korean piscivorous chub (*Opsariichthys bidens*) showed 149.9 ± 127.1 μg/kg (n = 99), and catfish (*Silurus asotus*) showed 145.6 ± 168.7 μg/kg (n = 201). Most of the species listed above are piscivorous fish. Fish-tissue mercury concentrations tend to increase with increasing tropic level, and they were higher in piscivore rather than omnivore and benthivore. The ratio of MeHg to total Hg in 176 fish samples of 17 species ranged from 74.4% to 96.6% and reached an average value of 83.0%.

Length-Normalized Mercury Concentrations in the Tissue of Freshwater Fish in Korea

Chan-Kook Kim[1,2], Tae-Woo Lee[1], Kun-Ho Park[1], Tae-Seob Choi[1], Jung-Suk Lee[1], Kyu-Tae Lee[1], Jihyun Lee[3], Mira Yoon[3], and Jong-Hyeon Lee[1]

[1] NeoEnbiz, Bucheon, Gyeinggi-Do, Korea
[2] School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea
[3] Environmental Health Policy, Ministry of Environment, Korea

Primary Contact Information:
Jihyun Lee, NeoEnbiz
#A-1306, Bucheon Daewoo TechnoPark, Dodang-dong 187-7, Bucheon, Gyeinggi-Do, 420-806, Korea
Email: jhlee@neoenbiz.com

This study was implemented to evaluate the spatial distribution of mercury concentrations in the tissue of freshwater fish in Korea. A significant relationship was found between mercury concentrations in fish samples and length of fish samples in each fish species. So length-normalized mercury concentrations were compared among different sites for four common fish species (i.e., crucian carp, Korean bullhead, bass, mandarin fish). The length-normalized concentrations for crucian carp (normalization for length of 15.7 cm) ranged from 11.0 μg/kg to 193.0 μg/kg, for Korean bullhead (normalization for length 15.4 cm) ranged from 24.5 μg/kg to 396.6 μg/kg, for bass (normalization for length 16.6 cm) ranged from 15.1 μg/kg to 657.8 μg/kg, and for mandarin fish (normalization for length 18.7 cm) ranged from 48.4 μg/kg to 357.0. The length-normalized concentrations showed a lower level in samples from the down reaches in the river basins than in those from an isolated small reservoir and a large artificial lake, which are located on the upper reaches of the river basins and far distant from industrialized areas. These phenomena are similar to a "biological hot spot" for mercury driven by landscape characteristics. No significant relationships were found between the length-normalized concentration of mercury in fish tissue for the four species and the concentrations of total mercury (total Hg) and methylmercury (MeHg) in environmental samples (water and sediment).

Direct Effects of Pesticides in Urban Streams in Western Washington on Coho Salmon Reproduction

K.A. King[1], C.E. Grue[1], J.M. Grassley[1], R.J. Fisk[1], and J.W. Hearsey[1]

[1]University of Washington, Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, Seattle, WA

Primary Contact Information:
Kerensa King, University of Washington, School of Aquatic and Fishery Sciences
Box 355020, 1122 NE Boat St., Seattle, WA 98195
Tel: 206-685-4195 Email: kerensa@u.washington.edu

The research presented represents the culmination of a 5-year effort to determine the effects of a pesticide cocktail, present in urban streams in western Washington, on different life stages of Coho salmon (*Oncorhynchus kisutch*). The cocktail consisted of 8 herbicides, 2 insecticides, a fungicide, and a common breakdown product; nominal concentrations were the maximums reported after stormwater events in fall. With the exception of the fungicide and breakdown product, formulated products (single AI) were used, and if possible, were selected from those available at retail outlets. In 2004 to 2005 and 2005 to 2006, research focused on adult Coho; recent monitoring efforts had suggested that pre-spawn mortality of Coho salmon had increased in natural waters, particularly in urban streams in western Washington. We found no effects on time to death, brain cholinesterase activity, sperm motility, or hatching success and growth of fry (from exposed adults) for 35 d post emergence. In 2006 to 2007, our objective was to

determine if there were effects on fertilization and eggs/sac fry to 35 days after swim-up as a result of a pulsed exposure to the chemical cocktail, simulating storm flows. In 2007 to 2009, we examined the effects of the pulsed exposure on fertilization through smoltification followed by the release of exposed and unexposed smolts to compare return rates. To date, results suggest that there were no effects on the endpoints examined and that other factors (e.g., general water quality, habitat, other contaminants) may be responsible for the reproductive effects observed in Coho salmon within urban streams in western Washington.

Cardiovascular Mortality among Frequent Consumers of Great Lakes Sport Fish

Lynda Knobeloch[1], Henry Anderson[1], Pamela Imm[1], and Carrie Tomasallo[1]

[1]Wisconsin Department of Health Services, Madison, WI

Primary Contact Information:
Lynda Knobeloch, Wisconsin Department of Health Services, Bureau of Environmental and Occupational Health
Madison, WI
Tel: 608 266-0923 Email: Lynda.Knobeloch@dhs.wisconsin.gov

The National Death Index was used to identify dates and causes of deaths that occurred among a cohort of 3,847 frequent and infrequent Great Lakes sport fish consumers who were recruited and interviewed between 1989 and 1995. Characteristics of this cohort allowed us to evaluate the interactive effects of beneficial nutrients found in fish and the adverse effects of contaminants, such as polychlorinated biphenyls (PCBs), dichlorodiphenyldichloroethylene (DDE), and methylmercury, found in Great Lakes sport fish, on human mortality. Analysis of age-adjusted death rates confirmed a protective effect of total fish intake against cardiovascular disease mortality among infrequent consumers of Great Lakes sport fish. However, a more complex pattern was observed among people who ate Great Lakes sport fish once a year or more. In this group, monthly ingestion of one to four fish servings was protective against cardiovascular deaths, but this benefit was not seen at higher ingestion rates. Deaths attributed to cancers of the liver, pancreas, female breast, ovary, and uterus were more common among frequent Great Lake sport fish consumers. However, the number of these deaths was too low to support rigorous statistical analysis. It is hoped that continued monitoring of mortality among this cohort will provide additional insights into the effect of fish intake and exposure to accumulative contaminants of the Great Lakes fishery.

Biomonitoring as an Intervention against Methylmercury Exposure

Lynda Knobeloch[1], Carrie Tomasallo[1], Pamela Imm[1], and Henry Anderson[1]

[1]Wisconsin Department of Health Services, Madison, WI

Primary Contact Information:
Lynda Knobeloch, Wisconsin Department of Health Services, Bureau of Environmental and Occupational Health
Madison, WI
Tel: 608 266-0923 Email: Lynda.Knobeloch@dhs.wisconsin.gov

During 2004, the Wisconsin Department of Health Services recruited 2,031 volunteers for a fish consumption and methylmercury exposure study. Participants completed a self-administered fish consumption questionnaire and provided a scalp hair sample for analysis. Approximately 6 to 10 weeks later, they received a letter advising them of their mercury level. People whose hair mercury levels exceeded 1 μg/g were advised to reduce their intake of large, predatory fish. Others were informed that mercury exposure was not an issue for them and were encouraged to continue to eat fish as part of a

healthy diet. In 2008, follow-up questionnaires and hair sampling kits were mailed to each 2004 study participant. These materials were returned by 1,139 people (i.e., 61% of those who were living and had valid mailing addresses). While overall fish intake increased slightly from 8,561 to 8,785 servings per month, nearly 30% of the cohort reported eating different kinds of fish in 2008. Hair mercury levels were lower in 61% of the follow-up participants, indicating that biomonitoring coupled with explanatory result letters reduced exposure to methylmercury without discouraging fish consumption. These findings support the public health benefit of methylmercury screening in conjunction with result-based education among frequent consumers of commercial and sport-caught fish.

Collaborative Research to Communicate and Reduce the Risks of Contaminated Seafood in Coastal Georgia

L. Liguori[1], L. Gentit[1], and K. Smith[1]

[1]Marine Extension Service, University of Georgia

Primary Contact Information:
Lisa Liguori, Fisheries Section Leader, Marine Extension Service, University of Georgia
715 Bay Street, Brunswick, GA 31520
Tel: 912-262-3382 Email: liguori@uga.edu

Glynn County, Georgia, is a coastal community with fishing traditions going back for generations. The county is also home to four Superfund sites, and many families continue to eat local seafood despite strict advisories. In this research project, students and commercial crabbers worked with extension agents to test local blue crabs for polychlorinated biphenyls (PCBs) and mercury near the LCP Chemicals Superfund site. High concentrations of Aroclor 1268, a marker PCB not manufactured anywhere else in the United States, were detected in the crab hepatopancreas (6.2 ppm). Total mercury levels in the crab flesh were also of concern (1.5 ppm). This ongoing collaborative work combines toxicology and ethnographic research to address local concerns and improve risk communication.

Working with a local teenager who often eats seafood from contaminated areas offered insight into local perspectives and interpretations of consumption advisories. When research revealed that removing the crab hepatopancreas (a local delicacy) eliminated virtually all risk of consuming PCBs, we offered hands-on crab cleaning workshops at a local high school. In addition to learning how to prepare crabs safely, over 140 students processed samples for laboratory analysis and participated in a crab-cleaning contest. Working with diverse community volunteers encouraged extension agents to add creative and practical perspectives to risk communication. Currently, these community-focused research methods are being applied and expanded to assess the risks of mercury consumption for members of a women's fishing cooperative in Yucatan, Mexico.

Quantitative Risk Reduction through Public Outreach to Anglers

Sharon Lin[1], Tiffany Jonick[2], Elizabeth Anderson[2], Coral Bruni[3], Stephen Groner[2], P. Wesley Schultz[3], and Frankie Orrala[4]

[1]U.S. Environmental Protection Agency, Superfund Division, San Francisco, CA
[2]S. Groner Associates, Inc., Long Beach, CA
[3]Action Research, Inc.
[4]Heal the Bay

Primary Contact Information:
Sharon Lin, U.S. Environmental Protection Agency, Superfund Division
75 Hawthorne St., SFD-7-1, San Francisco, CA 94105
Tel: 415-972-3446 Email: Lin.Sharon@epa.gov

Tiffany Jonick, S. Groner Associates, Inc.
4510 E. Pacific Coast Hwy, Ste. 300, Long Beach, CA 90804
Tel: 562-597-0205 Email: tjonick@sga-inc.net

In Southern California, white croaker caught within proximity to the Palos Verdes Shelf Superfund Site have been found to be contaminated with such high levels of dichlorodiphenyltrichloroethanes (DDTs) and polychlorinated biphenyls (PCBs) that fish consumption advisories recommend that this species of fish should not be consumed. In response to this risk, U.S. EPA initiated the development and implementation of an Angler Outreach Program designed to reduce the quantity of contaminated fish (specifically, white croaker) that anglers brought back to the community in a project called the Take Home Fish Assessment (THFA). In determining the program's effectiveness, the current project compares the number of white croaker that anglers took back to the community before and after a strategic intervention. Results indicate that the program was highly successful in positively modifying angler behavior. Post-outreach results demonstrate that strategic interventions reduced the number of white croaker entering the community, as well as the number of anglers who left the fishing site with white croaker. After the intervention, anglers also exhibited an increase in positive behavior with regard to their white croaker consumption habits.

In addition to achieving reductions in the removal of white croaker, another goal of this study was to understand the reduction of excess cancer risks associated with the consumption of white croaker through the efforts of the THFA. In averaging between the two sites, the excess cancer risk associated with average consumers was found to be 2.1×10^{-5} (2.1 excess incidences of cancer in 100,000 people), which resulted in approximately 2 incidences in the population of saltwater anglers in Los Angeles and Orange counties. After the program, this excess cancer risk was reduced to 1.2×10^{-5}, a 42% reduction. In other words, for every 40,000 people reached through the outreach, one person would be saved from developing cancer. This suggests that the THFA is successful in reducing the potential excess cancer risk associated with the regular consumption of white croaker.

Concentrations of Polychlorinated Biphenyls in Wild-Caught and Farm-Raised Shrimp from 14 Countries

D. Fillos[1], L.L.F. Scott[1], L.M. Nguyen[1], W.J. Luksemburg[2], and D.J. Paustenbach[1]

[1]ChemRisk, San Francisco, CA
[2]Vista Analytical Laboratory, El Dorado Hills, CA

Primary Contact Information:
William J. Luksemburg, Vista Analytical Laboratory
1104 Windfield Way, El Dorado Hills, CA 95762
Email: billux@vista-analytical.com

Measureable levels of persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs), in aquatic organisms are relatively well documented with recent studies indicating that shrimp may contain higher concentrations of these chemicals than other types of aquatic food products. In this study, we evaluated concentrations of the 209 PCB congeners in 87 samples of wild-caught and farm-raised shrimp and 3 samples of wild-caught crab from various countries around the world. No significant differences in PCB concentrations were observed between wild-caught and farm-raised shrimp. However, concentrations of PCBs differed significantly ($p<.0001$) among countries of origin. Lowest and highest mean concentrations of PCBs were observed in shrimp originating in Bangladesh and Belize, respectively. Differences in PCB concentrations observed among shrimp from varying geographic regions implies the source of PCB exposure could be related to regional contamination. Regardless, concentrations of PCBs measured in this study are well below government-established tolerance levels for PCBs in edible food.

Distribution of Polychlorinated Biphenyl Concentration in Wild-Caught and Farm-Raised Shrimp by Geographic Region

D. Fillos[1], L.L.F. Scott[1], L.M. Nguyen[1], W.J. Luksemburg[2], and D.J. Paustenbach[1]

[1]ChemRisk, San Francisco, CA
[2]Vista Analytical Laboratory, El Dorado Hills, CA

Primary Contact Information:
William J. Luksemburg, Vista Analytical Laboratory
1104 Windfield Way, El Dorado Hills, CA 95762
Email: billux@vista-analytical.com

Over a 3-month period, we collected samples of uncooked warm-water shrimp from numerous countries in an effort to describe concentrations of various persistent organic compounds in seafood products. In the present study, we re-categorized samples based on the region in which the sample originated to address limitations of our initial analysis because of a small number of samples for certain countries. Shrimp from North America were more commonly wild-caught (70% versus 26% for farm-raised), whereas the shrimp from Asia and South America were predominantly farm-raised (90 and 87%, respectively). Highest median concentrations, as well as highest variability among concentrations, were observed in shrimp from North America. However, no statistical differences in polychlorinated biphenyl (PCB) concentrations were observed among the different regions, even after adjusting for sample type. Despite the lack of differences in measured concentrations, evaluation of congener profiles and homologue fractions by region indicated that sources of PCB loadings (e.g., feed, pollution) may differ for each region.

An Investigation of Wild-Caught and Farm-Raised Shrimp Samples with High Concentrations of Polychlorinated Biphenyls

D. Fillos[1], L.L.F. Scott[1], L.M. Nguyen[1], W.J. Luksemburg[2], and D.J. Paustenbach[1]

[1]ChemRisk, San Francisco, CA
[2]Vista Analytical Laboratory, El Dorado Hills, CA

Primary Contact Information:
William J. Luksemburg, Vista Analytical Laboratory
1104 Windfield Way, El Dorado Hills, CA 95762
Email: billux@vista-analytical.com

As part of a study to characterize levels of different persistent organic pollutants in a variety of aquatic food products, 168 polychlorinated biphenyl (PCB) congeners/congener pairs were measured in samples of uncooked shrimp and crab and in cooked shrimp. Ten uncooked samples of shrimp were determined to be outliers, 60% of which were wild-caught and 40% of which were farm-raised. All but one of the outliers were from North American countries, with the majority of samples originating in the United States. As expected, the average number of congeners detected in the outliers was greater than the number detected in all other uncooked shrimp samples. While the percentage contribution of PCBs 28, 52/69, 90/101, 106/118, 138/163/164, 153, and 180 were generally similar between the outliers and all other uncooked shrimp samples, homologue fractions of mono-, di-, octa-, nona- and deca-PCBs varied considerably. Results from this evaluation suggest that for a few outliers, high concentrations of PCBs may be due to contaminated feed or local point sources. For other samples, excess loading of PCBs could be due to broader regional contamination.

Tuna Meltdown: Measuring Negative Public-Health Impacts on the Neurological Development of Children Born to Low-Income U.S. Mothers

David Martosko

Center for Consumer Freedom, Washington, DC

Primary Contact Information:
David Martosko, Center for Consumer Freedom
1090 Vermont Avenue NW #800, Washington, DC 20005
Tel: 202-463-7112 E-mail: 17hinook17@consumerfreedom.com

We sought to reliably measure negative public health impacts of warnings issued by government and environmental groups about trace levels of methylmercury present in commercially available fish. Using robust UPC-scan consumer purchasing data from the respected consumer-analyst firm ACNielsen, we examined how United States consumers have changed their seafood purchasing habits, especially regarding canned tuna. Canned tuna is the cheapest and most readily available dietary source of omega-3 fatty acids in the United States. The ACNielsen data show that 4.4 million U.S. households earning $30,000 or less completely eliminated their purchases of canned tuna between 2000 and 2006. In the same years, those households did not replace their canned-tuna purchasing with seafood from other (generally more expensive) market categories. This indicates that Americans in these 4.4 million poverty-level households were eating little to no fish at home. Women in these households gave birth to nearly 260,000 children during the years we examined. Contemporary research (Hibbeln et al., 2007) concludes that children whose mothers eat no fish during pregnancy are 29% more likely to have abnormally low IQs. This research suggests that public concern about methylmercury in fish is indirectly harming the neurological development of American children born to low-income mothers.

Composite Sampling with Fish Populations: Calculating a More Accurate Variance

John Mason

Environment International Ltd., Portland, OR

Primary Contact Information:
John Mason, Environment International Ltd
233 NE 60th Ave., Portland, OR 97216
Tel: 503-206-6914 Email: john.mason@eiltd.net

Environmental studies often employ the technique of composite sampling to obtain a single average value for multiple samples. The technique saves laboratory time and money by running just one analysis of the combined samples. Calculating means and variances using composited samples works for water and sediment samples, but the variance calculations are much more involved when sampling fish populations. Fish are considered segmented populations, meaning that they occur in readily identifiable units, whereas, water and sediment are considered to be nonsegmented populations, occurring as a homogenous mass. Calculating a variance for a segmented population cannot be done in the same way that it is done for nonsegmented populations. However, we present a few simple steps that enable a more accurate calculation of the variance to be made. These more accurate variances will increase the confidence and reliability of subsequent calculations of upper confidence limits on the mean and power and sample size analyses.

Mercury in Northern Pike from the Yukon Delta National Wildlife Refuge

Angela Matz[1] and Lori Verbrugge[2]

[1]U.S. Fish and Wildlife Service, Fairbanks, AK
[2]Alaska Division of Public Health, Anchorage, AK

Primary Contact Information:
Angela Matz, U.S. Fish and Wildlife Service
101 12th Ave., Room 110, Fairbanks, AK 99701
Tel: 907-456-0442 Email: angela_matz@fws.gov

[Abstract Not Available]

Evaluating Relative Risk from Multiple Chemicals in Single Species

Paul McCollum

Port Gamble S'Klallam Tribe, Kingston, WA

Primary Contact Information:
Paul McCollum, Port Gamble S'Klallam Tribe, Director, Natural Resources Department
31912 Little Boston Rd. NE, Kingston, WA 98346
Tel: 360-297-4792 Email: paulm@pgst.nsn.us

This poster represents example dietary limitation calculations for two subsistence and commercial fish and shellfish species important to Port Gamble S'Klallam tribal members. Puget Sound Chinook and Dungeness Crab are calculated using the most recent data sets of tissue contaminants to demonstrate human health–related monthly meal limitations based on U.S. EPA's *Guidance for Assessing Chemical Data for Use in Fish Advisories, Volume 2, Risk Assessment and Fish Consumption Limits*, Third Edition, November 2000 (herein referred to as Guidelines). This document can be accessed via the Web at http://www.epa.gov/waterscience/fishadvice/volume2/index.html. The results are calculated by simply

stepping through the calculations used in the Guidelines for expressing carcinogenic risk- based dietary limitations for multiple contaminants in a single species. Formula 3-10 for carcinogenic effects is shown below but can be more thoroughly reviewed in the appropriate sections of the Guidelines as referenced in the poster. Chronic systemic and developmental effects can also be calculated separately using individual chemical equations and combining their risk factors as the carcinogenic formula's do. The calculations result in only 0.67 allowable meals per year for Dungeness Crab and 0.057 meals per year for a stock of Puget Sound Chinook based on a 1 in 1 million cancer risk using 8-ounce meals. After factoring in additional chronic and developmental effects, considerably higher risk would be present.

Principal Equation for Carcinogenic Effects:

$$CR_{1im} = \frac{ARL \bullet BW}{\sum_{j=1}^{n} (C_{mj} \bullet P_j) \bullet CSF} \qquad (3\text{-}10)$$

where

CR_{lim} = maximum allowable fish consumption rate (kg/d)
ARL = maximum acceptable lifetime risk level (unitless)
BW = consumer body weight (kg)
C_{mj} = concentration of chemical contaminant *m* in fish species *j* (mg/kg)
P_j = proportion of a given species in the diet (unitless)
CSF = cancer slope factor, usually the upper 95 percent confidence limit on the linear term in the multistage model used by EPA ([mg/kg-d])$^{-1}$).

Attitudes and Knowledge of U.S. Healthcare Providers about the Safety and Nutritional Value of Seafood

Doris T. Hicks[1], Lori F. Pivarnik[2], Nicole L. Richard[2], Robert K. Gable[3], and Michael T. Morrissey[4]

[1] University of Delaware Sea Grant College Program
[2] University of Rhode Island, Department of Nutrition and Food Sciences
[3] University of Connecticut and Johnson & Wales University Educational Leadership, Doctoral Program
[4] Food Innovation Center Experiment Station, Oregon State University

Primary Contact Information:
Michael T. Morrissey, Professor, Food Innovation Center, Food Science and Technology, Oregon State University
1207 NW Naito Parkway, Suite 154, Portland, OR 97209
Tel: 503-872-6656 Email: michael.morrissey@oregonstate.edu

An internet-based survey was developed and implemented to ascertain the knowledge and attitudes of U.S. healthcare providers regarding the benefits and risks of seafood consumption. The survey addressed the following key areas: (1) demographics, (2) knowledge, (3) attitudes toward seafood safety/nutrition, and (4) attitudes toward the strength of scientific knowledge about seafood. Approximately 50% of survey respondents can be categorized as frequent seafood eaters (e.g., eat seafood >1/wk). Of 46 knowledge-based questions, the respondents overall knowledge score was only 56%. Professionals identifying themselves as Medical Doctor/Doctor of Osteopathy (MD/DO), Registered Dietician/Nutritionists (RD/N), Registered Nurse/Licensed Practical Nurse/Nurse Midwife (RNLP) or Nurse Practitioner/Physicians' Assistant scored 59%, 70%, 53%, and 57% respectively. All professionals scored below the mastery level, considered to be 80%. For knowledge categories of seafood safety/contaminants, seafood health/nutrition, and general seafood safety, the overall knowledge scores for the entire respondent pool were only 38%, 69%, and 59%, respectively. Overall attitude scores, based on a 5-point Likert scale (1=strongly disagree, 5=strongly agree) ranged from 2.3 to 3.5, with a total

average score of 3.3. These mediocre scores, coupled with very low knowledge scores, could present potential barriers for outreach efforts by food safety educators to U.S. healthcare providers. Only 170 (26%, N = 641) respondents knew the specific guidance recommended in the U.S. Food and Drug Administration (FDA)/U.S. EPA advisory about seafood. Of those answering correctly, 85 % were from the MD/DO, RD/N, and RNLP groups. Furthermore, 88% of these three medical groups identified themselves as Not Aware or Not Knowledgeable of the advisory and, therefore, were given the opportunity to read the guidance online prior to answering the knowledge questions about the advisory. Regardless of patient demographics, respondents indicated that the best place for patients to obtain seafood information and the best way to dispense information was through healthcare providers (e.g., MD/DO, RD/N) and brochures written by medical professionals or government agencies. Finally, the respondents indicated that the top three formats preferred for their own training about the benefits and risks of eating seafood were (1) brochures/pamphlets/fact sheets (57%), (2) quick reference guides (46%), and (3) Web-based training (38%). The results of this survey will enhance the identification and understanding of the challenges associated with providing clear, concise, and accurate information to the U.S. healthcare community regarding seafood health and safety issues.

Selenium-Health Benefit Values Provide More Accurate Predictions of Mercury-Dependent Health Risks

Nicholas V.C. Ralston[1] and Laura J. Raymond[1]

University of North Dakota, Energy & Environmental Research Center

Primary Contact Information:
Nicholas V.C. Ralston, University of North Dakota, Energy & Environmental Research Center
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018
Tel: 701-777-5066 Email: nralston@undeerc.org

Accurate methylmercury (MeHg) risk assessments require consideration of selenium (Se) availability as a concomitant variable. The binding affinity between Hg and Se is a million times higher than Hg's affinity for sulfur. Since all forms of life that have complex brains employ Se-dependent enzymes (i.e., selenoenzymes) to protect their brains against oxidative damage, most forms of animal life are extremely vulnerable to toxic effects of high MeHg exposure. By biochemical definition, MeHg is a highly selective irreversible inhibitor of selenoenzymes. Increased dietary Se appears to prevent toxic effects of MeHg by preventing Hg-dependent interruption of selenoenzyme activities. Although Se was first recognized as effective in counteracting Hg toxicity when animal studies showed Se was completely effective in preventing lethal effects of Hg poisoning 1967, its pivotal role in the Hg issue has been widely misunderstood until recently. The findings of animal and human studies consistently support the hypothesis that maternal MeHg exposures in excess of Se intake are directly associated with increasing risk of adverse fetal outcomes. In contrast, typical varieties of ocean fish are rich sources of Se occurring in great excess of Hg. This appears to explain why all recent studies have found that children of mothers that ate increasing amounts of ocean fish had no adverse effects, but instead gained 6 to 10 IQ points. These findings prompted development of the Se-Health Benefit Value (Se-HBV) as fish safety criteria. The Se-HBV incorporates absolute and relative amounts of Se and MeHg present in fish and provides a value that is easy for consumers and regulatory agencies to interpret. Foods that contain an excess of Hg and are therefore expected to have negative health effects will have negative Se-HBV's with magnitudes that are proportional to anticipated risks. Foods that are a good source of Se have positive Se-HBV's with magnitudes that directly correspond to their health benefits. Most lakes in North America have sufficient Se to provide fish with adequate amounts to have positive Se-HBV's, but fish from Se-depleted lakes may be far more hazardous than is currently recognized. In order to protect and improve child health, regulatory policies need to consider the role of dietary Se in the fish MeHg issue.

Selenium from Ocean Fish Protein Isolates Prevents Methylmercury Toxicity

Carla R. Ralston[1], Laura J. Raymond[1], John J. Kaneko[2], and Nicholas V.C. Ralston[1]

[1]University of North Dakota, Energy & Environmental Research Center, Grand Forks, ND
[2]PacMar Inc., Honolulu, HI

Primary Contact Information:
Carla R. Ralston, University of North Dakota, Energy & Environmental Research Center
15 North 23rd Street, Stop 9018, Grand Forks, ND 58202-9018

Risks of dietary methylmercury (MeHg) exposures are directly related to molar relationships with dietary selenium (Se) and require mutual consideration as concomitant variables to prevent statistical confounding. In this study, protein isolates from three varieties of ocean fish with different Hg:Se molar ratios, bigeye tuna, swordfish, and mako shark, were used as one-third of total protein sources in diets. Fish samples were delipidated, dried, reduced to fine powder, and added to diets in place of one-third of the torula yeast protein that was otherwise present in control diets. Dietary Se treatments consisted of torula yeast–based diets that were nutritionally complete, other than low Se (0.17 μmole/kg; ~0.02 ppm); were supplemented with sodium selenite to either normal (~1.0 μmole/kg) or rich (~10 μmole/kg) levels, or with Se from tuna, swordfish, or shark protein isolates (final concentrations: 3.5, 2.3, and 2.1 μmole Se/kg diet, respectively); and were prepared without added MeHg (0.08 μmole Hg/kg) or with MeHg added at 50 μmole Hg/kg diet (~10 ppm Hg). The Hg in the fish protein isolates contributed an additional 1.6, 2.3, and 3.6 μmole Hg/kg to diets they were added to, resulting in final MeHg concentrations ranging between 51.6 and 53.6 μmole Hg/kg. Weanling male Long Evans rats were initially all fed low Se diets to deplete their body tissues of Se, then they were switched to the indicated dietary treatments and monitored for effects on growth and motor function in a 6 (Se level) x 2 (Hg level) feeding study using 10 animals per treatment group (120 total rats). In the absence of added MeHg, all rats grew normally. However, MeHg-treated rats that were fed low Se diets showed depressed weight gains relative to the normal control group after 5 days on the diet treatment, started to lose weight after 6 weeks, and showed initial signs of hind limb crossing after 7 weeks. Meanwhile, rats fed normal or rich Se diets, or Se from tuna, swordfish, or shark grew normally, even in the presence of high MeHg and did not show any neurofunctional deficits. Regardless of whether the Se provided was inorganic or originated from fish protein, it appeared to be equally bioavailable and equally active in counteracting MeHg toxicity.

Public Health Information about the Safety of Seafood: Where Can I find it?

Dhitinut Ratnapradipa[1], Abdul Haseeb[2], Jesse Trushenski[3], and Alicia Wodika[4]

[1]College of Education and Human Services, Southern Illinois University, Carbondale, IL
[2]Memorial Hospital of Carbondale, Carbondale, IL
[3]Fisheries and Illinois Aquaculture Center, Southern Illinois University, Carbondale, IL
[4]Health Education and Recreation, Southern Illinois University, Carbondale, IL

Primary Contact Information:
Dhitinut Ratnapradipa, PhD, CHES, College of Education and Human Services, Southern Illinois University
Carbondale, IL 62901
Tel: 618-453-2777 Email: dhitinut@siu.edu

The objectives of this study are to identify, navigate, and analyze existing Web sources for the fish advisories and evaluate the benefit versus risk of fish consumption based on vulnerability status. Locating and navigating fish advisories can be as confusing as following the NASDAQ index. The public is strongly advised to check the local fish advisory, but many people lack the skill to access and understand

the numerous advisories available. Fish advisories provide information on which waterbodies contain fish that should be avoided or consumed in limited quantities based on tissue levels of five primary contaminant classes: mercury, polychlorinated biphenyls (PCBs), chlordane, dioxins, and dichlorodiphenyltrichloroethane (DDT). In the last decade, there has been an increase in fish advisories from different sources at the state and federal levels. For example, not only has the number of advisories for mercury increased from 2,436 in 2004 to 3,080 in 2006, but each fish advisory itself may have up to five different subclasses of information. Apart from the advisories, there are safe eating guidelines issued from different states informing the public about consumption recommendations, as well as providing broad coverage of the relative safety of wild and farm-raised fish in the popular media. Some regions of the United States have numerous fish advisories and safe eating guidelines, often resulting in confusion. Results of an Internet search for "fish advisories" range from 1.49 to 2.6 million results, so members of the public may be overwhelmed by the sheer amount of information available. U.S. EPA collects, centralizes, and updates the state fish advisories. The U.S. EPA Web site should be utilized as a clearinghouse to reduce confusion and simplify searches for information about safe seafood consumption. The U.S. EPA Web site also provides Internet links to the state advisories for people who are searching for locally specific information. In addition, the U.S. EPA Web site provides information on the relative benefits and risks of seafood consumption, specifically the importance of seafood as a source of lean protein and beneficial omega-3 fatty acids.

Detection of Illnesses Related to Seafood Consumption

Helen S. Rogers[1], Lorraine Backer[1], Rebecca LePrell[1], and Cristina Cooper[1]

[1]Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Health Studies Branch.

Primary Contact Information:
Helen S. Rogers, PhD, Health Studies Branch/DEHHE, Centers for Disease Control and Prevention
4770 Buford Hwy, MS F57, Chamblee, GA 30341
Tel: 770-488-3431 Email: hhs0@cdc.gov

Centers for Disease Control and Prevention (CDC) collects information about foodborne illness from the states using the National Outbreak Reporting System (NORS). From 1998 to 2005, the majority of foodborne outbreaks had no etiology defined (66%). Thirty-three percent of outbreaks were determined to have an infectious etiology, and only 3% had a chemical etiology. Of those with chemical etiology, over half were attributed to scombroid poisoning and 33% to ciguatoxin poisoning from seafood consumption. Difficulty in recognition of chemical and toxin syndromes, and collection of suitable specimens, likely results in many unidentified outbreaks. This poster will describe a differential for identifying the signs and symptoms of foodborne outbreaks with chemical etiology with special emphasis on seafood-related toxins and provide guidelines for biological sample collection.

Using Social Networking (Web 2.0) to Inform Sensitive Populations about Fish Consumption Advisories at Fish4Health.net

C.R. Santerre[1], S.N. Bossingham[1], and M.A. Rubesch[1]

[1]Foods and Nutrition, Purdue University

Primary Contact Information:
Charles R. Santerre, Ph.D., Professor of Food Toxicology, Foods and Nutrition, Purdue University
Stone Hall, Rm. 205, 700 W. State St., W. Lafayette, IN 47907-2059
Tel: 765-496-3443 Email: santerre@purdue.edu http://fn.cfs.purdue.edu/santerre/

The Fish4Health.net Web site provides YouTube video, mobile phone, and Iphone applications and podcasts to help women make informed decisions about the commercial and recreationally caught fish that they consume when pregnant or nursing. Advisories are provided in English and Spanish and for kosher consumers. The advisory information is accessible in grocery stores and restaurants, and some recipes are provided to encourage seafood consumption. If our efforts are successful, women will consume 8 to 12 ounces of fish per week, avoid species that are higher in environmental pollutants, and select those that are higher in omega-3 fatty acids.

Consuming Fish to Reduce Mercury Intake While Optimizing Omega-3 Fatty Acid Status

C.R. Santerre[1], T.E. Petersen[2], E.M. Janle[1], W.W. Campbell[1], G.P. McCabe[1], R. Mobley[2], H.H. Freiser[1], S. Speights[2], and M.L. Johnson[2]

[1]Purdue University
[2]Florida A&M University

Primary Contact Information:
Charles R. Santerre, Ph.D., Professor of Food Toxicology, Foods and Nutrition, Purdue University
Stone Hall, Rm. 205, 700 W. State St., W. Lafayette, IN 47907-2059
Tel: 765-496-3443 Email: santerre@purdue.edu http://fn.cfs.purdue.edu/santerre/

The specific aim for this ongoing study is to determine whether female subjects (18 to 40 years of age, target = 120) who enroll in the study with elevated hair mercury levels (> 0.8 ppm) and are then fed low-mercury fish (e.g., farmed salmon or farmed tilapia at 6 ounces [170 g]/week for 12 to 13 weeks) while avoiding other seafood, will significantly decrease their hair and blood mercury concentrations while maintaining or increasing their plasma omega-3 fatty acid (eicosapentaenoic acid [EPA]/docosahexaenoic acid [DHA]) levels.

A Quick and Accurate Method for Determining Mercury Levels in Fish Tissue Using Direct Mercury Analysis

Johan Nortje[1] and Dean Schmidt[1]

[1]Milestone Inc., Sandy, UT

Primary Contact Information:
Dean Schmidt, Regional Account Manager, Milestone Inc.
8360 S Sublette Circle, Sandy, UT 84093
Tel: 281-546-5974 E-mail: d.schmidt@milestonesci.com

The determination of mercury in fresh and saltwater species remains a primary focal point of both private and public organizations. These organizations make important regulatory and scientific decisions based

on the mercury levels found in fish tissue and, therefore, require a rapid, accurate method for mercury determination.

Traditionally, cold vapor atomic absorption spectrophotometry (CVAAS) has been used to measure mercury levels in fish. Although effective, this technique is time and labor intensive and requires complicated wet chemistry sample preparation.

In contrast, the mercury levels documented in this poster were collected using Milestone, Inc.'s Direct Mercury Analyzer (DMA-80). This instrument directly analyzes a sample via thermal decomposition and subsequent conversion of mercury to its elemental state by means of catalytic reduction. The total mercury in the sample is then measured by a dual-cell atomic absorption spectrophotometer. Total analysis time is approximately 6 minutes per sample.

Our results indicate that the DMA-80 is both an accurate and precise method for determining mercury concentrations in fish tissue. In addition, the results appear to be more precise than traditional CVAAS techniques.

Contaminant Analyses of Adult Salmon and Steelhead Returning to Three U.S. Fish and Wildlife Service Hatcheries

A.L. Gannam[1], J.W. Davis[2], R.G. Twibell[1], and S.L. Ostrand[1]

[1]USFWS, Abernathy Fish Technology Center, Longview, WA
[2] USFWS, Washington Fish & Wildlife Office, Lacey, WA

Primary Contact Information:
Ronald Twibell, USFWS, Abernathy Fish Technology Center
1440 Abernathy Creek Rd., Longview, WA 98632
Email: Ronald_Twibell@fws.gov

Returning adult salmon and steelhead were sampled at three National Fish Hatcheries (NFHs): Warm Springs NFH (spring Chinook, *Oncorhynchus tshawytscha*), Quilcene NFH (coho, *O. kisutch*), and Quinault NFH (steelhead, *O. mykiss*). Fifteen males and 15 females from each hatchery were collected during spawning, and a portion of muscle tissue, including skin, was sampled from the same area on each fish. Tissue samples were pooled so that there were three composite samples (5 fish per composite) from each sex. Samples were taken on spawning days at each hatchery: August 30, 2006, October 24, 2006, and December 13, 2006, respectively. In addition, 6 adult spring Chinook were collected in May and June 2006 at Warm Springs NFH at the time of distribution to tribal members. Four of the adults were males; 2 were females, with 1 of the females considered wild because it was unmarked. These fish were analyzed whole. Collection protocols generally followed U.S. EPA's guidelines (U.S. EPA Guidance for assessing chemical contaminant data for use in fish advisories, *Volume 1: Fish Sampling and Analysis* – 3rd Edition, U.S. EPA, Washington, DC [2000]). Samples were analyzed for congener-specific polychlorinated biphenyls (PCBs), dioxins and furans, organochlorines, polybrominated diphenyl ethers (PBDEs), and metals by laboratories contracting with the United States Fish and Wildlife Service's (USFWS's) Analytical Control Facility. Alpha Woods Hole Laboratory analyzed the tissues for metals, and the Geochemical and Environmental Research Group at Texas A&M University analyzed the tissues for the organic compounds. PBDEs were only detected in fish composites at Quilcene NFH and in female carcasses at Warm Springs NFH. Levels of PCBs and PBDEs were higher in whole carcasses of females than in skin on fillets from females, suggesting these contaminants may be present in greater concentrations in tissues other than muscle or skin. Data for PCBs illustrates some variability between hatcheries for male composites, but there is little variation for female composite samples. Given the small sample size, it is difficult to attribute these differences to any particular factor (e.g., hatchery location, fish species).

Table 1. Total PCBs and brominated diphenyl ethers (BDEs) reported in parts per million (ppm) wet weigh (ppm wet wt.) in the salmonids returning to NFHs. Values shown are an average of three composites; carcass data is an average of 4 male and 2 female whole fish.

	Warm Springs		Quilcene		Quinault	
	Composite		Composite		Composite	
	Male	Female	Male	Female	Male	Female
Total PCBs	0.0677	0.0363	0.1068	0.0477	0.1677	0.0448
Total BDEs	<DL	<DL	0.0069	0.0078	<DL	<DL
	Carcass					
	Male	Female				
Total PCBs	0.0457	0.0719				
Total BDEs	<DL	0.00135				

DL = detection limit.

Mercury Biomonitoring and Fish Consumption Patterns among Women in Northeast Florida

Sharleen Traynor[1], Greg Kearney[2], and Aaron Hilliard[1]

[1]Duval County Health Department, Division of Environmental Health and Disease Control
[2]Florida Department of Health, Division of Environmental Health

Primary Contact Information:
Sharleen Traynor, Duval County Health Department, Division of Environmental Health and Disease Control, Toxicology Program
900 University Blvd N, Jacksonville, FL 32211
Tel: 904-253-2031 Email: Sharleen_Traynor@doh.state.fl.us

Background: Mercury (Hg) is an environmental toxin that has been associated with harmful effects on neurological development, especially in fetuses and young children. The most common human exposure to mercury is through fish consumption. Mercury in the atmosphere is redeposited onto the earth with precipitation and is converted to methylmercury in aquatic environments. Mercury then works its way up the food chain through bioaccumulation. There has been growing concern over human exposure to mercury related to fish consumption in the United States, especially in areas that have high mercury emissions from coal-fired power plants and populations of frequent fish consumers. In the present study, mercury biomonitoring and fish consumption patterns were evaluated among women of child-bearing age who reside in Duval County, Florida. **Method:** Women age 18 to 49 were recruited from public and private health clinics and during community events. Eligible participants completed a questionnaire about fish consumption habits, knowledge of fish consumption advisories, pregnancy status, demographic and socioeconomic information, and mercury exposure history. Each participant also provided a scalp hair sample for mercury analysis. Frequencies, geometric means, and regression models were produced using SAS 9.2. **Results:** A total of 703 women participated in the study. The mean monthly fish consumption was 12.41 fish meals per month, which exceeds the recommended fish consumption for women of child-bearing age. Of the fish/shellfish consumers, 35.08% reported recent consumption of a high-mercury fish species. Fish consumption was highest among Asian/Pacific Islander women and women reporting highest annual household income. Only 15.65% of the women sampled reported being aware of the local fish consumption guidelines for Florida waterways, and 63.44% reported having heard about limiting fish consumption due to potential mercury exposure. These percentages were lower among pregnant women than nonpregnant women. The overall geometric mean hair Hg level was 0.293 µg/g. About 7.44% of the women had hair Hg levels exceeding the U.S. EPA's Reference Dose of 1 µg/g for hair mercury. Risk factors associated with elevated hair Hg levels include fish consumption, race, age, and income. **Conclusions:** Women in Duval County consume more fish than in other geographic areas of the United States, and local hair mercury levels in Northeast Florida are higher than national levels. Yet local

knowledge of advisories remains low. There is a need for increased education about fish consumption advisories and mercury exposure among populations at risk in Duval County.

Nutrient and Contaminant Tradeoffs: Exchanging Meat, Poultry, or Seafood for Dietary Protein

Ann L. Yaktine[1], Malden C. Nesheim[2], and Cara A. James[1]

[1]Food and Nutrition Board, Institute of Medicine, the National Academies
[2]Cornell University

Primary Contact Information:
Ann L. Yaktine, Food and Nutrition Board, Institute of Medicine, the National Academies
500 Fifth Street, NW, Washington, DC 20001
Tel: 202-334-1380 Email: ayaktine@nas.edu

When making food choices, consumers are faced with the dilemma of reconciling differences between health benefits and exposure to potential toxins. Analyses to estimate likely intake and exposure outcomes for young children and women of child-bearing age shows that seafood, chicken, and beef, while approximately equivalent in protein, vary in key nutrients of importance as well as in levels of certain contaminants. Increasing the variety of choices among meats, poultry, and seafood and consuming them in amounts consistent with current dietary guidelines and advisories will contribute toward meeting nutritional needs while reducing exposure to any single type of contaminant. This study was published in *Nutrition Reviews* 66(3):113–122, 2008.

Measurement of Volatile Organic Chemicals (VOCs) in Finfish and Shellfish Harvested from Commencement Bay, Washington

Marcia L. Bailey[1], Michael Hiatt[2], Dave Terpening[1], and Jean Zodrow[1]

[1]U.S. EPA Region 10, Seattle, WA
[2]U.S. EPA National Exposure Research Laboratory, Las Vegas, NV

Primary Contact Information:
Jean Zodrow, U.S. EPA Region 10
1200 Sixth Ave., Suite 900, Seattle, WA 98101
Tel: 206-553-1302 Email: zodrow.jean@epa.gov

U.S. EPA was invited to work with the Washington Department of Ecology in developing a Resource Conservation and Recovery Act (RCRA) Corrective Action Environmental Indicator Determination for Human Health Exposure for the former Occidental Chemical Corporation facility located in Commencement Bay, Tacoma, WA. Because the only potential significant exposure pathway was determined to be consumption of seafood, measurement of site-related chemicals in resident fish and shellfish was desired. The Washington Department of Fish and Wildlife provided U.S. EPA with 23 specimens of resident finfish and crab harvested from an area affected by releases of chlorinated VOCs from Occidental.

Specimens were stored at –20 degrees C at U.S. EPA's Manchester Laboratory. After partial thawing, filet and liver samples were obtained from each fish as individual samples. Hepatopancreas samples were obtained from each crab, as were leg/claw tissue samples. Opened cans of commercial tuna were used as "blanks" to detect if VOCs from the processing laboratory might contribute to VOCs detected in samples. Individual samples were weighed, foiled, and placed in glass vials for shipment in dry ice to National Exposure Research Laboratory (NERL). Further preparation and analysis was conducted by U.S. EPA NERL chemist Mike Hiatt, pursuant to a method he developed and patented: U.S. EPA SW-846 Method

8261, Volatile Organic Compounds by Vacuum Distillation in Combination with Gas Chromatography/Mass Spectrometry.

VOCs analyzed for Occidental were perchloroethylene (PCE), trichloroethylene (TCE), vinyl chloride, and hexachlorobutadiene. At least one VOC was detected by NERL in all samples. Vinyl chloride was not detected, but probably was not present as a contaminant in the immediate area where the tissue samples were obtained. Hepatopancreas samples showed consistent and highest VOC concentrations, the highest being 79.8 µg/kg PCE. PCE, TCE, and hexachlorobutadiene were detected in 90%, 83%, and 40% of all samples, respectively.

This study, while limited, demonstrates that the common assumption that VOCs will not be present in fish or shellfish tissue where VOCs have been released to surface waters is not necessarily true. Because anadromous species, particularly salmon, were not included in this study, this remains a data gap.