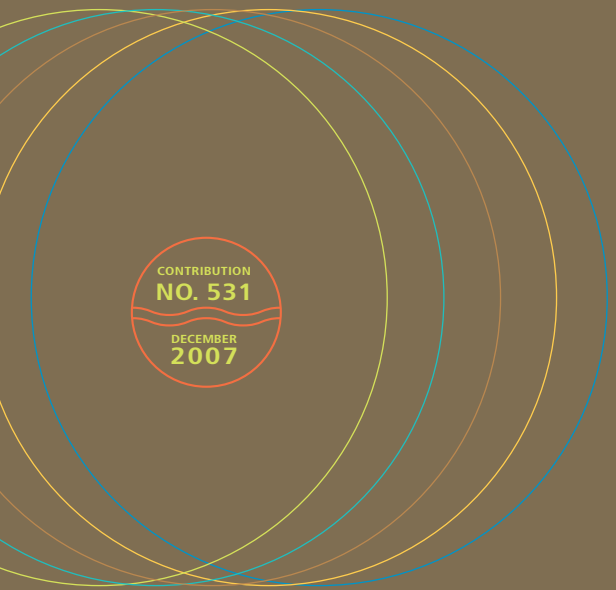
The Fish Mercury Project

Monitoring and Reducing Methylmercury Exposure in the Bay-Delta Watershed

San Francisco Estuary Institute



This report should be cited as:

SFEI. 2007. The Fish Mercury Project: Monitoring and Reducing Methylmercury Exposure in the Bay-Delta Watershed. SFEI Contribution 531. San Francisco Estuary Institute, Oakland, CA.

Cover Photographs:

Left: Collecting sport fish. Photograph by Jessica Kaslow.
Right: Collecting biosentinel fish. Photograph by Darell Slotton.

The Fish Mercury Project

Monitoring and Reducing Methylmercury Exposure in the Bay-Delta Watershed

San Francisco Estuary Institute

A Mid-term Report

The Fish Mercury Project (FMP) is a groundbreaking $4.7 million effort funded by CALFED (www.calwater.ca.gov) and conducted by a team of scientists led by the San Francisco Estuary Institute (SFEI – www.sfei.org). The FMP's near-term goal is reduction of human exposure to mercury in the Delta region through increased public awareness of fish contamination. The FMP also is providing information to water quality managers pursuing the ultimate, long-term solution to the mercury problem – reducing mercury accumulation in the food chains of our aquatic ecosystems.

To attain these goals, the FMP has developed innovative approaches to monitoring mercury in fish. Sport fish monitoring is being coordinated with the development of consumption advice, public outreach activities and educational materials. Members of the communities most affected by fish contamination are providing an unprecedented amount of input into these efforts, making this the first major water quality monitoring effort in California to incorporate environmental justice principles.

The FMP also is employing small fish as "biosentinels" to track the entry points of mercury into the food web. This innovative approach is advancing our understanding of mercury dynamics in the region's waters to help ecosystem managers reduce the movement of mercury into the food web.

This report provides a non-technical summary that is intended to give decision-makers, environmental managers, county agency staff, community leaders, and the public information they need to understand and ultimately solve the mercury problem. The FMP began in late 2004 and will end in the summer of 2008.

Overview of the Project. The report begins with an article providing background on the mercury problem in the Bay-Delta watershed and an overview of the Project *(page 6)*. The watershed includes thousands of miles of rivers and streams and thousands of lakes and reservoirs. This vast region supports a large and growing human population (currently over 9 million). Many of these people catch and eat fish from the watershed.

Unfortunately, fish contamination in the watershed is a serious environmental and public health concern. Intensive gold and mercury mining across the watershed has left a legacy of mercury contamination; as a result, many fish populations are tainted with mercury. In the Bay-Delta and surrounding areas, the contamination is among the most extensive in the state. An additional cause for concern relates to the ambitious habitat restoration programs underway in the Bay-Delta system. CALFED and others are investing considerable resources in restoring wetlands and other aquatic habitats, a process certain to provide substantial benefits for fish and wildlife populations. However, exacerbation of the existing mercury problem is a potential side effect of restoration activities because wetlands and newly flooded habitats can accelerate mercury uptake into the food chain.

Integrated Monitoring. Project scientists coined the term "integrated monitoring" to describe the FMP's approach to sport fish monitoring. Integrated monitoring consists of three components: monitoring mercury levels in fish, developing consumption advice and communicating risk. All three activities are influenced by input from stakeholders – e.g., communities affected by fish contamination. In developing monitoring plans, information is solicited from stakeholders on the places they fish and the species they consume. A high priority is then placed on sampling these species and locations. This targeted monitoring information is then used to develop consumption advice. Agencies involved in risk communication then work with stakeholders to convey this consumption advice back to the fishing communities.

The FMP is conducting the most extensive monitoring to date of mercury in sport fish in the Delta region *(page 22)*. In 2005, the FMP and other smaller programs collected over 2000 fish from 22 species and 69 popular fishing locations. Mercury concentrations in fish varied significantly among species, locations, and with fish size. Overall, largemouth bass was the most contaminated of the target species, and bluegill and redear sunfish were the least. The least contaminated locations sampled in 2005 were mainly in the central and southern Delta. The most contaminated locations were along the mainstem and tributaries of the Sacramento and San Joaquin Rivers, as well as the Cosumnes River. For many species (including largemouth bass, Sacramento sucker, and Sacramento pikeminnow), larger and older fish had higher concentrations of mercury.

Safe Eating Guidelines. To support development of safe eating guidelines *(page 34)*, the FMP team divided the very large study area into three parts. The San Joaquin River and South Delta (south of the San Joaquin River) were the focus during the first year. After a thorough evaluation, the

Office of Environmental Health Hazard Assessment (OEHHA – www.oehha.ca.gov) found that mercury levels in many types of fish from the South Delta area were quite low. These fish included bluegill and redear sunfish, catfish, clams, crayfish, crappie, carp, sucker, and even largemouth bass. Consumption of up to two meals per week (a total of six ounces cooked) of all of these species in this region is considered safe for all fish consumers. In comparison, some of the same species found in the San Joaquin River south of Stockton contained higher levels of mercury. The higher levels of mercury in largemouth bass from the San Joaquin River (south of the Port of Stockton) could be a concern for pregnant women and children. The safe eating guidelines for this region recommend that women of childbearing age and children avoid eating largemouth bass and other black bass.

Variation in mercury concentrations provides opportunities for consumers to reduce their mercury exposure by targeting fish with low concentrations. Consumers can still obtain the numerous health benefits provided by a diet that includes fish. Fish are a good source of protein and also contain "good fats" – omega-3 fatty acids – which support healthy hearts and brain development. Safe eating guidelines developed by OEHHA provide information on risks and benefits of eating fish that allow consumers to minimize their exposure to mercury and other pollutants while maintaining fish in their diets.

Risk Communication. Although fishing for food is a significant activity in the Bay-Delta watershed, anglers generally are not very aware of fish contamination issues and effective health protection measures. In the FMP, the California Department of Public Health (CDPH - www.cdph.ca.gov) is working with community-based organizations and county agency staff (comprising the "Local Stakeholder Advisory Group," or LSAG) to develop and implement strategies for informing the public about the benefits and risks of fish consumption *(page 46)*. CDPH has gathered information on fishing and risk communication from multiple sources across the watershed, through meetings with county agencies and other groups in 23 counties, discussions with anglers in focus groups (including over 100 anglers from Lao, Cambodian, Hmong, Vietnamese, Latino, Russian, African American, and Native American communities), surveys, interviews with fish and game wardens, and other sources. A major effort guided by the LSAG led to the posting of multi-language signs with safe fish eating guidelines in about 60 locations throughout the five Delta counties. The LSAG also guided the development, translation, and distribution of fish contamination educational materials, including printed cards, brochures, flyers, and posters; these materials were produced in multiple languages and a variety of literacy levels. Additionally, CDPH established a program providing small grants to community-based organizations to conduct outreach and education activities aimed at raising awareness in their communities *(pages 54-58)*.

Monitoring Restoration Projects. Darell Slotton from UC Davis is another partner in the FMP and is performing the most extensive monitoring ever conducted of small fish in the watershed *(page 64)*. These "biosentinels" are being collected from 50 sites throughout the watershed, especially near large wetland restoration projects. Encouraging results were obtained from the Napa Marsh area, the site of some of the most extensive wetland restoration activities in the watershed, including projects initiated in 1995, 2002, and 2006. Biosentinel fish collected in 2006 from a Napa Marsh salt pond that was opened to tidal action earlier that year had the lowest mercury observed for the indicator species across the entire watershed. Fish from other locations in this area also had low concentrations in both 2005 and 2006. These findings indicate that some restoration projects may be associated with reduced, rather than increased, mercury accumulation in the food chain. Other significant findings from the biosentinel work to date include the observation that seasonal variation in mercury uptake seems associated with episodic flooding of normally dry soils, documentation of significant year-to-year variation, and an improved general understanding of the spatial pattern of accumulation across the watershed.

Related Topics. The report also contains several sidebars on topics related to mercury in fish in the region, including the cleanup plan for methylmercury in the Delta *(page 76)*, monitoring and risk communication by Sacramento County (page 33), a discussion of environmental justice *(page 60)*, a California Indian perspective on the problem *(page 63)*, and exposure reduction strategies that go beyond consumption advice *(page 77)*.

Completing the Project. FMP activities will continue through August 2008. Reports to be completed at the end of the project will document the results of extensive monitoring in 2006 and 2007, safe eating guidelines for the Sacramento River and North Delta, and additional efforts to reduce mercury exposure in the near-term through effective communication of risk information to fish consumers. ●

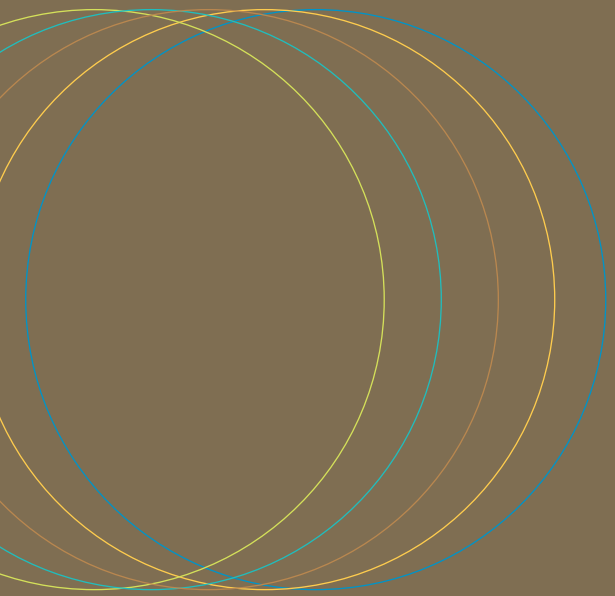


Table of Contents

Community Organization Profiles

Sidebars

Collecting small "biosentinel" fish with an e-boat.

Photograph by Darell Slotton.

CALFED Funds Major Project to Evaluate and Communicate Risks Related to Mercury in Fish in the Delta and its Watershed

J.A. Davis (jay@sfei.org) and J. Hunt, San Francisco Estuary Institute
D.G. Slotton, University of California, Davis
A.M. Ujihara, California Department of Public Health
R.K. Brodberg, California Office of Environmental Health Hazard Assessment
M.D. Stephenson, California Department of Fish and Game

Highlights

- Extensive gold and mercury mining in the Bay-Delta watershed has left a legacy of fish populations that are tainted with mercury and pose health risks to humans and wildlife
- Large-scale habitat restoration is planned for the watershed to promote the recovery of dwindling populations of fish and wildlife
- One unfortunate potential side-effect of this habitat restoration is exacerbation of the existing mercury problem
- Fish monitoring is essential to implementing the ultimate solution to the mercury problem: reducing mercury sources and concentrations in our aquatic ecosystems
- Fish monitoring can also provide a foundation for developing consumption advice and effectively communicating the advice to fish consumers to achieve a more rapid reduction in human exposure to mercury and other pollutants
- A novel aspect of the FMP is the explicit incorporation of environmental justice principles
- Another novel aspect of the FMP is the way in which monitoring of sport fish to characterize human exposure is being integrated with stakeholder involvement, advisory development, and risk communication in an approach referred to as “integrated monitoring”
- The FMP is breaking new ground by conducting biosentinel monitoring at a spatial scale that is unprecedented in California, establishing a foundation for evaluating the effects of habitat restoration on mercury in aquatic food webs

The Fish Mercury Project

The Fish Mercury Project (FMP) is a groundbreaking, $4.7 million effort funded by CALFED (www.calwater.ca.gov) that is providing the information on mercury concentrations in fish that is essential for reducing human and wildlife health risks related to mercury exposure in the Bay-Delta region. Mercury contamination of fish in the watershed is a serious environmental and public health concern. The FMP is working to achieve a rapid reduction in human exposure to mercury in the Bay-Delta region through increased public awareness of fish contamination. The FMP is also providing information needed by water quality managers as they pursue the ultimate, long-term solution to the mercury problem – reducing mercury accumulation in food chains of our aquatic ecosystems. This article provides background on the mercury problem in the Bay-Delta watershed and an overview of the Project.

A Vital Resource

Fisheries in the Bay-Delta watershed are a resource of great importance, supporting significant amounts of recreational and subsistence fishing activity by humans and an abundance of fish-eating wildlife species. The Bay-Delta watershed is vast, encompassing 40% of the land area of California, and including thousands of miles of rivers and streams and thousands of lakes and reservoirs *(Figure 1)*. The Delta alone has more than 700 miles of waterways. The watershed supports a large and growing human population, with approximately 8.8 million people in the counties directly bordering the Bay-Delta and more living further upstream. A significant fraction of this large population enjoys catching and eating sport fish. As one index of the magnitude of fishing activity in the Delta, in 1998 an estimated $378 million was spent for Delta-oriented boating and fishing recreation. Fishing is also a popular activity in the many rivers, streams, lakes, and reservoirs upstream of the Delta, and downstream in San Francisco Bay.

A State of Mines

Mining has had a profound influence on the course of history in California. The Gold Rush, which began in 1848 with the discovery of gold on the American River, caused a rapid growth in California's population, leading to the admission of California as a state in 1850 and a host of other social and environmental impacts. One unfortunate consequence of the extensive mining that began with the Gold Rush is a legacy of fish populations that are tainted with mercury and pose health risks to humans and wildlife.

Gold miners used mercury to separate gold from the crushed ore in hard rock mining and the gravel deposits in placer mining. An estimated 10 million pounds of mercury were released to the California environment by placer mining, with about 80-90% of this in the Sierra Nevada. Another 3 million pounds is estimated to have been released from hard rock mining operations. Dredging was another major category of mining that also employed mercury and resulted in contamination of the environment. Movement of mercury away from historic mining areas has proven to be very slow, and in many cases high concentrations are still found near the mines and in downstream water bodies. Water bodies downstream of historic gold mining districts *(Figure 2)* therefore continue to face impacts of mercury contamination.

Most of the mercury used in California gold mining was obtained from mercury mines in the northern California Coast Range *(Figure 2)*. Between 1846 and 1981 approximately 230 million pounds of mercury were produced in California, accounting for 88% of the mercury extracted in the entire U.S., and much of this production was from northern California Coast Range counties. Mercury losses to the environment during mercury ore processing ("furnace losses") are estimated to have been on the order of 75 million pounds. Contaminated tailings, soils, and drainage from abandoned mercury mine sites have caused mercury contamination of downstream waterbodies in the past and continue to supply contaminated sediments to the Bay-Delta today.

The Mercury Problem

Mercury exists in many different forms in the aquatic environment. *Methylmercury* is the form of primary concern because it is readily accumulated in the food web and poses a toxicological threat to highly exposed species. Mercury from historic mining districts and other sources is converted to methylmercury principally by bacteria in sediments of aquatic ecosystems, especially in situations where the sediments are low in oxygen. Methylmercury reaches higher concentrations with each step up the food chain, in a process known as "biomagnification" *(Figure 3)*.

Map by Ben Pease (www.peasepress.com); data courtesy of the Bay Institute and the San Francisco Estuary Institute, 1998.

Figure 1

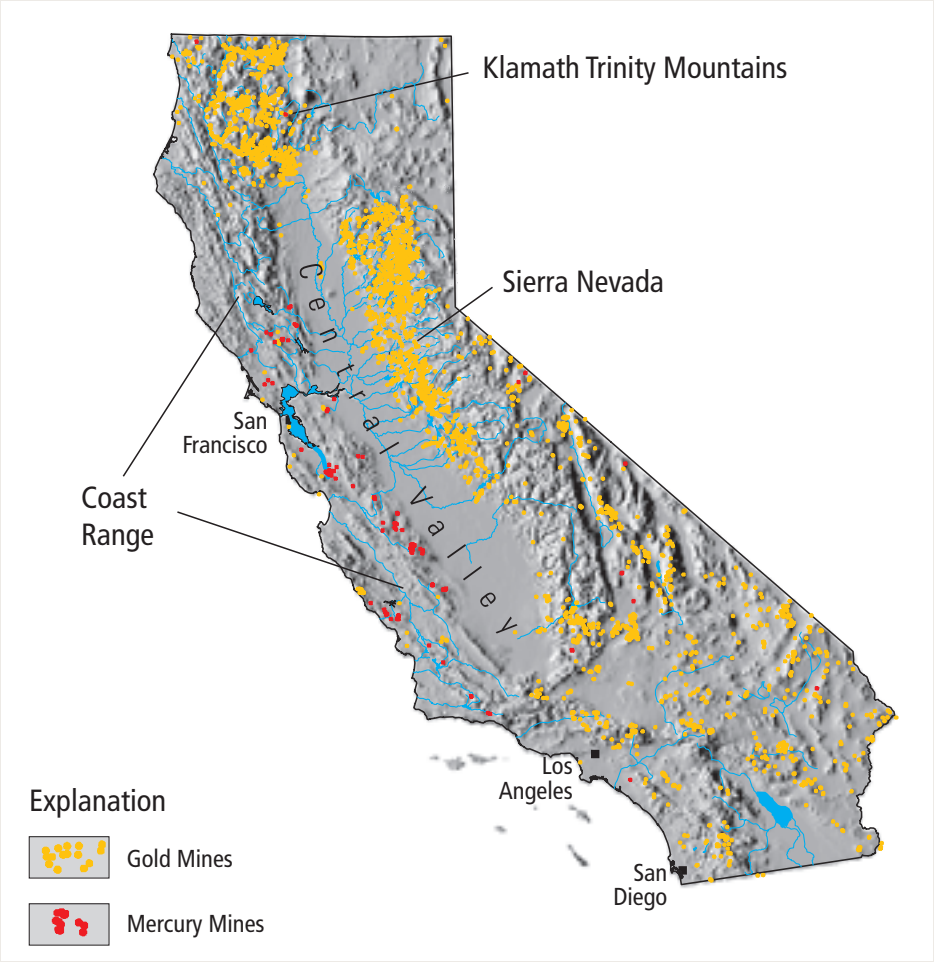
The Bay-Delta watershed is vast, *encompassing 40% of the land area of California, and including thousands of miles of rivers and streams and thousands of lakes and reservoirs. With a large and growing human population, approximately 8.8 million people in the counties directly bordering the Bay-Delta and more living further upstream, there is a great deal of fishing activity in the watershed for both recreation and subsistence.*

Mercury can still be panned from the Guadalupe River, as demonstrated by Rick Humphreys.

Photograph by Sarah Pearce.

A stakeholder field trip to a historic mercury mine.

Photograph by Sophat Sorn.



From Alpers et al. 2005.

Figure 2

Mining has had a profound influence on the history and environment of California, and on the environment. *The rich gold deposits of the Sierra Nevada motherlode are well known, but California (specifically the Coast Range of northern California) was also the most productive mercury-mining region in the nation. Unfortunately, the extensive gold and mercury mining that began in the 1840s has left behind a legacy of fish populations that are tainted with mercury and pose health risks to humans and wildlife.*

Figure 3

Mercury exists in many different forms in the aquatic environment. *Methylmercury is the form of primary concern because it is readily accumulated in the food web and poses a toxicological threat to highly exposed species. Mercury from historic mining districts and other sources is converted to methylmercury principally by bacteria in sediments of aquatic ecosystems, especially in situations where the sediments are low in oxygen. Methylmercury reaches higher concentrations with each step up the food chain – from water, to phytoplankton, to filterfeeders, to small fish, to sport fish – in a process known as "biomagnification". Concentrations in large predatory fish like striped bass end up being about 5 million times higher than in water.*

Accumulation of methylmercury in fish in many California water bodies is severe enough to cause concern for the health of humans and wildlife that consume them. A statewide review of fish monitoring data from the past 30 years (Davis et al. 2007) concluded that methylmercury contamination is common in California aquatic food webs, with long-term trends indicating little change over the past few decades. Large regions of the State contain sport fish with very high (greater than 0.9 parts per million, or ppm[1]) methylmercury concentrations *(Figure 4)*. Twenty-three of 298 locations (8%) sampled from 1998 – 2003 had a species with a median mercury concentration above 0.9 ppm. Only 26% of the locations had low concentrations (below 0.1 ppm[2]) for all species. Sixty-six percent of the locations sampled had intermediate concentrations, with at least one species above 0.1 ppm. In the San Francisco Bay-Delta, Central Valley, and surrounding areas the contamination is among the most extensive in the state.

Although fishing for food is a significant activity in the Bay-Delta watershed, anglers are not very aware about fish contamination issues and how to protect their health. In 1998-1999, the California Department of Public Health (CDPH) conducted the San Francisco Bay Seafood Consumption Study which found that about two-thirds of people fishing have no awareness or limited understanding of the existing San Francisco Bay fish advisory (SFEI 2001). The study also found that African Americans and Asians catch, prepare, and eat San Francisco Bay fish in ways that are likely to increase their exposure to chemical contaminants. More recent assessments by CDPH of risk communication needs and effectiveness in the watershed have concluded members of Southeast Asian, Latino, African-American, and Russian communities regularly eat fish from local waters and have generally low awareness of fish consumption advisories and the health risks of exposure to methylmercury in fish. They also found that county health departments are not undertaking public outreach and education activities.

Wildlife exposure is another facet of the mercury contamination problem. Recent studies indicate that methylmercury concentrations in eggs of several bird species are high enough to reduce hatching success. Methylmercury concentrations in the small fish that are preyed upon by birds have been shown to vary widely, with several hotspots in the watershed. In San Francisco Bay, the region with the most data, impacts on wildlife appear likely, and even endangered species are facing significant risks.

A major positive ecological development has occurred in recent years with the inception of the CALFED Bay-Delta Program, a collaborative effort among 25 state and federal agencies to improve water supplies in California and the health of the Bay-Delta watershed. This is recognized as the largest and most comprehensive water management and ecosystem restoration program in the nation. CALFED is investing considerable resources in restoring wetlands and other aquatic habitats, and this is certain to provide substantial benefits for fish and wildlife populations. However, one unfortunate side-effect of these restoration activities is the risk of exacerbating the existing mercury problem. Many studies around the world have demonstrated that the net production of methylmercury can be elevated in wetlands and newly flooded aquatic habitats. Our present understanding of mercury is not sufficient to predict which restoration or remediation projects will affect mercury accumulation in food webs on a local or regional scale. Thus, while some CBDA watershed remediation efforts are aimed at reducing mercury accumulation in the food web, some restoration and water management activities may potentially have the opposite effect and lead to local, and possibly regional, increases of mercury in fish, wildlife, and humans.

Addressing the Mercury Problem

CALFED's Mercury Strategy (Wiener et al. 2003) developed a valuable conceptual framework for linking mercury science with adaptive management[3] of water quality and habitat restoration in the Bay-Delta watershed. Wiener and coauthors pointed out that clear definition of a problem is an essential first step in addressing the problem. For mercury, they defined ***the primary problem in the Bay-Delta and other aquatic ecosystems as biotic exposure[4] to methylmercury***, and stated that the overall challenge to scientists and managers involved with ecological restoration in the Bay-Delta ecosystem is to avoid increasing – and to eventually decrease – biotic exposure to methylmercury. The same problem definition can be broadened to include other pollutants such as PCBs that, like mercury, accumulate in aquatic food webs.

1 When concentrations of mercury in fish reach 0.9 ppm, the California Office of Environmental Health Hazard Assessment (OEHHA) considers recommending that sensitive populations (women of child-bearing age and children) do not consume any fish.

2 For fish with concentrations in this range, OEHHA generally encourages fish consumption both for sensitive populations (women of child-bearing age and children) and the general population.

3 "Adaptive management" is a systematic process for continually improving management policies and practices by monitoring the outcomes of previously employed policies and practices.

4 "Biotic exposure" means exposure of living organisms

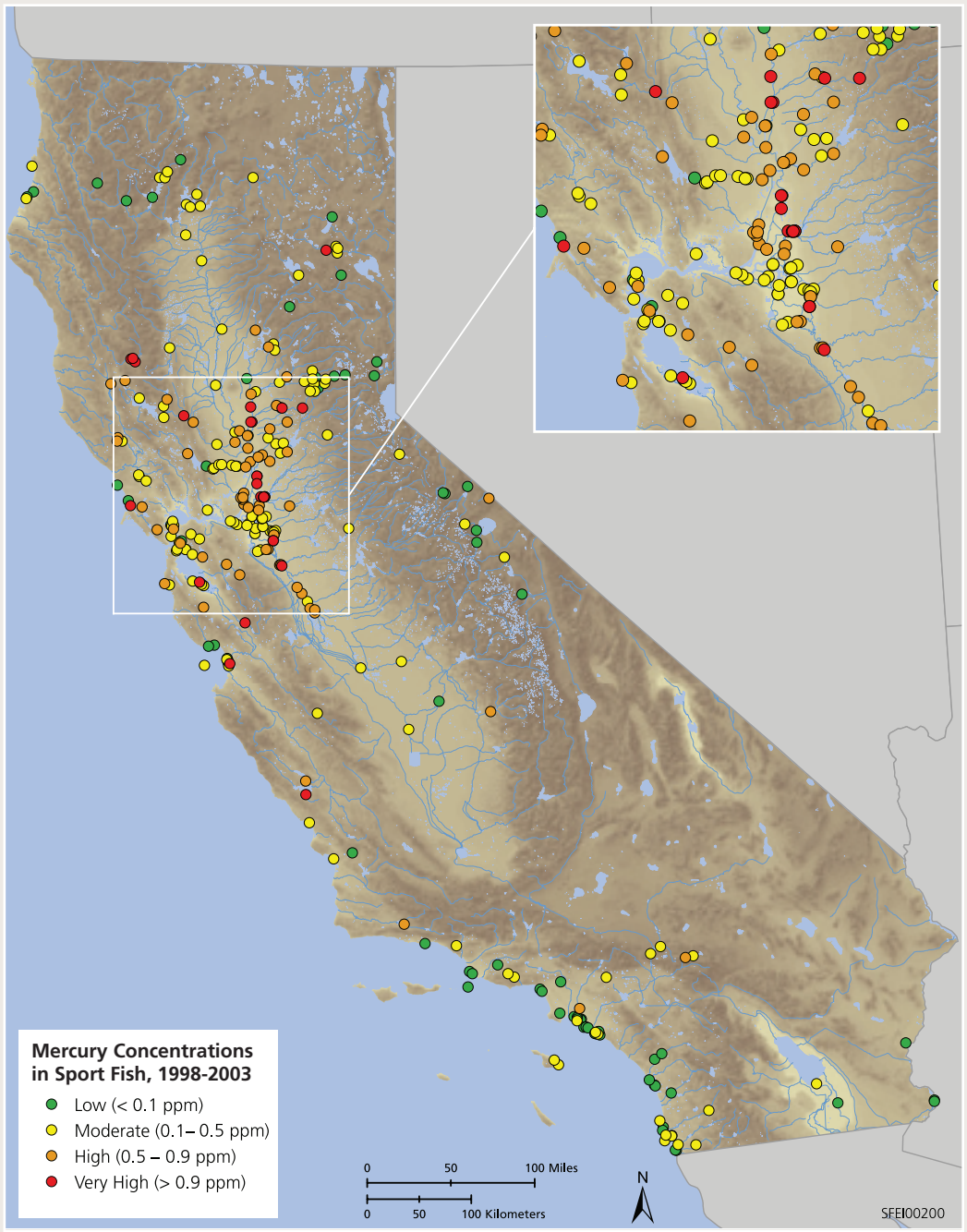


Figure 4

A statewide review of fish monitoring data from the past 30 years (Davis et al. 2007) concluded that high concentrations of methylmercury are common in California aquatic food webs. *Large regions of the State contain sport fish with very high (greater than 0.9 ppm) methylmercury concentrations. Twenty-three of 298 locations (8%) sampled from 1998 – 2003 had a species with a median mercury concentration above 0.9 ppm. Only 24% of the locations had low concentrations (below 0.1 ppm) for all species. Sixty-eight percent of the locations sampled had intermediate concentrations, with at least one species above 0.1 ppm. In the San Francisco Bay-Delta and surrounding areas the contamination is among the most extensive in the state.*

The ultimate solution to the mercury problem is to reduce mercury sources and concentrations in water and sediment of our aquatic ecosystems. This solution would reduce exposure to all species, including sensitive wildlife species and humans. Food web monitoring will be an essential part of management strategies to achieve this goal – a vital measure to gauge progress and evaluate the effectiveness of management actions. However, contamination of our watersheds and aquatic ecosystems is so pervasive that, even with serious cleanup actions, concentrations of mercury and other toxic chemicals in fish are likely to remain unacceptably high for at least 50 to 100 years. Furthermore, some activities planned for the near future (such as large scale wetland restoration) have the potential to exacerbate the existing problem.

While managers work toward the long-term cleanup of the watershed, food web monitoring can also provide a foundation for significantly reducing human exposure to pollutants in fish in a much shorter time-frame. This alternative approach involves thorough monitoring of pollutants in fish, developing clear guidance for safe fish consumption, and effectively communicating the guidance to anglers.

Fish consumption advisories have been issued for some of the State's water bodies. However, consumption advice does not presently exist for all of the areas that need it. Of the 66% of locations included in the review by Davis et al. (2007) with significant fish contamination, some are in areas presently under advisories, but many are not. In addition, it is likely that many areas that have not been sampled in recent years and are not under advisories also have elevated mercury concentrations. On the other hand, concentrations in some places and some species are lower, and with an awareness of this information the public can more fully enjoy the health benefits of consuming fish with low concentrations of pollutants.

With a foundation of solid monitoring information, consumption advice can be developed that steers anglers toward fish species and fishing locations that are relatively low in chemical concentrations. In the near-term, this is the best available approach to reducing human exposure to pollutants in Central Valley waterways while promoting the benefits of fishing. Groups with relatively high rates of fish consumption will benefit the most from this approach, including disadvantaged communities with their higher proportion of subsistence fishing.

The FMP was initiated to provide a demonstration of and foundation for both the long-term and short-term solutions to the mercury problem.

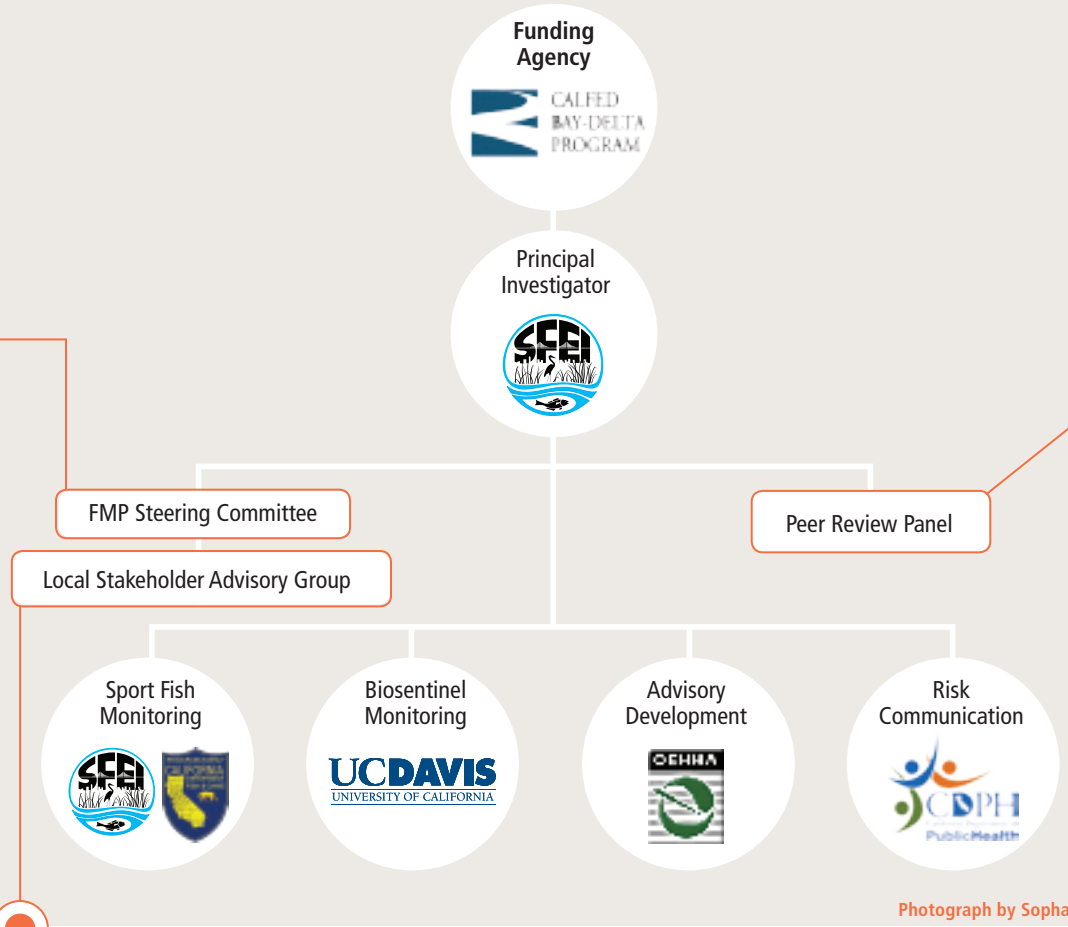
Organization of the Fish Mercury Project

The best way to develop an informative and relevant monitoring program is through a collaborative process that includes input from the environmental managers that will use the information generated to make management decisions, the stakeholders that will be affected by those decisions, and scientists that know how to obtain reliable information on the condition of the environment. The FMP is achieving this collaboration through an organizational structure that includes the funding agency (CALFED), a team of investigators, a Steering Committee that includes environmental managers and community stakeholders, and a Peer Review Panel *(Figure 5)*. This organizational structure and the process and technical approach being implemented in the FMP are completely consistent with the recommendations of the Mercury Strategy (Wiener et al. 2003).

The team of investigators assembled for the FMP consists of organizations and individuals that each possess a great deal of experience in the different disciplines included in the Project. While these institutions have coordinated efforts in the past, this is the first project that represents a true collaboration among all of these groups. The San Francisco Estuary Institute (SFEI) is the principal investigator and manager of the Project. The roles of the other investigators are shown in *Figure 5*.

The FMP Steering Committee *(Figure 5)* is a multidisciplinary, multi-institutional stakeholder group with members from government agencies, scientific and academic institutions, community-based organizations (CBOs), and other groups with interests in ecosystem health, environmental management, environmental justice, and public health. Resource managers need monitoring information to understand the condition of the habitats and populations they are protecting and how conditions change over time. Organizations involved in protecting human health need reliable and relevant monitoring information in order to craft messages that are effective in encouraging fish consumers to make healthy choices. Effective monitoring depends upon a clear understanding of the needs of these end-users of the information. Active participation of Steering Committee members in the planning, implementation, and communication phases of the FMP helps ensure that useful products are developed. The Steering Committee also serves as a hub for coordinating fish mercury monitoring in the watershed. This diverse group has been meeting approximately three times per year.

Figure 5
Organization of the FMP



FMP Steering Committee Members

Name	*Affiliation*
Carol Atkins	California Department of Fish and Game
Henry Clark	West County Toxics Coalition
Chris Foe	Central Valley Regional Water Quality Control Board
G. Fred Lee	G.Fred Lee and Associates
Doug Lovell	Federation of Fly Fishers
Sherri Norris	California Indian Environmental Alliance Bay Area Office
Shayaam Shabaka	Eco Village Farm Learning Center
Tim Stevens	California Department of Fish and Game
Bob Strickland	United Anglers of CA
Claus Suverkropp	Larry Walker Associates
Andria Ventura	Clean Water Action
LaDonna Williams	People for Children's Health and EJ
Janis Cooke	Central Valley Regional Water Quality Control Board
Elaine Quitiquit	Seventh Generation Fund
Vicki Fry	Sacramento Regional County Sanitation District
Marissa Fiero	Mechoopda Indian Tribe of Chico Rancheria
Rebekah Funes	Mechoopda Indian Tribe of Chico Rancheria
Tom Kimball	Central Valley Regional Water Quality Control Board

Photograph by Sophat Sorn.

Local Stakeholder Advisory Group

Review Panel

Barbara A. Knuth
Panel Chair
Dr. Barbara Knuth, at Cornell University, is a Senior Associate Dean in the College of Agriculture and Life Sciences, and a Professor of Natural Resource Policy and Management. She is known particularly for her work on risk perception, communication, and management associated with chemical contaminants in fish. See www.dnr.cornell.edu/hdru for more information.

Drew Bodaly
Dr. Drew Bodaly is a fish biologist who has specialized in the bioaccumulation of mercury in fish populations. He has conducted mercury research on natural lakes, reservoirs, and rivers and on mercury problems related to flooding, atmospheric deposition and point source pollution. He has published 70 papers and book chapters on mercury, fish genetics, and northern reservoirs. He was Research Scientist at Fisheries and Oceans Canada (Experimental Lakes Area) and is now Project Leader, Penobscot River Mercury Study in Maine.

Jim Wiener
Dr. James Wiener is with the University of Wisconsin-La Crosse River Studies Center, where he holds a Wisconsin Distinguished Professorship focusing on environmental and natural resource issues of importance to Wisconsin and the region. Much of his research focuses on mercury pollution, with emphasis on methylmercury contamination of aquatic food webs and assessment of ecosystem sensitivity to mercury. Jim led the development of the Mercury Strategy for the San Francisco Bay-Delta System and served as Technical Chair of the Eighth International Conference on Mercury as a Global Pollutant in Madison, Wisconsin, in August 2006.

Patricia McCann
Pat McCann is a scientist with the Health Risk Assessment Unit of the Minnesota Department of Health and coordinates the Fish Consumption Advisory Program. She holds a M.S. in Environmental Health from the University of Minnesota School of Public Health and a B.S. in Chemical Engineering from the University of Minnesota Institute of Technology. Pat coordinates the state fish consumption advisory program. She is involved in site selection for sampling fish for contaminants, data analysis, researching health effects of fish contaminants, developing consumption advice, and communicating this advice to the public.

Tom Grieb
Dr. Tom Grieb is chief scientist and vice president at Tetra Tech, Inc. His primary research interests include the behavior of metals in the aquatic environment and the application of statistical methods to environmental models and data sets. He worked with the San Francisco Bay Clean Estuary Partnership to develop the conceptual model for mercury in the Bay, which provides the technical basis for addressing management questions that have been identified as part of the establishment of the Bay mercury Total Maximum Daily Load (TMDL). He has also served as technical lead and project manager for the Copper and Nickel TMDL for South San Francisco Bay and the Guadalupe River Watershed Mercury TMDL.

The Local Stakeholder Advisory Group (LSAG) is a subcommittee of the Steering Committee *(Figure 5)*. The LSAG has a particular focus on guiding the development of products related to risk communication. Members of the LSAG include representatives of CBOs that are active in communicating to their communities, county health agencies, and others with an interest in communicating information on risks and benefits of eating sport fish.

Peer review (critical evaluation by outside experts) is an essential element of any scientific endeavor. The FMP represents a considerable effort, with an extensive and multifaceted scope and a significant investment of resources. This level of investment and technical effort calls for a high caliber of peer review. Consequently, a panel of experts has been assembled with national or international recognition as authorities in their fields. These reviewers are helping to ensure that the technical elements of the program meet appropriately high standards, and bring a perspective based on lessons learned from monitoring in other parts of the country and the world. The Review Panel is comprised of individuals with areas of expertise that specifically correspond to the major elements of the Project, including fish monitoring, advisory development, risk communication, and statistics and sampling design *(Sidebar, page 17)*. This Panel has been guiding the FMP from its earliest formative stages.

Project Goals and Objectives

At the beginning of the Project in early 2005, the Steering Committee and Review Panel met and carefully crafted a set of goals and objectives for the FMP *(Table 1)*. The organization of the Project and all of the tasks being carried out are linked to these goals and objectives.

A novel aspect of the FMP is that the goals and objectives explicitly mention risk communication "based on environmental justice principles." Environmental justice *(Sidebar, page 60)* is a high priority among water quality and resource management agencies. Food web monitoring, more specifically sport fish monitoring, is a topic that is strongly associated with environmental justice concerns. Many communities face the injustice of high exposure to mercury and other pollutants because they have high rates of fish consumption for either cultural or economic reasons, and because they obtain their fish from relatively contaminated water bodies in their neighborhoods.

The FMP is breaking new ground as the first major monitoring effort in California to explicitly incorporate environmental justice principles. Inclusion of CBOs as stakeholders is fundamental to this effort, and these organizations are tremendously valuable partners in monitoring and risk communication. They provide important input to sampling designs, including information on popular species and fishing locations. CBOs also represent one of the most effective channels for communicating information back to their constituencies, which in many cases include disadvantaged populations and communities of color that disproportionately bear the environmental injustice of fish contamination.

One key lesson learned from discussions within the FMP is that fully incorporating environmental justice into a fish monitoring and risk communication program requires involving CBOs in the planning and execution of the entire project, collaborating on activities that build local capacity for risk communication, and providing funding for stakeholder participation throughout the process. Through these discussions, the Project participants have identified areas in which our efforts in this realm can be improved. However, while the FMP has not reached the highest level of incorporation of environmental justice, it has taken a significant first step in that direction.

Integrated Monitoring - A New Approach

Another novel aspect of the FMP is the way in which monitoring of sport fish to characterize human health risks is being integrated with stakeholder involvement, advisory development, and risk communication. The term "integrated monitoring" has been coined to describe the combination of these four elements *(Figure 6)*.

Sound consumption advice is central to any strategy to sustain fishing while reducing exposure to toxic chemicals. Information developed through monitoring can be used to communicate to the public the health risks of pollutant exposure from fish consumption, steps that can be taken to reduce exposure, the health benefits of eating fish with low concentrations of pollutants, species and locations with high concentrations of pollutants, and species and locations with low concentrations of pollutants. Developing sound consumption advice depends on ***1)*** knowing where people fish, as well as what they catch and eat and ***2)*** recent and appropriate fish monitoring data.

Integrated monitoring includes three activities – monitoring, development of consumption advice, and risk communication – that are each

Table 1

Project Goals and Objectives

Project Goals

1 Protect human health in the short term by characterizing mercury concentrations in fish, developing safe consumption guidelines, and reducing exposure through risk communication based on environmental justice principles

2 Through food web monitoring, determine how habitat restoration and mercury clean-up actions affect methylmercury accumulation in the food web

3 Establish an organizational and technical foundation for cost-effective and scientifically defensible fish mercury monitoring that meets the identified needs of end users

4 Coordinate with the major ongoing science, management, and risk communication efforts to achieve efficiencies of scale and scope

Project Objectives

1 Characterize spatial and temporal trends in mercury in fishery resources

2 Demonstrate the use of biosentinel species to link ecosystem restoration, contaminant clean-up, and other landscape changes with spatial and temporal patterns in food web mercury

3 Assess health risks of consuming contaminated fish and communicate these risks to appropriate target audiences based on environmental justice principles

4 Establish a Steering Committee and stakeholder advisory groups to facilitate:

- a Stakeholder input into the monitoring and risk communication activities based on environmental justice principles
- b Coordination with other major science, management, and outreach/communication efforts

Figure 6

One innovative aspect of the FMP is the way in which monitoring of sport fish to characterize human health risks is being integrated with stakeholder involvement, advisory development, and risk communication. *The term "integrated monitoring" has been coined to describe the combination of these four elements. In developing monitoring plans, information is solicited from stakeholders on where they fish and what species they consume. Monitoring plans are also based on careful consideration of the information needed for developing consumption advice and communicating this information to the public. With the collaboration of stakeholders, scientists, risk assessors, and risk communicators, the information generated by monitoring is technically sound and of maximum utility to the stakeholders. In the final step in the cycle of integrated monitoring, agencies involved in risk communication work with stakeholders to build their capacity to communicate the advice emanating from the monitoring program back to their communities.*

influenced by input from stakeholders (communities affected by fish contamination) *(Figure 6)*. In developing monitoring plans, information is solicited from stakeholders on where they fish and what species they consume. A high priority is then placed on sampling these species and locations. Monitoring plans are also based on careful consideration of the information needed for developing consumption advice and communicating this information to the public. With the collaboration of stakeholders, scientists, risk assessors, and risk communicators, the information generated by monitoring is technically sound and of maximum utility to the stakeholders. Monitoring information is then used to develop consumption advice. The consumption advice is carefully crafted with consideration of input from risk communication specialists and stakeholders. Agencies involved in risk communication (primarily CDPH) then work with stakeholders to build their capacity to communicate the consumption advice back to their communities. Stakeholders and risk communication specialists can then enter a cycle of evaluating the effectiveness of their activities and refining their messages for maximum impact.

Much more detail on these four elements of integrated monitoring is provided in the other articles in this report.

Monitoring the Effects of Habitat Restoration on Mercury Cycling

Methylmercury concentrations in fish build up over the course of their lifespan, so the amount of mercury in a sport fish[5] is a result of multiple years of exposure. Furthermore, many sport fish species move throughout the watershed, and are not necessarily good indicators of food web contamination in local areas. For these reasons, sport fish are not the best indicators of trends over time and spatial patterns in food web mercury.

In contrast, small, young fish species spend their lives in a small area and have short lifespans that make them excellent indicators of variation in methylmercury concentrations in aquatic food webs (Wiener et al. 2007). Small fish, or "biosentinel", monitoring is also of value in assessing impacts of contaminants on fish-eating wildlife. Biosentinel fish monitoring is therefore one of the primary elements of the CALFED Mercury Strategy, and the key monitoring tool recommended for gauging methylmercury contamination of the Bay-Delta ecosystem during restoration.

5 The term "sport fish" is used to refer to species of fish that people like to catch and consume. These fish are typically greater than 8 inches in length and greater than one year old.

Another major area in which the FMP is breaking new ground is by conducting biosentinel monitoring over a geographic area of unprecedented size in California in order to establish a foundation for evaluating the effects of habitat restoration on mercury in aquatic food webs. A set of monitoring sites has been established to track interannual trends and possible impacts of restoration projects on the Delta region. Localized monitoring of numerous wetland restoration projects is also being performed in order to assess effects on mercury on a local scale. Similar to the selection of sport fish sampling locations, the sampling locations selected for biosentinel monitoring have been selected through discussions with restoration project managers.

Completing the FMP

The FMP began in late 2004. The third and final annual round of sampling was performed in the summer of 2007. After that, the final set of products for the Project will be completed in 2008. Reports to be completed at the end of the Project will document the results of extensive monitoring in 2006 and 2007, safe eating guidelines for the Sacramento River and north Delta, and additional efforts to reduce mercury exposure in the near-term through effective communication of risk and relevant information to fish consumers.

The FMP is intended to serve as a demonstration of innovative approaches to monitoring that will contribute to reduction of the exposure of humans and wildlife to methylmercury as rapidly and efficiently as possible. These approaches can also apply to other pollutants of concern in California that reach high concentrations in fish consumed by humans and wildlife. ●

Biosentinel collection in a salmon restoration area.

Photograph by Darell Slotten.

Dylan Service of Moss Landing Marine Lab with a largemouth bass.

Photograph by Jessica Kaslow.

Sport Fish Monitoring as the Foundation for Safe Eating Guidelines

Letitia Grenier (letitia@sfei.org), Aroon Melwani, Jennifer Hunt, Shira Bezalel, and Jay Davis, San Francisco Estuary Institute

Gary Ichikawa and Billy Jakl, California Department of Fish and Game

Wes Heim and Autumn Bonnema, Moss Landing Marine Laboratories

Highlights

- Sport fish monitoring provides information on the patterns of mercury concentrations in fish, which is needed to develop consumption guidelines and ultimately reduce exposure of fish consumers to mercury
- The Fish Mercury Project is conducting the most extensive monitoring ever of mercury in sport fish in the Central Valley
- Some species of fish tend to be high in mercury, while others tend to be low in mercury
- For many species, the larger the individual fish, the more mercury in each ounce of muscle
- The amount of mercury in a fish of a given species is often different depending on where that fish was caught
- Because mercury in fish varies by size, species, and location, the best way for people to reduce their intake of mercury is to follow safe eating guidelines established by the state for specific water bodies

What is Sport Fish Monitoring and Why Does it Matter?

Sport fish monitoring is a crucial step in the integrated monitoring approach of the Fish Mercury Project (FMP), because it provides information on the patterns of mercury concentrations in fish *(Figure 1)*. Which fish species are high and low? Which areas have fish with more or less mercury? Does it matter how big the fish is? Sport fish are collected according to a plan that is designed to answer these questions and others relevant to the Project goals.

The design of the sport fish sampling program is oriented toward filling gaps in our understanding of how mercury concentrations vary in the Bay-Delta watershed. The main thrust of the sport fish sampling design is to provide a foundation of data from which the California Office of Environmental Health Hazard Assessment (OEHHA) can develop safe eating guidelines and the California Department of Public Health (CDPH) can communicate these guidelines to fish consumers. The ultimate goal of this process of monitoring, advising, and communicating is to reduce the exposure to mercury of people that eat sport fish from the Delta and its watershed. Other important uses of the sport fish monitoring data include tracking change in mercury concentrations in fish over time and understanding how changes in the ecosystem, such as wetland restoration or mine clean-ups, impact the amount of mercury in local fish.

In designing the sport fish monitoring program, scientists from all five organizations involved in the FMP worked together to prioritize which questions to answer with the available resources and to decide on the details of which species to monitor and where. OEHHA scientists analyze where they have the greatest need for more data in order to develop safe eating guidelines. The CDPH contributes detailed information from their interactions with anglers about where people like to fish and which species they like to eat. Moss Landing Marine Laboratories (MLML) assesses the feasibility of the plan, given their field knowledge of where they can catch the necessary fish, and the biosentinel, or small fish, monitoring team coordinates their sampling to overlap with the sport fish team at certain sites. Scientists at the San Francisco Estuary Institute (SFEI) ensure that the monitoring design will also address questions about patterns in fish mercury over space and time, including which regions tend to be higher in fish mercury and whether mercury is decreasing in fish over the long term.

Once sport fish are collected and analyzed in the laboratory for mercury by MLML, the resulting data are studied for patterns by staff at SFEI *(Figure 2)*. Then OEHHA uses the data as part of their process to develop safe eating guidelines for a particular waterbody or fishing area. OEHHA also considers a variety of information beyond the sport fish data to determine recommended rates for consumption of locally caught fish. This consumption advice is detailed by size of fish, species, and fishing location, and takes into account the health benefits of eating fish as well as the hazards from contaminants *(page 34)*. CDPH communicates the consumption advice to members of the fishing community through outreach programs *(page 46)*.

Extensive Monitoring Completed in 2005

The FMP collected over 2000 fish from 22 species and 69 popular fishing locations in the Bay-Delta watershed in 2005 *(Figure 3)*. Sport fish were collected from the rivers, lakes, and reservoirs in the Delta, Central Valley, and foothills of the Sierra Nevada. Largemouth bass, white catfish, channel catfish, redear sunfish, bluegill, Sacramento sucker, Sacramento pikeminnow, common carp, and black crappie comprised the majority of the fish collected. The sampling locations spanned a wide geographic range, including the main tributaries to the Delta, with more detailed sampling in the Delta areas where restoration actions are planned.

This effort was the most extensive collection of fish ever in the Central Valley for the purpose of measuring mercury. The FMP investigators collaborated with scientists from the Central Valley Regional Water Quality Control Board (CVRWQCB) and the Sacramento River Watershed Program (SRWP) to develop a coordinated sampling plan and share resulting data. This collaboration allowed the budgets of all three projects to go farther and provide more information per dollar spent.

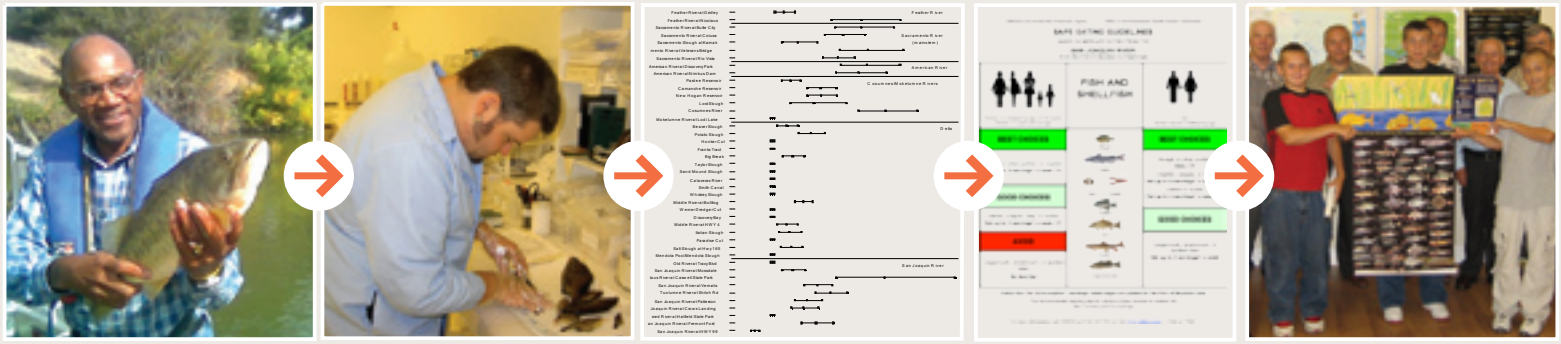
Six types of sites were sampled in 2005 *(Figure 3)*. Data from all the FMP, CVRWQCB, and SRWP sampling sites will be used to develop safe eating guidelines and communicate risk to stakeholders. These sites included popular fishing areas, as well as hatcheries for salmon and trout. Index, intensive, and restoration sites, in addition to providing data for development of consumption guidelines, were sampled to:

Collecting fish on the electroshocker boat.

Photograph by Jessica Kaslow.

Figure 1

Sport fish monitoring provides information on the patterns in mercury concentrations in fish. *Which fish species are high and low? Which areas have fish with more or less mercury? Does it matter how big the fish is? These questions are important to answer to give health agencies in California the information they need to develop safe eating guidelines for fish and communicate them to the people who eat sport fish. The ultimate goal of this process of monitoring, advising, and communicating is to reduce the exposure to mercury of people who eat sport fish from the Delta and its watershed.*



Field Sampling | Laboratory Analysis | Data Analysis | Advisory Development | Risk Communication

▲

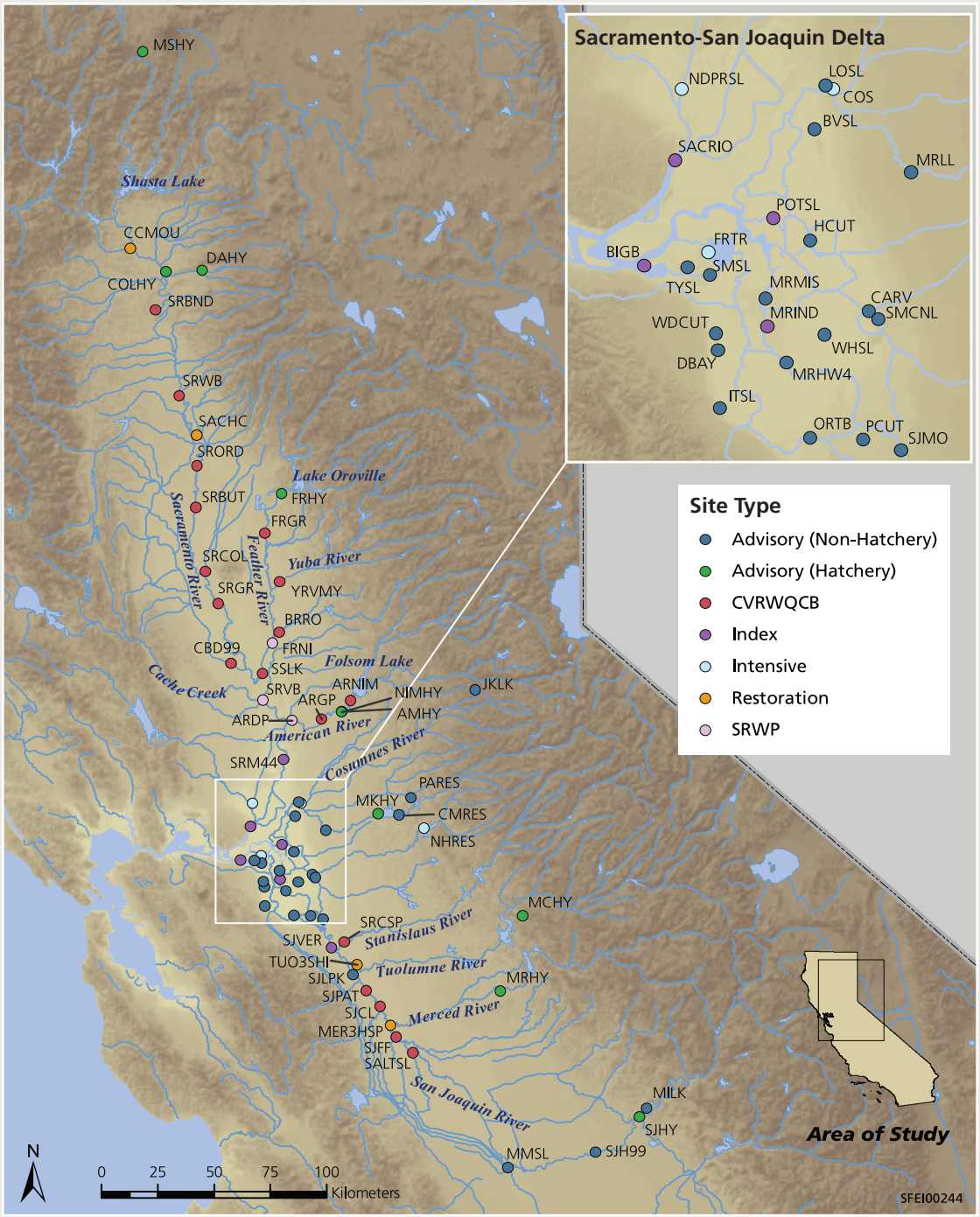
Figure 2

Once sport fish are collected, and analyzed for mercury, the Office of Environmental Health Hazard Assessment (OEHHA) evaluates the data. *OEHHA also factors in a variety of information beyond the sport fish data to determine recommended amounts of fish that can be eaten safely. This consumption advice is detailed by size of fish, species, and fishing location, and takes into account the health benefits of eating fish as well as the hazards from contaminants (see OEHHA article in this report). The California Department of Public Health communicates the safe eating guidelines to members of the fishing community through outreach programs.*

▶

Figure 3

Sport fish sampling in 2005 was the most extensive collection of fish ever in the Central Valley for the purpose of measuring mercury. *The Fish Mercury Project teamed up with other monitoring partners, the Central Valley Regional Water Quality Control Board and the Sacramento River Watershed Program, to develop a coordinated sampling plan and share resulting data.*



Site Code	Site Name
AMHY	American River Hatchery
ARDP	American River at Discovery Park
ARGP	American River at Goethe Park
ARNIM	American River at Nimbus Dam
BIGB	Big Break
BRRO	Bear River at Rio Oso
BVSL	Beaver Slough
CARV	Calaveras River
CBD99	Colusa Basin Drain at Road 99E
CCMOU	Clear Creek
CMRES	Camanche Reservoir
COLHY	Coleman Hatchery
COS	Cosumnes River
DAHY	Darrah Springs Hatchery
DBAY	Discovery Bay
FRGR	Feather River at Gridley
FRHY	Feather River Hatchery
FRNI	Feather River at Nicolaus
FRTR	Franks Tract
HCUT	Honker Cut
ITSL	Italian Slough
JKLK	Jenkinson Lake
LOSL	Lost Slough
MCHY	Moccasin Hatchery
MER3HSP	Merced River at Hatfield State Park
MILK	Millerton Lake
MKHY	Mokelumne Hatchery
MMSL	Mendota Pool/Mendota Slough
MRHW4	Middle River at Hwy 4
MRHY	Merced Hatchery
MRIND	Middle River at Bullfrog
MRLL	Mokelumne River at Lodi Lake
MRMIS	Middle River at Mildred Island
MSHY	Mount Shasta Hatchery
NDPRSL	Prospect Slough
NHRES	New Hogan Reservoir
NIMHY	Nimbus Hatchery
ORTB	Old River at Tracy Blvd.
PARES	Pardee Reservoir
PCUT	Paradise Cut
POTSL	Potato Slough
SACHC	Sacramento River at Hamilton City
SACRIO	Sacramento River at Rio Vista
SALTSL	Salt Slough at Hwy 165
SJCL	San Joaquin River at Crows Landing
SJFF	San Joaquin River at Fremont Ford
SJH99	San Joaquin River at Hwy 99
SJHY	San Joaquin Hatchery
SJLPK	San Joaquin River at Laird Park
SJMO	San Joaquin River at Mossdale
SJPAT	San Joaquin River at Patterson
SJVER	San Joaquin River at Vernalis
SMCNL	Smith Canal
SMSL	Sand Mound Slough
SRBND	Sacramento River at Bend Bridge
SRBUT	Sacramento River at Butte City
SRCOL	Sacramento River at Colusa
SRCSP	Stanislaus River at Caswell State Park
SRGR	Sacramento River at Grimes
SRM44	Sacramento River at RM44
SRORD	Sacramento River at Ord Bend
SRVB	Sacramento River at Veterans Bridge
SRWB	Sacramento River at Woodson Bridge
SSLK	Sacramento Slough at Karnak
TUO3SHI	Tuolumne River at Shiloh Rd.
TYSL	Taylor Slough
WDCUT	Werner Dredger Cut
WHSL	Whiskey Slough
YRVMY	Yuba River at Marysville

1) indicate trends over space and time in sport fish mercury contamination to assess the effects of restoration and remediation actions, and

2) link sport fish mercury to biosentinel (small fish) data.

The FMP Year 1 Work Plan for 2005 describes the sampling plan and the kinds of sites in great detail. You can access the Work Plan from the FMP web site. Visit www.sfei.org and follow the link on the right for the Fish Mercury Project.

Project scientists chose which fish to target for capture based on a variety of factors, depending on the type of site. In general, primary target species were either popular for human consumption (white catfish) or were useful for documenting trends in mercury over space and time (largemouth bass). Secondary target species were mainly chosen as species low in mercury that are potentially good alternatives for sport fishing and consumption (for example, redear sunfish and bluegill). Striped bass were not a primary target species for the first year of the Project, but are being sampled heavily in the latter two years.

The field crew collected fish from late July to mid-December 2005 with an electrofisher boat and fyke nets. Shocking the fish with electricity temporarily stuns them. The stunned fish float to the surface of the water, where the field team collects them and then wraps them in Teflon sheeting to keep them clean. Fyke nets are big funnels that guide fish into a trap. The captured fish are frozen on dry ice for transportation to the laboratory. The laboratory staff determine the amount of mercury in the fish muscle tissue by preparing fillets and analyzing samples with a Direct Mercury Analyzer. This machine is an innovation in laboratory technology that can analyze the concentration of mercury in a sample with minimal preparation beforehand.

Bigger is Not Always Better

Larger fish often have more mercury in each ounce of muscle. This relationship was discovered in early studies of mercury in the food web and is caused by two factors. First, larger fish tend to eat prey that are higher in the food web. Mercury increases with each step up in the food web as each fish accumulates mercury from the prey they are eating. This process of increasing contaminant concentrations in each level of the food web is called "biomagnification". The result is that larger fish eating higher in the food web often have higher mercury concentrations. Second, smaller fish tend to be younger, so they have had less time to accumulate mercury. Older individuals often have higher mercury, since they have been taking it in for a longer period of time. Fish do not have a good way of getting rid of mercury once they take it in through their diet. Therefore, mercury tends to stay in fish muscle and organs, once it has been deposited there. Scientists use fish length from head to tail as a measure of fish size.

This relationship of larger fish having higher mercury is sometimes, but not always, true when comparing species. For example, striped bass are a relatively large fish, and they tend to have higher mercury than bluegill, a relatively small fish. Larger fish can also have higher mercury within a species. For example, larger striped bass tend to have higher mercury than smaller striped bass. It's important to remember that this relationship does not turn out to be true in every case. Salmon are an example of a relatively large fish with relatively low mercury.

Our sampling showed that large individuals of largemouth bass, Sacramento sucker, and Sacramento pikeminnow had higher mercury than small individuals within the same species, while concentrations in large white catfish and channel catfish were not much higher than concentrations in smaller fish. For the remaining species, there were fewer data available to fully assess the relationship between mercury and size, because not as many fish were collected. Based on the fish that were collected from these remaining species, redear sunfish, bluegill, common carp, and black crappie did not show a strong relationship between mercury and size, while spotted bass, striped bass, hardhead, and smallmouth bass did. The analyses in this article of how fish mercury differed among regions of the Delta and Central Valley took into account the relationship between mercury and fish size. Therefore, the findings discussed below already factored out fish size as an explanation for the patterns described.

Some Fish Species High in Mercury, Others Low

Many species of sport fish from the Delta and its watershed collected in 2005 had mercury concentrations high enough to cause concern. However, many other fish species did not have elevated mercury, which means fish

consumers can find healthier alternatives to species that tend to be high in mercury. When examining the species at each sampling location that had the highest average mercury concentration, the majority of the sites (65%) fell in the moderate category (0.1 – 0.5 parts per million, or ppm). Eighteen percent of the locations corresponded to the high mercury concentration category (0.5 – 0.9 ppm), and the remaining sampling locations were in the low (< 0.1 ppm, 12%) and very high (> 0.9 ppm, 6%) ranges. Largemouth bass was the species that most often had the highest average concentration of all the species at a site, and Sacramento pikeminnow was often high as well. The species with the lowest average mercury concentration at each site fell in the low mercury category (< 0.1 ppm) at two-thirds (68%) of the sites and in the moderate range at the remaining sites. Redear sunfish most frequently had the lowest average mercury, with bluegill coming in second.

Overall, largemouth bass and Sacramento pikeminnow were the most contaminated of the target species, followed in decreasing order by common carp, Sacramento sucker, channel catfish, black crappie, white catfish, bluegill, and redear sunfish *(Figure 4)*. We ranked species based on their tendency to fall into different contamination categories. Most largemouth bass (62% of individual fish samples) and Sacramento pikeminnow (73%) samples fell in the high mercury category. Bluegill and redear sunfish were mainly in the low range (82% and 61%, respectively). The only other species with enough data to support generalizations regarding contamination were rainbow trout, brown bullhead, and Chinook salmon. All of these were mostly (> 80%) in the low mercury category.

Dylan Service of Moss Landing Marine Lab with a largemouth bass.
Photograph by Jessica Kaslow.

These rankings among species for degree of mercury contamination were as expected based on their positions in the food web. Largemouth bass are large sport fish (up to 600 mm in the samples collected) and are the top fish-eating predator in the Bay-Delta watershed. Adult largemouth consume a variety of fish and large invertebrates. High exposure to mercury was expected in this species, given its size and position in the food web. Common carp, Sacramento sucker, and channel catfish also grow rather large (commonly > 500 mm in this study), but their diets do not primarily consist of other fish. Rather, they eat benthic (sediment-dwelling) invertebrates, such as worms and clams, and decaying organic matter that contain less mercury. Redear sunfish are relatively small and occupy a lower position in the food web, feeding primarily on shellfish, particularly clams.

Where You Fish Makes a Difference

Mercury in fish followed clear patterns of higher and lower areas across the Delta and its watershed. These patterns were generally the same across the species studied, with a couple of exceptions. Our best data set for examining these geographical patterns is from largemouth bass, because largemouth bass were caught in large numbers at a wide variety of locations (over 500 fish total).

Mercury concentrations were higher in the Sacramento and San Joaquin Rivers and their tributaries, and lower in the Delta *(Figure 5)*. The least contaminated sites were mainly in the central and southern Delta and secondarily in the extreme southern reaches of the San Joaquin River. The most contaminated sites were along the mainstream and tributaries of the Sacramento and San Joaquin Rivers, as well as the Cosumnes River. This region corresponds to the area where intensive gold mining occurred in the Sierra Nevada, in which mercury was used to separate gold from ore.

Sacramento sucker and redear sunfish were the exceptions to this pattern. Sucker had concentrations in the Delta and San Joaquin River that were as high or higher than in the Sacramento River, while redear sunfish were low in the Delta but low almost everywhere else as well.

The reasons for these patterns are not well understood, and researchers are trying to understand what factors in the environment can cause mercury in the fish to be high or low. Scientists have proposed several hypotheses to explain geographic patterns in mercury. An important one of these hypotheses is the idea that wetlands can increase the amount of mercury in fish. This idea came from research in other parts of North America. Major wetlands restoration projects are planned in the Delta and in San Francisco Bay. The extensive loss of wetlands throughout this area

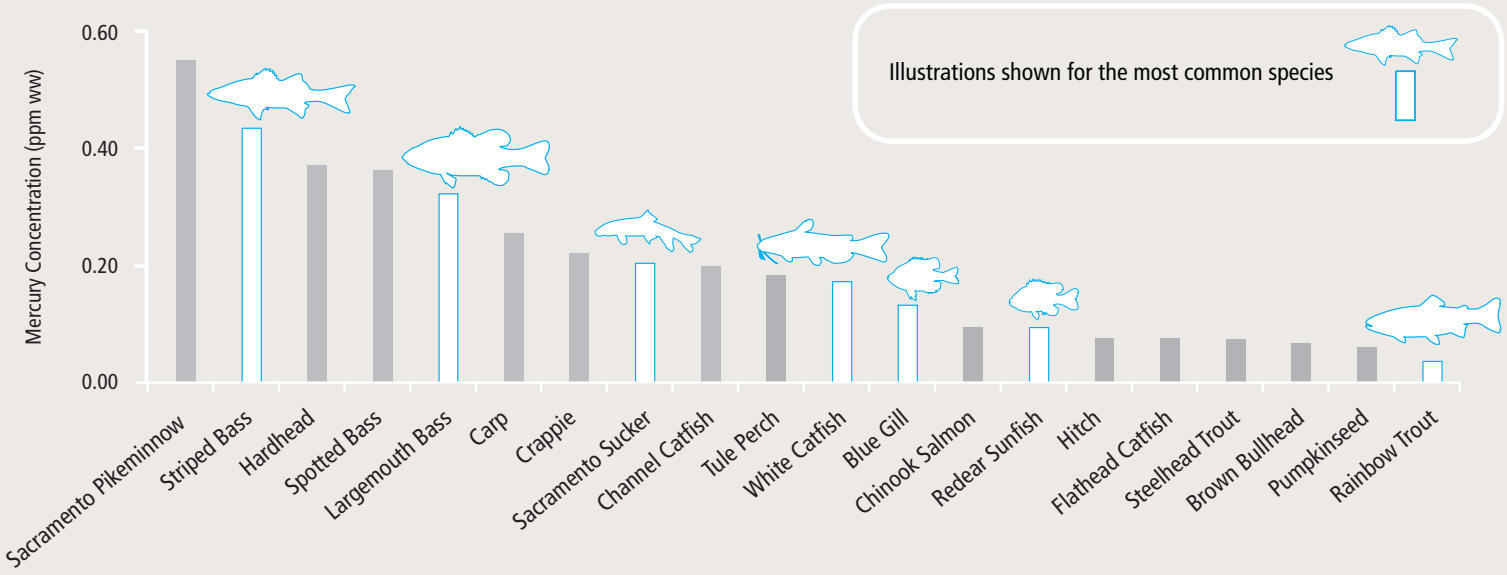


Figure 4

Some species of fish are high in mercury, while others tend to be low in mercury. *The species you choose to eat can greatly affect the amount of mercury you take in. Predatory fish that eat other fish, such as largemouth bass and pikeminnow, tend to be higher in mercury than fish like trout and redear sunfish that eat invertebrates which are lower in the food web. The reason for this pattern is that mercury increases at higher positions in the food web. Most fishing locations are home to a number of fish species, of which some are better and worse choices to eat in terms of mercury. Safe eating guidelines from OEHHA indicate which species are better and worse choices for that location. This figure shows average mercury within a species after applying size limits to account for the relationship between fish length and mercury based on the monitoring conducted throughout the region in 2005.*

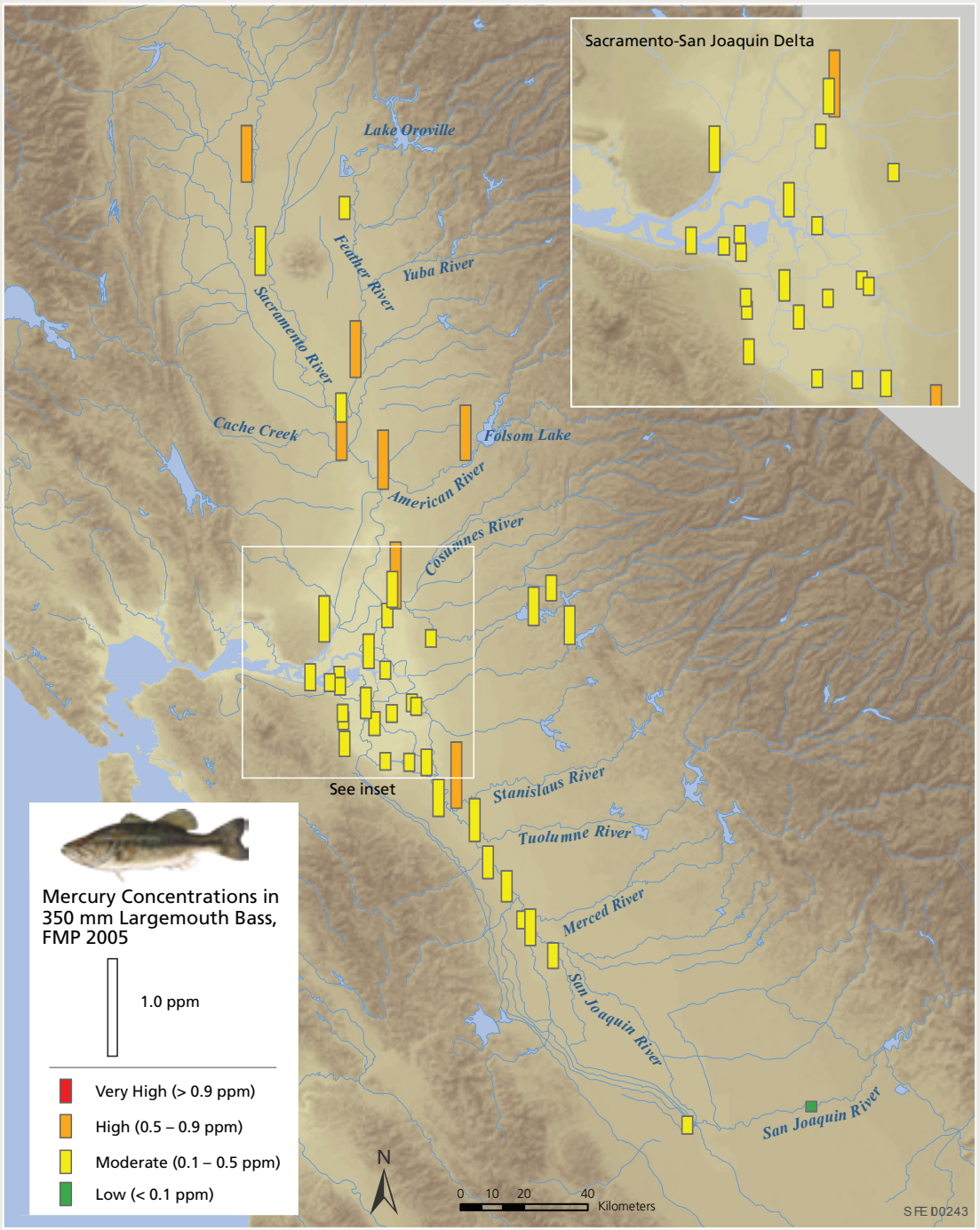


Figure 5

The amount of mercury in a fish can be different depending on where that fish is caught. *For example, largemouth bass from the Sacramento River tend to have higher mercury than in the central Delta. The general pattern seen here for largemouth bass tends to be similar in many sport fish species, including white catfish, channel catfish, carp, and bluegill. The reasons for this pattern are not well understood, and researchers are trying to understand what factors in the environment can cause mercury in the fish to be high or low.*

has caused many species to be endangered, as well as loss of services from wetland ecosystems, such as flood control and high fisheries production. Restoring wetlands will help solve these problems, but managers want to be sure that they don't make the mercury problem worse in doing so. However, the good news is that so far the studies in California have not indicated that the hypothesis is correct for the Bay-Delta. Once the full data set from this study is available in 2008, we will be able to better evaluate the hypotheses, including assessing the influence of wetlands on fish mercury.

Mercury Trends Over Time

Another goal of the sport fish sampling is to identify trends over time. There were eight sites where largemouth bass could be compared between the FMP sampling data from 2005 and fish collected in 2000 for a previous study. The same overall regional pattern occurred in both time periods, and no consistent pattern of increase, decrease, or lack of change held across all sites. Rather some sites increased, others decreased, and the rest stayed the same between 2000 and 2005. A five-year time span is rather short for mercury studies, so we also investigated the time trends over 10 – 20 years at the two sites that had enough largemouth bass data from earlier research. In both cases, the mercury concentrations changed somewhat from year to year, getting a little higher or a little lower, but did not show a clear long-term increase or decrease over 10 or 20 years.

Mercury in fish does not appear to be changing significantly over the long run, despite year-to-year fluctuations at some sites. This finding is in keeping with the hypothesis that mercury is moving very slowly through waterways of the Bay-Delta watershed, as discussed in the overview article. Mercury concentrations are likely to stay elevated for decades, because mercury cannot be broken down over time like some other contaminants. Major clean-up efforts will reduce mercury in the short- and long-term by removing and covering contaminated sediments at mining sites and other hot spots in the watershed.

Looking Forward

Sport fish will continue to be monitored for the rest of the Project. Fish were collected in 2006 from several more sites, mainly in the Sacramento River watershed, and collections will begin again soon for the 2007 sampling. The final report from the 2005 sampling is available on the Project web site, accessible from the SFEI home page (www.sfei.org). The final FMP report that will include the full data set from all three years (2005 – 2007) will be available in the fall of 2008. ●

FMP stakeholders assisting with fish collection.

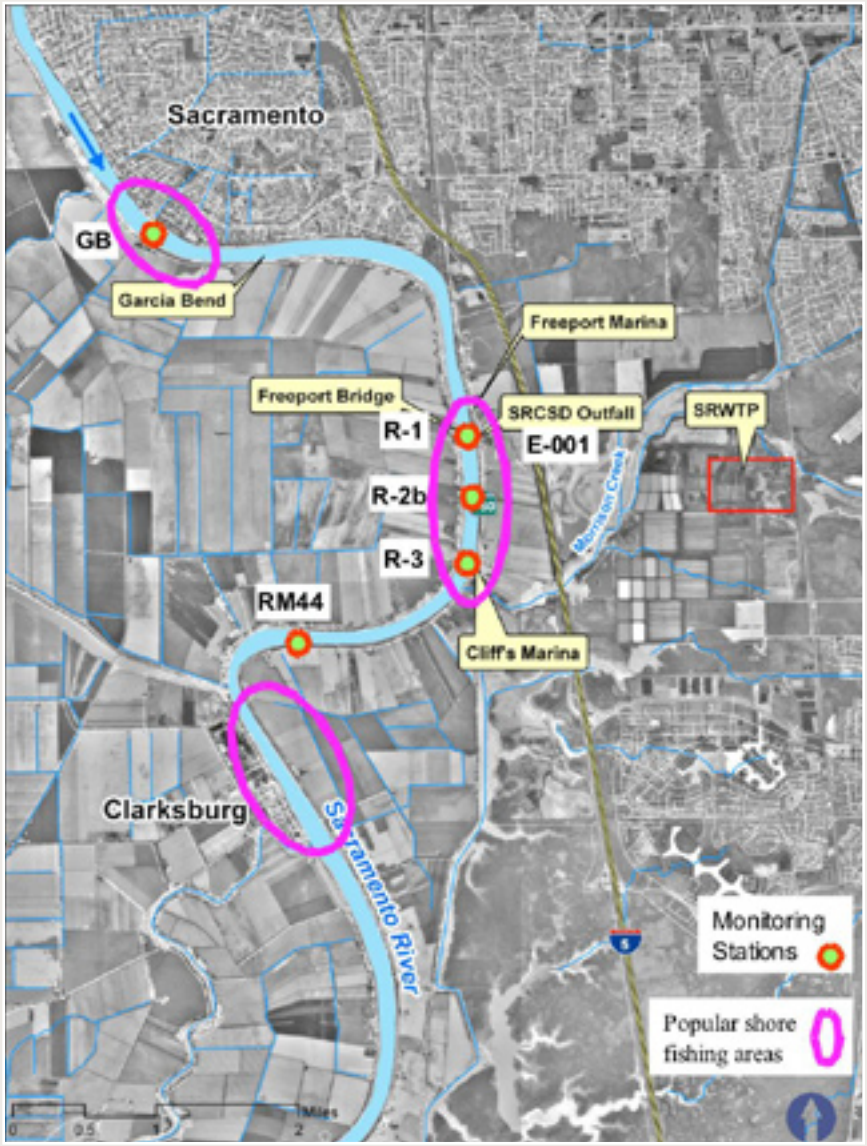
Photograph by Jessica Kaslow.

Sacramento County Mercury Monitoring and Risk Communication

The Sacramento Regional County Sanitation District (SRCSD) is undertaking a study to quantify the localized bioaccumulation of mercury in the lower Sacramento River where much of Sacramento's wastewater is discharged. Thousands of caged clams were placed upstream and downstream of the discharge and then caged and resident clams were collected over several months and analyzed for mercury content. Water and sediments at the same locations were also analyzed for mercury and several other related factors. Small biosentinel fish were also collected upstream and downstream of the dishcarge and analyzed for mercury. The study report is anticipated to be available in late 2007.

A unique component of this study is research into local fishing and fish consumption practices. Using a standardized set of questions, Dr. Fraser Shilling of UC Davis has surveyed close to 200 anglers and trained health education staff at the Southeast Asian Assistance Center (SAAC) to survey community members. SRCSD, SAAC, and Dr. Shilling have also held educational community meetings attracting over a hundred community members to discuss fish contamination and what can be done about both contamination and reducing health risks.

Contact: Vicki Fry, SRCSD (fryv@saccounty.net)



Monitoring stations and popular fishing areas near the Sacramento Regional County Sanitation District outfall.

Safe Eating Guidelines for Sport Fish: Your Key To Eating Healthy

M. Gassel (mgassel@oehha.ca.gov), California Office of Environmental Health Hazard Assessment
R.K. Brodberg, California Office of Environmental Health Hazard Assessment

Highlights

- Mixed messages about risks and benefits of eating fish are confusing
- The Office of Environmental Health Hazard Assessment (OEHHA) provides balanced messages to inform the public how to safely consume sport fish
- Eating fish provides numerous health benefits important to you and your family
- The healthy fats (omega-3 fatty acids) in fish reduce the risk of heart disease in adults, and improve brain development in babies and children; fish consumption may also help prevent strokes, reduce inflammation, prevent or treat depression, and reduce the risk of age-related blindness and dementia
- Some fish may be contaminated with a high level of mercury or other chemicals that can decrease the benefits of eating fish and impair development in babies and children
- Most of the popular fish species caught in the South Delta can be eaten regularly at the amounts recommended in the OEHHA Safe Eating Guidelines
- However, largemouth bass from the San Joaquin River south of the Port of Stockton contained more mercury, so OEHHA recommends that women of childbearing age and children avoid eating black bass from the San Joaquin River south of the Port of Stockton
- Following OEHHA's Safe Eating Guidelines will reduce your risks associated with contaminants found in fish while allowing you to get the benefits from eating fish

Mixed Messages

We often hear in the news that eating fish is "bad" for you because fish contain potentially harmful chemicals, such as mercury. At the same time, we are told that eating fish is "good" for you. Fish provide numerous health benefits. They are a source of relatively low-fat protein. They also contain essential nutrients including "good fats" known as omega-3 fatty acids. These nutrients support healthy hearts, nerves, and eyes, and are also necessary for brain development. Many people enjoy fishing and eating their catch. So what's a person to do? How do we know what to believe and what to do when it comes to eating fish?

Developing a Balanced Message

The Office of Environmental Health Hazard Assessment (OEHHA) brings together these different messages, and forms them into Safe Eating Guidelines to help Californians make their own decisions about eating fish. To do this, OEHHA uses the results of scientific studies on the risks and benefits of fish consumption, and results from monitoring fish from various water bodies to help people make choices that are in the best interest of their overall health. How does OEHHA do this?

OEHHA's Process

The first step is to understand what chemicals are in our fish and how they might harm us. OEHHA scientists carefully consider research on the potential adverse health effects of contaminants that may be found in fish, and stay up-to-date on what U.S. EPA and other national and international organizations have determined to be safe levels of exposure to these chemicals. Then this information is compared to levels of contaminants found in local fish. To do that, we must find out just what the levels of chemicals are in our fish. OEHHA plans studies to monitor chemicals in California fish. Biologists from the California Department of Fish and Game collect fish from local waters and measure how much of certain chemicals, such as mercury, have accumulated in the fish.

When OEHHA's scientists get the results back from the laboratory, they first make sure that the information is reliable and accurate, and can be used to assess exposure and risks. Next, they evaluate the chemical levels in the fish, using their knowledge about the kinds of effects that can occur from exposure to the contaminants and the levels that are likely to cause these effects. The scientists also consider whether some people might be more at risk than others to these potential health effects. For example, the developing nervous system, including the brain, is most sensitive to exposure to methylmercury in fish. When a subset of the population is more susceptible, such as children or pregnant women, OEHHA can customize the advice for those groups. The goal is to protect the fetus and children whose brains are developing when methylmercury is found at high levels in fish. On the other hand, people may experience added health benefits from eating fish, as explained below. The overall goal is for people to be able to minimize their risks while maximizing the benefits of eating fish.

Important Health Benefits from Eating Fish

OEHHA has reviewed recent studies about the benefits than can result from eating fish and has begun to make more use of that information when developing advice. Many studies have shown that regular fish consumption can be important for the prevention and treatment of heart disease. The American Heart Association makes recommendations to eat fish weekly to obtain these benefits. Other studies have suggested that fish consumption may help prevent strokes, reduce inflammation, prevent or treat depression, improve the development of vision in infants, and prevent age-related blindness in the elderly. Recent studies have also linked frequent fish consumption with healthier babies, a point that is especially important for pregnant mothers *(Figure 1)*.

OEHHA scientists believe that when we focus only on the risks of fish consumption, we are ignoring the equally important nutritional benefits provided by fish consumption that support good health and quality of life. Fish advisories that scare people away from eating any fish are not the best way to protect public health, and can even be detrimental. For instance, a recent study suggested that babies born to mothers that did not eat fish during pregnancy did not perform as well on tests of fine motor skills, verbal and social behavior, and communication compared to children of mothers who ate fish weekly. The public needs consumption guidelines that take into account all outcomes from eating fish and that provide the proper balance. Then, fish consumers and their families can receive the most benefit from eating fish while protecting themselves from harmful contaminants.

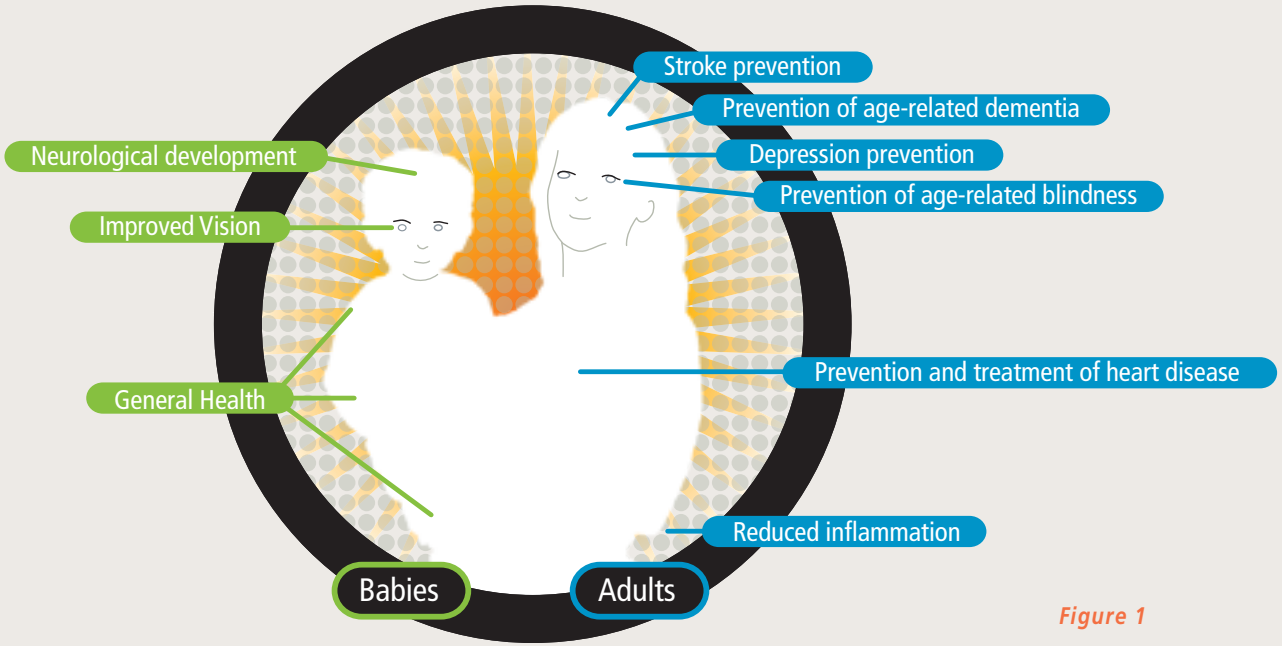


Figure 1

Some of the Potential Benefits from Eating Fish. *Many studies have shown that regular fish consumption can be important for the prevention and treatment of heart disease. The American Heart Association makes recommendations to eat fish weekly to obtain these benefits. Other studies have suggested that fish consumption may help prevent strokes, reduce inflammation, prevent or treat depression, and support good vision. Recent studies have also linked frequent fish consumption with better neurological development in babies, which is especially important news for pregnant women. The California Department of Public Health found that 76 percent of California women do not eat as much fish as the American Heart Association recommends (two 3-ounce servings per week).*

Communicating a balanced message can be challenging. It is important for people to know the health benefits from regular fish consumption. The key to encouraging fish consumption while taking into account the risks of eating contaminated fish is to provide clear information about which types of fish are best for people to eat. When the risks are high, OEHHA works to develop clear guidelines for those fish that should not be eaten regularly or at all. When the risks from eating particular types of fish are very small, OEHHA focuses more attention on the likely benefits to health, and presents a positive message in the guidelines. In places where both kinds of fish are found (those with higher and lower levels of chemicals), OEHHA emphasizes the safer alternatives.

OEHHA'S Role in the Fish Mercury Project

OEHHA's role in the Fish Mercury Project is to work with the other investigators and stakeholders to make sure that needed monitoring information is collected, and then to use this information in developing Safe Eating Guidelines for fish consumers. To learn about mercury levels in fish from the Sacramento-San Joaquin Delta, OEHHA and the other investigators first divided this very large study area into three parts – each part to be studied during one year of the three-year project. OEHHA staff selected the San Joaquin River and South Delta (south of the San Joaquin River) for the first year *(Figure 2)*. They began by gathering all fish data from this area that had been collected in past years to determine what was already known and what was not known about the locations and types of fish tested, and the levels of contamination. Next, OEHHA worked with staff from the California Department of Public Health to gather information on popular fishing locations and fish species favored by anglers in the region. OEHHA then developed a sampling plan, using the information provided by stakeholders. Fish and Game staff used the sampling plan to collect fish samples and brought them back to the lab to be analyzed for mercury. Once the analyses were completed, the results were sent to OEHHA for evaluation.

The study area was large. Sampling sites on the San Joaquin River alone spanned 160 miles. The samples came from locations far south in Fresno County to Contra Costa County where the San Joaquin and Sacramento Rivers join. Data were also collected on fish from other rivers in the South Delta, such as the Old and Middle Rivers, and many of the sloughs and flooded tracts in the South Delta. Numerous other water bodies accounted for a larger area in the Delta. OEHHA's goal was to determine whether the mercury levels were similar or different throughout the area. Comparisons of the results were first made between specific sites and then between subregions. Subregions included all the sampling sites in areas defined as hydrologic units (areas with similar natural geographic characteristics affecting the flow of water).

Delta Fish: A Good Catch

After a thorough evaluation, OEHHA found that mercury levels in many types of fish from the South Delta area were actually quite low. These fish included bluegill and redear sunfish, catfish, clams, crayfish, crappie, carp, sucker, and even largemouth bass. Compared to other water bodies with mercury advisories in California, these fish and shellfish from the South Delta contained the lowest average mercury levels of any location *(Figure 3)*. This finding is heartening, especially in light of OEHHA's efforts to convey the nutritional and health advantages of eating fish and to identify safe choices.

In comparison, many of the same species found in the San Joaquin River south of Stockton contained higher levels of mercury. For all species except largemouth bass, the difference was not great enough to change the consumption guidelines. The higher levels of mercury in largemouth bass from the San Joaquin River south of the Port of Stockton could be a concern for pregnant women and children. As a result of these findings, OEHHA developed two sets of safe eating guidelines, one for each of two large regions *(Figures 4 and 5)*:

- The South Delta – including the San Joaquin River from the Sacramento River to the Port of Stockton, and other rivers, sloughs, and flooded tracts in the Delta, south of the San Joaquin River
- The San Joaquin River south of the Port of Stockton to Friant Dam (near Fresno)

OEHHA found that all of the fish species listed above can be eaten regularly if they are caught in the South Delta. In other words, these fish do not pose a risk from exposure to methylmercury if eaten at the recommended amounts in the OEHHA Safe Eating Guidelines *(Figure 5)*. Because largemouth bass from the San Joaquin River south of the Port of Stockton

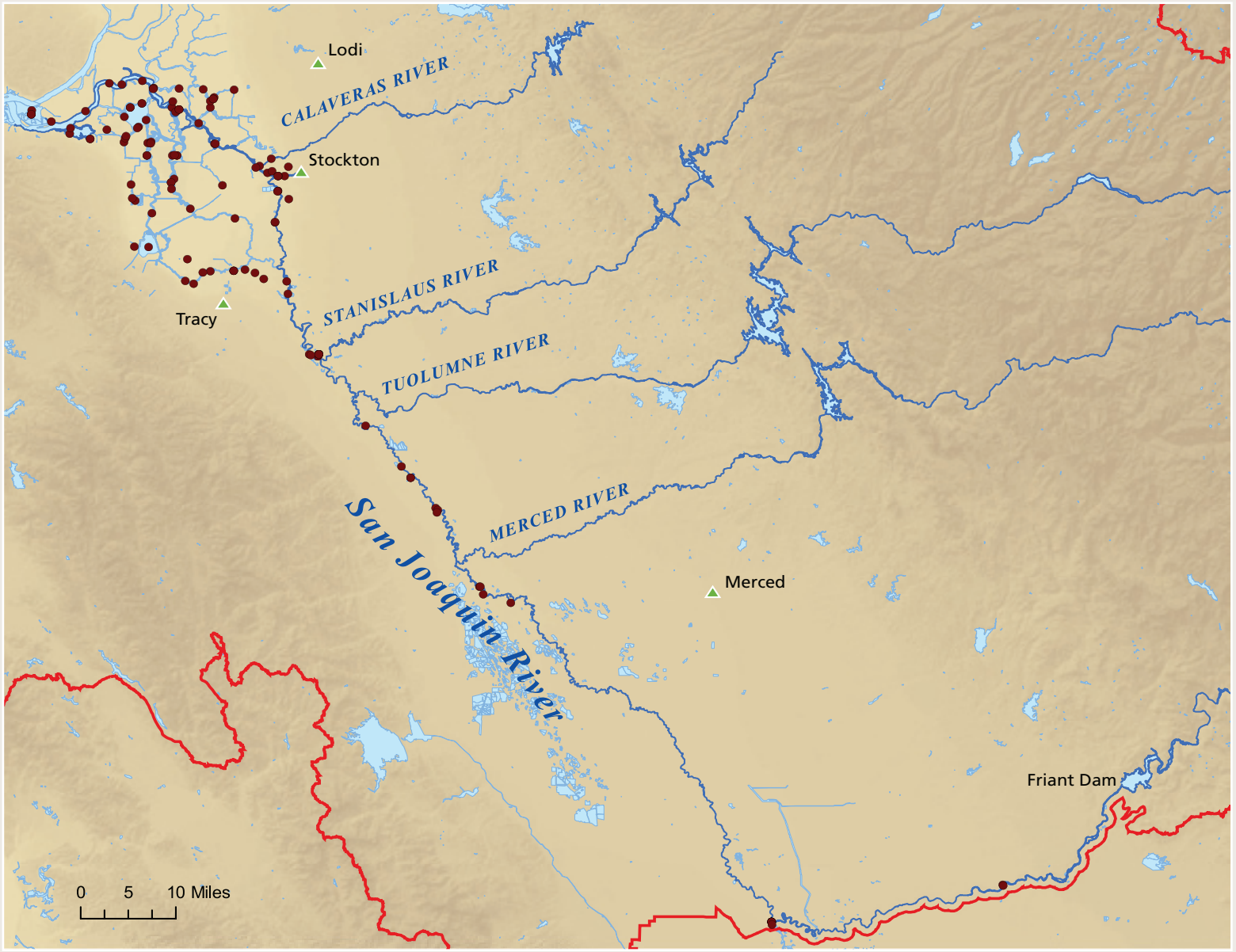


Figure 2

Sampling Sites in the South Delta and San Joaquin River. *The circles represent locations where fish were sampled. All sampling sites were located within the boundaries designated for the project by the California Bay Delta Authority (partially shown as a red line).*

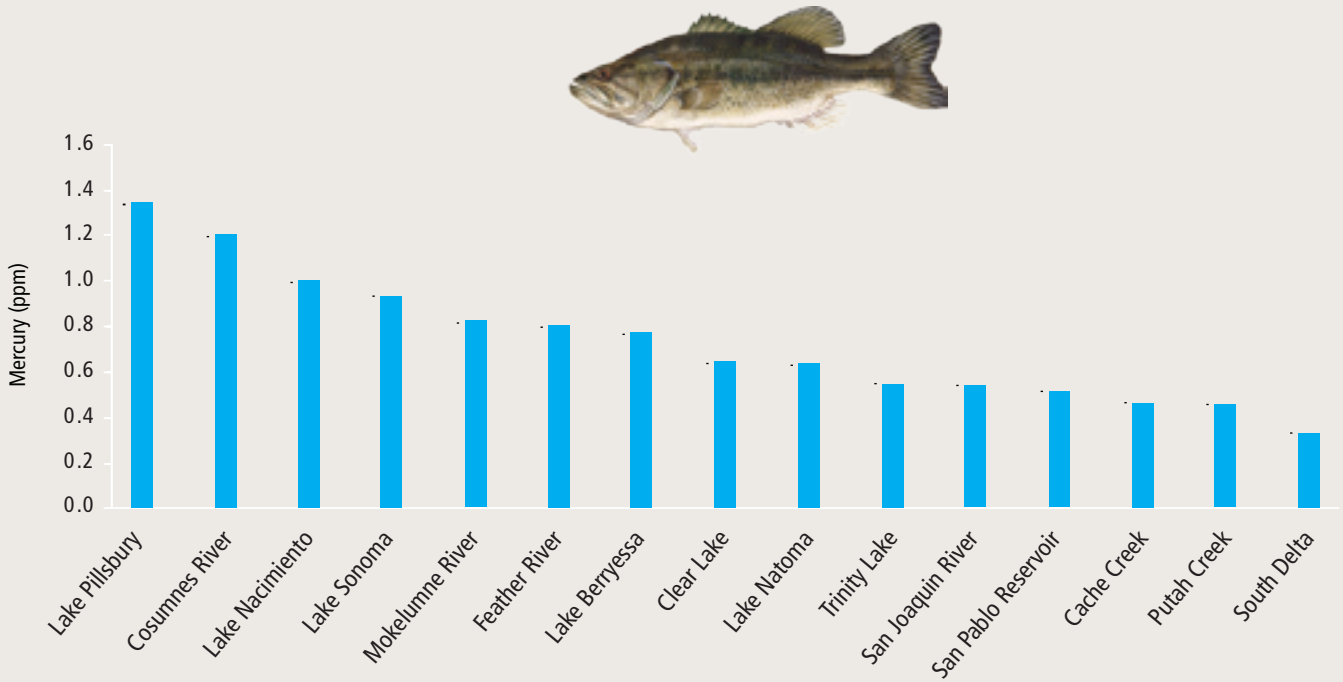


Figure 3

Comparison of Mercury Levels in Largemouth Bass from California Water Bodies with Mercury Advisories. *The average mercury concentration in largemouth bass collected in the South Delta was lower than in largemouth bass from all other water bodies in California that have mercury advisories.*

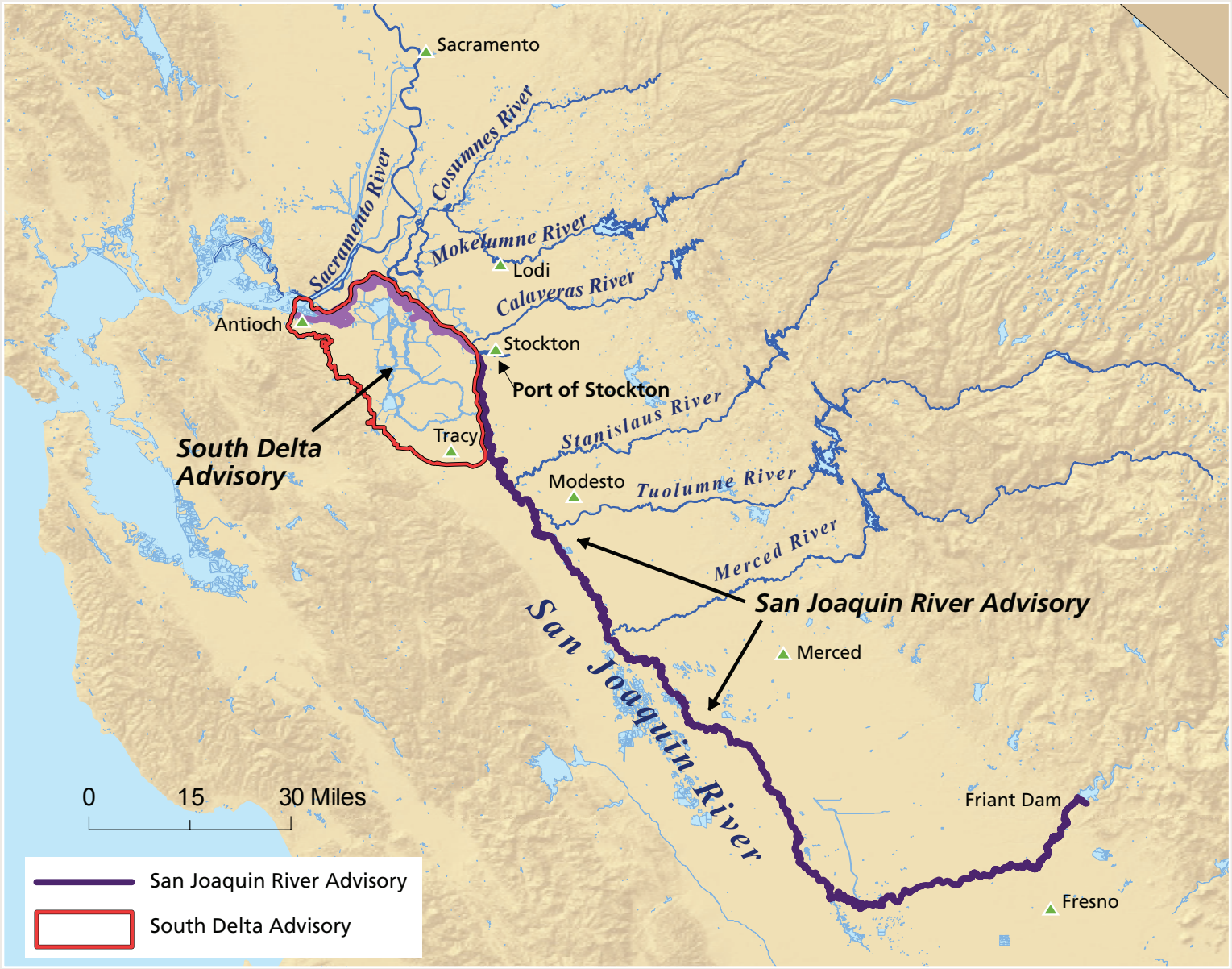


Figure 4

Map of South Delta and San Joaquin River Advisory Regions. *Draft Safe Eating Guidelines were developed for each of two regions: one for the South Delta, including the San Joaquin River from the Sacramento River to the Port of Stockton and other rivers, sloughs, and flooded tracts in the Delta south of the San Joaquin River; and one for the San Joaquin River from the Port of Stockton south to Friant Dam.*

contained more mercury, OEHHA recommends that women of childbearing age and children do not eat largemouth bass or other black bass species (such as smallmouth bass or spotted bass) from the San Joaquin River south of the Port of Stockton. The mercury levels in largemouth bass from the San Joaquin River would not necessarily cause harmful effects, but it is wise to avoid eating fish with this level of mercury. Furthermore, there are safer species of fish that can be eaten without much risk and that offer nutritional benefits. Therefore, it is better to avoid the fish that have higher mercury levels. OEHHA provides more cautious guidelines for women of childbearing age and children.

Advisory Still in Place for Striped Bass and Sturgeon

Fish Mercury Project studies of striped bass and sturgeon have also been planned, but were not complete at the time of writing. These studies are important because past studies have found highly variable concentrations of mercury, especially in striped bass, and recent data for these two popular species are insufficient to develop consumption guidelines. Therefore, until the study of these two fish species has been finished and the results are available, the long-standing advisory for San Francisco Bay-Delta continues to apply to striped bass and sturgeon from the South Delta. That advisory was based on findings of mercury and PCBs. The recommended limits are for all consumers. For further details on the advisories, see *www.oehha.ca.gov/fish.html*.

Bob Brodberg of OEHHA speaking to a Hmong radio audience.

Photograph by Jessica Kaslow.

Pesticides and PCBs

Some of the fish that were collected as part of the Fish Mercury Project will be tested for pesticides and PCBs (man-made chemicals used most commonly as electrical insulators). The results will be evaluated by OEHHA and considered when the final report and Safe Eating Guidelines for the San Joaquin River and South Delta are developed. An evaluation of other chemicals, such as PCBs, is important to be sure that they are not present in harmful amounts in fish that are found to be low in mercury. For the draft report, OEHHA reviewed older data on pesticides and PCBs in fish from the San Joaquin River and South Delta, and dioxins in fish from the Port of Stockton. Except for fish from the Port of Stockton, all of the other samples were very low in pesticides and PCBs. Samples of fish collected in the Port of Stockton area were found to contain higher levels of PCBs and dioxins. This area was contaminated in the past from activities at the McCormick and Baxter wood treatment plant and from other Port activities.

OEHHA met with staff from San Joaquin County and the California Department of Public Health to discuss these findings. Based on prior evaluations of these data, signs are currently posted that advise "no consumption" of fish and shellfish from the Port of Stockton area (Old Mormon Slough, New Mormon Slough, McLeod Lake, the Turning Basin, the Morelli Boat Ramp, and Lewis Park Boat Ramp). OEHHA has included these warnings with the draft Safe Eating Guidelines for the San Joaquin River and South Delta. OEHHA recommends that no one eat any fish or shellfish from the Port of Stockton area where signs are posted.

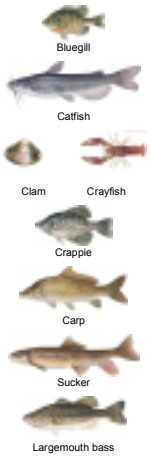
California Environmental Protection Agency Office of Environmental Health Hazard Assessment

SAFE EATING GUIDELINES

BASED ON MERCURY IN FISH FROM THE

SAN JOAQUIN RIVER

From the Port of Stockton to Friant Dam

Women of childbearing age (18-45 years) Children 17 years and younger	FISH AND SHELLFISH	Men Women beyond childbearing age
BEST CHOICES		**BEST CHOICES**
Bluegill or other sunfish, or crayfish **Eat up to 4 servings* a week** OR		Bluegill or other sunfish **Daily** OR Crayfish, crappie, or carp **Eat up to 6 servings* a week** OR Catfish or sucker **Eat up to 4 servings* a week** OR
GOOD CHOICES		**GOOD CHOICES**
Catfish, crappie, carp, or sucker **Eat up to 2 servings* a week** OR		Largemouth, smallmouth, or spotted bass **Eat up to 2 servings* a week**
AVOID		
Largemouth, smallmouth, or spotted bass **Do Not Eat**		

Follow the "No Consumption" warnings where signs are posted for the Port of Stockton area

* The recommended serving size for adults is three ounces of cooked fish (four ounces prior to cooking)

For more information, call OEHHA at (916) 323-7319 or visit www.oehha.ca.gov – Click on "Fish"

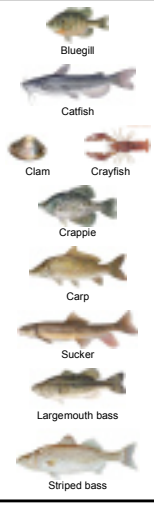
California Environmental Protection Agency Office of Environmental Health Hazard Assessment

SAFE EATING GUIDELINES

BASED ON MERCURY IN FISH FROM THE

SOUTH DELTA

INCLUDING THE SAN JOAQUIN RIVER FROM ITS CONFLUENCE WITH THE SACRAMENTO RIVER TO ITS CONFLUENCE WITH THE CALAVERAS RIVER, AND RIVERS, SLOUGHS, AND FLOODED TRACTS IN THE DELTA SOUTH OF THE SAN JOAQUIN RIVER

Women of childbearing age (18-45 years) Children 17 years and younger	FISH AND SHELLFISH	Men Women beyond childbearing age
BEST CHOICES		**BEST CHOICES**
Bluegill or other sunfish, catfish, clams, or crayfish **Eat up to 4 servings* a week** OR		Bluegill or other sunfish **Daily** OR Clams, crayfish, crappie, or carp **Eat up to 6 servings* a week** OR Catfish; sucker; largemouth, smallmouth, or spotted bass **Eat up to 4 servings* a week**
GOOD CHOICES		
Crappie; carp; sucker; largemouth, smallmouth, or spotted bass **Eat up to 2 servings* a week**		
AVOID		**AVOID**
Striped bass (18-27 inches) or sturgeon **No more than 2 servings* a month**		Striped bass(18-35 inches) or sturgeon **No more than 4 servings* a month**
Striped bass over 27 inches **Do Not Eat**		Striped bass over 35 inches **Do Not Eat**

Follow the "No Consumption" warnings where signs are posted for the Port of Stockton area

* The recommended serving size for adults is three ounces of cooked fish (four ounces prior to cooking)

For more information, call OEHHA at (916) 323-7319 or visit www.oehha.ca.gov – Click on "Fish"

Figure 5

Draft Safe Eating Guidelines for the South Delta and San Joaquin River.

OEHHA's Fish Consumption Advisories

OEHHA has developed fish consumption advisories and Safe Eating Guidelines for other water bodies in California ***(Figure 6)***. The advisories and related information including details on mercury and other chemicals can be found at www.oehha.ca.gov/fish.html.

Communicating the Results and Next Steps

OEHHA prepared a draft report (Gassel et al. 2007) that provides and explains the results from the Fish Mercury Project and previous studies of chemicals in fish and shellfish from the San Joaquin River and South Delta. The report includes the Safe Eating Guidelines that OEHHA is recommending for people that eat fish from the San Joaquin River and the South Delta. The report and guidelines, which can be accessed online at *http://www.oehha.ca.gov/fish/so_cal/sjrsd030907.html*, were first released as a draft to give members of the public and other agencies the opportunity to review them and provide comments. These comments will be considered by OEHHA staff and then incorporated in the future, as appropriate, into a final report and Safe Eating Guidelines.

After evaluating the study results, the most important task is to communicate the results to anglers and their families. OEHHA scientists and education and outreach specialists at the California Department of Public Health invited the health officers and environmental health directors from all counties in the study area to discuss the findings and how to best communicate them to the public. OEHHA coordinated with the California Department of Public Health to plan a workshop and training on the draft Safe Eating Guidelines for the San Joaquin River and South Delta, using the Fish Mercury Project's Local Stakeholder Advisory Group (LSAG) meeting as a venue. Members of the LSAG will serve as liaisons and educators for their communities. OEHHA also prepared a fact sheet and press release for the media to call attention to the evaluation and resulting guidelines when they were made available to the public.

Similar studies are underway for Years 2 and 3 of the Fish Mercury Project. Sampling was done in the Sacramento River and North Delta in the second year (2006). OEHHA will evaluate mercury levels in fish from that area and develop Safe Eating Guidelines. In the third year (2007) of the Fish Mercury Project, fish from the tributaries to the San Joaquin River, such as the Merced and Stanislaus rivers, and from some of the reservoirs along these rivers were sampled. These fish will be tested for mercury, and OEHHA will evaluate the results.

Summing It Up – What We Have Learned So Far

The information collected on mercury in fish from the San Joaquin River and South Delta represents one of the largest data sets for water bodies in California. This information has helped us to understand the distribution of mercury on a larger geographic scale, and OEHHA has been able to develop regional fish consumption guidelines as a result. The findings also raise more questions, such as why fish from the South Delta have lower levels of mercury than fish from most other water bodies in northern California *(Figure 3)*. Scientists from the Fish Mercury Project and other projects are studying this and other questions related to geographic patterns in mercury across the watershed.

The draft Safe Eating Guidelines provide anglers and their families with the information they need to choose fish to eat safely. It is vital that the Guidelines reach as many fishing families as possible so that they will know which kinds of fish are lowest in mercury and where it is safer for them to fish. OEHHA plans to work with the Department of Public Health team and other stakeholders to do more education and outreach. As part of this effort, more attention must be devoted to communicating the nutritional and health benefits from eating fish, and to increasing public awareness of the importance of achieving balance between the benefits and risks of fish consumption. ●

Figure 6

OEHHA Fish Consumption Advisories in California. *OEHHA has issued advisories for many water bodies in California. The majority of these are based on mercury in fish. For more information, visit www.oehha.ca.gov and click on "Fish".*

A posted Delta warning sign.
Photograph by Jessica Kaslow.

Protecting the Public's Health: Stakeholder Involvement and Risk Communication to Reduce Exposure to Mercury

Alyce Ujihara (alyce.ujihara@cdph.ca.gov), May Lynn Tan, Jessica Kaslow, Elana Silver, Lori Copan, Diana Lee, Tivo Rojas-Cheatham, Lani Kent, Ilinisa Hendrickson, and Ian Walker, California Department of Public Health

Highlights

- Through participation in meetings of the Fish Mercury Project (FMP) Steering Committee and Local Stakeholder Advisory Group (LSAG), stakeholders are providing valuable guidance on FMP activities, being informed on results from the Project and on related topics, and coordinating risk communication activities in affected communities
- Meetings with local agencies and other groups in 23 counties provided information on fishing activity that guided FMP sampling activities, and provided an opportunity to assess local concerns about fish contamination and a forum for sharing information about the FMP
- Discussions in eleven focus groups, with over 100 anglers from Lao, Cambodian, Hmong, Vietnamese, Latino, Russian, African American, and Native American communities, have provided information on popular species, consumption practices, and the effectiveness of different forms of risk communication
- A major effort guided by the LSAG led to the posting of multi-language signs with safe fish consumption guidelines in about 60 locations throughout the five Delta counties
- Also with guidance from the LSAG, educational materials about fish contamination have been produced, including printed cards, brochures, flyers, and posters, in multiple languages and a variety of literacy levels
- A training curriculum has been developed that can be used by individuals or groups wanting to learn about the effects of mercury and how to communicate consumption advice to at-risk populations
- By providing small grants to community-based organizations, the FMP is fostering the development of innovative educational activities, outreach programs, and media

Stakeholder Involvement in the Fish Mercury Project

The Environmental Health Investigations Branch of the California Department of Public Health (CDPH) believes that meaningful involvement from local stakeholders is an essential component of a successful project. Under the FMP, active involvement by a diverse group of stakeholders ensures that the Project activities are responsive to local needs and are sensitive to environmental justice concerns. Stakeholder involvement also builds local capacity to address fish contamination issues, and enhances collaborations with groups critical to the implementation of risk communication activities. This is because local stakeholders know best how to reach the impacted populations and the types of educational activities that will be effective in their communities. CDPH was asked to join the FMP team specifically to expand stakeholder involvement and risk communication activities in the Delta Watershed. While CDPH has been involved in fish contamination issues in other locations in California, addressing these issues in the Delta and Central Valley required extensive outreach efforts to engage and build collaborations with the many diverse communities in this new area.

Stakeholders participate in the FMP through two groups, the FMP Steering Committee and the Local Stakeholder Advisory Group (LSAG). CDPH has also sought local input through meetings and focus groups.

Fishing in the Delta.

Photograph by Jessica Kaslow.

The FMP Steering Committee

The FMP Steering Committee was formed in early 2005 to guide all FMP activities. As with many government-funded projects, input from representatives of other government agencies is assured. But because fish consumption issues directly impact many diverse communities, CDPH actively sought to include stakeholders who represented diverse, non-governmental interests. CDPH circulated information about the FMP to many organizations in the Delta and Central Valley, and requested nominations for its Steering Committee. From this process nine stakeholders representing angler, environmental, community, watershed, and tribal organizations joined the Steering Committee at its first meeting in March 2005. As we begin 2007, the third year of the FMP, eight of these stakeholders are still guiding the project *(Table 1)*.

Table 1

2007 FMP Steering Committee Non-Government Stakeholders

LaDonna Williams	People for Children's Health and Environmental Justice
Henry Clark	West County Toxics Coalition
Andria Ventura	Clean Water Action
Bob Strickland	United Anglers of California
Doug Lovell	Federation of Fly Fishers
Sherri Norris	California Indian Environmental Alliance
G. Fred Lee	G. Fred Lee and Associates
Shyaam Shabaka	EcoVillage Farm Learning Center

These stakeholders have exerted a strong influence on Project activities. Their early efforts resulted in revision of the FMP goals to state explicitly that the project would be "based on environmental justice principles." Their concerns over the lack of funding for community groups prompted the FMP to request and obtain funding to extend a grant program for community-based organizations in 2007. Also, at the request of the stakeholders, the Project established meeting stipends to help offset the costs borne by non-governmental groups when they attend Steering Committee and LSAG meetings. The Committee also guided the design of the fish sampling plan for the Delta so that it reflected the fishing practices of local communities.

Local Stakeholder Advisory Group (LSAG)

The second group guiding the FMP is the LSAG. The LSAG was formed in November 2003, under a prior CALFED project. The group's original purpose was to ensure local participation in the process of developing outreach, education, and training materials, and activities around fish consumption issues that were relevant to local communities. CDPH formed the group after conducting a series of in-depth meetings, also called needs assessments, with county agencies and community-based organizations. In the initial years of the LSAG, the group guided the development of new, multi-lingual educational materials.

The LSAG is now part of the FMP and continues to pursue its original, more specific purpose of involving local communities in risk communication. Current LSAG members include representatives from community-based groups serving Cambodian, Lao, Vietnamese, Hmong, African-American, Latino, and tribal populations; environmental groups; health departments in four Delta counties; and government agency staff. The group meets quarterly in different locations to best serve the large geographic area of the Project.

LSAG meetings generally focus on planning or reviewing education activities, and there is a strong emphasis on working collaboratively. For example, CDPH often asks community groups to test educational messages in their communities to ensure they are culturally and linguistically appropriate. The meetings also provide an opportunity for everyone to learn about how fish contamination issues impact different ethnic communities. The LSAG also provides an opportunity for its members to keep updated on current fish-related topics, such as new information on the health benefits of fish and the California Attorney General's lawsuits over canned tuna.

List of LSAG Institutions Active in 2007

- California Indian Environmental Alliance
- Clean Water Action/Clean Water Fund
- Contra Costa County Health Services
- DeltaKeeper
- Department of Fish and Game
- EcoVillage Farm Learning Center
- Lao Family of Stockton
- Lao Khmu Association
- Mechoopda Indian Tribe
- Office of Environmental Health Hazard Assessment
- People for Children's Health and Environmental Justice
- Sacramento County Department of Health
- Sacramento County Environmental Health
- Sacramento Regional County Sanitation District
- Sacramento River Watershed Program
- San Francisco Estuary Institute
- San Joaquin County Department of Public Works
- San Joaquin County Environmental Health
- San Joaquin County Public Health
- Solano County Resource Management
- State Water Resources Control Board
- Todos Unidos
- UC Cooperative Extension
- United Anglers of California
- United Cambodian Families
- Vietnamese Voluntary Foundation
- West County Toxics Coalition
- Yolo County Environmental Health
- Yolo County Public Health

Needs Assessments

Another important way the Project has obtained local stakeholder input has been through needs assessments. Needs assessments are a method for collecting qualitative information about a group's knowledge, awareness, level of concern, and information needs on a specific topic. CDPH staff met with representatives from 14 Delta watershed counties in 2005 and 2006 (Contra Costa, Colusa, Napa, Yolo, Sacramento, San Joaquin, Glenn, Shasta, Plumas, Tehama, Solano, Butte, Sutter, Yuba) and representatives from nine more counties within the target sampling area in late 2006 and 2007 (Amador, Calaveras, El Dorado, Fresno, Madera, Mariposa, Merced, Stanislaus, and Tuolumne).

The primary objectives of the needs assessments were to inform the counties about the Fish Mercury Project, to assess their current levels of concern about fish contamination, and to acquire information about fishing activity for each county, such as popular locations for fishing and the species typically caught and kept. In some of the counties, a more in-depth assessment was conducted to determine appropriate risk communication methods, to identify opportunities for collaboration, to assess training needs of county staff, and to learn about other organizations to contact.

The needs assessments started with meetings with county Health Officers and Directors of Environmental Health or their staff, and Department of Fish and Game wardens and lieutenants when possible. A standardized list of questions was used to guide each meeting. In general, county staff felt that fish contamination was a low priority compared to other public health issues, and in most cases they reported having limited health education staff to take on fish contamination outreach. However, they were all willing to provide information or suggest ways to gain information about fishing in their county, and they all expressed interest in local advisories that might be forthcoming from the FMP activities.

After the initial county needs assessment meetings, follow-up activities were conducted such as contacting additional county staff, meeting with staff of local community-based organizations, conducting site visits at fishing locations, coordinating focus groups with local anglers of different ethnicities, and conducting trainings for county staff or local groups on fish contamination issues. In many of the target counties, we contacted other local fishing experts who were recommended to us by the county representatives. These included staff from California Department of Fish and Game, US Army Corps of Engineers, US Forest Service, East Bay Municipal Utility District, and state and county parks. We distributed a standard self-administered survey to many of these key local fishing informants, and were able to get up-to-date information on local fishing activities.

Focus Groups

Where are anglers fishing? What fish are mostly commonly eaten? What messages work best with anglers? CDPH has been using focus groups to gain more information about fish consumption, and incorporate community perspectives into FMP activities. Focus groups are facilitated discussions of small groups of people to obtain information on behavior, attitudes, and other concepts that cannot be collected through surveys. CDPH is relying heavily on assistance from our community-based partners who help organize and recruit focus group participants and provide translation services. During 2005 and 2006, CDPH convened a series of 11 focus groups with a total of 107 anglers from Lao, Cambodian, Hmong, Vietnamese, Latino, Russian, African American, and Native American communities.

The focus groups were designed to obtain information about fishing locations and fish species of importance in each community in order to guide the FMP sampling plan. They also collected qualitative data on how advisory messages are perceived and understood, and appropriate methods and venues for communicating advisory information in each community. While insufficient data has been collected to date to draw broad conclusions, a number of common themes have arisen from the series of focus groups conducted thus far.

A focus group with the Slavic Assistance Center.

Photograph by Jessica Kaslow.

Striped bass, catfish, bluegill, and crappie emerged as the most commonly consumed fish caught in the Delta. Largemouth bass and carp were mentioned as well, but as less important fish. While sturgeon was also considered a prized fish, it is rarely caught. Of particular interest were the reasons that anglers gave for fishing. Most anglers reported that relaxation, recreation, and tradition were the most important reasons for fishing, but that catching fish was an important part of the experience; most participants reported consuming their catch. Very few anglers indicated that fishing was an important source of food for them.

Anglers' reactions to advisories have been useful in helping CDPH create appropriate messages. Anglers tended to be highly concerned for their health, but skeptical of the complex messages found in advisories. Many anglers expressed resistance to eating certain fish within advisory limits, preferring instead to avoid a fish completely if it was not safe to consume as much as they wanted. This concept in particular will need further exploration in future focus groups to improve the way advisories are presented. Participants were all supportive of increased access to advisory information; word of mouth, signage, and bait shops were consistently identified as potential sources of information for anglers, while the internet was rarely mentioned.

Talking About Risk

Because efforts to clean up mercury in the watershed will take many decades, risk communication is one way to reduce exposure to mercury in the short term. "Risk communication" includes outreach, education, and training activities to inform affected populations about fish contamination issues and encourage them to reduce their exposure. Educational messages are developed primarily around fish consumption advisories, but they constantly respond to the informational and cultural needs of affected populations. Risk communication can include information on causes of contamination, potential health effects, and culturally appropriate alternatives to contaminated fish.

In collaboration with our community partners, CDPH utilizes a variety of approaches in risk communication, including the development and distribution of multi-lingual materials, training on fish contamination issues, capacity-building activities, posting signs, and mini-grants to local agencies and community-based groups. These components will be described below.

The Delta Warning: A Sign

In April 2006, a colorful warning sign was posted around the Delta at fishing access points such as marinas, parks, and piers. The sign, entitled "Eat Delta Fish Safely," describes the existing striped bass and sturgeon advisory in seven languages, using color images to depict size limits and alternative fish to catch and eat. As a single component of a broader educational campaign, the warning sign has provided the opportunity to communicate the advisory to diverse populations who, in some cases, may not have access to the information elsewhere.

CDPH first considered undertaking the Delta signage project after being approached by the legislative director of Assemblyman Alan Nakanishi. Concerned that many people in his district were catching and eating fish from the Delta, Assemblyman Nakanishi sponsored legislation in 2004 to require the State Water Resources Control Board to post warning signs in the Delta. Unfortunately, the bill did not pass.

In early 2005, CDPH proposed that the Local Stakeholder Advisory Group collaborate on developing and posting a new warning sign for the Delta, based roughly on the San Francisco Bay warning sign that was created in 2002. There was much support from the group, but also many questions. What would the new signs look like? What languages would be included? Where would the signs be posted? Who would maintain them?

Over the next year, the LSAG guided the sign's design and production. The group also helped decide which languages to include on the sign – Spanish, Russian, Chinese, Vietnamese, Cambodian, Lao, and Hmong. All seven translations were field tested with community members. To acknowledge their active involvement in the sign's creation, the logos of 7 community groups and 3 county departments were incorporated into the design, along with a blank space to add additional local contact information. The sign was printed in two formats, a large waterproof outdoor version and a smaller indoor version.

The actual posting and maintenance of the sign has been done by many different groups, including county health and environmental health departments, community groups, marina operators, the University of California Cooperative Extension, and private landowners. The first sign went up in Solano County in April 2006. Over the following year, signs were posted in about 60

locations throughout the five Delta counties. As many Delta anglers know, some of the best fishing locations are along levees that can only be reached by remote dirt roads. These places pose a challenge for sign posting because there is often no suitable structure to hang the sign. Also, CDPH has identified numerous places where signs must be replaced or reinforced against vandalism.

With support from our local partners, CDPH will continue posting the sign in 2007. Through the Advisory Group and other local contacts, CDPH has identified many potential venues, including indoor locations such as bait stores or fishing license vendors. CDPH has begun an in-depth evaluation that involves revisiting sign locations and interviewing anglers about their awareness and understanding of the sign. High school students trained by EcoVillage Farm Learning Center *(page 54)* will assist CDPH in data collection for these evaluation activities.

For groups or individuals interested in helping with the posting effort, the sign may be ordered using the order form at the FMP website: ***www.sfei.org/cmr/fishmercury/***.

Educational Materials

With guidance from the Local Stakeholder Advisory Group, CDPH has produced a number of educational materials about fish contamination. The materials include printed cards, brochures, flyers, and posters, many of which are available in multiple languages. Materials are also available for a range of literacy levels, from a low-literacy brochure containing mostly pictures, to a recently updated, 20-page Frequently Asked Questions guide for health and social service providers. This latter document contains detailed information about the effects of mercury and Northern California fishing advisories. Wording and images in CDPH materials are field-tested with the intended audiences during and after their creation.

Also available is a training curriculum that can be used by individuals or groups wanting to learn not just about the effects of mercury, but also how to communicate advisories to at-risk populations. The curriculum contains five modules, each with learning objectives and interactive activities to utilize in a group setting. Examples of lessons include how culture affects fish consumption, how mercury affects the body throughout the lifespan, and how to share advisory information with others. The curriculum comes with a CD-Rom containing electronic copies of all materials needed for a complete training session. CDPH has provided training to health and social service providers, parks and recreation staff, and community groups.

All educational materials, including the training curriculum, FAQ guide, and the Delta Warning Sign, can be ordered free of charge using the order form available at the FMP website: ***www.sfei.org/cmr/fishmercury***. CDPH leads trainings on how to utilize the curriculum and many of our materials. If you are interested in attending one of these trainings, please contact us directly.

Outreach and Education Mini-Grant Program

A major focus of CDPH's work has been to build partnerships with local agencies and community-based organizations serving populations that have low awareness of fish advisories and may be at increased risk because fishing is an important part of their culture. This often includes people of color, low-income, and non-English speaking populations. Mini-grant funding of up to $10,000 is an effective way to enable these partner organizations to conduct outreach and education that is both culturally relevant and linguistically appropriate for their communities. The Outreach and Education Mini-Grant program, now in its third year, is administered by CDPH to assist local organizations or agencies in reaching communities with innovative educational activities, outreach programs, or forms of media.

Groups have been eligible to apply for a mini-grant if they serve a priority audience, such as pregnant and breastfeeding women, women of childbearing age, anglers, youth and students, or seniors. Because new health advisories were recently issued for the Sacramento-San Joaquin Delta, the lower Feather River, Putah Creek, and the San Joaquin River, extra consideration was given in 2007 to organizations serving populations in these particular areas. Grantees participate in the Local Stakeholder Advisory Group and share updates about their projects quarterly.

In January 2006, five organizations working in the Delta were awarded mini-grants (described below). In late 2006, the new 2007 Request for Proposals was released. Proposals were reviewed and scored by a panel representing several partner organizations. Seven groups were selected to receive grants ranging from $6,000 to $10,000, and their projects will continue through the end of 2007.

Figure 1

The FMP's Local Stakeholder Advisory Group guided the design and production of a warning sign for the Delta. *The Group also helped decide which languages to include on the sign – Spanish, Russian, Chinese, Vietnamese, Cambodian, Lao, and Hmong. To acknowledge their active involvement in the sign's creation, the logos of 7 community groups and 3 county departments were incorporated into the design. The sign describes the existing striped bass and sturgeon advisory, using color images to depict size limits and alternative fish to catch and eat. As one component of a broader educational campaign, the warning sign has provided the opportunity to communicate the advisory to diverse populations who, in some cases, may not have access to the information elsewhere.*

EcoVillage Farm Learning Center

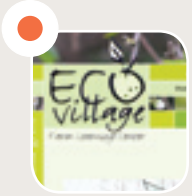
Richmond

Shyaam Shabaka at EcoVillage wants his students to take charge of not just their lives but their world. The first step, he believes, is taking better care of each other. EcoVillage is nestled on the edge of a community better known for oil refineries, crime, and gang violence, an environment that leaves many of his students at a disadvantage. His program focuses on building self-esteem and responsibility by involving them in hands-on environmental education and stewardship. "We want to broaden the range of people involved in environmental and social justice work," Mr. Shabaka says. A trip to the farm learning center might encompass animal husbandry, urban forestry, fence building, or environmental protection. With the Delta watershed literally in his backyard, Mr. Shabaka's five and a half acre community has goats, chickens, rabbits, ducks, pigs, fruit trees, and an organic vegetable and herb garden.

The FMP's mini-grant has become an integral part of Mr. Shabaka's program. EcoVillage works with twenty different schools and programs in Contra Costa County. More than 300 students and educators participated in their Middle College High School Environmental Conference, which included student led workshops on mercury contamination. An additional 75 students graduated from fish education workshops at EcoVillage. Mr. Shabaka has established a weekly presence at the Farm Fresh Produce Stand at Kaiser Permanente Medical Center in Richmond, distributing a healthy fish message beside the array of fruits and vegetables. They have also been actively involved in signage, posting eleven Delta warning signs at locations where community members reported fishing, and at four bait shops.

Like many community-based leaders, Mr. Shabaka believes that cultural sensitivity goes far deeper than ethnic representation on fact sheets and brochures. His outreach puts emphasis on meeting individual needs. "Don't ask a question you don't need the answer to," he says, "focus on *their* needs." By providing information in smaller portions, his approach gives more time to developing personal relationships with the understanding that you won't change the world in one sitting.

Shyaam Shabaka of EcoVillage Farm Learning Center.
Photograph by Yolanda Bulls.



More information available at www.ecovillagefarm.org

Ma'at Youth Academy

Richmond

The Ma'at Youth Academy incorporates the qualities of an ancient Egyptian goddess into their work in fish contamination education. Founded 12 years ago to foster research, education, and community activism to address environmental hazards in Contra Costa County, Ma'at adopted the Egyptian word for Truth and Justice—and the goddess that embodies those principles—as their name.

Ma'at's successful environmental programs include the Community and Global Ecology, a hands-on curriculum taught in public middle and high school classrooms in Contra Costa and Alameda county schools; the Youth Environmental Ambassadors of Health!, designed to teach environmental stewardship skills to students through community activism and education; and Environmental Coalition for Community Health, a community organizing program to reduce pollution and industrial accidents in communities of color and low-income areas.

The scarcity of funding for mercury education tailored to multicultural and low-income neighborhoods has made it difficult to build upon successful programs. Ma'at's Founder and Executive Director Sharon Fuller has found that organizations are usually more interested in funding work in asthma and air quality for Contra Costa residents. "Mercury is more insidious because it's not immediately recognized," she says, making it more difficult to obtain funding. She also perceives the issue as having been erroneously viewed by funders as more relevant to Asian communities than to African-American and Latino populations.

The FMP's mini-grant has helped Ma'at expand their ongoing fish programs, and add vital components. The funding enabled Ma'at to train two Health Education Specialists and two Youth Educators from local high schools to coordinate their educational efforts. Ma'at staff developed an educational poster board that was utilized at the Richmond and San Pablo Women, Infants, and Children (WIC) clinics, the John Muir Center's Earth Day event, and at the Richmond Farmer's Market. A companion flyer was created as a "take home" piece to re-enforce messages from one-on-one sessions with clients.

Richmond Harbor, one of Ma'at's primary outreach sites.

Photograph by Kathy Sloan.

To ensure a culturally relevant and effective approach, Ma'at hires educators directly from the target community, individuals with first-hand knowledge of fishing and consumption habits. They rely heavily on a "story telling" approach, similar to the oral tradition of African Americans, with the belief that talking from similar experiences engages people in the process.

In Ms. Fuller's eyes, the most significant "product" of their collaboration with the FMP has been their increased capacity to participate in broader collaborations and disseminate information to the community. She plans to begin distribution of newly developed fish consumption posters, created in collaboration with the County Health Department and funded in part by the mini-grant, to WIC clinics countywide within the next six months.

More information available at www.maatya.org

Todos Unidos

Antioch

Some aspects of a local community based organization are nearly impossible for larger organizations to replicate. These groups, and the staff that run them, grow directly from the communities they serve, sharing a common history and commitment. When Carlos Torres of the League of United Latin American Citizens Todos Unidos talks with anglers in Antioch, his son often joins him, making it clear that he's no stranger in the community. The community is a part of who he is.

Similarly, Todos Unidos's roots reach deep into the Antioch community, stretching out to refugees, anglers, farmers, mothers, and teens. In 2006, the organization shared fish consumption information by participating in 17 fairs and conferences, ranging from the 2006 Women's Summit to the yearly almond and corn festivals. They met with clients from the Young Latina Mothers Group, as well as the Refugee Health Promotion and Disease Prevention program. They conducted five workshops at health clinics, parent groups, and Head Start programs, and reached an estimated 1500 individuals with a personal message about fish consumption.

In order to work with such a diverse population, Todos Unidos tailors their communication to fit their clients. Like other mini-grant groups, they found that people often stopped eating fish completely when informed about mercury and other contaminants. As a result, Todos Unidos decided to revise their outreach to emphasize the benefits of safe fish consumption. Their approach begins with connecting the home to the larger environment, encouraging clients to look at how their personal behavior may affect the world around them. They participated in a community clean-up with the East Bay Parks District at the new park area of the Bay Point Waterfront, and manned a booth at the Pittsburg Earth Day Celebration.

Mr. Torres also collaborates with other agencies with overlapping interests. His educational display places fish mercury information right beside guidance on how to dispose of mercury products like light bulbs, thermometers, and batteries—once again connecting personal behavior to the larger issue. Similarly, he is modifying his distribution plan to work with an agency that specializes in distributing materials to the community -- the public library system.

A Todos Unidos display on safe fish consumption.

Photograph by Jessica Kaslow.

Todos Unidos has lots of plans for the future. Their website is midway through its construction and already prominently features mercury in fish information. He hopes to strengthen relationships with the sanitation department that processes mercury waste products, and put up posters and materials in the local libraries. He's also committed to more workshops and community events, and expanding use of the media through public service announcements.

More information available at www.todosunidos.net

United Cambodian Families

Stockton

"Do you think you can teach a crocodile how to swim?" is the response Sophat Sorn received one day when speaking to a group of Cambodian fishermen. Crocodiles are strong and efficient swimmers; they learn their skills early in life. Similarly, Cambodians are born into a culture of fishing, learning early on how to fish well. "I hope to teach a crocodile where to swim," was Mr. Sorn's response. His message emphasizes safer places to fish and safer fish to eat, and shies away from messages about not eating fish.

United Cambodian Families (UCF) developed out of the Cambodian community's need for a voice in Stockton. Cambodians in Stockton make up 98% of the Cambodian population in San Joaquin County, and 15% of their total population in California. Many are first generation immigrants, fleeing a country plagued by years of political turmoil. UCF focuses on addressing the pressing needs of their community, which includes everything from housing to help filing tax returns.

For a community where almost everyone eats fish daily, mercury education qualifies as a pressing need. Making anglers aware of the dangers of mercury in fish has been difficult, given the invisible nature of the danger. UCF discovered that many anglers were unaware of fish consumption advisories. And when told about the risks of over-consumption, many were quick to point out that rivers and lakes back home in Cambodia are murky, while the waters of the Delta are clear.

UCF's strategy has been to identify leaders to convey their message. Vice President Lim Leang defines a leader as anyone willing to take initiative and responsibility, not necessarily someone who holds an official position of power. In his eyes, leaders are people who speak up for others. As a part of their Mercury in Fish campaign, UCF developed strong relationships with groups like The Asian Pacific Self-Development and Residential Association, and with local Buddhist temples. UCF distributed education materials in Khmer at community events such as the Cambodian New Year celebration, and wrote articles for their newsletter. Some of their major accomplishments have been in the area of audio and video. Influenced in part by the importance of oral history and story-telling in Cambodian culture, UCF developed an educational audio tape. The recording uses music to draw in the listener, and emphasizes the cultural importance of their message. They also developed a video on fish consumption, which they are hoping to release in 2007.

Sophat Sorn of United Cambodian Families.
Photograph by Shannon Sorn.

Compassion is a word that comes up frequently in speaking with Sophat Sorn and Lim Leang. It's a part of the communal bond that already exists before they begin their education; it's the twinkle in a listener's eye, Mr. Sorn says, that appears right before they thank you for the information.

More information available at www.unitedcambodianfamilies.org

Vietnamese Voluntary Foundation (VIVO)

Stockton

The philosophy at the Vietnamese Voluntary Foundation (VIVO) is that they work "not from the check, but from the heart." For Lan Doan, Program Manager, this means focusing on her client's daily needs even when they go beyond VIVO's program areas of case management, senior health, school readiness, and mercury in fish education. Clients often appear in her doorway needing assistance with Medi-Cal, housing forms, and paperwork for low-income assistance programs. Though she's only 25% time right now, her work hours are closer to full time.

Ms. Doan sees fish education as a daily need. Many of her clients either fish or eat fish every day, and fishing in the local watersheds is part of the Vietnamese and Hmong cultural tradition. In 2006, VIVO's Mercury in Fish program focused extensively on outreach. VIVO concentrated much of their outreach on the Farmington Apartment complex, which houses a large Hmong population. They distributed posters and educational cards to the Transcultural Clinic and at Stockton's Literacy Day at the Park. They also made presentations at the Calvary Mission Alliance Church, and First Five, a program for families with children under five years of age. One of the most exciting events for Lan was the two-day Hmong New Year celebration, which attracted more than 4000 people. And at VIVO's offices, you're likely to get a small serving of fish education with every visit.

For Ms. Doan, brochures, flyers, and posters are really aids for holding conversations about fish. "Materials are not enough," she insists. "How do I know they are having any impact?" She uses them to get people in the door. Lan notes that many of her clients are not used to speaking out; she has to be very friendly, and build trust. In her community, people respond to the messenger. If you are helpful and friendly, they'll trust you and learn. If not, they switch off. She takes time to learn about their families and background, and tailors the pace and depth of her education accordingly. Providing daycare, and making educational workshops fun and interesting are key components of her approach. She encourages potential clients to "bring a friend," and she encourages questions, lots of questions. "The more they question, the more they learn," she says. Most often, she's asked about who did the study and developed the materials. For Ms. Doan, these are questions about trust. Once you have that, education becomes easy.

Lan Doan of VIVO at the 2007 FMP Annual Meeting.
Photograph by Shira Bezalel.

"People are very happy to get this knowledge", she says. She believes her community members are very concerned about their health, especially when it comes to diabetes and cancer, and they are willing to learn how to eat fish more safely.

Ms. Doan doesn't expect to stop talking about fish anytime soon. She wants to focus her efforts on seniors, who often use their free time to fish for the family. VIVO is currently developing a fish education calendar that will go on refrigerators. And they have grant applications in the works for addressing immigrant and elderly wellness. Fish, she expects, will play a significant role in all of these programs.

More information available at
www.microviet.netfirms.com/vivoonline/index.htm

A focus group meeting with CARE.
Photograph by Jessica Kaslow.

CARE(ful) Input into Sampling Plans

In order to ensure that the FMP conducts sampling in locations where community members actually fish (and for species that they actually eat) the California Department of Public Health (CDPH) interviewed county staff, fishing experts, and local community groups. In March 2007, CDPH met with California Amer-Asian Resource Education (CARE), a newly-formed community group in Fresno. Approximately fifteen CARE leaders and board members were present.

Cultural practices among Southeast Asian communities in California have sometimes led to damaged natural resources, wildfires, conflicts with other users and land owners, and negative stereotypes for the community. CARE aims to provide resources and education to improve land management practices in these communities. After hearing about the fish contamination issues in the Delta watershed, CARE members were eager to enter into a partnership with CDPH to disseminate information to their constituents.

CARE members reported that they fish frequently, and that eating fish is an important part of their cultural tradition. Pregnant women in particular eat fish to ensure the health of their babies. None of the CARE members had heard any warnings about mercury or other chemical contaminants in fish. They were also disappointed to learn that there is currently not enough data to determine whether it is safe to eat the fish caught at many of their favorite fishing sites. This, however, will soon be remedied, as many sites mentioned by CARE members have already been sampled by the FMP or are being considered for 2007, including Millerton Lake, San Luis Reservoir, the California Aqueduct, and the Delta Mendota Canal.

Prior to the meeting, fishing advisories had been issued at two popular sites for CARE members: the San Joaquin River and Lake Nacimiento. (We were surprised to hear that Lake Nacimiento was a popular spot, being a two hour drive from Fresno!) Despite the publicity and outreach efforts, none of the meeting attendees had heard warnings about eating fish from either place. This is perhaps not surprising, as the media coverage regarding these new advisories has been far from Fresno, and in English and Spanish only.

CARE members at the meeting offered many useful suggestions on how to communicate fish information to the large Southeast Asian community in the Fresno area. These included appearing on the local Hmong radio station, posting signs at fishing sites and markets, and handing out culturally appropriate materials at community festivals. The March 2007 meeting marked the start of what we hope will be a long collaboration with CARE. Through this partnership, the FMP can ensure that the sampling will include appropriate locations and species, and that the results of that sampling are communicated back to the Southeast Asian community in Fresno.

Environmental Justice

When it comes to incorporating the principles of Environmental Justice (EJ), CALFED's Fish Mercury Project (FMP) has broken new ground, providing more opportunities for community involvement than any major environmental monitoring project in California has ever done before.

Jay Davis, Principal Investigator for the FMP, has learned from participating in this Project that EJ is really about the fair treatment of all people regardless of race, culture, or income. The goal extends across the board, from environmental laws to education. "In the short term, fair treatment means providing all fish consumers with information they can use right now to reduce their exposure to mercury and other pollutants."

It's a tall order. To truly be an EJ project, the creation of the FMP would have been motivated from the local community, rather than the scientific community. As such, the goals, priorities, and strategies may have been slightly different. In the FMP, community group participation began after the budget and the general design of the Project had already been established. Initial discussions included some frustration until the Project investigators learned about EJ and the community groups understood the administrative constraints around this Project. While the community leaders and the Project investigators may not see exactly eye to eye on every issue, everyone agrees that the FMP is essential and that the actual inclusion of EJ and community participation have been integral to its success.

Some communities are disproportionately exposed to mercury from fish caught in the Delta watershed. Many of these communities engage in fishing as part of their culture or out of economic need, relying on fish as a nutritious food source; and many have language barriers that restrict their access to information about safe fish consumption. To address these issues, the FMP has invited community participation at nearly every level of the program. The FMP has actively sought information about local fishing practices through focus groups and needs assessments, so that fish sampling would include the species and fishing locations preferred by communities. The FMP established a Steering Committee, a multidisciplinary, multi-institutional group that consists of representatives from government agencies, scientific and academic institutions, and community-based organizations. Also included are participants from angler organizations, environmental groups, community social service organizations, and tribal groups. The Steering Committee functions to guide the FMP, providing oversight on project plans, monitoring, and risk communication activities. Upon its formation, the Steering Committee immediately modified the FMP's goals and objectives to specifically state that Project activities focus on "reducing exposure through risk communication based on environmental justice principles."

The FMP also relied on the Local Stakeholder Advisory Group, convened by the California Department of Public Health (CDPH), to meet the EJ goal of providing information to all communities affected by fish contamination. The Advisory Group membership includes county health and environmental health agencies, and diverse community-based organizations representing

Shyaam Shabaka of EcoVillage Farm Learning Center speaking at the 2007 FMP Annual Meeting.

Photograph by Shira Bezalel.

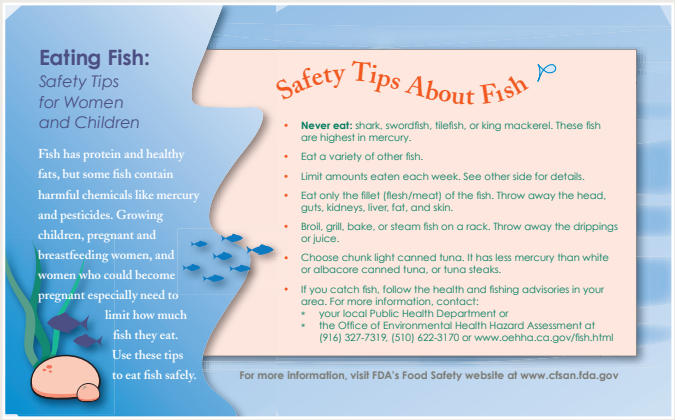
target communities. Members of the Advisory Group have guided CDPH in the development, translation, and dissemination of educational materials, conducted mini-grant funded outreach projects, reviewed and participated in training activities, and helped plan a Fish Forum in December 2005.

One important component of the FMP's EJ approach has been the mini-grant program, which funds community organizations to conduct mercury education. Their role has been to develop and implement educational activities specifically for their communities, and provide guidance to CDPH on the development of materials. By funding community organizations directly, the FMP ensured that education would be culturally appropriate. In addition, community organizations are often more effective in providing education, because of their pre-existing relationships with the local population. The activities and accomplishments of the mini-grant recipients are outlined in their individual pages.

LaDonna Williams, a Steering Committee member and Executive Director of People for Children's Health and Environmental Justice, appreciates the efforts being made in the FMP to incorporate EJ, however she thinks that much more needs to be done in future projects, including actual involvement from the very beginning in project design and implementation, with substantial funding for EJ communities. Ms. Williams thinks that FMP investigators have begun to listen to communities, more than in the past, but must do more to actually include their suggestions and recommendations. "California has a reputation of being progressive," she says, "but we have yet to fulfill that image." In future projects like the FMP, she would like to see a greater percentage of the overall budget dedicated towards the grantees, and more shared ownership of the project. This means bringing in community voices even earlier in the process. The community's input can be helpful in every aspect of the work, from guiding project objectives, to developing monitoring plans and educational programs.

Jay Davis agrees that there is room for improvement. He, too, would like to see future efforts that make more money available for community organization outreach projects, which have touched thousands of hard-to-reach anglers and their families. He'd like to more fully include representatives from affected communities in the earliest stages of project development, with funds allocated for their participation, and believes the FMP will serve as a model for broadening scientific studies to embrace EJ principles. Finally, he hopes that educators will continue to think of creative and effective ways of communicating risk information.

Incorporation of EJ principles in the FMP has been valuable not only for the community groups, but also for the investigators who have been better able to focus their monitoring of mercury in fish. This approach has generated data that are of great value in reducing human exposure to mercury from contaminated fish in the Delta. By taking this step forward, the FMP has provided a demonstration of the many benefits of including EJ in an environmental monitoring project.



A card with safety tips for women developed by the CDPH.

Fish Consumption Among Low-income Women in the Delta

Fishing is important to many people living in California's Sacramento-San Joaquin Delta watershed. In many cultures, fishing is a traditional activity, and it is a fun and relaxing way for families and friends to spend time together. Fishing is also a good way to get healthy, low-cost food. However, because of runoff from abandoned gold and mercury mines, certain Delta watershed fish are contaminated with mercury, which can harm brain development in young children and developing fetuses. Government health advice recommends that women and children limit the amount of fish that they eat from stores, restaurants, and local waters, including the Delta.

In order to find out more about how much fish women in the Delta eat, and whether they have heard the warnings about mercury in fish, CDPH conducted a survey. CDPH interviewed 500 women at a Women, Infants, and Children (WIC) clinic in Stockton. The women were all low-income, and came from many different cultures (52% Hispanic, 19% Asian, 14% white, 12% African American, 2% Native American).

Almost all of the women (95%) ate fish from stores and restaurants. Many (32%) ate fish that they or their friends and family caught locally. Almost all Hmong (86%) and Cambodian (75%) women ate fish caught locally. Except for one person, everyone who ate fish caught locally also ate fish from stores and restaurants.

Most white women (77%) had heard the warnings about eating fish, but only 49% of African Americans, 41% of Asians, 37% of Hispanics, and 36% of Native Americans had heard the warnings. Overall, less than half of women had heard warnings (45%), and even fewer (31%) could list specific things that they could do to make sure they weren't exposed to too much mercury. Women with more schooling were more likely to know about the health warnings.

Women ate an average of seven ounces of fish per week. The groups who ate the most fish were African Americans (ten ounces per week) and Asians (nine ounces per week). Women who had heard warnings about eating fish ate less fish than other women. More than a quarter of the women (28%) ate more fish than the warnings recommend (twelve ounces of fish from stores or restaurants, or six ounces of locally caught fish, per week).

The survey showed that fish contamination issues may have the greatest impact on certain cultures, particularly African Americans and Asians, who eat a lot of fish but tend not to be aware of health warnings about eating fish. Locally, it may take decades to clean up the mercury pollution. In the meantime, greater efforts should be made to make sure that people of all cultures have access to important information about fish contamination.

More information available at www.cieaweb.org

A California Indian Perspective on the Fish Mercury Problem

Prior to 1848 there were hundreds, if not thousands, of California Indian tribes in the greater Sacramento and San Joaquin river regions, each with thousands of years of historical residence hunting, fishing, and gathering food in the region's ocean, bays, rivers, streams, and wetlands. Today there are over 55 federally recognized tribes from this area and many others that are unrecognized, each with distinct languages, cultures, and regional knowledge.

The gold discovered in 1848 stimulated a "war of extermination" to literally wipe out the Tribes of California. During a 20-year period their population plummeted from over 150,000 to 31,000 as result of disease, forced relocations, and outright massacres. In 1851 the State of California authorized volunteer citizens to receive payments from 25 cents to three dollars for California Indian heads and ears, thus funding the genocide of entire Indian communities. In only one year of this period, the U.S. Federal Government compensated the state of California in the amount of one million dollars for the "Suppression of Indian Hostilities." As a result of these policies, most of the California Indians that are left today are the survivors of massacres and bloodshed. It is through this historical lens that tribal members view the environmental legacy of the California Gold Rush and its continued impact on the health of the People and on cultural survival.

California Tribes lived a subsistence way of life based upon native plants, animals, birds, and the fish that were once abundant within these waterways. Traditional ways of life have been severely limited in California due to habitat loss, water reallocation, and pollution. Historic gold mining has filled spawning areas with mercury-laden silt. Even worse, 90% of California's rivers contain hydroelectric and/or reservoir dams that block fish passage, create areas where mercury is more likely to accumulate in fish, and limit river flows through the state's reservoir and diversion systems.

To tribal fishing peoples in California the relationship between fish and human consumption is one of prayer, shared responsibility, and the continuation of the people. Today, tribal members are at increased risk due to mercury contamination through distinct cultural practices such as basket-making, making of regalia, exposure to contaminated sacred sites, and differing consumption patterns. Many tribal community members "return home" each year to celebrate the continued health of the earth, water, air, and all life that depends on it. In many communities the relationship with fish is honored through ceremony and feasting on local traditional subsistence foods, which in their uncontaminated forms are literally medicine to the people. During this time many community members travel from urban to rural areas and back, consuming large quantities of fish each week and bring home canned, dried, and fresh fish that is eaten throughout the year. Women carry the burden of balancing culture and risk reductions as current advisories require them to limit or abstain from their cultural foods until after childbearing age and to limit the participation of their children.

Although many native California Tribes at this time cannot solely rely on their former subsistence way of life, most are seeking to exercise their rights of sovereignty to utilize traditional environmental knowledge and implement better management solutions, cleaner standards, and habitat restoration and protection so future generations can enjoy what was once abundant in California. It is imperative that agencies and organizations working towards cleanup of California's lands and waters consult with and work with tribes to develop sound environmental policies and standards that will benefit all people in California. Tribes are looking towards short-term actions to protect the people currently, while always thinking of long-term solutions and a time when the People can return to a subsistence and ceremonial way of life, gathering fish in our rivers with ceremony and celebration, welcoming the fish back each year.

Contact:
Sherri Norris, California Indian Environmental Alliance, sherri@cieaweb.org.

A Mississippi silverside, one of the principal biosentinel species.

Photograph by Darell Slotton.

Small Fish as Biosentinels of Fine-scale Patterns in Methylmercury Contamination in the Watershed

D.G. Slotton and S.M. Ayers, University of California, Davis

Highlights

- Small, young-of-the-year fish, or "biosentinels", are sensitive, fine-scale indicators of methylmercury in aquatic food webs
- The FMP Biosentinel Program is monitoring approximately 50 sites across the watershed, particularly in and around large wetland restoration areas
- Some wetlands were found to have relatively low methylmercury exposure, including the Napa Marsh and parts of the North Delta
- Significant seasonal trends were found in some areas, with dramatic spikes in small fish mercury linked particularly to episodic flooding of normally dry soils
- Inter-annual sampling identified the Suisun Marsh region as a 2006 hot spot

Introduction: Why Biosentinels?

The UC Davis component of the Fish Mercury Project (FMP) uses small, young-of-year fish as its primary mercury monitoring tool. These localized little fish are a key element of the CBDA Mercury Strategy and are referred to as **mercury biosentinels.** The small biosentinels complement the sport fish and human health components of the program by providing **a sensitive measure of methylmercury exposure to the aquatic food web.** "Methylmercury exposure" refers to that key fraction of mercury that has been converted to toxic methylmercury, made its way from the sediments into the water, and is actively moving into the aquatic food web. In particular, biosentinels can provide detailed information about varying levels of methylmercury exposure for fish, both geographically and over time. In other words, they help to answer the "where" and "when" questions of how methylmercury is getting into fish and the rest of the food web.

One of the reasons for initiating the biosentinel monitoring program is to track the potential effects of wetland restoration projects on methylmercury exposure levels in the watershed. Certain wetland environments have been shown to provide ideal conditions for the production of methylmercury, often resulting in increased exposure and increased concentrations in fish. As large new wetland restorations are implemented in the Bay-Delta, the concern is that they may result in elevated exposure and increased fish concentrations, both locally and regionally. Biosentinel monitoring can provide quick and detailed feedback on how exposure levels may change in relation to these developments. It is an ideal tool to identify the management practices and natural processes that result in higher or lower levels of methylmercury uptake by fish.

The amount of mercury in adult sport fish (those caught for recreational or subsistence purposes) is a result of the methylmercury taken up throughout their multi-year lives and throughout the potentially varied locations they have lived. By virtue of the young age and small home ranges of certain small biosentinel species, the timing and location of their mercury exposure can be nearly pinpointed. Their absolute mercury concentrations are typically considerably lower than those of the larger, older sport fish, but they are well above analytical detection and it is the relative differences between similar samples from different sites and times that is key.

The FMP biosentinel monitoring is based on 20 years of methodological development and refinement in California by UC Davis scientists. Previous regional studies (including two funded by CBDA) have demonstrated that mercury levels in biosentinel organisms are closely linked to methylmercury concentrations in water (seasonally-averaged), as well as to mercury in sport fish. They provide a dynamic, fish-based, direct measure of exposure to the food web. They also represent mercury levels in the prey items of both sport fish and fish-eating wildlife.

A major focus of the FMP biosentinel monitoring is to track and provide feedback on the potential effects various wetland restoration projects may have on methylmercury exposure, both locally and regionally. Small biosentinel fish can provide information about the varying methylmercury exposure levels of adjacent wetland tracts or neighboring small tributaries. Other important uses of biosentinel monitoring are the identification of mercury sources in contaminated watersheds and the tracking of cleanup effectiveness at remediation sites such as abandoned mercury mines.

Because the biosentinels used are typically young-of-year fish, samples from one year to the next are, by definition, entirely different crops of fish, each exposed solely to conditions of the year sampled. They can thus provide quick and significant feedback if exposure conditions are changing from year to year. In addition to long term trends, biosentinels can also provide a measure of natural, year-to-year variability, which should be taken into account when assessing trends at restoration and remediation sites. Finally, the short life spans of these small, young fish cause them to also register exposure changes from one season to the next if they occur, potentially allowing us to determine if and when methylmercury exposure may change during the course of a year.

First Year FMP Biosentinel Monitoring

In contrast with the sport fish monitoring program, which mainly targets different areas of the watershed each year, the biosentinel monitoring primarily follows trends at the same sites and regions over time. The first major spatial sampling of biosentinels for the FMP was conducted in late summer through fall of 2005 at 49 sites distributed across the Bay-Delta watershed *(Figure 1)*. Most of these sites were linked to wetland restoration monitoring.

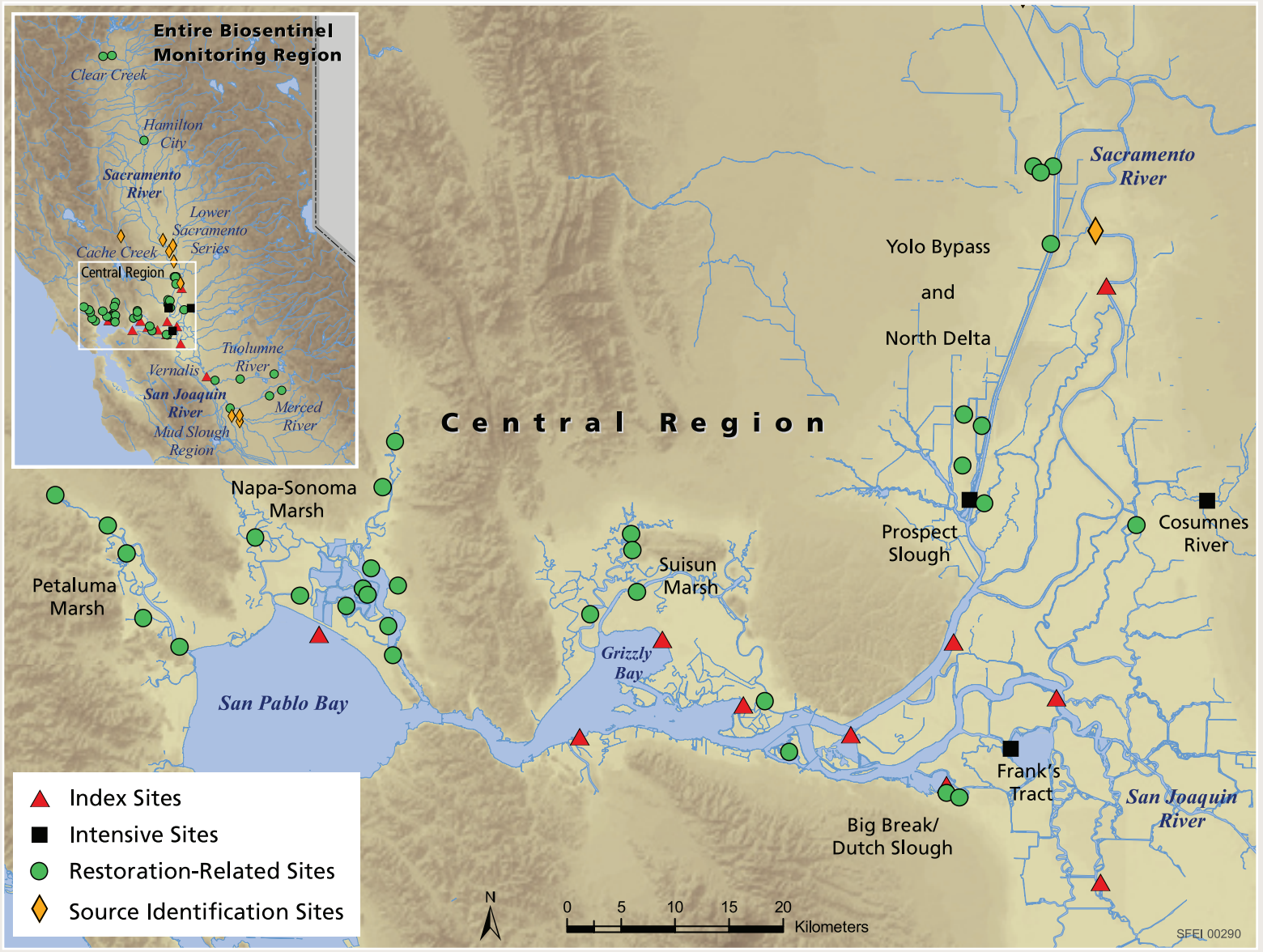


Figure 1

Biosentinel sampling locations, 2005-2007. *Approximately 50 sites are sampled each fall, with about 20 of these also tracked seasonally. The majority of sites are distributed in and around major wetland restoration areas.*

Fourteen of the sites were chosen as regional index locations. These were distributed across the central portion of the watershed, to provide a frame of reference for sites at and around major restoration areas. They include sites on the two main tributary rivers, the Sacramento and San Joaquin, and sites distributed across the Delta region and west to the North Bay. Three of the indexes were designated as "intensive" sites, where multiple species of fish and invertebrates are collected, to look at potential bioaccumulation relationships between and among species. The intensive sites span a range of mercury exposure conditions, from relatively low exposure in Frank's Tract, to moderate exposure in Prospect Slough downstream of the Yolo Bypass, to the Cosumnes River, a documented mercury hot spot in the watershed.

Monitoring also included sites in upstream, tributary portions of the CBDA management zone, including salmon habitat restoration areas on the Merced and Tuolumne Rivers and Clear Creek near Redding. These sites have potential mercury issues linked to former gold mine dredging that utilized mercury to varying degrees. Elevated mercury may still be present in the streamside gravels. Biosentinel monitoring in these areas was designed to identify problem areas as well as apparently clean reaches where local streamside gravels might be safely used in salmon habitat restoration. The main function, though, of the monitoring at these and other restoration and remediation sites, is to track relative methylmercury exposure over time. Cache Creek, a major cleanup target area in the watershed, was sampled in continuation of prior UC Davis biosentinel work in that drainage. Another set of tributary sites are distributed around Mud Slough (an identified methylmercury hot spot in the watershed) and the southern San Joaquin River.

The bulk of the sampling sites, however, are distributed in and around major planned or existing wetland restoration zones, most of which are found within the Bay-Delta proper. These include series of sites in and around the Yolo Bypass and North Delta flooded tracts, the Suisun Marsh, the Napa-Sonoma Marsh, and Big Break and the planned Dutch Slough restoration.

Because of the different types of aquatic habitat across the watershed, there are different fish species in some regions and different biosentinels must be used. We found prickly sculpin *(Cottus asper)* to be the most widespread and site-specific sentinel species in a number of the tributary regions, including the Clear Creek, Merced River, and Tuolumne River salmon restoration sites, together with a series of sites along the Sacramento River. In Coast Range streams of the historic mercury mining districts, California roach *(Hesperoleucus symmetricus)* and speckled dace *(Rhinichthys osculus)* are typically the most appropriate, available sentinels. However, throughout the main, central zone of the monitoring, the primary target species has been the Mississippi silverside *(Menidia audens)*, a species that was introduced from the Mississippi River drainage and has spread far and wide in the decades since. Silversides are present to varying degrees across much of the Delta, into the Bay, and in the lower reaches of the Sacramento and San Joaquin Rivers. They are frequently the most abundant prey fish species at the sites where they occur. They have proven to be excellent biosentinels, allowing us to compare nearly identical samples over time and across a large portion of the watershed. Secondary species are also collected as available, to provide backup evidence of apparent trends seen in the primary sentinels. In the silverside zone, secondary species include threadfin shad *(Dorosoma petenense)* and the small shrimp Palaemon macrodactylus. In a portion of the eastern and southern Delta where silversides and sculpin are scarce, juvenile largemouth bass *(Micropterus salmoides)* are used as a primary biosentinel species.

Biosentinel sampling is conducted by the UC Davis research team using a wide variety of techniques. In each sampling of a particular site, 30 similar individual fish are taken of the primary species, each to be analyzed individually for mercury ***(Figure 2)***. This makes for a large analytical load but gives strong statistical power to detect differences in mercury concentrations among locations and over time. Methods have been refined over many years to preserve the integrity of these fragile samples through all stages of the collection, preservation, processing, and analytical phases.

Mississippi silversides.
Photograph by Darrell Slotton.

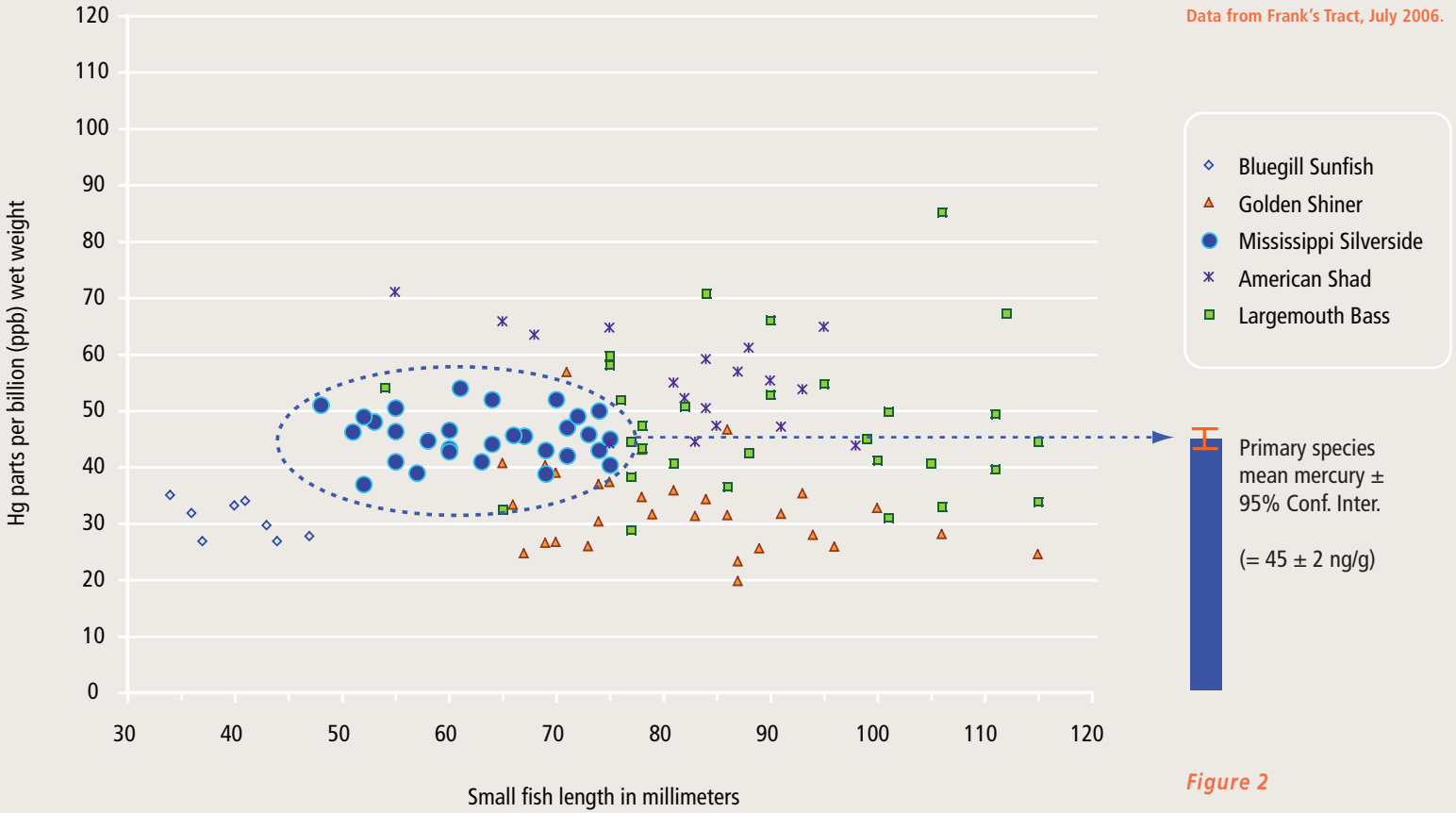


Figure 2

Multiple individual biosentinel sampling approach. *Mercury concentrations vs. small fish size from a single site-sampling event; primary species in large, blue symbols. Thirty very similar individuals of the primary species are collected and analyzed, leading to strong statistics for each collection that can be compared to other sites and times.*

Across the full range of watershed sampling sites, broad spatial trends were generally consistent with the patterns in exposure found in preliminary survey work we conducted in 1998-2000, as well as with sport fish monitoring and the Regional Board's water monitoring. As before, the highest sentinel fish mercury levels were typically found on the periphery of the Bay-Delta, with lower levels in the central and southern Delta. Some of the areas with the most notably elevated exposure levels included the Yolo Bypass, the Cosumnes River, and Mud Slough.

From a watershed management perspective though, it is the ability of the biosentinels to identify and provide feedback on finer scale exposure trends, both geographically and over time, that may be most useful. Following, in the rest of this article, we focus on several of the most important of these more localized and seasonal findings obtained in the first 15 months of the FMP biosentinel program.

Not All Wetlands Are Mercury Hot Spots: The Napa Marsh Story

The former salt ponds of the Napa Marsh are site of some of the most extensive wetland restoration activities in the watershed. CALFED constructed a 623 acre project at the base of the American Canyon on the east side of the Napa River. The California Department of Fish and Game manages the large former salt ponds on the west side of the river and in spring 2006 did extensive work reconfiguring the formerly isolated Ponds 4 and 5 of the complex (1731 acres) and opening them to tidal flows. They also added new tidal openings and reconfigured the large Pond 3 (1314 acres), which had been illegally breached several years earlier (2002) and is currently without vegetation. Another pond (2A, 561 acres) was opened to tidal flows 12 years ago and has evolved into a fully vegetated wetland, providing a local example of the conditions likely to develop over time in the new restoration projects. Additional restoration projects are planned. This region has received our most intensive biosentinel coverage to date.

The Fall 2005 silverside data, which were collected prior to the 2006 Califronia Department of Fish and Game salt pond projects, were somewhat surprising *(Figure 3)*. Fish samples from the central marsh region did not exhibit elevated concentrations relative to surrounding areas. Instead, they had statistically *lower* concentrations than matching fish from upstream on the Napa River or outside the marsh in San Pablo Bay. Furthermore, the fully vegetated Pond 2A was statistically lowest in silverside mercury of all the Napa Marsh sites.

Corresponding samples of near-identical silversides taken a year later in the fall of 2006 remained the same as those of 2005 at sites outside of the Napa Marsh, including the Napa River upstream in Napa and downstream at Highway 37, in San Pablo Bay, and in Black John Slough off the Petaluma River. Within the Napa Marsh itself, however, concentrations *dropped* relative to 2005. Silversides collected within the recently breached Pond 4/5 complex not only contained dramatically lower methylmercury than all other samples in the local region, they had the lowest mercury we have ever recorded for this species across the entire watershed, averaging 0.014 ppm. Statistically significant declines from 2005 levels were also seen at adjacent sites (China Slough, American Canyon wetlands, and Pond 2A), though at a more moderate concentration range of 0.028–0.038 ppm). These data indicate that the newly breached ponds are creating a net decline in methylmercury exposure.

Collecting fish with a beach seine at Frank's Tract.

Photograph by Darell Slotton.

Figure 3

North Bay 2005 and 2006 biosentinel mercury trends. *Silverside sampling found Napa-Sonoma Marsh (see Figure 1 for location) to contain lower fish mercury than adjacent aquatic habitats. Petaluma Marsh (see Figure 1 for location) was identified as a zone of elevated exposure, possibly linked to episodic flooding of the extensive high marsh found in that area.*

This may be related to the chemistry of the former salt pond sediments inhibiting the production of methylmercury and/or the subsequent bioaccumulation by aquatic organisms. It is not known whether this fascinating pattern will persist over the long-term. However, the continued lower fish mercury levels throughout the Napa Marsh, as compared to surrounding control sites, and low levels in the older, vegetated Pond 2A indicate that this large restoration zone may represent an important case where wetland environments may not result in a local or regional increase in methylmercury exposure to the aquatic food web.

Additional encouraging results were found in parts of the North Delta, where vegetated marsh habitat at Liberty Island and Little Holland Tract showed statistically lower biosentinel fish mercury than adjacent non-vegetated sites. Also, recent Sonoma Creek data indicate a low exposure environment in that part of the Napa-Sonoma Marsh. In contrast, 2006 sampling of the upper Petaluma River region indicated a high exposure environment, with biosentinel fish containing more than double the concentrations seen in the Napa-Sonoma Marsh and an order of magnitude higher than levels in the recently breached Napa Pond 4/5 complex. This was consistent with findings of elevated exposure in upland marsh habitats of the Petaluma watershed by San Francisco Estuary Institute, U.S. Geological Survey, and others.

The large differences in methylmercury exposure levels between these systems is remarkable. Ongoing research may identify the root causes. In any case, the biosentinel approach provides a valuable tool to monitor trends and provide important feedback to wetland managers, as they try to develop critical wildlife habitat without adding to the mercury problem. The North Bay data demonstrate how well these young fish can differentiate varying methylmercury exposure conditions between relatively nearby locations and habitats, as well as between years.

Dramatic Seasonal Trends Identified in 2006

Small, young-of-year, biosentinel fish can change their mercury concentrations significantly in just a matter of months if exposure conditions change. This allows us to investigate potential seasonal shifts in methylmercury exposure. Seasonal biosentinel studies were originally planned for the three intensive sites of Frank's Tract, Prospect Slough, and the Cosumnes River, which were known to span a range of exposure conditions. Because of the importance of major wetland/restoration regions in the biosentinel program, additional seasonal sites were added in the Yolo Bypass, Suisun Marsh, and Napa Marsh. These have been further supplemented by sites on the lower Sacramento and San Joaquin Rivers and several other sites. Sampling was conducted in February, May, July, and September 2006, in addition to the initial October/November 2005 collections. First year results document some significant seasonal trends. Data from representative sites are shown in *Figure 4*.

Frank's Tract, located in the center of the Delta, is representative of sites that showed little seasonal variation. A slight increase was noted in the spring and summer. In contrast, many of the sites located on the perimeter of the Bay-Delta exhibited large changes across the year, apparently related to the historically high flood flows of 2006. The Yolo Bypass site (Toe Drain) and downstream Prospect Slough are representative of sites that were exposed to early flooding in the form of winter rain runoff. The Bypass flooded deeply throughout the winter. Silverside mercury levels at these sites jumped up by 60-90% between November and February, with later month-classes of quickly growing fish showing concentrations back to near pre-flood levels by summer. In contrast, sites like the San Joaquin and Cosumnes Rivers that received flood flows later in the year in conjunction with spring snowmelt showed little change between November and February collections. However, extreme (400-500%) increases in small fish mercury were found at these two sites by July, with subsequent month-classes of silversides exhibiting concentrations that declined to near-baseline levels. Concentrations in 45-75 mm (2-3 inch) silversides reached levels averaging 0.243 ppm at Vernalis and an astounding 0.869 ppm in the Cosumnes River, with individual fish as high as 2.000 ppm. These were concentrations that should be of serious concern, particularly in relation to wildlife exposure.

The flooding-related increases in exposure measured with the biosentinels closely corresponded to water studies by the Central Valley Regional Water Quality Control Board, which found elevated concentrations of methylmercury in water at some of the same locations and dates. **What these sites had in common was *episodic flooding* of normally dry valley soils.** Whether this is a typical phenomenon or one linked primarily to very high flooding years may be determined with ongoing monitoring. However, this same pattern has also been observed at other intensively studied sites in the U.S. and Canada.

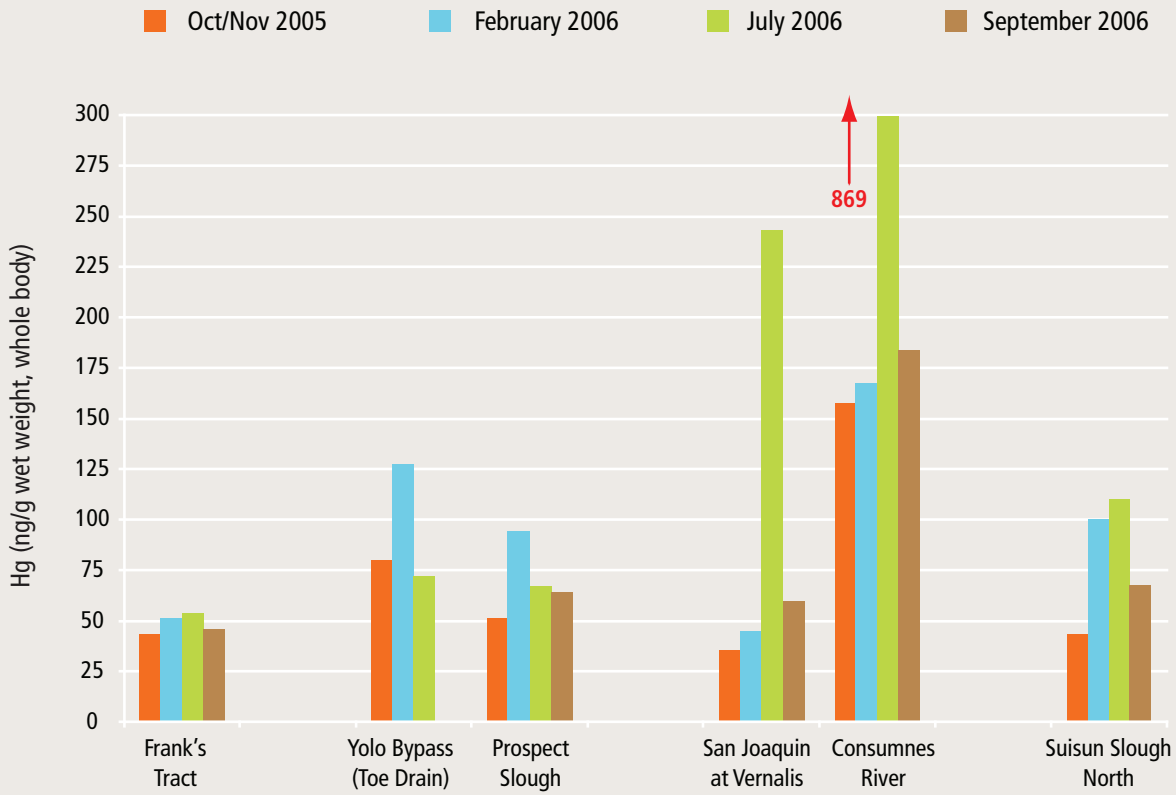


Figure 4

Strong seasonal trends seen in 2006, apparently linked to flooding events. *Several representative patterns include: lack of any major trend at sites like Frank's Tract; winter spikes in exposure linked to winter rain run-off flooding (Yolo Bypass, Prospect Slough); spring-summer spikes linked to later, snowmelt-based flooding (San Joaquin and Cosumnes Rivers); and extended spikes at Suisun Marsh linked to a combination of managed and natural flooding.*

Data from the Suisun Marsh region showed a unique seasonal pattern, in that they demonstrated significant increases (>100%) through both the winter and spring, while the region has no substantial river inflows and thus would not be expected to experience notable episodic flooding related to the high water year. In actuality, though, Cal. Fish and Game personnel report that a combination of very high flows in incoming drainage canals and elevated tide levels from the general upstream flooding led to the failure of a number of levees, resulted in a substantial area of additional flooding in the Suisun Marsh.

The hypothesis that episodic flooding can lead to higher methylmercury in fish was further supported in the Suisun Marsh region, where man-made seasonal flooding is a routine part of wetland management. The Suisun index (channel) sites were found to exhibit sharp increases in biosentinel mercury as early as December, prior to any significant rainfall or associated natural flooding. These increases were consistent with water data collected by Moss Landing Marine Lab, which indicated elevated methylmercury in water draining from seasonally-flooded, managed ponds. The biosentinel data indicate that this source may be linked to seasonally elevated exposure to fish in the region.

Inter-annual Trends: Identification of a Fall 2006 Hot Spot: Suisun Marsh

A second annual sampling over a broad geographical area of the watershed was conducted in November 2006, again at approximately 50 sites that mostly overlapped with those from 2005. The annual fall samplings let us look at potential trends from year to year across the watershed, using young fish that experienced all of their mercury exposure and uptake in the year they were sampled.

A number of sites across the watershed had somewhat elevated biosentinel fish mercury in fall 2006 as compared to 2005, particularly those at and near regions that experienced the earlier flooding-related increases. Other sites were statistically unchanged between the two years. The most notable inter-annual changes (other than the declining exposure phenomenon in Napa Marsh) were seen in the Suisun Marsh region *(Figure 5)*, with 2006 silverside concentrations increasing to more than two times higher than in near-identical samples from 2005, for example Montezuma Slough sites, averaging 0.120-0.132 ppm in 2006 as compared to 0.033-0.053 ppm in 2005. Interestingly, the elevated mercury levels were confined to the marsh area, with adjacent index sites statistically unchanged from 2005. The precise causes of this apparent fall 2006 methylmercury hot spot are unclear at this time, but the biosentinel data clearly identify the phenomenon. Potential causes may be related to changes in pond management, if that occurred, or residual effects from the 2006 local flooding. It may have been partially linked to general flood flows across the watershed, potentially depositing fresh, relatively bioavailable inorganic mercury that could be readily converted to methylmercury. The 2006 anomaly could also be related to the location of the Suisun Marsh in the portion of the Estuary where a transition from freshwater to saline (salt) conditions occurs.

In the first 15 months of the Fish Mercury Project, UC Davis biosentinel monitoring has identified broad and fine-scale geographic trends in methylmercury exposure to fish, seasonal spikes in exposure, and trends between years. In 2007, we will further explore the seasonality of fish methylmercury exposure with collections at over 20 sites during the various seasons of this much reduced flood year, as compared to 2006. Final collections of biosentinel fish samples from approximately 50 locations across the watershed will be conducted in November 2007. Given the success of the biosentinel monitoring in identifying trends that will help inform managers on how to manage wetlands and habitats more effectively for mercury, it is hoped that these efforts will be supported into the future.

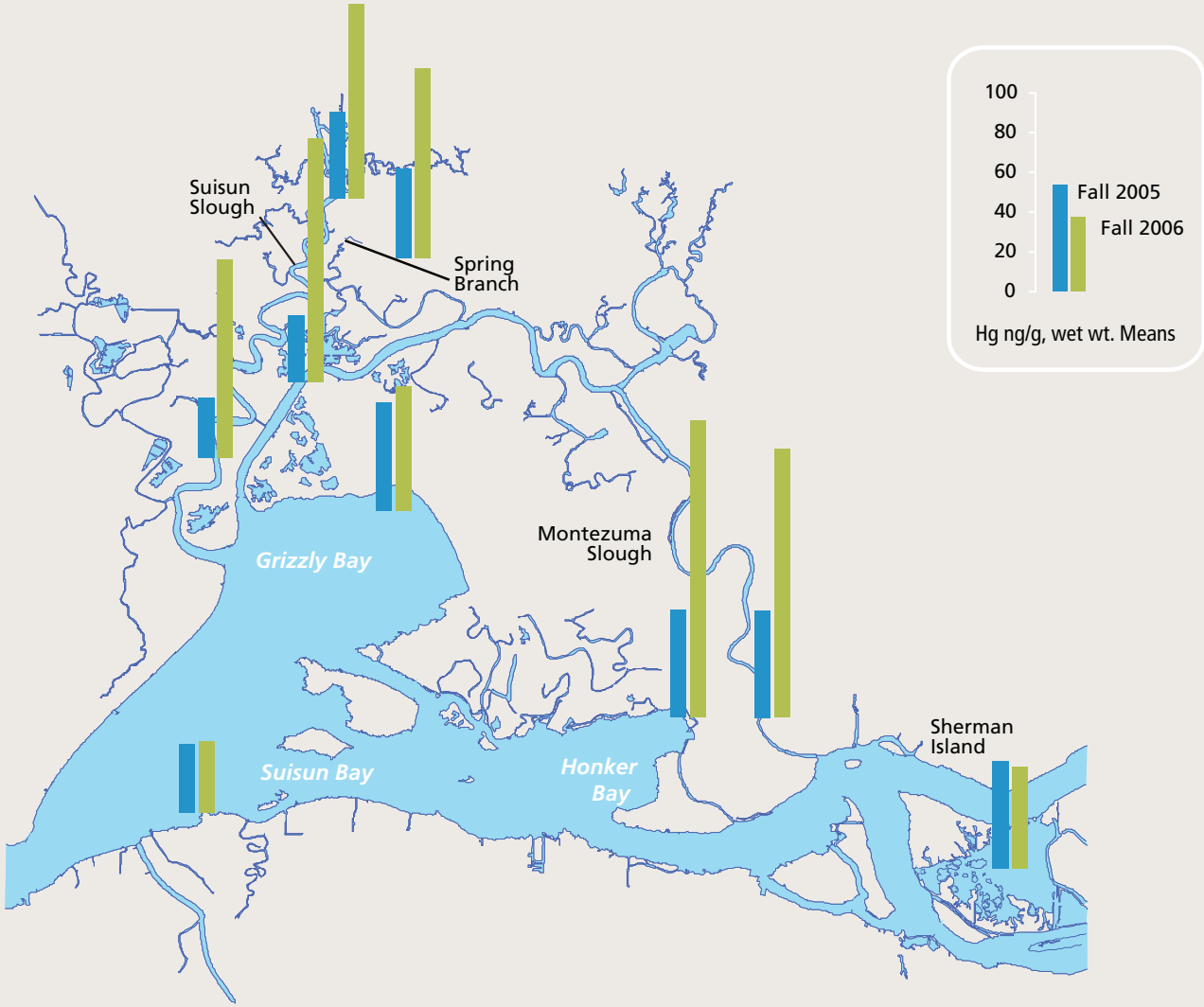
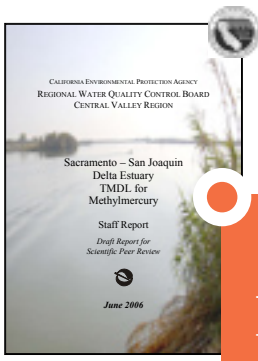


Figure 5

Suisun Marsh identified as a Fall 2006 watershed "hot spot". *Year-on-year sampling found large increases in small fish mercury in Suisun Marsh (see Figure 1 for location) in 2006, while control sites outside the marsh remained unchanged from 2005. Possible causes are under investigation.*



The Sacramento-San Joaquin Delta Methylmercury TMDL

The Federal Clean Water Act requires states to identify waters that do not meet legal water quality standards because of the presence of one or more contaminants. Water quality standards are established to protect the uses of a water body, such as fishing, swimming, drinking, and supporting wildlife habitat. In order to address contaminant problems, states are also required to establish a "Total Maximum Daily Load" (TMDL) for each impaired water body.

A TMDL represents the maximum amount, or "load" (usually expressed as a rate, such as kilograms per day) of a pollutant that a particular water body can receive and still meet water quality standards. A TMDL control program describes how much a pollutant must be reduced in order to meet water quality standards and requires specific reductions in the amounts that various sources of the contaminant can release into the watershed. A TMDL addresses nonpoint (such as runoff and agriculture) as well as point sources (such as wastewater treatment) of a pollutant.

In 1990, the State Water Resources Control Board identified the Sacramento-San Joaquin River Delta waterways as impaired for mercury because of the existence of a fish consumption advisory. The Central Valley Water Board is developing a TMDL and implementation plan to address mercury in the Delta. A central goal will be to reduce the amount of methylmercury (the form of mercury that accumulates in living organisms) in the watershed's fish, which people and wildlife catch and eat. A draft technical TMDL report containing an analysis of the sources of both methylmercury and total mercury, proposed numeric targets in fish tissue, and analysis of the statistically significant linkage between methylmercury concentrations in water and fish, was released in June 2006.

The Central Valley Water Board will adopt the Delta Methylmercury TMDL as an amendment to the primary water quality planning document for the Central Valley, termed the "Basin Plan". Amending the Basin Plan occurs in a structured process that involves public participation (at workshops, and through written comments and testimony at public hearings), independent scientific review, and State environmental review. A public hearing on the Delta Methylmercury Basin Plan Amendment is expected in Summer 2007. The proposed implementation plan calls for a study period to better characterize methylmercury loads from specific sources and to test management practices to reduce the amount of both methylmercury and total mercury entering the Delta.

Documents related to the Delta Methylmercury TMDL program, including the draft TMDL Report, latest draft of proposed Basin Plan Amendment language, scientific peer reviews, and stakeholder comments, are available on the Central Valley Water Board Delta Methylmercury TMDL Program website (http://www.waterboards.ca.gov/centralvalley/programs/tmdl/deltahg.html). Interested persons may subscribe to an email list for notification of events and documents related to the Delta mercury program by going to the Central Valley Water Board's homepage (http://www.waterboards.ca.gov/centralvalley/), clicking on the button for "Email list-subscribe" located on the right side of the page, and subscribing to the email list of choice.

Contact:
Janis Cooke, Central Valley Water Board, jcooke@waterboards.ca.gov.

Risk Reduction: Going Beyond Consumption Advice

While it will take many decades to bring waters impaired by mercury and other bioaccumulative contaminants back to safe levels for high rates of fish consumption, communities of color and low-income communities with a prevalence of subsistence fishing are at risk of serious health impacts, especially among their children. While fish advisories and educational outreach on eating and cooking practices can help anglers make consumption decisions, they are limited in protecting public health. Information about eating and cooking practices can send mixed messages because different contaminants collect in different parts of a fish. In addition, many anglers may be forced to ignore guidelines and warnings because of the greater need to put food on the table. As a result, a number of public advocates have called for the development of risk reduction strategies that go beyond public communication and address the actual physical dangers to subsistence fishing communities as part of regional clean up plans or TMDLs. They have also suggested that the discharger community participate in facilitating a community-oriented process by which such strategies can be developed and sustained.

In 2005, the State Water Resources Control Board issued Resolution 2005-0060. In it, the State Board mandated that both the San Francisco Bay Area and the Central Valley Regional Boards, in developing mercury TMDLs in the Bay and Delta, "investigate ways, consistent with their regulatory authority, to address public health impacts of mercury in San Francisco Bay/Delta fish, including activities that ***reduce actual and potential exposure of and mitigate health impacts*** to those people and communities most likely to be affected by mercury in San Francisco Bay-Delta caught fish, such as subsistence fishers and their families". (Resolved Number 10, http://www.waterboards.ca.gov/resdec/resltn/2005/rs2005-0060.pdf, emphasis added) .

This mandate sets the stage for breaking new ground in protecting impacted communities in the Delta region by going beyond communication and developing risk or exposure reduction strategies. The goal is to actually reduce subsistence fishers' exposure to contaminants from the Delta. Objectives can include reducing dependence on contaminated fish, ensuring access to healthy food choices, and developing medical and other services to mitigate impacts from exposure.

No one, including those who have advocated for such a risk reduction mandate, believes this will be an easy task. One thing is clear; community input will be essential to create strategies fitting the particular needs of the regions' diverse populations. While a process to create a community-driven risk reduction program has yet to be established, participation in the Fish Mercury Project and the Local Stakeholder Advisory Group has lead to discussions between groups like Clean Water Fund, the California Indian Environmental Alliance, People for Children's Health and the Environment, and Regional Board and DHS staff on how to proceed. It is their hope to take some first steps in meeting the State Board's mandate by bringing together key stakeholders and experts to focus on how best to create a process by which a sustainable risk reduction program can be developed for the Delta region.

Contact:
Andria Ventura, Clean Water Action, aventura@cleanwater.org.

References

Davis

Alpers, Charles N., Michael P. Hunerlach, Jason T. May, and Roger L. Hothem. 2005. Mercury Contamination from Historical Gold Mining in California. Fact Sheet 2005-3014 Version 1.1, Revised October 2005. U.S. Geological Survey, Sacramento, CA. http://ca.water.usgs.gov/mercury/fs06100.html

Davis, J.A., J. L. Grenier, A.R. Melwani, S. Bezalel, E. Letteney, and E. Zhang. 2007 (in press). Bioaccumulation of pollutants in California waters: A review of historic data and assessment of impacts on fishing and aquatic life. Surface Water Ambient Monitoring Program, State Water Resources Control Board, Sacramento, CA.

SFEI. 2001. San Francisco Bay seafood consumption study. San Francisco Estuary Institute, Oakland, CA. 291 pages. http://www.sfei.org/rmp/sfcindex.htm

Wiener, J.G., C.C. Gilmour, and D.P. Krabbenhoft. 2003. Mercury strategy for the Bay-Delta ecosystem: unifying framework for science, adaptive management, and ecological restoration. CALFED Bay-Delta Mercury Project, Sacramento, CA. http://www.science.calwater.ca.gov/pdf/MercuryStrategyFinalReport.pdf

Wiener, J.G., R.A. Bodaly, Steven S. Brown, Marc Lucotte, Michael C. Newman, Donald B. Porcella, Robin J. Reash, and Edward B. Swain. 2007. Monitoring and

Evaluating Trends in Methylmercury Accumulation in Aquatic Biota. Pages 87-122 in Reed Harris, David P. Krabbenhoft, Robert Mason, Michael W. Murray, Robin Reash, Tamara Saltman (eds.). Ecosystem Responses to Mercury Contamination: Indicators of Change. CRC Press, Boca Raton, FL.

Gassel

Gassel, Margy, Robert K. Brodberg, Susan Klasing, Sue Roberts. 2007. Draft Safe Eating Guidelines for Fish and Shellfish from the San Joaquin River and South Delta (Contra Costa, San Joaquin, Stanislaus, Merced, Madera, and Fresno Counties). California Office of Environmental Health Hazard Assessment, Sacramento, CA. http://www.oehha.ca.gov/fish/so_cal/sjrsd030907.html

The 2006 FMP Annual Meeting. Photograph by Jay Davis.

Credits and Acknowledgments

Report Editors Andria Ventura, Jay Davis

Project Management Jennifer Hunt

Design & Layout Linda Wanczyk

Information Graphics Linda Wanczyk, Joanne Cabling

Printing Alonzo Printing, www.alonzoprinting.com

The Paper
Reincarnation™ is the most environmentally friendly matte coated paper stock in the world and is made from 100% recycled content, 50% Post-Consumer Waste, and processed entirely without chlorine.

The Ink
Soy-based ink made from soybeans. Soy ink is removed more easily than regular ink during the de-inking process of recycling and the waste that generated is not hazardous and can be treated easily.

Contributions to the FMP

SFEI Staff
Josh Collins, Mike Connor, Nicole David, Todd Featherston, Ben Greenfield, Cristina Grosso, Rainer Hoenicke, Frank Leung, Lawrence Leung, Sarah Lowe, John Oram, Irene Poche, Linda Russio, Stephanie Seto, Predrag Stevanovic, Meredith Williams, Don Yee, Eric Zhang

Thanks to the FMP Peer Review Panel for extremely valuable guidance on this document and all FMP Products:

Barbara Knuth, Chair

Jim Wiener

Drew Bodaly

Tom Grieb

Patricia McCann

Funding provided by the CALFED Ecosystem Restoration Program, grant #ERP-02D-P67. The investigators acknowledge the state of California, CALFED, the Resources Agency, the California Bay-Delta Authority, the California Department of Fish and Game, the California Department of Water Resources, and all of CALFED's cost sharing partners, and thank Carol Atkins, Donna Podger, Mary Menconi, and Leann Androvich for project support.

San Francisco Estuary Institute • www.sfei.org • 7770 Pardee Lane, Oakland, CA 94621 • p: 510-746-SFEI (7334) • f: 510-746-7300

What Can I Do?

Get Involved! There are many ways that each of us, as individuals, can work towards reducing exposure to toxic chemicals. Here are some ideas on how we all can make a difference.

1

Educate yourself on fish contamination issues and share the information with others.

Important websites include:

- **Safe Eating Guidelines**
  www.oehha.ca.gov/fish.html
- **Sport Fishing Regulations**
  www.dfg.ca.gov/regulations/index.html
- **Fish Mercury Project**
  www.sfei.org/cmr/fishmercury
- **California Department of Public Health Fish Information**
  www.ehib.org/topic.jsp?topic_key=8
- **USEPA/FDA Advisory Information**
  www.epa.gov/waterscience/fish/
- **Environmental Justice**
  www.calepa.ca.gov/EnvJustice/

2

Participate in development of clean-up plans for mercury and other toxic chemicals. Express your views on fish contamination, clean-up efforts, education and outreach, and risk reduction to the Water Boards.

- **San Francisco Bay**
  www.waterboards.ca.gov/sanfranciscobay/TMDL/tmdlpublicparticipation.htm
- **Central Valley**
  www.waterboards.ca.gov/centralvalley/water_issues/tmdl/public_participation/index.html

3

Express your views to your legislators on fish contamination, clean up efforts, education and outreach, and risk reduction. Find your legislators' contact information at:

www.leginfo.ca.gov/yourleg.html

4 Join a civic group and work with local community members to reduce the amount of toxic chemicals in your community.

- **Clean Water Action**
  A non-profit advocacy group that works to improve water quality and reduce the amount of toxic chemicals in our water
  www.cleanwateraction.org/ca/

- **Save the Bay**
  A non profit membership organization working to improve the quality of San Francisco Bay and the Delta
  www.savesfbay.org

- **Baykeeper/Deltakeeper**
  Get involved in citizen monitoring
  www.baykeeper.org

5 Dispose of mercury-containing products properly

- **Compact Fluorescent Light Bulbs (CFLs)**
  The following locations accept fluorescent bulbs for either recycling or proper waste disposal:

  - **Alameda County**
    www.stopwaste.org. Their Recycling Hotline is (877)-STOPWASTE. Also Ikea in Emeryville accepts the bulbs

  - **Contra Costa County**
    - Some Longs Drugs, Rite Aid Drugs and Radio Shack stores accept CFLs.
    - Central Contra Costa HHW Collection Program - Martinez
      1-800-646-1431 or www.centralsan.org/
    - West County Resource Recovery - Richmond
      1-888-412-9277 or www.recyclemore.org/

  - **Sacramento County**
    www.sacgreenteam.com/about.htm

  - **Solano County**
    www.recycle-guide.com/index.cfm?page=recycling&id=10&cat=4 or call 1-800-CLEANUP. Vallejo Garbage Service also accepts CFLs

  - **West Delta**
    Delta Household Hazardous Waste Collection Facility - Antioch
    (925) 756-1990

- **Mercuric oxide button batteries**
  (found in hearing aids, pagers, watches, cameras)

  - **Alameda County Household Waste** (see above)
  - **Solano County NiCad Battery Drop-Off Locations** you can call 1-800-CLEANUP or 1-800-8-BATTERY (Charge up to Recycle)
  - **West Contra Costa County**
    Many ACE, Longs and Walgreens stores accept batteries. A full list is at www.recyclemore.com/article_subpage.asp?subpagekey=445

- **More information** on products containing mercury available at www.epa.gov/epr/products/mercury.htm and www.dtsc.ca.gov/HazardousWaste/Mercury/

www.sfei.org

printed on recycled paper