

PROJECT TITLE A Pilot Program for Monitoring, Stakeholder Involvement, and Risk Communication Relating to Mercury in Fish in the Bay-Delta Watershed (“the Fish Mercury Project”) - CBDA Project # ERP 02D-P67

PRINCIPAL INVESTIGATORS AND KEY PROJECT PERSONNEL

Jay Davis, Jennifer Hunt, and Letitia Grenier: San Francisco Estuary Institute
Darell Slotton and Shaun Ayers: University of California Davis
Robert Brodberg and Margy Gassel: California Office of Environmental Health Hazard Assessment
Mark Stephenson and Gary Ichikawa: California Department of Fish and Game
Alyce Ujihara, May Lynn Tan, Jessica Kaslow, and Elana Silver, : California Department of Health Services

INTRODUCTION TO THE PROJECT

The Fish Mercury Project (FMP) is a multifaceted three-year project that is examining mercury in fish in the Bay-Delta watershed (Figure 1) and increasing public awareness of fish contamination issues, with the overall goal of reducing mercury exposure in humans and wildlife. The Project is closely following the recommendations of CBDA’s “Mercury Strategy” (Wiener et al. 2003) relating to monitoring mercury in the watershed in support of adaptive management.

Oversight for this project is provided by a Peer Review Panel (PRP) and a Steering Committee (SC). The Steering Committee is a multidisciplinary, multi-institutional participatory group with members from government agencies, scientific and academic institutions, community-based organizations, and other groups with interests in ecosystem health, environmental management, environmental justice, and public health. The Peer Review Panel consists of five experts in fish mercury monitoring, advisory development, and risk communication on fish contamination issues. The PRP has been providing input in-person at the FMP Annual Meetings and via email as needed throughout the year. These groups developed the goals and objectives for the Project (Appendix, Table 1).

The FMP has completed two annual rounds of sampling, and is conducting the third and final round this year. Stakeholder involvement, development of safe eating guidelines, and risk communication activities have proceeded in concert with the fish monitoring.

PROJECT TIMETABLE AND PROGRESS

Starting Date November 2004

Target Completion Date August 14, 2008

Project Status

Is the Project on schedule? The Project has completed tasks on schedule. Currently, planning is underway for the third round of sport fish sampling to be conducted this summer. Biosentinel sampling is being conducted throughout the year. A nontechnical report on the Project is in preparation that will be used in communicating Project findings and activities to a broad audience. We are also working on development of the largemouth bass bioenergetics/mechanistic model. We expect to have a first draft by October 2007. EHIB/IAI will be holding a second forum on education and outreach activities in October 2007. The Sacramento River/North Delta fish consumption advisory will be completed by OEHHA in January 2008. Sampling will be completed by December 2007 and final reports for the Project will be completed by July 2008.

Project Milestones Achieved

- Steering Committee formed and quarterly (approximately) meetings held
- Assembled peer review panel and annual meetings held
- Local Stakeholder Advisory Group (LSAG) formed and quarterly meetings held
- Project web site established: <http://www.sfei.org/cmr/fishmercury/>
- Peer-reviewed goals and objectives established
- Peer reviewed sampling plans for 2005 and 2006 completed
- QAPP materials developed
- Participation in CalFed Intercomparison QA studies
- Sport fish and biosentinel sampling completed in 2005 and 2006
- Annual reports for two CBDA Mercury Workshops prepared
- Two FMP Annual Meetings convened
- Two years of mini-grants provided for risk communication by local community based organizations
- Public Forum on the Public Health Impact of Fish Contamination held in 2005
- Technical report on 2005 sport fish sampling completed
- Technical report on 2005 biosentinel sampling completed
- Technical report drafted: "The Relationship between Landscape Features and Sport Fish Mercury in the Sacramento-San Joaquin Delta Watershed"
- Technical report drafted (in collaboration with the SWAMP): "Bioaccumulation of pollutants in California waters: a review of historic data and assessment of impacts on fishing and aquatic life"
- Draft Report: Safe Eating Guidelines for the South Delta and San Joaquin River completed
- Many presentations and posters at conferences: International Conference on Mercury as a Global Pollutant 2006, CALFED Science Conference, National Water Quality Monitoring Conference, International Conference on Rivers and Civilization

PROJECT HIGHLIGHTS AND RESULTS

GENERAL HIGHLIGHTS

- **A novel aspect of the FMP is that the goals and objectives explicitly incorporate “environmental justice principles.”** Environmental justice is a high priority among water quality and resource management agencies. Sport fish monitoring is a topic that is strongly associated with environmental justice concerns. Inclusion of community-based organizations (CBOs) as stakeholders is a fundamental requirement for incorporating environmental justice principles.
- **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; this approach is described as “integrated monitoring”.** Integrated monitoring is a cycle that begins and ends with the stakeholders. 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 (primarily DHS in the FMP) work with stakeholders to build their capacity to communicate the advice emanating from the monitoring program back to their communities.
- **The FMP is breaking new ground by conducting biosentinel monitoring at a spatial scale that is unprecedented in California in order to establish a foundation for evaluating the effects of habitat restoration on mercury in aquatic food webs.** (see below for more detail)

SPORT FISH MONITORING

- **The Fish Mercury Project is conducting the most extensive survey ever of mercury in sport fish in the Central Valley.** In 2005 the FMP collected over 2000 sport fish from 22 species and 69 popular fishing locations in the Bay-Delta watershed. 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.
- **Some species of fish are high in mercury, while others are low in mercury.** Overall, largemouth bass and pikeminnow were the most contaminated of the target species, followed in decreasing order by carp, sucker, channel catfish, black crappie, white catfish, bluegill, and redear sunfish (Figure 1).

- **Some fishing locations are high in mercury, while others are low in mercury.** Mercury concentrations were higher in the Sacramento and San Joaquin Rivers and their tributaries and lower in the Delta (Figure 2). 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, and the Cosumnes River. This region corresponds to the area where intensive gold mining occurred in the Sierra Nevada.

DEVELOPMENT OF SAFE EATING GUIDELINES

- **OEHHA is developing Safe Eating Guidelines that will help fish consumers reduce the risks and get the benefits from eating fish.** OEHHA has developed a draft report – “Health Advisory: Draft Safe Eating Guidelines for Fish and Shellfish from the San Joaquin River and South Delta (Contra Cost, San Joaquin, Stanislaus, Merced, Madera, and Fresno Counties).” Guidelines for the North Delta and Sacramento River will be drafted later this year.
- **All of the popular fish species caught in the South Delta can be eaten regularly at the amounts recommended in the OEHHA Safe Eating Guidelines.** 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.
- **However, black 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 these species 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 there are safer fish to eat that can provide benefits without much risk.

RISK COMMUNICATION

- **Risk communication needs assessments in 21 counties have obtained information on fishing activity to guide FMP sampling and levels of concern about fish contamination, and provided opportunities to share information generated in the FMP with local agencies.** 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 Fish Mercury Project activities.
- **Discussions in eleven focus groups with a total of 117 anglers from Lao, Cambodian, Hmong, Vietnamese, Latino, Russian, African American, and Native American communities have indicated popular species, consumption practices, and the effectiveness of different forms of risk communication.** Striped bass, catfish, bluegill, and crappie emerged as the most commonly consumed fish

caught in the Delta. 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; and most participants reported consuming their catch. Very few anglers indicated that fishing was an important source of food for them. 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. 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.

- **A major effort guided by the LSAG led to signs being posted in about 60 locations throughout the five Delta counties.** Seven languages were included on the sign--Spanish, Russian, Chinese, Vietnamese, Cambodian, Lao, and Hmong. All seven translations were field tested with community members. Posting and maintenance of the sign have been done by many different groups, including county health departments, community groups, marina operators, the University of California Cooperative Extension, and private landowners.
- **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.** Wording and images in DHS materials are field-tested within the intended audiences during and after their creation.
- **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.** The curriculum contains five modules, each with learning objectives and interactive activities to utilize in a group setting.
- **A FMP program providing small grants to community-based organizations is fostering the development of innovative educational activities, outreach programs, and media.** In January 2006, five organizations working in the Delta were awarded mini-grants. In seven groups were selected to receive grants ranging from \$6,000 - \$10,000, and their projects will continue through the end of 2007.

BIOSENTINEL MONITORING

- **The FMP Biosentinel Program is the largest application of small fish monitoring as a mercury exposure feedback tool ever conducted in California.** First year monitoring included the collection and analysis of over 4000 individual, carefully selected small fish from 50 sites across the watershed, distributed particularly in relation to large wetland restoration areas. A subset of the sites is additionally being sampled seasonally.
- **Some wetlands were found to have lower methylmercury exposure than adjacent non-vegetated habitats,** including the Napa Marsh (Figure 3) and parts of the North Delta. This positive finding suggests that not all wetlands may promote mercury problems. Biosentinel fish were confirmed to differentiate exposure differences on a fine scale.
- **Significant seasonal trends were found in some areas,** with dramatic spikes in small fish mercury linked primarily to episodic flooding of normally dry soils (Figure

4). The effect was accentuated by the presence of mercury loading sources and the timing of flooding in the warmer spring-fall period. Episodic flooding included rivers topping their banks in floodplains and bypasses (San Joaquin, Cosumnes, Yolo Bypass), seasonally flooded managed ponds (Suisun Marsh), and possibly some high tidal wetlands that are inundated only occasionally (Petaluma Marsh).

- **Inter-annual sampling identified the Suisun Marsh region as a 2006 hot spot as compared to 2005** (Figure 5). Young-of-year fish used in biosentinel work are an entirely new crop of fish each year, exposed only to that year's exposure conditions and providing a quick feedback tool for management. The possible causes of the 2006 Suisun elevation are still under investigation.

POTENTIAL MANAGEMENT IMPLICATIONS OF FINDINGS TO DATE

- Active stakeholder involvement is essential to addressing environmental justice in human health-oriented environmental monitoring projects, and is extremely valuable in program design and in risk communication.
- Sport fish and biosentinel monitoring are essential performance measures for projects that have the potential to influence methylmercury bioaccumulation at a local or regional scale.
- While some sport fish in some locations have methylmercury concentrations that pose potential risks to humans and wildlife, concentrations in other species and locations are low enough that people can still enjoy the benefits of fishing and fish consumption.
- Methylmercury concentrations in certain sport fish in the San Joaquin River south of the Port of Stockton pose potential risks to consumers. Reducing sources of food web methylmercury in this region should be a priority for water quality managers.
- Some affected communities are not receiving information about the risks associated with consuming contaminated fish. More effective communication of risk information to all affected communities is needed. Community-based organizations can be very effective in communicating this information.
- In contrast to the general pattern observed in other parts of the country, in some cases Bay-Delta wetlands and wetland restoration projects have relatively low concentrations of methylmercury in their food webs. This is a new finding, so the mechanisms behind it are not yet understood. Identifying which wetlands have high food web mercury and which ones have low food web mercury and then identifying the mechanisms behind these patterns may provide restoration managers with approaches that allow restoration to proceed while minimizing increases in methylmercury exposure to humans and wildlife.
- Episodic flooding of normally dry soils appears to be a cause of increases in food web mercury in nearby aquatic ecosystems. If this pattern is confirmed, restoration managers should attempt to avoid designs with this feature.
- Regions with elevated mercury identified in the sport fish sampling include the Feather River, the Sacramento River, the American River, the Cosumnes and Mokelumne Rivers, and the San Joaquin River south of the Delta. Understanding and reducing sources of food web methylmercury in these regions should be a priority for water quality managers.

- Regions with elevated mercury identified in the biosentinel sampling include the Petaluma River, Suisun Marsh, Yolo Bypass, Cosumnes River, Mud Slough and, seasonally last year, the San Joaquin River. Understanding and reducing sources of food web methylmercury in these regions should be a priority for water quality managers.

Figure 1. Mercury concentrations in four species of sport fish. Quadrants represent individual species and colors correlate with mercury concentration ranges indicated in the legend. Size limits were applied.

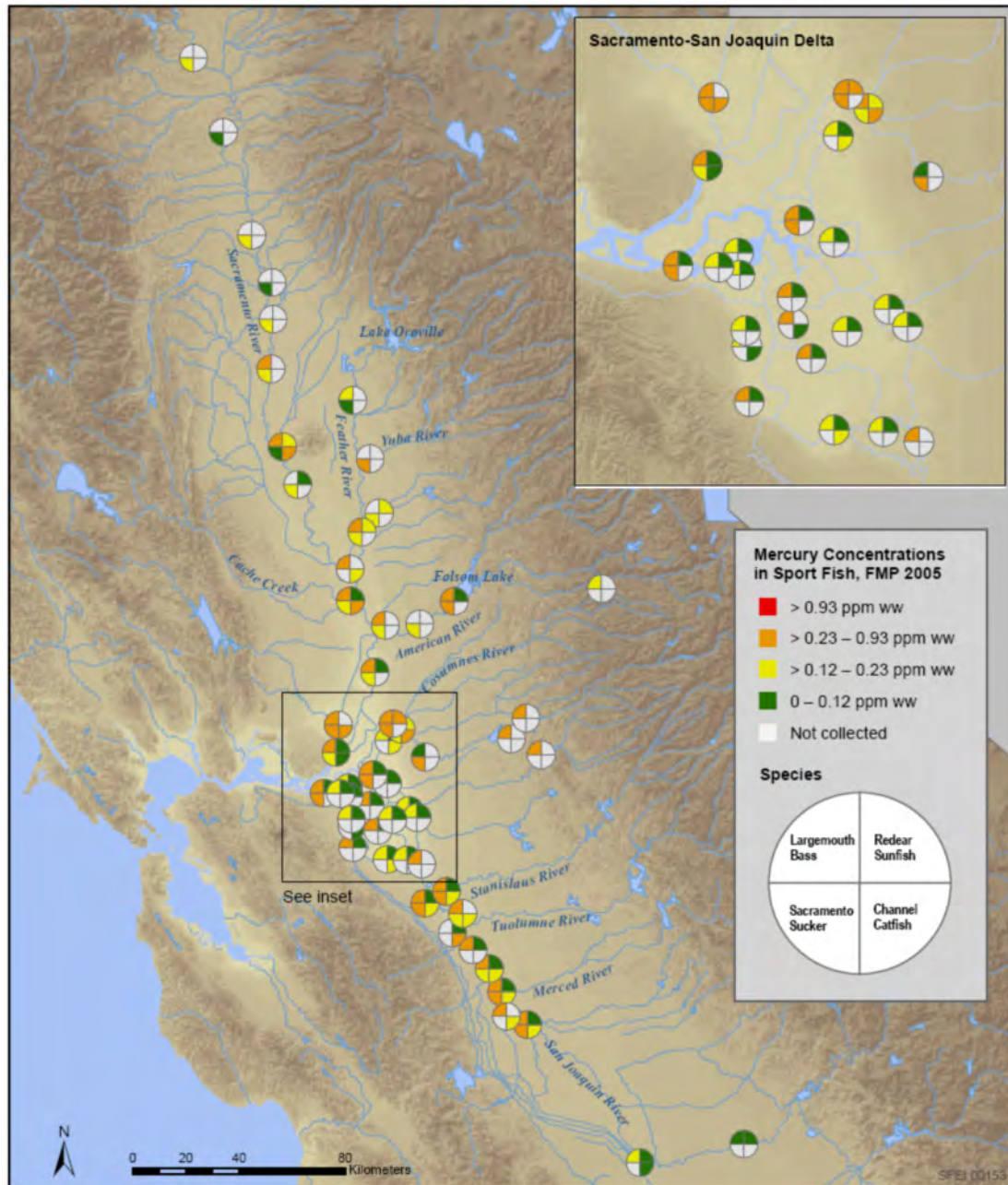


Figure 2. Spatial comparison of largemouth bass mercury concentrations estimated at standard length of 350 mm (mean and 95% confidence interval). Locations are listed in geographic order from north (top) to south (bottom).

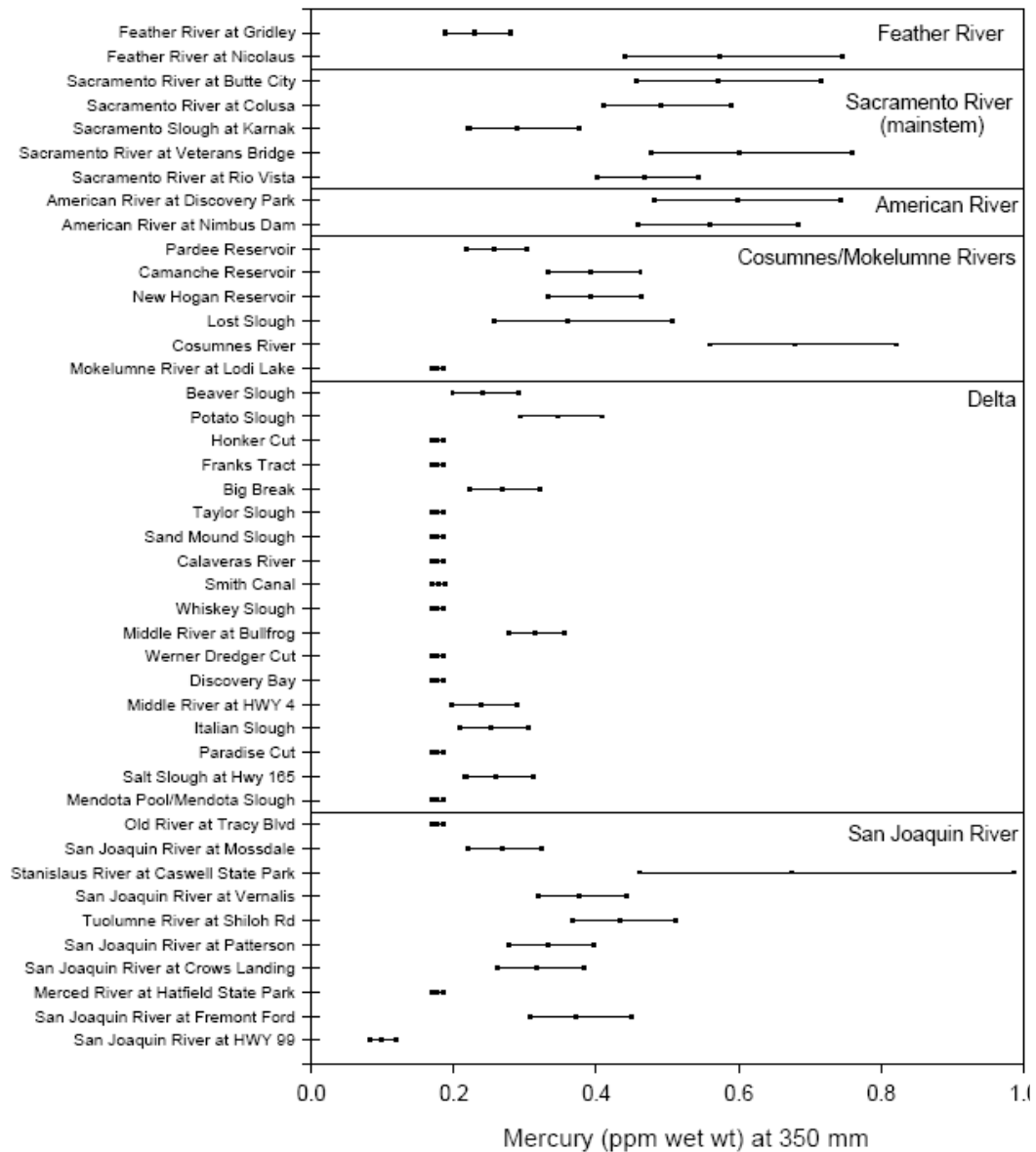


Figure 3. North Bay silverside mercury, Fall 2005 and Fall 2006, demonstrating spatial differentiation, lower exposure Napa-Sonoma Marsh, elevated Petaluma Marsh, and inter-annual change.

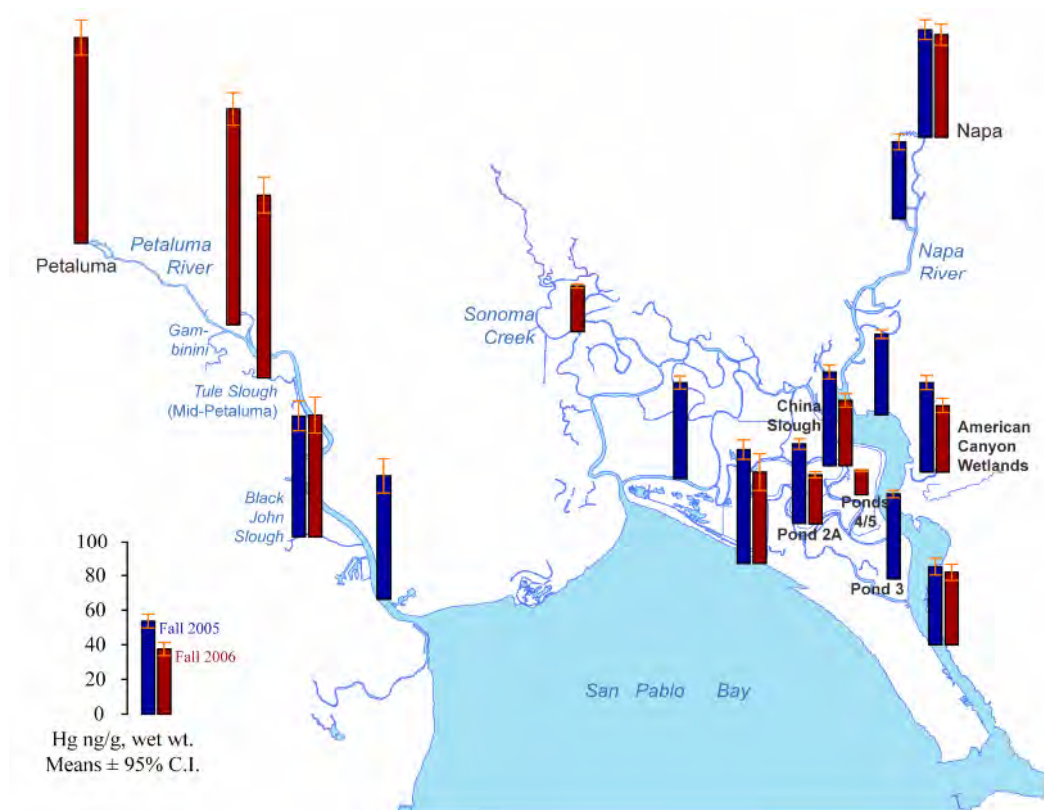


Figure 4. Patterns of seasonal variation in silversides at representative biosentinel monitoring sites following 2006 high flooding, mean Hg ($n=30$) \pm 95% confidence intervals.

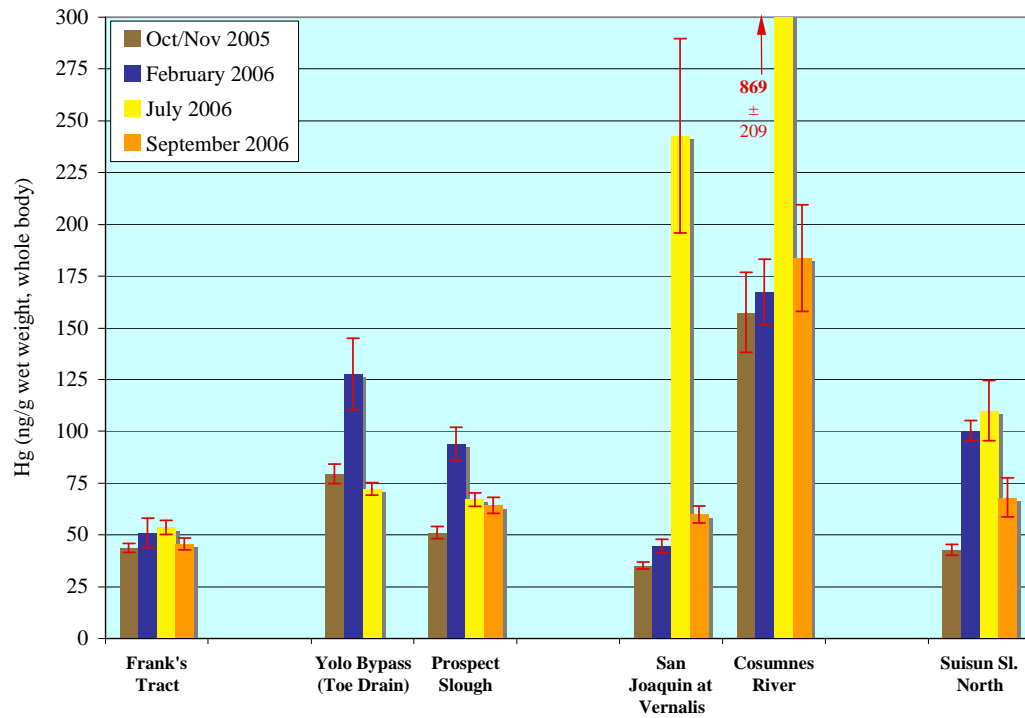
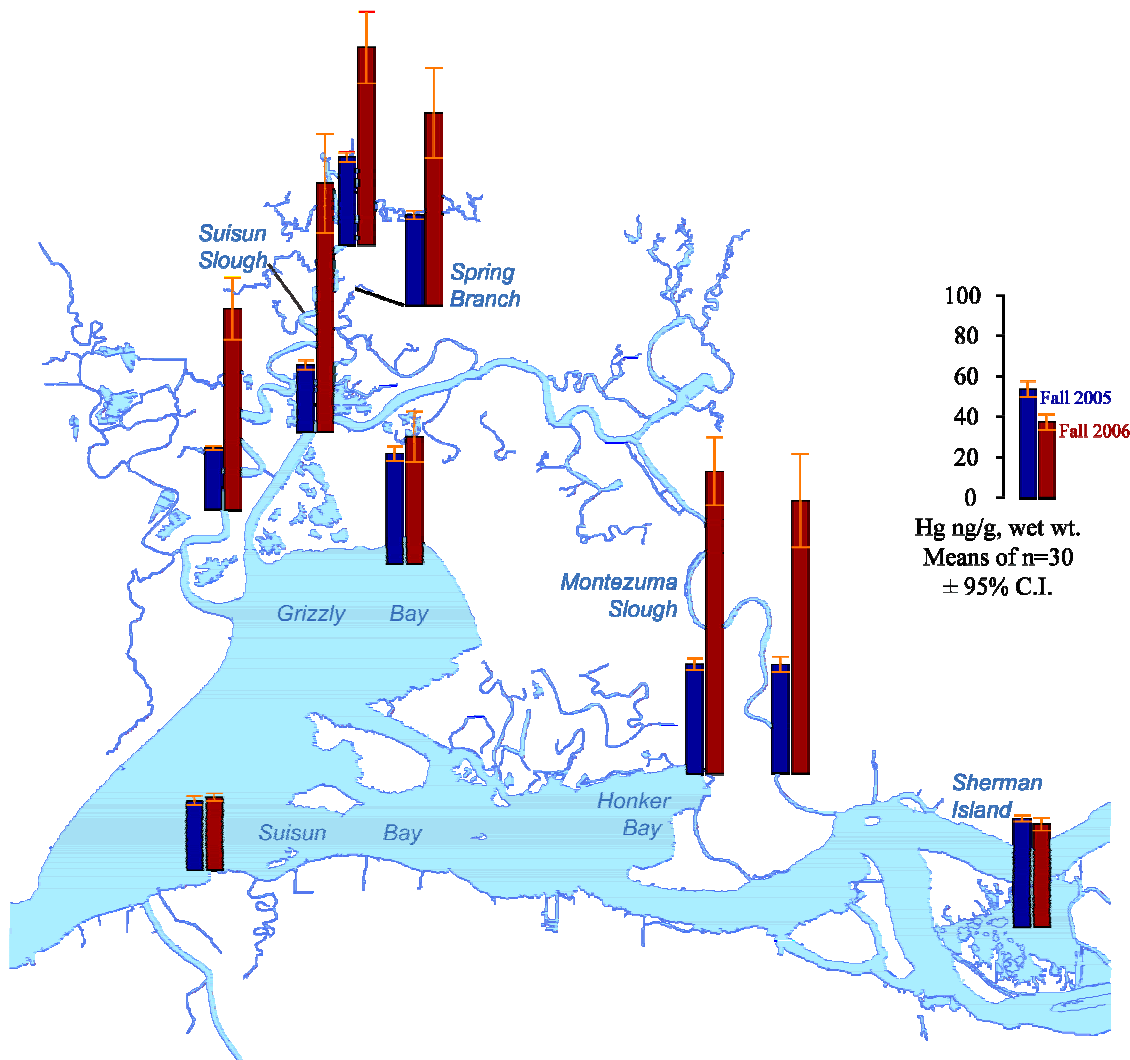


Figure 5. Suisun Marsh Region 2005 and 2006 biosentinel fish mercury, showing spatial variation, inter-annual change, and identification of a 2006 hot spot.



APPENDIX

Appendix Figure 1. Map of the Project area. The vast majority of the sampling is being conducted within the boundaries of the Ecosystem Restoration Program's Ecological Management Units. A few samples are being collected in the broader boundary of the ERP.



Appendix Table 1. Fish Mercury 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, and
 - b. coordination with other major science, management, and outreach and communication efforts

APPENDIX Table 2: PRODUCTS TO DATE

PLANNING DOCUMENTS

- Davis, J.A., et al. 2005. FINAL WORKPLAN FOR YEAR 1 OF THE CALIFORNIA BAY-DELTA AUTHORITY FISH MERCURY PROJECT: FISH SAMPLING AND ANALYSIS. CBDA Project # ERP 02D-P67.
- Davis, J.A., et al. 2006. FINAL WORKPLAN FOR YEAR 2 OF THE CALIFORNIA BAY-DELTA AUTHORITY FISH MERCURY PROJECT: FISH SAMPLING AND ANALYSIS. CBDA Project # ERP 02D-P67.

TECHNICAL REPORTS

- Grenier, L., A. Melwani, J. Hunt, S. Bezalel, J. Davis, G. Ichikawa, B. Jakl, W. Heim, A. Bonnema, and M. Gassel. 2007. California Bay-Delta Authority Fish Mercury Project: Year 1 Annual Report – Sport Fish Sampling and Analysis Final Report. San Francisco Estuary Institute, Oakland, CA.
- Slotton, D.G., S. Ayers, and R.D. Weyand. 2006. CBDA BIOSENTINEL MERCURY MONITORING PROGRAM FIRST YEAR DRAFT DATA REPORT COVERING SAMPLING CONDUCTED AUGUST 2005 – FEBRUARY 2006. University of California Davis, Davis, CA.
- Melwani, A.R., S. N. Bezalel, J. L. Grenier, J. A. Hunt, A. H. Robinson, and J. A. Davis. 2007. Draft Report: Landscape Analysis of Historical Fish Mercury Data, Relationship between Landscape Features and Sport Fish Mercury in the Sacramento-San Joaquin Delta Watershed. San Francisco Estuary Institute, Oakland, CA.
- Gassel, M., R.K. Brodberg, S. Klasing, and S. Roberts. 2007. Health Advisory: Draft Safe Eating Guidelines for Fish and Shellfish from the San Joaquin River and South Delta (Contra Cost, San Joaquin, Stanislaus, Merced, Madera, and Fresno Counties). California Office of Environmental Health Hazard Assessment, Sacramento, CA.

PRESENTATIONS

- Tan, M.L., 2005. Promoting Awareness and Understanding of Fish Advisories Using Culturally Relevant Approaches. Presented at American Public Health Association Annual Meeting, Philadelphia, PA.
- Slotton, D.G., S.M. Ayers, and R.D. Weyand. 2006. Initiation of a Long Term, Restoration Focused Biosentinel Mercury Monitoring Program for the San Francisco Bay Watershed. Presented at the 8th International Conference on Mercury as a Global Pollutant, Madison, WI.
- Slotton, D.G., S.M. Ayers, and R.D. Weyand. 2006. Biosentinel Mercury Monitoring in Support of Restoration Management Across the Bay-Delta Watershed. Presented at the 2006 CalFed Science Conference, Sacramento, CA.
- Grenier, L.G., et al. 2006. Mercury contamination of sport fish in the Delta and its watershed: Results from the first year of CBDA Fish Mercury Project sampling. Presented at the 2006 CalFed Science Conference, Sacramento, CA.

- Grenier, L.G. et al. 2006. Mercury monitoring in California sport fish: past, present, and future. Presented at the National Water Quality Monitoring Conference, San Jose, CA.
- Davis, J.A. and M. Connor. 2007. Monitoring PBTs in California Waters: Existing Programs and Lessons Learned. Presented at Commission for Environmental Cooperation Workshop for Development of a National Environmental and Assessment Program in Mexico, Cuernavaca, Morelos, Mexico, February 13-15, 2007.
- Davis, J.A., J. Letitia Grenier, Aroon Melwani, Shira Bezalel, Jennifer Hunt, Alyce Ujihara, and Robert Brodberg. 2006. Mercury monitoring in California sport fish: A historical review and recommendations for the future. Presented at 8th International Conference on Mercury as a Global Pollutant, Madison, WI, August 2006.
- Wiener, J., J.A. Davis, R. Brodberg, and A. Ujihara. 2006. A Framework for Near-Term Reduction of Human Exposure to Methylmercury during Restoration of the San Francisco Bay-Delta Ecosystem. Presented at International Conference on Rivers and Civilization, LaCrosse, WI.

POSTERS

Silver, E., L. Copan, J. Kaslow, et al. 2005. California's Delta Watershed Fish Project. National Forum on contaminant in Fish, US Environmental Protection Agency, Baltimore, MD.

Ujihara, A., M.L. Tan, J. Kaslow, et al. 2005. The Delta Watershed Fish Project: Reducing Exposure to Mercury through Outreach and Education. CALFED Bay-Delta Program, Annual Workshop and Review of Mercury Projects, Sacramento.

Kaslow, J., A. Ujihara, M.L. Tan, et al. 2006. Mercury contamination of Fish: Involving Anglers and Other Stakeholders in Protecting Human Health. EcoHealth One. Madison, WI.

Kaslow, J., A. Ujihara, M.L. Tan, et al. 2006. Mercury in Fish: Involving Community Stakeholders in Fish Monitoring and Risk Communication. National Environmental Public Health Conference, Atlanta, GA.

Ujihara, A., et al. 2006. The Fish Mercury Project: Involving Stakeholders in Monitoring and Risk communication in the Sacramento-San Joaquin Delta Watershed. National Monitoring Conference, San Jose.

Ujihara, A., J. Davis, J. Kaslow, et al. 2006. Reducing Mercury Exposure in California: Risk Communication. Eighth International Conference on Mercury as a Global Pollutant. Madison, WI.