Summary of Mercury Proposal for FY18/19 Workplan

Continued monitoring of sport fish and water is proposed to address the highest priority information needs related to implementation and revision of the Methylmercury TMDL (re-opening of the TMDL is tentatively scheduled for 2020). Annual monitoring of sport fish will firmly establish baseline concentrations and interannual variation in support of monitoring of long-term trends as a critical performance measure for the TMDL. Monitoring of water on a near-monthly basis will solidify the linkage analysis (the quantitative relationship between methylmercury in water and methylmercury in sport fish) in the TMDL and be valuable in verifying trends and patterns predicted by a numerical model of methylmercury transport and cycling being developed for the Delta and Yolo Bypass by the California Department of Water Resources (DWR) - this model will allow testing of various water management scenarios.

The cost for the full proposal for mercury monitoring, with 10 water sampling events, is $323,798.
Reduced cost options:

- 10 water sampling events: $323,798
- 9 water sampling events: $300,504
- 8 water sampling events: $277,210

If a reduced cost option is selected, the Mercury Subcommittee will discuss how to spread the events throughout the months of the year.

Management Drivers Addressed

Mercury monitoring addresses the Delta Methylmercury TMDL, which establishes goals for cleanup and calls for a variety of control studies and actions.

Assessment Questions Addressed

Two tiers of assessment questions have been defined for the mercury monitoring program. **Primary** assessment questions are those that are explicitly addressed by the monitoring and drive the monitoring design. **Secondary** assessment questions are addressed to some extent by the monitoring, but are not drivers of the monitoring design. The monitoring will contribute some information on but will not fully answer the secondary assessment questions.

Primary Assessment Questions

Status and Trends

ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

ST1.A. Do trends over time in methylmercury in sport fish vary among Delta subareas?

Sources, Pathways, Loadings & Processes

SPLP1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish?

SPLP1.A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)?

Fish-Water Linkage Analysis
(new priority question articulated by Mercury Subcommittee)

FWLA1. Are there key datasets needed to strengthen the technical foundation of contaminant control programs?

Secondary Assessment Questions

Status and Trends

ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

ST1.B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology?

Sources, Pathways, Loadings & Processes

SPLP1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish?

SPLP1.B. How do internal sources and processes influence methylmercury levels in fish in the Delta?

SPLP1.C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?

Forecasting Scenarios

FS1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?

Data Quality Objectives/Null Hypothesis

The initial and preliminary data quality objective (DQO) is the ability to detect a trend of mercury in fish tissue of 0.040 ppm/yr. This DQO can be refined when additional data are available. The null hypothesis is that there is no trend. MQOs are identical to those used in other mercury studies throughout the state and the country for determinations of impairment and trend detection. These MQOs generally call for indices of accuracy and precision to be within 25% to 30% of expected values.

Monitoring to Support Implementation of the Methylmercury TMDL

Executive Summary

Continued monitoring of sport fish and water is proposed to address the highest priority information needs related to implementation and revision of the Methylmercury TMDL (re-opening of the TMDL is tentatively scheduled for 2020). Annual monitoring of sport fish will firmly establish baseline concentrations and interannual variation in support of monitoring of long-term trends as a critical performance measure for the TMDL. Monitoring of water on a near-monthly basis will solidify the linkage analysis (the quantitative relationship between methylmercury in water and mercury in sport fish) in the TMDL and be valuable in verifying trends and patterns predicted by a numerical model of methylmercury transport and cycling being developed for the Delta and Yolo Bypass by the California Department of Water Resources (DWR) - this model will allow testing of various land and water management scenarios.

Background and Motivation

Concentrations of methylmercury in fish from the Delta exceed thresholds for protection of human and wildlife health. The Methylmercury TMDL (Wood et al. 2010) is the driver of actions to control methylmercury in the Delta, establishing water quality goals and directing various discharger groups to conduct monitoring and implement measures to minimize methylmercury impairment of beneficial uses.

The TMDL established three water quality objectives for methylmercury in fish tissue: 0.24 ppm in muscle of large, trophic level four (TL4) fish such as black bass; 0.08 ppm in muscle of large TL3 fish such as carp; and 0.03 ppm in whole TL2 and TL3 fish less than 50 mm in length. Furthermore, the TMDL established an implementation goal of 0.24 ppm in largemouth bass at a standard size of 350 mm as a means of ensuring that all of the fish tissue objectives are met. Largemouth bass are widely distributed throughout the Delta and are excellent indicators of spatial variation due to their small home ranges. Past data for largemouth bass were a foundation for the development of the TMDL, including the division of the Delta into eight subareas. Monitoring of largemouth bass in these subareas therefore provides the most critical performance measure of progress in addressing methylmercury impairment in the Delta.

The TMDL describes a statistically significant relationship between the annual average concentration of methylmercury in unfiltered water and average mercury in 350 mm largemouth bass when data are organized by subarea. This linkage provides a connection, essential for management, between methylmercury inputs from various pathways (e.g., municipal wastewater, municipal stormwater, agricultural drainage, sediment flux in open waters, and wetland restoration projects) and impairment of beneficial uses. Because of this linkage, the TMDL established an implementation goal of 0.06 ng/L of unfiltered aqueous methylmercury. In response to TMDL control study requirements, the Department of Water Resources (DWR) is leading development of numerical methylmercury transport and cycling simulation models for the Delta and Yolo Bypass. Monitoring of aqueous methylmercury is therefore needed to:

1) better quantify the fish-water linkage that is the foundation of the TMDL,

2) evaluate attainment of the TMDL implementation goal,

3) support calculations of mercury and methylmercury loads and mass balances,

4) support development of mercury models for the Delta and Yolo Bypass, and

5) support evaluation of the fish data by providing information on processes and trends.

In FY 2016/2017 the Delta RMP initiated a methylmercury monitoring program for fish and water. Largemouth bass were collected in late summer 2016 (September) from six locations distributed across the subareas. Quarterly sampling of methylmercury and mercury (and ancillary parameters) in water at five locations began in August 2016.

In FY 2017/2018, methylmercury monitoring of fish and water continued. Funding was allocated to sample fish at six locations and water at six locations for eight months. The eight months to be sampled were to be the March-October period used for the linkage analysis in the TMDL. In late 2017, the Mercury Subcommittee decided that a more optimal use of the available funds would be to shift to sampling water at eight locations (adding locations in the West Delta and at the export pumps) and to add sampling in January and February (Table 1). The FY 2017/2018 plan also included funds for quarterly sediment sampling to support the DWR methylmercury modeling effort, and any future methylmercury modeling.

Applicable Management Decisions and Assessment Questions

The Delta Methylmercury TMDL is the embodiment of management decisions for methylmercury in the Delta, establishing goals for cleanup and calling for a variety of control studies and actions. With providing information to support TMDL implementation in mind, the Mercury Subcommittee carefully considered, refined, and prioritized the assessment questions articulated by the Steering Committee and Technical Advisory Committee for mercury.

Two tiers of assessment questions have been defined for the mercury monitoring program. **Primary** assessment questions are those that are explicitly addressed by the monitoring and drive the monitoring design. Secondary assessment questions are addressed to some extent by the monitoring, but are not drivers of the monitoring design. The monitoring will contribute some information but will not fully answer the secondary assessment questions.

Primary Assessment Questions

One priority question for this initial phase of methylmercury monitoring is from the Status and Trends category of the DRMP management and assessment questions:

Status and Trends

ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

ST1.A. Do trends over time in methylmercury in sport fish vary among Delta subareas?

Question 1A is a high priority for managers that relates to the TMDL, and is a primary driver of the sampling design for fish monitoring. Annual monitoring of fish mercury is urgently needed to 1) firmly establish a baseline for each Delta subarea and 2) to characterize the degree of interannual variation, which is essential to designing an efficient monitoring program for detection of long-term trends. In addition to addressing status and trends, this monitoring will establish a foundation for tracking the effectiveness of management actions - another category of the Delta RMP core management questions.

Sources, Pathways, Loadings and Processes

SPLP1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish?

SPLP1.A. What are the loads from tributaries to the Delta (measured at the point where tributaries cross the boundary of the legal Delta)?

A mass budget for methylmercury in the Delta is a critical element of the TMDL. The mass budget provides essential context for understanding the importance of inputs from discharges and internal sources and processes. Obtaining data to expand and update the dataset on methylmercury inputs to the Delta is a high priority to support TMDL refinement and implementation. Methylmercury export from the Delta is similarly an important component of the mass budget and a high priority information need.

Fish-Water Linkage Analysis
(new priority question articulated by Mercury Subcommittee)

FWLA1. Are there key datasets needed to strengthen the technical foundation of contaminant control programs?

Another priority question that will be addressed by this proposal relates to the linkage analysis discussed in the previous section, which is a key element of the technical basis for the TMDL. This question was not articulated in the core management questions and assessment questions established by the Steering Committee, but was nevertheless identified as a priority by the Mercury Subcommittee. Additional data on methylmercury in water is one of the key datasets needed to strengthen the technical foundation of the TMDL.

Secondary Assessment Questions

ST1. What are the status and trends in ambient concentrations of methylmercury and total mercury in sport fish and water, particularly in subareas likely to be affected by major existing or new sources (e.g., large-scale restoration projects)?

ST1.B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology?

The time series for methylmercury in fish and water that are created to answer the primary assessment questions will also be influenced by variation in climate, hydrology, and ecology, and will provide information on the role of these factors. For example, the first two years of monitoring have already spanned the end of a prolonged drought and a high flow year, providing an opportunity to examine the impact of extreme variation in flow on methylmercury concentrations in fish and water.

Sources, Pathways, Loadings and Processes

SPLP1. Which sources, pathways and processes contribute most to observed levels of methylmercury in fish?

SPLP1.B. How do internal sources and processes influence methylmercury levels in fish in the Delta?

SPLP1.C. How do currently uncontrollable sources (e.g., atmospheric deposition, both as direct deposition to Delta surface waters and as a contribution to nonpoint runoff) influence methylmercury levels in fish in the Delta?

Forecasting Scenarios

FS1. What will be the effects of in-progress and planned source controls, restoration projects, and water management changes on ambient methylmercury concentrations in fish in the Delta?

These secondary assessment questions relating to Sources, Pathways, Loadings, and Processes and Forecasting Scenarios for this initial phase of methylmercury monitoring relate to one of the major control studies called for in the TMDL: an effort to combine modeling, field data, and laboratory studies to evaluate the potential effects of water project operational changes on methylmercury in Delta channels. The Department of Water Resources (DWR) is currently developing two mathematical models, one each for the Delta and Yolo Bypass, that will allow testing of various water management scenarios (DiGiorgio et al. 2016). These models will be useful in addressing this set of Delta RMP management questions. The opportunity to inform these models, which are being developed with a considerable investment of funding from the California Department of Water Resources (DWR), makes monitoring to address these questions a near-term priority for the Delta RMP. The water monitoring included in this proposal will generate data that are valuable for verifying trends and patterns predicted by the methylmercury models.

Approach

Fish Sampling

Design	7 fixed sites (Figure 1), largemouth bass only - adding a site in the West Delta in this round
Key Indicator	Annual average methylmercury in muscle fillet of 350 mm largemouth bass (or similar predator species), derived through analysis of 16 individual bass or other predator species at each location
Parameters	Total mercury*, Total length, Fork length, Weight, Sex, Moisture, Estimated age
Frequency	Annual
Schedule	Monitor through 2025 and then re-evaluate. Sample in summer or early fall.
Co-location	Water MeHg and Hg Other water parameters
Contractors	SFEI (design, data management, reporting), MLML (sample collection, chemical analysis, reporting)
Coordination	DWR, USGS (sampling of flow monitoring stations)

* Total mercury measured as proxy of methylmercury because methylmercury comprises more than 90% of the total mercury in fish.

Summary of Results to Date

Results from the first year of DRMP methylmercury monitoring are presented in the Year One Data Report (Davis et al. 2018). The report provides details on the sample collection and processing, chemical analysis, quality assurance, and the results. Highlights of the results are briefly discussed here.

Results from the first round of DRMP fish monitoring are presented in Figure 2, with data from prior fish sampling in or near these stations provided for context. Time series with more than three observations are available for four of the six locations. The existing time series are characterized by a high degree of inconsistency in locations, species, and sampling approach over time, highlighting the need to build a consistent dataset for trend evaluation. The data do suggest a preliminary answer to management question 1A. The data suggest a decline in concentrations at the San Joaquin River at Vernalis over the period of record, while concentrations appeared to be stable at the other three locations. Therefore, the data give a

preliminary indication that trends do vary among the Delta subareas. Additional rounds of consistent sampling are needed to confirm this preliminary interpretation.

Water Sampling

Design	8 fixed sites (**Figure 1**) - adding sites for export from the Delta in this round (Mallard Island in the west Delta and the Delta Mendota Canal for a water project export site)
Key Indicator	March-October average total (unfiltered) methylmercury at each location
Parameters	Total (unfiltered) methylmercury, filtered methylmercury, unfiltered total mercury, filtered total mercury, suspended solids, chlorophyll a, dissolved organic carbon (field filtered), volatile suspended solids. Field measurements will include dissolved oxygen, pH, and specific conductance.
Other Important Parameters	Nutrients (ALK, NH3, CL, DOC, HARD, NO3/NO2, N (total), OPO4, TPHOS, SiO2, SO4, TDS, TOC), grain size. Budget assumes these are covered by other studies.
Frequency	10 events per year (8 monthly events + 2 storm or winter events)
Schedule	Monitor through 2020 and then re-evaluate
Co-location	Sport fish sampling (at 7 of the sites, excluding Delta Mendota Canal) Other water parameters
Coordination	DWR, USGS (sampling of flow monitoring stations)

Summary of Results to Date

Results for March-October average total (unfiltered) methylmercury at each location for the first year of sampling are briefly summarized here. Data for the other water parameters are presented in the Year One Data Report (Davis et al. 2018).

Figure 3 presents long-term time series of March to October annual averages of total unfiltered MeHg concentrations for Delta RMP sites. Sacramento River concentrations have remained constant with good agreement between historic data and current data. Cache Slough 2016 concentration was lower than what was reported previously but the 2017 concentration was within historic ranges. No historic data are available for Little Potato Slough. Middle River MeHg concentrations were highly variable with 2016–17 concentrations within the range of historic data. The San Joaquin River 2016 MeHg concentration was lower than previously reported values. However, the 2017 measurement was the highest concentration ever reported for this site.

Data Quality

The measurement quality objectives (MQOs) for measurements of methylmercury and mercury in fish and water are shown in Appendix 1. These MQOs are the same as MQOs used in mercury studies throughout California, with statewide fish monitoring by the Surface Water Ambient Monitoring Program as a prominent example. The MQOs generally call for indices of accuracy and precision to be within 25% to 30% of expected values. Data of this quality are routinely used for determinations of impairment and trend detection throughout the state and the country. The variance attributable to the analytical process is one of the contributors to the overall variance observed in the data. This variance is therefore accounted for in the power estimates provided in the next section.

Power to Detect Long-term Trends - Fish Sampling

The power to detect interannual trends in largemouth bass mercury on a per site basis was evaluated using existing data. Even the best existing time series for the Delta have low statistical power to detect trends due to infrequent sampling and varying sampling designs of studies performed over the years (Figure 2). One of the goals of the initial phase of Delta RMP fish mercury monitoring is to obtain robust information on interannual variation to support future power analysis. As part of the mercury proposal for FY 2017/2018 we conducted a power analysis on the small amount of information presently on hand. Appendix 2 provides the methods and details on the results. This analysis will be updated after a few years of new data have accumulated.

Power analysis summary

Power for trend detection at a single site based on grand mean estimates of observed variance across sites. Pink shading indicates scenarios with greater than 80% power.

		10 Years		20 Years		30 Years	
Trend	N Fish/Yr	Annual	Biennial	Annual	Biennial	Annual	Biennial
0.010 ppm/yr	12	0.11	0.09	0.20	0.15	0.40	0.27
0.020 ppm/yr	12	0.13	0.13	0.44	0.27	0.81	0.60
0.030 ppm/yr	12	0.21	0.17	0.69	0.45	0.99	0.85
0.040 ppm/yr	12	0.29	0.19	0.88	0.61	1.00	0.98
0.010 ppm/yr	16	0.21	0.19	0.33	0.27	0.55	0.44
0.020 ppm/yr	16	0.27	0.24	0.65	0.46	0.93	0.77
0.030 ppm/yr	16	0.36	0.32	0.86	0.64	1.00	0.96
0.040 ppm/yr	16	0.47	0.36	0.97	0.82	1.00	1.00

These preliminary results indicate that increasing the number of fish per site would be effective in increasing power. With 16 fish per site and annual sampling, 80% power would be expected for several of the 20-year scenarios. Beginning with year 2 (FY 2017/2018) the design for fish monitoring was therefore being modified to include 16 fish per site. The monitoring results for the San Joaquin at Vernalis suggest that trends of up to 0.040 ppm/yr are possible. The results highlight the importance of initiating consistent time series.

Power Analysis - Water Sampling

Not applicable. The primary objectives of the water sampling are to strengthen the linkage analysis and support model development. The water monitoring is not intended as a tool for long-term trend monitoring.

Reporting/Deliverables

Deliverable	**Due Date**
Draft Data Report on Year 2 (FY 17/18)	December 2018
Final Data Report on Year 2 (FY 17/18)	February 2019
Draft Data Report on Year 3 (FY 18/19)	December 2019
Final Data Report on Year 3 (FY 18/19)	February 2020

Budget

		Actual	Actual	Old Plan	Proposed: 10 water events	Proposed: 9 water events	Proposed: 8 water events	Planned	Planned
	Fiscal Year	**2016/17**	**2017/18**	**2018/19**	**2018/19**	**2018/19**	**2018/19**	**2019/20**	**2020/21**
	Fish Sampling Year	**2016**	**2017**	**2018**	**2018**	**2018**	**2018**	**2019**	**2020**
Fish	Bass Monitoring at Six Sites: Sampling and Analysis (DRMP)	$45,344	$51,804	$53,358	$53,358	$53,358	$53,358	$54,959	$56,608
Fish	1 Site Add on				$7,521	$7,521	$7,521	$7,747	$7,979
	MLML In-Kind	($8,262)	($5,100)	($5,100)	($5,100)	($5,100)	($5,100)	($5,100)	($5,100)
Water	Water Monitoring at **Five** Sites, Quarterly: Sampling and Analysis (DRMP)	$65,310							
	MLML In-Kind	($12,392)							
	Water Monitoring at **Six** Sites, 8 months: Sampling and Analysis		$152,952	$157,541	$154,703	$154,703	$154,703	$159,344	$164,124
	Water 2 site 8 month add on				$51,568	$51,568	$51,568	$53,115	$54,708
	Water, 2 winter event, 8 sites				$51,568	$25,784	$0	$53,115	$54,708
	MLML In-Kind		($16,700)	($16,700)	($24,900)	($22,410)	($19,920)	($24,900)	($24,900)
Sediment	Sediment Monitoring at Six Sites, Quarterly: Sampling and Analysis		$29,260	$30,138	$0	$0	$0	$0	$0
	MLML In-Kind		($3,200)	($3,200)	$0	$0	$0	$0	$0
Data Management, Oversight, Reporting	SFEI Data Management and QA Review	$15,000	$19,545	$20,131	$29,930	$29,930	$29,930	$30,828	$31,753
	SFEI Oversight and Coordination	$3,000	$5,000	$5,150	$5,150	$5,150	$5,150	$5,305	$5,464
	Interpretive Report							$20,000	
	Total	$128,654	$258,561	$266,318	$353,798	$328,014	$302,230	$384,412	$375,345
	MLML In-Kind	($20,654)	($25,000)	($25,000)	($30,000)	($27,510)	($25,020)	($30,000)	($30,000)
	Total Cost to RMP	**$108,000**	**$233,561**	**$241,318**	**$323,798**	**$300,504**	**$277,210**	**$354,412**	**$345,345**

Table 1. *Sampling schedule for Delta RMP mercury monitoring. The March-October period used for the linkage analysis in the TMDL is indicated in bold font.*

	FY 2016/17												FY 2017/18												FY 2018/19												FY 2019/20											
	2016						2017						2018												2019												2020											
	7	**8**	**9**	**10**	11	12	1	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11	12	1	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11	12	1	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11	12	1	2	**3**	**4**	**5**	**6**
Fish (6 sites)		X												X																																	
Fish (7 sites)																										X												X									
Water (5 sites)		X			X			X		X																																				
Water (6 sites)																X																															
Water (8 sites)																			X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X
Sediment (6 sites)																X			X			X		X																							

Figure 1. Planned sampling sites for methylmercury in FY18/19.

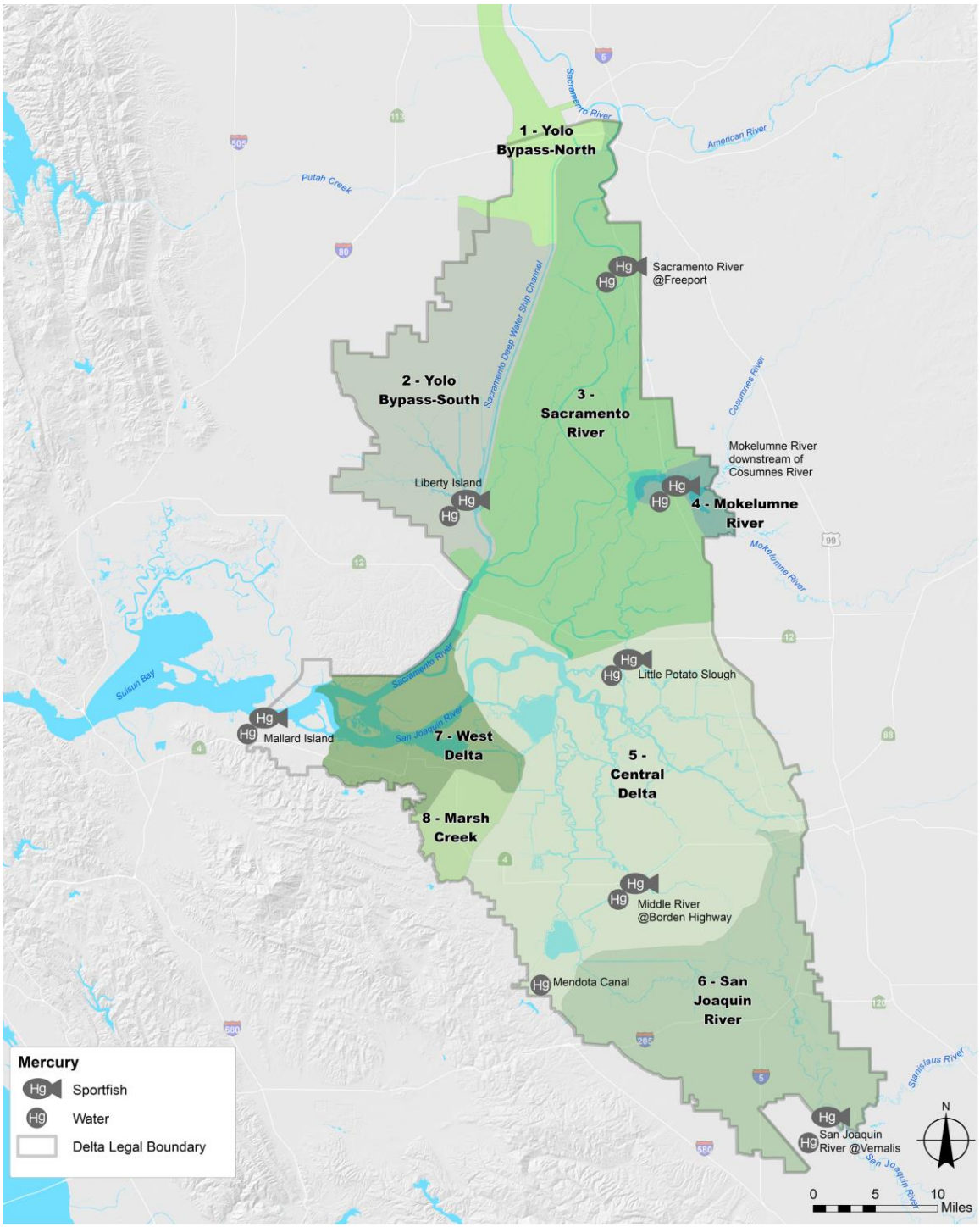


Figure 2. *Long-term time series of mean mercury (ppm wet weight) in black bass for Delta RMP stations and nearby stations sampled historically. Details on following page.*

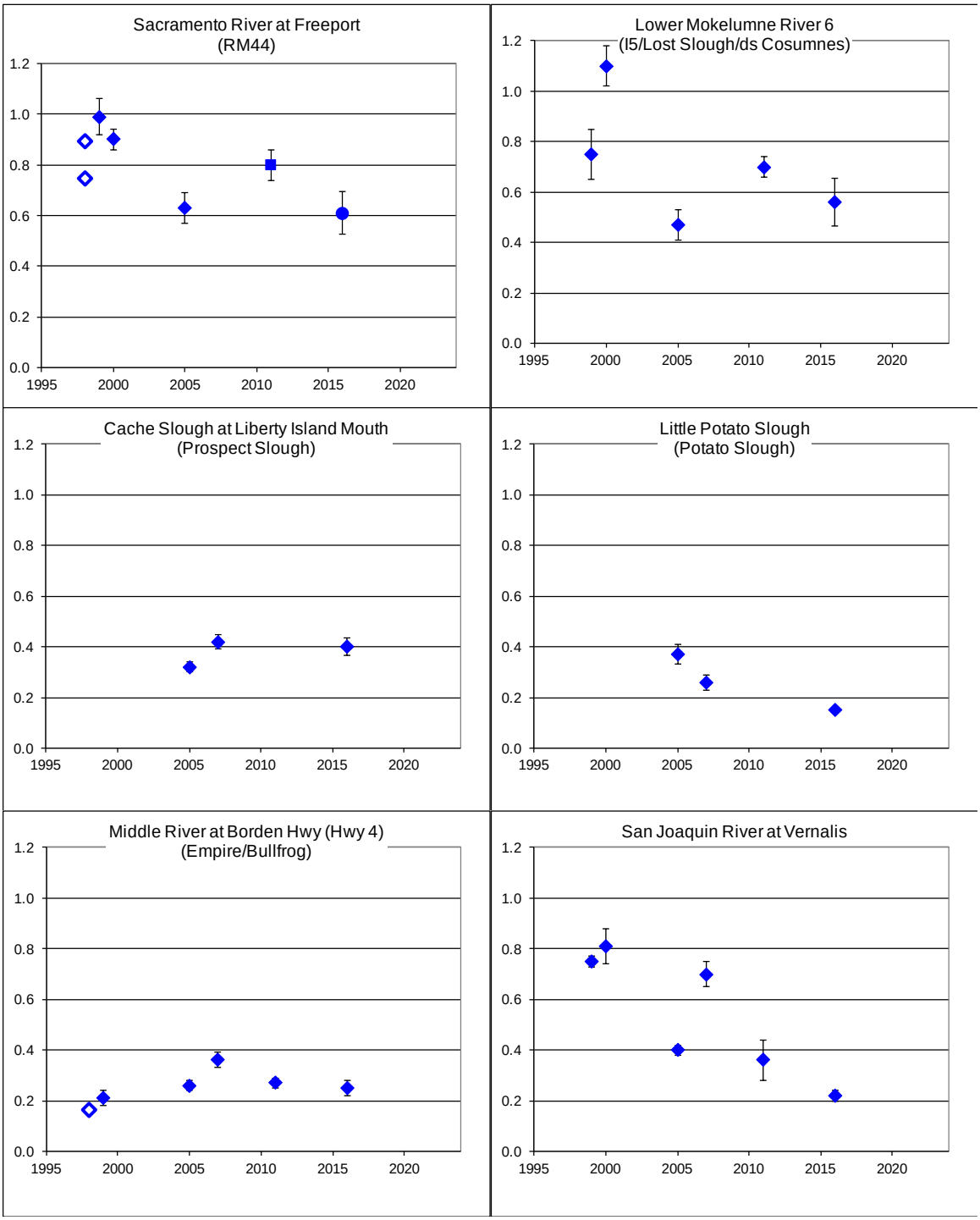


Figure 2 Details

Points generally show 350 mm length-adjusted means (exceptions to this noted in plot details below) and error bars indicate two times the standard error. Filled symbols indicate 350 mm length-adjusted means, hollow symbols indicate individual composite samples or arithmetic means when the station did not have a significant length:mercury correlation. Diamonds indicate largemouth bass; squares are spotted bass; circles are smallmouth bass. Data sources: Delta RMP - 2016; the Surface Water Ambient Monitoring Program (Davis et al. 2013) - 2011; the Fish Mercury Project (Melwani et al. 2009) - 2005-2007; the CALFED Mercury Project (Davis et al. 2003) - 1999-2000; the Delta Fish Study (Davis et al. 2000) - 1998; and the Sacramento River Watershed Program (2002) - 1998.

Sacramento River at Freeport
Stations - Freeport: 2016; RM44: All other years
Statistics - Individual composite results: 1998; 350 mm length adjusted mean: all other years

Lower Mokelumne River 6
Stations - Lower Mokelumne River 6: 2016; Mokelumne River near I-5: 2011; Lost Slough: 2005; Mokelumne River downstream of the Cosumnes River: 1999, 2000

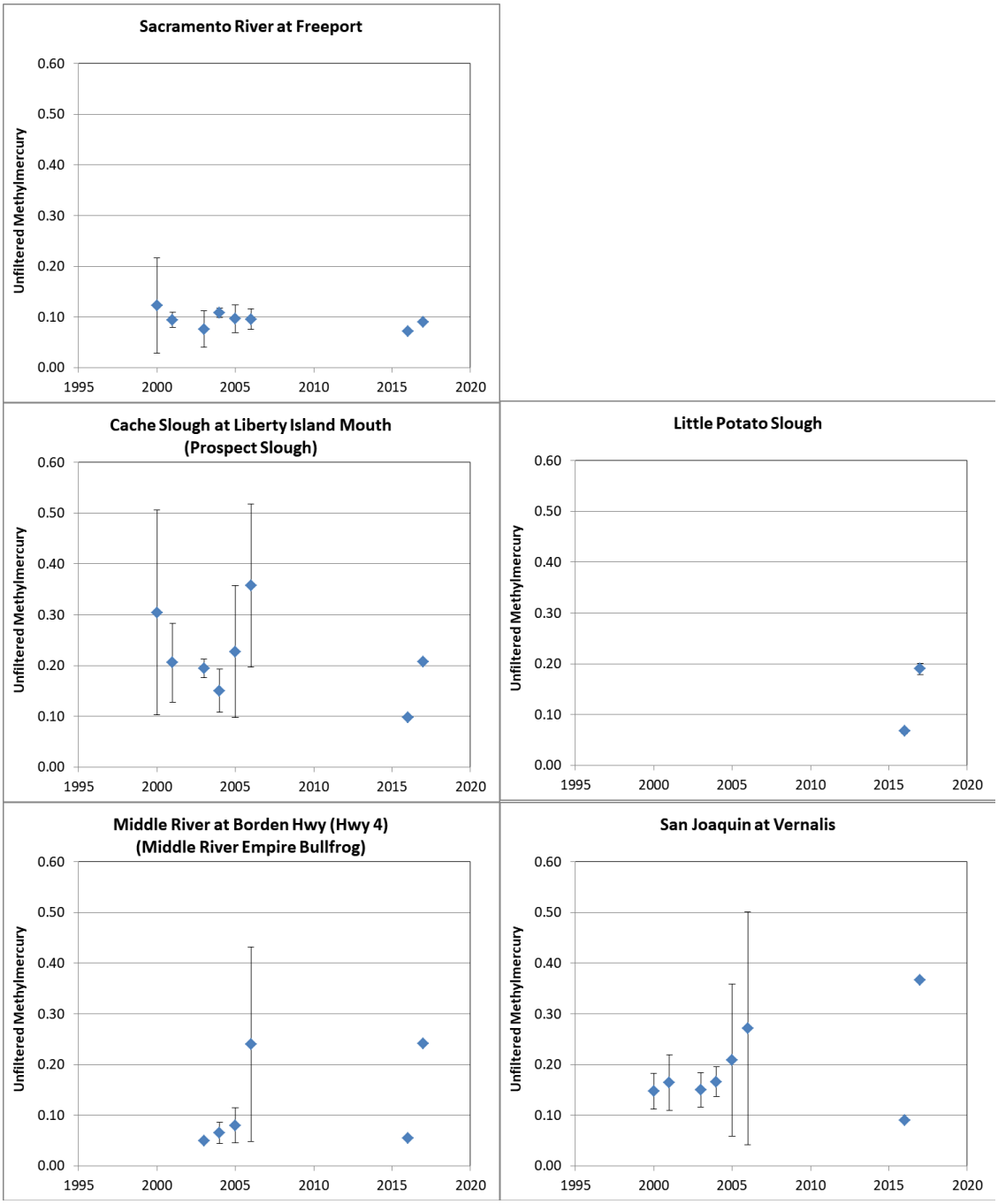
Cache Slough at Liberty Island Mouth
Stations - Cache Slough at Liberty Island Mouth: 2016; Prospect Slough: 2005, 2007

Little Potato Slough
Stations - Little Potato Slough: 2016; Potato Slough (aka San Joaquin River at Potato Slough): 2005, 2007

Middle River at Borden Hwy (Hwy 4)
Stations - Middle River at Borden Hwy (Hwy 4): 2016; Middle River near Empire Cut: 2011; Middle River at Bullfrog: 1998, 1999, 2007; Middle River at HWY 4: 2005
Statistics - Individual composite result: 1998; 350 mm length adjusted mean: all other years

San Joaquin River at Vernalis
Stations - Same station all years

Figure 3. Annual mean aqueous unfiltered methylmercury concentration at each Delta RMP monitoring station sampled from August 2016 through April 2017. Plots based on March-October data.



References

DiGiorgio, Carol, Helen Amos, Jamie Anderson, Maninder Bahia, Cody Beals, Don Beals, David Bosworth, et al. "Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions." Sacramento, California, 2016. http://scienceconf2016.deltacouncil.ca.gov/content/creation-mercury-models-delta-and-yolo-bypass-linking-modeling-and-delta-regulatory.

Wood, Michelle L., Chris G. Foe, Janis Cooke, and Stephen J. Louie. "Sacramento – San Joaquin Delta Estuary TMDL for Methylmercury: Staff Report." Sacramento, California: Central Valley Regional Water Quality Control Board, 2010. http://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/april_2010_hg_tmdl_hearing/apr2010_tmdl_staffrpt_final.pdf.