SWAMP
Surface Water Ambient Monitoring Program

| *Final Monitoring Plan* | 2011 |
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# Sampling and Analysis Plan for a Screening Study of Bioaccumulation in California Rivers and Streams

July 2011

California Water Boards

http://www.waterboards.ca.gov/water_issues/programs/swamp

FINAL

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The Bioaccumulation Oversight Group (BOG)

Surface Water Ambient Monitoring Program

July 2011

**ACKNOWLEDGEMENTS**

This Sampling Plan was prepared by SFEI and MLML on behalf of the Bioaccumulation Oversight Group (BOG) and the SWAMP. Substantial input to the plan was received from the BOG and the BOG Peer Review Panel.

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## I. INTRODUCTION

This document presents a plan for sampling and analysis of sport fish in a one-year screening survey of bioaccumulation in California rivers and streams. This work will be performed as part of the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). This effort is part of a new long-term Bioaccumulation Monitoring Project that is providing comprehensive monitoring of bioaccumulation in California water bodies.

Oversight for this Project is being provided by the SWAMP Roundtable. The Roundtable is comprised of State and Regional Water Board staff and representatives from other agencies and organizations including USEPA, the California Department of Fish and Game, the California Office of Environmental Health Hazard Assessment, and the University of California. Interested parties, including members of other agencies, consultants, or other stakeholders are also welcome to participate.

The Roundtable has formed a subcommittee, the Bioaccumulation Oversight Group (BOG), which focuses on the Bioaccumulation Monitoring Project. The BOG is comprised of State and Regional Water Board staff and representatives from other agencies and organizations including USEPA, the Department of Fish and Game, the Office of Environmental Health Hazard Assessment, the Southern California Coastal Waters Research Project, and the San Francisco Estuary Institute. The members of the BOG individually and collectively possess extensive experience with bioaccumulation monitoring.

The BOG has also convened a Bioaccumulation Peer Review Panel that is providing programmatic evaluation and review of specific deliverables emanating from the Project, including this Sampling Plan. The members of the Panel are internationally recognized authorities on bioaccumulation monitoring.

The BOG was formed and began developing a strategy for designing and implementing a statewide bioaccumulation monitoring program in September 2006. To date the efforts of the BOG have included a two-year screening survey of bioaccumulation in sport fish of California lakes and reservoirs (2007 and 2008) and another two-year screening survey of the California coast in 2009 and 2010. A final report on the lakes survey is available (Davis et al. 2010; http://www.swrcb.ca.gov/water_issues/programs/swamp/lakes_study.shtml). A report presenting results from the first year of the coast survey is available (Davis et al. 2011; http://www.waterboards.ca.gov/water_issues/programs/swamp/coast_study.shtml).

## II. GENERAL ASPECTS OF THE SWAMP BIOACCUMULATION MONITORING PROJECT

### A. Addressing Multiple Beneficial Uses

Bioaccumulation in California water bodies has an adverse impact on both the fishing and aquatic life beneficial uses (Davis et al. 2007). The fishing beneficial use is affected by human exposure to bioaccumulative contaminants through consumption of sport fish. The aquatic life beneficial use is affected by exposure of wildlife to bioaccumulative contaminants, primarily piscivorous species exposed through consumption of small fish. Different indicators are used to monitor these different types of exposure. Monitoring of status and trends in human exposure is accomplished through sampling and analyzing sport fish. On the other hand, monitoring of status and trends in wildlife exposure can accomplished through sampling and analysis of wildlife prey (small fish, other prey species) or tissues of the species of concern (e.g., bird eggs or other tissues of juvenile or adults of the species at risk).

Over the long-term, a SWAMP bioaccumulation monitoring program is envisioned that assesses progress in reducing impacts on both the fishing and aquatic life beneficial uses for all water bodies in California. In the near-term, however, funds are limited, and there is a need to demonstrate the value of a comprehensive statewide bioaccumulation monitoring program through successful execution of specific components of a comprehensive program. Consequently, the BOG has decided to focus on sampling that addresses the issue of bioaccumulation in sport fish and impacts on the fishing beneficial use. This approach is intended to provide the information that is the highest priority for the state government and the public. Monitoring focused on evaluating the aquatic life beneficial use should be included in the Project in the future.

### B. Addressing Multiple Monitoring Objectives and Assessment Questions for the Fishing Beneficial Use

The BOG has developed a set of monitoring objectives and assessment questions for a statewide program evaluating the impacts of bioaccumulation on the fishing beneficial use (Table 1). This assessment framework is consistent with frameworks developed for other components of SWAMP, and is intended to guide the bioaccumulation monitoring program over the long-term. The four objectives can be summarized as 1) status; 2) trends; 3) sources and pathways; and 4) effectiveness of management actions.

Over the long-term, the primary emphasis of the statewide bioaccumulation monitoring program will be on evaluating status and trends. Bioaccumulation monitoring is a very effective and essential tool for evaluating status, and is most cost-effective tool for evaluating trends for many contaminants. Monitoring status and trends in bioaccumulation will provide some information useful for identifying sources and pathways and for evaluating the effectiveness of management actions at a broader geographic scale. However, other types of monitoring (i.e., water and sediment

monitoring) and other programs (regional TMDL programs) are also needed for addressing sources and pathways and effectiveness of management actions.

In the near-term, the primary emphasis of the statewide bioaccumulation monitoring program will be on evaluating Objective 1 (status). The reasons for this are:

1. a systematic statewide assessment of status has never been performed and is urgently needed;
2. we are starting a new program and establishing a foundation for future assessments of trends;
3. past monitoring of sport fish established very few time series that are useful in trend analysis that this program could have built upon.

## C. Addressing Multiple Habitat Types

SWAMP has defined the following categories of water bodies:

- lakes and reservoirs;
- bays and estuaries;
- coastal waters;
- large rivers;
- wadeable streams; and
- wetlands.

Due to their vast number, high fishing pressure, and a relative lack of information on bioaccumulation (Davis et al. 2007), lakes and reservoirs were identified as the first priority for monitoring. Coastal waters, including bays and estuaries, were selected as the next priority, due to their importance for sport fishing and a relative lack of past monitoring. Rivers and streams will be the last in the series of water body types to be covered with a statewide screening study. The Roundtable has decided that the rivers and streams survey will be a one-year study, given available resources and that it is possible to provide reasonable coverage of popular fishing locations in a one-year effort. Wetlands will not be covered due to the low fishing pressure in those habitats. Another cycle of statewide surveys of lakes and reservoirs, the coast, and rivers and streams will occur, but the timing of the next round of surveys has not yet been established.

In summary, focusing on two closely associated habitat types (rivers and streams), one objective (status), and one beneficial use (fishing) will allow us to provide reasonable coverage and a thorough assessment of bioaccumulation in these habitats in a one-year study.

## III. DESIGN OF THE RIVERS AND STREAMS SURVEY

### A. Management Questions for this Survey

In response to information needs articulated by the state and regional Water Boards, two management questions have been articulated to guide the 2011 screening survey of the status of bioaccumulation in sport fish on the California coast. Questions relating to 303(d) listing (included in the lakes survey) and spatial patterns (included in the coast survey) were not a priority for managers and were not included in this survey.

**Management Question 1 (MQ1)**
Status of the Fishing Beneficial Use
*For popular fish species, what percentage of popular fishing areas have low enough concentrations of contaminants that fish can be safely consumed?*

Answering this question is critical to determining the degree of impairment of the fishing beneficial use across the state due to bioaccumulation. This question places emphasis on characterizing the status of the fishing beneficial use through monitoring of the predominant pathways of exposure – the popular fish species and fish areas. This focus is also anticipated to enhance public and political support of the program by assessing the resources that people care most about. The determination of percentages captures the need to perform a statewide assessment of the entire California coast. While a significant amount of monitoring in rivers and streams has been conducted (reviewed in Davis et al. [2007]), a systematic statewide survey has never been performed. The emphasis on safe consumption calls for: a positive message on the status of the fishing beneficial use; evaluation of the data using thresholds for safe consumption; and performing a risk-based assessment of the data.

The data needed to answer this question are average concentrations in popular fish species from popular fishing locations. Inclusion of as many popular species as possible is important to understanding the nature of impairment in any areas with concentrations above thresholds. In some areas, some fish may be safe for consumption while others are not, and this is valuable information for anglers. Monitoring species that accumulate high concentrations of contaminants ("indicator species") is valuable in answering this question: if concentrations in these species are below thresholds, this is a strong indication that an area has low concentrations.

**Management Question 2 (MQ2)**
Need for Further Sampling
*Should additional sampling of bioaccumulation in sport fish (e.g., more species or larger sample size) in an area be conducted for the purpose of developing comprehensive consumption guidelines?*

This screening survey of California rivers and streams will provide a preliminary indication as to whether some areas that have not been sampled thoroughly to date may require consumption guidelines. Consumption guidelines provide a mechanism for

reducing human exposure in the short-term. The California Office of Environmental Health Hazard Assessment (OEHHA), the agency responsible for issuing consumption guidelines, considers a sample of 9 or more fish from a variety of species abundant in a water body to be the minimum needed in order to issue guidance. It is valuable to have information not only on the species with high concentrations, but also the species with low concentrations so anglers can be encouraged to target the low species. Answering this question is essential as a first step in determining the need for more thorough sampling in support of developing consumption guidelines. Large stretches of rivers in the Central Valley that are popular for fishing are already under advisories.

**Overall Approach**

The overall approach to be taken to answer these two questions is to perform a statewide screening study of bioaccumulation in sport fish in California rivers and streams. Answering these questions, as has been done for lakes and reservoirs and the coast, will provide a basis for decision-makers to understand the scope of the bioaccumulation problem both in rivers and streams and across all of these water body types, and will provide regulators with information needed to establish priorities for both cleanup actions and development of consumption guidelines.

It is anticipated that the screening study may lead to more detailed followup investigations of areas where consumption guidelines and cleanup actions are needed. Funding for these followup studies will come from other local or regional programs rather than the SWAMP statewide monitoring budget.

The approach in this study is consistent with the approaches taken in the previous statewide surveys of bioaccumulation in California lakes and reservoirs (Davis et al. 2010) and on the California coast (BOG 2009). Adding information on bioaccumulation in rivers and streams to that already obtained for the other water body types will complete a comprehensive statewide assessment of the impact of contaminants on the fishing beneficial use in California.

## B. Coordination

The BOG is seeking to coordinate with other programs to leverage the funds for this survey and achieve more thorough studies relating to bioaccumulation in California rivers and streams.

One significant collaboration will be with the Central Valley Regional Water Quality Control Board (CVRWQCB). The CVRWQCB is providing $16K for supplemental sampling at 13 sites to support development of a mercury TMDL for the Sierra Nevada foothill region. The Water Board will fund analysis of sediment (total mercury: sieved for fines [<63 microns], 2 samples per site), water (total mercury, total methylmercury, SSC; 1 sample per site), and additional fish (total mercury; whatever large species is most abundant at the time of sampling other than rainbow or brown trout; at least 7 inches in total length; 3 samples of the same species per site). It is highly likely

that the additional fish species collected will coincide with the secondary target list for this study (Sacramento pikeminnow, Sacramento sucker, etc. – see Table 3).

The study will also be coordinated with a study conducted by USGS and funded by the State Board to develop assessment tools for evaluating mercury cleanups and for making 303(d) listing decisions. The $700,000 project will be designed to validate the use of sediment mercury concentration data for listing. The project will begin in 2011 with a review of existing data, followed by sampling to fill data gaps in 2012. The project will attempt to establish a consistent relationship between mercury bioaccumulation in fish tissue and sediment total mercury. The study will conduct sampling at 20 stream reaches and 13 lakes and reservoirs in gold mining regions of the Sierra Nevada foothills. Sediment analyses will include total mercury, methylmercury, reactive mercury, and iron and sulfur species. Fish tissue analyses will also be conducted where they are needed. Water analyses will also be conducted. Coordination with the SWAMP survey will allow the USGS study to establish a more extensive empirical dataset to support the development of the assessment tools.

Coordination on a small-scale will occur with the Water Boards from Regions 1 and 6 to obtain information on microcystin in fish fillets. Microcystin is a toxin produced by cyanobacteria that can undergo blooms in eutrophic water bodies. Cyanobacteria blooms are known to occur in the Klamath River in Region 1. In coordination with Region 1, microcystin in fish fillets will be analyzed in fish collected from the Klamath River station and in salmon collected from the Iron Gate Fish Hatchery on the Klamath River. Cyanobacteria blooms also occur in Bridgeport Reservoir in Region 6. In coordination with Region 6, microcystin in fish fillets will be analyzed in fish collected from the station on the East Walker River below Bridgeport Reservoir.

## C. Sampling Locations

California has over 211,000 miles of rivers and streams (Davis et al. 2007) that span a diversity of habitats and fish populations, and dense human population centers with a multitude of popular fishing locations. Conducting a statewide survey with a limited budget is a challenge. The approach being employed to sample this vast area is to conduct a complete sampling (or census) of the entire population of the most popular river and stream fishing locations in the state. Popular fishing locations were identified from Stienstra (2004) and discussions with stakeholders. Stienstra (2004) rated fishing spots on a scale of 1 to 10 based on three elements: number of fish, size of fish, and scenic beauty. With the budget available for this survey we are able to sample all of the river and stream locations with a Stienstra rating of 6 or higher. The locations selected for inclusion are listed in Table 2. Table 2 also includes the Stienstra rating and other information regarding the rationale and specifications of each sampling location.

Consideration was also given to information obtained from and priorities expressed by staff from the Regional Water Boards. In some instances, Water Board staff were aware of popular locations not rated or not given a high rating by Stienstra

(2004). In other instances Water Board information needs were a factor that drove inclusion of particular locations.

In all, the available budget can accommodate sampling of 56 river and stream locations. In addition, the budget covers collection and analysis of anadromous species (salmon and steelhead) upon their return migration to six hatcheries (three of each). This was considered to be the most efficient and appropriate approach to collecting these species that range throughout the river systems and are not closely connected with any particular location.

A list of alternate locations was also developed in case problems are encountered at any of the 56 primary candidate locations or additional funds are identified to allow coverage of more locations.

## D. Sampling Design At Each Location

### 1. Species Targeted

Given the focus of the screening study on the fishing beneficial use, the species to be sampled will be those that are commonly caught and consumed by anglers. Other factors considered include abundance, geographic distribution, and value as indicators for the contaminants of concern. The abundance and geographic distribution of species are factors that facilitate sample collection and assessment of spatial patterns in contamination. For example, largemouth bass is very common and widely distributed, and these factors contribute to making this an appropriate indicator species even though it is less popular for consumption than some other species.

The goal of this screening study is to determine whether or not popular fishing locations in California rivers and streams have unacceptably high concentrations of contaminants. Given this goal, the study is focusing on indicator species that tend to accumulate the highest concentrations of the contaminants of concern. Different contaminants tend to reach their highest concentrations in different species. Methylmercury biomagnifies primarily through its accumulation in muscle tissue, so top predators such as largemouth bass tend to have the highest concentrations. In contrast, the organic contaminants of concern biomagnify, but primarily through accumulation in lipid. Concentrations of organics are therefore are also influenced by the lipid content of the species, with species that are higher in lipid having higher concentrations. Bottom-feeding species such as channel catfish and common carp tend to have the highest lipid concentrations in their muscle tissue, and therefore usually have the highest concentrations of organics. Selenium also biomagnifies primarily through accumulation in muscle, but past monitoring in the San Joaquin Valley (Beckon et al. 2010) suggests that bottom-feeders accumulate slightly higher concentrations, perhaps an indication of a stronger association with the benthic food web.

Consequently, this study will target, where possible, two indicator species at each location – a top predator (e.g., largemouth bass) as a mercury indicator and a high lipid,

bottom-feeding species (e.g., channel catfish, common carp) as an organics and selenium indicator. Another advantage of this approach is that it provides a characterization of both the pelagic and benthic food chains. These considerations led USEPA (2000) to recommend this two-species approach in their guidance document for monitoring in support of development of consumption advisories. Most of the river and stream sampling locations selected are expected to have only one abundant group of species: trout. In these cases, one trout species will be sampled as an indicator for all the target analytes. This approach is practical, as it is not common to find multiple trout species in abundance at a single location, and cost-effective. If both rainbow and brown trout are present, brown trout will be collected as they have the potential to have a higher trophic position and accumulate more methylmercury than rainbow trout.

Fish species are distributed unevenly across the State, with different assemblages in different regions (e.g., high Sierra Nevada, Sierra Nevada foothills, and Central Valley) and a variable distribution within each region (Moyle 2002). To cope with this, the sampling crew will have a prioritized menu of several potential target species (Table 3). Primary target species will be given the highest priority. If primary targets are not available in sufficient numbers, secondary targets have been identified. Other species will also be observed in the process of fish collection. This "bycatch" will not be collected, but the sampling crew will record estimates of the numbers of each species observed. This information may be useful if followup studies are needed at any of the sampled locations.

## 2. Locations

In sport fish sampling it is frequently necessary to sample over a linear course of 0.5 – 1 miles to obtain an adequate number of fish. A sampling location in this study can therefore be thought of as a reach of river or stream channel with an length of 1 mile. An example of the target boundaries for one sampling location is shown in Figure 1.

Since the goal of the study is to characterize human exposure, the locations will be established near centers of most intensive fishing activity for a given river or stream site. For the locations mentioned in Stienstra (2004), an attempt will be made to sample those locations as precisely as possible.

## 3. Size Ranges and Compositing

Chemical analysis of trace organics is relatively expensive ($544 per sample for PCB congeners and $584 per sample for organochlorine pesticides), and the management questions established for this survey can be addressed with good information on average concentrations, so a compositing strategy will be employed for these chemicals. This is consistent with the approach taken for the previous surveys of lakes and the coast.

Chemical analysis of total mercury is much less expensive ($60 per sample), and, consistent with the previous surveys, SWAMP stakeholders would like to obtain information pertaining to management questions in addition to the ones listed on page 6.

The additional questions relate to evaluation of spatial variation among locations and of trends over time. Consequently, the sampling design for the mercury indicator species (black bass, pikeminnow, and striped bass) includes analysis of mercury in individual fish. For the mercury indicator species, an analysis of covariance approach will be employed, in which the size:mercury relationship will be established for each location and an ANCOVA will be performed that will allow the evaluation of differences in slope among the locations and the comparison of mean concentrations and confidence intervals at a standard length, following the approach of Tremblay (1998). Experience applying this approach in the Central Valley indicates that 10 fish spanning a broad range in size are needed to provide robust regressions (Davis et al. 2003, Melwani et al. 2007).

Specific size ranges to be targeted for each species are listed in Table 4. The key mercury indicators include largemouth bass, striped bass, and any other black bass species that may be collected. These species have a high trophic position and a strong size:mercury relationship. These species will be analyzed as individuals for mercury. The numbers and sizes indicated for these species will provide the size range needed to support ANCOVA. In addition, the size range for black bass takes the legal limit for these species (305 mm, or 12 inches) into account. The goal for black bass is to have a size distribution that encompasses the standard length (350 mm) to be used in statistical comparisons. This length is near the center of the distribution of legal-sized fish encountered in past studies (Davis et al. 2003, Melwani et al. 2007). Similarly, the size range for striped bass takes the legal limit for these species (457 mm, or 18 inches) into account, and would provide the range of sizes needed to establish the length:mercury relationship within locations.

In many rivers and streams only trout species will be available. Past sampling of rainbow trout in the Bay-Delta watershed has found low concentrations and a weak size:mercury relationship. Therefore, for these species the ANCOVA approach will not be used. Mercury will generally be analyzed in composites, with a specified size range targeted to control for size rather than a wide span to support a regression-based analysis. These trout will also be analyzed as composites for organics. The size ranges established for trout are based on a combination of sizes prevalent in past sampling (Melwani et al. 2007) and the 75% rule recommended by USEPA (2000) for composite samples. In some cases larger trout may be available. If this occurs (except for rainbow trout larger than 16 inches in anadromous waters because they are considered steelhead and are protected by CDFG), the larger fish will be retained and all of the trout from that location will be analyzed as individuals. This will help in determining whether there are differences between resident or older hatchery transplants and newer hatchery transplants.

Catfish, carp, bullhead, and sucker are the primary targets for high lipid bottom-feeders. These species will be the primary targets for organics and selenium. Organics are expected to be highest in these species based on past monitoring in the Toxic Substances Monitoring Program and other studies (Davis et al. 2007). Selenium is expected to be highest in these species, although the difference is not as distinct as for the organics, based on data from the Grassland Bypass Project (Beckon et al. 2010).

Methylmercury is expected to be highest in the pelagic predators, but concentrations are also expected to be above thresholds for concern in the bottom-feeders, so mercury will be analyzed in the bottom-feeder composites as well. Samples for these species will be analyzed as composites. The size ranges established for trout are based on a combination of sizes prevalent in past sampling (Melwani et al. 2007) and the 75% rule recommended by USEPA (2000) for composite samples.

Secondary targets have been identified that will be collected if the primary targets are not available. These species would be processed for potential analysis of mercury, selenium, and organics. The samples would be analyzed as composites. The size ranges established are based on a combination of sizes prevalent in past sampling (Melwani et al. 2007) and the 75% rule recommended by USEPA (2000) for composite samples.

The sampling crew will be reporting their catch back to the BOG on a weekly basis to make sure that the appropriate samples are collected and to address any unanticipated departures from sampling protocols.

**E. Sample Processing and Analysis**

Upon collection each fish collected will be tagged with a unique ID. Each fish collected will be linked to the latitude/longitude where it was collected. Several parameters will be measured in the field, including total length (longest length from tip of tail fin to tip of nose/mouth), fork length (longest length from fork to tip of nose/mouth), and weight. Total length changes with freezing and thawing and is best noted in the field for greatest accuracy and because it is the measure used by fishers and wardens to determine whether a fish is legal size. Determining fork length at the same time simplifies matters, and might help with IDs later to sort out freezer mishaps. For large fish (e.g., salmon, carp, and steelhead which can be greater than 40 lb) there will be times that it is necessary to process fish in the field.

Whole fish will be wrapped in aluminum foil and frozen on dry ice for transport to the laboratory, where they will be stored frozen at -20°C. Fish will be kept frozen wrapped in foil until the time of dissection. Dissection and compositing of muscle tissue samples will be performed following USEPA guidance (USEPA 2000). At the time of dissection, fish will be placed in a clean lab to thaw. After thawing, fish will cleaned by rinsing with de-ionized (DI) and ASTM Type II water, and handled only by personnel wearing polyethylene or powder-free nitrile gloves (glove type is analyte dependent). All dissection materials will be cleaned by scrubbing with Micro® detergent, rinsed with tap water, DI water, and finally ASTM Type II water.

Composites will be created based on the 75% rule recommended by USEPA (2000). In general, fish will have the skin dissected off, and only the fillet muscle tissue will be used for analysis. This is inconsistent with the guidance of USEPA (2000) that recommends that fish with scales have the scales removed and be processed with skin on, and skin is only removed from scaleless fish (e.g. catfish). The BOG is aware of this difference, but favors skin removal. Skin removal has been repeatedly used in past

California monitoring. All fish (with limited exceptions) in Toxic Substances Monitoring Program, the Coastal Fish Contamination Program, and the Fish Mercury Project have also been analyzed skin-off. Processing fish with the skin on is very tedious and results in lower precision because the skin is virtually impossible to homogenize thoroughly and achieving a homogenous sample is difficult. Also, skin-on preparation actually dilutes the measured concentration of mercury because there is less mercury in skin than in muscle tissue. The most ubiquitous contaminant in fish in California that leads to most of our advisories is methylmercury. By doing all preparation skin-off we will be getting more homogeneous samples, better precision for all chemicals, and definitely a better measure of mercury concentrations, which are our largest concern. The analysis of axial fillets without skin was also advised by a bi-national workgroup concerning the monitoring and analysis of mercury in fish (Wiener et al. 2007).

Mercury will be analyzed according to EPA 7473, "Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry" using a Direct Mercury Analyzer. Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Three blanks, a standard reference material (such as IAEA-407 or NRCC DORM-3), as well as a method duplicate and a matrix spike pair will be run with each set of samples.

Selenium will be digested according to EPA 3052M, "Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices", modified, and analyzed according to EPA 200.8, "Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry". Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Two blanks, a standard reference material (2976 or NRCC DORM-3), as well as a method duplicate and a matrix spike pair will be run with each set of samples.

Organics analyses will be performed by the California Department of Fish and Game Water Pollution Control Lab in Rancho Cordova, CA. Organochlorine pesticides, PCBs, and PBDEs will be analyzed according to WPCL-GC-006 "Analysis of Extractable Synthetic Organic Compounds in Tissues and Sediment (including Organochlorine Pesticides, Polychlorinated Biphenyls (PCBs) and PBDEs) by GC/ECD or Gas Chromatography with detection and quantitation by tandem mass spectrometry (MSMS). Microcystins and microcystin metabolites will be analyzed according to WPCL-LC-065, "Determination of Microcystins and Microcystin Metabolites in Water and Tissue by Enhanced LC/MS/MS." Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be

performed after every 10 samples. Initial and continuing calibration verification values must be within ±25% of the true value, or the previous 10 samples must be reanalyzed. One blank, a laboratory control spike (LCS), a CRM (if available), and a method duplicate and a matrix spike pair will be run with each set of samples.

## F. Analytes

Table 5 provides a summary of list of analytes for the study. Since the study is focused on assessing the impacts of bioaccumulation on the fishing beneficial use, the list is driven by concerns over human exposure. Contaminants were included if they were considered likely to provide information that is needed to answer the management questions for the study (see pages 6-7). A detailed list of analytes is provided in Table 6.

Additional discussion of the analytes is provided below.

### Ancillary Parameters

Ancillary parameters to be measured in the lab include moisture and lipid (Table 6). Fish sex will also be determined for all samples as it comes at no extra cost and can be valuable in interpreting the data. Each fish collected will be linked to the latitude/longitude where it was collected.

### Methylmercury

Methylmercury is the contaminant of greatest concern with respect to bioaccumulation on a statewide basis. Based on past monitoring (reviewed by Davis et al. 2007), methylmercury is expected to exceed thresholds of concern at many locations. Methylmercury will be measured as total mercury. Nearly all of the mercury present in edible fish muscle is methylmercury, and analysis of fish tissue for total mercury provides a valid, cost-effective estimate of methylmercury concentration (Wiener et al. 2007). Mercury will be analyzed in all samples because a substantial proportion of samples of each species are expected to exceed thresholds of concern.

### PCBs

PCBs are the contaminant of second greatest concern with respect to bioaccumulation on a statewide basis (Davis et al. 2007). PCBs will be analyzed using a congener specific method. A total of 55 congeners will be analyzed (Table 6). PCBs will be analyzed in one composite sample from each location. The species with the greatest expected concentrations (i.e., the organics indicator species where they are present) will be analyzed.

Legacy pesticides

Based on past monitoring (Davis et al. 2007), legacy pesticides are generally expected to exceed thresholds of concern in a very small percentage of California river and stream locations. Individual compounds recommended by USEPA (2000) will be analyzed (Table 6). Legacy pesticides will be analyzed in one composite sample from each location. The species with the greatest expected concentrations (i.e., the organics indicator species where they are present) will be analyzed.

Selenium

Past monitoring (e.g., Beckon et al. 2010) indicates that selenium concentrations are not likely to be above thresholds in this study. However, selenium analysis of one composite from each location was included primarily to support a national effort by USEPA to develop a selenium criterion for fish tissue.

PBDEs

Few data are currently available on PBDEs in California sport fish, and a threshold of concern has not yet been established. However, a rapid increase in concentrations in the 1990s observed in San Francisco Bay and other parts of the country raised concern about these chemicals, and led to a ban on the production and sale of the penta and octa mixtures in 2006 (Oros et al. 2005). The deca mixture is still produced commercially. A threshold of concern is anticipated to be established soon by USEPA. The most important PBDE congeners with respect to bioaccumulation are PBDEs 47, 99, and 100. Coverage of a larger number of locations was considered a higher priority than inclusion of PBDE analysis, which is relatively expensive ($584 per sample). PBDEs are presently a low priority due to the lack of accepted assessment thresholds. In addition, since PBDEs were not included in the lakes or coast surveys, there are no data to place river data in context. Archived samples will be available for analysis if PBDE analysis is desired in the future. The archiving plan will include selection of a subset of locations that are particularly valuable for trend analysis, and long-term storage of samples from these locations.

Dioxins and Dibenzofurans

Few data are available on dioxins and dibenzofurans in California sport fish. Perhaps the best dataset exists for San Francisco Bay, where samples from 1994, 1997, 2000, 2003, and 2006 indicated that concentrations in high lipid species exceeded a published screening value of 0.3 TEQs (for dioxins and furans only) by five fold (Greenfield et al. 2003). However, there are no known major point sources of dioxins in the Bay Area and the concentrations measured in the Bay are comparable to those in rural areas of the U.S. OEHHA did not include dioxins in their recent evaluation of guidance tissue levels for priority contaminants due to the lack of data for dioxins in fish throughout the state (Klasing and Brodberg 2008). Given the relatively high cost of

dioxin analysis and these other considerations, OEHHA recommended that dioxins not be included in this screening study (Table 7).

Organophophates, PAHs, TBT, and Cadmium

Past monitoring (e.g., San Francisco Bay work – SFBRWQCB 1995) indicates that concentrations of these chemicals in sport fish are generally far below thresholds of concern for human exposure. Therefore, they will not be included in the present study.

Other Emerging Contaminants

Other emerging contaminants are likely to be present in California sport fish. Examples include perfluorinated chemicals, other brominated flame retardants in addition to PBDEs, and others. Thresholds do not exist for these chemicals, so advisories or 303(d) listing are not likely in the near future. However, early detection of increasing concentrations of emerging contaminants can be very valuable for managers, as evidenced by the PBDE example. Measuring emerging contaminants would not directly address the management questions guiding this study, so analysis of these chemicals is not included in the design. Archives of each composite will be retained and made available for analysis of emerging contaminants in the future (see Section G). The archiving plan will include selection of a subset of locations that are particularly valuable for trend analysis, and long-term storage of samples from these locations with particular consideration given to evaluating trends in emerging contaminants.

Microcystin

Concerns regarding microcystin were described in Section III.B.

Omega-3 Fatty Acids

Klasing and Brodberg (2008) concluded that there is a significant body of evidence and general scientific consensus that eating fish at dietary levels that are easily achievable, but well above national average consumption rates, appears to promote significant health benefits, including decreased mortality, and that because of the unique health benefits associated with fish consumption, the advisory process should be expanded beyond a simple risk paradigm in order to best promote the overall health of the fish consumer. Much of the health benefits of fish consumption are derived from their relatively high content of key omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). When these data are available, OEHHA can take them into consideration in developing safe eating guidelines. Few data are available on the omega-3 content of wild fish. Due to the limited funding available, omega-3 fatty acids were not included on the analyte list.

## F. Quality Assurance

This effort will adhere to quality assurance requirements established for the SWAMP. A QAPP specific to this effort is in preparation (Bonnema 2011).

## G. Archiving

Samples will be stored in both short-term and long-term archives. Samples in the short-term archive are stored at -20 °C and are intended for use in the identification of short-term time trends (i.e. < 5-10 years), the investigation of yet unidentified chemical contaminants, and addressing quality assurance issues that may arise during the routine analyses of samples. These samples are intended for the analysis of chemicals which are not expected to degrade in five years of storage at -20 °C. The short-term archives will be located in an off-site freezer facility rented by Moss Landing Marine Laboratory. The facility is not equipped with a backup generator; however, in the event of power failure the facility contingency plan is to keep the freezer closed, providing maintenance of low temperatures for several days.

Through a partnership with the Regional Monitoring Program for Water Quality in the San Francisco Estuary, selected samples can also be stored in a state-of-the-art long-term storage facility operated by NIST (Klosterhaus 2010). Samples in this long-term archive will be stored at -150 °C in liquid nitrogen (LN2) vapor freezers and are primarily intended for use in the identification of time trends occurring over decadal time frames (i.e. > 10 years). Samples stored in LN2 vapor freezers are not expected to degrade over time and are thus reliable for chemical contaminant studies occurring well into the future. The long-term archive was established in 2010 and is located in the Marine Environmental Specimen Bank (Marine ESB), operated by NIST at the Hollings Marine Laboratory in Charleston, SC. The Marine ESB is characterized by having well-developed banking protocols and standard operating procedures (SOPs), computerized sample tracking (chain-of-custody) systems, maintenance of many forms of data associated with original specimens, and large investments in state-of-the-art facilities and equipment required to store specimens over long periods of time. The Marine ESB emphasizes cryogenic storage using LN2 vapor storage freezers, security systems, and electronic monitoring of storage conditions 24 hours a day, 365 days a year. The Marine ESB also maintains high efficiency particulate air (HEPA)-filtered clean air laboratories for cleaning storage containers, preparing banked specimens for analysis, and processing and storing samples. Additional details about the Marine ESB facility are described in Pugh et al. (2007).

A number of small volume sub-samples, rather than one or two large volume samples, are prepared for archiving to avoid subjecting the samples to several freeze-thaw cycles. Each sub-sample contains a sufficient amount of material for most chemical analysis, and when needed, can be removed from the freezer and sent to the appropriate laboratory without the need to sub-sample.

For routine sampling locations, up to five 50 g aliquots of each composite analyzed for organics will be archived. This will provide an integrative, representative sample for each location that can be reanalyzed in later years to confirm earlier analyses, look for new chemicals of concern, provide material for application of new analytical methods, provide material for other ecological research, and other purposes. Samples for the short-term archive will be stored in either glass jars with Teflon-lined lids for non-fluorinated organic chemical and trace metal analysis or in polyethylene (PE) or polypropylene (PP) for fluorinated chemical (i.e. PFCs) or trace metals analysis. Four of the five archive jars will be glass with a Teflon lined lid (e.g., I-Chem 200 series glass jars). One separate aliquot will be kept in a polypropylene jar for potential analysis of perfluorinated compounds. These archived samples will be stored at -20°C.

At sites considered a high priority for trend analysis of emerging contaminants (Table 2), five aliquots will be archived. Three of the five archived aliquots will be stored in the long-term archive at NIST. Two 15-20 g aliquots for the long-term archive will be stored in two 22 ml Teflon jars for non-fluorinated organic chemical and trace metal analysis and one 15-20 g aliquot in two 10 ml PP cryovials for fluorinated chemical analysis (in order to obtain sufficient mass for future analysis, two cryovials will replace one standard archive jar). Glass and PE/PP containers are the least expensive containers and thus are used when possible; however, only Teflon and PP cryovials are able to withstand liquid nitrogen temperatures for long periods without shattering and are therefore used for storing samples in the long-term archive. The other two of the five aliquots will be stored in 50 g glass jars with Teflon lids and archived at -20C.

Teflon and cryo-containers used for the storage of samples in the long-term archive are pre-cleaned by NIST Marine ESB personnel using established protocols (Pugh et al. 2007) and shipped to SFEI contract laboratories or designated field personnel for use. For storage of samples in the short-term archive, glass and plastic containers are pre-cleaned using appropriate acids or solvents by MPSL-DFG or purchased pre-cleaned commercially (e.g. from Fisher or ESS Vial). For containers purchased ‘pre-cleaned’ from ESS Vial or other companies, a minimum of two per shipment will not be opened and kept in storage with the other samples in case container contamination issues arise.

## H. Ancillary Data

In addition to the primary and secondary target species, other species will also be observed in the process of sample collection. This “bycatch” will not be collected, but the sampling crew will record estimates of the numbers of each species observed. This information may be useful if followup studies are needed in any of the sampled locations.

## I. Timing

Sampling will be conducted from February 2011 through November 2011. Seasonal variation in body condition and reproductive physiology are recognized as factors that could affect contaminant concentrations. However, sampling as many

locations as possible is essential to a statewide assessment, and it will take this many months to sample the locations targeted.

## J. Data Assessment

MQ1 will be assessed by comparing results from each location to thresholds established by OEHHA in Klasing and Brodberg (2008) (Table 7). Maps, histograms, and frequency distributions will be prepared to summarize these comparisons.

MQ2 will be assessed in consultation with OEHHA.

## K. Products and Timeline

A report on the 2011 sampling will be drafted by January 2013. The final report, incorporating revisions in response to reviewer comments, will be completed and released in May 2013.

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Table 1. Bioaccumulation monitoring assessment framework for the fishing beneficial use.

***D.1. Determine the status of the fishing beneficial use throughout the State with respect to bioaccumulation of toxic pollutants***

D.1.1 What are the extent and location of water bodies with sufficient evidence to indicate that the fishing beneficial use is at risk due to pollutant bioaccumulation?

D.1.2 What are the extent and location of water bodies with some evidence indicating the fishing beneficial use is at risk due to pollutant bioaccumulation?

D.1.3 What are the extent and location of water bodies with no evidence indicating the fishing beneficial use is at risk due to pollutant bioaccumulation?

D.1.4 What are the proportions of water bodies in the State and each region falling within the three categories defined in questions D.1.1, D.1.2, and D.1.3?

***D.2. Assess trends in the impact of bioaccumulation on the fishing beneficial use throughout the State***

D.2.1 Are water bodies improving or deteriorating with respect to the impact of bioaccumulation on the fishing beneficial use?

D.2.1.1 Have water bodies fully supporting the fishing beneficial use become impaired?

D.2.1.2 Has full support of the fishing beneficial use been restored for previously impaired water bodies?

D.2.2 What are the trends in proportions of water bodies falling within the three categories defined in questions D.1.1, D.1.2, and D.1.3 regionally and statewide?

***D.3. Evaluate sources and pathways of bioaccumulative pollutants impacting the fishing beneficial use***

D.3.1 What are the magnitude and relative importance of pollutants that bioaccumulate and indirect causes of bioaccumulation throughout each Region and the state as a whole?

D.3.2 How is the relative importance of different sources and pathways of bioaccumulative pollutants that impact the fishing beneficial use changing over time on a regional and statewide basis?

***D.4. Provide the monitoring information needed to evaluate the effectiveness of management actions in reducing the impact of bioaccumulation on the fishing beneficial use***

D.4.1 What are the management actions that are being employed to reduce the impact of bioaccumulation on the fishing beneficial use regionally and statewide?

D.4.2 How has the impact of bioaccumulation on the fishing beneficial use been affected by management actions regionally and statewide?

Table 2. Sampling locations.

| Region | Station Code | Station Name | Rationale | Trend Station | SPoT Station | Target Specie | Target Latitude | Target Longitude |
|---|---|---|---|---|---|---|---|---|
| 1 | 111VD6485 | Van Duzen River near Dinsmore | Replaced Smith River @ Crescent City | X | | trout | 40.48892 | -123.62577 |
| 1 | 103SFSRGC | South Fork Smith River near Goose Creek | ranked high by Stienstra | | | trout | 41.68481 | -123.91932 |
| 1 | 109MADHAT | Mad River (Mad River Fish Hatchery) | Requested by RB | | | steelhead | 40.85413 | -123.99074 |
| 1 | 111EELFCS | Eel River (Van Arsdale Fishing Counting Stati | Requested by RB | | | salmon | 39.38569 | -123.11677 |
| 1 | 113GUASRP | Gualala River, South Fork near Rockpile Creek | ranked high by Stienstra | | | trout | 38.75050 | -123.47024 |
| 1 | 114CCPOTV | Cold Creek at Potter Valley | ranked high by Stienstra | | | trout | 39.24405 | -123.12179 |
| 1 | 114RURHAT | Russian River (Coyote Valley Dam Egg Collection Site) | Large amount industry/agriculture | | | steelhead | 39.19679 | -123.18668 |
| 1 | 114LDSROR | Laguna de Santa Rosa at Occidental Rd | Large immigrant population catching | X | | blackfish? | 38.42381 | -122.82803 |
| 1 | 105KLMHAT | Klamath River (Iron Gate FH) | Microcystin, Huge Tribal fishery | | | salmon | 41.92956 | -122.44210 |
| 1 | 105KLAMOR | Klamath River at Orleans | ranked high by Stienstra | X | | trout | 41.30162 | -123.53607 |
| 1 | 106TRWILC | Trinity River at Willow Creek | ranked high by Stienstra | X | | trout | 40.93784 | -123.61863 |
| 5 | 541MER522 | San Joaquin River at Lander Avenue | ranked high by Stienstra | X | X | trout, largemouth bass | 37.29528 | -120.85028 |
| 5 | 506SHA950 | Pit River at Big Bend | ranked high by Stienstra | | | trout | 41.02071 | -121.91032 |
| 5 | 526FRIRMA | Fall River at Island Road near McArthur | ranked high by Stienstra | | | trout | 41.08887 | -121.49308 |
| 5 | 526HCRDOS | Hat Creek downstream Old Station | Se data would be helpful for comparison to the Hg data. | | | trout | 40.73061 | -121.43757 |
| 5 | 505MRLFFC | McCloud River at Lower Falls below Fowlers Camp | ranked high by Stienstra | | | trout | 41.24317 | -122.02470 |
| 5 | 525SRCCSP | Sacramento River near Castle Crags State Park | ranked high by Stienstra | | | trout | 41.14893 | -122.31209 |
| 5 | 508ADVSBB | Sacramento River at Bend Bridge Near Red Bluf | ranked high by Stienstra | X | | trout, pike minnow, sucker | 40.25283 | -122.22667 |
| 5 | 520SACLSA | Sacramento River at Colusa near Bridge Street | already 303(d) listed for PCBs | X | X | largemouth bass, trout, sunfish,striped bass | 39.21415 | -122.00031 |
| 5 | 515FRUPYC | Feather River upstream Yuba City | OCs TMDL underway; important site for future Hg control program compliance | X | | largemouth bass, trout, striped bass | 39.33486 | -121.63230 |
| 5 | 510INDM44 | Sacramento River at RM44 | already 303(d) listed for PCBs. However, this is a good long-term monitoring location. Delta Hg Control Program compliance location. | X | X (3.5 mi upstream of SPoT) | largemouth bass | 38.43520 | -121.51960 |
| 5 | 510ST1492 | San Joaquin River off Pt Antioch near fishing | OCs TMDL underway. Very near Delta Hg Control Program compliance location. | X | | striped bass, largemouth bass, catfish | 38.03233 | -121.76566 |

Table 2. Sampling locations.

| Region | Station Code | Station Name | Rationale | Trend Station | SPoT Station | Target Specie | Target Latitude | Target Longitude |
|---|---|---|---|---|---|---|---|---|
| 5 | 519SWPDCP | American River near Discovery Park | more PCBs data and Se data might be useful | X | X | largemouth bass, catfish, sunfish | 38.59970 | -121.50550 |
| 5 | 518SPCOCR | Spanish Creek at Oakland Camp Road crossing | Could be important to Tribes. | | | trout | 39.97902 | -120.90526 |
| 5 | 518PLU901 | Feather River Middle Fork at Sloat | ranked high by Stienstra | | | trout | 39.86085 | -120.72789 |
| 5 | 518SED030 | Warner Creek 30 | Could be important to Tribes. | | | trout | 40.36374 | -121.30668 |
| 5 | 518SED082 | Jamison Creek 82 | Could be important to Tribes. Also, a mine cleanup is planned for 2011 that could affect fish Hg levels. | | | trout | 39.74051 | -120.70642 |
| 5 | 518MFFRUC | Feather River, Middle Fork upstream Clio | ranked high by Stienstra | X | | trout | 39.74776 | -120.56605 |
| 5 | 518NFFRBB | Feather River, North Fork above Beldon Bridge | close to site ranked high by Stienstra (below Bridge site catch and release only) | | | trout | 40.01370 | -121.22616 |
| 5 | 517YRSFNW | Yuba River, South Fork near Washington | ranked high by Stienstra | | | trout | 39.36081 | -120.78331 |
| 5 | 517YRSFLS | Yuba River, South Fork upstream Lake Spaulding | ranked high by Stienstra | | | trout | 39.30588 | -120.53559 |
| 5 | 514RRRUBS | Rubicon River downstream Rubicon Springs | ranked high by Stienstra | | | trout | 39.02538 | -120.25095 |
| 5 | 514ARSFCL | American River, South Fork at Coloma | ranked high by Stienstra | | | trout | 38.80123 | -120.88978 |
| 5 | 541INDVRN | San Joaquin River at Vernalis (FMP) | OCs TMDL underway. However, this is a good long-term monitoring location. Delta Hg Control Program compliance location. Ranked high by Stienstra. | X | X | largemouth bass, catfish | 37.67130 | -121.25920 |
| 5 | 544MOKNH5 | Mokelumne River near I-5 | OC TMDL underway. Delta Hg Control Program compliance location. | X | X (5 mi away) | largemouth bass | 38.25593 | -121.44257 |
| 5 | 544LSAC12 | San Joaquin R at Louis Park | ranked high by Stienstra | X | | largemouth bass, catfish | 37.95558 | -121.34626 |
| 5 | 544MREMPC | Middle River near Empire Cut | OC TMDL underway. Very near Delta Hg Control Program compliance location. | X | | largemouth bass | 37.96942 | -121.53339 |
| 5 | 531ADVMOK | Mokelumne River (Mokelumne River FH) | Representative of steelhead/salmon in rivers. | X | | steelhead/salm | 38.2254 | -121.02562 |
| 5 | 540SJRMFA | San Joaquin River, Middle Fork near Agnew Mea | ranked high by Stienstra | | | trout | 37.67504 | -119.09097 |
| 5 | 537MCRABB | Merced River at Briceburg | ranked high by Stienstra | | | trout | 37.60495 | -119.96703 |
| 5 | 536TRCHEC | Tuolumne River at Cherry Creek | ranked high by Stienstra | | | trout | 37.88902 | -119.97229 |
| 5 | 532MFCRPP | Cosumnes River, Middle Fork at Pi Pi | Only public fishing site in the entire Cosumnes Watershed mentioned in the DFG Online Fishing Guide. | | | trout | 38.56680 | -120.44250 |
| 5 | 554KRKRNV | Kern River at Kernville | ranked high by Stienstra | | | trout | 35.75578 | -118.42219 |
| 6 | 633WCR004 | West Fork Carson River, at HWY 89 (Hope Valley) | ranked high by Stienstra | | | trout | 38.77819 | -119.91694 |

Table 2. Sampling locations.

| Region | Station Code | Station Name | Rationale | Trend Station | SPoT Station | Target Specie | Target Latitude | Target Longitude |
|---|---|---|---|---|---|---|---|---|
| 6 | 635MTR002 | Middle Truckee River, Below Bronco Cr | ranked high by Stienstra | X | | trout | 39.38455 | -120.02211 |
| 6 | 632ECR009 | Carson River, East Fork upstream of Hangman's | ranked high by Stienstra | | | trout | 38.65837 | -119.72553 |
| 6 | 630EWK002 | East Walker River below Bridgeport Reservoir | Microcystin | X | | trout | 38.34209 | -119.20743 |
| 6 | 630VIR002 | Virginia Creek S of Bridgeport | ranked high by Stienstra | | | trout | 38.15060 | -119.18927 |
| 6 | 631WWK011 | West Walker River, near Chris Flat Campground | ranked high by Stienstra | | | trout | 38.39542 | -119.45165 |
| 6 | 637CE0143 | Susan River 0.6mi above Jensen Slough | requested by RB6 | X | | trout | 40.41203 | -120.64571 |
| 6 | 630BUC003 | Buckeye Cr, above Eagle Cr (abv campground) | ranked high by Stienstra | | | trout | 38.23491 | -119.35887 |
| 6 | 601LVC001 | Lee Vining Cr, at Moraine Camp | ranked high by Stienstra | | | trout | 37.92998 | -119.16364 |
| 6 | 603LOW009 | Owens River at Hwy 6 | ranked high by Stienstra | X | | trout | 37.39752 | -118.35485 |
| 6 | 603BSP009 | Bishop Creek near USFS boundary | ranked high by Stienstra | | | trout | 37.33046 | -118.49630 |
| 6 | 603BIG003 | Big Pine Creek, near USFS boundary | ranked high by Stienstra | | | trout | 37.14488 | -118.31767 |
| 6 | 603IND002 | Independence Creek above Independence | ranked high by Stienstra | | | trout | 36.79825 | -118.20801 |
| 6 | 603LPC001 | Lone Pine Creek, at USGS gage | ranked high by Stienstra | | | trout | 36.60118 | -118.08231 |
| 7 | 715CRBLYT | Colorado River at Blythe | ranked high by Stienstra | X | | largemouth bass, bluegill, catfish | 33.76634 | -114.50677 |
| 8 | 801SARERL | Santa Ana River E of Redlands | ranked high by Stienstra | X | | trout | 34.18105 | -116.92853 |

Table 3. Target species and their characteristics.

| | Foraging Type | | Trophic Level | Distribution | | | |
|---|---|---|---|---|---|---|---|
| Species | Water column | Bottom feeder | | Low Eleva-tion | Foothi lls | High Elevati on | Priority for Collection |
| Largemouth bass | X | | 4 | **X** | **X** | | **1** |
| Smallmouth bass | X | | 4 | x | **X** | | 2 |
| Spotted bass | X | | 4 | x | **X** | | 2 |
| Sacramento pikeminnow | X | | 4 | x | x | | 2 |
| Striped bass | X | | 4 | x | | | 2 |
| White catfish | | X | 4 | x | x | | 2 |
| Brown bullhead | | X | 3 | x | | | 2 |
| Channel catfish | | X | 4 | **X** | **X** | | **1** |
| Common carp | | X | 3 | **X** | **X** | | **1** |
| Sacramento sucker | | X | 3 | x | x | | 2 |
| Tilapia | | X | 3 | | | | 2 |
| Bluegill | X | | 3 | **X** | **X** | | 2 |
| Green sunfish | X | | 3 | **X** | **X** | | 2 |
| Black crappie | X | | 3/4 | x | x | | 2 |
| Redear sunfish | X | | 3 | **X** | **X** | | 2 |
| Rainbow trout | X | | 3 | x | x | **X** | **1** |
| Brown trout | X | | 3/4 | | x | x | **1** |
| Brook trout | X | | 3 | | | x | 2 |

Trophic levels are the hierarchical strata of a food web characterized by organisms that are the same number of steps removed from the primary producers. The USEPA's 1997 Mercury Study Report to Congress used the following criteria to designate trophic levels based on an organism's feeding habits:

Trophic level 1: Phytoplankton.
Trophic level 2: Zooplankton and benthic invertebrates.
Trophic level 3: Organisms that consume zooplankton, benthic invertebrates, and TL2 organisms.
Trophic level 4: Organisms that consume trophic level 3 organisms.

**X widely abundant** X less widely abundant "A" primary target for collection "B" secondary target for collection

Table 4. Target species, size ranges, and processing instructions.

| | Process as Individuals and/or Composites | Process for Organics: 1=first choice, 2=second choice | Numbers and Size Ranges (mm) |
|---|---|---|---|
| **Primary Targets** | | | |
| **Group 1: Pelagic Predators** | | | |
| Black bass (largemouth, smallmouth, spotted) | I* | 2 | 2X(200-249), 2X(250-304), 5X(305-407), 2X(>407) |
| Striped bass | I* | 2 | 2X(<250), 2X(250-457), 6X(>457) |
| Sacramento pikeminnow | I* | 2 | 3X(200-300), 3X(300-400), 3X(400-500) |
| Rainbow trout | C* | 2 | 5X(300-400) |
| Brown trout | C* | 2 | 5X(300-400), and keep up to five fish > 400 if present |
| Brook trout | C* | 2 | 5X(300-400), and keep up to five fish > 400 if present |
| **Group 2: Bottom feeder** | | | |
| White catfish | C | 1 | 5X(229-305) |
| Channel catfish | C | 1 | 5X(375-500) |
| Common carp | C | 1 | 5X(450-600) |
| Brown bullhead | C | 1 | 5X(262-350) |
| Sacramento sucker | C | 1 | 5X(375-500) |
| **Secondary Targets: collect these if primary targets are not available** | | | |
| Bluegill | C | 2 | 5X(127-170) |
| Redear sunfish | C | 2 | 5X(165-220) |
| Black crappie | C | 2 | 5X(187-250) |
| Tilapia | C | 2 | ?? |
| Green sunfish | C | 2 | ?? |
| Kokanee | | 2 | ?? |

I* - process as individuals for mercury, also prepare a composite using middle of size range for selenium and if other species are not available for organics;
C* - process as composites, but as individuals for mercury if fish > 400 mm are collected

Table 5. Summary of analytes included in the study.

| **Analyte** | **Included in Screening Study?** |
|---|---|
| Methylmercury[1] | Some individuals, all composites |
| Selenium | All composites |
| PCBs | One composite per location |
| DDTs | One composite per location |
| Dieldrin | One composite per location |
| Aldrin | One composite per location |
| Chlordanes | One composite per location |
| Microcystins | Included at two locations and a hatchery |
| PBDEs | Not included |
| Dioxins | Not included |
| Perfluorinated chemicals | Not included |
| Omega-3 fatty acids | Not included |

[1] Measured as total mercury, which provides a direct estimate of methylmercury in fish muscle.

Table 6. Parameters to be measured.

## FISH ATTRIBUTES

1. Total length
2. Fork length
3. Weight
4. Sex
5. Moisture
6. Lipid content

## METALS AND METALLOIDS

1. Total mercury
2. Selenium

## PESTICIDES

### Chlordanes

1. Chlordane, cis-
2. Chlordane, trans-
3. Heptachlor
4. Heptachlor epoxide
5. Nonachlor, cis-
6. Nonachlor, trans-
7. Oxychlordane

### DDTs

1. DDD(o,p')
2. DDD(p,p')
3. DDE(o,p')
4. DDE(p,p')
5. DDMU(p,p')
6. DDT(o,p')
7. DDT(p,p')

Table 6. Parameters to be measured (continued).

### Cyclodienes

1. Aldrin
2. Dieldrin
3. Endrin

### HCHs

1. HCH, alpha
2. HCH, beta

### Others

1. Dacthal
2. Endosulfan I
3. Hexachlorobenzene
4. Methoxychlor
5. Mirex
6. Oxadiazon

### PCBs

1. PCB 008
2. PCB 011
3. PCB 018
4. PCB 027
5. PCB 028
6. PCB 029
7. PCB 031
8. PCB 033
9. PCB 044
10. PCB 049
11. PCB 052

Table 6. Parameters to be measured (continued).

12. PCB 056
13. PCB 060
14. PCB 064
15. PCB 066
16. PCB 070
17. PCB 074
18. PCB 077
19. PCB 087
20. PCB 095
21. PCB 097
22. PCB 099
23. PCB 101
24. PCB 105
25. PCB 110
26. PCB 114
27. PCB 118
28. PCB 126
29. PCB 128
30. PCB 137
31. PCB 138
32. PCB 141
33. PCB 146
34. PCB 149
35. PCB 151
36. PCB 153
37. PCB 156
38. PCB 157
39. PCB 158
40. PCB 169
41. PCB 170

Table 6. Parameters to be measured (continued).

42. PCB 174
43. PCB 177
44. PCB 180
45. PCB 183
46. PCB 187
47. PCB 189
48. PCB 194
49. PCB 195
50. PCB 198/199
51. PCB 200
52. PCB 201
53. PCB 203
54. PCB 206
55. PCB 209

## Algal Toxins

Microcystins
1. MC-RR
2. MC-LR
3. MC-YR
4. MC-LA

MC metabolites
1. Desmethyl-LR
2. Desmethyl-RR

Cyanotoxins
1. anatoxin a

Table 7. Assessment thresholds (ng/g wet weight).

**Thresholds for concern based on an assessment of human health risk from these pollutants by OEHHA** (Klasing and Brodberg, 2008). All values given in ng/g (ppb). The lowest available threshold for each pollutant is in bold font. One serving is defined as 8 ounces (227 g) prior to cooking. The FCG and ATLs for mercury are for the most sensitive population (i.e., women aged 18 to 45 years and children aged 1 to 17 years).

| Pollutant | Fish Contaminant Goal | Advisory Tissue Level (3 servings/week) | Advisory Tissue Level (2 servings/week) | Advisory Tissue Level (No Consumption) |
|---|---|---|---|---|
| Chlordanes | **5.6** | 190 | 280 | 560 |
| DDTs | **21** | 520 | 1000 | 2100 |
| Dieldrin | **0.46** | 15 | 23 | 46 |
| Mercury | 220 | **70** | 150 | 440 |
| PCBs | **3.6** | 21 | 42 | 120 |
| Selenium | 7400 | **2500** | 4900 | 15000 |


Figure 1. Example of the 0.5 mi sampling radius surrounding each sampling location.