SWAMP
Surface Water Ambient Monitoring Program

Final Monitoring Plan	June 2015

SAMPLING AND ANALYSIS PLAN FOR LONG-TERM MONITORING OF BASS LAKES AND RESERVOIRS IN CALIFORNIA

The Bioaccumulation Oversight Group (BOG)
Surface Water Ambient Monitoring Program

SWAMP-MP-SB-2016-0001

CALIFORNIA Water Boards

www.waterboards.ca.gov/swamp

FINAL

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ACKNOWLEDGEMENTS

This Sampling Plan was prepared by the San Francisco Estuary Institute (SFEI) and Moss Landing Marine Laboratory (MLML) on behalf of the Bioaccumulation Oversight Group (BOG) and the Surface Water Ambient Monitoring Program (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 long-term program to track status and trends in concentrations of contaminants in the many California lakes and reservoirs (collectively referred to as "lakes" in this document) where bass species are present. This work will be performed as part of the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). The SWAMP mission is to provide resource managers, decision makers, and the public with timely, high-quality information to evaluate the condition of all waters throughout California.

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

A subcommittee of the Roundtable, the Bioaccumulation Oversight Group (BOG), focuses on bioaccumulation monitoring. The BOG is composed of State and Regional Water Board staff and representatives from other agencies and organizations including USEPA, the Department of Fish and Wildlife, the Office of Environmental Health Hazard Assessment, 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 and Analysis 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),
- a two-year screening survey of the California coast (2009 and 2010),
- a one-year survey of California rivers and streams (2011),
- a two-year study of mercury accumulation in grebes on California lakes and reservoirs (2012-2013), and
- a one-year study (2014) of lakes with relatively low concentrations of contaminants in sport fish.

Final reports on the sport fish surveys are available (Davis et al. 2010; Davis et al. 2012; Davis et al. 2013; http://www.mywaterquality.ca.gov/monitoring_council/bioaccumulation_oversight_group/#mpr).

II. GENERAL ASPECTS OF THE SWAMP BIOACCUMULATION MONITORING PROGRAM

A. 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 (Table 1) in support of the SWAMP mission. This assessment framework is consistent with the 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 the most cost-effective tool for evaluating trends for many contaminants. Monitoring status and trends in bioaccumulation will provide 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.

SWAMP sport fish surveys have done a great deal to document the status of bioaccumulation impacts on beneficial uses in California. Mercury has been shown to be a particular concern across all water body types, and this has triggered the development of a statewide TMDL for mercury in reservoirs. The SWAMP wildlife study conducted in 2012 and 2013 provided a means of estimating risk and impacts to aquatic life beneficial uses based on mercury concentrations observed in fish (Ackerman et al. in prep). However, the initial status information generated by SWAMP is now almost 10 years old. It is now an appropriate time for SWAMP to establish a plan for meeting the objectives of SWAMP and the bioaccumulation monitoring program by providing updated information on status and tracking trends for bioaccumulative contaminants.

This sampling and analysis plan represents the first step in developing a long-term program to provide status and trend monitoring of bioaccumulation across the three major water body categories that support the fishing beneficial use: lakes and reservoirs, rivers and streams, and the coast. Within these water body categories, different subcategories have different sampling needs (Table 2).

Some subcategories have or will have a need for annual monitoring. The Delta Regional Monitoring Program (Delta RMP), for example, has identified a need for annual sampling of black bass (a term encompassing largemouth, smallmouth, and spotted bass) in the Delta to provide a baseline and track trends in support of the Delta Methylmercury TMDL (row 6 of Table 2). Similarly, reservoirs where actions are taken

as part of the statewide mercury TMDL will need to be monitored on an annual basis to determine the effectiveness of actions that are taken to reduce mercury bioaccumulation (row 3 of Table 2).

A need for monitoring of sites within San Francisco Bay on a five-year cycle has been identified and is being met by the Bay RMP.

For water bodies where bioaccumulation has been determined to be a concern, a 10-year cycle for providing updated information on status would be a practical minimum revisit frequency. The information generated from these updates will be useful to the state and regional boards in impairment assessments and 303(d) list updates.

Other subcategories of water bodies have been shown to generally be of low concern with respect to bioaccumulation. These water bodies should still be revisited periodically, but can be revisited less frequently than the water bodies with contamination problems. Chief among these are numerous lake and river sites where trout have been sampled and found to have low concentrations of contaminants. A 20-year cycle would be sufficient for these water bodies.

Some of the monitoring that is needed will be provided by other programs. Other programs (TMDL program, Delta RMP, and Bay RMP) are expected to provide the sampling that is needed on one-year and five-year cycles. An appropriate role for SWAMP is to address the needs that are not being covered by other programs.

Lakes with black bass account for a large number and proportion of the water bodies that are not being covered by other programs and need to be sampled at a 10-year frequency. A list of 187 priority bass lakes that the regional boards are interested in monitoring has been developed. This document presents a long-term plan for repeated, systematic sampling of these water bodies.

III. SAMPLING DESIGN

A. Management Questions for this Study

Two primary management questions have been articulated to guide the design of this long-term monitoring effort. In addition, two secondary management questions have been identified to guide interpretation of the results of the monitoring.

1. Primary Management Questions

Management Question 1 (MQ1)

What are the recent average concentrations of contaminants of concern in each priority bass lake or reservoir?

Answering this question will address the critical need of managers and the public for timely, high-quality information on the status of contaminant bioaccumulation in priority water bodies. As mentioned above, this information will be useful to the state and regional boards in impairment assessments and 303(d) list updates. A list of priority bass lakes to include in this monitoring has been developed with input from the regional boards.

Mercury is the contaminant of greatest concern in most bass lakes and will be the primary focus of this monitoring. However, PCBs and organochlorine pesticides also reach levels of concern in a small subset of these lakes and will be monitored in those situations.

The data needed to answer this question are average concentrations of contaminants of concern in the species with a tendency to accumulate high concentrations. For mercury, top predators such as black bass tend to accumulate relatively high concentrations. Furthermore, black bass have been established as an excellent quantitative mercury bioaccumulation indicator for California because they are amenable to size-standardization. High-lipid, bottom-feeding species such as catfish, carp, and sucker have a tendency to accumulate relatively high concentrations of organic contaminants of concern (PCBs and legacy pesticides).

Management Question 2 (MQ2)

What is the trend in statewide average bass mercury concentrations in fish in priority bass lakes and reservoirs?

A statewide control program for mercury is being developed by the State Water Resources Control Board: (http://www.waterboards.ca.gov/water_issues/programs/mercury/). Mercury TMDLs also have been developed for other water bodies, including the Delta, San Francisco Bay, and some lakes and reservoirs. For all of the mercury control plans in the state, it is critically important to know whether food web mercury concentrations are trending up or

down on a regional or statewide scale. A statewide increasing trend could obscure the beneficial effects of management actions to reduce mercury bioaccumulation. In the absence of awareness of such a trend, false conclusions could be drawn that actions are not having the desired effect. On the other hand, the existence of a general declining trend could give the impression that actions are more effective than they actually are.

It is plausible to hypothesize that food web mercury could be increasing across the state, either due to increasing atmospheric mercury emissions in Asia (Chen et al. 2012, Drevnick et al. 2015) or due to global warming (Schneider et al. 2009). Several recent studies have reported evidence of regional increases in food web mercury in north-central North America (e.g., Monson 2009, Monson et al. 2011, Gandhi et al. 2014), although the most recent data from Minnesota suggest a return to a long-term pattern of decline (Bruce Monson, personal communication). Hypothesized causes of these regional trends include global atmospheric emissions, climate change, invasive species, and changes in food web structure.

The data needed to answer this question are measurements of statewide average concentrations that are repeated over time. The large number and wide distribution of bass lakes that have been identified as priorities for sampling provide a population of water bodies that can be sampled to assess statewide and regional trends in food web mercury over time. Repeated rounds of sampling of randomly selected subsets of these lakes would yield a time series of representative, average statewide concentrations. These statewide averages would be based on concentrations in black bass, which have been demonstrated to be indicator species that are representative of conditions in the water body where they are collected and that yield data that are comparable across water bodies and over time.

2. Secondary Management Questions to Guide Data Interpretation

a. What fractions of the lakes show decreases, increases, or no change in mercury concentration in fish?

Monitoring of mercury in clusters of lakes in other regions of North America have shown that temporal trends in fish mercury levels commonly vary among lakes, with some lakes showing decreases, some showing increases, and some showing no change. Examination of fish mercury levels from the small number of California lakes that have been sampled twice (first in 2007-2008 and again in 2012 or 2013) suggest that this outcome can be expected in California as well.

b. What factors appear to be driving changes in mercury concentrations in fish?

Environmental managers will want to know what causal factors of processes are contributing to such variability in temporal trends among lakes. The monitoring data obtained in this program will be used to develop hypotheses regarding factors and processes causing observed trends. The development of hypotheses may stimulate focused investigations by scientists in academic, state, and federal sectors.

B. Overall Approach

The overall approach to be taken to answer these two questions will be to establish a long-term cycle for sampling the 187 priority bass lakes and reservoirs that have been identified by the regional boards. Sampling of the entire group of lakes and reservoirs will occur in five biennial rounds of sampling over a 10-year period. The cycle will then be repeated. This effort will ensure that each of these lakes is sampled once every 10 years to provide updated information on concentrations of priority contaminants. By creating five randomly selected subsets (or "rotating panels") of the overall population, each round of sampling will yield a representative estimate of the statewide average mercury concentration that will add to a long-term time series to allow evaluation of the statewide trend in food web mercury.

C. Coordination

The BOG is coordinating with other efforts to significantly leverage the SWAMP statewide monitoring funds available for this survey.

The Los Angeles Regional Water Quality Control Board (Region 4) will conduct extensive sampling of Region 4 lakes this summer. Seven Region 4 lakes that will be part of the first rotating panel for the statewide program will be covered by the Region 4 study. This will free up resources to sample an increased overall number of lakes in Panel 1.

The Regional Boards will be contacted prior to future rounds of sampling to explore opportunities for coordinated sampling, in-kind support, or direct funding of this sampling program.

D. Selection of Lakes to Be Sampled

The pool of lakes considered for sampling consisted primarily of those included in the 2007-2008 SWAMP lakes survey, with the addition of others sampled from 2002-2012 for which data were placed in the California Environmental Data Exchange Network (CEDEN), a centralized repository of data on California's water bodies, including streams, lakes, rivers, and the coastal ocean.

The focus of this monitoring effort is on lakes where black bass (largemouth bass, smallmouth bass, and spotted bass) are known to be present. Black bass are indicator species that are suited to answering the management questions with regard to mercury, the contaminant of greatest concern.

An initial list of candidate lakes for inclusion in this monitoring was developed based on past sampling. Lakes sampled by SWAMP in 2007-2008 included 222 lakes that were targeted as priorities for sampling by the regional boards, supplemented by a random sampling of 50 lakes. Lakes sampled by other programs and represented in CEDEN were another group of targeted lakes included on the initial list.

This initial list was reviewed by regional board staff, who decided which lakes should be included on the draft final list (Appendix 1) for their regions. In some cases, regional board staff identified bass lakes for inclusion that were not already on the initial list.

Lakes were included on the list whether they had high, moderate, or low concentrations of mercury, as tracking status and trends for all of these water bodies was considered important to managers. Some of the bass lakes included in previous sampling (especially some of the random lakes from the 2007-2008 SWAMP survey) were excluded because they are not publicly accessible for fishing.

A total of 187 bass lakes were included on the final list. The annual SWAMP bioaccumulation monitoring budget is sufficient for sampling about 35 lakes in any given year. A biennial sampling scheme can therefore cover the entire list over a 10-year period.

E. Design of the Long-Term Sampling Schedule

Any systematic schedule for revisiting each of the 187 lakes on a 10-year cycle would be sufficient to answer Management Question 1. The statistical ability and power to answer Management Question 2 (i.e., assess the trend in statewide average bass mercury concentration), however, depends on how the lakes are selected and sampled.

With regard to Management Question 2, the 187 priority bass lakes are being defined as the population of interest. One important feature of the sampling design in regard to assessing statewide trend in this population is that each round of sampling should be representative of the entire population of bass lakes. A probabilistic, or random, design is the best way to obtain a representative sample of the priority bass lakes with each round of sampling. Each round should be randomly drawn from the entire population. Randomized sampling would provide a practical and completely unbiased approach to inferring the condition of all priority bass lakes in the State from a limited sample of the whole population.

There are different ways in which these random draws could be done. One is a random draw with replacement. With this approach, in round one of sampling a subset of lakes (e.g., 38 lakes, or one-fifth of the 187 lakes) would be drawn from the overall pool of 187. In round two, another random draw would be made from the same overall pool of 187 lakes. While a random draw with replacement would be a good way of obtaining a representative statewide average concentration each year to answer Management

Question 2, it would not be compatible with the need to sample each of the 187 lakes on a 10-year cycle to answer Management Question 1.

A rotating panel design would provide a means of obtaining random rounds of sampling as well as a means of revisiting each priority bass lake on a predictable, fixed 10-year cycle. With a rotating panel design, round one of sampling would begin with a random draw of 38 lakes from the overall pool of 187 lakes. This first draw would establish one permanent group of lakes (Panel 1) that would be sampled in year 1 and then again in years 11, 21, and so on. The second draw of 38 lakes would be made from the remaining pool of 152 lakes to form Panel 2. Panel 2 would be sampled in years 3, 13, 23, and so on. Each of these rotating panels would represent a random sample of the entire population of 187 priority bass lakes.

Power analysis was conducted to assess whether sampling approximately 35 lakes per round could yield sufficient power to detect a statewide trend of a realistic magnitude in an acceptably short period of time, and how the design could be optimized to maximize power within resource constraints. Details of the methods and the results are presented in Appendix 2. The power analysis indicates that a design with biennial sampling of 10 fish from each of 30 lakes per year can detect a trend of 0.004 ppm/yr in 20 yr and a trend of 0.008 ppm/yr in 12 yr. Power would be only slightly better with 35 or 40 lakes, or with a larger number of fish. The biennial sampling scheme that works well given the resource constraints of the SWAMP bioaccumulation monitoring program does not yield much less power than an annual scheme, even assuming the same number of lakes (30) are sampled in both schemes.

How the rotating panels are selected is another consideration. The method of choice for developing an array of randomized monitoring locations is the generalized random tessellation-stratified (GRTS) approach developed for USEPA's Environmental Monitoring and Assessment Program (Stevens and Olsen 2004, Theobald et al. 2007). The GRTS approach achieves a random point distribution that is spatially balanced – in other words, it avoids the spatial clustering that often occurs in a conventional random sample.

The rotating panel design will provide a robust basis for estimating the trend in statewide average bass mercury concentration for the priority bass lakes. Another benefit of the randomization is that it will be possible to examine trends on a post-hoc basis in various strata at a finer scale. For example, trends may be different in different geographic regions or in lakes with different characteristics. The randomization built into the design will randomly place points in all of the strata that might be of interest. Of course, the power for evaluating these finer-scale trends will be lower due to the lower number of data points in each stratum, so longer time periods will be required to detect them.

Some of the lakes in a panel may not be accessible in the year in which they are designated for sampling. For example, the present year, 2015, is the fourth year of a drought and some lakes may not be accessible (boat ramps are above the water). Lakes

that are not sampled in their assigned year will be sampled either in the following calendar year (if possible) or in the next round of biennial bass lake sampling. The data for these lakes will be excluded from calculations of annual statewide means.

The panel assignments for the lakes included in this program are shown in Table 3.

F. Sampling Design At Each Lake

The goal of this sampling is to provide repeated measures of contaminant concentrations in fish to allow for status updates and assessment of long-term trends. The sampling therefore will largely replicate the approach used in prior sampling, whether the sampling was done as part of the 2007-2008 SWAMP survey (BOG 2007) or as part of another study. The one general difference from past sampling will be a narrower focus on mercury in black bass. Bass mercury will be measured in all of these lakes. PCBs and organochlorine pesticides will only be measured at a subset of the lakes that have relatively high concentrations of these chemicals. High-lipid bottom-feeders (e.g., carp or catfish) will be targeted for organics analysis.

1. Sport Fish

a. Targeted Species

This monitoring will focus on species that have been established as robust indicators in past sampling: bass species for mercury and high-lipid bottom-feeders for organics.

Methylmercury biomagnifies primarily through its accumulation in muscle tissue, so top predators such as largemouth bass tend to have the highest concentrations. Past sampling has demonstrated that measurement of mercury in individual largemouth bass yields data (size-standardized concentrations) that provide a reliable index of the degree of food web contamination in each lake, and that can be compared across lakes and within lakes over time.

In contrast, although the organic contaminants of concern biomagnify, they do so primarily through accumulation in lipid. Concentrations of organics are therefore 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.

Prior sampling for these mercury and organics indicator species has established a baseline against which future data can be compared to allow assessment of long-term trends.

If the target species are not available, other potential targets will be considered (Tables 4 and 5). 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. To cope with these differences in species availability, the sampling crew will have a prioritized menu of potential target species. Primary target species will be given the highest priority. If primary targets are not available in sufficient numbers, secondary targets will be collected.

Other species will also be observed in the process of electroshocking. 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 additional follow-up studies are needed at any of the sampled lakes.

b. Sampling Locations Within Each Lake

As much as possible, the same sampling locations visited in previous sampling will be visited again for this survey.

Lakes and reservoirs in California vary tremendously in size, from hundreds of small ponds less than 10 ha to Lake Tahoe at 50,000 ha. As lakes increase in size it becomes necessary to sample more than one location to obtain a representative characterization of the water body.

In sport fish sampling using an electroshocking boat, it is frequently necessary to sample over a linear course of 0.5 – 1 mi to obtain an adequate number of fish. A sampling location in this study can therefore be thought of as a circle with a diameter of 1 mile. For small lakes less than 500 ha in size, one sampling location covers a significant fraction of the surface area of the lake. Therefore, for lakes less than 500 ha, one location will be sampled. For lakes of medium size (500 – 1000 ha), two locations will generally be sampled. For lakes in the large (1000 – 5000 ha) and very large categories (>5000 ha), two to four locations will be sampled, with a goal of three locations for large lakes and four locations for very large lakes. Since the primary goal of the study is to characterize human exposure, the existing locations have been established near centers of fishing activity.

Decisions regarding the number and placement of any new locations will be made in consultation with Regional Board staff with local knowledge of the lakes. Criteria to be considered in determining the placement of sampling locations will include the existence of discrete centers of fishing activity, known patterns of spatial variation in contamination or other factors influencing bioaccumulation, road or boat ramp access, and possibly other factors.

c. Fish Size Ranges and Composite Preparation

Chemical analysis of mercury is relatively inexpensive, and SWAMP partners would like to be able to have statistical power to quantitatively answer questions related to mercury trends over time and differences among lakes. Consequently, the sampling design for the mercury indicator species includes analysis of mercury in individual fish. For the mercury indicator species, an analysis of covariance approach will be employed where possible, in which the size:mercury or age:mercury relationship will be established for each location and an ANCOVA will be performed. The ANCOVA will allow evaluation of differences in slope of the regression relation among the locations and comparison of mean concentrations and confidence intervals at a standardized total length, following the approach of Tremblay (1998). Experience applying this approach in past sampling indicates that to provide robust regressions, 11 fish spanning a broad range in size are needed (Davis et al. 2003, Melwani et al. 2007). The power analysis conducted to guide this sampling design (Appendix 2) indicated that increasing the number of fish per lake had little effect on power. The target number per lake was therefore kept at 11.

Chemical analysis of trace organics is relatively expensive, and the management questions established for this study can be adequately addressed with good information on average concentrations. Therefore the compositing strategy employed in the 2007-2008 survey will again be employed for these chemicals (Figures 2 and 3).

Specific size ranges to be targeted for each species are listed in Table 6. Black bass (including largemouth, smallmouth, and spotted bass) and Sacramento pikeminnow (included in Group 1) are the key mercury indicators. These species have a high trophic position and a strong size:mercury relationship. These species will be analyzed for mercury only (unless a bottom-feeding species is not present), and will be analyzed individually. 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 standardized total 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).

Catfish, carp, bullhead, and sucker are the primary targets for high-lipid bottom-feeders. These species will be analyzed for organics in selected lakes. 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). Samples for these species will be analyzed as composites.

Secondary targets have been identified (Table 6) for collection if the primary targets are not available. These species would be processed for potential analysis of mercury and organics. The samples would be analyzed as composites. The size ranges established for bottom-feeders 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 complications.

d. Compositing and Archiving

Strategies for compositing and archiving will vary somewhat for lakes of different size. The overall strategy will be described first for small lakes, followed by a discussion of the differences for larger lakes.

Small Lakes

Figure 2 illustrates the approach to be taken for the predator and bottom-feeding species in small lakes (<500 ha). As described above, the predator species will be analyzed for mercury only and as individual fish. All samples of the predator species will be analyzed. Small lakes will be treated as one sampling location, so fish from anywhere in the lake will be counted toward meeting the targets for each size range listed in Table 6. For ANCOVA, one common regression line will be developed to describe the size:mercury relationship for the lake as a whole. Aliquots from these samples will be archived after they are analyzed in case of any problems or other circumstances calling for reanalysis at a later time.

The bottom-feeding species in selected lakes will be analyzed as composites for organics (Figure 2). Two composite samples will be processed and analyzed. Aliquots from all composites will be archived in case of any problems or other circumstances calling for analysis or reanalysis at a later time.

Larger Lakes

For lakes in the medium, large, and very large categories the basic approach will be similar, with a couple of modifications. Figure 3 illustrates the approach using a medium lake as the example. The first difference from the small lake approach is that sampling locations will be treated discretely. For the predator species, this means that 12 fish spanning a wide range of sizes will be targeted for each location to support the development of a size:mercury regression and an estimated mean concentration at standardized total length for each location. From these location means a lake-wide mean can be calculated. Similarly, the design for large and very large lakes will treat each sampling location discretely, typically with three and four locations, respectively, in each lake.

For the bottom-feeder species, discrete composites will be prepared for each location. These composites will be homogenized, analyzed, and archived.

2. Prey Fish

Prey fish (25-100 mm) will be sampled using traps, seines, and dip nets from shoreline areas adjacent to the locations where sport fish are collected. Ten individuals each from the three most common prey fish species will be sampled from each lake. We will target the following primary prey fish target species at all lakes: Inland silversides, young-of-the-year largemouth bass, young-of-the-year bluegill, and threadfin shad. Other species that are within the target size range may be collected if the primary targets are not available. Efforts will be made to sample the same species across all lakes, and when not possible fish that overlap in trophic guild will be sampled. Extra species of fish in the correct size ranges will be retained, and decisions on species to analyze for mercury will be made after all fish are collected each year.

Prey fish will be composited by species in each lake and analyzed for mercury and selenium.

G. Sample Processing and Analysis

1. Sport Fish

Fish will be collected in accordance with MPSL-102a, Section 7.4 (Appendix 3). Whenever possible an electro-fishing boat will be used; however, it may be necessary to employ another method also described in Section 7.4.

The following adaptation to MPSL-102a, Section 7.4.5 (Appendix 3) has been made for this study: at the dock, each fish collected will be placed on a measuring board covered with a clean plastic bag; fork and total length will be recorded. Weight will be measured with a digital spring scale and recorded. Large fish will be partially dissected in the field using the following protocol: fish will be placed on a cutting board covered with a clean plastic bag where the head, tail, and guts are removed using a clean (laboratory detergent, DI) cleaver. The cleaver and cutting board will be re-cleaned between fish species, per site if multiple stations are sampled.

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., carp, which can be greater than 40 lb) there will be times when it is necessary to process fish in the field.

Whole fish or field-processed fish will be wrapped in aluminum foil and placed in a clean, labeled zipper-style bag. All samples will be kept cold on ice until frozen in a freezer or on dry ice within 24 hours of collection. Samples will be stored at -20°C at the laboratory until dissection and homogenization. Homogenates will also be frozen until analysis is performed. Frozen tissue samples have a 12-month hold time from the date of collection (USEPA 2000); however, the BOG Review Panel has advised that samples kept frozen, with minimal thaw-freeze cycles, for several years have no appreciable degradation of organic contaminants.

All sport fish will be dissected "skin off". This is inconsistent with the guidance of USEPA (2000) that recommends that fish with scales should have the scales removed and be processed with skin on, and skin should only be removed from scale-less 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 also have 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 mercury. 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).

Fish are filleted to expose the flesh. It is important to maintain the cleanliness of the tissue for analysis; therefore any flesh that has been in direct contact with the skin, with instruments in contact with skin, or with any potential contaminant surface such as foil or a plastic bag, must be eliminated from the analyzed sample. The exposed edges of the fillet should be trimmed by 1/4 inch with a clean scalpel or fillet knife to remove this potentially contaminated tissue.

How a sample is dissected is greatly dependent on the types of analyses being conducted. Tissue from individual fish for mercury analysis only will be dissected from the fillet above the lateral line. When composites must be created, equal tissue weights are taken from 5 individual fish following the 75% size rule recommended by USEPA (2000) and homogenized into a Location Composite with a target weight of 200 g or greater. Tissue for composites will be taken from the fillet of each fish above the lateral line and from the belly to include areas of higher lipid content. Figures 2 and 3 diagram compositing strategies and target sizes for predator and bottom species.

Mercury will be analyzed by the Moss Landing Marine Laboratory Marine Pollution Studies Lab according to USEPA Method 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-4), 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 Wildlife Water Pollution Control Lab in Rancho Cordova, CA. Organochlorine pesticides and PCBs 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)." 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 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.

It will be desirable in this monitoring program to statistically detect small, gradual changes in mercury levels in sport fish. During the course of this multi-decadal monitoring program, substantial changes may occur in the analytical methods, instrumentation, and personnel applied to the analyses of samples. Accordingly, accuracy, precision, and bias will be quantified and reported along with the contaminant data. Trends in quality assurance metrics should be examined to assess whether bias may have contributed to temporal trends in concentrations of bioaccumulative contaminants.

Xx add information on methods for aging using scales

H. Analytes in Sport Fish

Table 7 provides a summary list of sport fish analytes for the study. The monitoring is focused on tracking trends in 1) mercury in bass and 2) organics from lakes with relatively high organics concentrations. A detailed list of fish attributes and analytes is provided in Table 8.

Additional discussion of the analytes is provided below.

Ancillary Parameters

Each fish collected will be linked to the latitude/longitude where it was collected, and field measurements of length and weight will be documented as described above. Ancillary parameters to be measured in the lab include moisture and lipid (Table 8). Fish sex will 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.

Scales will be collected from black bass species and analyzed for age.

Methylmercury

Methylmercury is the contaminant of greatest concern with respect to bioaccumulation on a statewide basis (Davis et al. 2010). 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 lakes because of the high proportion of bass lakes with elevated concentrations, and an interest in tracking whether the few lakes with low concentrations remain that way.

PCBs

PCBs are the contaminant of second-greatest concern with respect to bioaccumulation on a statewide basis (Davis et al. 2010). PCBs will be analyzed using a congener-specific method. A total of 55 congeners will be analyzed (Table 8). PCBs will be analyzed in one composite sample from each lake. The species with the greatest expected concentrations (i.e., the organics indicator species where they are present) will be included. PCBs will be measured in lakes that had average sum of congener concentrations above 20 ppb in the most recent sampling, or on request from the Regional Boards.

Legacy Pesticides

Legacy pesticides may be present at concentrations of concern in some locations. Individual compounds recommended by USEPA (2000) will be analyzed (Table 8). The species with the greatest expected concentrations (i.e., the organics indicator species where they are present) will be analyzed. Organochlorine pesticides will be measured in lakes that had average DDT concentrations above 500 ppb in the most recent sampling, or on request from the Regional Boards.

I. Quality Assurance

This effort will adhere to quality assurance requirements established for the SWAMP. A QAPP that applies to this effort has been prepared (Bonnema 2015).

J. Archiving

1. Sport Fish

Sample aliquots will be stored in short-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 that 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 equipped with a backup generator in the event of a power outage.

A number of small-volume sub-samples, rather than one or two large-volume samples, will be prepared for archiving to avoid subjecting the samples to several freeze-thaw cycles. Each sub-sample will contain 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 each sampling location, up to three 40-50 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 or polypropylene for fluorinated chemical (i.e., PFCs) or trace metals analysis. Two of the three 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.

For storage of samples in the short-term archive, glass and plastic containers will be 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.

K. Ancillary Data

In addition to the primary and secondary target species, other species will 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 follow-up studies are needed in any of the sampled locations.

L. Timing

The first round of sampling will be conducted from June 2015 through November 2015. Seasonal variation in body condition and reproductive physiology, as well as limnological characteristics, are recognized as factors that could affect contaminant concentrations, so the period of sampling will be kept as narrow as possible.

M. Data Assessment

MQ1 will be assessed by calculating mean concentrations of priority contaminants in the priority bass lakes that are sampled. The current status will be evaluated by comparing sport fish results from each location to the regulatory thresholds developed by the Water Boards. The current concentrations and status will be compared to past concentrations and status.

MQ2 will be assessed by calculating the size-standardized mean concentrations of mercury in black bass from each priority water body, and then calculating the grand mean of these means. Eventually enough data points will be generated for this time series to allow analysis for a significant trend using regression. Simple linear regression and more complex multivariable regression models (e.g., include "lake" as a variable, as done in the power analysis [Appendix 2] will be explored.

N. Products and Timeline

A data report on this 2015 sampling will be drafted by March 2017. A fact sheet and a final data report, incorporating revisions in response to reviewer comments, will be completed and released in May 2017. The data will posted to the My Water Quality Portal in May 2017. A draft interpretive report on this monitoring effort will be prepared in March 2021 after the third round of sampling is conducted in 2019. The final interpretive report will be completed and released in May 2021.

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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. Draft long-term sport fish sampling schedule. X = funded by SWAMP, O = funded by another program

General water body category	**Specific category** (numbers are approximate)	**Revisit frequency for each water body**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Lakes	1) Bass Lakes (**n=190**) (Statewide Core Monitoring)	10 yr	X		X		X		X		O		O		O		O		
	2) Bass Lakes - those not yet sampled	One-time surveys		X		X													
	3) Bass Lakes - where actions are taken	1 yr		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
	4) Trout Lakes - <0.2 ppm (**n=90**)	20 yr												X	X	X			
	5) Trout Lakes - >0.2 ppm (n=5)	10 yr				X									X				
Rivers and Streams	6) Bass sites in Delta (n=10)	1 yr		O	O	O	O	O	O	O	O	O	O		O		O		O
	7) Other bass/sucker sites (n=10)	10 yr							X										X
	8) Trout Sites - <0.2 ppm (**n=50**)	20 yr																	X
	9) Trout Sites - >0.2 ppm (n=10)	10 yr							X										X
Coast	10) SF Bay	5 yr					O					O					O		
	11) SC Bight (n=27)	10 yr					O										O		
	12) Other coast zones (**n=35**)	10 yr						X										X	

Table 3. Panel assignments for the lakes included in the long-term sampling program.

Panel	Region	Map Label Number	Lake Name	County	siteID (draw #)	Latitude	Longitude
1	7	129	Havasu, Lake	San Bernardino	EQUAL-001	34.4025	-114.269
1	4	131	Crystal Lake	Los Angeles	EQUAL-002	34.3187	-117.847
1	9	185	Barrett		EQUAL-153	32.6917	-116.665
1	5	52	Berryessa, Lake	Napa	EQUAL-154	38.6155	-122.252
1	4	121	Elizabeth Lake	Los Angeles	EQUAL-155	34.666	-118.403
1	5	64	New Melones Lake	Calaveras, Tuolumne	EQUAL-156	37.9919	-120.507
1	5	83	McSwain, Lake	Mariposa	EQUAL-157	37.5164	-120.295
1	5	56	Beach Lake	Sacramento	EQUAL-158	38.4407	-121.485
1	1	1	Copco Lake	Siskiyou	EQUAL-159	41.9813	-122.302
1	5	117	Brite Valley Lake	Kern	EQUAL-160	35.1069	-118.543
1	5	41	Camp Far West Reservoir	Yuba, Placer, Nevada	EQUAL-161	39.0339	-121.283
1	4	157	La Mirada Park Lake	Los Angeles	EQUAL-162	33.904	-118.004
1	7	183	Sunbeam Lake	Imperial	EQUAL-163	32.7846	-115.688
1	5	98	O'Neill Forebay	Merced	EQUAL-164	37.0762	-121.039
1	5	59	Camanche Reservoir	San Joaquin, Amador, Ca	EQUAL-165	38.2186	-120.95
1	3	114	Santa Margarita Lake	San Luis Obispo	EQUAL-166	35.3216	-120.464
1	5	88	Eastman Lake	Madera, Mariposa	EQUAL-167	37.2245	-119.978
1	5	17	Butt Valley Reservoir	Plumas	EQUAL-168	40.1326	-121.166
1	4	138	Balboa, Lake	Los Angeles	EQUAL-169	34.1816	-118.495
1	1	13	Ruth Lake	Trinity	EQUAL-170	40.3161	-123.392
1	5	71	Woodward Reservoir	Stanislaus	EQUAL-171	37.8558	-120.86
1	5	36	Zayak/Swan Lake	Nevada	EQUAL-172	39.1356	-121.133
1	3	112	Nacimiento, Lake	San Luis Obispo	EQUAL-173	35.7569	-121.005
1	4	160	Cerritos Park Lake	Los Angeles	EQUAL-174	33.8513	-118.061
1	5	105	545TU0164-BOG Other Lake 164	Madera	EQUAL-175	36.8653	-119.807
1	4	153	Ken Hahn Park Lake	Los Angeles	EQUAL-176	34.0086	-118.364
1	2	87	Vasona Reservoir	Santa Clara	EQUAL-177	37.2458	-121.968
1	5	8	Britton, Lake	Shasta	EQUAL-178	41.0202	-121.626
1	5	76	Don Pedro Reservoir	Tuolumne	EQUAL-179	37.6981	-120.375
1	4	125	Castaic Lake	Los Angeles	EQUAL-180	34.5249	-118.599
1	5	47	Folsom Lake	Sacramento, Placer, El Dc	EQUAL-181	38.7396	-121.093
1	4	145	Santa Fe Reservoir	Los Angeles	EQUAL-182	34.1171	-117.955
1	5	110	Success Lake	Tulare	EQUAL-183	36.0791	-118.913
1	9	172	San Marcos, Lake	San Diego	EQUAL-184	33.127	-117.204
1	3	106	Roberts Lake (Laguna Del Rey)	Monterey	EQUAL-185	36.6075	-121.858
1	5	9	Shasta Lake	Shasta	EQUAL-186	40.8253	-122.398
1	5	79	McClure, Lake	Mariposa	EQUAL-187	37.6624	-120.21
2	5	60	New Hogan Lake	Calaveras	EQUAL-003	38.175	-120.771
2	5	10	Whiskeytown Lake	Shasta	EQUAL-004	40.6255	-122.575
2	9	167	Skinner		EQUAL-005	33.5889	-117.053
2	3	123	Cachuma, Lake	Santa Barbara	EQUAL-006	34.5944	-119.943
2	5	50	Natomas, Lake	Sacramento	EQUAL-007	38.6501	-121.194
2	2	74	Upper San Leandro Reservoir	Alameda, Contra Costa	EQUAL-008	37.7761	-122.117
2	4	155	Wilderness Park Lake	Los Angeles	EQUAL-009	33.9368	-118.1
2	5	113	Isabella Lake	Kern	EQUAL-010	35.6658	-118.427
2	5	24	Mile Long Pond	Butte	EQUAL-011	39.4286	-121.634
2	3	103	Pinto Lake	Santa Cruz	EQUAL-012	36.956	-121.773
2	9	174	Hodges, Lake	San Diego	EQUAL-013	33.0684	-117.114
2	5	19	Black Butte Lake	Tehama, Glenn	EQUAL-014	39.7581	-122.379
2	5	44	Davis Creek Reservoir	Yolo	EQUAL-015	38.8591	-122.359
2	5	102	Los Banos Reservoir	Merced	EQUAL-016	36.9799	-120.964

Panel	Region	Map Label Number	Lake Name	County	siteID (draw #)	Latitude	Longitude
2	7	177	Ferguson Lake	Imperial	EQUAL-017	32.972	-114.5
2	6	124	Palmdale Lake	Los Angeles	EQUAL-018	34.5506	-118.121
2	5	58	Pardee Reservoir	Amador, Calaveras	EQUAL-019	38.2659	-120.843
2	1	2	Iron Gate Reservoir	Siskiyou	EQUAL-020	41.9722	-122.402
2	8	166	Elsinore, Lake	Riverside	EQUAL-021	33.6667	-117.341
2	5	115	Webb, Lake	Kern	EQUAL-022	35.2226	-119.262
2	5	14	Mountain Meadows Reservoir	Lassen	EQUAL-023	40.2738	-120.962
2	2	67	San Pablo Reservoir	Contra Costa	EQUAL-024	37.923	-122.238
2	4	156	Magic Johnson Lakes		EQUAL-025	33.9192	-118.261
2	9	180	Jennings, Lake	San Diego	EQUAL-026	32.8586	-116.886
2	5	27	Collins Lake	Yuba	EQUAL-027	39.3359	-121.318
2	3	95	Chesbro Reservoir	Santa Clara	EQUAL-028	37.1227	-121.709
2	9	168	Laguna Niguel Park Lake	Orange	EQUAL-029	33.547	-117.705
2	1	26	Pillsbury, Lake	Lake	EQUAL-030	39.4274	-122.931
2	2	63	Nicasio Lake	Marin	EQUAL-031	38.0859	-122.732
2	2	96	Coyote Lake	Santa Clara	EQUAL-032	37.1208	-121.552
2	9	173	Sutherland, Lake	San Diego	EQUAL-033	33.102	-116.774
2	6	133	Silverwood Lake	San Bernardino	EQUAL-034	34.2847	-117.334
2	5	40	Lake of the Pines	Nevada	EQUAL-035	39.0356	-121.063
2	3	116	Lopez Lake	San Luis Obispo	EQUAL-036	35.1973	-120.469
2	4	158	Alondra Park Lake	Los Angeles	EQUAL-037	33.8814	-118.334
2	5	94	Hensley Lake	Madera	EQUAL-038	37.1272	-119.878
3	5	20	Oroville, Lake	Butte	EQUAL-039	39.5799	-121.36
3	5	69	Marsh Creek Reservoir	Contra Costa	EQUAL-040	37.8876	-121.726
3	4	139	Sepulveda Lake	Los Angeles	EQUAL-041	34.1755	-118.473
3	9	182	Loveland Reservoir	San Diego	EQUAL-042	32.7865	-116.768
3	5	33	Blue Lakes	Lake	EQUAL-043	39.175	-123.016
3	2	91	Lexington Reservoir	Santa Clara	EQUAL-044	37.1735	-121.986
3	4	141	Lindero, Lake	Los Angeles	EQUAL-045	34.1487	-118.79
3	6	39	Tahoe, Lake (Tahoe Keys)	Placer, El Dorado	EQUAL-046	39.1024	-120.159
3	1	4	Reservoir F	Modoc	EQUAL-047	41.5564	-120.88
3	5	78	Modesto Reservoir	Stanislaus	EQUAL-048	37.6629	-120.654
3	8	165	Hemet, Lake	Riverside	EQUAL-049	33.667	-116.694
3	4	122	Pyramid Lake	Los Angeles	EQUAL-050	34.6573	-118.785
3	5	31	Wildwood, Lake	Nevada	EQUAL-051	39.2394	-121.21
3	3	111	San Antonio, Lake	Monterey, San Luis Obisp	EQUAL-052	35.8916	-121.061
3	4	148	Puddingstone Reservoir	Los Angeles	EQUAL-053	34.0903	-117.801
3	5	85	Bass Lake	Madera	EQUAL-054	37.3133	-119.551
3	5	30	Scotts Flat Reservoir	Nevada	EQUAL-055	39.2767	-120.915
3	2	84	Calaveras Reservoir	Alameda, Santa Clara	EQUAL-056	37.4553	-121.805
3	4	149	Echo Park Lake	Los Angeles	EQUAL-057	34.0736	-118.261
3	9	184	Sweetwater Reservoir	San Diego	EQUAL-058	32.6962	-116.987
3	1	48	Sonoma, Lake	Sonoma	EQUAL-059	38.7394	-123.069
3	2	86	Stevens Creek Reservoir	Santa Clara	EQUAL-060	37.2958	-122.079
3	4	144	Sherwood, Lake	Ventura	EQUAL-061	34.1395	-118.868
3	5	46	Slab Creek Reservoir	El Dorado	EQUAL-062	38.7875	-120.676
3	5	6	Siskiyou Lake	Siskiyou	EQUAL-063	41.2801	-122.338
3	5	68	Tulloch Reservoir	Calaveras, Tuolumne	EQUAL-064	37.8944	-120.572
3	6	127	Little Rock Reservoir	Los Angeles	EQUAL-065	34.4811	-118.024
3	5	54	William Pond (Arden Pond)	Sacramento	EQUAL-066	38.5839	-121.334
3	9	164	Diamond Valley Reservoir		EQUAL-067	33.68	-117.027

Panel	Region	Map Label Number	Lake Name	County	siteID (draw #)	Latitude	Longitude
3	4	130	Casitas, Lake	Ventura	EQUAL-068	34.3828	-119.36
3	2	75	Chabot, Lake (San Leandro)	Alameda	EQUAL-069	37.7272	-122.103
3	4	151	Legg Lake	Los Angeles	EQUAL-070	34.0358	-118.061
3	5	23	Thermalito Afterbay	Butte	EQUAL-071	39.4566	-121.658
3	2	89	Ogier Quarry Ponds	Santa Clara	EQUAL-072	37.183	-121.693
3	5	28	East Park Reservoir	Colusa	EQUAL-073	39.3295	-122.507
3	2	53	Henne, Lake	Napa	EQUAL-074	38.5877	-122.462
3	5	100	San Luis Reservoir	Merced	EQUAL-075	37.0436	-121.071
3	7	175	Wiest Lake	Imperial	EQUAL-076	33.0423	-115.49
4	6	136	Arrowhead, Lake	San Bernardino	EQUAL-077	34.2565	-117.185
4	5	57	Amador, Lake	Amador	EQUAL-078	38.2959	-120.875
4	8	154	Prado Lake	San Bernardino	EQUAL-079	33.9472	-117.648
4	5	104	Pine Flat Lake	Fresno	EQUAL-080	36.8903	-119.26
4	2	82	Lower Crystal Springs Reservoir	San Mateo	EQUAL-081	37.5313	-122.371
4	4	152	Belvedere Park Lake	Los Angeles	EQUAL-082	34.035	-118.158
4	5	16	Antelope Lake	Plumas	EQUAL-083	40.1784	-120.595
4	2	90	Calero Reservoir	Santa Clara	EQUAL-084	37.1805	-121.787
4	9	169	O'Neill Lake	San Diego	EQUAL-085	33.3292	-117.322
4	5	21	Stony Gorge Reservoir	Glenn	EQUAL-086	39.5413	-122.522
4	2	61	Soulejoule Lake	Marin	EQUAL-087	38.1475	-122.777
4	9	171	Wohlford, Lake	San Diego	EQUAL-088	33.1754	-116.989
4	4	126	Castaic Lagoon	Los Angeles	EQUAL-089	34.5061	-118.61
4	5	42	Combie, Lake	Nevada, Placer	EQUAL-090	39.0067	-121.043
4	4	161	El Dorado Park Lakes	Los Angeles	EQUAL-091	33.825	-118.085
4	5	101	Millerton Lake	Fresno, Madera	EQUAL-092	37.0097	-119.667
4	2	77	Shadow Cliffs Reservoir	Alameda	EQUAL-093	37.6696	-121.836
4	9	179	El Capitan		EQUAL-094	32.8826	-116.792
4	5	38	Indian Valley Reservoir	Lake	EQUAL-095	39.1135	-122.541
4	2	93	Almaden Reservoir	Santa Clara	EQUAL-096	37.1625	-121.831
4	4	146	Malibou Lake	Los Angeles	EQUAL-097	34.1071	-118.758
4	5	43	Union Valley Reservoir	El Dorado	EQUAL-098	38.8615	-120.405
4	6	11	Pete's Valley Reservoir	Lassen	EQUAL-099	40.5442	-120.452
4	8	135	Big Bear Lake	San Bernardino	EQUAL-100	34.2633	-116.944
4	5	119	Castac Lake	Kern	EQUAL-101	34.8353	-118.843
4	4	147	Peck Road Water Conservation Pa	Los Angeles	EQUAL-102	34.1023	-118.013
4	5	25	New Bullards Bar Reservoir	Yuba	EQUAL-103	39.4282	-121.122
4	2	81	Del Valle Reservoir	Alameda	EQUAL-104	37.5797	-121.694
4	9	186	Morena Reservoir	San Diego	EQUAL-105	32.686	-116.537
4	2	62	Chabot, Lake (Vallejo)	Solano	EQUAL-106	38.1363	-122.236
4	3	97	Loch Lomond Reservoir	Santa Cruz	EQUAL-107	37.1102	-122.065
4	4	120	Hughes, Lake	Los Angeles	EQUAL-108	34.6755	-118.447
4	5	45	Finnon Reservoir	El Dorado	EQUAL-109	38.7986	-120.749
4	1	5	Shastina, Lake	Siskiyou	EQUAL-110	41.5203	-122.394
4	7	132	Gene Wash Reservoir	San Bernardino	EQUAL-111	34.2974	-114.172
4	4	134	Hansen Dam Lake	Los Angeles	EQUAL-112	34.266	-118.388
4	1	7	Trinity Lake	Trinity	EQUAL-113	41.0532	-122.7
4	8	159	Perris Reservoir	Riverside	EQUAL-114	33.8535	-117.175
5	5	51	San Juan Pond	Sacramento	EQUAL-115	38.6229	-121.287
5	2	70	Lafayette Reservoir	Contra Costa	EQUAL-116	37.8824	-122.141
5	6	109	Haiwee Reservoir	Inyo	EQUAL-117	36.228	-117.964
5	5	22	Robinson Pond	Butte	EQUAL-118	39.4698	-121.598

Panel	Region	Map Label Number	Lake Name	County	siteID (draw #)	Latitude	Longitude
5	2	92	Anderson Lake	Santa Clara	EQUAL-119	37.1661	-121.625
5	9	178	Miramar Reservoir		EQUAL-120	32.9157	-117.101
5	1	32	Mendocino, Lake	Mendocino	EQUAL-121	39.2352	-123.008
5	1	55	Spring Lake	Sonoma	EQUAL-122	38.4557	-122.653
5	9	170	Lake Henshaw		EQUAL-123	33.2376	-116.75
5	6	137	Gregory, Lake	San Bernardino	EQUAL-124	34.2421	-117.271
5	1	3	Dead Lake	Del Norte	EQUAL-125	41.7836	-124.227
5	4	162	Harbor Lake (Machado Lake)	Los Angeles	EQUAL-126	33.7875	-118.293
5	5	15	Almanor, Lake	Plumas	EQUAL-127	40.2289	-121.155
5	5	65	Contra Loma Reservoir	Contra Costa	EQUAL-128	37.9744	-121.827
5	9	181	Murray Reservoir		EQUAL-129	32.7868	-117.043
5	5	34	Lower Blue Lake (Lake County)	Lake	EQUAL-130	39.1642	-123
5	3	99	Uvas Reservoir	Santa Clara	EQUAL-131	37.0757	-121.703
5	4	140	Calabasas Lake	Los Angeles	EQUAL-132	34.1531	-118.638
5	5	12	California, Lake	Tehama	EQUAL-133	40.3444	-122.201
5	5	73	Bethany Reservoir		EQUAL-134	37.7775	-121.608
5	9	176	Cuyamaca, Lake		EQUAL-135	32.9875	-116.582
5	4	128	Piru, Lake	Ventura	EQUAL-136	34.463	-118.75
5	3	118	Oso Flaco Lake	San Luis Obispo	EQUAL-137	35.0305	-120.622
5	5	18	Paradise Lake	Butte	EQUAL-138	39.8584	-121.582
5	5	72	Los Vaqueros Reservoir	Contra Costa	EQUAL-139	37.8169	-121.738
5	4	142	Toluca Lake	Los Angeles	EQUAL-140	34.1466	-118.349
5	9	187	Lower Otay Reservoir	San Diego	EQUAL-141	32.6193	-116.916
5	5	37	Clear Lake	Lake	EQUAL-142	39.1156	-122.829
5	4	143	Westlake Lake	Los Angeles, Ventura	EQUAL-143	34.1425	-118.829
5	5	49	Jenkinson Lake	El Dorado	EQUAL-144	38.7214	-120.553
5	5	80	Turlock Lake	Stanislaus	EQUAL-145	37.5961	-120.57
5	8	163	Irvine Lake	Orange	EQUAL-146	33.7684	-117.714
5	5	35	Rollins Reservoir	Nevada, Placer	EQUAL-147	39.1546	-120.932
5	3	108	Hernandez Reservoir	San Benito	EQUAL-148	36.393	-120.834
5	5	107	Kaweah, Lake	Tulare	EQUAL-149	36.4	-118.966
5	5	29	Englebright Lake	Yuba, Nevada	EQUAL-150	39.2832	-121.235
5	2	66	Bon Tempe Lake	Marin	EQUAL-151	37.9558	-122.6
5	4	150	Lincoln Park Lake	Los Angeles	EQUAL-152	34.0667	-118.202
	187						

Table 4. Target species and their characteristics: mercury.

	Foraging Type		Trophic Level	Distribution			
Species	Water column	Bottom feeder		Low Eleva-tion	Foothills	High Elevation	Priority for Collection
Largemouth bass	X		4	**X**	**X**		**A**
Smallmouth bass	X		4	x	**X**		**A**
Spotted bass	X		4	x	**X**		**A**
Sacramento pikeminnow	X		4	x	x		B

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 5. Target species and their characteristics: PCBs and organochlorine pesticides.

	Foraging Type		Trophic Level	Distribution			
Species	Water column	Bottom feeder		Low Eleva-tion	Foothills	High Elevation	Priority for Collection
Largemouth bass	X		4	**X**	**X**		B
Smallmouth bass	X		4	x	**X**		B
Spotted bass	X		4	x	**X**		B
Sacramento pikeminnow	X		4	x	x		B
White catfish		X	4	x	x		**A**
Brown bullhead		X	3	x			**A**
Channel catfish		X	4	**X**	**X**		**A**
Carp		X	3	**X**	**X**		**A**
Sacramento sucker		X	3	x	x		**A**
Tilapia		X	3				B
Bluegill	X		3	**X**	**X**		B
Green sunfish	X		3	**X**	**X**		B
Crappie	X		3/4	x	x		B
Redear sunfish	X		3	**X**	**X**		B

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 6. Target species, size ranges, and processing instructions. I - process as individuals. C - process as composites.

	Process for Mercury	**Process for Organics and Selenium**	**Numbers and Size Ranges (mm)**
Primary Targets: stay on location until one of these targets from both Group 1 and 2 is obtained, or collect secondary targets if primary targets are not available			
Group 1) Predator			
Black bass	I		2X(200-249), 2X(250-304), 6X(305-407), 2X(>407)
Sacramento pikeminnow	I		3X(200-300), 6X(300-400), 3X(400-500)
Group 2) Bottom feeder			
White catfish	C	C	5X(229-305)
Channel catfish	C	C	5X(375-500)
Common carp	C	C	5X(450-600)
Brown bullhead	C		5X(262-350)
Sacramento sucker	C	C	5X(375-500)
Secondary Targets: collect these if primary targets are not available			
Bluegill	C	C	5X(127-170)
Redear sunfish	C	C	5X(165-220)
Black crappie	C	C	5X(187-250)
Tilapia	C	C	5X(235-314)
Green sunfish	C	C	Xx

Table 7. Summary of sport fish analytes included in the monitoring.

Analyte	**Included in Study?**
Methylmercury[1]	All individuals
PCBs	Selected composites
DDTs	Selected composites
Dieldrin	Selected composites
Aldrin	Selected composites
Chlordanes	Selected composites

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

Table 8. Parameters to be measured in sport fish.

FISH ATTRIBUTES

1. Total length
2. Fork length
3. Standard length (small fish only)
4. Weight
5. Sex
6. Moisture
7. Lipid content
8. Age (for black bass)

METALS AND METALLOIDS

1. Total mercury

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')

Cyclodienes

1. Aldrin
2. Dieldrin
3. Endrin

HCHs

1. HCH, alpha
2. HCH, beta

Others

1. Dacthal

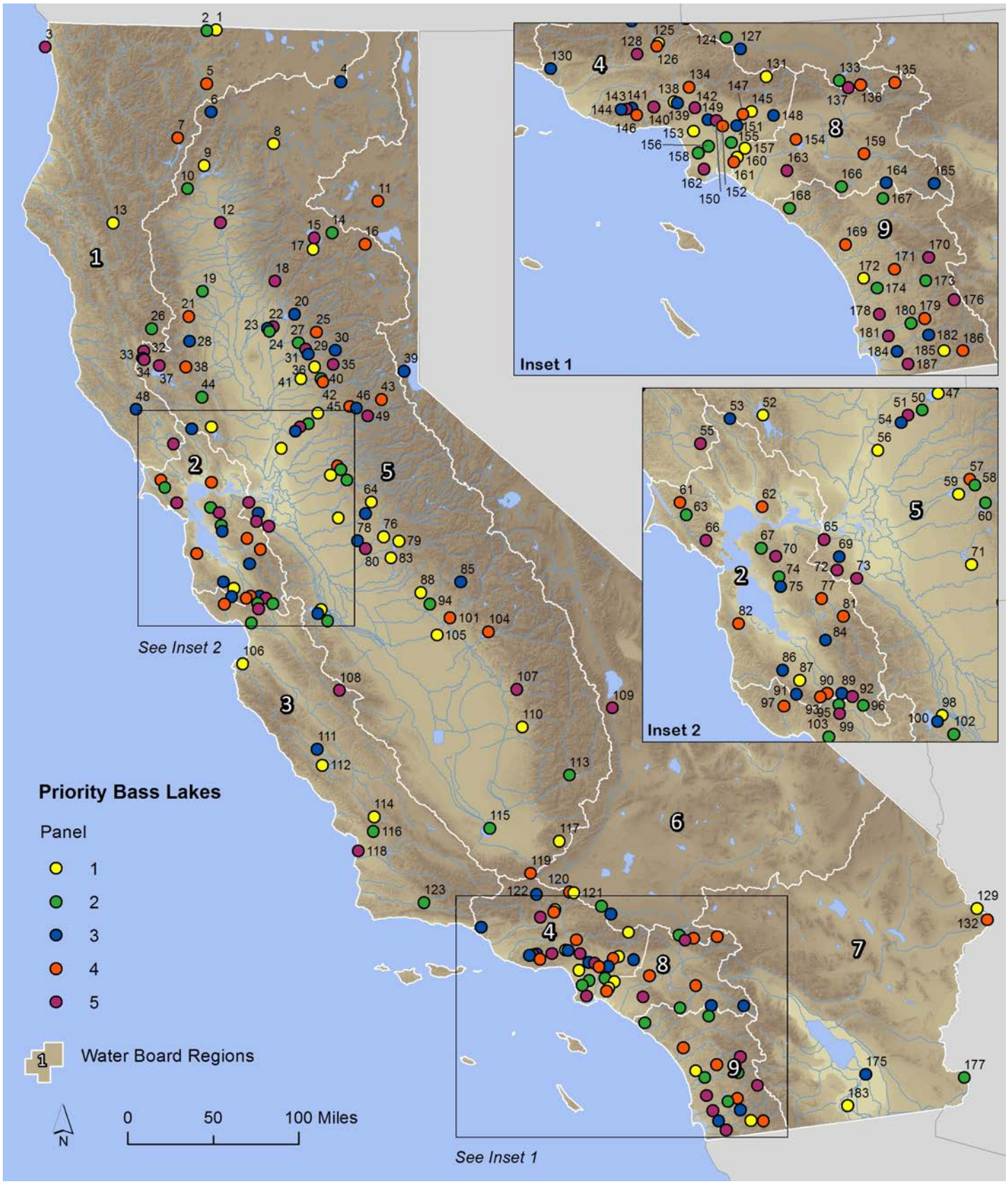
2. Endosulfan I
3. Hexachlorobenzene
4. Methoxychlor
5. Mirex
6. Oxadiazon

PCBs

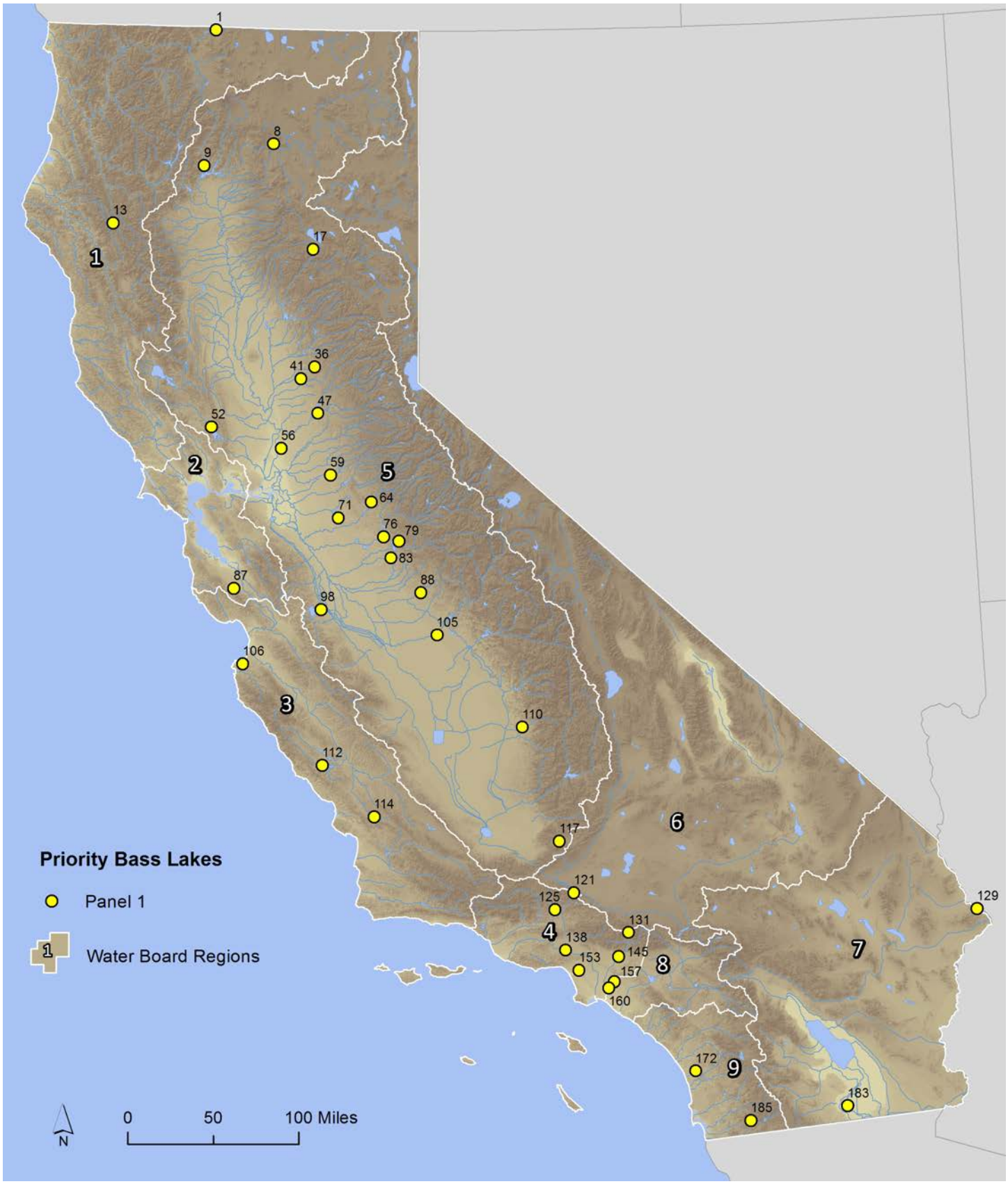
1. PCB 008
2. PCB 011
3. PCB 018
4. PCB 027
5. PCB 028
6. PCB 029
7. PCB 031
8. PCB 033
9. PCB 044
10. PCB 049
11. PCB 052
12. PCB 056
13. PCB 060
14. PCB 064
15. PCB 066
16. PCB 070
17. PCB 074
18. PCB 077
19. PCB 087
20. PCB 095
21. PCB 097
22. PCB 099
23. PCB 101
24. PCB 105
25. PCB 110
26. PCB 114
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
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

Figure 1. Maps of sampling locations. Lake names are indicated in Table 3.



Panel 1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83
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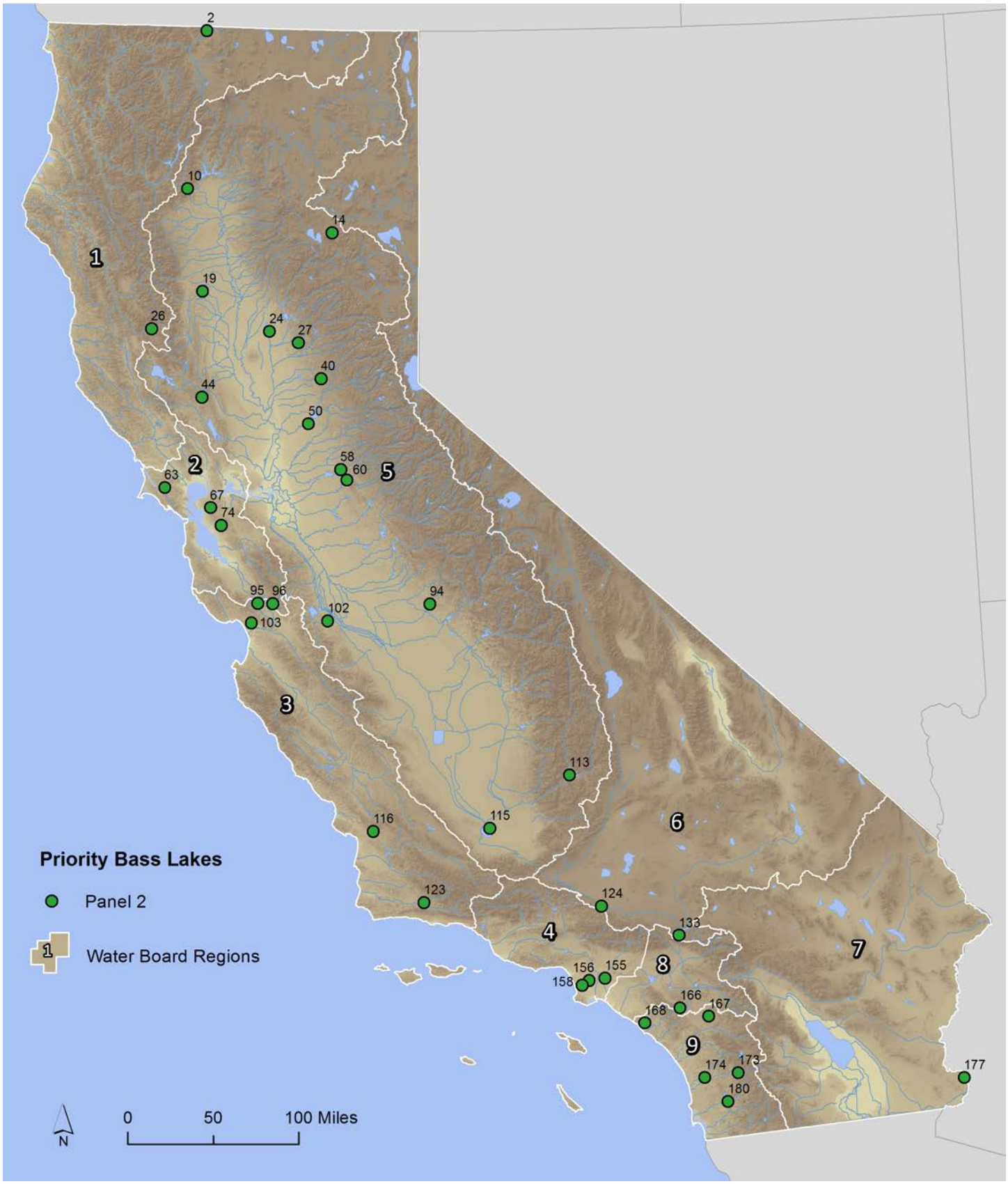
98
105
106
3
110
112
114
117
6
121
125
129
4
131
138
153
145
157
160
8
7
172
9
183
185
Priority Bass Lakes
Panel 1
1
Water Board Regions
N
0
50
100 Miles

Panel 2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116
115
123
124
133
156
155
158
166
167
168
174
173
180
177
1
2
3
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5
6
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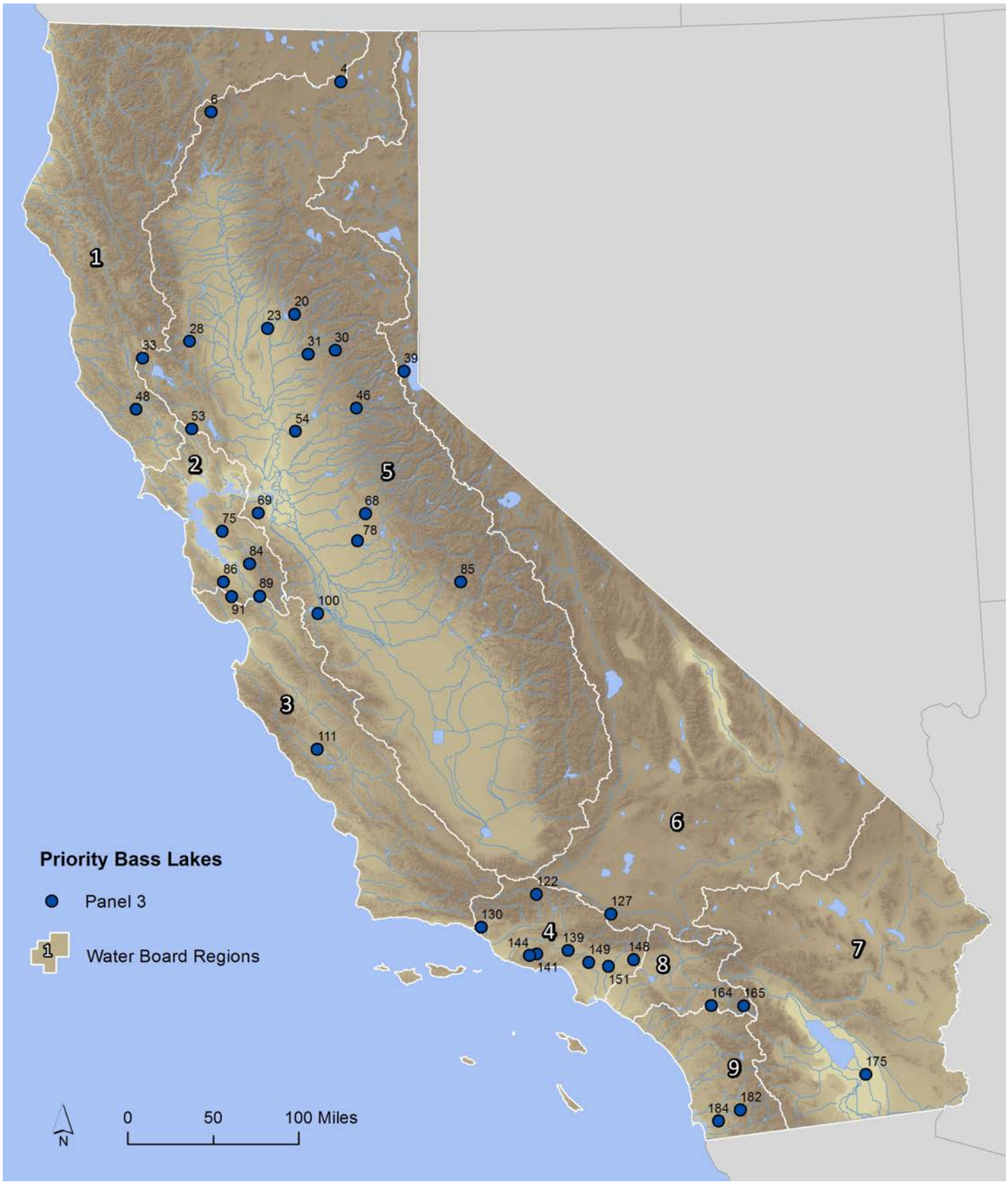
9
Priority Bass Lakes
Panel 2
Water Board Regions
0
50
100 Miles
N

Panel 3


Priority Bass Lakes
Panel 3
Water Board Regions
0
50
100 Miles
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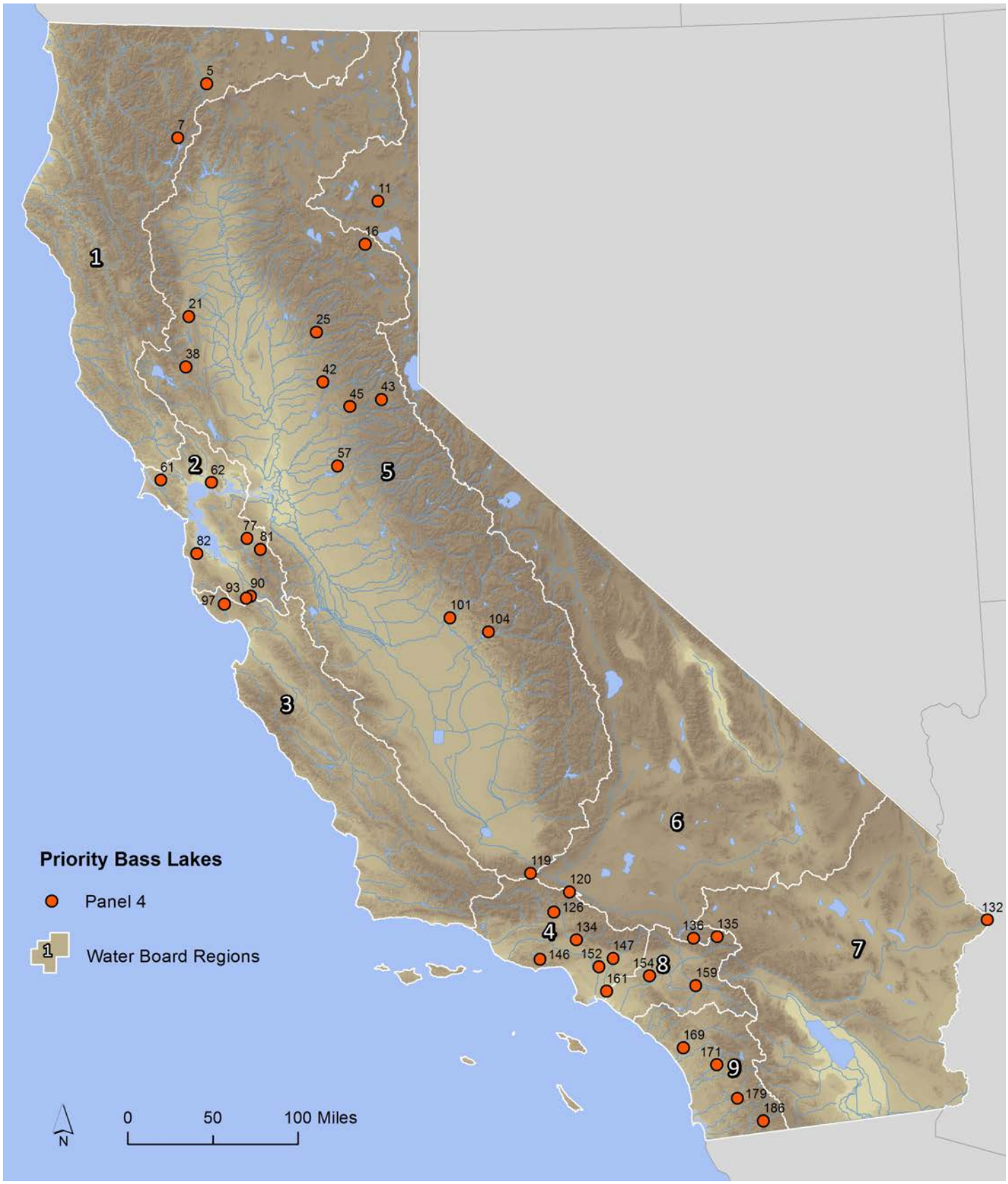
Panel 4


Priority Bass Lakes
Panel 4
Water Board Regions
0
50
100 Miles
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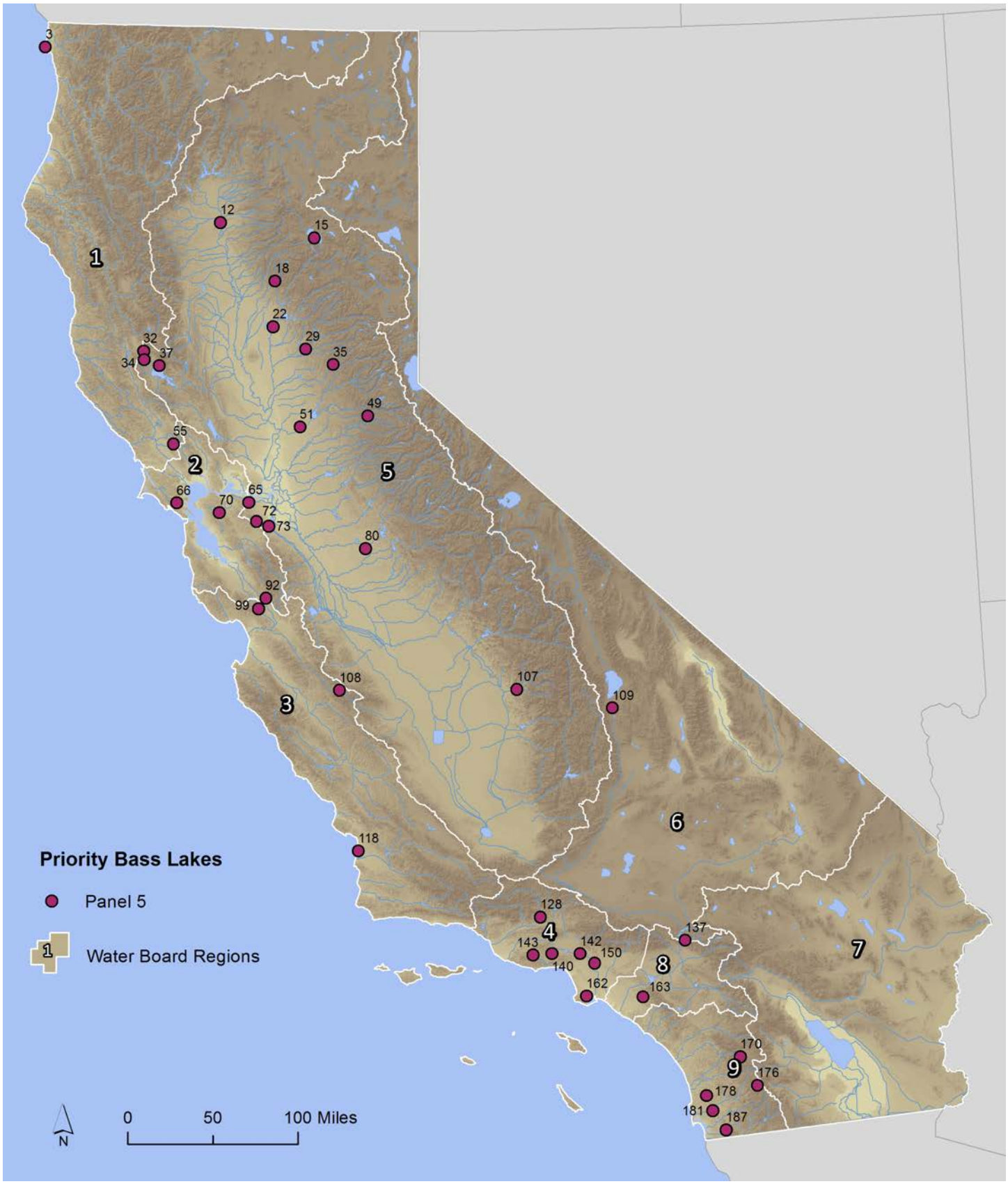
Panel 5


Priority Bass Lakes
Panel 5
Water Board Regions
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50
100 Miles
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Figure 2. Sampling design for a small lake.

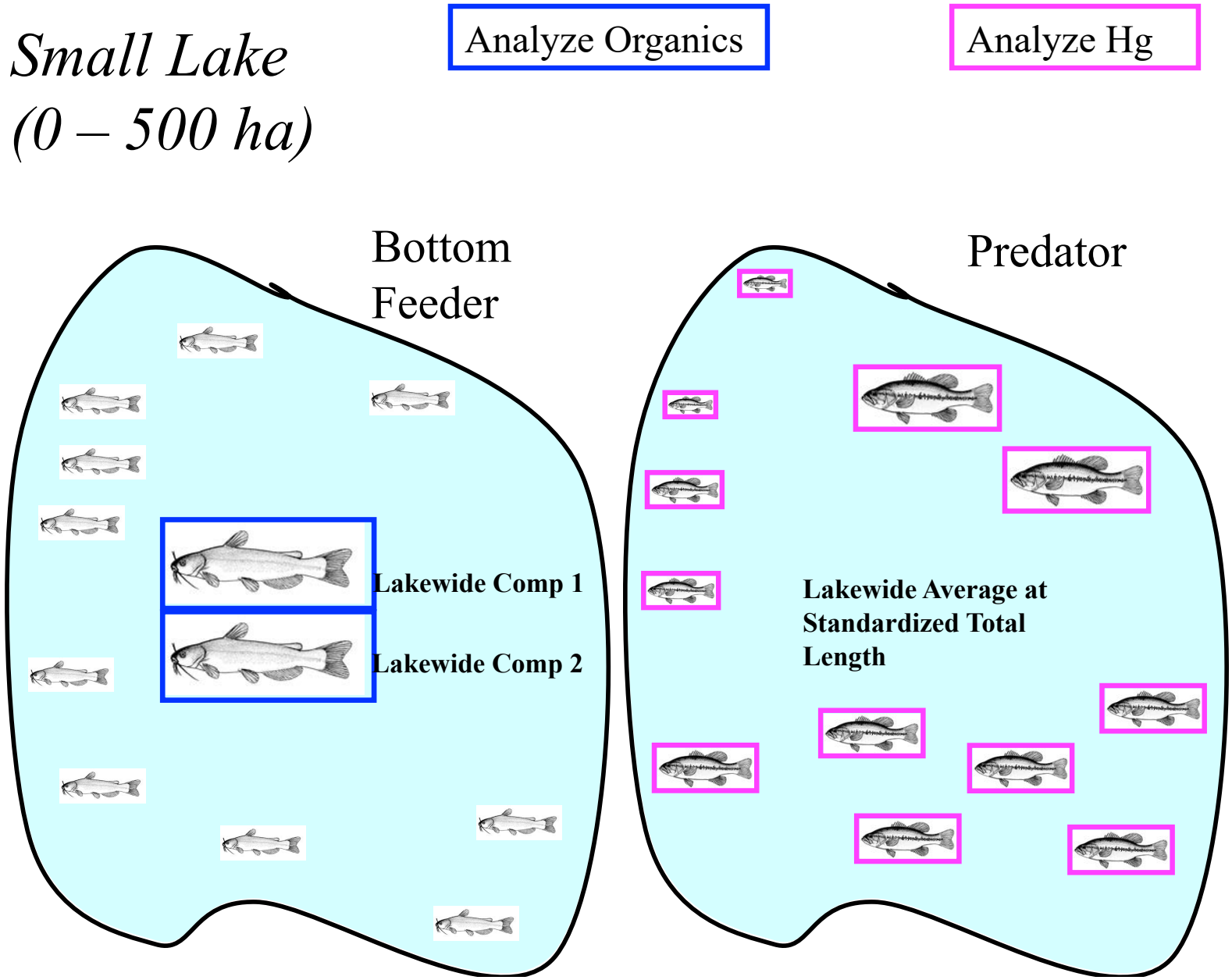
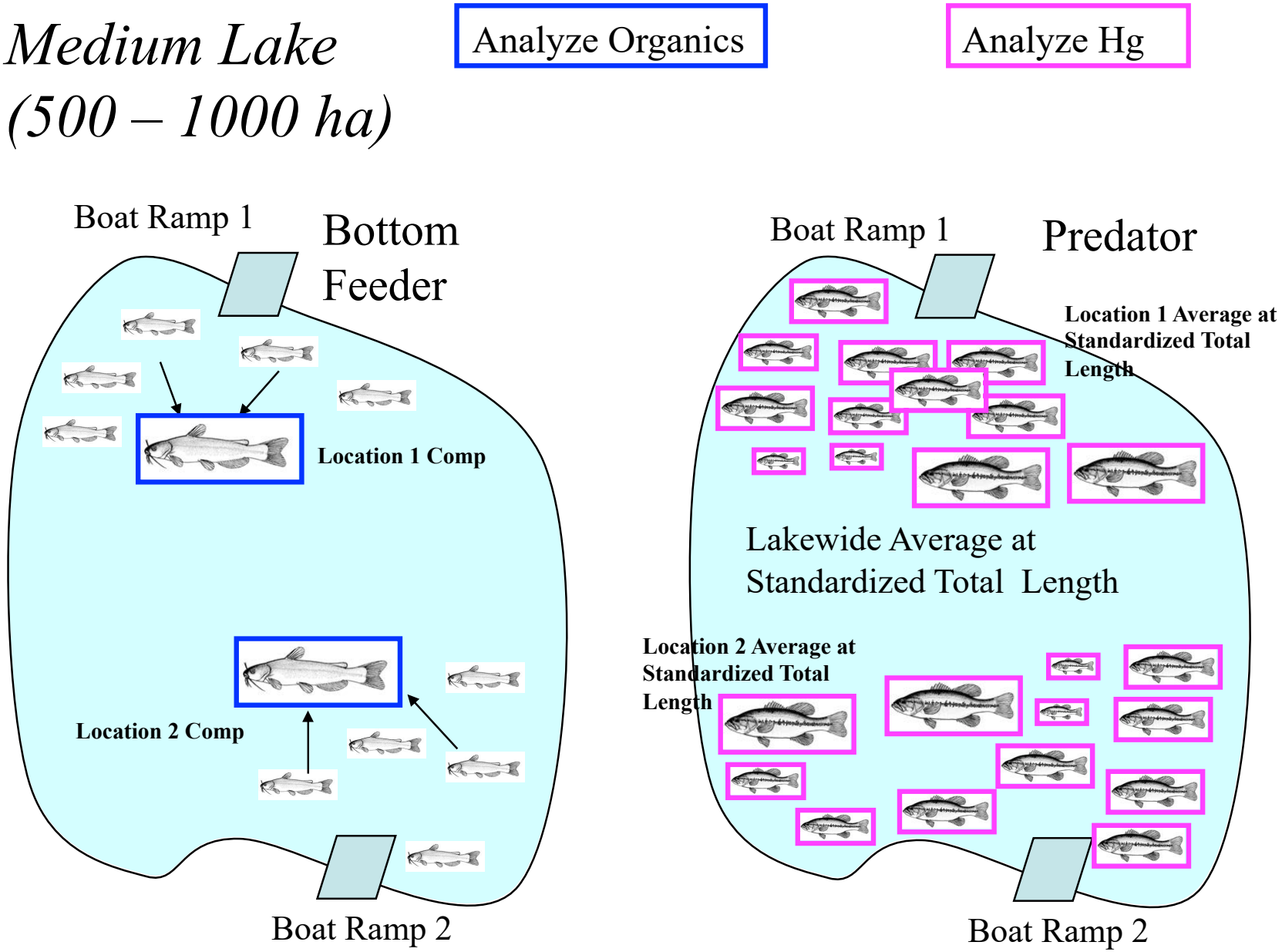


Figure 3. Sampling design for a medium-sized lake.



Regional Board	Station Name for Statewide Mercury Program Database	Bass Type Sampled	On 2010 303(d) List as Mercury Impaired (a)	Regional Board Prioritization for Long-Term Monitoring [X=INCLUDE]	Regional Board Rationale/Comments	Panel Number	Small	Medium	Large	Extra-large	Random	Targeted	Moderate PCBs (>20)	High PCBs (>100)	High DDTs (>500)	Gary Comments	Standard-ized Fish Hg Conc. (mg/kg) PRELIMINARY
1	Copco Lake	LMB	X'	X			X					X					0.31
1	Dead Lake	LMB	X'	X			X					X					0.37
1	Iron Gate Reservoir	LMB	X'	X			X					X					0.33
1	Mendocino, Lake	LMB	X	X	(US Bureau of Reclamation does some bass sampling alre			X				X					0.55
1	Pillsbury, Lake	LMB	X	X				X				X					0.98
1	Reservoir F	LMB		X			X				X						0.15
1	Ruth Lake	LMB	X'	X			X					X					0.71
1	Shastina, Lake	LMB	X	X			X					X				did not have bass the last time sam	0.23
1	Sonoma, Lake	LMB	X	X	(US Bureau of Reclamation does some bass sampling alre			X				X					0.64
1	Spring Lake	LMB		X	Gary will be sampling Spring Lake for Re	1	X					X					0.38
1	Trinity Lake	LMB	X	X						X		X					0.43
2	Vasona Reservoir	LMB		X	PCBs		X					X	X	X			0.16
2	Lafayette Reservoir	LMB	X	X			X					X					0.34
2	Shadow Cliffs Reservoir	LMB	X	X			X					X	X				0.39
2	Nicasio Lake	LMB	X	X			X					X					0.4
2	Chabot, Lake (Vallejo)	LMB		X			X					X	X				0.41
2	Henne, Lake	LMB		X			X				X						0.41
2	Lexington Reservoir	LMB		X	important reference site for Guad Hg												0.44
2	Ogier Quarry Ponds	LMB		X			X				X						0.45
2	San Pablo Reservoir	LMB	X	X			X					X					0.48
2	Del Valle Reservoir	LMB	X	X			X					X					0.56
2	Stevens Creek Reservoir	LMB	X	X			X					X	X				0.7
2	Coyote Lake	LMB		X			X					X					0.76
2	Lower Crystal Springs Reservoir	LMB		X			X				X					Fishing not allowed.	0.85
2	Soulejoule Lake	LMB	X^	X			X					X					0.94
2	Anderson Lake	LMB	X	X			X					X					0.98
2	Upper San Leandro Reservoir	LMB		X			X				X					Fishing not allowed.	1.01
2	Calero Reservoir	LMB	X^	X			X					X					1.13
2	Almaden Reservoir	LMB	X^	X			X					X	X				3.1
2	Bon Tempe Lake	LMB	X	X	before sampling I would inquire of Marin Municipal W		X					X					0.33
2	Chabot, Lake (San Leandro)	LMB	X	X	PCBs		X				X		X	X			0.57
2	Calaveras Reservoir	LMB	X	X	before sampling I would inquire of SFPUC what new data			X			X					Fishing not allowed.	0.59
3	Cachuma, Lake	LMB		X					X			X					0.5
3	Chesbro Reservoir	LMB	X	X			X					X	X			I believe it went dry this last summe	1.04
3	Hernandez Reservoir	LMB		X			X					X					0.83
3	Loch Lomond Reservoir	LMB		X			X					X					0.11
3	Lopez Lake	LMB		X			X					X					0.1
3	Nacimiento, Lake	LMB & SMB	X	X					X			X					1.1
3	Oso Flaco Lake			X													0.03
3	Pinto Lake	LMB		X			X					X			X		0.18
3	Roberts Lake (Laguna Del Rey)			X													0.07
3	San Antonio, Lake	LMB	X	X					X			X					0.24
3	Santa Margarita Lake	LMB		X	important fishing lake		X					X					0.07
3	Uvas Reservoir	LMB	X	X			X					X				I believe it went dry this last summe	0.91
4	Alondra Park Lake	LMB		X			X					X	X				0.20
4	Balboa, Lake			X			X					X					0.01
4	Belvedere Park Lake	LMB		X			X					X	X				0.061
4	Calabasas Lake	LMB		X			X					X	X				0.03
4	Casitas, Lake	LMB	X	X				X				X					0.34
4	Castaic Lagoon	LMB		X			X					X				Low water made for difficult launch	0.18
4	Castaic Lake	LMB	X	X				X				X					0.27
4	Cerritos Park Lake	LMB		X			X						X				0.13
4	Crystal Lake	LMB		X			X					X					0.95
4	Echo Park Lake	LMB		X	recently restored		X					X	X	X			0.08
4	El Dorado Park Lakes	LMB	X	X			X					X					0.36

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4	Elizabeth Lake			X			X					X					**0.04**
4	Hansen Dam Lake	**LMB**		X			X					X					**0.49**
4	Harbor Lake (Machado Lake)	**LMB**		X	undergoing restoration - supported bass in the past		X					X					**0.07**
4	Hughes, Lake	**LMB**		X			X					X					**0.20**
4	Ken Hahn Park Lake	**LMB**		X			X					X	X				**0.3**
4	La Mirada Park Lake	**LMB**		X			X						X				**0.33**
4	Legg Lake	**LMB**		X			X					X	X	X	X		**0.18**
4	Lincoln Park Lake	**LMB**		X			X					X					**0.15**
4	Lindero, Lake	**LMB**		X			X					X					**0.1**
	Magic Johnson Lakes			X	added to the list												
4	Malibou Lake	**LMB**		X			X				X		X				**0.12**
4	Peck Road Water Conservation P	**LMB**		X			X					X	X				**0.36**
4	Piru, Lake	**LMB**		X			X					X				Low water made for difficult launch	**0.46**
4	Puddingstone Reservoir	**LMB**	**X**	X			X					X	X				**0.44**
4	Pyramid Lake	**LMB**	**X**	X				X				X	X	X			**0.35**
4	Santa Fe Reservoir	**LMB**		X			X					X	X				**0.59**
4	Sepulveda Lake			X			X					X					**0.01**
4	Sherwood, Lake	**LMB**	**X**	X			X					X					**0.54**
4	Toluca Lake	**LMB**		X			X					X					**0.01**
4	Westlake Lake	**LMB**		X			X					X					**0.09**
4	Wilderness Park Lake			X			X										**0.02**
5	531TU0073-BOG Other Lake 007	**LMB**		X			X				X						**0.20**
5	545TU0164-BOG Other Lake 164	**LMB**		X			X				X						**0.20**
5	Almanor, Lake	**SMB**	**X**	X						X		X					**0.17**
5	Amador, Lake	**LMB**		X			X					X					**0.6**
5	Antelope Lake	**LMB**		X			X					X					**0.11**
5	Bass Lake	**LMB**		X			X					X					**0.09**
5	Beach Lake	**LMB**	**X**	X	No public fishing, but could still be useful for trend analysis and is 303(d)-listed												**0.36**
5	Berryessa, Lake	**LMB**	**X**	X						X		X					**0.55**
5	Bethany Reservoir	**LMB**		X			X										
5	Black Butte Lake	**LMB & SMB**	**X**	X					X			X					**0.58**
5	Blue Lakes	**LMB**		X			X					X					**0.16**
5	Brite Valley Lake	**LMB**		X			X					X					**0.29**
5	Britton, Lake	**SMB**	**X**	X			X					X					**0.23**
5	Butt Valley Reservoir	**SMB**		X				X				X					**0.15**
5	California, Lake	**LMB**		X			X				X						**0.27**
5	Camanche Reservoir	**LMB**	**X**	X					X			X					**0.33**
5	Camp Far West Reservoir	**SPB**	**X**	X				X				X					**0.77**
5	Castac Lake	**LMB**		X	may not remain on the list, but I don't want to drop it		X				X						**0.32**
5	Clear Lake	**LMB**	**X^**	X						X		X					**0.45**
5	Collins Lake	**LMB**		X			X					X					**0.38**
5	Combie, Lake	**LMB**	**X**	X			X				X						**0.79**
5	Contra Loma Reservoir	**LMB**		X			X					X					**0.20**
5	Davis Creek Reservoir	**LMB**	**X**	X	No public fishing, but could still be useful for trend analysis and is 303(d)-listed												**2.42**
5	Don Pedro Reservoir	**LMB**	**X**	X					X			X					**0.44**
5	East Park Reservoir	**LMB**	**X**	X				X				X					**0.47**
5	Eastman Lake	**LMB**		X				X				X					**1.04**
5	Englebright Lake	**LMB & SPB**	**X**	X			X					X					**0.47**
5	Finger Lake	**LMB**		X			X				X						**0.29**
5	Finnon Reservoir	**LMB**		X													**0.46**
5	Folsom Lake	**LMB**	**X**	X					X			X					**0.52**
5	Hensley Lake	**LMB**	**X**	X				X				X					**0.71**
5	Indian Valley Reservoir	**LMB**	**X**	X					X								**0.88**
5	Isabella Lake	**LMB**		X					X			X					**0.19**
5	Jenkinson Lake	**LMB & SMB**		X			X					X					**0.16**

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5	Kaweah, Lake	LMB	X	X				X				X					0.5
5	Lake of the Pines	LMB		X			X				X						0.07
5	Los Banos Reservoir	LMB		X			X					X					0.55
5	Los Vaqueros Reservoir	LMB		X				X				X					0.24
5	Lower Blue Lake (Lake County)	LMB		X			X				X						0.3
5	Marsh Creek Reservoir	LMB	X	X	No public fishing, but could still be useful for trend analysis and is 303(d)-listed												0.76
5	McClure, Lake	LMB	X	X					X			X					0.73
5	McSwain, Lake	LMB		X			X					X					0.54
5	Mile Long Pond	LMB	X	X													0.24
5	Millerton Lake	LMB	X	X					X			X					0.36
5	Modesto Reservoir	SMB	X	X				X				X					0.24
5	Mountain Meadows Reservoir	LMB		X													0.08
5	Natomas, Lake	LMB	X	X			X					X					0.49
5	New Bullards Bar Reservoir	LMB	X	X					X			X					0.39
5	New Hogan Lake	LMB	X	X					X			X					0.42
5	New Melones Lake	LMB	X	X				X				X					0.39
5	O'Neill Forebay	LMB	X	X				X				X	X				0.20
5	Oroville, Lake	LMB & SMB	X	X						X		X					0.57
5	Paradise Lake	LMB		X			X					X					0.16
5	Pardee Reservoir	LMB	X	X				X									0.28
5	Pine Flat Lake	LMB	X	X					X		X						0.55
5	Robinson Pond	LMB	X	X													0.72
5	Rollins Reservoir	LMB & SMB	X	X			X					X					0.48
5	San Juan Pond	LMB		X													0.13
5	San Luis Reservoir	LMB	X	X						X		X	X	X			0.61
5	Scotts Flat Reservoir	LMB	X	X			X					X					0.32
5	Shasta Lake	LMB & SPB	X	X						X		X				very small bass caught	0.29
5	Siskiyou Lake	SMB		X			X					X					0.24
5	Slab Creek Reservoir	<SPM>	X	X	CDFW Fishing Guide cites Slab Creek Reservoir as historically having bass (https://map.dfg.ca.gov/fishing/), and fishing websites indicate bas												0.41
5	Stony Gorge Reservoir	LMB	X	X				X				X					0.32
5	Success Lake	BlckB (not specified)		X	CDFW Fishing Guide cites Success Lake as historically having b				X			X					0.26
5	Thermalito Afterbay	LMB	X	X				X			X		X				0.16
5	Tulloch Reservoir	LMB	X	X			X					X					0.37
5	Turlock Lake	LMB	X	X					X			X					0.20
5	Union Valley Reservoir	LMB		X				X				X					0.42
5	Webb, Lake	LMB		X			X					X					0.22
5	Whiskeytown Lake	LMB	X	X					X			X					0.18
5	Wildwood, Lake	LMB	X	X													0.75
5	William Pond (Arden Pond)	LMB		X	lower priority												0.08
5	Woodward Reservoir	LMB	X	X				X				X					0.25
5	Zayak/Swan Lake	LMB		X			X				X						0.98
6	Arrowhead, Lake	LMB	X'	X			X					X					0.34
6	Gregory, Lake	LMB	X'	X			X					X					0.19
6	Haiwee Reservoir	LMB		X													0.12
6	Little Rock Reservoir	LMB	X'	X			X					X					0.92
6	Palmdale Lake	LMB		X			X				X		X				0.13
6	Pete's Valley Reservoir	LMB		X													0.20
6	Silverwood Lake	LMB	X'	X			X					X	X	X			0.49
6	Tahoe, Lake (Tahoe Keys)			X						X		X					0.13
7	Ferguson Lake	LMB		X	optional		X				X						0.09
7	Gene Wash Reservoir	LMB		X	Not all target species have been caught		X				X					Not accessible	0.08
7	Havasu, Lake			X	Heavily fished, got largemouth and striped bass in most recent samplin					X		X					0.03
7	Sunbeam Lake	LMB		X	optional		X										0.01
7	Wiest Lake	LMB		X	optional		X					X					0.01
8	Big Bear Lake	LMB	X	X	Popular fishing lake and recreation area; on 303d list for Hg; one				X			X	X	X			0.18

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8	Elsinore, Lake	**LMB**		X	Popular fishing lake (#5 priority)			X				X	X				**0.06**
8	Hemet, Lake	**LMB**		X	Popular fishing lake (#6 priority)		X					X					**0.06**
8	Irvine Lake	**LMB**		X	Very popular fishing spot (#1 priority)		X					X					**0.48**
8	Perris Reservoir	**LMB**		X	Very popular; it's also a state recreation area (#2 priority)			X				X					**0.1**
8	Prado Lake	**LMB**		X	Popular in the park and very close to urban areas; m		X					X					**0.07**
9	Hodges, Lake	**LMB**	**X**	X	High priority		X					X					**0.29**
9	Jennings, Lake	**LMB**		X	Medium priority. Likely subject to NPDES permit		X					X					**0.16**
9	Laguna Niguel Park Lake			X	High priority												**0.03**
9	Loveland Reservoir	**LMB**		X	Medium priority		X				X						**0.63**
9	Lower Otay Reservoir	**LMB**		X	High priority		X					X	X				**0.20**
9	Morena Reservoir	**LMB**		X	High priority		X					X					**0.36**
9	O'Neill Lake	**LMB**		X	Medium priority. Military Base												**0.37**
9	San Marcos, Lake	**LMB**		X	Medium priority												**0.32**
9	Sutherland, Lake	**LMB**		X	High priority		X					X					**0.34**
9	Sweetwater Reservoir	**LMB**		X	High priority		X					X					**0.23**
9	Wohlford, Lake	**LMB**		X	Medium priority		X					X					**0.05**
9	Skinner			X	New addition. High priority												
9	Diamond Valley Reservoir			X	New addition. High priority. State Water Project Water												
9	Murray Reservoir			X	New addition. High priority												
9	Cuyamaca, Lake			X	New addition. High priority												
9	Miramar Reservoir			X	New addition. High priority Untreated Aqueduct												
9	Barrett			X	New addition. High priority Northern Strain, No harvest												

APPENDIX 2

POWER ANALYSIS FOR MANAGEMENT QUESTION 2:

DETECTION OF A TREND IN STATEWIDE AVERAGE BASS MERCURY CONCENTRATION FOR PRIORITY BASS LAKES

I. Approach

The goal of this analysis was to estimate the power to detect trends in statewide average Hg concentration in largemouth bass from California lakes and reservoirs.

Power is simply the probability of drawing the right conclusion, where the conclusion is based on data gathered under a specified sampling plan and analyzed using an appropriate statistical test. In the context of testing statistical hypotheses, null hypotheses (H_0), alternative hypotheses (H_A), and allied probability distributions are defined. In this context, power (P) is the probability of rejecting H_0 given that the true value is a point in H_A. In the present case, the null hypothesis is simple (trend = 0) and alternate hypothesis is the composite hypothesis (trend > 0).

H_0: β, the slope of the mean Hg concentration for the lake population is zero

or

H_0: $\beta = 0$

and the alternative hypothesis the form

H_A: the slope of the mean Hg concentration for the lake population is positive

or

H_A: $\beta > 0$

The alternative is a composite hypothesis because any positive value of the slope is in the alternative space. Thus, the test doesn't have a single value of power. Rather, the power depends on the particular point, i.e., the actual value of the slope, in the alternative that happens to be true. The effect size is just the difference between the value of the null hypothesis and the selected point in H_A where power is evaluated. For this reason, power analyses frequently are expressed in the form of *power curves* where the effect size is varied over the values in the alternative hypothesis while the other factors are held constant. Power curves are useful for informing decisions on sampling design and resource allocation, because alternative scenarios can be compared easily.

In some instances, power can be evaluated analytically, but in this case, where we are interested in power for a particular population, it would be difficult or impossible to do so. We needed to evaluate power via Monte Carlo simulation, where we drew a sample of lakes, simulated a fish sample for each lake, simulated a Hg concentration for each fish, and carried out the sampling over time while a known trend was imposed on the Hg concentration. For any given set of parameters we ran this simulation 1000 times

and calculated power by determining the number of times, out of 1000, a significant trend in Hg concentration over time could be detected.

II. Assumptions made and values used

(1) **The population of interest was largemouth bass in priority California bass lakes**. For this analysis the population of lakes in the sample universe was based on the 142 popular sport fish lakes where largemouth bass were sampled in the 2007-2008 SWAMP monitoring.

(2) **Choosing lakes to sample in different years was done one of two ways: 1) using a new random sample (sampling with replacement) in each year or** 2) **randomly assigning lakes to panels and cycling through the panels in a fixed order, one panel per year.** The panel design allowed lakes to be sampled more evenly.

(3) **Baseline Hg concentrations for each fish were randomly assigned from lake-specific distributions calculated from the 2007- 2008 SWAMP data.** The advantage of a lake-specific distribution is that it preserves spatial properties of the real population. The disadvantage is more variance than in a composite distribution (combined over all the SWAMP lakes). We assumed a log-normal distribution for each lake.

(4) **Size-standardized Hg concentrations (350 mm) were used to account for differences in fish length by lake.**

(5) **Trends were imposed on the baseline Hg data using two multipliers for each year of the simulation: one to account for a regional trend in fish Hg concentrations and another random term to account inter-annual variation unrelated to directional regional trends.** The range used for the regional trend was a yearly increase of 0.004-0.016 ppm, based on patterns seen in other regions (e.g., Monson 2009, Monson et al. 2011, Gandhi et al. 2014). Trend was added either as a constant value or as a distribution that varied within a given range (standard deviation of up to 0.1) between lakes.

(6) **The tests used to detect a slope > 0 were either a simple linear regression of the mean concentration versus time, or a more complex linear model that accounted for lake effect**.

III. Results

The results of the power analysis suggest we should be able to detect realistic trends in regional Hg bioaccumulation (0.004-0.016 ppm/yr increase) over a timeframe that is relevant to managers (10-30 years) using the recommended level of sampling effort (30 sites per year, 10 fish per site; **Table 1**). Power was greatest when using a panel design for site selection and when accounting for lake effects in the statistical analysis (**Table 2**). In this analysis, trend was added using two distinct approaches, either as a constant applied to each site evenly, or as a distribution, where trend varied between lakes. Applying trend as a distribution rather than a constant is meant to provide a more realistic estimate of power, however this had little effect on power unless the variability in trend was assumed to be very large (**Table 3**). Although 30 sites sampled per year (either annually or biennially) and 10 fish sampled per site represent a realistic and achievable sampling effort, power could be somewhat improved by increasing either the number of fish sampled per lake (**Table 4**) or the number of lakes sampled per year (**Table 5**).

Table 1. Length of time (yr) needed to detect various statewide bass Hg trends (0.004-0.016 ppm/yr increase) with a power of at least 0.80, sampling 30 lakes per year, 10 fish per lake, and assuming either annual or biennial sampling. This assumes sites were sampled in panels and that lake effect was accounted for in the statistical analysis.

	Years to Detect a Trend	
	Annual Sampling	**Biennial Sampling**
Increase of **0.016 ppm/yr**	7 yrs	10 yrs
Increase of **0.008 ppm/yr**	9 yrs	12 yrs
Increase of **0.004 ppm/yr**	16 yrs	20 yrs

Table 2. Comparison of different lake selection designs and statistical analysis approaches, showing the length of time (years) needed to detect a regional Hg trend of 0.008 ppm/yr increase with a power of at least 0.80. These scenarios assume sampling 30 lakes per year and 10 fish per lake.

Lake Sampling Design	Statistical Analysis	Years to Detect a Trend	
		Annual Sampling	Biennial Sampling
Random sampling with replacement	Simple regression	22 yrs	28 yrs
Panel design	Simple regression	17 yrs	22 yrs
Random sampling with replacement	Regression with lake effect	10 yrs	14 yrs
Panel design	Regression with lake effect	9 yrs	12 yrs

Table 3. Length of time (years) needed to detect a regional increase in sport fish Hg of 0.008 ppm/yr with a power of at least 0.80, sampling 10 fish per site, 30 sites per year, sites sampled in panels, and using a linear model with lake effect to assess trends. Comparison of two approaches for adding in trend: 1) as a constant (0.008 ppm/yr) applied to each site evenly, or 2) as a distribution, where trend varied between lakes, with the mean of the distribution centered on 0.008 ppm/yr. In both cases a term accounting for inter-annual variation within a lake (unrelated to regional trends) was added.

	Method for adding trend into model		
	Constant trend among lakes (0.008ppm/yr)	**Distribution of trends among lakes (0.008 +/- 0.002 ppm/yr increase)**	**Distribution of trends among lakes (0.008 +/- 0.1 ppm/yr increase)**
Annual Sampling	9 yrs	10 yrs	14 yrs
Biennial Sampling	12 yrs	12 yrs	20 yrs

Table 4. Length of time (years) needed to detect a regional trend of 0.008 ppm/yr increase in Hg with a power of at least 0.80, sampling a variable number of fish (10-15) per site. This assumes 30 sites were sampled per year, sites were sampled in panels in each year, and lake effect was accounted for in the statistical analysis.

	Number of Fish per Lake			
	10	**12**	**15**	**20**
Annual Sampling	9 yrs	9 yrs	9 yrs	8 yrs
Biennial Sampling	12 yrs	12 yrs	12 yrs	10 yrs

Table 5. Length of time (years) needed to detect a regional trend of 0.008ppm/yr increase in Hg with a power of at least 0.80, sampling a variable number of lakes per year (20-50). This assumes 10 fish were sampled per site, sites were sampled randomly in each year, and lake effect was accounted for in the statistical analysis. For this comparison sites were sampled randomly in each year, rather than by panel, because the code developed does not allow us to easily adjust the number of lakes per panel.

	Number of Lakes per Year			
	20	**30**	**40**	**50**
Annual Sampling	13 yrs	10 yrs	9 yrs	8 yrs
Biennial Sampling	18 yrs	14 yrs	14 yrs	12 yrs

APPENDIX 3

Method # MPSL-102a

SAMPLING MARINE AND FRESHWATER BIVALVES, FISH AND CRABS FOR TRACE METAL AND SYNTHETIC ORGANIC ANALYSIS

1.0 Scope and Application

1.1 The following procedures describe techniques of sampling marine mussels and crabs, freshwater clams, marine and freshwater fish for trace metal (TM) and synthetic organic (SO) analyses.

2.0 Summary of Method

2.1 Collect mussels, clams, crabs, or fish. Mussels or clams to be transplanted are placed in polypropylene mesh bags and deployed. Mussels and clams to be analyzed for metals are double-bagged in plastic zipper-closure bags. Bivalves to be analyzed for organics are wrapped in PE cleaned aluminum foil prior to placement in the zipper-closure bags. Fish are wrapped whole or proportioned where necessary in cleaned Teflon sheets or aluminum foil and subsequently placed into zipper-closure bags. Crabs for TM and/or SO are double-bagged in plastic zipper-closure bags.

2.2 Each sample should be labeled with Date, Station Name, and any other information available to help identify the sample once in the lab.

2.3 After collection, samples are transported back to the laboratory in coolers with ice or dry ice. If ice is used, care must be taken to ensure that ice melt does not come into direct contact with samples.

3.0 Interferences

3.1 In the field, sources of contamination include sampling gear, grease from ship winches or cables, ship and truck engine exhaust, dust, and ice used for cooling. Efforts should be made to minimize handling and to avoid sources of contamination.

3.2 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or elevated baselines, causing inaccurate analytical results. All materials should be demonstrated to be free from interferences under the conditions of the analysis by running method blanks initially and with each sample lot.

3.3 Polypropylene and polyethylene surfaces are a potential source of contamination for SO specimens and should not be used whenever possible.

4.0 Apparatus and Materials

Procedures for equipment preparation can be found in Method # MPSL-101.

4.1 Anchor Chains

4.2 Backpack Shocker (electro-fishing)

4.3 Boats (electro-fishing and/or for setting nets)

4.4 Bone Saw

4.5 Camera, digital

4.6 Cast Nets (10’ and 12’)

4.7 Data Sheets (see MPSL QAP Appendix E for example)

4.8 Daypacks

4.9 Depth Finder

4.10 Dip Nets

4.11 Dry Ice or Ice

4.12 Gill Nets (various sizes)

4.13 GPS

4.14 Heavy Duty Aluminum Foil, prepared

4.15 Heavy Duty plastic bags, Clear 30 gallon

4.16 Inflatable Buoy

4.17 Labels, gummed waterproof: Diversified Biotech Part #: LCRY-1258

4.18 Nylon Cable Ties, 7/16” wide x 7” long

4.19 Other (minnow traps, set lines, throw nets, etc)

4.20 Otter Trawl (various widths as appropriate)

4.21 Permanent Marking Pen

4.22 Plastic bucket, 30 gallon

4.23 Plastic Ice Chests

4.24 Polyethylene Gloves: VWR Part # 32915-166, 32915-188, and 32915-202

4.25 Polypropylene Mesh, 76mm wide with 13mm mesh

4.26 Polypropylene Mesh, 50mm wide with 7mm mesh

4.27 Polypropylene Line, 16mm

4.28 Rods and Reels

4.29 Screw in Earth Anchor, 4-6" diameter

4.30 Scuba Gear

4.31 Seines (various size mesh and lengths as appropriate)

4.32 Stainless Steel Dive Knives

4.33 Trap Nets (hoop or fyke nets)

4.34 Teflon Forceps

4.35 Teflon Sheet, prepared

4.36 Teflon Wash Bottle, 500 mL

4.37 Wading Gear

4.38 Zipper-closure Polyethylene Bags, 4milx13"x18": Packaging Store Part # zl401318redline

5.0 Reagents

5.1 Tap water (Tap)

5.2 Deionized water (DI)

5.3 Type II water (ASTM D1193): Use Type II water, also known as MilliQ, for the preparation of all reagents and as dilution water.

5.4 Micro Detergent: ColeParmer Part # 18100-20

5.5 Methanol: VWR Part # JT9263-3

5.6 Petroleum Ether: VWR Part # JT9265-3

6.0 Sample Collection, Preservation and Handling

6.1 All sampling equipment will be made of non-contaminating materials and will be inspected prior to entering the field. Nets will be inspected for holes and repaired prior to being used. Boats (including the electroshocking boat) will be visually checked for safety equipment and damage prior to being taken into the field for sample collection.

6.2 To avoid cross-contamination, all equipment used in sample collection should be thoroughly cleaned before each sample is processed. Ideally, instruments are made of a material that can be easily cleaned (e.g. Stainless steel, anodized aluminum, or borosilicate glass). Before the next sample is processed, instruments should be washed with a detergent solution, rinsed with ambient water, rinsed with a high-purity solvent (methanol or petroleum ether), and finally rinsed with MilliQ. Waste detergent and solvent solutions must be collected and taken back to the laboratory.

6.3 Samples are handled with polyethylene-gloved hands only. The samples should be sealed in appropriate containers immediately.

6.4 Mussels and clams to be analyzed for metals are double-bagged in zipper-closure bags. Bivalves to be analyzed for organics are wrapped in prepared aluminum foil prior to placement in zipper-closure bags.

6.5 Fish are wrapped in part or whole in prepared Teflon sheets and subsequently placed into zipper-closure bags.

6.6 Crabs analyzed for metals and/or organics are double-bagged in plastic zipper-closure bags.

6.7 Data is recorded for each site samples are transplanted to or collected from. Data includes, but is not limited to station name, sample identification number, site location (GPS), date collected or transplanted, collectors names, water depth, photo number, ocean/atmospheric conditions (if appropriate), description of site, and drawing if necessary.

6.8 A chain of custody form (MPSL QAP Appendix E) will accompany all samples that are brought to the lab. All samples that are processed in the lab MUST be checked in according to Method # MPSL-104.

6.9 Samples are maintained at -20°c and extracted or digested as soon as possible.

7.0 Procedure

7.1 Sample collection - mussels and clams

7.1.1 The mussels to be transplanted (*Mytilus californianus*) are collected from Trinidad Head (Humboldt Bay Intensive Survey), Montana de Oro (Diablo Canyon Intensive Survey), and Bodega Head (all other statewide transplants). The freshwater clam (*Corbicula fluminea*) source is Lake Isabella or the Sacramento River. Analyze mussel and clam samples for background contaminates prior to transplanting.

7.1.2 Polyethylene gloves are worn while prying mussels off rocks with dive knives. Note: polyethylene gloves should always be worn when handling samples. Mussels of 55mm to 65mm in length are recommended. Fifty mussels are collected for each TM and each SO sample.

7.1.3 Collected mussels are carried out of collection site in zipper-closure bags placed in cleaned nylon daypacks. For the collection of resident samples where only one or two samples are being collected the mussels are double bagged directly into a labeled zipper-closure bag. Samples for SO are wrapped first in prepared aluminum foil.

7.1.4 Clams (*Corbicula fluminea*) measuring 20 to 30mm are collected by dragging the clam dredge along the bottom of the lake or river. The clams are poured out of the dredge into a 30 gallon plastic bag. Clams can also be collected by gloved hands in shallow waters and placed in labeled zipper-closure bags. 25-200 clams are collected depending on availability and necessity for analyses.

7.1.5 Data is recorded for each site samples are collected from. Data includes, but is not limited to station name, date collected, collectors names, water depth, GPS readings, photo, ocean/atmospheric conditions (if appropriate), description of site, and drawing if necessary.

7.2 Transplanted sample deployment

7.2.1 With polyethylene gloves, fifty transplant mussels are placed in each 76mm X 13mm polypropylene mesh bag. Each bag represents one TM or one SO sample. A knot is tied at each end of mesh bag and reinforced with a cable tie. On one end another cable tie is placed under the cable tie which will be used to secure the bag to the line for transplant deployment. The mussels in the mesh bag are divided into three groups of approximately equal size and sectioned with two more cable ties.

7.2.2 Once bagged, the mussels are placed in a 30 gallon plastic bag and stored in a cooler (cooled with ice) for no more than 48 hours. The ice is placed in zipper-closure bags to avoid contamination.

7.2.3 If marine samples are held for longer than 48 hours they are placed in holding tanks with running seawater at the lab. Control samples for both SO and TM are also held in the tank.

7.2.4 For freshwater clams: clams (25-200) are placed in 50mm X 7mm polypropylene mesh bags using identical procedures to those used with mussels (section 7.2.1). If clams need to be stored for more than 48 hours, the mesh bags are deployed either in a clean source or in holding tanks with running freshwater at the lab until actual sample deployment.

7.2.5 The mussels are attached to an open water transplant system that consists of a buoy system constructed with a heavy weight anchor (about 100lbs) or screw-in earth anchor, 13mm polypropylene line, and a 30cm diameter subsurface buoy. The sample bags are attached with cable ties to the buoy line about 15 feet below the water surface. In some cases the sample is hung on suspended polypropylene lines about 15 feet below the water surface between pier pilings or other surface structures. Creosote-coated wooden piers are avoided because they are a potential source of contamination. In some cases the mussels are hung below a floating dock. In shallow waters a wooden or PVC stake is hammered into the substrate and the mussel bags are attached by cable ties to the stake.

7.2.6 The clams are deployed by attaching the mesh bag with cable ties to wooden or PVC stakes hammered into substrate or screw in earth anchors. The bags containing clams are typically deployed 15cm or more off the bottom. In areas of swift water, polypropylene line is also attached to the staked bags and a permanent object (piling, tree or rock).

7.2.7 Transplants are usually deployed for 1-4 months. Ideally mussels are transplanted in early September and retrieved in late December and early January. Clams are usually transplanted in March or April and retrieved in May or June.

7.2.8 Data is recorded for each site samples are transplanted to or collected from. Data includes, but is not limited to station name, date collected or transplanted, collectors names, water depth, GPS readings, photo, ocean/atmospheric conditions (if appropriate), description of site, and drawing if necessary.

7.3 Sample Retrieval

7.3.1 The transplanted or resident and control mussels analyzed for TM are double bagged in appropriately sized and labeled zipper-closure bags.

7.3.2 All mussels to be analyzed for SO are wrapped in prepared aluminum foil (Method # DFG 101). The foil packet is double bagged in appropriately sized and labeled zipper-closure bags. Note: samples should only contact the dull side of the foil.

7.3.3 The bags containing samples are clearly and uniquely identified using a water-proof marking pen or pre-made label. Information items include ID number, station name, depth (if from a multiple sample buoy), program identification, date of collection, species and type of analysis to be performed.

7.3.4 The samples are placed in non-metallic ice chests and frozen using dry ice or regular ice. (Dry ice is used when the collecting trip takes more than two days.) At the lab, samples should be stored at or below -20°c until processed.

7.4 Sample Collection – Fish

7.4.1 Fish are collected using the appropriate gear for the desired species and existing water conditions.

7.4.1.1 Electro-fisher boat- The electro-fisher boat is run by a trained operator, making sure that all on board follow appropriate safety rules. Once on site, adjustment of the voltage, amps, and pulse for the ambient water is made and recorded. The stainless steel fish well is rinsed with ambient water, drained and refilled. The shocked target fish are placed with a nylon net in the well with circulating ambient water. The nylon net is washed with a detergent and rinsed with ambient water prior to use. Electro-fishing will continue until the appropriate number and size of fish are collected.

7.4.1.2 Backpack electro-fisher- The backpack shocker is operated by a trained person, making sure that all others helping follow appropriate safety rules. The backpack shocker is used in freshwater areas where an electro-fisher boat can not access. Once on site, adjustment of the voltage, amps, and pulse for the ambient water is made and recorded. The shocked target fish are captured with a nylon net and placed in a 30 gallon plastic bag. The nylon net is washed with a detergent and rinsed with ambient water prior to use. Electro-fishing will continue until the appropriate number and size of fish are collected.

7.4.1.3 Fyke or hoop net- Six-36 inch diameter hoops connected with 1 inch square mesh net is used to collect fish, primarily catfish. The net is placed parallel to shore with the open hoop end facing downstream. The net is placed in areas of slow moving water. A partially opened can of cat food is placed in the upstream end of the net. Between 2-6 nets are placed at a site overnight. Upon retrieval a grappling hook is used to pull up the downstream anchor. The hoops and net are pulled together and placed on a 30

gallon plastic bag in the boat. With polyethylene gloves the desired fish are placed in a 30 gallon plastic bag and kept in an ice chest with ice until the appropriate number and size of fish are collected.

7.4.1.4 Otter-trawl- A 14 foot otter trawl with 24 inch wooden doors or a 20 foot otter trawl with 30 inch doors and 80 feet of line is towed behind a boat for water depths less than 25 feet. For water depths greater than 25 feet another 80 feet of line is added to capture fish on or near the substrate. Fifteen minute tows at 2-3 knots speed are made. The beginning and ending times are noted on data sheets. The trawl is pulled over the side of the boat to avoid engine exhaust. The captured fish are emptied into a 30 gallon plastic bag for sorting. Desired fish are placed with polyethylene gloves into another 30 gallon plastic bag and kept in an ice chest with ice.

7.4.1.5 Gill nets- A 100 yard monofilament gill net of the appropriate mesh size for the desired fish is set out over the bow of the boat parallel to shore. The net is retrieved after being set for 1-4 hours. The boat engine is turned off and the net is pulled over the side or bow of the boat. The net is retrieved starting from the down-current end. If the current is too strong to pull in by hand, then the boat is slowly motored forward and the net is pulled over the bow. Before the net is brought into the boat, the fish are picked out of the net and placed in a 30 gallon plastic bag and kept in an ice chest with ice.

7.4.1.6 Beach seines- In areas of shallow water, beach seines of the appropriate length, height, and mesh size are used. One sampler in a wetsuit or waders pulls the beach seine out from shore. The weighted side of the seine must drag on the bottom while the float side is on the surface. The offshore sampler pulls the seine out as far as necessary and then pulls the seine parallel to shore and then back to shore, forming a half circle. Another sampler is holding the other end on shore while this is occurring. When the offshore sampler reaches shore the two samplers come together with the seine. The seine is pulled onto shore making sure the weighted side drags the bottom. When the seine is completely pulled onshore, the target fish are collected with polyethylene gloves and placed in a 30 gallon plastic bag and kept in an ice chest with ice. The beach seine is rinsed off in the ambient water and placed in the rinsed 30 gallon plastic bucket.

7.4.1.7 Cast net- A 10 or 12 foot cast net is used to collect fish off a pier, boat, or shallow water. The cast net is rinsed in ambient water prior to use and stored in a covered plastic bucket. The target fish are sampled with polyethylene gloves and placed in a 30 gallon plastic bag and kept in an ice chest with ice.

7.4.1.8 Hook and line- Fish are caught off a pier, boat, or shore by hook and line. Hooked fish are taken off with polyethylene gloves and placed in a Ziploc™ bag or a 30 gallon plastic bag and kept in an ice chest with ice.

7.4.1.9 Spear fishing- Certain species of fish are captured more easily by SCUBA divers spearing the fish. Only appropriately trained divers following the dive safety program guidelines are used for this method of collection. Generally, fish in the kelp beds are more easily captured by spearing. The fish are shot in the head area to prevent the fillets from being damaged or contaminated. Spear tips are washed with a detergent and rinsed with ambient water prior to use.

7.4.2 As a general rule, five fish of medium size or three fish of larger size are collected as composites for analysis. The smallest fish length cannot be any smaller than 75% of the largest fish length. Five fish usually provides sufficient quantities of tissue for the dissection of 150 grams of fish flesh for organic and inorganic analysis. The medium size is more desirable to enable similar samples to be collected in succeeding collections.

7.4.3 When only small fish are available, sufficient numbers are collected to provide 150 grams of fish flesh for analysis. If the fish are too small to excise flesh, the whole fish, minus the head, tail, and guts are analyzed as composites.

7.4.4 Species of fish collected are chosen for their importance as indicator species, availability or the type of analysis desired. For example, livers are generally analyzed for heavy metals. Fish without well-defined livers, such as carp or goldfish, are not collected when heavy metal analyses are desired.

7.4.5 Fish collected, too large to fit in clean bags (>500 mm) are initially dissected in the field. At the dock, the fish are laid out on a clean plastic bag and a large cross section from behind the pectoral fins to the gut is cut with a cleaned bone saw or meat cleaver. The bone saw is cleaned (micro, DI, methanol) between fish and a new plastic bag is used. The internal organs are not cut into, to prevent contamination. For bat rays, a section of the wing is cut and saved. These sections are wrapped in prepared Teflon sheets, double bagged and packed in dry ice before transfer to the freezer. During lab dissection, a subsection of the cross section is removed, discarding any tissue exposed by field dissection.

7.4.6 Field data (MPSL QAP Appendix E) recorded include, but are not limited to site name, sample identification number, site location (GPS), date of collection, time of collection, names of collectors, method of collection, type of sample, water depth, water and atmospheric conditions, fish total lengths (fork lengths where appropriate), photo number and a note of other fish caught.

7.4.7 The fish are then wrapped in aluminum foil or Teflon sheets if thylates are analyzed. The wrapped fish are then double-bagged in zipper-closure bags with the inner bag labeled.

The fish are put on dry ice and transported to the laboratory where they are kept frozen until they are processed for chemical analysis.

7.5 Sample Collection- Crabs

7.5.1 Crab/lobster traps- Polyethylene traps are baited to collect crabs or lobsters. Traps are left for 1-2 hours. The crabs are placed in a zipper-closure bag or a 30 gallon plastic bag and kept in an ice chest with ice.

8.0 Analytical Procedure

8.1 Tissue Preparation procedures can be found in Method # MPSL-105.

8.2 Trace Metal and Mercury Only digestion procedures can be found in EPA 3052, modified, and Method # MPSL-106, respectively.

8.3 Trace Metals are analyzed with ICP-MS according to EPA 200.8.

8.4 Mercury samples are analyzed by FIMS according to Method # MPSL-103 or by DMA and EPA 7473.

8.5 Methylmercury tissue samples are extracted and analyzed according to Method # MPSL-109.

9.0 Quality Control

9.1 Field Replicates: project specific requirements are referenced for field replication.

9.2 A record of sample transport, receipt and storage is maintained and available for easy reference.

10.0 References

10.1 Flegal, R.A. 1982. In: Wastes in the Ocean, Vol VI: Near Shore Waste Disposal. B.H. Ketchum (ed.). John Wiley and Sons Inc. Publishers, New York, 1982.

10.2 Goldberg, E.D., ed. 1980. The International Mussel Watch. National Academy of Sciences Publ., Washington, D.C.

10.3 Gordon, R.M., G.A. Knauer and J.H. Martin. 1980a. *Mytilus californianus* as a bioindicator of trace metal pollution: variability and statistical considerations. Mar. Poll. Bull. 9:195-198.

10.4 Hayes, S. P. and P. T. Phillips. 1986. California State Mussel Watch: Marine water quality monitoring program 1984-85. State Water Resources Control Board Water Quality Monitoring Report No. 86-3WQ.

10.5 EPA. 1995. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1: Fish Sampling and Analysis. EPA 823-R-95-007.