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Sampling and Analysis Plan for a Screening Study of Bioaccumulation on the California Coast

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FINAL

SAMPLING AND ANALYSIS PLAN FOR A SCREENING STUDY OF BIOACCUMULATION ON THE CALIFORNIA COAST

The Bioaccumulation Oversight Group (BOG)

Surface Water Ambient Monitoring Program

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I. INTRODUCTION

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

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

The Roundtable has formed a subcommittee, the Bioaccumulation Oversight Group (BOG), that focuses on the Bioaccumulation Monitoring Project. The BOG is composed of State and Regional Board staff and representatives from other agencies and organizations including USEPA, the Department of Fish and Game, 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 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 been focused on a two-year screening survey of bioaccumulation in sport fish of California lakes and reservoirs (Davis et al. 2008). Under this effort, fish were collected in the summers of 2007 and 2008. A report on results from the first year is available (http://www.waterboards.ca.gov/water_issues/programs/swamp/lakes_study.shtml). A final report covering both years of the survey will be prepared in the fall of 2009.

II. GENERAL ASPECTS OF THE SWAMP BIOACCUMULATION MONITORING PROJECT

A. Addressing Multiple Beneficial Uses

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

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

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

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

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

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

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

C. Addressing Multiple Habitat Types

SWAMP has defined the following categories of water bodies:

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

Due to their vast number, high fishing pressure, and a relative lack of information on bioaccumulation (Davis et al. 2007), lakes and reservoirs were identified as the first priority for monitoring. Coastal waters have been selected as the next priority, due to their importance for sport fishing and a relative lack of past monitoring. A Coastal Fish Contamination Monitoring Program was in initiated in 1998 (Gassel et al. 2002). This program was developed to assess the health risks of consumption of sport fish and shellfish from nearshore waters along the entire California coast. The CFCP was considered to be a critical component of a comprehensive coastal water quality protection program, and an important opportunity to build a long-term coastal monitoring database for water quality and contaminants in fish. However, the CFCP, along with the other two major state bioaccumulation monitoring programs (the Toxic Substances Monitoring Program and the State Mussel Watch Program) were discontinued in 2003 as plans for SWAMP began to take shape. Systematic monitoring of bioaccumulation in fish on the coast was therefore only in place for a few years. Given the extensive area, multiple habitats (coastline, bays and estuaries), diversity of species to be covered, and the amount of funding available ($500,000 of SWAMP funds for sampling and analysis), the coastal waters survey is also going to be a two-year effort spanning 2009 and 2010. In 2011, SWAMP will monitor bioaccumulation in California rivers and streams. In 2012, the long-term plan calls for beginning another five-year cycle of monitoring, with another two-year lake survey.

In summary, focusing on two closely associated habitat types (the coast and bays and estuaries), one objective (status), and one beneficial use (fishing) will allow us to provide reasonable coverage and a thorough assessment of bioaccumulation in California’s coastal waters over a two-year period.

III. DESIGN OF THE COASTAL WATERS SURVEY

A. Management Questions for this Survey

Three management questions have been articulated to guide the 2009-2010 survey of the status of bioaccumulation in sport fish on the California coast. These management questions are specific to this initial screening effort.

One major difference between this set of questions and the questions for the lakes survey is that the question regarding 303(d) listing is not included here. The 303(d) question was a major driver of the design of the lakes survey. On the coast, however, 303(d) listing is not a high priority for the Water Boards.

Management Question 1 (MQ1)

Status of the Fishing Beneficial Use
For popular fish species, what percentage of popular fishing areas have low enough concentrations of contaminants that fish can be safely consumed?

Answering this question is critical to determining the degree of impairment of the fishing beneficial use across the state due to bioaccumulation. This question places emphasis on characterizing the status of the fishing beneficial use through monitoring of the predominant pathways of exposure – the popular fish species and fish areas. This focus is also anticipated to enhance public and political support of the program by assessing the resources that people care most about. The determination of percentages captures the need to perform a statewide assessment of the entire California coast. The emphasis on safe consumption calls for: a positive message on the status of the fishing beneficial use; evaluation of the data using thresholds for safe consumption; and performing a risk-based assessment of the data.

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

Management Question 2 (MQ2)

Regional Distribution
What is the distribution of contaminant concentrations in fish within regions?

Answering this question will provide information that is valuable in formulating management strategies for observed contamination problems. This information will allow managers to prioritize their efforts and focus attention on the areas with the most severe problems. Information on regional distribution will also provide information on sources and fate that will be useful to managers.

This question can be answered with different levels of certainty. For a higher and quantified level of certainty, a statistical approach with replicate observations in the spatial units to be compared is needed. In some cases, managers can attain an adequate level of understanding for their needs with a non-statistical, non-replicated approach. With either approach, reliable estimates of average concentrations within each spatial unit are needed.

Management Question 3 (MQ3)

Need for Further Sampling

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

This screening survey of the entire California coast will provide a preliminary indication as to whether many areas that have not been sampled thoroughly to date may require consumption guidelines. Consumption guidelines provide a mechanism for reducing human exposure in the short-term. The California Office of Environmental Health Hazard Assessment (OEHHA), the agency responsible for issuing consumption guidelines, considers a sample of 9 or more fish from a variety of species abundant in a water body to be the minimum needed in order to issue guidance. It is valuable to have information not only on the species with high concentrations, but also the species with low concentrations so anglers can be encouraged to target the low species. The diversity of species on the coast demands a relatively large effort to characterize interspecific variation. Answering this question is essential as a first step in determining the need for more thorough sampling in support of developing consumption guidelines.

Overall Approach

The overall approach to be taken to answer these three questions is to perform a statewide screening study of bioaccumulation in sport fish on the California coast. Answering these questions will provide a basis for decision-makers to understand the scope of the bioaccumulation problem and will provide regulators with information needed to establish priorities for both cleanup actions and development of consumption guidelines.

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

B. Coordination

Through coordination with other programs, SWAMP funds for this survey are going to be highly leveraged to achieve a much more thorough statewide assessment than could be achieved by SWAMP alone.

First, this effort will be closely coordinated with bioaccumulation monitoring for Bight ’08, a comprehensive regional monitoring program for the Southern California Bight (SCB). Every five years, dischargers in the SCB collaborate to perform this regional monitoring. Bioaccumulation monitoring is one element of the Bight Program. Most of the work for this most recent round of Bight monitoring was performed in 2008. The bioaccumulation element, however, was delayed to 2009 in order to allow coordination with the SWAMP survey. The Bight group wanted to conduct sport fish sampling, but lacks the infrastructure to perform sample collection. The Bight group is therefore contributing approximately $240,000 worth of analytical work (analysis of PCBs and organochlorine pesticides in 225 samples) to the joint effort. This is allowing more intensive sampling of the Bight region than either program could achieve independently.

The SWAMP survey will also be coordinated with intensive sampling in San Francisco Bay by the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). The RMP conducts thorough sampling of contaminants in sport fish in the Bay on a triennial basis (see Hunt et al. [2008] for the latest results). This sampling has been conducted since 1994. The RMP will provide complete and thorough coverage of the Bay, with no additional effort by SWAMP needed. In addition, to coordinate with the SWAMP effort, the RMP will analyze additional species to allow for more extensive comparisons of the Bay with coastal areas and bays in other parts of the state. The RMP will benefit from this collaboration by SWAMP contributing: 1) a statewide dataset that will help in interpretation of RMP data and 2) a statewide report that will include an assessment and reporting of Bay data that will make production of a separate report by the RMP unnecessary. The RMP effort represents $215,000 of sampling and analysis.

In addition, the Region 4 Water Board is going to supplement the statewide survey with another $110,000 to provide for more thorough coverage of the SCB.

In all, these collaborations are more than doubling the total amount of SWAMP funding available for sampling and analysis in year 1 of the coastal waters survey. Each of the collaborating programs will benefit from the consistent statewide assessment, increased information due to sharing of resources, and efforts to ensure consistency in the data generated by the programs (e.g., analytical intercalibration).

The Bight group and the RMP each have committees that provide oversight of these long-term monitoring programs and a history of monitoring in their regions. Consequently, the sampling design in each of these regions will vary in minor ways from the design for the rest of the state. More information on these programs and the specific designs for these regions is provided in Section L.

C. Phased Approach

The survey is being conducted over two years to allow thorough coverage of the entire coast with available funds. The study is being phased to facilitate coordination and continuing demonstration of successful monitoring by placing a priority on generating information that is of maximum value to regulators and the public.

In year 1, sampling will focus on the SCB (Water Board regions 4, 8 and 9 – see Figure 1) and San Francisco Bay and adjacent coastal areas (Region 2). This will allow for coordination with Bight ’08 and the RMP, which are scheduled for 2009. This will also provide a basis for a report on year 1 that describes bioaccumulation in the most populated and heavily fished areas in the state near San Francisco and Los Angeles.

Sampling in year 2 will cover the other coastal regions (1 and 3) and any other remaining areas not covered in year 1. The second year report will present the data for these areas and also provide a comprehensive assessment of the entire two-year dataset.

D. Spatial Considerations

California has over 3000 miles of coastline that spans a diversity of habitats and fish populations, and dense human population centers with a multitude of popular fishing locations. Sampling this vast area with a limited budget is a challenge.

The approach being employed to sample this vast area is to divide the coast into 69 spatial units called “zones” (Figure 2). The use of this zone concept is consistent with the direction that OEHHA will take in the future in development of consumption guidelines for coastal areas. Advice has been issued on a pier-by-pier basis in the past in Southern California, and this approach has proven to be unsatisfactory. All of these zones will be sampled, making a probabilistic sampling design unnecessary.

The sampling will be focused on nearshore areas, including bays and estuaries, in waters not exceeding 200 m in depth, and mostly less than 60 m deep. These are the coastal waters where most of the fishing occurs.

Several criteria were considered in drawing the boundaries of the zones.

1. Fishing pressure. Zones are smaller and more numerous in areas with more fishing pressure. The location of fishing piers and other fishing access points was an important factor in zone delineation. On the other hand, the zones are larger in remote areas with little fishing activity.
2. Even distribution. To ensure coverage of the entire coast, the zones are generally spread evenly throughout, with adjustments made for fishing pressure as described above.

3. Homogeneity of contamination. Land use and hydrology were considered in drawing boundaries to reflect known patterns of contamination.
4. Stakeholder interest. The boundaries were reviewed by stakeholders (Water Board representatives, stakeholders in the Bight Group) and modified according to their needs.

Popular fishing locations were identified from Jones (2004) and discussions with stakeholders. Zones were developed in consultation with Water Board staff from each of the nine regions, Bight Group stakeholders, and the BOG.

C. Sampling Design Within Each Zone

1. Species Targeted

Selecting fish species to monitor on the California coast is a complicated task due to the relatively high diversity of species, regional variation over the considerable expanse of the state from north to south, variation in habitat and contamination between coastal waters and enclosed bays and harbors, and the varying ecological attributes of potential indicator species. The list of possibilities was narrowed down by considering the following criteria, listed in order of importance.

1. Popular for consumption
2. Sensitive indicators of problems (accumulating relatively high concentrations of contaminants)
3. Widely distributed
4. Species that accumulate relatively low concentrations of contaminants
5. Represent different exposure pathways (benthic vs pelagic)
6. Continuity with past sampling

Information relating to these criteria is presented below.

The BOG elected not to include shellfish in this survey, due to the limited budget available and the lower consumption, lower risks to human health, and the added expense that would be required to collect shellfish. Monitoring of mussels is still being performed in California by NOAA’s National Mussel Watch Program (using resident mussels) and by the Department of Fish and Game at more than 20 stations (using transplanted mussels). An additional consideration is that for mercury, the analysis of shellfish for methylmercury (rather than total Hg) would be required for a meaningful assessment. Determination of methylmercury is much more labor intensive and costly than determination of total Hg.

Popular for Consumption

As recommended by USEPA (2000) in their document “Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories,” the primary factor considered in selecting species to monitor was a high rate of human consumption. Fortunately, good information on recreational fish catch is available from the Recreational Fisheries Information Network (RecFIN), a product of the Pacific States Marine Fisheries

Commission (PSMFC). Established in 1992, RecFIN is designed to integrate state and federal marine recreational fishery sampling efforts into a single database to provide important biological, social, and economic data for Pacific coast recreational fishery biologists, managers and anglers. Fish catch data are available at: www.recfin.org/forms/est2004.html. Additional data were obtained from Wade Van Buskirk of the PSMFC. The data were for the period Jan 2005 to Dec 2007.

Many different taxonomic groups of fish are found on the coast (e.g., rockfish, surfperch, or sharks) and some of these groups consist of quite a diversity of species. The sampling design is based primarily on coverage of a representative of selected groups within each zone. RecFIN data were used to identify the groups to target. Table 2 shows these data for the three regions (south, central and north) and specific data for the coast (ocean < 3 mi) and bays and harbors. Data include mass of catch in tonnes and counts in thousands (parentheses). The mass and catch data were ranked for each region, then the ranks for each species were averaged to obtain an average rank. The average rank was used as the index of popularity for fish consumption. For example, in southern California coastal waters, the most popular groups included chub mackerel; perch; flatfish; sharks, skates, and rays; rockfish; and croaker. The popular groups varied among the three regions of the state (south, central, and north) and between coastal waters and bays and harbors.

The next task was to select species within each group that will be targeted for sampling. For these decisions, RecFIN data for individual species were considered (Table 3). For example, rockfish are a popular group along most of the coast. Data for individual rockfish species were examined to identify the most popular species in each region. In coastal waters ("ocean < 3 mi" in Tables 2 and 3) of southern California, kelp bass (which were included in the "rockfish" group), were the most popular species in this group by far. Therefore, this species was selected as the primary target species for the rockfish group in this region. Since it is not always possible to collect the species that are targeted in every zone, the sampling crew will have a prioritized menu of other potential target species. Primary target species will be given the highest priority. If primary targets are not available in sufficient numbers, secondary targets have been identified. For rockfish, in the southern California ocean region, barred sand bass were the second most abundant species, and are at the top of a list of several possible secondary target species. In this manner, the RecFIN data were used to select primary and secondary targets for all of the sampling strata along the coast.

Sensitive Indicators

While catch data were the primary determinant of the list of target species, some adjustments were made to ensure an appropriate degree of emphasis on sensitive indicators of contamination. USEPA (2000) also recommends consideration of this (expressed as "the potential to bioaccumulate high concentrations of chemical contaminants") as a criterion of major importance. Including these species is useful in assessing the issue of safe consumption (contained in MQ1) – if the sensitive indicator species in an area are below thresholds of concern then this provides an indication that all species in that area are likely to be below thresholds.

Different contaminants have different mechanisms of accumulation and therefore a combination of species is needed to ensure inclusion of the appropriate sensitive indicators. Methylmercury biomagnifies primarily through its accumulation in muscle tissue, so predators such as sharks tend to have the highest methylmercury concentrations. In contrast, the organic contaminants of concern also biomagnify, but primarily through accumulation in lipid. Concentrations of organics are therefore also influenced by the lipid content of the species, with species that are higher in lipid having higher concentrations. Species such as white croaker tend to have high lipid concentrations in their muscle tissue, and therefore usually have the highest concentrations of organics. Other factors in addition to lipid are also important for some organics. Trophic position and age are important for highly hydrophobic pollutants such as the highly chlorinated PCBs (including the major ones like PCB153, 138, 180). Most studies show that there is lifetime accumulation of high log Kow organohalogen compounds that are not metabolized. Sex may also be influential since the sole mechanism of excretion may be egg production in females (Ross Norstrom, personal communication).

Consequently, target species in this study will include both high lipid species such as croaker and surfperch, and predators that accumulate mercury such as sharks. These considerations had an influence on the target species list. For example, white croaker has a high potential for accumulation of organics and has been sampled extensively in past studies in both southern California and San Francisco Bay. Therefore, even though white croaker did not quite make the list of the top five most popular species in these areas, it was still included as a primary target.

Spatial Distribution

Consideration in selection of target species was also given to their spatial distribution in order to provide better information for answering MQ2 (regional distribution). This is also recommended as an important criterion to consider by USEPA (2000). Due to interspecific variation in bioaccumulation, the availability of consistent species across the spatial units of interest is critical to maximizing information obtained on spatial patterns. The sampling design complies with this criterion as much as possible, given the primary consideration given to the two criteria described previously. As one example, shiner surfperch were selected as a secondary target for the central California coast, even though their catch was a bit lower than walleye surfperch, in order to allow for better comparison with the shiner surfperch data for central California bays and harbors.

Other Factors

Other factors were considered but did not have a major influence on the design due to the limited resources available.

- Cleaner species. Provide information useful in developing safe eating guidelines. More focused effort to obtain information on these species is left to future studies.
- Different exposure pathways (benthic vs pelagic). Not a high priority with the limited budget.
- Continuity with past sampling. This was a consideration in some areas, but past sampling also focused on the popular species, so the actual influence of this was not significant.

The Target Species

Table 4 shows the lists of primary and secondary species for each region and stratum based on the considerations discussed above. The available budget will allow for analysis of five species per zone. Therefore, the Table shows five primary targets for each stratum. One exception is the coast in southern California, where (in accordance with Bight Group preferences) the fifth species to be analyzed will be determined based on what is caught in the sample collection process.

A summary of basic ecological attributes of the primary and secondary target species is presented in Table 5. This information will be useful in performing spatial comparisons in cases where it was not possible to collect the same species in the spatial units to be compared. In these cases, comparisons may be evaluated for species from the same guilds and with similar attributes. Information on each species was gathered from FishBase (http://www.fishbase.org/), CDFG's Marine Sportfish Identification website (http://www.dfg.ca.gov/marine/fishid.asp), Oregon State University's Marine Species with Aquaculture Potential (http://hmsc.oregonstate.edu/projects/msap/index.html), and discussions with Jim Allen of SCCRWP (personal communication). Species were classified into guilds based on prey items, foraging type and habitat in an attempt to identify different species across the state with similar exposure pathways.

2. Sampling Sites

Within each zone, specific sites will be selected for sample collection. Criteria to be considered in determining the placement of sampling sites will include the existence of discrete centers of fishing activity, road or boat ramp access, known patterns of spatial variation in contamination or other factors influencing bioaccumulation, and possibly other factors. The primary emphasis will be on sampling in areas that are popular for fishing. Popular fishing areas will be identified through published sources (e.g., Jones [2004]) and consultation with agency staff.

3. Replication

There will be no replication of sites within a zone. If the sampling crew is unable to obtain sufficient samples at the first site sampled, they will move to the next site where fishing pressure is high and it is likely to obtain the needed samples.

In general, there will be only one composite sample (compositing is discussed further below) collected for each species in each zone. With the limited resources available, it is considered a higher priority to obtain information on different species than to attempt to provide a stronger basis for statistical spatial comparisons among zones. It is recognized that this will make data interpretation less conclusive. Exceptions to this are the southern California Bight (SCB) and San Francisco Bay. In the SCB, the Bight Group is making funds available for analyzing three replicates of kelp bass, white croaker, and one other species within each zone. These are not site replicates, however – the replicates can be collected from a single site, if that is possible, or from multiple sites if that is necessary. These are simply multiple replicates of the target species from a given zone. This same basic approach will be followed in San Francisco Bay, but the Bay will be divided relatively finely into five zones.

4. Size Ranges and Compositing for Each Species

Size Ranges and Compositing

Chemical analysis of trace organics is relatively expensive ($519 per sample for PCB congeners and $557 per sample for organochlorine pesticides), and the management questions established for this survey can be addressed with good information on average concentrations, so a compositing strategy will be employed for these chemicals.

Chemical analysis of mercury is much less expensive ($65 per sample) and mercury concentrations are known to be closely correlated with fish size in many species. Collecting data on mercury concentrations in individual fish can provide a basis for statistical analysis (ANCOVA) to evaluate spatial or temporal patterns in a manner that filters out the influence of fish size (for example, see Davis et al. [2008]). Consequently, the sampling design for selected mercury indicator species includes analysis of mercury in individual fish. For the mercury indicator species, an analysis of covariance approach will be employed, in which the size:mercury relationship will be established for each location and an ANCOVA will be performed that will allow the evaluation of differences in slope among the locations and the comparison of mean concentrations and confidence intervals at a standard length, following the approach of Tremblay (1998). Experience applying this approach in the Central Valley indicates that to provide robust regressions 10 fish spanning a broad range in size are needed (Davis et al. 2003, Davis et al. 2008).

Specific size ranges to be targeted for each species are listed in Table 6.
Kelp Bass, Olive Rockfish, Black Rockfish, Blue Rockfish, and Brown Rockfish are the key mercury indicators. These species have a high trophic position and a strong size:mercury relationship. In addition, Shiner Surfperch will be analyzed as individuals for Hg because of their cosmopolitan distribution. These species will be analyzed individually for mercury, and composites from these fish will also be prepared for analysis of organics. The numbers and sizes indicated for these species will provide the size range needed to support ANCOVA.

Size ranges for other species are based on a combination of sizes prevalent in past sampling: RMP (Greenfield et al. 2005) and the CFCP (Gassel et al. 2002) and the 75% rule recommended by USEPA (2000) for composite samples. The target ranges for each species are defined by the minimum sizes listed in Table 6 and an upper bound based on the 75% rule.

In cases when more than 5 fish of one species are collected in a zone, composites will be created using the following guidelines:

1. Size: The middle interquartile will be used for composites. This eliminates bias towards either large or small fish.
2. Location: Fish collected from different locations within a zone will be distributed among composites.
3. Date of Catch: Fish collected at the same or different locations on different days will be distributed among composites. This guideline will take a higher priority on fish known to be active swimmers such as mackerel.
4. Mode of Catch: Fish collected via different methods, such as hook and line, seine or pole spear, will be distributed among composites.

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. Sample Processing and Analysis

Upon collection each fish collected will be tagged with a unique ID. 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 fishers and wardens use 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.

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

Composites will be created based on the 75% rule recommended by USEPA (2000). In general, fish will have the skin dissected off, and only the fillet muscle tissue will be used for analysis. This is inconsistent with the guidance of USEPA (2000) that recommends that fish with scales have the scales removed and be processed with skin on, and skin is only removed from scaleless fish (e.g. catfish). The BOG is aware of this difference, but favors skin removal. Skin removal has been repeatedly used in past California monitoring. All fish (with limited exceptions) in Toxic Substances Monitoring Program, the Coastal Fish Contamination Program, and the Fish Mercury Project have also been analyzed skin-off. Processing fish with the skin on is very tedious and results in lower precision because the skin is virtually impossible to homogenize thoroughly and achieving a homogenous sample is difficult. Also, skin-on preparation actually dilutes the measured concentration of mercury because there is less mercury in skin than in muscle tissue. The most ubiquitous contaminant in fish in California that leads to most of our advisories is 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 national workgroup concerning the monitoring and analysis of mercury in fish (Wiener et al. 2007). Surfperch samples will be an exception to this rule. Surfperch are too small for skin removal. Procedures used in past monitoring (removing heads, tails, and viscera; leaving muscle with skin and skeleton to be included in the composites as in the RMP) will be used.

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

Selenium will be digested according to EPA 3052M, “Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices”, modified, and analyzed according to EPA 200.8, “Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry”. Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Two blanks, a standard reference material (2976 or DORM-2), as well as a method duplicate and a matrix spike pair will be run with each set of samples.

Most organics analyses will be performed by the California Department of Fish and Game Water Pollution Control Lab in Rancho Cordova, CA. Organochlorine pesticides will be analyzed according to EPA 8081AM, "Organochlorine Pesticides by Gas Chromatography". PCBs and PBDEs will be analyzed according to EPA 8082M, "Polychlorinated Biphenyls (PCBs) by Gas Chromatography". Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±25% of the true value, or the previous 10 samples must be reanalyzed. One blank, a laboratory control spike (LCS), as well as a method duplicate and a matrix spike pair will be run with each set of samples.

Analysis of split samples and additional replicates for organics in the Southern California Bight will be performed by several labs that participate in Bight monitoring (see Section L below).

E. Analytes

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

Additional discussion of the analytes is provided below.

Ancillary Parameters

Ancillary parameters to be measured in the lab include moisture and lipid (Table 8). Fish sex will not be determined for all samples as it is not considered critical for this statewide screening study. However, determination of sex has been requested by the Bight Program for fish from that region, and this will be performed.

Methylmercury

Methylmercury is the contaminant of greatest concern with respect to bioaccumulation on a statewide basis. Based on past monitoring (Gassel et al. 2002), methylmercury is expected to exceed the threshold of concern in many coastal zones. 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. Mercury will be analyzed in all samples because a substantial proportion of samples of each species are expected to exceed the threshold of concern.

PCBs

PCBs are the contaminant of second greatest concern with respect to bioaccumulation on a statewide basis (Davis et al. 2007). PCBs will be analyzed using a congener specific method. A total of 55 congeners will be analyzed (Table 8). This list includes many of those identified as additional candidates for inclusion on the congener list by Sanborn and Brodberg (2007 – “Appendix 1: Detailed Evaluation of Organic Analytes to Include in the Study”). PCBs will be analyzed in all composite samples.

Legacy pesticides

Based on past monitoring (Gassel et al. 2002), legacy pesticides are generally expected to exceed thresholds of concern in a very small percentage of California coastal zones. An exception to this would be the portion of the SCB with significant historic contamination. Pesticides will be analyzed in all composite samples.

PBDEs

Few data are currently available on PBDEs in California sport fish, and a threshold of concern has not yet been established. However, a rapid increase in concentrations in the 1990s observed in San Francisco Bay and other parts of the country raised concern about these chemicals, and led to a ban on the production and sale of the penta and octa mixtures in 2006 (Oros et al. 2005). The deca mixture is still produced commercially. A threshold of concern is anticipated to be established soon by USEPA. The most important PBDE congeners with respect to bioaccumulation are PBDEs 47, 99, and 100. It is anticipated that funds will be obtained to allow for analysis of PBDE congeners. A total of 12 congeners will be analyzed (Table 8). PBDEs will be analyzed in two composite samples from each zone (if funding allows).

Dioxins and Dibenzofurans

Few data are available on dioxins and dibenzofurans in California sport fish. Perhaps the best dataset exists for San Francisco Bay, where samples from 1994, 1997, 2000, 2003, and 2006 indicated that concentrations in high lipid species exceeded a published screening value of 0.3 TEQs (for dioxins and furans only) by five fold (Greenfield et al. 2003). However, there are no known major point sources of dioxins in the Bay Area and the concentrations measured in the Bay are comparable to those in rural areas of the U.S. OEHHA did not include dioxins in their recent evaluation of guidance tissue levels for priority contaminants due to the lack of data for dioxins in fish throughout the state (Klasing and Brodberg 2008). Given the relatively high cost of dioxin analysis and these other considerations, OEHHA recommended that dioxins not be included in this screening study (Table 7). Dioxins are considered a higher priority by the RMP, so these analytes will be included for high lipid species (white croaker and shiner surfperch) in San Francisco Bay. The RMP will analyze dioxins and dibenzofurans, but not coplanar PCBs. Analysis of dioxins and dibenzofurans has also been identified as a high priority for Humboldt Bay, so samples for Humboldt Bay zones will also be analyzed for these chemicals.

Selenium

Past monitoring (Greenfield et al. 2005, Gassel et al. 2002) indicates that selenium concentrations are not likely to be above thresholds in this study, except perhaps for white sturgeon in San Francisco Bay. OEHHA has requested including selenium on the analyte list for year 1 of the Coastal Survey to confirm that concentrations are indeed below thresholds. If this proves true, it is likely that selenium analysis will not be conducted in year 2.

Organophophates, PAHs, TBT, and Cadmium

Past monitoring (e.g., San Francisco Bay work – SFBRWQCB 1995) indicates that concentrations of these chemicals in sport fish are generally far below thresholds of concern for human exposure. Therefore, they will not be included in the present study. One exception is selenium in San Francisco Bay, where a cleanup plan is being developed and the Water Board has requested additional information on concentrations in sport fish.

Other Emerging Contaminants

Other emerging contaminants are likely to be present in California sport fish. Examples include perfluorinated chemicals, other brominated flame retardants in addition to PBDEs, and others. Thresholds do not exist for these chemicals, so advisories or 303(d) listing are not likely in the near future. However, early detection of increasing concentrations of emerging contaminants can be very valuable for managers, as evidenced by the PBDE example. Measuring emerging contaminants would not directly address the management questions guiding this study, so analysis of these chemicals is not included in the design. Archives of each composite will be retained and made available for analysis of emerging contaminants in the future (see Section G.) An exception is San Francisco Bay, where the Regional Monitoring Program will be analyzing perfluorinated chemicals (see Section L).

Omega-3 Fatty Acids

Klasing and Brodberg (2008) concluded that there is a significant body of evidence and general scientific consensus that eating fish at dietary levels that are easily achievable, but well above national average consumption rates, appears to promote significant health benefits, including decreased mortality, and that because of the unique health benefits associated with fish consumption, the advisory process should be expanded beyond a simple risk paradigm in order to best promote the overall health of the fish consumer. Much of the health benefits of fish consumption are derived from their relatively high content of key omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). When these data are available, OEHHA can take them into consideration in developing safe eating guidelines. Few data are available on the omega-3 content of wild fish. The RMP is planning on obtaining these data for San Francisco Bay fish.

F. Quality Assurance

This effort will adhere to quality assurance requirements established for the SWAMP. A QAPP specific to this effort is in preparation (Bonnema 2009).

One of the analytical challenges in this project will be coordinating among different laboratories that will be generating organics data. The Bight Group resource contribution to the study is in the form of analytical chemistry for more than 200 organics samples. Multiple labs from the Bight Group will participate. Discussions are underway to select labs that are capable of generating data of sufficient quality for the study. An intercalibration exercise is planned for the participating labs to identify any comparability problems before analysis of the field samples is initiated (see Appendix 1).

G. Archiving

As described above, aliquots of homogenates of all samples analyzed will be archived on a long-term basis to provide for reanalysis in case of any mishaps or confirmation, as well as for analysis of emerging contaminants.

Up to five 50 g aliquots of each composite created will be archived. This will provide a integrative, representative sample for each zone 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.

Four of the five archive jars will be glass with a Teflon lined lid (e.g., I-Chem 200 series glass jars). In addition, a separate archive aliquot will be kept in a polypropylene jar for potential analysis of perfluorinated compounds. Archived samples will be stored at -20°C.

H. Ancillary Data

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

I. Timing

Sampling will be conducted from May 2009 through October 2009. Seasonal variation in body condition and reproductive physiology are recognized as factors that could affect contaminant concentrations. However, sampling as many zones as possible is essential to a statewide assessment, and it will take this many months to sample the zones targeted for 2009.

J. Data Assessment

MQ1 will be assessed by comparing results from each zone to thresholds established by OEHHA in Klasing and Brodberg (2008) (Tables 9 and 10). Maps, histograms, and frequency distributions will be prepared to summarize these comparisons.

MQ2 will be assessed through analysis of variance (or analysis of covariance for the species with mercury in individual fish) for the areas where replicate samples are available (SCB and San Francisco Bay). For the other areas, nonstatistical methods will be used (mapping and graphing). Comparison of concentrations between regions may be performed by treating zones within each region as “replicates”.

MQ3 will be assessed in consultation with OEHHA.

K. Products and Timeline

A technical report on the 2009 sampling will be drafted by September 2010 and will include an assessment of data from two of the most heavily fished portions of the coast near the population centers of Los Angeles and San Francisco. The final report, incorporating revisions in response to reviewer comments, will be completed in January 2011.

A second round of sampling is planned for 2010. This work would follow the same approach described in this document, but focusing on the remaining zones in Regions 1 and 3, and any other zones not yet covered in 2009. This sampling would begin May 2010. Preliminary results from the 2009 sampling will be evaluated to determine whether any adjustments to the design are needed.

L. Regional Enhancements in San Francisco Bay and the Southern California Bight

San Francisco Bay

The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) is coordinating closely with the SWAMP Coastal Waters Survey. The RMP conducts thorough sampling of contaminants in sport fish in the Bay on a triennial basis (see Hunt et al. [2008] for the latest results). This sampling has been conducted since 1994. A sampling plan for the RMP effort in 2009 has been prepared (Hunt 2009). The RMP will provide complete and thorough coverage of the Bay, with no additional effort by SWAMP needed. Furthermore, to coordinate with the SWAMP effort, the RMP will analyze additional species to allow for more extensive comparisons of the Bay with coastal areas and bays in other parts of the state. The RMP will benefit from this collaboration by SWAMP contributing: 1) a statewide dataset that will help in interpretation of RMP data and 2) a statewide report that will include an assessment and reporting of Bay data that will make production of a separate report by the RMP unnecessary. The RMP effort represents $215,000 of sampling and analysis.

Some important points to note about the coordination of these two efforts include:

- The zones to be sampled for the RMP are centered around the locations shown in Figure 3.
- The RMP will sample additional species beyond the standard SWAMP list for central California bays and harbors (Table 11). The additional species are striped bass, white sturgeon, and northern anchovy.
- The RMP will also measure additional analytes beyond the standard SWAMP list (Table 11). These include dioxins and dibenzofurans, perfluorinated chemicals, and omega-3 fatty acids.
- Replication within the San Francisco Bay zones will be included for some species (Table 12). The plan for replication is based on experience from multiple rounds of previous sampling. Three replicate composites of shiner surfperch will be collected from each Bay zone. Multiple replicates of white croaker will be collected (n=12), but since this species moves throughout the Bay the samples will be collected opportunistically wherever they are found.
- Multiple white sturgeon tissue types will be analyzed for selenium. Muscle fillet, muscle biopsy and liver will be analyzed. The RMP is investigating moving towards non-lethal sampling of white sturgeon in future monitoring.
- White croaker (one of the primary organic contaminant indicators) has historically been analyzed skin-on in the RMP. Skin-on analysis of organic contaminants provides information that is the most protective of human health. However, OEHHA’s current sport fish consumption advisories, for white croaker, recommend removal of skin prior to eating. Additionally, the SWAMP will be analyzing this species skin-off in the Coastal Survey. To be comparable to the SWAMP program and the OEHHA consumption advisory, the RMP is moving toward skin-off analysis of white croaker. In 1997, the RMP did a side-by-side analysis of white croaker skin-on and skin-off (n=4 composites). Average PCB concentrations were 39% lower in the skin-off analysis while DDT levels were about 40% lower. The initial side-by-side analysis, due to the small sample size, did not provide enough information to definitively establish a relationship between skin-on and skin-off contaminant levels. SFEI looked through the literature for other white croaker skin-on/off data. The Palos Verdes Shelf fish monitoring program performed a side by side skin-on/off analysis with white croaker individuals. PCB and DDT levels were highly variable between the skin-on and skin-off analyses – ranging from 2-24 times lower in the skin-off analysis. In order to continue the RMP long-term data set, the RMP will perform additional side-by-side skin-on and skin-off analysis for PCBs, PBDEs, OC pesticides, and dioxins. This additional analysis will increase the cost of dissection/compositing as well as the analysis portion for white croaker – an additional $30,360.
- In order to be comparable to the SWAMP sampling plan, three additional species were added to RMP sampling – one composite for each region (3) in San Francisco Bay: leopard shark, California halibut, and jacksmelt. These species were part of the historical RMP sport fish sampling but were discontinued after 2003.
- The RMP has traditionally published a report on each round of sport fish monitoring. In 2009, to optimize use of available funds, the RMP will rely on the

SWAMP report for disseminating information from this round of sampling. The cost savings from this arrangement is being used to collect and analyze additional samples that enhance comparability of the SWAMP and RMP designs.

The Southern California Bight

The 2008 Southern California Bight Regional Marine Monitoring Program (Bight'08) is coordinating closely with the SWAMP Coastal Waters Survey. The Bight'08 monitoring program has conducted sampling approximately every five years starting in 1994. In each of the three previous surveys, results have indicated widespread tissue bioaccumulation. At times, the levels of bioaccumulation in fish tissue have exceeded thresholds for risk to wildlife consumers (Schiff and Allen, 2001; Allen et al 2007). However, this will be the first time since 1991 that a Bightwide survey of sport fish tissues for human health risk will be conducted. These data will be used by Regional Water Boards and NPDES permittees for evaluating local permit-based monitoring requirements and could be used by OEHHA for new or updated fish advisories or closures in the southern California Bight.

The Bight'08 Monitoring Program has actively engaged SWAMP for collaboration in the tissue monitoring program. The value of the collaboration is the sharing of effort. For the Bight'08 program, the effort of SWAMP to collect fish covers resources not available to Bight'08 agencies. For the SWAMP, the effort of Bight'08 to analyze samples enables additional species and replicates per species beyond what could be accommodated within the SWAMP budget.

Below is a list of the similarities and differences between the two programs:

- Identical list of monitoring questions
- Common primary target species list
- Additional secondary species list
- Additional replicate samples per target species
- Increased number of fishing zones in the southern California Bight
- Multiple labs will analyze organics in the Bight samples, with varying methods and detection limits

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Figure 1. Water Board regional boundaries.

Figure 2. Fishing zones delineated for this survey. Each zone is numbered in pink and outlined in red. Fishing locations are also indicated. A Google Earth layer with the zones is available on the BOG website: http://www.swrcb.ca.gov/water_issues/programs/monitoring_council/bioaccumulation_oversight_group/

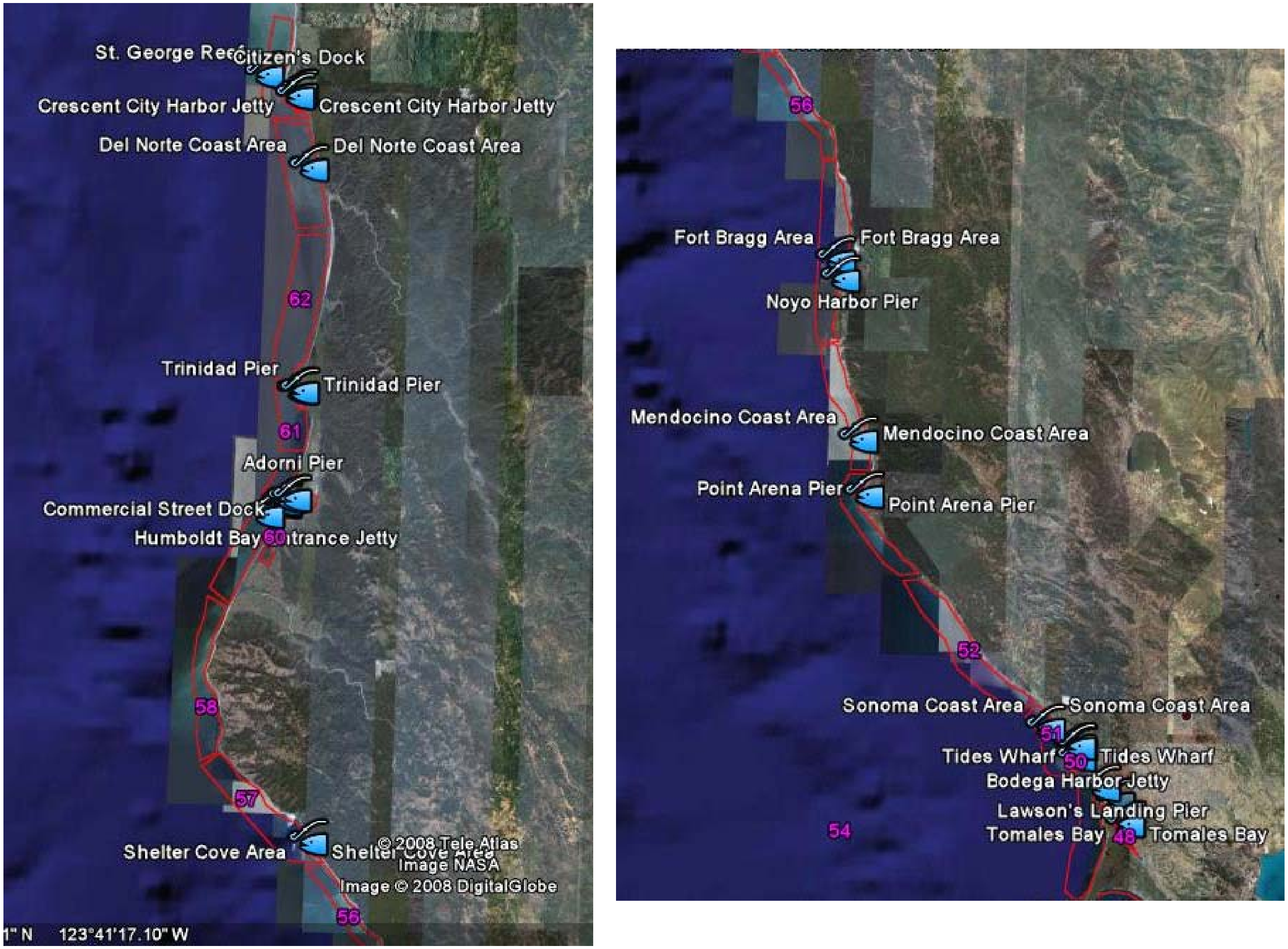

Figure 2. Zone maps (continued).

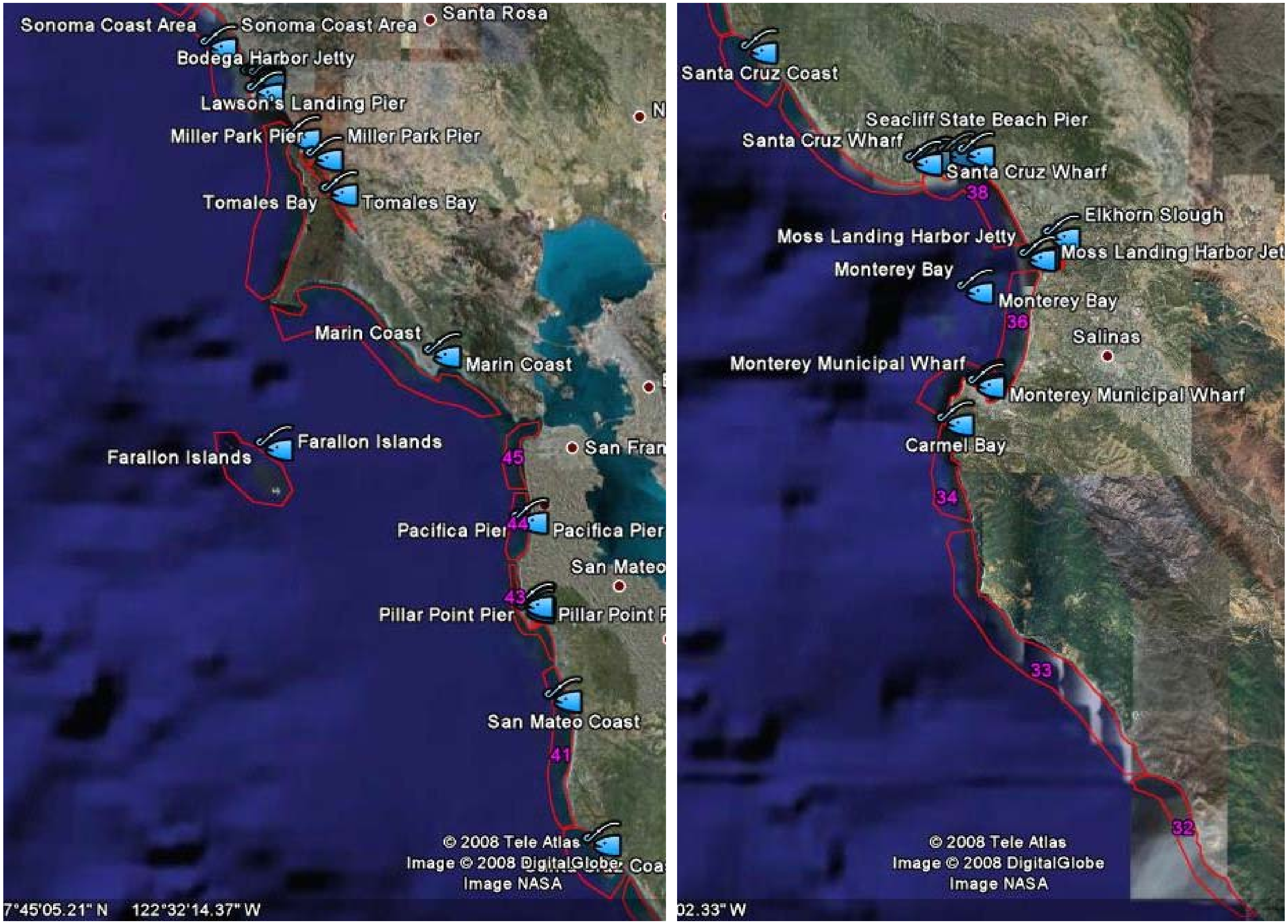

Figure 2. Zone maps (continued).

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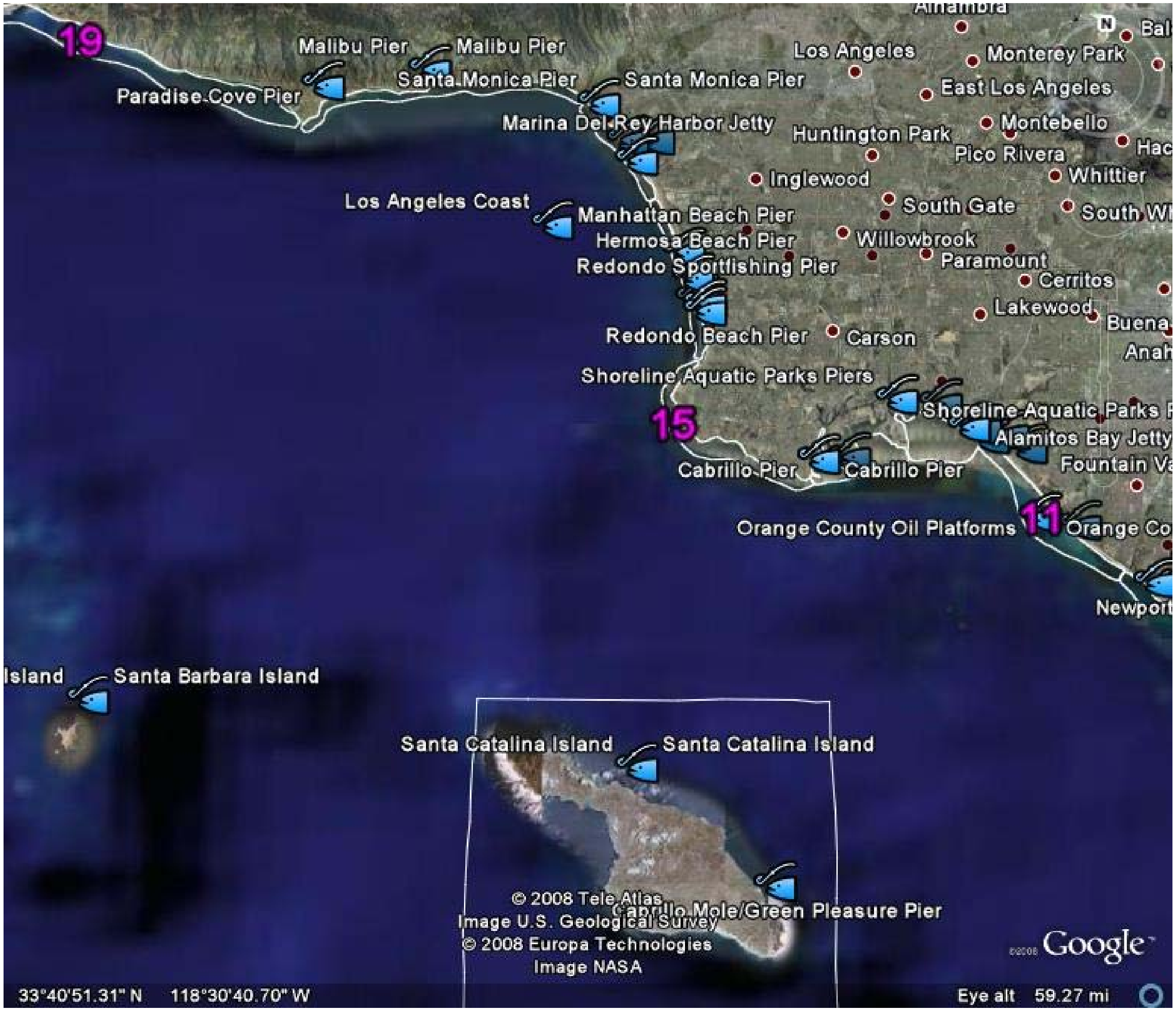


Figure 2. Zone maps (continued).

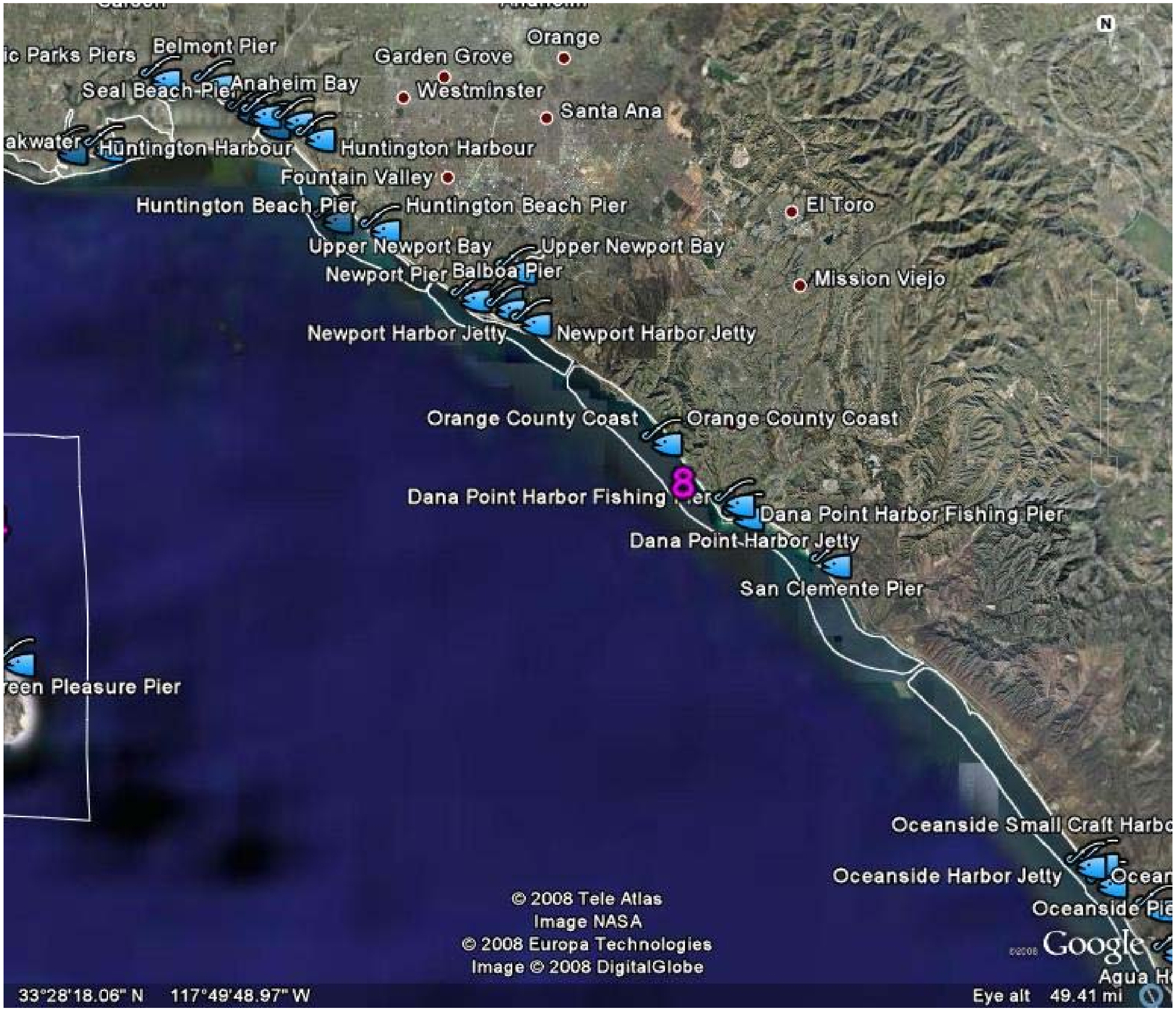


Figure 2. Zone maps (continued).

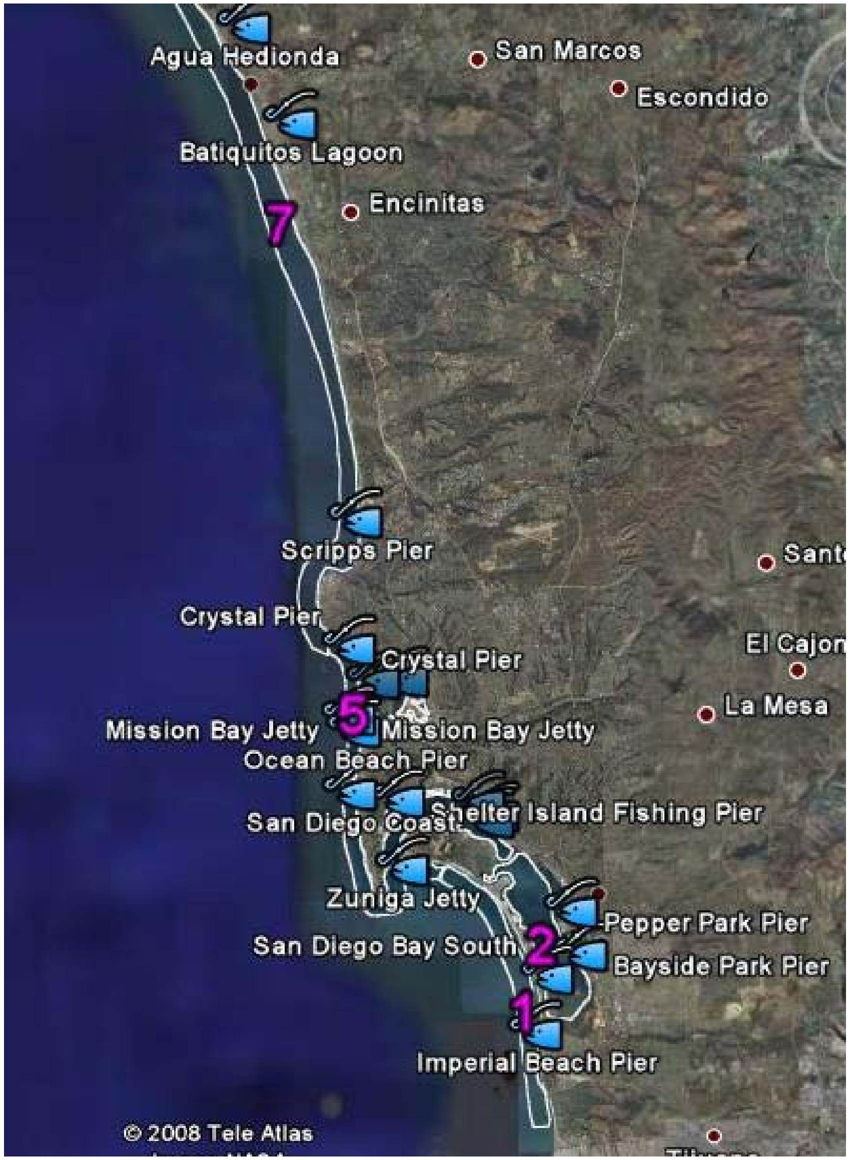


Figure 3. Zones in San Francisco Bay will be centered around the locations shown in this map.

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. RecFIN catch data for major groups of species, including data for the three regions (south, central and north) and specific data for the coast (ocean < 3 mi) and bays and harbors from January 2005 through December 2007. Data include mass of catch in tonnes and counts in thousands (parentheses). The mass and catch data were ranked for each region, then the ranks for each species were averaged to obtain an average rank. The average rank was used as the index of popularity for fish consumption.

	COASTAL	BAYS HARBORS	Ocean <3mi Total			Bays/Harbors Total		
SoCal	Ocean <3mi Total	Bays/Harbors Total	Rank Mass	Rank Count	**Ave Rank**	Rank Mass	Rank Count	**Ave Rank**
Sharks, skates & rays	🟩 1069 (515)	🟩 231 (180)	2	6	🟦 4	2	5	🟦 3.5
Cabezon	74 (99)	1.75 (2.3)						
Top- & Jacksmelt	145 (925)	🟩 46 (405)	8	5	6.5	5	4	🟦 4.5
Rockfish spp	🟩 533 (1190)	20.73 (22.68)	5	4	🟦 4.5	7	7	7
Perch spp	🟩 574 (3281)	🟨 45 (212)	4	2	🟦 3	6		
Croaker spp	🟩 392 (1996)	🟩 132 (553)	6	3	🟦 4.5	4	2	🟦 3
Flatfish	🟨 625 (621)	🟩 479 (414)	3		🟦 3	1	3	🟦 2
Jack Mackerel	19.24 (153.4)	2.362 (26.18)		7			6	
Chub (Pacific) Mackerel	🟩 1359 (7648)	🟩 147 (845)	1	1	🟦 1	3	1	🟦 2
Lingcod	177.2 (106.4)	2.359 (1.364)	7	8	7.5			
Sturgeon								
Tuna (non-mackerel)	46.13 (5.247)	2.571 (0.25)						
Salmon	1.425 (0.456)							

- 🟩 TOP 5
- 🟨 RUNNERS UP
- 🟪 A HIGH PRIORITY EXCEPTION
- 🟦 TOP 5 IN OVERALL RANK

			Ocean <3mi Total			Bays/Harbors Total		
CenCal	Ocean <3mi Total	Bays/Harbors Total	Rank Mass	Rank Count	**Ave Rank**	Rank Mass	Rank Count	**Ave Rank**
Sharks, skates & rays	249.5 (127.2)	🟩 1065 (410)				1	3	🟦 2
Cabezon	48.95 (33.46)	3 (5)						
Top- & Jacksmelt	🟩 3151 (462)	🟩 111 (707)	1	3	🟦 2	3	1	🟦 2
Rockfish spp	🟩 1825 (3283)	🟩 33 (91)	2	1	🟦 1.5	6	5	🟦 5.5
Perch spp	🟩 351 (1514)	🟩 46 (427)	5	2	🟦 3.5	5	2	🟦 3.5
Croaker spp	🟪 28 (184)	🟪 13 (52)		8			6	
Flatfish	🟨 192 (259)	🟩 185 (163)	6	5	5.5	2	4	🟦 3
Jack Mackerel	3.592 (23.21)	0.389 (2.216)						
Chub (Pacific) Mackerel	🟨 60 (294)	1.842 (11.73)	8	4	6		7	
Lingcod	🟩 574 (247)	8.116 (4.083)	4	6	🟦 5	8		
Sturgeon	0.157 (0.013)	🟨 83 (10)				4	8	6
Tuna (non-mackerel)	61.19 (7.26)		7					
Salmon	🟩 730 (187)	12.2 (3.555)	3	7	🟦 5	7		

- 🟩 TOP 5
- 🟨 RUNNERS UP
- 🟪 A HIGH PRIORITY EXCEPTION
- 🟦 TOP 5 IN OVERALL RANK

Table 2. Continued. RecFIN catch data for major groups of species, including data for the three regions (south, central and north) and specific data for the coast (ocean < 3 mi) and bays and harbors from January 2005 through December 2007. Data include mass of catch in tonnes and counts in thousands (parentheses). The mass and catch data were ranked for each region, then the ranks for each species were averaged to obtain an average rank. The average rank was used as the index of popularity for fish consumption.

			Ocean <3mi Total			Bays/Harbors Total		
NorCal	Ocean <3mi Total	Bays/Harbors Total	Rank Mass	Rank Count	**Ave Rank**	Rank Mass	Rank Count	**Ave Rank**
Sharks, skates & rays	14.48 (5.723)	26 (13)	7	8	7.5	1	4	2.5
Cabezon	32 (18)	0.594 (0.387)	6	4	5	8		
Top- & Jacksmelt	1 (7)	2 (16)		7		7	2	4.5
Rockfish spp	476 (599)	9 (14)	2	1	1.5	2	3	2.5
Perch spp	100 (197)	6 (23)	4	2	3	3	1	2
Croaker spp								
Flatfish	9 (7)	2.274 (0.964)	8	6	7	6	7	6.5
Jack Mackerel	0.129 (0.333)	0.009 (0.004)						
Chub (Pacific) Mackerel	0.007 (0.042)	0.019 (0.114)						
Lingcod	200 (70)	4 (2)	3	3	3	4	5	4.5
Sturgeon								
Tuna (non-mackerel)	76 (9)		5	5	5			
Salmon	480	4 (1)	1		🟦	5	6	5.5

	🟩	TOP 5
limited fishing -	🟨	RUNNERS UP
	🟪	A HIGH PRIORITY EXCEPTION
	🟦	TOP 5 IN OVERALL RANK

Table 3. RecFin catch data for individual popular species, including data for the three regions (south, central and north) and specific data for the coast (ocean < 3 mi) and bays and harbors from January 2005 through December 2007. Green shading indicates most popular species within each group.

	SoCal				CenCal				NorCal			
	Ocean <3mi Total		Bays/Harbors Total		Ocean <3mi Total		Bays/Harbors Total		Ocean <3mi Total		Bays/Harbors Total	
	# (thou)	wt (metric tons)	# (thou)	wt (metric tons)	# (thou)	wt (metric tons)	# (thou)	wt (metric tons)	# (thou)	wt (metric tons)	# (thou)	wt (metric tons)
Olive Rockfish	42	15	1	0	171	125	1	0	8	5	0	0
Kelp Bass	🟩 1834	🟩 946	314	131	0	0	0	0				
Black Rockfish	8	3	0	0	🟨 248	135	6	🟨 3	🟩 332	🟩 283	🟩 10	🟩 7
Vermilion Rockfish	182	138	1	1	🟨 247	🟨 298	1	1	31	48	0	0
Canary Rockfish	2	1	0	0	64	31	0	0	17	9	0	0
Yellowtail Rockfish	7	3	0	0	115	52	0	0	11	7	0	0
Barred Sand Bass	🟨 1210	🟨 665	🟨 422	🟨 162	0	0	0	0				
Spotted Sand Bass	150	72	🟩 990	🟩 444	0	0	0	0				
California Scorpionfish	384	145	38	14	0	0	0	0				
Brown Rockfish	60	22	5	2	200	142	🟩 35	🟩 13	2	2	0	0
Copper Rockfish	65	44	0	0	73	72	0	0	7	10	1	0
Grass Rockfish	21	11	1	1	31	19	🟨 11	🟨 4	2	2	0	0
Gopher Rockfish	18	5	0	0	🟨 255	102	2	1	7	4	0	0
Black and Yellow Rockfish	1	0	0	0	23	10	0	0	0	0	0	0
Kelp Rockfish	22	8	0	0	15	8	1	0	0	0		
Bocaccio	85	72	0	0	16	26	0	0				
Blue Rockfish	82	30	0	0	🟩 953	🟩 482	5	2	🟨 109	🟨 56	🟨 1	🟨 1
Lingcod	106	177	1	2	247	574	4	8	70	200	2	4
Shiner Perch	154	4	🟨 20	1	🟨 156	5	🟩 233	🟩 10	2	0	2	0
Walleye Surfperch	🟨 447	🟨 36	12	1	🟨 161	21	🟨 39	🟨 4	2	0	🟩 8	1
Silver Surfperch	1	0	0	0	16	3	6	1	4	0	0	0
Spotfin Surfperch			0	0	3	0	0	0				
Black Perch	93	27	🟩 58	🟩 17	9	4	🟨 36	🟩 10				
Striped Seaperch	4	1	0	0	48	20	5	2	🟨 11	🟨 6	3	1
Rubberlip Seaperch	11	4	4	1	10	4	3	2				
Rainbow Seaperch	3	0	0	0	5	1	4	0	1	0	0	0
Barred Surfperch	🟩 1304	🟩 259	10	2	🟩 613	🟩 171	12	3				
Redtail Surfperch	0	0	0	0	68	🟨 31	5	2	🟩 146	🟩 81	🟨 6	🟩 4
Calico Surfperch	3	1	1	0	27	10	1	0	4	2		
White Seaperch	21	4	13	2	18	5	15	3				
Pile Perch	7	4	4	🟨 3	4	3	3	2	0	0	0	0
Brown Smoothhound	4	4	2	1	🟩 38	🟩 33	🟨 26	🟨 22	🟩 2	🟩 2	🟨 2	1
Gray Smoothhound	7	7	🟨 4	🟨 3	0	0	1	3	0	0		
Leopard Shark	🟩 88	🟩 124	🟩 6	🟩 10	🟨 13	🟩 31	🟩 146	🟩 339	0	0	1	🟨 2
Spiny Dogfish	🟨 10	🟨 22	0	0	7	🟨 12	4	4	🟩 2	🟩 2	🟩 5	🟩 6
Bat Ray	46	131	22	59	26	88	92	346	0	1	3	13
Pacific Sanddab	80	11	1	0	199	21	78	8	2	2		
Topsmelt	151	10	164	7	6	0	109	5	0	0		
Jacksmelt	🟩 774	🟩 135	🟩 241	🟩 39	🟩 456	🟩 80	🟩 598	🟩 106	🟩 7	🟩 1	🟩 16	🟩 2

🟩 Top
🟨 Runner Up

Table 4. Target species in each region for coastal waters and bays and harbors. Numbers indicate priorities for secondary targets. Species in italics are those that will be analyzed as individuals for Hg as well as composited for other analytes. If the target species to be analyzed as individuals for Hg are not available substitutions will be made. Asterisks indicate species that were in the top five in catch for each habitat by region combination.

Coast <3mi	**SoCal**	**CenCal**	**NorCal**
Primary	_Kelp Bass*_		
	Olive Rockfish		
		Black Rockfish	_Black Rockfish*_
		Blue Rockfish*	_Blue Rockfish_
			Lingcod*
	Barred Surfperch*	Barred Surfperch*	
			Redtail Surfperch*
		Salmon*	Salmon*
	Chub Mackerel*		
	White Croaker	White Croaker	
Secondary	Barred Sand Bass*		
	Spotted Sand Bass		
	Scorpionfish		
		Olive Rockfish	
		Lingcod #6*	
			Cabezon #6*
	Walleye Surfperch*		Walleye Surfperch
		Shiner Surfperch	
		Jacksmelt #7*	
	Yellowfin Croaker		

Bays/Harbors	**SoCal**	**CenCal**	**NorCal**
Primary	_Kelp Bass*_		
			Black Rockfish*
	Spotted Sand Bass*		
	Shiner Surfperch	_Shiner Surfperch*_	_Shiner Surfperch_
			Redtail Surfperch*
	Leopard Shark	Leopard Shark*	Leopard Shark
		Halibut*	
		Jacksmelt*	Jacksmelt*
	White Croaker	White Croaker	
Secondary	Barred Sand Bass*		
	Scorpionfish		
		Brown Rockfish*	
		Black Rockfish	
			Blue Rockfish
			Lingcod #7*
	Chub Mackerel		
	Walleye Surfperch	Walleye Surfperch	Walleye Surfperch #8
		Black Perch	
	Grey Smoothound		
		Brown Smoothound	Brown Smoothound
			Spiny Dogfish #6*
	Topsmelt*		
	Jacksmelt*		

Table 5. Target species and their characteristics. Sources were from various websites and pers comm.; primarily http://www.fishbase.org, and http://hmsc.oregonstate.edu/projects/msap/PS/masterlist/fish/

Group	Species	Trophic Level	Primary Prey	Feeding Position	Habitat	Range	Depth
Basses (Serranidae)	Kelp Bass (*Paralabrax clathratus*)	4	Small fishes (including anchovies, sardines, surfperch), squid, octopus, crabs, shrimps, and amphipods	mid-water	in or near kelp beds, but may be associated with any structure	Washington to Baja	0-50m
	Barred Sand bass (*Paralabrax nebulifer*)	3	fishes and crustaceans	demersal	sandy bottom among or near rocks	Santa Cruz, CA to Baja	0-183m
	Spotted Sand bass (*Paralabrax maculatofasciatus*)	4	small fishes and benthic crustaceans, clams	demersal	sand or mud bottom near rocks and eelgrass	Monterey, CA to Mexico	0-60m
Rockfish (Scorpaenidae)	Blue Rockfish (*Sebastes mystinus*)	2	tunicates, hydroids, jellyfishes, and larval and juvenile fishes	mid-water	deep rocky reefs ro hard, flat substrates	Bering Sea to Baja	0-100m
	Black Rockfish (*Sebastes melaops*)	3	juvenile rockfish, euphausids and amphipods (upwelling), and invertebrates (non-upwelling)	mid-water	kelp beds	Alaska to SoCal	0-366m
	California Scorpionfish (*Scorpaena guttata*)	3	juvenile cancer crabs, small fishes (anchovy), octopi, isopods and shrimp	demersal	sandy and rocky areas in association with rocky reefs	Monterey Bay to Baja	0-183m
	Olive Rockfish (*Sebastes serranoides*)	3-4	fishes (particularly juvenile rockfishes), octopi, squid, copepods and crab larvae	mid-water	areas of reef or giant kelp, over hard, high relief	Northern CA to Baja (abundant SoCal to Mendocino County)	0-146m
	Brown Rockfish (*Sebastes auriculatus*)	3	small fishes, crab, shrimp, isopods and polychaetes	demersal	hard bottom; aggregate near rocks, oil platforms, sewer pipes	Alaska to Baja	0-128m
Lingcod (Hexagrammidae)	Lingcod (*Ophiodon elongatus*)	4	mostly fishes but also crustaceans, octopi and squid	demersal	near rocks	Alaska to Baja	to 475m
Croaker (Sciaenidae)	White Croaker	3	polychaetes, small	benthic	Over sandy bottoms	BC to Baja	to

	(*Genyonemus lineatus*)		shrimps, crabs and mollusks				183m
	Yellowfin Croaker (*Umbrina roncador*)	3	crustaceans and fishes	benthic	coastal waters and estuaries		
Salmon (Salmonidae)	Chinook Salmon (*Onchorhynchus tshawytscha*)	4	primarily fishes, but also crustaceans and other inverts	mid-water	inshore and offshore, rivers and some lakes	Alaska to Ventura River, CA	to 375m
Surfperch (Embiotocidae)	Barred surfperch (*Amphistichus argenteus*)	3	sand crabs, clams and other inverts	benthic	surf of sand beaches, also near rocks, pilingsand other structures	Bodega Bay, CA to Baja	0-7m
	Redtail surfperch (*Amphistichus rhodoterus*)	3	Small crustaceans, small crabs, shrimp, mussels or marine worms	benthic	sand beaches in surf on exposed coasts	Vancouver Island, BC to Avila Beach, CA	0-7m
	Shiner perch (*Cymatogaster aggregata*)	3	calanoid copepods, crustaceans, mollusks,	mid-water/ demersal	eelgrass beds, piers and pilings	Alaska to Baja	0-146m
	Walleye surfperch (*Hyperprosopan argenteum*)	3	crustaceans, amphipods, isopods, small fish, mycids	mid-water	surf of sand beaches, and over sand near rocks	Vancouver Island to Baja	0-18m
	Black perch (*Embiotoca jacksoni*)	2	amphipods, crabs, worms	benthic	rocky areas near kelp, sand bottoms of coastal bays and around piers and pilings	Ft Bragg, CA to Baja	0-46m
New World Silversides (Atherinopsidae)	Jacksmelt (*Atherinopsis californiensis*)	2	crustaceans, fish larvae	mid-water	inshore areas, including bays	Yaquina Bay, OR to Baja	
	Topsmelt (*Atherinops affinis*)	2	zooplankton, algae	benthic/ mid-water	bays, muddy and rocky areas and kelp beds	Vancouver Island to Baja	
Mackerels (Scombridae)	Pacific Chub Mackerel (*Scomber japonicus*)	3	copepods, crustaceans, euphausids, small fishes and squids	mid-water	pelagic	Indo-Pacific	to 300m
Hound Sharks (Triakidae)	Leopard Shark (*Triakis semifasciata*)	3	nektonic and benthic fishes, crustaceans, octopi and clams	demersal	enclosed muddy bays, estuaries and lagoons	Oregon to Baja	to 91m
	Brown Smoothhound (*Mustelus henlei*)	3	crabs, shrimp and some fishes	benthic	offshore, soft bottom	Northern CA to Baja	to 200m

	Gray Smoothound (*Mustelus californicus*)	3	mostly crabs, ghost shrimp, and small fish	benthic	inshore and offshore soft bottom, entering shallow muddy bays	Northern CA to Baja	to 200m
Dogfish Sharks (Squalidae)	Spiny Dogfish (*Squalus acantias*)	4	fishes, crustaceans, squid and octopi	benthic/ mid-water	Near bottom in enclosed bays and estuaries, also mid-water and near surface	Bering Sea to Chile	to 1460m
Sand Flounder (Paralichthyidae)	California Halibut (*Paralichthys californicus*)	3-4	fishes and squids	demersal	sandy bottoms, also in bays and estuaries	Northern WA to Baja	to 183m
Sculpins (Cottidae)	Cabezon (*Scorpaenichthys marmoratus*)	3	crustaceans, fish and mollusks	demersal	rocky, sandy and muddy bottoms, kelp beds	Southeastern AK to Baja	to 200m

Benthic – feeding on the bottom Demersal – feeding on or near bottom

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.

Table 6. Target species, size ranges, and numbers to include in composites.

		Primary or Secondary	**Number in Composites**	**Size Range (mm)**
Rockfish	Kelp Bass	P	5	>305 (255-350 individuals for Hg)
	Blue Rockfish	P,S	5	>305 (255-350 individuals for Hg)
	Black Rockfish	P,S	5	>305 (255-350 individuals for Hg)
	Barred Sandbass	S	5	>305
	Scorpionfish	S	5	>255
	Spotted Sandbass	S	5	>305
	Olive Rockfish	S	5	>255 (220-350 individuals for Hg)
	Brown Rockfish	P	5	>255 (220-350 individuals for Hg)
Lingcod		P,S	3	
Croaker	White Croaker	P	5	>200
	Yellow Croaker	S	5	>200
Chinook Salmon		P		
Surfperch	Barred	P	5	>150
	Redtail	P	5	>263
	Shiner	P,S	20	>100 (80-173 individuals for Hg)
	Walleye	P,S	5	>150
	Black	S	5	>150
Smelt	Jacksmelt	P	5	>220
	Topsmelt	S	5	>200
Chub Mackerel		P		
Shark	Leopard Shark	P	3	>915
	Spiny Dogfish	P	3	>610

	Brown Smoothhound	S	3	>610
	Gray Smoothound	S	3	>610
California Halibut		P	3	>558
Cabezon		S	5	>381

Table 7. Summary of analytes included in the study.

Analyte	**Included in Screening Study?**
Methylmercury[1]	Some individuals, all composites
PCBs	All composite samples
DDTs	All composite samples
Dieldrin	All composite samples
Aldrin	All composite samples
Chlordanes	All composite samples
PBDEs	Two composite samples per zone
Dioxins	SF Bay only
Perfluorinated chemicals	SF Bay only, archives created for remainder
Selenium	All composite samples (year 2 contingent upon year 1 results)
Omega-3 fatty acids	SF Bay only

[1] Measured as total mercury.

Table 8. Parameters to be measured.

FISH ATTRIBUTES

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

METALS AND METALLOIDS

1. Total mercury
2. Selenium

PESTICIDES

Chlordanes

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

DDTs

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

Cyclodienes

1. Aldrin
2. Dieldrin
3. Endrin

HCHs

1. HCH, alpha
2. HCH, beta
3. HCH, gamma

Table 8. Parameters to be measured (continued).

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

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

Table 8. Parameters to be measured (continued).

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

PBDEs (these would be estimated values obtained along with PCB congeners at no additional cost)

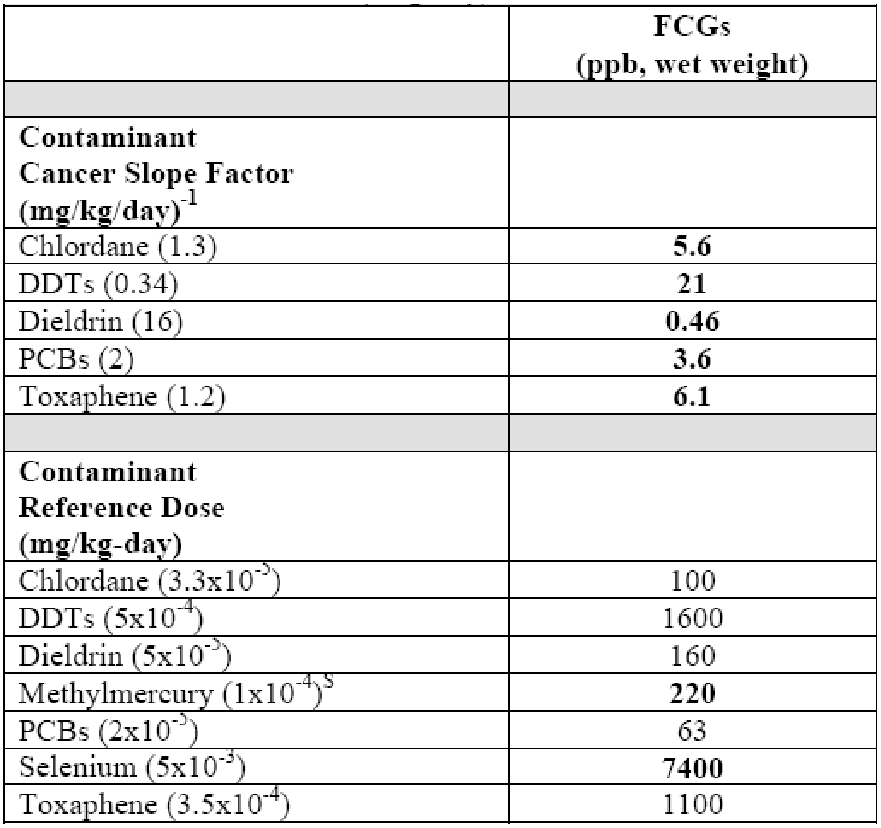
1. PBDE 017
2. PBDE 028
3. PBDE 047
4. PBDE 066
5. PBDE 085
6. PBDE 099
7. PBDE 100
8. PBDE 138
9. PBDE 153
10. PBDE 154
11. PBDE 183
12. PBDE 190

Table 8. Parameters to be measured (continued).

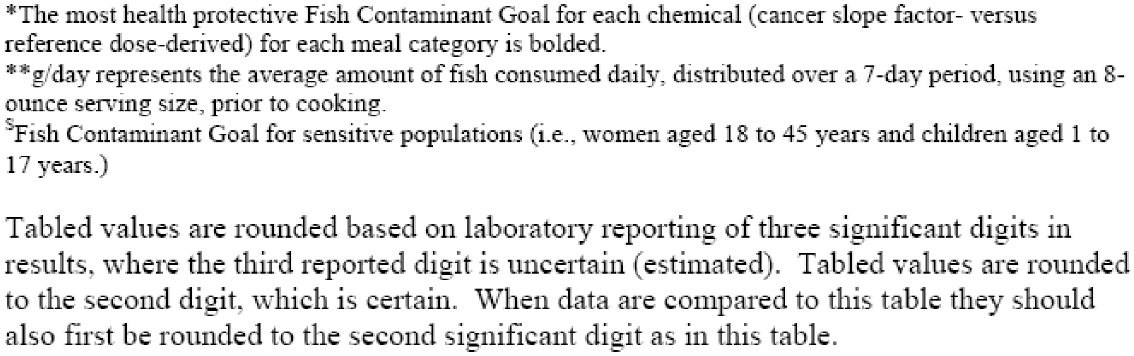
Dioxins and Dibenzofurans

HpCDD, 1,2,3,4,6,7,8-
HpCDF, 1,2,3,4,6,7,8-
HpCDF, 1,2,3,4,7,8,9-
HxCDD, 1,2,3,4,7,8-
HxCDD, 1,2,3,6,7,8-
HxCDD, 1,2,3,7,8,9-
HxCDF, 1,2,3,4,7,8-
HxCDF, 1,2,3,6,7,8-
HxCDF, 1,2,3,7,8,9-
HxCDF, 2,3,4,6,7,8-
OCDD, 1,2,3,4,6,7,8,9-
OCDF, 1,2,3,4,6,7,8,9-
PeCDD, 1,2,3,7,8-
PeCDF, 1,2,3,7,8-
PeCDF, 2,3,4,7,8-
TCDD, 2,3,7,8-
TCDF, 2,3,7,8-

Table 9. Fish Contaminant Goals (FCGs) for Selected Fish Contaminants Based on Cancer and Non-Cancer Risk* Using an 8-Ounce/Week (prior to cooking) Consumption Rate (32 g/day)** From Klasing and Brodberg (2008).



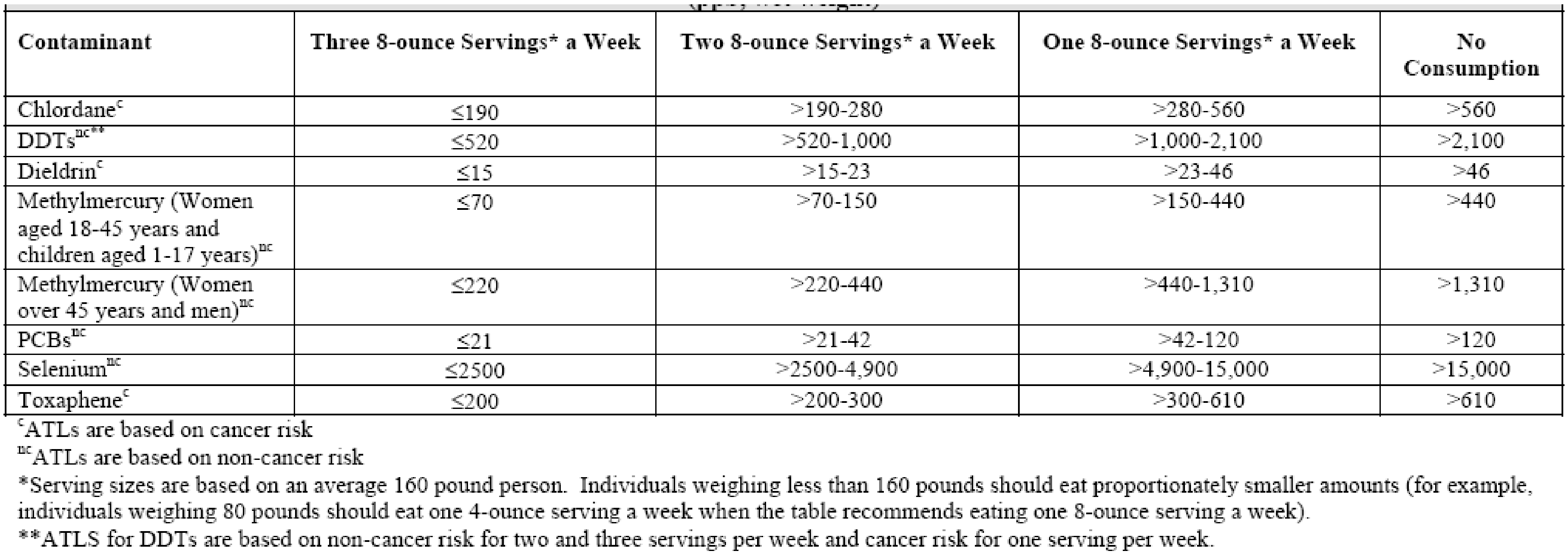
	FCGs **(ppb, wet weight)**
Contaminant **Cancer Slope Factor** **(mg/kg/day)$^{-1}$**	
Chlordane (1.3)	**5.6**
DDTs (0.34)	**21**
Dieldrin (16)	**0.46**
PCBs (2)	**3.6**
Toxaphene (1.2)	**6.1**
Contaminant **Reference Dose** **(mg/kg-day)**	
Chlordane (3.3x10^{-5})	100
DDTs (5x10^{-4})	1600
Dieldrin (5x10^{-5})	160
Methylmercury (1x10^{-4})^{S}	**220**
PCBs (2x10^{-5})	63
Selenium (5x10^{-3})	**7400**
Toxaphene (3.5x10^{-4})	1100



*The most health protective Fish Contaminant Goal for each chemical (cancer slope factor- versus reference dose-derived) for each meal category is bolded.
**g/day represents the average amount of fish consumed daily, distributed over a 7-day period, using an 8-ounce serving size, prior to cooking.
^{S}Fish Contaminant Goal for sensitive populations (i.e., women aged 18 to 45 years and children aged 1 to 17 years.)

Tabled values are rounded based on laboratory reporting of three significant digits in results, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. When data are compared to this table they should also first be rounded to the second significant digit as in this table.

Table 10. Advisory Tissue Levels (ATLs) for Selected Fish Contaminants Based on Cancer or Non-Cancer Risk Using an 8-Ounce Serving Size (Prior to Cooking) (ppb, wet weight). From Klasing and Brodberg (2008).



Contaminant	**Three 8-ounce Servings* a Week**	**Two 8-ounce Servings* a Week**	**One 8-ounce Servings* a Week**	**No Consumption**
Chlordane[c]	≤190	>190-280	>280-560	>560
DDTs[nc**]	≤520	>520-1,000	>1,000-2,100	>2,100
Dieldrin[c]	≤15	>15-23	>23-46	>46
Methylmercury (Women aged 18-45 years and children aged 1-17 years)[nc]	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)[nc]	≤220	>220-440	>440-1,310	>1,310
PCBs[nc]	≤21	>21-42	>42-120	>120
Selenium[nc]	≤2500	>2500-4,900	>4,900-15,000	>15,000
Toxaphene[c]	≤200	>200-300	>300-610	>610

[c] ATLs are based on cancer risk

[nc] ATLs are based on non-cancer risk

*Serving sizes are based on an average 160 pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for example, individuals weighing 80 pounds should eat one 4-ounce serving a week when the table recommends eating one 8-ounce serving a week).

**ATLS for DDTs are based on non-cancer risk for two and three servings per week and cancer risk for one serving per week.

Tabled values are rounded based on laboratory reporting of three significant digits in results, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. When data are compared to this table they should also first be rounded to the second significant digit as in this table.

Table 11. Species to be collected and analytes for RMP 2009 sport fish monitoring. Numbers indicate counts of composite samples to be collected and analyzed.

	Fish Collection	Composite - Organics	Individual - Metals	OC Analyses (PCBs, Pesticides)	PBDEs	Dioxins	Hg - Indiv	Hg - Comp	Se	PFC	Omega 3s
White Croaker	12	12		24	24	24			12	3	
Placeholder (archive and other species TBD)											
Striped Bass	6	6	18	6	6		18		6	3	
Shiner Surfperch	15	5		15	15	10		15	15	3	
White Sturgeon (South Bay and San Pablo Bay)	4	4	12	4	4				36	3	
Leopard Shark	3	3		3	3		9		3	3	
Halibut	3	3		3	3			3	3	3	
Jacksmelt	4	4		4	4			4	4		
Anchovy	9	9		9	9				9	3	
Subtotals	56	46	30	68	68	34	27	22	88	21	TBD

Table 12. RMP fish sampling plan, 2009.

Species	White Croaker	Shiner Surfperch[3]	Striped Bass[1]	White Sturgeon[2]	Anchovy	Leopard Shark	CA Halibut	Jacksmelt
Target # size classes	1	1	2	1	1	1	1	1
Target # fish per composite	5	20	3	3	5-20	3	3	5
Target size range (cm)	20–30	10–15	Small: 45-59 Medium: 60-82 Large: >82*	Small: 117-133	Legal size	Small 90-105	55-92	21-30
# of Composites	12	15	6	4	9	3	3	4
Tissue sampled	Muscle with skin and without skin	muscle with skin and skeleton	muscle without skin	muscle without skin	Whole body	Muscle without skin	Muscle without skin	muscle with skin and skeleton
South Bay Bridges	Where you catch them	3	Where you catch them	2	Where you catch them	1		1 or 2
Oakland Harbor	Where you catch them	3	Where you catch them		Where you catch them			1 or 2
San Francisco Water Front	Where you catch them	3	Where you catch them		Where you catch them		1	
Berkeley	Where you catch them	3	Where you catch them		Where you catch them	1 (or SF waterfront)	1	
San Pablo Bay	Where you catch them	3	Where you catch them	2	Where you catch them	1	1	1 or 2