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OFF-REFUGE INVESTIGATIONS SUB-ACTIVITY

CA – Mercury Bioaccumulation in California Waterbodies: Assessing Sources and Pathways to Predict Risk to Fish and Wildlife

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by

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II. INTRODUCTION

We propose to conduct an investigation aimed at identifying potential patterns, pathways, and wildlife communities at risk from bioaccumulative contaminants in California with the ultimate goal of assessing whether contaminants may be affecting wildlife beneficial use in waterbodies throughout the State. We propose to assess bioaccumulation, initially in lakes, but ultimately in rivers, estuaries, bays, etc. The main objective will be to assess mercury bioaccumulation, but other priority pollutants such as selenium, PCBs, PBDEs, and DDTs will be addressed on a more limited scale. This project proposes, in conjunction with partners, to comprehensively assess mercury loadings, bioaccumulation factors (BAF), the increase in concentration from water into biota, and trophic transfer factors within the aquatic food chain via direct measurement of concentrations in water, zooplankton, benthic macroinvertebrates, small fish, sport fish, and aquatic dependent wildlife.

The goals and objectives of this project are numerous and are related to assessing, modeling, managing and regulating mercury contaminated lakes in the State based on site specific data. We propose to develop models based on site specific data on water quality, environmental variables, aquatic community structure, and trophic transfer factors at focal lakes to predict mercury accumulation that can be compared to observed values at these sites. The data and models will help identify critical pathways and robust trophic transfer factors that can be applied to lakes around the State to predict mercury accumulation and risk in lakes where comprehensive assessments do not exist and/or are not feasible. Best Management Practices (BMP) can be developed based on site specific conditions to manage and minimize mercury accumulation and risk. The BAFs and trophic transfer factors can also be used to refine risk assessments to aquatic dependent wildlife in the State and develop wildlife values protective of trust resources based on site specific data. Lastly, they will be used to assess the status of aquatic dependent wildlife relative to published effects thresholds for mercury toxicity.

II.A. Background and Justification

Mercury is the most pervasive bioaccumulative contaminant within California (Davis et al 2007). California has an extensively documented mercury contamination problem in its estuaries and bays. There are also data to suggest it is a problem in streams, rivers, lakes, and reservoirs around the State (Davis et al 2007, Weiner et al 2004, Alpers and Hunerlach 2000). The problem is a function of extensive mercury mining in its Coast Ranges, and transport of mercury into the Sierra Nevada to be used in the gold mining industry. Much of the mercury remains as dredge waste at mercury and gold mines, as well as in the water, sediments, and biota within these systems. Widespread mercury contamination has led to 72 listings of California waterbodies on the State's EPA-approved Clean Water Act (CWA) 303(d) list of impaired waterbodies in 2002. There are 104 waterbodies proposed for listing on the State's 2006 list (Tom Kimball Pers. Comm.). There are also currently 46 human health consumption advisories for various waterbodies around the State as a result of mercury contamination (Robert Brodberg Pers. Comm.). Many of the 303(d) listings are proposed due to fish tissue exceeding the US Environmental Protection Agency's (USEPA) 2001 proposed methymercury water quality criterion for the protection of human health. However, recent reviews conducted by the U.S. Fish and Wildlife Service (USFWS) suggests that this proposed fish tissue criterion may not be protective of certain species of aquatic dependent wildlife (USFWS 2003, USFWS 2004). Therefore, most if not all, of the waterbodies listed under the 303(d) list are likely also posing a significant risk to wildlife resources, and may continue to do so even if fish tissue concentrations were reduced to the proposed human health criterion. Despite the work done to assess mercury contamination in lakes relative to human health, little is known about mercury bioaccumulation patterns in different types of California waterbodies and how this relates to the risk posed by widespread mercury contamination to fish and aquatic dependent wildlife within the State.

USFWS Involvement in Assessing USEPA's Mercury Criterion and the Development of State and Regional Mercury Objectives

In 2000, USEPA promulgated the California Toxics Rule (CTR; USEPA, 2000) to bring California into compliance with CWA section 303(c)(2)(B). With the CTR, USEPA promulgated total recoverable mercury criteria for the protection of human health of 0.050 micrograms per liter (μg/L) for consumption of water and organisms, and 0.051 μg/L for consumption of organisms only. Some California Regional Water Quality Control Boards have water quality control plans that contain mercury objectives that are more stringent than the CTR criteria. If there is both a CTR criterion and an applicable objective for a water body, the more stringent of the two values applies.

Under section 304(a) of the CWA, USEPA must periodically revise criteria for water quality to accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects of pollutants on human health. After review of the existing CTR mercury human health criteria, USEPA concluded that it was more appropriate to derive a section 304(a) criteria guidance for methylmercury based on fish tissue (including shellfish) concentrations, rather than water column-concentrations. An appropriate fish tissue concentration is more closely tied to the CWA goal of protecting the public health because it is based directly on the dominant human exposure route for methylmercury, ingestion of mercury contaminated fish and shellfish. Therefore, USEPA published revised methylmercury fish tissue criteria guidance in 2001 as 0.3 mg/kg wet weight (ww) of methylmercury in edible portions of fish and shellfish (USEPA, 2001). To determine whether this criterion would be protective of listed species in California, the USEPA contracted the Sacramento FWO's Environmental Contaminants Division (SFWO-ECD) to perform an assessment of the 0.3 mg/kg value (USFWS 2003). A methodology was jointly developed by USFWS and USEPA scientists to calculate predicted methylmercury concentrations in prey that would be protective of piscivorous wildlife.

In California, the Regional Water Quality Control Boards (Regional Boards) must develop total maximum daily load (TMDL) limits and site-specific objectives, if appropriate, to address 303(d) listed waterbodies. Subsequent to the USFWS risk assessment of the USEPA criterion, the Central Valley and the San Francisco Bay Regional Boards began to develop TMDLs on their most impaired waterbodies—the Cache Creek watershed and the Guadalupe River, respectively. To assist the Regional Boards in this process the State Board contracted the SFWO-ECD to provide input and review of the work done by the Regional Board staff (USFWS 2004).

The California State Water Resources Control Board (State Board) is considering adopting a statewide policy for methylmercury that would apply to inland waters, enclosed bays, and estuaries in the State. The policy would be based on the USEPA's 2001 fish tissue-based human health criteria guidance. As such, elements of the proposed policy may include a methylmercury fish tissue objective, a total mercury water quality objective, a methylmercury water quality objective, or some combination of these objectives. The State also proposes to implement mercury regulatory guidance that is protective of wildlife beneficial uses. In order to derive and implement a tiered approach to mercury regulation as proposed by the State, detailed information on mercury biogeochemistry and exposure must be collected for humans as well as wildlife. This includes information on mercury concentrations in water as well as key components of the aquatic community. Mercury fate and transport within aquatic systems is especially critical when evaluating risk to humans and wildlife from widespread mercury contamination.

Mercury Risk Assessment

Aquatic dependent wildlife species are at most risk from mercury contamination and avian taxa have been shown to be especially sensitive to mercury toxicity. Mercury toxicity in birds has its greatest effect on reproduction, via reduced egg hatchability, reduced breeding effort, and altered breeding behavior (reviews by Scheuhammer 1987, Thompson 1996, Wolfe et al. 1998, Wiener et al. 2003a). As such we will assess mercury risk and BAF calculations based on avian reproduction as the most sensitive endpoint for risk assessment. The protection of wildlife cannot be evaluated by simply comparing a protective generic dietary concentration determined for any given species with the generic dietary concentration proposed by the human health criterion. A comprehensive assessment of the protectiveness for wildlife from the USEPA fish tissue criterion was conducted by the USFWS in 2003 and again in 2004 (USFWS 2003, 2004).

One of the primary considerations in constructing the risk assessment to evaluate wildlife protection was to assess mercury dynamics in aquatic foodwebs. In conducting the risk assessment a generalized trophic level approach was used in which trophic level 1 organisms such as plants, phytoplankton and algae are consumed by trophic level 2 herbivores, planktivores, and detritivores, which are consumed by trophic level 3 predators, which are then consumed by the top predators in trophic level 4. Predator-prey relationships in real-world ecosystems are generally more complex than this simple linear model. However, the risk assessment methodology employed in the USFWS evaluations were based on the assumption that the general concepts underlying the simple linear food chain model remain a valid approach for estimating methylmercury trophic transfer in aquatic biota since it is rare that detailed trophic level relationships and mercury bioaccumulation factors are available for a given waterbody.

This consideration of trophic levels was necessary because methylmercury is a highly bioaccumulative pollutant which concentrates in biological tissues and biomagnifies as it moves through successively higher trophic levels in a food chain. The fish tissue criterion was not derived by assuming specific methylmercury concentrations in any particular trophic level. Instead, 0.3 mg of methylmercury per kg of fish and shellfish tissue was determined to be protective for human populations eating from various trophic levels, rather than from any particular trophic level, with an average consumption rate of 17.5 g/day. However, due to the characteristics of methylmercury described above, aquatic food chains do not attain a steady-state condition wherein aquatic biota from all trophic positions exhibit the same tissue concentrations. Instead, organisms higher on the food chain contain greater concentrations than those lower on the food chain. For example, if fish and shellfish from trophic level 2 (e.g., herbivorous fish) contain concentrations of 0.3 mg/kg, then biota from trophic levels 3 and 4 (e.g., predatory fish) will undoubtedly have higher tissue concentrations. Conversely, if aquatic biota from the highest trophic level in the system have tissue methylmercury concentrations of 0.3 mg/kg, examination of lower order biota will show substantially lower tissue concentrations. The results of the initial risk assessment concluded that 0.3 mg/kg ww in trophic level 4 fish tissue would be protective of all at risk listed species in California, with the exception of the California least tern and the Yuma clapper rail (USFWS 2003). Further revision of the risk assessment methodology determined that the TRC might not be protective of resident bald eagles and other piscivorous birds and mammals in California, and the predicted protective level in trophic level 4 fish greater than 150 mm was determined to be 0.20 mg/kg ww (USFWS 2004). This wildlife target fish tissue concentration is being currently proposed by the State for waters that do not have the potential to provide habitat for the California least tern, which has a different predicted protective value based on 50 mm or smaller fish (USFWS 2003).

Status of Contamination in California

In order to assess the applicability of human and wildlife derived methylmercury objectives in California there is a need to define the status of mercury contamination throughout the state. As mentioned there are substantial data generated for a few specific locations and ecosystems within the State, such as the San Francisco Bay (Ackerman et al. 2007, Davis 2007), the Sacramento-San Joaquin River Delta (Davis et al 2007), Clear Lake (Suchanek et al 2007), Cache Creek and the Guadalupe River watersheds, the Yuba River (May et al. 2000), Trinity River (May et al. 2005), Eagle Lake (Eagles-Smith et al. 2006), and some Sierra Nevada streams (Perterson et al 2007). However, there is a significant data gap in the status of mercury in the more than 9,000 lakes and reservoirs that exist within the State. These waterbodies are significant resources for human fishing activity as well as sites of critical importance for aquatic dependent wildlife taxa. Limited data from some studies (See discussion below) suggests that mercury could pose a significant risk to humans and wildlife in lakes and reservoirs around the state.

The Yuba River watershed is generally considered to be significantly impacted by mercury contamination from historic gold mining. A survey of 5 reservoirs within the Yuba River watershed found 89 percent of bass (typically trophic level 4) between 250 and 400 mm total length exceeded the 0.3 mg/kg EPA fish tissue guidance, with 9 percent exceeding 1 mg/kg ww (May et al. 1999). If the 0.2 mg/kg ww wildlife target value is applied to these data then 95 percent of the bass collected in these reservoirs exceed levels thought to be protective of bald eagles and other piscivorous wildlife. Calculated critical thresholds for sensitive mustelid species such as mink and otter are around 0.1 mg/kg ww (Yeardley et al. 1998) to 0.06 mg/kg ww in trophic level 3 fish less than 150 mm (USFWS 2004). If these values are applied all fish samples collected exceed the critical threshold.

Data from the Pit River which is considered to have relatively low mercury inputs suggests that operation and maintenance of hydropower reservoirs on this watershed may significantly increase mercury risk in this system. Fish tissue data from Lake Britton, the main reservoir on the Pit River system, showed 26 percent of collected fish between 300 and 600 mm were above the 0.3 mg/kg ww EPA value, and the number increases to 35 percent when the 2004 USFWS bald eagle wildlife target is used (D.G. Slotton unpublished data). If the 0.06 mg/kg ww calculated mustelid wildlife target is applied to these data then the number of samples exceeding the critical threshold increases to 57 percent. Although mercury concentrations in source water to Lake Britton are low, factors such as eutrophication and operation of large portions of the Lake at shallow depths and warmer temperatures are believed to significantly increase methylmercury production and accumulation in aquatic biota.

Clear Lake, California is a lake of substantial human fishing pressure due to its trophy bass fishery, and provides nesting habitat for numerous aquatic dependent wildlife, such as western grebes and osprey. The lake is also designated as an EPA Superfund site because of an abandoned mercury mine on its shores that has deposited more than 100 metric tonnes of mercury into the sediments. A recent study in Clear Lake found that 88 percent of largemouth bass 200-570 mm exceeded the 0.3 mg/kg ww EPA value, and all fish exceeded the 0.06 mg/kg calculated mustelid wildlife value (Suchanek et al. 2007). Conversely, Eagle Lake, in Lassen County is a system devoid of point source inputs and contains biota with very low concentrations. The endemic Eagle Lake rainbow trout is the highest trophic level fish in that system and is highly sought after by anglers. Mercury concentrations in adult trout between 300 and 550 mm were well below threshold levels, with no fish exceeding the 0.3 mg /kg EPA threshold, and only 6 percent of individuals exceeding the 0.06 mg/kg calculated mustelid value (Eagles-Smith 2006). Interestingly, in both of these systems, trophic position was a less important predictor of mercury accumulation in numerous species than were age (length) or degree of benthic foraging.

II. B. Scientific Objective(s)

The main scientific objective of this project is to identify the level of risk posed by widespread mercury contamination to USFWS trust resources across a wide variety of California lakes. We will also assess the critical pathways in the aquatic environment that affect mercury accumulation in California lakes. We will develop models based on comprehensive data collected at focal lakes that can be used to predict mercury risk at other sites and guide managers and regulators in developing BMPs for assessing mercury risk, reducing mercury risk, and monitoring management strategy effectiveness. We will directly or in conjunction with partners address the following hypotheses:

1. Mercury concentrations in eggs and/or tissues of piscivorous bird species most at risk from mercury contamination in lakes around California are elevated above published lowest observed adverse effects thresholds.
2. Mercury concentrations in prey items of trust resources are above risk assessment target values.

3. Mercury inputs and aquatic community composition are the greatest determinants of mercury risks to fish and wildlife.
4. Bioaccumulation factors and trophic transfer factors differ amongst lake type.
5. Bioaccumulation factors and trophic transfer factors will be affected by varying water quality parameters (such as temperature, pH, nutrient loads, etc).
6. Bioaccumulation factors and trophic transfer factors will be affected by different watershed and environmental variables (such as percent cover, cover type, population density, land use, etc.)

II.C. Management Action(s)

As mentioned, one of the first goals of this project is to produce site specific data on mercury loadings and pathways at focal lakes. These data would help in identifying those factors that most impact mercury accumulation in aquatic biota in order to help develop best management practices (BMP) to reduce risk posed by mercury in lakes throughout the State. A small fraction of the lakes in the State will have comprehensive site specific data on mercury loads, water quality, and concentrations in biota. In these instances the models developed at focal lakes can be applied to predict bioaccumulation rates and trophic transfer based on limited site specific data including some combination of mercury concentrations in water, physical-chemical properties, aquatic community composition, or mercury concentrations in biota. The information gathered from these models can be compared to currently accepted regulatory criteria to help guide the need for further assessment and/or regulatory action and identify those pathways that can be most effectively targeted to control mercury accumulation and risk in California lakes. The data gathered from this project will be important in the decision making process for numerous state and federal agencies. The BAFs and trophic transfer factors can be applied to previous risk assessment methodologies to further refine assessments of mercury concentrations in prey items that would be protective of trust resources. These data would be used in developing TMDLs, BMPs, and inform other management actions at lakes and reservoirs within the state. Ideally, the information gathered from the overall effort would be collected such that models could be applied to lakes and reservoirs throughout the western states and potentially on a national scale. Specific management actions include:

1. Develop site-specific fish tissue objectives for Clean Water Act TMDLs in the lakes and watersheds where the samples are collected;
2. Develop guidance on determining statewide and site-specific fish tissue objectives for Clean Water Act TMDLs in California and elsewhere;
3. Determine an appropriate level of biota monitoring needed to address TMDL development and implementation as well as long-term trends in mercury concentrations in fish and piscivorous wildlife, and
4. Provide data for assessing impacts to trust species for Federal Energy Regulatory Commission (FERC) relicensing, Endangered Species Act section 7 consultations, and recommendations under the Fish and Wildlife Coordination Act.

III. METHODS

III. A. Data Collection and Analysis

Proposed Partner Sampling Efforts

In late spring through early fall of 2007 the Bioaccumulation Oversight Group (BOG,) which is a component of the State's Surface Water Ambient Monitoring Program (SWAMP), will be sampling 80, out of 216, randomly selected lakes around the State of California based on fishing usage, as human health criteria are a main priority of this project. The pool of lakes were selected on a probabilistic basis based on distribution throughout the State, size, and fishing use as this sampling is largely targeted at sport fish to derive information to guide criteria development for protection of human health. The sequence was determined using the generalized random tessellation-stratified (GRTS) approach developed for USEPA's Environmental Monitoring and Assessment Program (Stevens and Olsen 2004). The GRTS approach achieves a random point distribution that is spatially balanced to avoid spatial clustering that often occurs in a conventional random sample. This methodology has proven successful in a recent assessment of mercury contamination in western streams (Peterson et al. 2007) and greatly increases inferences that can be made from site specific data to larger landscape and regional patterns. After the first year of sampling is completed, it will be possible to make a preliminary assessment of mercury contamination in water and sportfish and use these data to make inferences about the status of all the popular lakes.

To assess the status of lakes statewide the sample of lakes must also be representative of the full spectrum of lake systems within the state without regard to fishing use. To correct for any bias in lake selection due to emphasis on fishing pressure the BOG will also be collecting fish from 50 other lakes selected using the GRTS methodology in an attempt to assess mercury contamination in large fish throughout the state regardless of fishing pressure. This will provide key information to assist the State in developing its biennial 305(b) report under the CWA. The remaining 136 heavily fished lakes will be sampled in 2008 and 2009. Mercury in water and other water quality parameters will be measured as part of this effort as well. Water samples will be analyzed for unfiltered methylmercury as well as suspended sediment concentrations. The water quality data collected by the BOG study will follow the same procedures used for a national study of water quality in lakes to be conducted this summer by USEPA. That protocol calls for sampling the deepest part of a lake recording a depth profile from the surface to the bottom at every 0.5 or 1.0 meter depending on depth. Following this methodology will allow comparison of lakes sampled in this study to other California lakes, as well as other lakes in the surrounding states. The EPA Lakes study will be recording DO, pH, temperature, and Secchi depth. In partnership with this effort we will develop a list of potential lakes suitable for deriving data that can be used to assess impairment of wildlife beneficial use and to develop bioaccumulation factors (BAFs), the increase in concentration from water into biota, and trophic transfer factors that might be applicable to model mercury accumulation and impacts in lakes throughout the State and perhaps the western region of the United States.

Proposed Sampling Plan (with Partners)

We propose to utilize sport fish mercury and water quality data collected by the BOG in conjunction with information on mercury inputs (low vs. high), nutrient regime (eutrophic vs.

oligotrophic), lake type (natural vs. managed) to select a subset of lakes to be sampled more intensively for mercury in water, invertebrates, small fish, sport fish, and birds (eggs and/or individuals), where present (Table 1). Mercury loading is an important determinant of mercury bioaccumulation and risk. Low mercury sites will be defined as waterbodies at or below current basin plan criteria and/or with no identifiable point source loads. Conversely, high mercury lakes will be defined as those waterbodies above current basin plan criteria and/or with identified point source loading. Nutrient regime and nutrient cycling are also important parameters affecting mercury bioaccumulation and aquatic community structure. Lakes will be identified as either eutrophic or oligotrophic. Management regime is another key component of mercury cycling in lake systems as factors such as lake level and water temperature are affected by management and operations in certain managed lakes and reservoirs. We propose to do two replicates of the 8 types of lakes described in Table 1 resulting in 16 sample lakes throughout the state.

Table 1. General lake category combinations

eutrophic	oligotrophic	low Hg	High Hg	Natural	Managed
x		x		x	
x		x			x
x			x	x	
x			x		x
	x	x		x	
	x	x			x
	x		x	x	
	x		x		x

To further refine our assessment of mercury bioaccumulation in these systems we propose to analyze stable isotopes of carbon and nitrogen to better assess trophic relationships relative to mercury accumulation. This will allow us to better refine the relationship between mercury concentration and trophic transfer by normalizing each system to its relative trophic structure using ratios of stable nitrogen isotopes as a proxy for trophic level rather than assigning a particular species to a particular trophic level on an a priori basis. We will use ANCOVA to control for fish length and nitrogen isotope ratios to control for trophic position to assess mercury accumulation in invertebrates, small fish, and avian taxa to be used in calculating BAFs and trophic transfer rates. Since different species and trophic guilds will occur at different lakes we will conduct ANCOVA analysis at the individual species level as well as at the genus level, and at the trophic guild level to assess mercury concentrations in biota and bioaccumulation rates in California lakes. In the case of avian taxa an analysis at the family or order level may be necessary.

Other information to be used in this prioritization includes ancillary water quality data to ensure a cross section of lake types. Collecting information on basic water quality parameters of each lake will be helpful in understanding spatial patterns in mercury loading, methylmercury production and bioaccumulation. These data will also allow a better characterization of differences in mercury biogeochemical cycling and bioaccumulation between lake types and how this affects mercury risk. In this study, we propose to add electrical conductivity, alkalinity, and chlorophyll a concentration as a proxy for primary productivity. Other water quality parameters under consideration include DOC, nitrogen, phosphorus, and sulfur. All of these parameters are key components of the mercury biogeochemical process. We also propose to include landscape and regional level analyses using parameters such as lake area, shoreline area, land use/cover, population, elevation, watershed size, and precipitation and runoff data within each watershed through the use of GIS techniques. Water quality and landscape parameters will be analyzed using an ANOVA/ANCOVA approach or Pearson product moment correlations where appropriate to quantitatively determine which factors most significantly impact mercury tissue concentrations and trophic transfer in invertebrates, small fish, sportfish, and aquatic dependent wildlife.

The sampling effort will be designed to take advantage of the large quantity of fish and water quality data already being taken by the BOG and past data collected by others where possible. We propose to sample 2 small fish species at each BOG sportfish sampling site with 20 individuals per species being collected for individual analysis. This study will only assess those lakes in the BOGs small or medium category. Fish species and sizes will be selected to represent not only avian prey composition, but what is believed to represent trophic level 2 and trophic level 3 fish to better calculate lake specific BAFs. As trophic level 2 fish will likely be uncommon we propose to sample 5 composite samples of a representative benthic foraging macroinvertebrate and 5 composite samples of zooplankton at each fish sampling location to better characterize mercury dynamics at the base of the foodweb.

Priority fish species will be young-of-year and/or juvenile (50-200 mm) piscivorous species such as bass and pikeminnow and representative littoral foraging species such as bluegill or crappie. At some locations, primarily at higher elevations, salmonids such as rainbow, brook, and brown trout will be the predominant fish species. Other species may include redsides, shiner, logperch or silversides. Suckers and carp may be collected when appropriate. We intend to target fish between 50 and 200 mm to ensure adequate coverage of size classes in the range of piscivorous wildlife prey and continuity with data collected for sportfish. We plan to archive additional fish for primary and secondary species, and other species likely to be encountered such as benthic foraging catfish or carp, to be analyzed on an as needed basis. Monitoring data from western streams suggests that large non-piscivorous fish species and small fish (<120 mm) have similar mercury accumulation patterns (Peterson et al. 2007). To the extent possible we will also sample eggs or individuals from 2 aquatic dependent avian species utilizing these lakes as foraging and/or breeding habitat. Avian species of highest priority are colonial obligate piscivores such as cormorants or grebes and colonial facultative piscivores such as egrets and herons. If possible eggs from high trophic level raptors such as eagles and osprey will be sampled as well. If monitoring data for species such as eagles and osprey suggests they are resident year round, feathers could be sampled at some sites as well.

Table 1. Proposed sampling design by taxa and lake size

Sampling design for 16 lakes (up to 8 in each size class)

lake size	bentic invert.	TL 2 invert	non-pisc. fish	pisc. fish	omni. bird	pisc. bird	total samples
<500 ha.	5	5	20	20	10	10	70
>500 ha.	10	10	40	40	10	10	120

The ultimate goal of this study is to develop models that not only predict mercury accumulation observed in biota from focal lakes, but that can be broadly applicable to lakes throughout California to accurately predict mercury accumulation and risk with limited site specific data. These models may then be used by resource managers and regulatory agencies to model the potential risk posed by mercury in lakes throughout the State. A secondary objective of this investigation is to get a preliminary assessment of mercury concentrations in aquatic dependent wildlife to include in the risk assessment models and to compare with published toxicity thresholds. Sampling efforts are proposed to be split between 2008 and 2009. Funding has been requested for FY 2010 to either resample lakes to further refine information on mercury dynamics in a particular lake or to continue sampling in conjunction with the BOG and other groups who anticipate funding into 2010. An estimated 1,520 biota samples will be collected over the first two years of this off-refuge investigation with funding identified for further sampling in the third year to be prioritized based on available partnerships and priorities identified in years 1 and 2. The ultimate goal of this project is to develop a methodology that can be applied across large sections of the state and to different waterbody types to identify sites where mercury risk may be an issue and model the relative magnitude of that risk to fish and wildlife resources.

III. B. Proposed Schedule of Milestones

Year 1 – Fall and Winter 2007-2008-Obtain all state and federal permits and property access prior to sampling. April to early September –collect all fish, egg, and water samples. Ship all samples to analytical facilities by October 1, 2008. Develop data base of field sampling and prepare progress report.

Year 2 - Receive results from year 1 and synthesize data for use in planning field season by March 15, 2009.

April to early September – Collect all water, fish, and avian samples.
Ship all samples to analytical facilities by October 1, 2009. Develop data base of field sampling.

May - prepare progress report including data from year 1.

Year 3 - Receive results from year 2 and synthesize data from year 1 and 2 for use in planning field season by March 15, 2010.

April to early September - Collect all water, fish, and avian samples.
Ship all samples to analytical facilities by August 15, 2010. Develop data base of field sampling.

May - prepare progress report including data from year 1 and 2.

Year 4 - Receive results from year 3 and synthesize data from year 1 - 3. Develop final progress report in May, 2011.

Final Report of publication quality by Sept. 30, 2011.

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V. ROLES, RESPONSIBILITIES, AND PARTNERSHIPS

V. A. Roles and Responsibilities

The principal investigators are:
Thomas Maurer, Terry Adelsbach, and Collin Eagles-Smith
U.S. Fish and Wildlife Service, Environmental Contaminants Division,
Sacramento Fish and Wildlife Office

Adelsbach and Eagles-Smith will be responsible for overall scientific design and Maurer will provide guidance and supervise implementation of the project. Adelsbach and Eagles-Smith in conjunction with partners will carry out field collections, prepare catalogs, ship samples, examine embryos, construct spreadsheets and analyze data. Adelsbach and Eagles-Smith will prepare the final report with assistance from partners. Maurer will review and edit the final report. Operational funds have been requested to cover oversight and limited fieldwork by Adelsbach and/or Eagles-Smith. Field technicians for field sampling will be provided through partnership with the State's BAF project and the BOG sportfish sampling project. Analytical funds for all invertebrate and small fish samples are requested as part of this project. Mercury in water, large portions of water quality, and all sportfish analyses are being provided by partners.

V. B. Partnerships

Statewide Bioaccumulation Factor Development:
Tom Kimball, Environmental Scientist, California State Water Resources Control Board, Division of Water Quality, Sacramento, Ca.
As previously mentioned the State is undertaking development of statewide BAFs to assist in the interpretation and application of water quality objectives that are likely to be expressed in fish tissue concentrations. These BAFs are currently largely driven by concentrations observed in water and sportfish. As part of the BAF project and the project proposed here we intend to calculate BAFs for water into aquatic biota and trophic transfer rates for invertebrates, small fish, sportfish, and fish eating wildlife. The BAF project will provide assistance in collecting water chemistry data, fish collection and analysis, field assistance as well as assistance in the

development of wildlife specific BAFs. Over the life of the proposed project the approximate partnership contribution from the State BAF project will be $200,000.

Bioaccumulation Oversight Group
Dr. Jay Davis, Environmental Scientist, San Francisco Estuary Institute, Richmond, Ca.
The BOG is composed of State and Regional Board staff and representatives from other agencies and organizations including USEPA, the California 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 effort is primarily interested in establishing status of mercury contamination in sportfish within the State. As such, all of the sportfish sampling and a considerable amount of water quality and water chemistry data would be provided in partnering with the BOG. Over the life of this project the estimated level of partnership contribution would be $1.5 million. This partnership would primarily exist in the early stages of the work proposed here with $700,000 in mid-late 2007 (early FY2008) and $800,000 available in 2008 (FY2008-2009). It is anticipated that continued funding for the BOG would be identified into calendar years 2009 and 2010, but at the time of this proposal the source and amounts were not yet identified.

VI. BUDGET

VI. BUDGET					
EXPENDITURES	**Year 1 FY 2008**	**Year 2 FY 2009**	**Year 3 FY 2010**	**Year 4 FY 2011**	**All Years**
Field Operations					
Personnel - Field	$ 60,000.00	$ 65,000.00	$ 65,000.00	$ -	$ 190,000.00
Personnel - Data Analysis	$ 10,000.00	$ 9,000.00	$ 9,000.00	$ 10,000.00	$ 38,000.00
Personnel - Report Writing	$ 5,000.00	$ 5,000.00	$ 5,000.00	$ 15,000.00	$ 30,000.00
Travel	$ 15,000.00	$ 15,000.00	$ 15,000.00	$ -	$ 45,000.00
Supplies	$ 5,000.00	$ 1,000.00	$ 1,000.00	$ -	$ 7,000.00
Equipment				$ -	$ -
Non-ACF Analytical	$ 51,680.00	$ 51,680.00	$ 51,680.00	$ -	$ 155,040.00
Hg ($68.00/sample)					
Stable isotope analysis	$ 7,600.00	$ 7,600.00	$ 7,600.00	$ -	$ 22,800.00
$10.00/sample					
Other (Specify)			$ -	$ -	$ -
Regional Overhead (X%)			$ -	$ -	$ -
Operational Subtotal	*$ 154,280.00*	*$ 154,280.00*	*$ 154,280.00*	*$ 25,000.00*	*$ 487,840.00*
PACF Analytical					*$ -*
Total Funding	**$ 154,280.00**	**$ 154,280.00**	**$ 154,280.00**	**$ 25,000.00**	**$ 487,840.00**