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PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLIC HEALTH DESIGNED SCREENING STUDY

FINAL PROJECT REPORT

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1. STUDY OBJECTIVES AND BACKGROUND

The objective of this study, hereafter referred to as the California Lakes Study, was to measure the levels of selected target chemicals in fish from two California lakes in order to provide an initial data base to determine whether additional sampling and health evaluation of the data are warranted in either lake. San Pablo Reservoir and Black Butte Reservoir were selected primarily because geological data suggested that the levels of mercury in some sport fish in these lakes might reach levels of concern for frequent fish consumers. Also, populations consuming high amounts of fish (e.g., subsistence fishers) were believed to fish in these lakes.

Black Butte Reservoir is on the eastern side of the California coast range. The lake straddles Glenn and Tehama Counties, which are primarily agricultural counties in the Central Valley, and is located north of other more populated urban areas such as Sacramento. Cinnabar deposits were mined for mercury throughout the coast range and fish consumption advisories based primarily on mercury concentrations in fish muscle tissue remain in force on several lakes in the coast range. There are consumption advisories for fish in Lake Berryessa and Clear Lake which are near Black Butte Reservoir (OEHHA,1987). This suggested that other lakes in this mountain range might contain bioavailable mercury that could build up to levels of concern in higher trophic level fish. The Toxic Substances Monitoring Program collected a very limited number of samples of fish from Black Butte in 1984 and 1985 (Water Resources Control Board, 1990). Two fillet sample of largemouth bass contained 0.18 and 0.26 ppm mercury and two fillet samples of crappie contained 0.05 and 0.42 ppm of mercury, respectively.

Black Butte Reservoir is operated by the U.S. Army Corps of Engineers. Storage in this reservoir began in 1963 and the lake covers a maximum of about 4500 surface acres of water. This is a warm water reservoir that supports primarily largemouth bass, crappie, catfish (channel, and some white and bullheads), and bluegill. There are three boat ramps, a small marina, and camping and day-use areas. Boat launching fees are charged and a California fishing license is required for sport fishers. Many fishers fish from boats but shore fishing sites are also available. According to staff in the local Women Infants and Children Program (WIC), Black Butte Reservoir is a popular fishing site for Hmong living in the northern Central Valley.

San Pablo Reservoir is also located in the coast range but it is on the western side near San Francisco Bay. San Pablo Reservoir is in Contra Costa County, which is a highly populated suburban county in the San Francisco Bay area. There are existing fish consumption advisories for fish in several lakes in a watershed in nearby Santa Clara County due to mercury levels in fish tissue (California Department of Health Services, 1987). There is also a consumption advisory for San Francisco Bay fishes due primarily to mercury and levels of PCBs in fish tissue (OEHHA, 1994). Prior to this study, no fish samples had been collected and analyzed for chemical contaminants from this lake. A survey by the Asian Pacific Environmental Network (APEN) found that this is a very popular fishing location for many fishers from the Laotian community in Contra Costa County (APEN, 1998).

San Pablo Reservoir is operated by the East Bay Municipal Utility District. The lake covers about 860 surface acres of water. The Reservoir is operated as a day-use facility for about nine months during the year. It closes to the public in mid-November and reopens in mid-February. Picnicking facilities are available and there are two boat ramps and a small rental marina. A separate fee is charged for parking, fishing or launching boats. A California fishing license is also required. These fees help support a large fish stocking program. The lake is stocked with rainbow trout and channel catfish. Fish are stocked as often as 1-3 times a week depending on the season. Typically about 1,000 pounds of a species are added at each stocking. In addition to these stocked species, this warm water reservoir also contains largemouth bass, crappie, bluegill, carp and some sturgeon which were previously planted.

2. FISH SAMPLING AND COMPOSITING

The fish sampling and sample preparation methods used in this study are described in more detail in the Quality Assurance Project Plan (QAPP, Appendix 1). In general, fish were collected from a boat using electroshocking, fyke nets or gill nets. After capture, fish were maintained in a live well until they could be processed for transport to the analytical laboratory. The weight and length of individual fish were measured on shore and the fish were identified according to species, wrapped in aluminum foil bags and frozen on dry ice for transport.

The desired target species for collection and an approximate number of fish to be collected per lake were identified in consultation with the USEPA contract manager and USEPA Region 9 staff before the field sampling was initiated. Fish samples were grouped by species and size (total length). The actual number of composites of each species and the number and sizes of fish in individual sample composites were decided after the collection at each lake was completed. Fish species were selected and composites were organized with the intent of maximizing the amount of information on popular sport fish of different species and sizes that are caught and consumed from each lake. Composites were made from muscle tissue of individual fish as described in the QAPP (Appendix 1).

Fish samples were collected at San Pablo Reservoir on November 5, 6, 12 and 13, 1997. The target species selected were largemouth bass, crappie, carp, rainbow trout and channel catfish. Samples of largemouth bass, rainbow trout and carp were collected along the shoreline using electroshocking. Crappie were collected in fyke nets, and channel catfish were collected primarily by gill netting. Samples were designated as being collected in the north (the dam is in the north area) or south reaches of this smaller oval lake. Additional details on the collection locations, times and methods are included in the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999)(Appendix 2).

Fish samples from San Pablo Reservoir were made into twelve composites. In some cases, fish of the same species from the northern location were included with individuals from the south area to maintain size classes. This was done because analyzing more samples based on consistent size classes was deemed to be more important than comparing fish caught at different locations. Differences in chemical contamination at different locations were not expected in this small lake and would have required collecting more replicate samples to increase the probability of detecting differences. Two composites were made of rainbow trout (three fish each), channel catfish (four fish each), and carp (four fish each). Five composites were made of largemouth bass (three fish each), and one composite of crappie (four fish each). The average length, weight and estimated age of fish in these composites are given in Table 1.

Fish samples were collected at Black Butte Reservoir on November 25, and December 4 and 5, 1997. The target species selected for Black Butte were largemouth bass and channel catfish. Crappie and carp were taken as by-catch. Samples of largemouth bass were collected along the shoreline using electroshocking. Crappie, carp and channel catfish were collected primarily by gill netting. This lake has two creek inlets and other irregular coves and these features were used to identify three sample stations. Samples were collected from Burris Creek Arm, Stony Creek Arm, and Angler's Cove (Fisherman's Cove and extending to the dam). Additional details on the collection locations, times and analytical methods are included in the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999)(Appendix 2).

Fish samples from Black Butte Reservoir were made into nineteen composites. One composite of carp (three fish) and one composite of crappie (three fish) were included to get some information on these species in this lake. The crappie composite had to be made from fish from two locations. The carp composite was from Angler's Cove. Nine composites were made of largemouth bass (three fish each), and eight composites were made of channel catfish (four fish each). Two largemouth bass composites and one channel catfish composite were from Angler's Cove. Four largemouth bass and four channel catfish composites were from the Stony Creek Arm. And three largemouth bass and three channel catfish composites were from the Burris Creek Arm. The average length, weight and estimated age of fish in these composites are given in Table 2.

3. CHEMICAL ANALYSIS

Chemical analyses were done as described in the QAPP. The California Department of Fish and Game Water Pollution Control Laboratory (WPCL) dissected fish muscle tissue, made it into the designated composites discussed above, and homogenized the tissue composites. Nine composites were split and 100 grams of homogenized tissue were delivered to the California Department of Toxic Substances Control Hazardous Materials Laboratory (HML) for analysis of dioxins/furans and three PCB congeners. Homogenates of one composite each of rainbow trout, channel catfish, largemouth bass, crappie and carp from San Pablo Reservoir were extracted and analyzed by HML. Homogenates of two composites each of largemouth bass and channel catfish from Black

Butte Reservoir were extracted and analyzed by HML. HML analyzed these samples for 7 chlorinated dibenzodioxin compounds, 10 chlorinated dibenzofuran compounds and three coplanar PCB congeners. See the HML data report (May 19, 1998)(Appendix 3) for additional details. WPCL extracted and analyzed all composite homogenates for 4 metals and 35 organic compounds, plus 46 PCB congeners. See the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999) for additional details on the chemicals analyzed, analytical methods, and detection limits (Appendix 2).

4. ANALYTICAL RESULTS AND QUALITY ASSURANCE

The chemical results and quality assurance measures are discussed in more detail in the HML data report (Petreas, May 19, 1998) (Appendix 3) and the Environmental Chemistry Data and Quality Assurance Report (Department of Fish and Game, 1999) (Appendix 2), and memoranda from Dr. Gerald Pollock, (June 17, 1998; December 30, 1998; June 7, 1999) the project quality assurance officer (Appendix 4).

Some problems were noted in the analyses. Disulfoton, a target chemical analyte being analyzed for the first time, was not successfully measured by the method used. Further investigation showed that it was lost on the Florisil column used in a cleanup step. Since a relatively small amount of disulfoton was applied to crops in California (0.05% of total pound applied in 1995, Department of Pesticide Regulation, 1996) the loss of this analyte was not critical. Low level PCB contamination in glassware was also observed for some congeners. The level was low enough that it did not impact the evaluation of samples for health concerns. Overall there were no major problems that compromised the analytical results.

The final data reported by both laboratories were judged to pass Quality Assurance as outlined in the QAPP (Dr. Pollock, June 7, 1999). Therefore, these data, as qualified by the analytical laboratories, may be used for evaluation of tissue concentrations of chemicals of human health concern in sport fish from San Pablo Reservoir and Black Butte Reservoir.

5. COMPARISON OF CHEMICAL RESULTS TO SCREENING VALUES

Screening Values were established in the QAPP for a number of chemicals specifically for the California Lakes Study. The Screening Value (SV) approach is recommended by USEPA (1995) to identify chemical contaminants in fish tissue at concentrations which may be of human health concern for frequent consumers of sport fish. The SVs are not intended as levels at which consumption advisories should be issued but are useful as a guide to identify fish species and chemicals from a limited data set, such as this one, for which more intensive sampling, analysis or health evaluation are to be recommended. The USEPA has recommended SVs for 25 specific chemical contaminants that have been observed to bioaccumulate in fish tissues in various waterways throughout the United

States. Some of the chemicals for which USEPA has recommended SVs were not used extensively in California. Screening Values specific to the California Lakes Study (CLS-SVs) were described and calculated in the QAPP for chemicals that were used in California and were more likely to bioaccumulate in sport fish in California lakes. The USEPA and CLS-SVs for these chemicals are reproduced from the QAPP in Table 3.

Table 4 shows the range of chemical concentrations measured in fish from San Pablo Reservoir for which there are CLS-SVs in Table 3. The CLS-SVs for individual chemicals were not exceeded in any samples in most species. The shaded boxes in Table 4 indicate fish species for which at least a portion of the chemical concentration range exceeded the CLS-SV. These chemicals and species are examined closely in the next section.

The CLS-SVs for chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ were exceeded by all channel catfish samples from San Pablo Reservoir. Channel catfish are stocked in this lake and show the highest levels of a number of canceled pesticides, PCBs and dioxin TEQ. Therefore, it is possible to postulate that some of these chemicals were accumulated from environmental or feed exposures at the fish farm(s) at which the catfish were raised. The stocked rainbow trout did not show this same pattern of chemicals. They only exceeded the CLS-SVs for dieldrin and PCBs. And levels of these chemicals in trout were about ten times lower than for the same chemicals in the channel catfish.

Among resident fish species at San Pablo Reservoir, carp exceeded the CLS-SVs for chlordane, dieldrin, PCBs and dioxin TEQ. Their levels of these chemicals were about one-fourth of those measured in the catfish. Largemouth bass also exceeded the CLS-SVs for dieldrin and PCBs, but not chlordane and dioxin TEQ; and the levels in bass were lower than in carp. Largemouth bass, however, were the only species for which any and all samples exceeded the CLS-SV for mercury in San Pablo Reservoir. The single crappie sample had the lowest level for all CLS-SV chemicals and just barely exceeded the CLS-SV for dieldrin.

Table 5 shows the range of chemical concentrations measured in fish from Black Butte Reservoir for which there are CLS-SVs in Table 3. Even fewer CLS-SVs were exceeded in fish in this lake than in San Pablo Reservoir. Again, the shaded boxes in Table 5 indicate fish species for which some portion of the range of chemical concentration exceeds the CLS-SV. These chemicals and species are examined closely in the next section.

All samples in all fish species (i.e., carp, crappie, channel catfish and largemouth bass) in Black Butte Reservoir exceeded the CLS-SV for mercury. Channel catfish are the only species for which any of the CLS-SVs for pesticides are exceeded. In this case the toxaphene CLS-SV was exceeded in some samples. Some largemouth bass samples just barely exceeded the CLS-SV for PCBs. In general, the data suggest that fewer organic chemicals accumulated in fish in this lake.

6. EVALUATION OF FISH EXCEEDING SCREENING VALUES IN EACH RESERVOIR

The mean total length, weight, percent lipid, and estimated age of the fish in all composites from San Pablo and Black Butte Reservoirs are given in Tables 1 and 2, respectively. These data are summarized from Appendix 2 (Department of Fish and Game, 1999). The mean chemical concentrations in each fish species from San Pablo and Black Butte Reservoirs for chemicals for which there are CLS-SVs are given in Tables 6 and 7, respectively. The information in these Tables is referred to in the discussion below.

Stocked and resident fish species can be caught from San Pablo Reservoir so both were sampled in this study. The stocked fish collected for this study were captured from the lake and their residence time in San Pablo Reservoir prior to capture is not known. The estimated ages of rainbow trout and channel catfish given in Table 1 are not an accurate indicator of residence time because fish of different sizes and ages are stocked in the lake.

Two composites of rainbow trout from San Pablo Reservoir were analyzed. Only the CLS-SVs for dieldrin and PCBs were exceeded in these samples. The larger and older trout in composite A had 4.6 ppb dieldrin which is twice the dieldrin CLS-SV of 2 ppb. The smaller and younger trout in composite B had 1.6 ppb dieldrin which is essentially at the CLS-SV. Both trout composites showed essentially the same concentrations of PCBs (i.e., 20 and 18 ppb Aroclor 1254). This is right at the CLS-SV of 20 ppb for PCBs expressed as Aroclors and the mean PCB level in trout (19 ppb) is just below the CLS-SV. This is a limited sample of this species and it would be worthwhile to collect and analyze additional samples to better characterize the levels of the chemicals in the trout population that are at the CLS-SV levels. This stocked species could be sampled directly from the fish farm(s).

Two samples of channel catfish from San Pablo Reservoir were analyzed. The chemical concentrations in the composite of larger-sized and medium-sized catfish were well above (at least twice the value) the CLS-SVs for chlordane (30 ppb), dieldrin (2 ppb), toxaphene (30 ppb), PCBs (20 ppb) and dioxin TEQ (0.3 ppt). The concentrations of total DDT (SV 100 ppb) and heptachlor expoxide (SV 4 ppb) also exceeded the CLS-SVs but by less than twice the value, even in the composite of larger sized catfish. These fish have accumulated several pesticides, as well as PCBs to concentrations above the CLS-SVs. Although the dioxin TEQ also exceeded the CLS-SV, this observed concentration is within the USEPA background range for fish (1.2 ± 1.6 ppt) and similar to the level found in some fish from San Francisco Bay (Pollock, May 27, 1998). Two composites is a limited sample of this species and it would be important to collect and analyze additional samples to better characterize the levels of all chemicals in the catfish population that are at or above the CLS-SV level.

Two samples of carp from San Pablo Reservoir were analyzed, and one was analyzed in duplicate. The concentrations of chlordane, dieldrin, PCBs and dioxin TEQ exceeded the

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CLS-SVs in both carp composites analyzed. Because carp are bottom feeders and have high lipid content they are more likely than the other two resident species sampled to accumulate these hydrophobic chemicals. The highest values for chlordane and dioxin TEQ in carp were about twice their respective CLS-SVs. The dioxin TEQ value was within the USEPA range for background levels of dioxin in fish tissue (see above). The highest values for dieldrin and PCBs in carp were greater than twice their respective CLS-SVs. Two composites is a limited sample of this species and it would be worthwhile to collect and analyze additional samples to better characterize the levels of those chemicals in the catfish population that are at or above the CLS-SV level.

The resident carp have feeding habits similar to the channel catfish introduced into San Pablo Reservoir (both are bottom feeders). A comparison of the concentrations of chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ for these two species showed less accumulation on a wet weight basis in the carp than in the channel catfish (see Tables 4 and 6). In general, the concentrations of these chemicals in channel catfish were about three to four times greater than in the carp, although the catfish are of equal or smaller size (see ratios in Table 8). One hypothesis to explain this difference is that since the channel catfish were a stocked species it is possible that some of the contamination was due to exposure during the raising of these fish.

A comparison between the concentration of lipophilic organic chemicals in the stocked channel catfish and the resident carp can be used to test this hypothesis. If exposed to equal concentrations of lipophilic organic chemicals these species are expected to bioaccumulate similar levels of these chemicals due to their similar feeding habits (bottom feeders) and high lipid content of their muscle tissue (catfish mean lipid, 11.2%; carp mean lipid, 7.3%). A comparison with other resident species would be less appropriate because the crappie and largemouth bass are not bottom feeders and had low lipid content (0.3% and 0.6%, respectively).

Table 8 shows the ratios of the concentration of chlordane, total DDT, dieldrin, heptachlor expoxide, toxaphene, PCBs and dioxin TEQ in channel catfish and carp from San Pablo Reservoir. The relative pattern of abundance of these chemicals in these two species was very similar. The concentrations of all of these lipophilic organic chemicals in channel catfish were about 3-4 times that in the carp. A comparison between the ratios of lipid normalized and age normalized concentrations of chemicals for these species is also shown in Table 8. These data were normalized to see if the higher lipid content and/or greater age of the channel catfish might account for this large and consistent difference in chemical concentrations between these species. Normalizing the chemical concentration data is a simple way of discovering whether the factor used to adjust the concentration accounts for some of the variation in the data. The analysis discussed here and shown in Table 8 is limited because the data base for carp (2 composites) and channel catfish (2 composites) is small. More sophisticated and powerful statistical methods could be used if more replicate samples were available.

The normalized results in Table 8 showed that lipid content and age contribute to this difference in concentration. Adjusting for lipid content approximately reduced the unadjusted ratio by 50% and adjusting for age reduced the apparent higher bioaccumulation in catfish to a ratio of 1.5 or less for all chemicals. This showed that much of the variation in chemical concentration between the carp and the catfish was due to differences in the age and/or lipid content of these species. Although the conclusion is limited by the small data base, this suggests that the differences in chemical concentration observed between these species may be accounted for by differences in age and lipid content and are not because catfish were raised and exposed elsewhere part of their lives. The pattern of relative abundance of these chemicals in these two species also supports a common exposure. The catfish were approximately 7-11 years old and had probably survived several years in San Pablo Reservoir after stocking. So, it appears unlikely that the catfish bioaccumlated much of their observed tissue concentration from a source other than San Pablo Reservoir. To eliminate this possibility, additional samples should be collected directly from the fish farm(s) providing channel catfish and the results compared to additional samples collected from the reservoir.

The CLS-SV for dieldrin was also exceeded in all five composites of largemouth bass from San Pablo Reservoir by two to four times the CLS-SV value. All of these composites were near the CLS-SV for PCBs expressed as Aroclors. One of these composites was of large-sized fish, two were medium-sized and two were small-sized fish. Only the composite from the largest (mean total length 543 mm) and oldest (about 8 years of age) fish was above the SV for PCBs. However, largemouth bass of all legal sizes (above 305 mm) and ages (about 3-8 years) exceeded the CLS-SV for mercury (300 ppb). The mercury concentration increased with the average size and age of the fish in these composites. These are based on an adequate number of samples and distribution of fish sizes to characterize the largemouth bass population for this lake. Therefore, the results can be considered representative of chemical concentrations in the largemouth bass population.

Only one composite of crappie was available for analysis so this was a very limited sample. The concentrations of most chemicals were lower in crappie than in the other sampled species. The dieldrin concentration was at the CLS-SV. This was the only CLS-SV exceeded in this species in San Pablo Reservoir. Additional samples of this species should be collected and analyzed to better characterize the dieldrin levels in the crappie population at San Pablo Reservoir.

As noted in the previous section, very few CLS-SVs were exceeded in composites of fish sampled from Black Butte Reservoir (see Tables 5 and 7). Mercury was an exception; the mercury CLS-SV was reached or exceeded in all sampled species. These results were less compelling for carp and crappie because only one composite was analyzed for each of these species. The mercury CLS-SV is 300 ppb and the mercury concentrations in carp and crappie were 300 and 340 ppb, respectively. In channel catfish, however, all 8 composites exceeded the CLS-SV and the average mercury concentration was 400 ppb. All nine largemouth bass composites exceeded the CLS-SV and the average mercury concentration was 700 ppb. Mercury concentration tends to increase with increasing fish size and age in largemouth bass. However, this relationship was not evident in the channel catfish in Black Butte Reservoir.

A good number of samples and a distribution of fish sizes were obtained for the largemouth bass (9 composites, 2 large 3 medium and 4 small-sized) and channel catfish (8 composites, 4 large and 4 medium-sized) in Black Butte Reservoir. The chemical results for each respective species are consistent and are considered representative of the population of largemouth bass or channel catfish in the lake. Additional samples of carp and crappie should be collected and analyzed to better characterize the levels of mercury in these populations in the lake. This is especially important because the levels measured in the limited sampling are very near the CLS-SV level.

The CLS-SV for toxaphene (30 ppb) was exceeded in one of 8 channel catfish composites (41.8 ppb). Oddly, this was the only composite sample in which the concentration of toxaphene was above the detection limit. This was one of the composites containing larger catfish, but there were two others composed of similar sized catfish in which toxaphene was not detected. This result was checked and verified by the WPCL and it was noted that other samples also contained indications of toxaphene, but below the detection limit (see Appendix 2). The mean concentration for all composites was 14 ppb which is half of the CLS-SV. Additional analyses could be considered to better characterize the concentration of toxaphene in catfish samples from Black Butte Reservior.

The CLS-SV for PCBs (20 ppb) was reached in one of nine largemouth bass samples. This composite SCA-B was not composed of larger fish and showed typical lipid content for largemouth bass. This result stood out since this was the only sample (of any fish species from this lake) in which any Aroclor was detected above the detection limit. Aroclor 1254 was detected at 20 ppb in this sample. No Aroclor 1248 or 1260 was detected at quantifiable levels in any composite of largemouth bass or other species in Black Butte Reservoir. The mean concentration for all largemouth bass composites was 2.2 ppb assuming that the other composites were truly at zero level, but this cannot be measured. This is an under-estimate since there were PCB congeners detected in other samples, but at concentrations below the quantition levels for Aroclors. Additional analyses could be considered to better characterize the concentration of PCBs in fish samples from Black Butte Reservior; although the health concerns for PCBs do not appear high.

7. DISCUSSION

The primary objective of this study was to measure the levels of selected target chemicals in fish from San Pablo Reservoir and Black Butte Reservoir in order to provide an initial data base to determine whether additional sampling or evaluation of health concerns was warranted for either lake. Preliminary comparison of the measured levels of chemicals to CLS-SVs suggests that there are potential health concerns from consuming fish from both lakes. The chemicals of concern and the species of concern differ somewhat between the lakes. Further health evaluation of the data is warranted for both lakes. However, the data are limited on some of the species for which additional sampling is necessary.

San Pablo Reservoir and Black Butte Reservoir were selected for study because of the potential for mercury to be elevated in high trophic level fish (e.g., largemouth bass). The largemouth bass population in both lakes was well sampled in this study and chemical analysis showed that mercury concentrations in this species in both lakes were elevated above the CLS-SVs. In addition, the results showed that the other species sampled in Black Butte Reservoir (i.e., channel catfish, crappie, and carp) have elevated mercury levels. This result is most pertinent for the largemouth bass in San Pablo Reservoir and the largemouth bass and channel catfish in Black Butte Reservoir because a sufficient number of samples for these species were collected to characterize the populations in the lakes. The populations of crappie and carp in Black Butte Reservoir were not well characterized for mercury level and further sampling and analysis are recommended.

In Black Butte Reservoir, one sample in eight catfish composites exceeded the CLS-SV for toxaphene, and one in nine bass composites exceeded the CLS-SV for PCBs. The mean concentration of these chemicals in these well characterized species did not exceed the CLS-SV and, as such, the findings do not indicate a health concern.

For San Pablo Reservoir, additional samples and analysis are recommended for the following: chlordane, dieldrin, PCBs and dioxin TEQ in resident carp; dieldrin and PCBs in the stocked rainbow trout; and chlordane, dieldrin, PCBs, toxaphene and dioxin TEQ in channel catfish. This is based on cases where CLS-CVs are exceeded but only two composites of each species were collected and analyzed.

As discussed above, the stocked trout and channel catfish should also be sampled directly from the fish farm(s) to clarify whether significant exposure to organic chemicals occurs before they are put in this lake. This sampling and analysis should be discussed and coordinated with representatives of the East Bay Municipal Utility District.

The results of this study are important for all fishers at these lakes. They are especially pertinent to certain fishing populations as described below.

At San Pablo Reservoir it is important to further investigate the channel catfish contamination because catfish were noted as the most frequently consumed species by Laotian fishers (by 47.4% of surveyed fishers) in Contra Costa County in the APEN (1998) survey. And many of these ethnic fishers fish at San Pablo Reservoir (APEN, 1998). According to the APEN survey trout were consumed almost as often (by 40% of survey fishers) as catfish and, based on the data in this study, there was not a health concern due to chemical contamination of this stocked species in this lake.

There is no comparable survey of ethnic fishers for Central Valley lakes and rivers. According to a local health staff (Women, Infants and Children Program/Department of Health Services, personal communication) largemouth bass was the species favored by

Hmong fishers at Black Butte Reservoir. Consequently, the finding of elevated mercury concentrations in this species is especially pertinent to this fishing population.

The data collected from this project will be considered by OEHHA for an evaluation of the human health implications of consuming fish from San Pablo Reservoir and Black Butte Reservoir and for the development of fish consumption advisory options as appropriate.

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Table 1: Physical Characteristics of Fish in Composites from San Pablo Reservoir

Composite	Mean total length (mm)	Mean weight (gm)	Mean percent lipid	Mean estimated age (yrs)
Rainbow trout-A	519	1861	4.3	5
Rainbow trout-B	352	587	4.0	3
Channel catfish-A	582	2457	11.8	10
Channel catfish-B	509	1596	10.5	7
Largemouth bass-A	543	3141	0.8	8
Largemouth bass-B	462	1760	0.6	6
Largemouth bass-C	415	1226	0.7	5
Largemouth bass-D	353	612	0.3	3
Largemouth bass-E	405	1106	0.4	4
Crappie-A	252	263	0.3	3
Carp-A	523	2476	8.0	3
Carp-B	524	2331	6.5	3

Table 2: Physical Characteristics of Fish in Composites from Black Butte Reservoir

Composite	Mean total length (mm)	Mean weight (gm)	Mean percent lipid	Mean estimated age (yrs)
Crappie-MS-A	345	646	0.2	4
Carp-AC-A	478	1126	1.6	4
Largemouth bass-AC-A	503	2141	1.7	6
Largemouth bass-AC-B	402	960	0.3	4
Largemouth bass-SCA-A	372	716	0.1	4
Largemouth bass-SCA-B	312	398	0.1	3
Largemouth bass-SCA-C	308	388	0.2	3
Largemouth bass-SCA-D	302	384	0.1	3
Largemouth bass-BCA-A	507	2012	0.2	6
Largemouth bass-BCA-B	318	461	0.1	3
Largemouth bass-BCA-C	315	380	0.3	3
Channel catfish-AC-A	484	1016	2.4	6
Channel catfish-SCA-A	519	1227	2.3	7
Channel catfish-SCA-B	500	1142	3.8	7
Channel catfish-SCA-C	439	703	2.6	6
Channel catfish-SCA-D	426	647	1.8	5
Channel catfish-BCA-A	534	1460	4.9	8
Channel catfish-BCA-B	531	1382	3.0	8
Channel catfish-BCA-C	435	665	1.7	6

Table 3: USEPA and California Lakes Study Screening Values

CHEMICAL	USEPA Value[1] (ppb)	CLS-SV Study Value[2] (ppb)
Chlordane[3]	80	30
Chlorpyrifos	30,000	10,000
Total DDT[4]	300	100
Diazanon	900	300
Disulfoton	500	100
Dieldrin	7	2
Total endosulfan[5]	60,000	20,000
Endrin	3000	1000
Ethion	5000	2000
Heptachlor epoxide	10	4
Hexachlorobenzene	70	20
γ-hexachlorocyclohexane (lindane)	80	30
Toxaphene	100	30
PCBs[6]	10	20
Dioxin TEQ[7]	0.7 ppt	0.3 ppt
Arsenic[8]	3000	1000
Cadmium	10,000	3000
Mercury[9]	600	300
Selenium	50,000	20,000

1: USEPA SVs (USEPA, 1995) for carcinogens were calculated for a 70 kg adult using a cancer risk of 1x10-5. SVs for non-cancer effects were calculated for a 70 kg adult and exposure at the RfD (hazard quotient of 1). A fish consumption value of 6.5 g/day was used in both cases.

2: California SVs (CLS-SVs) specifically for this study were calculated according to USEPA guidance (USEPA, 1995). CLS-SVs for carcinogens were calculated for a 70 kg adult using a cancer risk of 1x10-5. CLS-SVs for non-cancer effects were calculated for a 70 kg adult and exposure at the RfD (hazard quotient of 1). A fish consumption value of 21 g/day was used in both cases. (see QAPP, 1998, Appendix 1)

3: Sum of alpha and gamma chlordane, cis- and trans-nonachlor and oxychlordane.

4: Sum of othro and para DDTs, DDDs and DDEs.

5: Sum of endosulfan I and II.

6: Expressed as the sum of Aroclor 1248, 1254 and 1260.

7: Expressed as the sum of TEQs for dibenzodioxin and dibenzofuran compounds which have an adopted TEF.

8: Measured as total arsenic in this study.

9: Measured as total mercury in this study.

Table 4: Range of Chemical Concentrations in Fish from San Pablo Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Rainbow trout	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	1.7 – 3.3	122.9 – 176	34 – 55.8	4.1	9.7 – 11.8
Chlorpyrifos	0.4* - 0.4*	0.4* - 0.4*	0.4* - 0.4*	0.4*	0.4* - 0.4*
Total DDT	8.4 – 10.4	104.9 – 160.8	29.9 – 49.2	4.6	3.8 – 14.2
Diazanon	12.5* - 12.5*	12.5* - 12.5*	12.5* - 12.5*	12.5*	12.5* - 12.5*
Disulfoton	LC	LC	LC	LC	LC
Dieldrin	1.6 – 4.6	42.4 – 54.2	14.1 – 20.1	2.5	4.4 – 8.9
Total endosulfan	4.2 – 6.3	4.4 – 6	4.4 – 6.9	3*	3* - 3*
Endrin	0.6* - 0.6*	0.6* - 0.6*	0.6* - 0.6*	0.6*	0.6* - 0.6*
Ethion	7.5* - 7.5*	7.5* - 16.2	7.5* - 7.5*	7.5*	7.5* - 7.5*
Heptachlor epoxide	0.3* - 0.7	5 – 6.4	1.5 – 2.2	0.3*	0.3* - 0.3*
Hexachloro-benzene	0.1* 0.3	0.6 – 0.8	0.3 – 0.4	0.1*	0.1* - 0.1*
γ-hexachloro-cyclohexane	0.1* - 0.1*	0.5 – 0.6	0.3 – 0.3	0.1*	0.1* - 0.1*
Toxaphene	10* - 10*	52.7 – 96.5	10* - 24.1	10*	10* - 20.5
PCBs as Aroclors	18 – 20	179 – 248	30 – 84	ND*	17 – 24
Dioxin TEQ (ppt)	0.19	1.5	0.61	0.08	0.14
Arsenic	290 – 310	240 – 370	260 – 440	260	120 - 180
Cadmium	5* - 5*	5* - 5*	5* - 5*	5*	5* - 5*
Mercury	30 – 30	70 –160	50 –60	160	370 – 770
Selenium	200 – 230	100 – 110	160 – 190	170	120 - 190

*: all values below Method Detection Limit (MDL).

ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.

LC: chemical lost on extraction column, no result.

Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

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Table 5: Range of Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	1.8 – 4.2	2.2	0.5*	0.5* - 2
Chlorpyrifos	0.4* - 0.4*	0.4*	0.4*	0.4* - 0.4*
Total DDT	8.7 – 16.3	9.3	2.2*	2.5 – 10.7
Diazanon	12.5* - 12.5*	12.5*	12.5*	12.5* - 12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.3* - 1	0.3*	0.3*	0.3* - 0.3*
Total endosulfan	3* - 3.9	3*	3*	3* - 3*
Endrin	0.6* - 0.6*	0.6*	0.6*	0.6* - 0.6*
Ethion	7.5* - 7.5*	7.5*	7.5*	7.5* - 7.5*
Heptachlor epoxide	0.3* - 0.3*	0.3*	0.3*	0.3* - 0.3*
Hexachlorobenzene	0.1* - 0.1*	0.1*	0.1*	0.1* - 0.1*
γ-hexachloro-cyclohexane	0.1* - 0.1*	0.1*	0.1*	0.1* - 0.1*
Toxaphene	10* - 41.8	10*	10*	10* - 10*
PCBs as Aroclors	ND - ND*	ND*	ND*	ND - 20
Dioxin TEQ (ppt)	0.04* - 0.09	NA	NA	0.08* - 0.11
Arsenic	25 – 60	25	220	50 - 270
Cadmium	5* - 5*	10	5*	5* - 5*
Mercury	340 – 500	300	340	370 - 1300
Selenium	150 – 460	590	490	390 - 520

*: all values below Method Detection Limit (MDL).
ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.
LC: chemical lost on extraction column, no result.
NA: not analyzed for dibenzodioxins or dibenzofurans.
Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 6: Mean Chemical Concentrations in Fish from San Pablo Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Rainbow trout	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.5	149.5	41.7	4.1	10.7
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*	0.4*
Total DDT	9.4	132.9	39.6	4.6	11.3
Diazanon	12.5*	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC	LC
Dieldrin	3.1	48.3	16.2	2.5	6.8
Total endosulfan	5.3	5.2	5.5	3*	3*
Endrin	0.6*	0.6*	0.6*	0.6*	0.6*
Ethion	7.5*	11.9	7.5*	7.5*	7.5*
Heptachlor epoxide	0.5	5.7	1.9	0.3*	0.3*
Hexachloro-benzene	0.2	0.7	0.4	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.6	0.3	0.1*	0.1*
Toxaphene	10*	74.6	18	10*	14.1
PCBs as Aroclors	19	213.5	54.3	ND*	19.4
Dioxin TEQ (ppt)	0.19	1.5	0.61	0.08	0.14
Arsenic	300	310	310	260	150
Cadmium	5*	5*	5*	5*	5*
Mercury	30	120	60	160	520
Selenium	220	110	180	170	170

*: all values below Method Detection Limit (MDL).

ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.

LC: chemical lost on extraction column, no result.

Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 7: Mean Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.6	2.2	0.5*	0.8
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*
Total DDT	13	9.3	2.2*	4.4
Diazanon	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.4	0.3*	0.3*	0.3*
Total endosulfan	3.2	3*	3*	3*
Endrin	0.6*	0.6*	0.6*	6*
Ethion	7.5*	7.5*	7.5*	7.5*
Heptachlor epoxide	0.3*	0.3*	0.3*	0.3*
Hexachlorobenzene	0.1*	0.1*	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.1*	0.1*	0.1*
Toxaphene	14	10*	10*	10*
PCBs as Aroclors	ND*	ND*	ND*	2.2
Dioxin TEQ (ppt)	0.07	NA	NA	0.1
Arsenic	40	25	220	160
Cadmium	5*	10	5*	5*
Mercury	400	300	340	700
Selenium	210	590	490	460

*: all values below Method Detection Limit (MDL).
ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.
LC: chemical lost on extraction column, no result.
NA: not analyzed for dibenzodioxins or dibenzofurans.
Shaded boxes indicate fish species for which a portion of the chemical concentration range exceeds the SV.

Table 8: Comparison of Ratio of Selected* Organic Chemical Concentrations in Channel Catfish and Carp from San Pablo Reservoir

CHEMICAL	Channel catfish	Carp	Ratio catfish/carp	(ppb/ % lipid except as noted)	Channel catfish	Carp	Ratio catfish/carp	(ppb/year of age except as noted)	Channel catfish	Carp	Ratio catfish/carp
Chlordane	149.5	41.7	3.6	**Lipid normalized Chlordane**	**1334.8**	**571.2**	**2.3**	**Age normalized Chlordane**	**17.6**	**13.9**	**1.3**
Total DDT	132.9	39.6	3.4	**Lipid normalized Total DDT**	**1186.6**	**542.5**	**2.2**	**Age normalized Total DDT**	**15.6**	**13.2**	**1.2**
Dieldrin	48.3	16.2	3.0	**Lipid normalized Dieldrin**	**431.3**	**221.9**	**1.9**	**Age normalized Dieldrin**	**5.7**	**5.4**	**1.1**
Heptachlor epoxide	5.7	1.9	3.0	**Lipid normalized Heptachlor epoxide**	**50.9**	**26.0**	**2.0**	**Age normalized Heptachlor epoxide**	**0.7**	**0.6**	**1.2**
Toxaphene	74.6	18	4.1	**Lipid normalized Heptachlor epoxide**	**666.1**	**246.6**	**2.7**	**Age normalized Heptachlor epoxide**	**8.8**	**6**	**1.5**
PCBs as Aroclors	214.2	55.3	3.9	**Lipid normalized PCBs as Aroclors**	**1912.5**	**757.5**	**2.5**	**Age normalized PCBs as Aroclors**	**25.2**	**18.4**	**1.4**
Dioxin TEQ (ppt)	1.5	0.61	2.5	**Lipid normalized Dioxin TEQ (ppt/% lipid)**	**13.4**	**8.4**	**1.6**	**Age normalized Dioxin TEQ (ppt/% lipid)**	**0.2**	**0.2**	**1**
Mean % lipid	11.2	7.3	1.5								
Mean age in composite (years)	8.5	3	2.8								

Chemical concentrations in unshaded boxes are expressed on a wet weight basis. Concentrations in ppb and normalized ppb except as noted.
Chemical concentrations in shaded boxes are "normalized" by dividing the chemical concentration by the mean percent lipid value or age for that fish species. These lipid or age normalized values should not be compared to SVs or ATCs which are expressed on a wet weight basis.
*These organic chemicals were selected because they are hydrophobic and because the SV was exceeded in channel catfish from San Pablo Reservoir.

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APPENDIX 1

QUALITY ASSURANCE PROJECT PLAN

FOR

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

APPENDIX 2

ENVIRONMENTAL CHEMISTRY DATA AND QUALITY ASSURANCE REPORT

FOR THE

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

WATER POLLUTION CONTROL LABORATORY

FINAL CALIFORNIA LAKES
STUDY PROJECT REPORT

June 1999

APPENDIX 3

HAZARDOUS MATERIALS LABORATORY DATA REPORT

FOR THE

PREVALENCE OF SELECTED TARGET CHEMICAL CONTAMINANTS IN SPORT FISH FROM TWO CALIFORNIA LAKES: PUBLICH HEALTH DESIGNED SCREENING STUDY

HAZARDOUS MATERIALS LABORATORY

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APPENDIX 4

QUALITY ASSURANCE MEMORANDA FROM

Dr. GERALD A. POLLOCK