Update of Organochlorine (OCl) "Legacy" Pesticide and PCB Concentrations in Delta and Central Valley Fish

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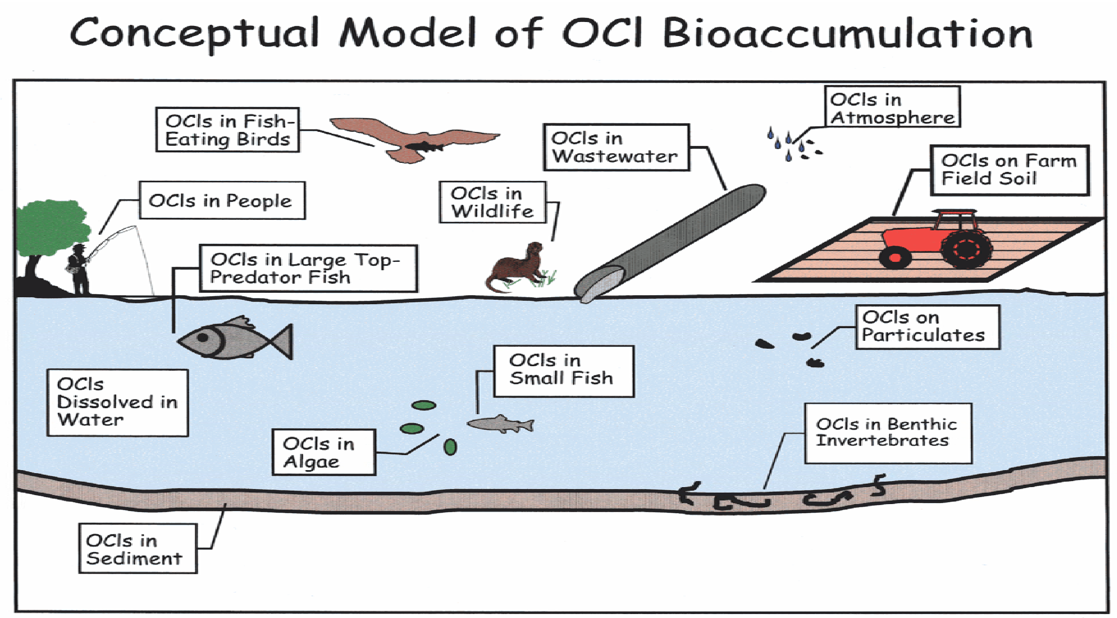

Report of G. Fred Lee & Associates, El Macero, California

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Executive Summary

The California State Water Resources Control Board (SWRCB) has been monitoring the "legacy" (formerly used) organochlorine (OCl) pesticides, such as DDT, chlordane, dieldrin, toxaphene, etc.) in fish tissue since 1978. Those data, has shown that the concentration of some of these pesticides in some fish from some waterbodies exceeded the concentrations that represent a threat to human health for those who eat large amounts of the fish. Lee and Jones-Lee (2002) developed a comprehensive report on the TSMP and other fish tissue monitoring data that had been collected through the late 1990s. That report included a comparison of the fish tissue concentrations with the US EPA (1995) and OEHHA (1999) human health screening values for evaluating the potential human health hazards presented by consuming a certain amount of fish with legacy pesticide or PCB residue in the edible tissue.

As part of an effort to provide updated information on the current Central Valley fish tissue concentration data, Dr. Chris Foe of the Central Valley Regional Water Quality Control Board (CVRWQCB) obtained funds to analyze fish that had been collected previously and stored frozen but not analyzed, and to collect and analyze additional fish. That effort resulted in a 2005 database for OCl legacy pesticide and PCB concentrations in fish tissue in the Central Valley. This report presents the results of the 2005 fish collection tissue data for the organochlorine legacy pesticides and PCBs with emphasis on fish collected from the Delta. In addition the results of the 2005 fish collected from the San Joaquin River and the Sacramento River and some of their tributaries.

In 2005, 232 fish were collected at Beaver Slough, Big Break, Clifton Court Forebay, Discovery Bay, Franks Tract, Lodi Lake, Lost Slough, Middle River @ Bullfrog, Old River @Tracy Blvd, Orwood Tract, Paradise Cut, Prospect Slough, SJR Potato Slough, SJR Vernalis, Sand Mound Slough, Smith Canal, Whiskey Slough Sacramento River at River Mile 44 and Sacramento River @ Rio Vista in the Delta. In the past, including the late 1990s, tissue from fish from many of these locations contained concentrations of several of the OCl legacy pesticides and PCBs in excess of the Office of Environmental Health and Hazard Assessment (OEHHA) 1999 human health screening values.

Data for fish tissue concentrations are reported as either µg/kg or as ng/g. These units are the same. All fish tissue concentrations are reported on a wet weight basis.

SJR Vernalis. San Joaquin River (SJR) Vernalis site provides an integrating site for persistent organochlorine legacy pesticide and PCBs in the SJR watershed. The SJR watershed upstream of Vernalis is an area of intense agriculture where there was extensive use of legacy pesticides. The total 2005 DDT concentration in tissue of the Sacramento Sucker (338 µg/kg), and carp (232 µg/kg) exceeded the OEHHA 1999 screening value of 100 µg/kg; these levels do not exceed the OEHHA 2006 proposed screening value of 560 µg/kg. The concentration of dieldrin in the tissue of the Sacramento Sucker (3.44 µg/kg) and carp (2.5 µg/kg) exceeded the OEHHA 1999 screening value; they are below the OEHHA 2006 proposed value of 16 µg/kg. The concentrations of toxaphene in the tissue of all of the 2005 Vernalis fish measured were below the 1999 OEHHA screening value of 30 µg/kg and also below the 220 µg/kg proposed 2006 screening value. The concentrations of chlordane in all 2005 Vernalis fish were also below the OEHHA 1999 screening value of 30 µg/kg and the proposed 2006 value of 200 µg/kg.

The concentration of PCBs in Sacramento Sucker tissue (27 µg/kg (wet weight)) exceeded the OEHHA human health screening value of 20 µg/kg. Tissue from the other fish from the Vernalis site had PCB concentrations below that screening value of 20 µg/kg.

Overall, except for the exceedance of the OEHHA screening value for PCBs in the Sacramento Sucker, fish tissue levels of legacy pesticides in SJR fish at Vernalis do not exceed screening values if OEHHA adopts its 2006 proposed human health fish tissue screening values.

Sacramento River Mile 44 Site. In October 2005 five largemouth bass, 10 Chinook salmon and Sacramento Sucker were collected at the Sacramento River Mile 44 site. None of the fish collected at RM 44 site exceeded the OEHHA 1999 screening value of 100 µg/kg for DDT analyzed in this study. A white catfish sample collected in 1998 had total DDT above this screening value. The previous (pre 2000) dieldrin data show a couple of white catfish samples with concentrations above the 1999 OEHHA screening value of 2 µg/kg. No white catfish were collected at RM 44 in the 2005.

The total PCBs in fish collected in 2005 were above the OEHHA 1999 and proposed 2006 as well as the US EPA human health screening values.

Fifteen fish were collected in August 2005 from the Sacramento River @ Rio Vista which were analyzed in three composites of five fish each. The Sacramento Sucker composite had total DDT at 92 µg/kg just under the OEHHA 1999 Screening value of 100 µg/kg. The carp composite total DDT of 149 µg/kg. The white catfish composite total DDT was 29 µg/kg. OEHHA adoption of the 2006 screening value of 560 µg/kg element violations of the total DDT screening value would eliminate the violations of this screening value.

None of the composites from Sacramento River @ Rio Vista exceeded the OEHHA 1999 dieldrin screening value of 2 µg/kg.

Two of the three fish composites from Sacramento River @ Rio Vista had total PCBs above the OEHHA screening values of 20 µg/kg at 24 and 33 µg/kg.

Other Delta Sites. Prospect Slough, SJR Potato Slough, and Discovery Bay had some of the fish collected at Delta locations above the DDT OEHHA 1999 screening value of 100 µg/kg. None of the fish composites contained DDT above the OEHHA 2006 proposed screening values of 560 µg/kg. Prospect Slough, and SJR Potato Slough also had dieldrin above the OEHHA 1999 screening value of 2 µg/kg, but none were above the OEHHA 2006 proposed screening value of 16 µg/kg.

Overall, based on the 2005 fish collection from the Delta the concentrations of the organochlorine legacy pesticides concentrations have decreased from the previous sampling. None of the fish taken in 2005 had organochlorine legacy pesticides above the US EPA screening values. Further if OEHHA should adopt the 2006 proposed fish tissue screening values all the Delta legacy pesticide 303(d) listings could be delisted.

The situation with PCBs concentrations in Delta fish is such that Big Break, Lodi Lake, Prospect Slough, SJR Potato Slough, Smith Canal, Whiskey Slough as well as SJR at Vernalis and Sacramento River Mile 44 and Sacramento River @ Rio Vista all had PCBs above the OEHHA 1999 and the OEHHA 2006 as well as the US EPA screening values. The PCBs are likely currently in the sediments of the area from where the fish with elevated PCB concentrations in fish.

The 2005 fish sampling has shown that PCBs are still a major cause of excessive bioaccumulation of organochlorine compounds in the SJR watershed and the Delta cause some of the to hazardous to those who use substantial fish from these waters as food.

SJR and its Tributaries

The 2005 fish collection and analysis included collection of fish from the Cosumnes River, Calaveras River, SJR Patterson, SJR Crows Landing, SJR Freemont Ford, Stanislaus River @ Caswell, SJR Laird Park, Tuolumne River @ Shiloh, Merced River @ Hatfield, and Salt Slough. SJR Crows Landing, SJR Freemont Ford, Stanislaus River @ Caswell, SJR Laird Park, and the Tuolumne River @ Shiloh, all had fish with concentrations of DDT in excess of the 1999 OEHHA screening value of 100 ng/g. All of these sites fish DDT concentrations were less than the OEHHA proposed 2006 screening value of 560 ng/g. One of the sets of fish (Sacramento Sucker) taken from Tuolumne River @ Shiloh DDT concentrations exceeded the US EPA screening value of 300 ng/g.

SJR Crows Landing, Tuolumne River @ Shiloh and the Salt Slough fish samples all had dieldrin concentrations above the OEHHA 1999 screening value of 2 ng/g. All of these fish had dieldrin tissue concentrations below the OEHHA proposed 2006 screening value of 16 ng/g as well as the US EPA screening value for dieldrin of 7 ng/g.

SJR Crows Landing, Stanislaus River @ Caswell and the Tuolumne River @ Shiloh fish samples all had fish with tissue concentrations of PCBs above the OEHHA 1999 and the proposed 2006 screening values of 20 ng/g as well as the US EPA screening value of 10 ng/g.

Sacramento River and Its Tributaries

In 2005 207 fish were collected in the Sacramento River and its watershed. These fish were analyzed in 41 composites. Fish were collected at American River @ Discovery Park, American River @ Nimbus Dam, American River Hatchery, Bear River between Feather River & HWY 99 (near Rio Oso), Clear Creek, Colusa Basin Drain @ Rd 99E, Darrah Springs Hatchery, Feather River @ Gridley, Feather River @ Nicolaus, Feather River Hatchery, Mt. Shasta Hatchery, Nimbus Hatchery, Sacramento River @ Bend

Bridge, Sacramento River @ Colusa, Sacramento River @ Grimes, Sacramento River @ Hamilton City, Sacramento River @ Ord Bend, Sacramento River @ Rio Vista, Sacramento River @ RM44, Sacramento River @ Woodson Bridge, Sacramento River at Veterans Bridge, Sacramento Slough @ Karnak, Yuba River @ Marysville.

One of composites of channel catfish collected at Sacramento River @ Veterans Bridge had total DDT above (109 µg/kg) the OEHHA screening value of 100 µg/kg. All other Sacramento River upstream of Sacramento and the tributary fish tissue DDT concentrations were below this screening value.

Dieldrin just above the OEHHA 1999 screening value of 2 µg/kg. was found in the composite of channel catfish in the Sacramento River @ Colusa, Sacramento River @ Grimes and Sacramento Slough @ Kernak. None of the composites collected had dieldrin above the OEHHA proposed dieldrin screening value of 16 µg/kg.

The American River @ Discovery Park, Sacramento River @ Colusa, Sacramento River @ Rio Vista, Sacramento River @ RM44, Sacramento River at Veterans Bridge, Sacramento Slough @ Karnak, all had PCBs above the OEHHA and US EPA screening values.

It is apparent that there are several waterbodies in the Delta, San Joaquin River and the Sacramento River some of their tributaries with fish with excessive PCBs.

Toxicity to Tissue Residue Host Organism

In addition to concern about the human health impacts of organochlorine residues in edible fish, there is concern about the potential impacts of an aquatic organisms organochlorine body burden on the host organism. The US Army Corps of Engineers (US ACOE, 1997) developed "The Environmental Residue-Effects Database (ERED)." Jarvinen and Ankley (1999) of the US EPA published, "Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals." This publication presents a comprehensive, critically-reviewed, literature based assessment of the concentrations of chemicals found in aquatic organisms relative to observed effects on the organisms. Generally it has been found that the concentration OCls in Central Valley fish tissue are somewhat less that that has been found to be adverse to the host organisms. This situation does not rule out the possibility that combination of body burden residues could be adverse to host organisms that is not now known.

Comparison to Central Valley Excessive Fish Tissue Organochlorine Pesticide and PCB 1997 -2000 and 2005 Data .

Lee and Jones-Lee (2002) compiled a table of the occurrence of excessive Central Valley organochlorine legacy pesticide and PCB data based on fish collected during 1997-2000.

San Joaquin River Watershed.

Mud and Salt Sloughs are tributaries of the San Joaquin River that enter the River below Lander Avenue but above the Merced River. White catfish taken from Mud Slough in

1998 had concentrations of total DDT, dieldrin, toxaphene and total PCBs above OEHHA 1999 screening values. Mud Slough fish were not sampled in 2005. There has been no recent (pre 2000) fish tissue data collected from Salt Slough. However, older data showed exceedances of total DDT, dieldrin and toxaphene. The 2005 channel catfish fish collected at Salt Slough had excessive dieldrin but the Total DDT and Toxaphene were below the OEHHA 1999 screening values.

Channel catfish and largemouth bass were collected from the Merced River at the Hatfield St. Recreation Area in 1998. These fish contained excessive concentrations of total DDT, dieldrin, chlordane, toxaphene and total PCBs above the OEHHA 1999 screening values. The 2005 fish collected at the Merced River Hatfield St Recreation area did not contain excessive organochlorine legacy pesticide or PCB concentrations.

The San Joaquin River at Crow's Landing receives the upstream discharges of Mud Slough, Salt Slough and the Merced River. The recent (pre 2000) largemouth bass data collected at this location did not show exceedances for any of the OCls. However in 2005 one set of Sacramento Sucker collected at this location had excessive total DDT, dieldrin and PCBs compared to the OEHHA 1999 screening values.

The westside tributaries to the SJR (Orestimba Creek, Spanish Grant Drain, Del Puerto Creek, Olive Avenue Drain, Ingram Creek and Hospital Creek) are major sources of OCs for the San Joaquin River. These waterbodies were found in the early 1990s to contain measurable concentrations of several of the OCs of concern in the water column that could bioaccumulate to excessive levels in aquatic organisms. There are no recent (pre 2000) and 2005 data on OC concentrations in aquatic organisms taken from the westside tributaries. This is an area that should be a high priority for further study.

Overall, with respect to the San Joaquin River watershed, the eastside and westside tributaries of the SJR contain fish with exceedances of one or more OCls. It also appears that these tributaries are discharging sufficient concentrations of some OCls to cause the fish taken from the San Joaquin River at Vernalis to contain excessive DDT, dieldrin, chlordane, toxaphene and PCBs.

Sacramento River Watershed. The Colusa Basin Drain is a main agricultural drain in the Central Sacramento Valley. Carp taken from the drain have been found to contain excessive DDT and dieldrin. White catfish did not contain excessive OCs. Previously, excessive chlordane and toxaphene have been found; however, there are no recently collected data with adequate sensitivity to ascertain the current situation with regard to toxaphene and chlordane in Colusa Basin Drain fish. The fish from this drain have recently been found to contain PCBs below the OEHHA screening values. The 2005 fish collected in the Colusa Basin Drain did not contain excessive organochlorine legacy pesticides and PCBs.

White catfish taken from the Sacramento Slough in 2000 contained excessive dieldrin and PCBs. Largemouth bass did not have excessive dieldrin, but did have excessive

PCBs. DDT and chlordane were less than OEHHA 1999 screening values. No fish were collected at this location in 2005.

Sacramento River at Veteran's Bridge had excessive PCBs in white catfish. One set of carp had excessive PCBs compared to the OEHHA screening values.

Recently (pre 2000) sampled largemouth bass from the American River had exceedances of PCBs, while excessive dieldrin was found in pike minnow. In 2005 one composite of Sacramento Sucker contained excessive PCBs.

Sacramento River at Mile 44 had excessive DDT, dieldrin and PCBs in white catfish and excessive DDT and PCBs in largemouth bass. In 2005, there were no exceedances of the organochlorine legacy pesticides at this locations while the PCBs in Sacramento Sucker collected at this location were in excess of the OEHHA screening values

Delta. The Port of Stockton Turning Basin had excessive PCBs and DDT in largemouth bass. No fish were collected at this location in 2005.

Largemouth bass and white catfish taken from the Smith Canal at Yosemite Lake contained excessive PCBs. The white catfish collected at this location did not contain excessive organochlorine legacy pesticides , but continued to contain excessive PCBs.

The San Joaquin River below Turner Cut and the Central Delta have not recently (pre 2000) been found to contain excessive OCls (DDT and PCBs) in fish. No fish were collected at this location in 2005.

Sycamore Slough near Mokelumne River had an exceedance of dieldrin found in largemouth bass. No fish were collected at this location in 2005.

White catfish taken from Old River at several locations have been found to contain excessive DDT and, at one location, PCBs. The 2005 fish collect from Old River near the Tracy Blvd Bridge did not contain excessive OCls.

Excessive DDT in largemouth bass from Paradise Cut was found in the pre 2000 sampling. In.2005 the Paradise Cut fish (white catfish) did not contain excessive OCls.

Tulare Lake Basin. No problems were encountered with excessive OCls in recently sampled King's River fish. No fish were collected in this area in the 2005 fish collection.

Overall Comparison of the 1997 – 2000 to the 2005 fish tissue residue shows that for a number of locations in the Central Valley has decreased for the organochlorine legacy pesticides below the OEHHA 1999 screening values. The PCB concentration in fish tissue has not changed significantly during this period.

Irrigated Lands Ag Waiver Monitoring Data

In 2003 the Central Valley Regional Water Quality Control Board (CVRWQCB) initiated a limited scope monitoring program to begin to characterize the concentration of potential pollutants in waterbodies that are dominated drainage from irrigated agricultural areas. A review of the data that the CVRWQCB has collected from 2003 through the winter 2006-7. During this period 213 samples of water were collected and analyzed for DDT, DDE and DDD from so-called Zone 2 which is predominately the Delta and near Delta sampling sites.

Examination of this data base shows that there were 9 of these water samples with concentration of DDT, DDE and/or DDD above the detection limit of the analytical method used for the analysis. The CVRWQCB have adopted the approach of listing a water sample as having excessive DDT, DDE and DDD if any of the concentrations reported above the analytical method detection limits used for the analysis of the samples. Table 2 present a listing of these samples. Examination of the complete data shows that a wide range of analytical method detection limits ranging from about 0.001 µg/L and almost 1 µg/L.

During the period August 2004 through February 2005 a series of water samples was taken from a "Drain to Grant Line Canal off Wing Levee Rd." These samples contained DDT or DDE at 0.004 to 0.007 µg/L. No additional samples of water were taken at this location. Sediment samples were also taken at this location in August 2004. These samples showed DDT at 4.3 µg/kg, DDE at 14.4 µg/kg and DDD at 1.8 µg/kg.

In May, June and July 2006, water samples were taken at Kellogg Creek along Hoffman Ln, Marsh Creek at Concord Ave or Sand Creek at Highway 4 Bypass. These samples all had concentrations of DDT and DDE above the detection limits of the analytical method used. The concentrations were in the range of 0.05 to 0.5 µg/L. All other water samples collected in the Delta and near the Delta (Zone 2) were reported as less than the detection limit.

The CVRWQCB IL Ag Waiver staff have listed as the critical concentration in a water sample as a value that exceeds the California Toxics Rule (CTR) concentration of 0.00059 µg/L for DDT and DDE and 0.00083 µg/L. According to the approach used by the US EPA in developing the CTR criteria, concentration of these chemicals in water can bioaccumulate to a sufficient extent to be an unacceptable health risk to increased risk of acquire cancer from eating fish that have been taken from water with concentrations of DDT, DDE or DDD above the CTR criterion.

A comparison of the CTR criteria and the analytical detection limit used in the analysis of a water samples shows all of the detection limits used in the Ag Waiver water quality monitoring at a least a factor of 10 to as much as a 1000 or so to high to measure the DDT, DDE and DDE at concentrations that could potentially bioaccumulate to excessive levels in fish taken from this water. Therefore essentially all the data for the Ag Waiver water quality monitoring of DDT, DDE and DDD that are listed a "non detect" could have one of more of these chemicals in fish tissue above a screening value.

Since the US EPA water quality criteria are based on worst case assumptions (maximum bioaccumulation, toxicity etc.) it is possible that DDT, DDE and DDD can be present in a water sample above the CTR criterion and not have excessive bioaccumulation in fish in the water. This is a result of the fact that some waters contains particles especially organic and organic coated inorganic particles tend to reduce the bioavailability of DDT, DDE, or DDD for uptake by fish. While this problem has been well known since the early 1970s, it is only recently that the US EPA to work to shifting the regulation of chemicals like DDT that tend to bioaccumlate based on fish tissue concentrations rather than chemical concentrations in water samples. Basically the analysis of water samples for DDT etc is unreliable for evaluating whether there is excessive DDT in water. As discussed by Lee and Jones-Lee (2007) this must be done by measuring the concentration of DDT etc in edible fish tissue with a comparison to screening values.

The Ag Waiver monitoring of Delta water samples for PCBs were reported as "non detect." Nineteen water samples were analyzed for PCBs in the Delta and near Delta waters. The typical analytical detection limit was about 1 µg/L. The US EPA CTR criterion value 0.00017 µg/L. As with DDT etc, the PCB analytical methods used in the Ag Waiver water quality monitoring in the Delta were grossly inadequate to determine if excessive PCBs are present in the water being sampled. However, from the analysis of fish tissue taken from the Delta and in the SJR and its watershed there is sufficient sources of PCBs to bioaccumulate to excessive concentration in edible fish.

In August 2004 six sediment samples were collected at several locations in the Delta. These sediment samples all had measurable concentrations of DDT and DDE in the range of about 1 to 19 µg/kg. It is not possible to evaluate the concentrations of DDT and DDE as exceeding a regulatory limit since there are no regulatory limits for these chemicals in sediments. It is also not possible to evaluate whether these sediments are a significant source of DDT and DDE that is bioaccumulating in fish of the area since the uptake by fish is likely controlled by food web bioaccumulation (see Lee and Jones-Lee 2002 for a discussion of this issue).

Another problem with chemical concentration in the water column approach to evaluate potential PCBs bioaccumulation to excessive levels is that the bioaccumulation is not necessarily based on dissolved PCBs in water to fish. A much more likely situation is that excessive bioaccumulation occurs via food web uptake where benthic organisms take PCBs from the sediments. These PCBs are taken up via food web bioaccumulation that does not involve dissolved in the water column. This same situation also applies to bioaccumulation of DDT and many organochlorine legacy pesticides etc.

Adjustment of Fish Tissue Screening Values – Environmental Justice Issues

The magnitude of a fish tissue human health screening value is dependent on the assumed rate of fish consumption (meals/week) and the "allowed" cancer risk used in computing the value. For example, the US EPA (1995) uses an "allowed" cancer risk of one additional cancer occurring in a million people who consume fish with the screening value concentration at the rate of one meal per week over their lifetime. OEHHA (1999) uses an “allowed” cancer risk of one in one hundred thousand. Changing the “allowed” cancer risk from one in a million to one in one hundred thousand changes the screening value by a factor of 10.

In 2006 the California Office of Environmental Health Hazard Assessment (OEHHA) proposed revised fish tissue screening values (SVs) for protection of human health (Klasing and Brodberg 2006). According to Klasing and Brodberg (2006), screening values are defined by the US EPA as *“concentrations of target analytes in fish or shellfish tissue that are of potential public health concern and that are used as threshold values against which levels of contamination in similar tissue collected from the ambient environment can be compared. Exceedance of these SVs should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted”* (U.S. EPA, 2000). Examination of the OEHHA 1999 and proposed 2006 shows that for some chemicals there are significant differences. These differences are the result of several factors, including new information on the potential human health impacts of the chemicals (updated RfD-reference dose values), and changes in the assumed fish consumption rates and allowed cancer risk.

If the OEHHA 2006 screening values are adopted, could have significant impact on waterbodies’ being listed as Clean Water Act 303(d) impaired due to excessive concentrations of a chemical of concern in edible fish/shellfish tissue.

Examination of the basis for OEHHA’s 2006 proposed screening values shows that there are a number of important policy issues that need to be considered in adoption of these values as values upon which 303(d) listings would be based. The current screening value allowed cancer risk is one additional cancer case in 100,000 people (10^{-5}) who consume an average of 21g per day of fish at the screening value over a 70-year lifetime. The average person is assumed to weigh 70kg. OEHHA’s proposed screening value is based on an allowed cancer risk of one additional cancer case in 10,000 people (10^{-4}) who consume an average of 12 meals per month (90g per day) of fish at the screening value over a 70-year lifetime. A meal is assumed to consist of eight ounces (227g) of fish (uncooked). In raising the allowed cancer risk from 10^{-5} to 10^{-4}, Brodberg (pers. comm. 2006) has indicated that the allowable range of cancer risk used by regulatory agencies across the country is 10^{-4} to 10^{-6}; therefore, the 10^{-4} value is within the allowable range. He indicated that increasing the allowed cancer risk to 10^{-4} reflects a position that there are significant health benefits from eating fish, even those fish that contain potentially hazardous chemicals at less than the proposed screening value.

One of the issues of controversy today in establishing fish screening values for potential carcinogens is the assumption about the amount of fish consumed. Increasing the fish consumption from the current 21g per day to the new 90 g/day (12 meals per month) is a step toward providing greater protection for those who consume more fish from a local waterbody than the average person in the US. However, there are still individuals (subsistence fishermen) in economically disadvantaged and minority populations who are projected to consume more than 12 meals per month of locally-caught contaminated fish. Adjusting the screening values to protect these individuals would require that the values be decreased in proportion to the increased amount of fish consumed. In some areas this can become an important environmental justice issue.

The adoption of the OEHHA proposed 2006 screening value would eliminate the exceedances of fish tissue concentrations for the Delta thereby providing a basis for delisting the Delta waterbodies as Clean Water Act 303(d) listing and eliminate the need to conduct a TMDL to control the excessive bioaccumulation organochlorine legacy pesticides in edible fish. If however the CVRWQCB/SWRCB determine that the OEHHA use of 10^{-4} should be lowered to 10^{-5} or 10^{-6} cancer risk more typical of normally used cancer risks and/or want to provide public health protection than that proposed by OEHHA as the fish consumption rate by those who consume local fish as a larger part of their food supply then the screening values assumed in this review would be decreased and fish from some areas of the Delta would continue to be found to have excessive organochlorine legacy pesticides. This could become an important environmental justice issue that will need to be addressed. The CVRWQCB current efforts in developing a TMDL to reduce excessive bioaccumulation of mercury in Central Valley fish which includes consideration of environmental justice issues of fish consumption rates in establishing screening values for mercury fish tissue residues could be important in addressing appropriate fish consumption rates for Central Valley fish to protect public health.

Future Studies

The 2005 organochlorine Delta fish tissue data should be of value in helping the CVRWQCB select those areas where additional fish tissue data should be collected to confirm the appropriateness of delisting Delta and other Central Valley waterbodies from the CWQ 303(d) listing and thereby element the need to develop a TMDL to control the excessive bioaccumulation of organochlorine legacy pesticides. White catfish should be collected from the Sacramento River downstream Sacramento. Also fish should be taken from the Port of Stockton and the Deep Water Ship Channel near the Port to determine if these fish still contain excessive organochlorine legacy pesticides, PCBs and dioxins.

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UNITS OF MEASURE

µg	microgram
µg/g	micrograms per gram
µg/L	micrograms per liter(0.10 µg/L = 100 ng/L)
µm	micrometer
cm	centimeter
g	gram
g/day	grams per day
g/L	grams per liter
in	inch
kg	kilogram
L	liter
lbs	pounds
m	meter
mg	milligram
mg/g	milligrams per gram
mL	milliliter
mm	millimeter
ng	nanograms
ng/L	nanograms per liter (100 ng/L = 0.10 µg/L)
ppb	parts per billion, µg/kg
ppm	parts per million, mg/kg or µg/g
ppt	parts per trillion, ng/kg

Organochlorine Compounds of Interest

Common Name	Chemical Name
Aldrin	(1α, 4α, 4aβ, 5α, 8α, 8aβ) 1,2,3,4,10,10–hexachloro–1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthylene
Γ-BHC (γ-HCH)	1α,2α,3β,4α,5α,6β-hexachlorocyclohexane, gamma isomer
Chlordane	1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindan
DDD	1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethane
DDE	dichloro diphenyl dichloroethylene
DDT	dichloro diphenyl trichloroethane
Dieldrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro (endo,exo) 1,4:5,8-dimethanonaphthalene
Dioxin	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
Endosulfan	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide
Endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-(endo,endo)-1,4:5,8-dimethanonaphthalene
Heptachlor	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1*H*-indene
Heptachlor epoxide	2,3,4,5,6,7,8-heptachloro-1a,1b,5,5a,6,6a-hexahydro-2,5-methano-2*H*-indeno(1,2b)oxirene
Lindane	see γ-BHC
PCB	polychlorinated biphenyls, sum of the chlorinated biphenyls whose analytical characteristics resemble those of Aroclor-1016, 1221, 1232, 1242, 1248, 1254, and 1260
2,3,7,8 - TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
Toxaphene	polychlorinated camphene (67-69% chlorine); camphene = 2,2-dimethyl-3-methylenebicyclo-[2.2.1]heptane; 2,2-dimethyl-3-methylenenorbornane

Source: Larson, *et al*. (1997) and Cheng (1990)

<u>TCDD Equivalents</u> shall mean the sum of the concentrations of chlorinated dibenzodioxins (2,3,7,8-CDDs) and chlorinated dibenzofurans (2,3,7,8-CDFs) multiplied by their respective toxicity factors, as shown in the table below.

Isomer Group	Toxicity Equivalence Factor
2,3,7,8-tetra CDD	1.0
2,3,7,8-penta CDD	0.5
2,3,7,8-hexa CDDs	0.1
2,3,7,8-hepta CDD	0.01
octa CDD	0.001
2,3,7,8 tetra CDF	0.1
1,2,3,7,8 penta CDF	0.005
2,3,4,7,8 penta CDF	0.5
2,3,7,8 hexa CDFs	0.1
2,3,7,8 hepta CDFs	0.01
octa CDF	0.001

Source: SWRCB, California Ocean Plan (1998a)

List of Acronyms and Abbreviations

303(d) List	Clean Water Act 303(d) List of Impaired Waterbodies
§	Section (as in a law or regulation)
Basin Plan	Water Quality Control Plan (Basin Plan) Central Valley Region ; Sacramento River and San Joaquin River Basins
BCF	Bioconcentration factor
CCC	Criterion Continuous Concentration
CDFG	California Department of Fish and Game
CMC	Criterion Maximum Concentration
CTR	California Toxics Rule
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Federal Clean Water Act
CWC	California Water Code
total DDT	DDT + DDE+ DDD
Delta	Sacramento-San Joaquin Delta
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
LC_{50}	Lethal concentration which kills 50 percent of test organisms in a given period of time
MCL	Maximum contaminant level
OCls	Group A Pesticides [aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan, and toxaphene], DDT, Polychlorinated Biphenyls (PCBs), Dioxins, Furans
OEHHA	Office of Environmental Health Hazard Assessment
OP	Organophosphate
PCBs	Polychlorinated Biphenyls
Porter-Cologne or Porter-Cologne Act	Porter-Cologne Water Quality Control Act as amended
RfD	Reference dose
SARWQCB	Santa Ana Regional Water Quality Control Board
SJR	San Joaquin River
State Board or SWRCB	California State Water Resources Control Board
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSMP	Toxic Substance Monitoring Program (SWRCB)

List of Acronyms and Abbreviations

TUa	Toxic Units, Acute
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USFDA	U.S. Food and Drug Administration
USGS	United States Geological Survey

Introduction

The California State Water Resources Control Board (SWRCB) has been monitoring the "legacy" (formerly used) organochlorine (OCl) pesticides, such as DDT, chlordane, dieldrin, toxaphene, etc.) in fish tissue since 1978. Those data, which were collected as part of the SWRCB Toxic Substances Monitoring Program (TSMP), has shown that the concentration of some of these pesticides in some fish from some waterbodies exceeded the concentrations that represent a threat to human health for those who eat large amounts of the fish. Lee and Jones-Lee (2002) developed a comprehensive report on the TSMP and other fish tissue monitoring data that had been collected through the late 1990s. That report included a comparison of the fish tissue concentrations with the US EPA (1995) and OEHHA (1999) human health screening values for evaluating the potential human health hazards presented by consuming a certain amount of fish with legacy pesticide or PCB residue in the edible tissue.

Lee and Jones-Lee (2004) developed a report entitled, "Delta Water Quality Issues" that included the TSMP data and other sources that were collected for Delta fish and included in the Lee and Jones-Lee (2002) report. The complete 2002 fish tissue and sediment organochlorine legacy pesticide and PCBs data on a 6 ft by 9 ft Excel spreadsheet which are available upon request from Dr. G. Fred Lee at gfredlee@aol.com.

The Lee and Jones-Lee (2002, 2004) concluded that there was need for updated information on current concentrations of OCl legacy pesticides and PCBs in fish tissue to determine if the downward trend seen for several of the legacy pesticides has continued. As part of an effort to provide updated information on the current Central Valley fish tissue concentration data, Dr. Chris Foe of the Central Valley Regional Water Quality Control Board (CVRWQCB) obtained funds to analyze fish that had been collected previously and stored frozen but not analyzed, and to collect and analyze additional fish. That effort resulted in a 2005 database for legacy pesticide and PCB concentrations in fish tissue in the Central Valley. This report presents the results of the 2005 fish collection tissue data for the organochlorine legacy pesticides and PCBs with emphasis on fish collected from the Delta. In addition the results of the 2005 fish collected from the San Joaquin River and the Sacramento River and some of their tributaries.

Fish tissue data is reported as either ug/kg or ng/g. These units are equivalent concentrations. All fish tissue concentration are reported on a wet weight basis.

Human Health Fish Tissue Screening Values

Table 1 presents the US EPA 1995, OEHHA 1999 and OEHHA 2006 proposed human health fish tissue screening values. Examination of Table 1 shows that OEHHA proposed 2006 revised fish tissue screening values for several of the OCl legacy pesticides, such as DDT, are significantly greater than the 1999 values. However, the 2006 proposed PCB screening value is the same as the 1999 value. At this time the OEHHA 2006 proposed revised screening values are still under review by OEHHA.

Table 1
US EPA and OEHHA Screening Values (μg/kg, (ng/g) wet weight)

CHEMICAL	US EPA Value[1]	OEHHA Value[2]	OEHHA 2006 Proposed Value[8]
Chlordane[3]	80	30	200
Total DDT[4]	300	100	560
Dieldrin	7	2	16
Total endosulfan[5]	60,000	20,000	
Endrin	3,000	1,000	
Heptachlor epoxide	10	4	
γ-hexachlorocyclohexane (lindane)	80	30	
Toxaphene	100	30	220
PCBs[6]	10	20	20
Dioxin TEQ[7]	0.7 ppt	0.3 ppt	
Methylmercury			80
Selenium			1,940

Source: SARWQCB (2000)
1: USEPA SVs (US EPA, 1995b) 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 OEHHA (1999) SVs (CLS-SVs) specifically for this study were calculated according to US EPA guidance (US EPA, 1995b). 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
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: OEHHA (Klasing and Brodberg 2006).
(For the above references, see Lee and Jones-Lee 2002.)

Review of the 2005 Delta Fish Organochlorine Legacy Pesticide and PCB Data

In 2005, 232 fish were collected at Beaver Slough, Big Break, Clifton Court Forebay, Discovery Bay, Franks Tract, Lodi Lake, Lost Slough, Middle River @ Bullfrog, Old River @Tracy Blvd, Orwood Tract, Paradise Cut, Prospect Slough, SJR Potato Slough, SJR Vernalis, Sand Mound Slough, Smith Canal, Whiskey Slough Sacramento River at River Mile 44 and Sacramento River @ Rio Vista in the Delta. A map showing the location of the Delta is presented in Appendix A. Appendix B presents a listing of the locations of 2005 fish collection locations shown Appendix A map.

With few exceptions white catfish, Sacramento Sucker, largemouth bass, were collected with a few sites Sacramento Pikeminnow, redear sunfish, channel catfish, stripped bass, Sacramento Perch, Carp, and bluegill were collected.

SJR Vernalis. San Joaquin River (SJR) Vernalis site provides an integrating site for persistent organochlorine legacy pesticide and PCBs in the SJR watershed. The SJR watershed upstream of Vernalis is an area of intense agriculture where there was extensive use of legacy pesticides. As discussed by Lee and Jones-Lee (2002) in the past, including the late 1990s, tissue from fish from that location contained concentrations of several of the legacy pesticides and PCBs in excess of the OEHHA 1999 human health screening values. Four- to five-fish composites of 7 different types of fish collected in 2005 from the SJR Vernalis site were analyzed. Figures 1 through 4 are plots of the concentrations of several of the legacy pesticides and PCBs measured in tissue of fish from the SJR Vernalis site between 1978 and 2005. The values presented in the plots are the average concentrations in the composites. The spreadsheet presenting those data in Appendix C. Examination of those data for 2005 shows that the concentration of PCBs in Sacramento Sucker tissue (27 µg/kg (wet weight)) exceeded the OEHHA human health screening value of 20 µg/kg. Tissue from the other fish from the Vernalis site had PCB concentrations below that screening value of 20 µg/kg.

The total 2005 DDT concentration in tissue of the Sacramento Sucker (338 µg/kg), and carp (232 µg/kg) exceeded the OEHHA 1999 screening value of 100 µg/kg; these levels do not exceed the OEHHA 2006 proposed screening value of 560 µg/kg. The concentration of dieldrin in the tissue of the Sacramento Sucker (3.44 µg/kg) and carp (2.5 µg/kg) exceeded the OEHHA 1999 screening value; they are below the OEHHA 2006 proposed value of 16 µg/kg. The concentrations of toxaphene in the tissue of all of the 2005 Vernalis fish measured were below the 1999 OEHHA screening value of 30 µg/kg and also below the 220 µg/kg proposed 2006 screening value. The concentrations of chlordane in all 2005 Vernalis fish were also below the OEHHA 1999 screening value of 30 µg/kg and the proposed 2006 value of 200 µg/kg.

Overall, except for the exceedance of the OEHHA screening value for PCBs in the Sacramento Sucker, fish tissue levels of legacy pesticides in SJR fish at Vernalis will no exceed screening values if OEHHA adopts its 2006 proposed human health fish tissue screening values.

Sacramento River Mile 44 Site. In October 2005 5 largemouth bass, 10 Chinook salmon and Sacramento Sucker were collected at the Sacramento River Mile 44 site. None of the fish collected at RM 44 site exceeded the OEHHA 1999 screening value of 100 µg/kg for the organochlorine legacy pesticides analyzed in this study. Figure 6 presents a plot of the dieldrin for the period A white catfish sample collected in 1998 had total DDT above this screening value. The dieldrin data show a couple of white catfish samples with concentrations above the 1999 OEHHA screening value of 2 µg/kg. No white catfish were collected at RM 44 in the 2005. There is need to collect white catfish from the Sacramento River downstream of Sacramento to determine if the values found in past years at RM 44 and Hood are persisting today.

Figure 1

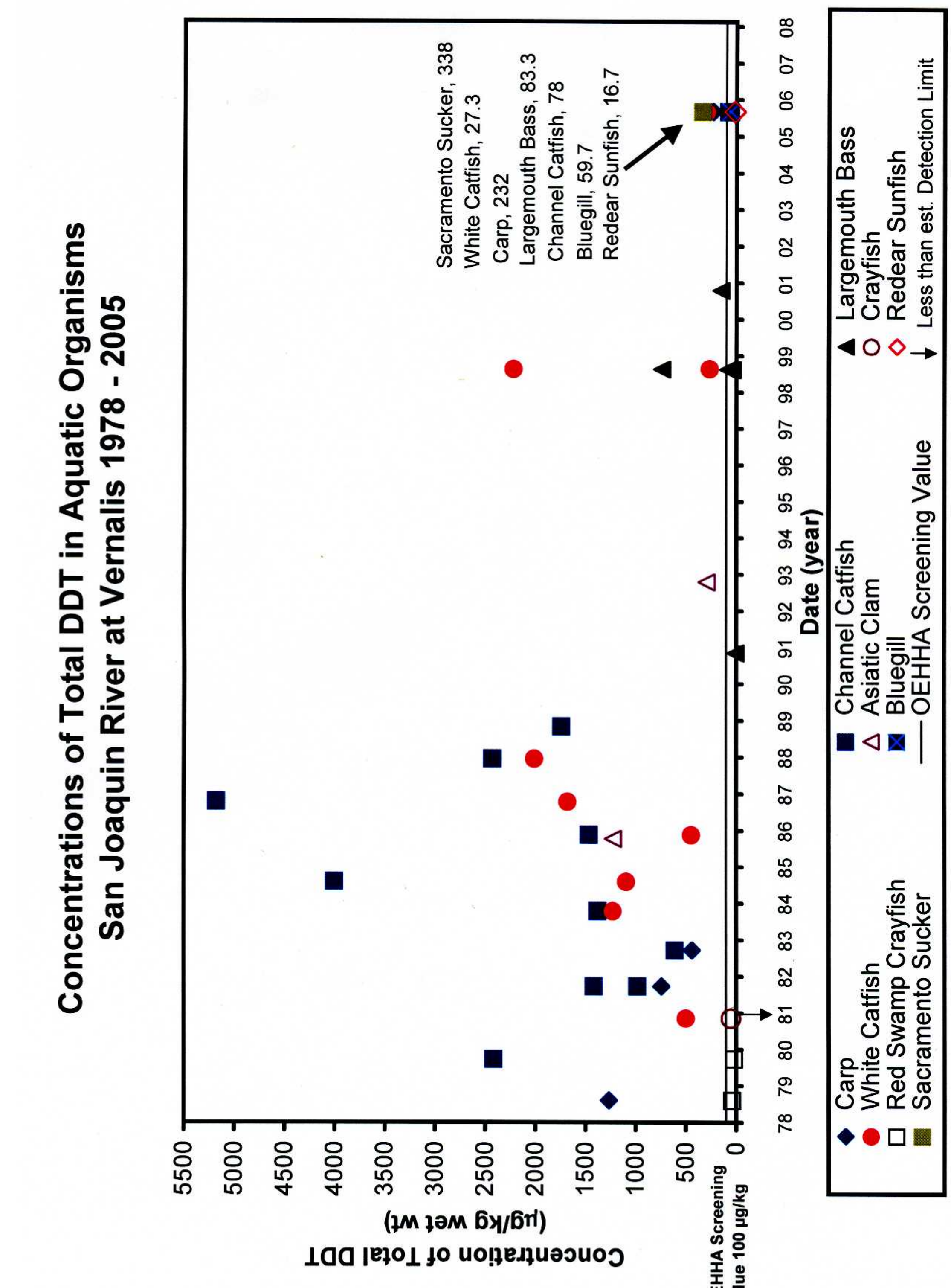

Concentrations of Total DDT in Aquatic Organisms
San Joaquin River at Vernalis 1978 - 2005
Concentration of Total DDT
(µg/kg wet wt)
OEHHA Screening
Value 100 µg/kg
Date (year)
Sacramento Sucker, 338
White Catfish, 27.3
Carp, 232
Largemouth Bass, 83.3
Channel Catfish, 78
Bluegill, 59.7
Redear Sunfish, 16.7
Carp
White Catfish
Red Swamp Crayfish
Sacramento Sucker
Channel Catfish
Asiatic Clam
Bluegill
OEHHA Screening Value
Largemouth Bass
Crayfish
Redear Sunfish
Less than est. Detection Limit

Figure 2

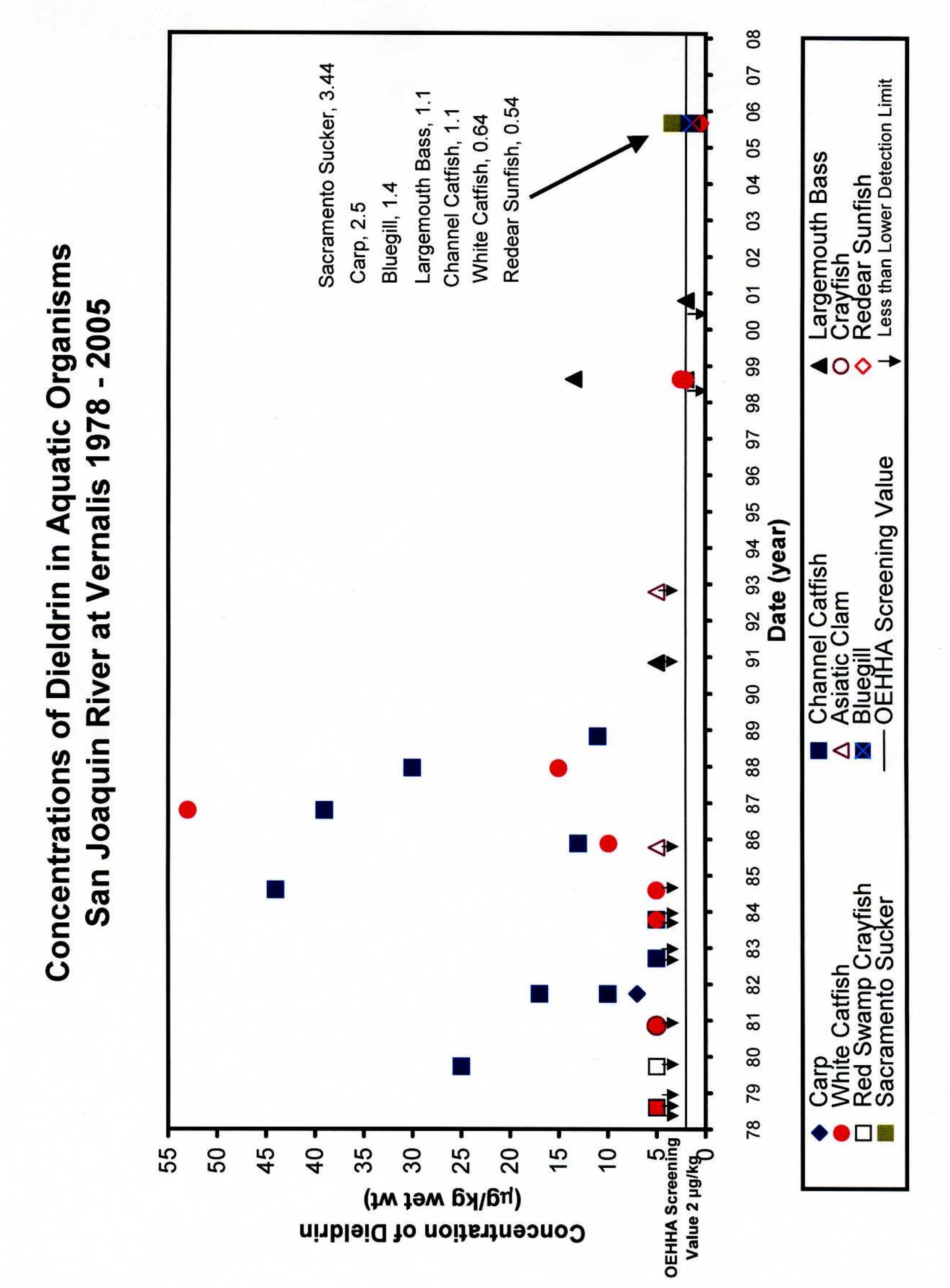
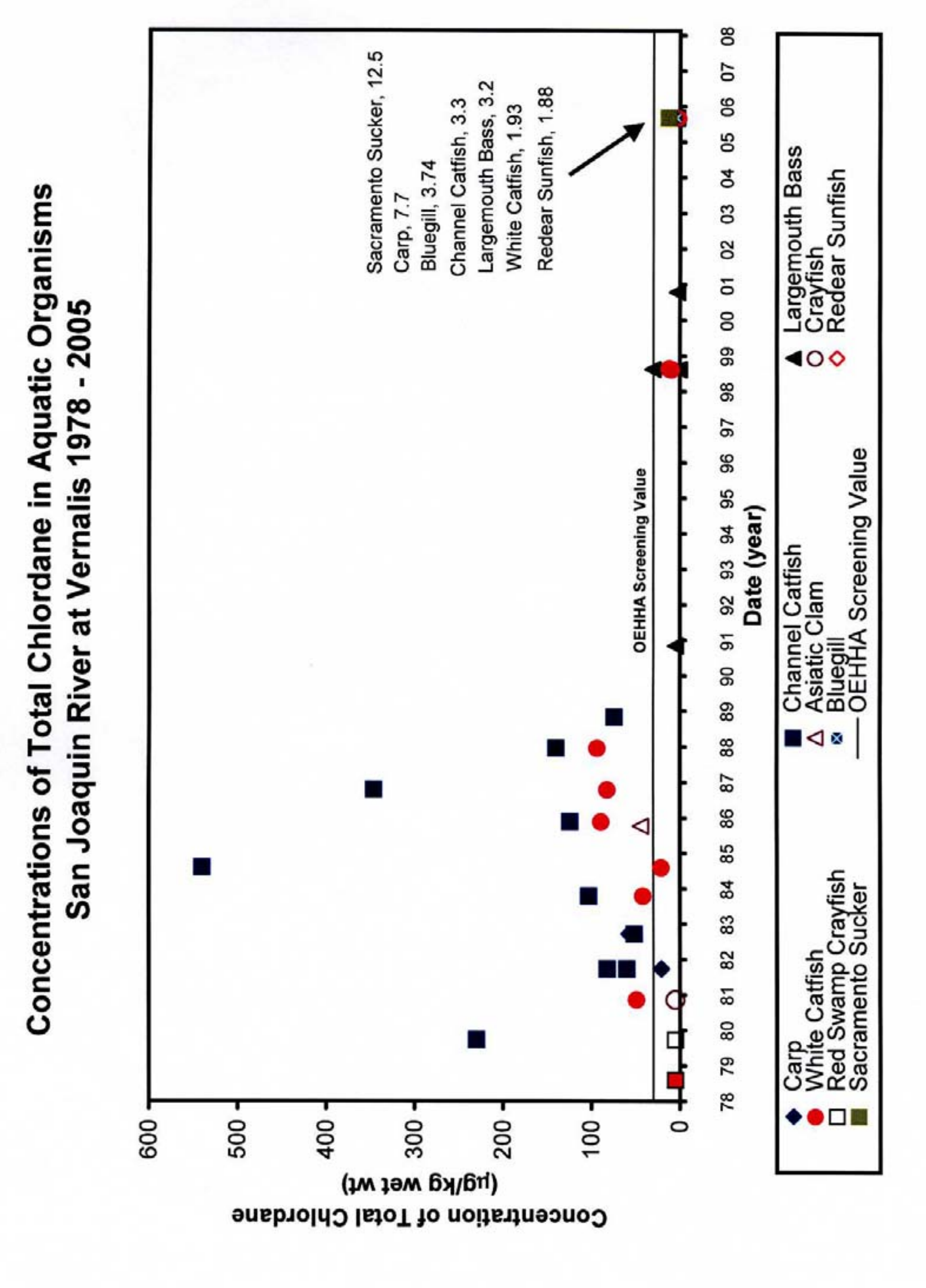
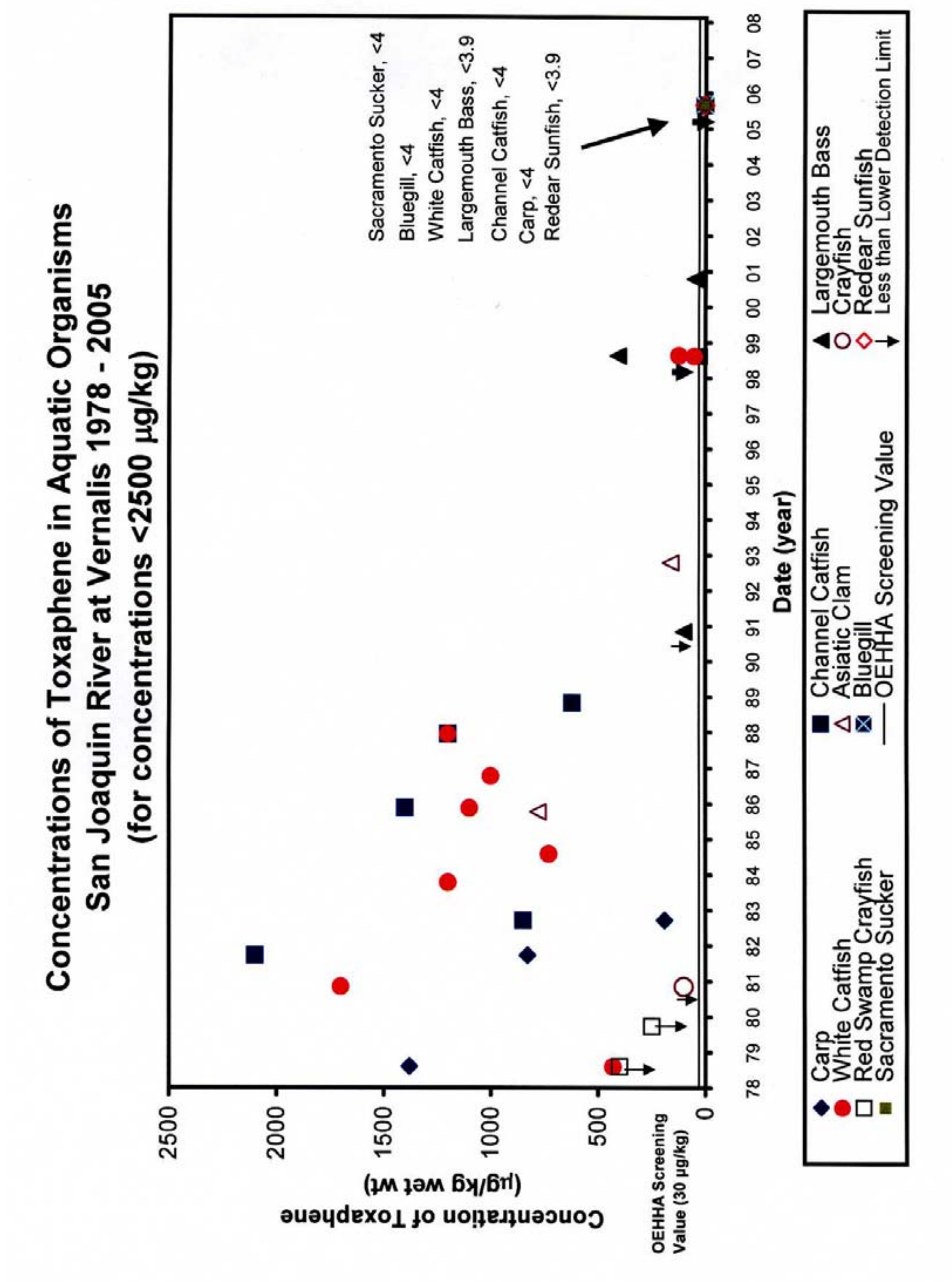

Concentrations of Dieldrin in Aquatic Organisms
San Joaquin River at Vernalis 1978 - 2005
Sacramento Sucker, 3.44
Carp, 2.5
Bluegill, 1.4
Largemouth Bass, 1.1
Channel Catfish, 1.1
White Catfish, 0.64
Redear Sunfish, 0.54
Concentration of Dieldrin (µg/kg wet wt)
OEHHA Screening Value 2 µg/kg
55
50
45
40
35
30
25
20
15
10
5
0
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Date (year)
Carp
White Catfish
Red Swamp Crayfish
Sacramento Sucker
Channel Catfish
Asiatic Clam
Bluegill
OEHHA Screening Value
Largemouth Bass
Crayfish
Redear Sunfish
Less than Lower Detection Limit

Figure 3



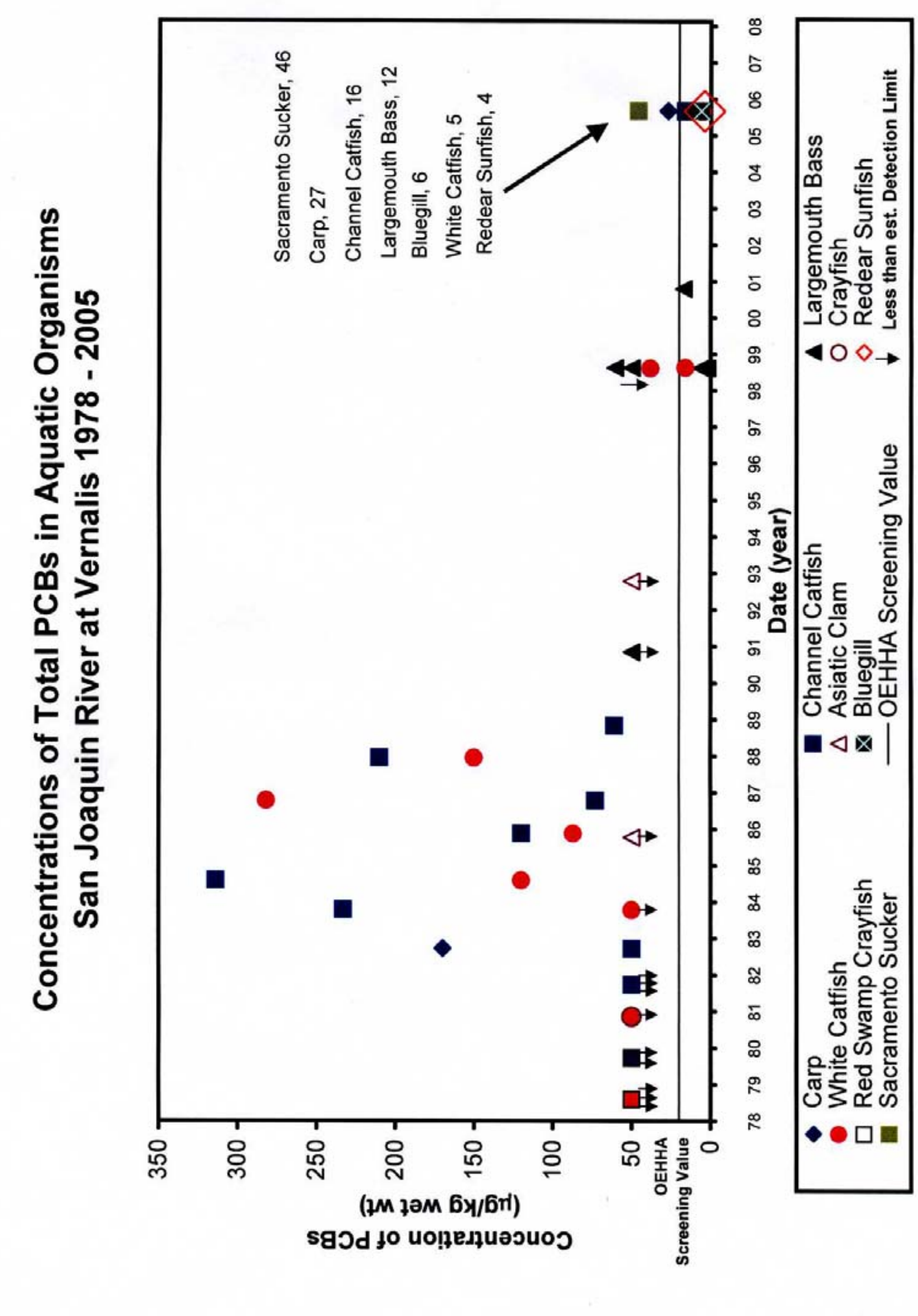
Concentrations of Total Chlordane in Aquatic Organisms
San Joaquin River at Vernalis 1978 - 2005
Concentration of Total Chlordane (µg/kg wet wt)
600
500
400
300
200
100
0
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Date (year)
OEHHA Screening Value
Sacramento Sucker, 12.5
Carp, 7.7
Bluegill, 3.74
Channel Catfish, 3.3
Largemouth Bass, 3.2
White Catfish, 1.93
Redear Sunfish, 1.88
Carp
White Catfish
Red Swamp Crayfish
Sacramento Sucker
Channel Catfish
Asiatic Clam
Bluegill
OEHHA Screening Value
Largemouth Bass
Crayfish
Redear Sunfish

Figure 4



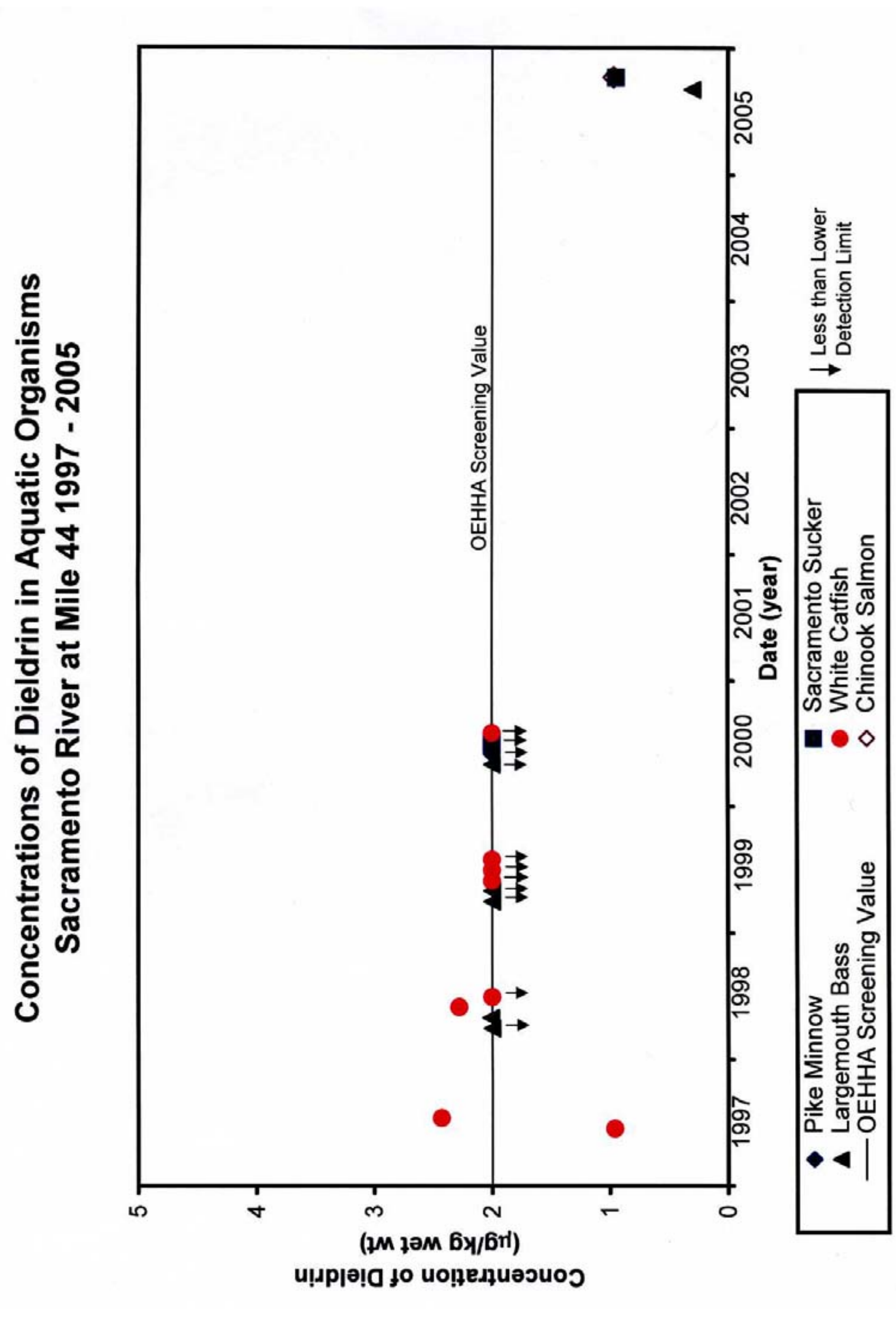
Concentrations of Toxaphene in Aquatic Organisms
San Joaquin River at Vernalis 1978 - 2005
(for concentrations <2500 µg/kg)
Concentration of Toxaphene
(µg/kg wet wt)
2500
2000
1500
1000
500
0
OEHHA Screening
Value (30 µg/kg)
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Date (year)
Sacramento Sucker, <4
Bluegill, <4
White Catfish, <4
Largemouth Bass, <3.9
Channel Catfish, <4
Carp, <4
Redear Sunfish, <3.9
Carp
White Catfish
Red Swamp Crayfish
Sacramento Sucker
Channel Catfish
Asiatic Clam
Bluegill
OEHHA Screening Value
Largemouth Bass
Crayfish
Redear Sunfish
Less than Lower Detection Limit

Figure 5



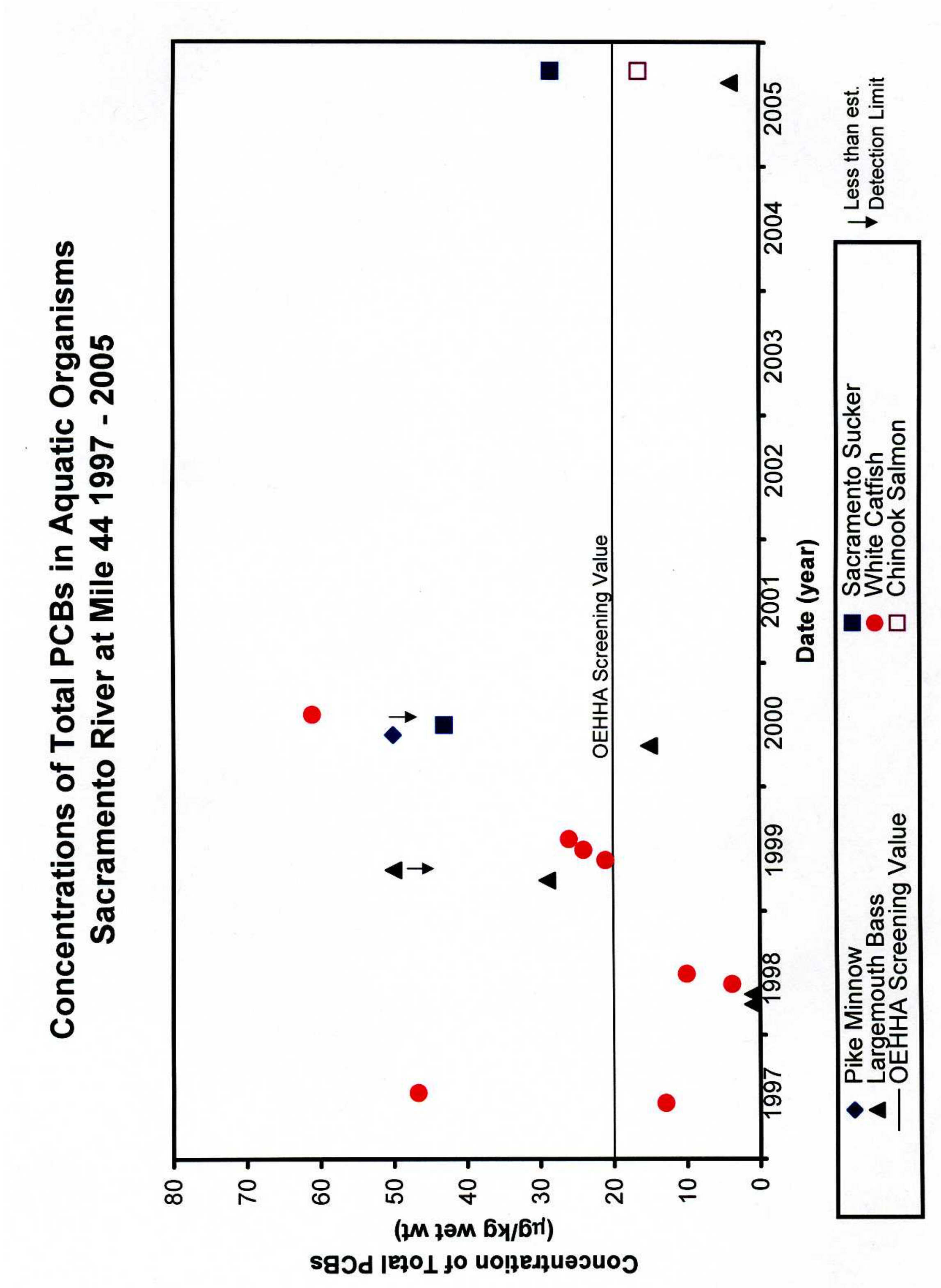
Concentrations of Total PCBs in Aquatic Organisms
San Joaquin River at Vernalis 1978 - 2005
Concentration of PCBs (µg/kg wet wt)
350
300
250
200
150
100
50
OEHHA Screening Value
0
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Date (year)
Sacramento Sucker, 46
Carp, 27
Channel Catfish, 16
Largemouth Bass, 12
Bluegill, 6
White Catfish, 5
Redear Sunfish, 4
Carp
White Catfish
Red Swamp Crayfish
Sacramento Sucker
Channel Catfish
Asiatic Clam
Bluegill
OEHHA Screening Value
Largemouth Bass
Crayfish
Redear Sunfish
Less than est. Detection Limit

Figure 6



Concentrations of Dieldrin in Aquatic Organisms
Sacramento River at Mile 44 1997 - 2005
Concentration of Dieldrin (µg/kg wet wt)
0
1
2
3
4
5
1997
1998
1999
2000
2001
2002
2003
2004
2005
Date (year)
OEHHA Screening Value
Pike Minnow
Largemouth Bass
OEHHA Screening Value
Sacramento Sucker
White Catfish
Chinook Salmon
Less than Lower Detection Limit

Figure 7



Concentrations of Total PCBs in Aquatic Organisms
Sacramento River at Mile 44 1997 - 2005
Concentration of Total PCBs
(µg/kg wet wt)
80
70
60
50
40
30
20
10
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
Date (year)
OEHHA Screening Value
Pike Minnow
Largemouth Bass
OEHHA Screening Value
Sacramento Sucker
White Catfish
Chinook Salmon
Less than est.
Detection Limit

The total PCBs found in various types of fish taken from the Sacramento River at Mile 44 during the period 1997 through 2005 are plotted in Figure 7. There were a number of white catfish, largemouth bass and Sacramento sucker with concentrations of total PCBs above the 1999 OEHHA screening value.

Sacramento River @ Rio Vista. Fifteen fish were collected in August 2005 from the Sacramento River @ Rio Vista which were analyzed in three composites of 5 fish each. The Sacramento Sucker composite had total DDT at 92 µg/kg just under the OEHHA 1999 Screening value of 100 µg/kg. The carp composite total DDT of 149 µg/kg. The white catfish composite total DDT was 29 µg/kg. OEHHA adoption of the 2006 screen value of 560 µg/kg element violations of the total DDT screening value.

None of the composites from Sacramento River @ Rio Vista exceeded the OEHHA 1999 screening value of 2 µg/kg.

Two of the three fish composites from Sacramento River @ Rio Vista had total PCBs above the OEHHA screening values of 20 µg/kg at 24 and 33 µg/kg.

Other Delta Sites. Prospect Slough, SJR Potato Slough, and Discovery Bay had some of the fish collected at locations above the DDT OEHHA 1999 screening value of 100 µg/kg. None of the fish composites contained DDT above the OEHHA 2006 proposed screening values of 560 µg/kg. Prospect Slough, and SJR Potato Slough also had dieldrin above the OEHHA 1999 screening value of 2 µg/kg, but none were above the OEHHA 2006 proposed screening value of 16 µg/kg.

Overall based on the 2005 fish collection from the Delta the concentrations of the organochlorine legacy pesticides concentrations have decreased from the previous sampling. None of the fish taken in 2005 had organochlorine legacy pesticides above the US EPA screening values. Further if OEHHA should adopt the 2006 proposed fish tissue screening values all the Delta legacy pesticide 303(d) listings could be delisted.

The situation with PCBs concentrations in Delta fish is such that Big Break, Lodi Lake, Prospect Slough, SJR Potato Slough, Smith Canal, Whiskey Slough as well as SJR at Vernalis and Sacramento River Mile 44 and Sacramento River @ Rio Vista (discussed above) all had PCBs above the OEHHA 1999 and the OEHHA 2006 as well as the US EPA screening values. While PCBs are typically found in fish near industrial areas or in areas where electric transformer spills has occurred, the finding of excessive PCBs in fish taken form the Delta at a several Delta areas raises questions about the source of the PCBs. The PCBs are likely currently in the sediments of the area from where the fish with elevated PCB concentrations in fish.

Since the fish sampled in 2005 are mobile it is possible that they obtained the elevated PCB concentrations from other areas. It is possible that sampling small less mobile fish form selected areas of the Delta could help determine the areas of the Delta with elevated PCBs in the sediments that is serving as a source of PCBs that is maintaining some Delta fish with elevated PCBs.

As discussed by Lee et al. (2002) simply finding PCBs in sediments does not mean the sediments are significant sources of PCBs for the food web. White catfish and largemouth bass taken from Smith Canal in 1978 in the city of Stockton contained about 100 ng/g (µg/kg) wet weight of the PCBs. It was found that a Yosemite Lake sediment sample collected in September 2001 (which is located at the upstream end of Smith Canal) contained about 1,000 ng/g dry weight of PCBs. The Yosemite Lake sediment sample had a total organic carbon (TOC) content of about 5.8%. This elevated concentration of TOC would make the PCBs in Yosemite Lake sediments less bioavailable than those associated with lower levels of TOC. Incubation of *Lumbriculus* (an oligochaete-worm) in the Smith Canal sediment samples, following the US EPA standard bioaccumulation testing procedure, showed that at least some of the PCBs were bioavailable, with exposure to Yosemite Lake sediment resulting in a 310 ng/g concentration (wet weight) in the worms after the 28-day incubation period.

The standard US EPA (2000) standard bioaccumulation testing procedure to evaluate the bioavailability of PCBs and for that matter other pollutants in sediments.

The 2005 white catfish taken from Smith Canal had PCBs at 20 and 21 ng/g, i.e., just at the OEHHA existing and proposed screening values. This finding indicates the PCBs in white catfish in Smith Canal Yosemite Lake had decreased significantly.

SJR and Delta Watershed Sites

The 2005 fish collection and analysis included collection of fish from the Cosumnes River, Calaveras River, SJR Patterson, SJR Crows Landing, SJR Freemont Ford, Stanislaus River @ Caswell, SJR Laird Park, Tuolumne River @ Shiloh, Merced River @ Hatfield, and Salt Slough. A spread sheet presenting this data is presented in Appendix C. SJR Crows Landing, SJR Freemont Ford, Stanislaus River @ Caswell, SJR Laird Park, and the Tuolumne River @ Shiloh, all had fish with concentrations of DDT in excess of the 1999 OEHHA screening value of 100 ng/g. All of these sites fish DDT concentrations were less than the OEHHA proposed 2006 screening value of 560 ng/g. One of the sets of fish (Sacramento Sucker) taken from Tuolumne River @ Shiloh DDT concentrations exceeded the US EPA screening value of 300 ng/g.

SJR Crows Landing, Tuolumne River @ Shiloh and the Salt Slough fish samples all had dieldrin concentrations above the OEHHA 1999 screening value of 2 ng/g. All of these fish had dieldrin tissue concentrations below the OEHHA proposed 2006 screening value of 16 ng/g as well as the US EPA screening value for dieldrin of 7 ng/g.

SJR Crows Landing, Stanislaus River @ Caswell and the Tuolumne River @ Shiloh fish samples all had fish with tissue concentrations above the OEHHA 1999 and the proposed 2006 screening values of 20 ng/g as well as the US EPA screening value of 10 ng/g.

The 2005 fish sampling has shown that PCBs are still a major cause of excessive bioaccumulation of organochlorine compounds in the SJR watershed and the Delta cause some of the to hazardous to those who use substantial fish from these waters as food.

Sacramento River and Its Tributaries
In 2005 207 fish were collected in the Sacramento River and its watershed. These fish were analyzed in 41 composites. Fish were collected at American River @ Discovery Park, American River @ Nimbus Dam, American River Hatchery, Bear River between Feather River & HWY 99 (near Rio Oso), Clear Creek, Colusa Basin Drain @ Rd 99E, Darrah Springs Hatchery, Feather River @ Gridley, Feather River @ Nicolaus, Feather River Hatchery, Mt. Shasta Hatchery, Nimbus Hatchery, Sacramento River @ Bend Bridge, Sacramento River @ Colusa, Sacramento River @ Grimes, Sacramento River @ Hamilton City, Sacramento River @ Ord Bend, Sacramento River @ Rio Vista, Sacramento River @ RM44, Sacramento River @ Woodson Bridge, Sacramento River at Veterans Bridge, Sacramento Slough @ Karnak, Yuba River @ Marysville. The Sacramento River RM 44 and Rio Vista data have been discussed with the Delta data above.

One of composites of channel catfish collected at Sacramento River @ Veterans Bridge had total DDT above (109 µg/kg) the OEHHA screening value of 100 µg/kg. All other Sacramento River upstream of Sacramento and the tributary fish tissue DDT concentrations were below the this screening value.

Dieldrin just above the OEHHA 1999 screening value of 2 µg/kg. was found in the composite of channel catfish in the Sacramento River @ Colusa, Sacramento River @ Grimes and Sacramento Slough @ Kernak. None of the composites collected had dieldrin above the OEHHA proposed dieldrin screening value of 16 µg/kg.

The American River @ Discovery Park, Sacramento River @ Colusa, Sacramento River @ Rio Vista, Sacramento River @ RM44, Sacramento River at Veterans Bridge, Sacramento Slough @ Karnak, all had PCBs above the OEHHA and US EPA screening values. It is apparent that there are several waterbodies in the Delta, San Joaquin River and the Sacramento River some of their tributaries with fish with excessive PCBs.

Toxicity to Tissue Residue Host Organism
In addition to concern about the human health impacts of organochlorine residues in edible fish, there is concern about the potential impacts of an aquatic organisms organochlorine body burden on the host organism. As part of developing regulatory approaches for disposal of contaminated dredged sediments, the US Army Corps of Engineers (US ACOE, 1997) developed "The Environmental Residue-Effects Database (ERED)." This database is a compilation of information on the concentrations of chemicals in aquatic organism tissue and their apparent effects on aquatic life. The

ERED is available electronically from http://ered1.wes.army.mil/ered/index.cfm. It was last updated June 2001. It now contains 3,463 results of 736 studies on 188 species for 222 analytes.

The issue of critical concentrations of bioaccumulatable chemicals in aquatic life tissue is one that has been addressed by the US EPA. Jarvinen and Ankley (1999) have published a review, Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals. This publication presents a comprehensive, critically-reviewed, literature based assessment of the concentrations of chemicals found in aquatic organisms relative to observed effects on the organisms. The Jarvinen and Ankley (1999) database has well over 3,000 entries for 200 chemicals, and is based on 500 references. The organochlorine pesticide database includes 15 organochlorine pesticides, with 473 endpoints and 91 references, representing 68 aquatic species, 46 of which were freshwater.

Lee and Jones-Lee (2002) have discussed this issue with respect to the current state of knowledge o0n the impact of a fish organochlorine residue body burden on the health of the fish in the Central Valley. Generally it has been found that the concentration in fish tissue are somewhat less that that has been found to be adverse to the host organisms. This situation does not rule out the possibility that combination of body burden residues could be adverse to host organisms that is not now known.

Discuss duplicate values

At several duplicate sets of fish were collected and composited in separate composites. This data shows

Comparison to Central Valley Excessive Fish Tissue Organochlorine Pesticide and PCB 1997 -2000 and 2005 Data .

Lee and Jones-Lee (2002) compiled a table of the occurrence of excessive Central Valley organochlorine legacy pesticide and PCB data based on fish collected during 1997-2000. This table is presented as Table 3. A discussion of this table is adapted from the Lee and Jones (2002) report is presented below with a comparison to the 2005 fish tissue concentrations found at the same location.

San Joaquin River Watershed. The uppermost point where fish have been recently (1997-2000) collected and organochlorine legacy pesticide and PCBs (OCs) have been measured with adequate sensitivity in the San Joaquin River watershed was at the San Joaquin River at Highway 99. The largemouth bass collected in 2000 did not show exceedances of the OEHHA 1999 screening value at this location for each of the primary OCs of concern. No fish were collected at this location in 2005. Further down the SJR at Lander Avenue, only dieldrin in white catfish collected in 1998 was above the OEHHA 1999 screening value. DDT, chlordane, toxaphene and PCBs were all below the OEHHA 1999 screening value. No fish were collected at this location in 2005.

Mud and Salt Sloughs are tributaries of the San Joaquin River that enter the River below Lander Avenue but above the Merced River. White catfish taken from Mud Slough in 1998 had concentrations of total DDT, dieldrin, toxaphene and total PCBs above OEHHA 1999 screening values. Mud Slough fish were not sampled in 2005. There has been no recent (pre 2000) fish tissue data collected from Salt Slough. However, older data showed exceedances of total DDT, dieldrin and toxaphene. The 2005 channel catfish fish collected at Salt Slough had excessive dieldrin but the Total DDT and Toxaphene were below the OEHHA 1999 screening values.

Table 2 (from Lee and Jones-Lee 2002)

Summary of Central Valley Waterbodies with Excessive OC Residues Based on 1997 - 2000 Organism Tissue Data and OEHHA Screening Values

Location	Total DDT	Dieldrin	Total Chlordane	Total Toxaphene	Total PCBs
San Joaquin River Watershed					
San Joaquin River at Highway 99	O	o	O	o	o
San Joaquin River at Lander Avenue	O	x	O	o	o
Mud Slough	X	x	?	x	x
Salt Slough	x?	x?	?	x?	?
Merced River	X	x	O	x	x
San Joaquin River at Crow's Landing	O	o	O	o	o
Orestimba Creek	x?	x?	?	x?	?
Spanish Grant Drain	x?	?	?	x?	x?
Olive Avenue Drain*	--	--	--	--	--
Turlock Irrigation District, Lateral #5	O	?	?	?	?
Del Puerto Creek	x?	?	?	?	?
Ingram Creek*	--	--	--	--	--
Hospital Creek*	--	--	--	--	--
Lower Tuolumne River	X	x	O	x	x
Stanislaus River	X	x?	?	x?	x
San Joaquin River at Vernalis	X	x	X	x	x
San Joaquin River "at Bowman Road"	X	?	O	?	x
San Joaquin River at Mossdale	x?	?	?	?	?
San Joaquin River "at Highway 4"	X	?	O	?	o
Sacramento River Watershed					
McCloud River	O	o	O	o	o
Clear Creek	O	o	O	o	o
Sacramento River at Keswick	O	?	O	--	x
Sacramento River at Bend Bridge, near Hamilton City	O	o	O	o	o
Mill Creek	O	o	O	o	o
Deer Creek	O	o	O	o	o
Big Chico Creek	O	o	O	o	o
Sacramento River at Colusa	O	?	O	--	x
Sutter Bypass	x?	x?	X?	x?	x?

Feather River near Nicolaus/Hwy 99	O	o	O	o	x
Feather River at Forbestown	--	--	--	--	x?
Yuba River	x?	?	?	?	?
East Canal near Nicolaus	x?	x?	?	?	?
Sacramento Slough	O	x	O	--	x
Colusa Basin Drain	X	x	X?	x?	o
Sacramento River at Veteran's Bridge	O	?	O	--	x
Natomas East Main Drain	O	?	O	?	x

Table 10 (Cont.)

Sacramento River Watershed (Cont.)	Total DDT	Dieldrin	Total Chlordane	Total Toxaphene	Total PCBs
Arcade Creek	O	x?	X?	?	?
American River at Discovery Park	O	x	O	?	x
American River at Watt Avenue	x?	x?	X?	--	x?
American River at J Street	O	?	O	--	x
Sacramento River at Mile 44	X	x	O	--	x
Sacramento River at Hood	X	x	X	x	x
Cache Creek	O	?	?	?	o
Putah Creek	X	?	O	?	o?
Cache Slough	O	x	O	--	o
Sacramento River at Rio Vista	O	?	?	?	o
Delta					
Port of Stockton Turning Basin	X	?	O	?	x
Port of Stockton near Mormon Slough	O	x	?	?	x
Smith Canal	O	?	O	?	x
San Joaquin River around Turner Cut	O	?	O	?	o
White Slough downstream from Disappointment Slough	O	?	?	?	o
San Joaquin River at Potato Slough	O	?	O	?	x
San Joaquin River off Point Antioch	O	?	?	?	o
Sycamore Slough near Mokelumne River	O	x	?	?	?
Mokelumne River between Beaver and Hog Sloughs	O	?	?	?	o
Middle River at Bullfrog	O	?	?	?	o
Old River	X	?	O	?	x
Paradise Cut	X	?	O	?	o
Old River at Central Valley Pump	X	?	O	x	?
O'Neill Forebay/California Aqueduct	x?	?	X?	?	x?
Tulare Lake Basin					
King's River	O	?	O	?	o
Kern River	o?	?	?	?	--

x At least one fish sample taken in the late 1990s or 2000 was above the OEHHA screening value.

o None of the fish samples taken in the late 1990s or 2000 were above the OEHHA screening value.
? The analytical methods used were not sufficiently sensitive to measure the OC at the OEHHA screening value.
o? The concentrations of an OC were just below the OEHHA screening value.
x? The concentration of an OC was above the screening value in the past but either has not been recently analyzed or the recent analytical methods used did not have sufficient sensitivity.
-- No measurements were made for this OC.
* Organochlorine pesticides have been found in the water column at potentially significant concentrations. No data are available on the bioaccumulation of the OCls for this waterbody.

Channel catfish and largemouth bass were collected from the Merced River at the Hatfield St. Recreation Area in 1998. These fish contained excessive concentrations of total DDT, dieldrin, chlordane, toxaphene and total PCBs above the OEHHA 1999 screening values. The 2005 fish collected at the Merced River Hatfield St Recreation area did not contain excessive organochlorine legacy pesticide or PCB concentrations.

The San Joaquin River at Crow's Landing receives the upstream discharges of Mud Slough, Salt Slough and the Merced River. The recent (pre 2000) largemouth bass data collected at this location did not show exceedances for any of the OCs. However in 2005 one set of Sacramento Sucker collected at this location had excessive total DDT, dieldrin and PCBs compared to the OEHHA 1999 screening values.

The westside tributaries to the SJR (Orestimba Creek, Spanish Grant Drain, Del Puerto Creek, Olive Avenue Drain, Ingram Creek and Hospital Creek) are major sources of OCs for the San Joaquin River. These waterbodies were found in the early 1990s to contain measurable concentrations of several of the OCs of concern in the water column that could bioaccumulate to excessive levels in aquatic organisms. There are no recent (pre 2000) and 2005 data on OC concentrations in aquatic organisms taken from the westside tributaries. This is an area that should be a high priority for further study.

The mid- to lower eastside tributaries (Stanislaus River and Tuolumne River) of the San Joaquin River contain fish with excessive concentrations of several OCs. These tributaries are potentially contributing certain OCs to the San Joaquin River to cause fish taken from the San Joaquin River at Vernalis to show exceedances of the primary OCs of concern.

Fish taken recently from the San Joaquin River at Bowman Road and Highway 4 have had exceedances of one or more OCs. There has been no recent sampling of fish from the San Joaquin River at Mossdale. No fish were collected at these locations in 2005.

Overall, with respect to the San Joaquin River watershed, the eastside and westside tributaries of the SJR contain fish with exceedances of one or more OCs. It also appears that these tributaries are discharging sufficient concentrations of some OCs to cause the fish taken from the San Joaquin River at Vernalis to contain excessive DDT, dieldrin, chlordane, toxaphene and PCBs.

Sacramento River Watershed. The Sacramento River and its tributaries above the Colusa Basin Drain (except at Keswick for PCBs), have been found, through recent (pre 2000) fish collection, to have fish with OCs at less than the OEHHA 1999 screening value. No fish were collected in this area in 2005. While a 1997 sampling showed that there was an exceedence of PCBs in rainbow trout collected in the Sacramento River at Keswick, the subsequent samplings did not show this problem.

The Colusa Basin Drain is a main agricultural drain in the Central Sacramento Valley. Carp taken from the drain have been found to contain excessive DDT and dieldrin. White catfish did not contain excessive OCs. Previously, excessive chlordane and toxaphene have been found; however, there are no recently collected data with adequate sensitivity to ascertain the current situation with regard to toxaphene and chlordane in Colusa Basin Drain fish. The fish from this drain have recently been found to contain PCBs below the OEHHA screening values. The 2005 fish collected in the Colusa Basin Drain did not contain excessive organochlorine legacy pesticides and PCBs.

The recent (pre 2000) white catfish and largemouth bass samplings from the Feather River near Nicolaus/Highway 99 have shown no exceedances of organochlorine pesticides. However, PCBs were found in pike minnow from the Feather River near Nicolaus/Highway 99 in excess of the OEHHA 1999 screening value. The 2005 fish collected from the Nicolaus also did not have any exceedances of OEHHA 1999 screening values and PCBs.

In 1980, a variety of types of fish from the Feather River at Forbestown did show exceedances of PCBs. No fish were collected at this location in 2005. The exceedances found in 1980 relate to the use of PCB oils for road dust control. There has been no followup on this situation. It is suggested that this should be followed up to determine the current situation.

White catfish taken from the Sacramento Slough in 2000 contained excessive dieldrin and PCBs. Largemouth bass did not have excessive dieldrin, but did have excessive PCBs. DDT and chlordane were less than OEHHA 1999 screening values. No fish were collected at this location in 2005.

Sacramento River at Veteran's Bridge had excessive PCBs in white catfish. One set of carp had excessive PCBs compared to the OEHHA screening values.

Natomas East Main Drain white catfish and largemouth bass contained excessive PCBs. No fish were collected in 2005 at this location.

Recently (pre 2000) sampled largemouth bass from the American River had exceedances of PCBs, while excessive dieldrin was found in pike minnow. In 2005 one composite of Sacramento Sucker contained excessive PCBs.

Sacramento River at Mile 44 had excessive DDT, dieldrin and PCBs in white catfish and excessive DDT and PCBs in largemouth bass. In 2005, there were no exceedances of the organochlorine legacy pesticides at this locations while the PCBs in Sacramento Sucker collected at this location were in excess of the OEHHA screening values

Sacramento River at Hood had white catfish and largemouth bass showing exceedances of all of the primary OCls of concern. No fish were taken from this location in 2005.

Excessive DDT was found in largemouth bass obtained from Putah Creek. No fish were taken at this location in 2005.

Largemouth bass from Cache Slough had exceedances of dieldrin. No fish were collected at this location in 2005.

Delta. The Port of Stockton Turning Basin had excessive PCBs and DDT in largemouth bass. No fish were collected at this location in 2005.

Dieldrin and PCBs were found in *Corbicula fluminea* sampled from the Port of Stockton near Mormon Slough. No fish were collected in 2005.

Largemouth bass and white catfish taken from the Smith Canal at Yosemite Lake contained excessive PCBs. The white catfish collected at this location did not contain excessive organochlorine legacy pesticides , but continued to contain excessive PCBs.

The San Joaquin River below Turner Cut and the Central Delta have not recently (pre 2000) been found to contain excessive OCs (DDT and PCBs) in fish. No fish were collected at this location in 2005.

Sycamore Slough near Mokelumne River had an exceedance of dieldrin found in largemouth bass. No fish were collected at this location in 2005.

White catfish taken from Old River at several locations have been found to contain excessive DDT and, at one location, PCBs. The 2005 fish collect from Old River near the Tracy Blvd Bridge did not contain excessive OCs.

Excessive DDT in largemouth bass from Paradise Cut was found in the pre 2000 sampling. In.2005 the Paradise Cut fish (white catfish) did not contain excessive OCs.

Tulare Lake Basin. No problems were encountered with excessive OCls in recently sampled King's River fish. No fish were collected in this area in the 2005 fish collection.

Overall Comparison of the 1997 – 2000 to the 2005 fish tissue residue shows that for a number of locations in the Central Valley has decreased for the organochlorine legacy pesticides below the OEHHA 1999 screening values. The PCB concentration in fish tissue has not changed significantly during this period.

Irrigated Lands Ag Waiver Monitoring Data

The Central Valley Regional Water Quality Control Board CVRWQCB initiated a limited scope monitoring program to begin to characterize the concentration of potential pollutants in waterbodies that are dominated drainage from irrigated agricultural areas. Information on this program is at, http://www.waterboards.ca.gov/centralvalley/programs/irrigated_lands/index.html. A review of the data that the CVRWQCB has collected from 2003 through the winter 2006-7. During this period 213 samples of water were collected and analyzed for DDT, DDE and DDD from so-called Zone 2 which is predominately the Delta and near Delta sampling sites. The complete data set is available at, http://www.waterboards.ca.gov/centralvalley/programs/irrigated_lands/monitoring_activity/index.html. Some of water samples are taken from waterbodies that are not part of the Delta waters. A listing of sampling sites and a map showing the location of the sampling sites is attached.

Examination of this data base shows that there were 9 of these water samples with concentration of DDT, DDE and/or DDD above the detection limit of the analytical method used for the analysis. The CVRWQCB have adopted the approach of listing a water sample as having excessive DDT, DDE and DDD if any of the concentrations reported above the analytical method detection limits used for the analysis of the samples. Table 2 present a listing of these samples. Examination of the complete data shows that a wide range of analytical method detection limits ranging from about 0.001 µg/L and almost 1 µg/L.

During the period August 2004 through February 2005 a series of water samples was taken from a "Drain to Grant Line Canal off Wing Levee Rd." These samples contained DDT or DDE at 0.004 to 0.007 µg/L. No additional samples of water were taken at this location. Sediment samples were also taken at this location in August 2004. These samples showed DDT at 4.3 µg/kg, DDE at 14.4 µg/kg and DDD at 1.8 µg/kg.

In May, June and July 2006, water samples were taken at Kellogg Creek along Hoffman Ln, Marsh Creek at Concord Ave or Sand Creek at Highway 4 Bypass. These samples all had concentrations of DDT and DDE above the detection limits of the analytical method used. The concentrations were in the range of 0.05 to 0.5 µg/L. All other water samples collected in the Delta and near the Delta (Zone 2) were reported as less than the detection limit.

The CVRWQCB IL Ag Waiver staff have listed as the critical concentration in a water sample as a value that exceeds the California Toxics Rule (CTR) concentration of 0.00059 µg/L for DDT and DDE and 0.00083 µg/L. According to the approach used by the US EPA in developing the CTR criteria, concentration of these chemicals in water can bioaccumulate to a sufficient extent to be an unacceptable health risk to increased risk of acquire cancer from eating fish that have been taken from water with concentrations of DDT, DDE or DDD above the CTR criterion.

A comparison of the CTR criteria and the analytical detection limit used in the analysis of a water samples shows all of the detection limits used in the Ag Waiver water quality monitoring at a least a factor of 10 to as much as a 1000 or so to high to measure the DDT, DDE and DDE at concentrations that could potentially bioaccumulate to excessive levels in fish taken from this water. Therefore essentially all the data for the Ag Waiver water quality monitoring of DDT, DDE and DDD that are listed a "non detect" could have one of more of these chemicals in fish tissue above a screening value.

Since the US EPA water quality criteria are based on worst case assumptions (maximum bioaccumulation, toxicity etc.) it is possible that DDT, DDE and DDD can be present in a water sample above the CTR criterion and not have excessive bioaccumulation in fish in the water. This is a result of the fact that some waters contains particles especially organic and organic coated inorganic particles tend to reduce the bioavailability of DDT, DDE, or DDD for uptake by fish. While this problem has been well known since the early 1970s, it is only recently that the US EPA to work to shifting the regulation of chemicals like DDT that tend to bioaccumlate based on fish tissue concentrations rather than chemical concentrations in water samples. Basically the analysis of water samples for DDT etc is unreliable for evaluating whether there is excessive DDT in water. As discussed by Lee and Jones-Lee (2007) this must be done by measuring the concentration of DDT etc in edible fish tissue with a comparison to screening values. Further information on this issue is provided by Lee and Jones-Lee (2002).

In the 1960s G. F. Lee and his graduate students at the University of Wisconsin, Madison Water Chemistry Program were among the first in the US to find that PCBs were wide spread contaminants in water and fish. Veith and Lee (1971 reported on finding PCBs at high concentrations in the Milwaukee River in Wisconsin. Subsequently, Lee and his graduate students found that the amount of PCBs in fish tissue varied significantly dependent on the characteristics of the water in which the PCBs and fish were located. For example PCBs in Lake Superior water bioaccumulated to a much greater extent than the same concentration of PCBs in water from the Hudson River near Manhattan, NY. This situation was reported by Veith et al. (1979) in the American Fisheries Society review of the US EPA "Rebook of Water Quality Criteria 1976.

In the 1970s G. F. Lee and his graduate students conducted studies on the chemical characteristics of water and sediments and aquatic life toxicity taken from over 100 locations in US waterways as part of the US Army Corps Dredged Material Research Program. These studies included measurement of organochlorine pesticides and PCBs. The results were reported by Lee et al. (1978) and Jones and Lee (1978). Lee and Jones (1979) develop a special report for the Corps of Engineers on the occurrence and potential water quality significance of PCBs in aquatic sediments. It is with this background that the following comments are made on the PCB situation in the Delta water and sediments.

The Ag Waiver monitoring of Delta water samples for PCBs were reported as "non detect." Nineteen water samples were analyzed for PCBs in the Delta and near Delta waters. The typical analytical detection limit was about 1 µg/L. The US EPA CTR criterion value 0.00017 µg/L. As with DDT etc, the PCB analytical methods used in the Ag Waiver water quality monitoring in the Delta were grossly inadequate to determine if excessive PCBs are present in the water being sampled. However, from the analysis of fish tissue taken from the Delta and in the SJR and its watershed there is sufficient sources of PCBs to bioaccumulate to excessive concentration in edible fish.

In August 2004 six sediment samples were collected at several locations in the Delta. These sediment samples all had measurable concentrations of DDT and DDE in the range of about 1 to 19 µg/kg. It is not possible to evaluate the concentrations of DDT and DDE as exceeding a regulatory limit since there are no regulatory limits for these chemicals in sediments. It is also not possible to evaluate whether these sediments are a significant source of DDT and DDE that is bioaccumulating in fish of the area since the uptake by fish is likely controlled by food web bioaccumulation (see Lee and Jones-Lee 2002 for a discussion of this issue).

Another problem with chemical concentration in the water column approach to evaluate potential PCBs bioaccumulation to excessive levels is that the bioaccumulation is not necessarily based on dissolved PCBs in water to fish. A much more likely situation is that excessive bioaccumulation occurs via food web uptake where benthic organisms take PCBs from the sediments. These PCBs are taken up via food web bioaccumulation that does not involve dissolved in the water column. This same situation also applies to bioaccumulation of DDT and many organochlorine legacy pesticides etc.

It would be of interest to examine whether those waterbodies with measured PCBs in the water column also have been found to have excessive PCBs in fish taken from that water. However there is insufficient matches between areas where Delta fish were collected in 2005 have been taken from an area where PCB have been measured in the water column. As discussed above because of food web bioaccumulation from PCBs in sediments through organisms is likely controlling the bioaccumulation of PCBS in Delta fish.

Organochlorine Legacy Pesticides Toxicity. With the concentrations of DDT in some Delta waters at about 0.5 μg/L there is potential concern about the potential aquatic life toxicity to zooplankton and fish. The US EPA 1986 Water Quality Criteria for DDT and its metabolites as 0.001 μg/L as the 24 hr average with a maximum concentration of 0.1 μg/L. US EPA (1980a) provides information on the development of these criteria. Included in this report is a listing of the available database of DDT to aquatic life.

The US EPA Office of Pesticide Program (2002) Ecotoxocity Database lists the LC_{50} for DDT in the range of a few tenth μg/L to about 5 μg/L for zooplankton (Daphnia sp.) and several types of fish.

If the DDT reported in several Delta locations water samples of about 0.5 μg/L is in a bioavailable form, the DDT could cause toxicity to zooplankton and fish.

The US EPA (1986, 1980b) lists the acute toxicity of PCBs as 2.0 μg/L. It is unlikely that PCBs are present in Delta water in a bioavailable form that would cause toxicity to aquatic life.

Adjustment of Fish Tissue Screening Values – Environmental Justice Issues

The magnitude of a fish tissue human health screening value is dependent on the assumed rate of fish consumption (meals/week) and the "allowed" cancer risk used in computing the value. For example, the US EPA (1995) uses an "allowed" cancer risk of one additional cancer occurring in a million people who consume fish with the screening value concentration at the rate of one meal per week over their lifetime. OEHHA (1999) uses an "allowed" cancer risk of one in one hundred thousand. Changing the "allowed" cancer risk from one in a million to one in one hundred thousand changes the screening value by a factor of 10.

In 2006 the California Office of Environmental Health Hazard Assessment (OEHHA) proposed revised fish tissue screening values (SVs) for protection of human health (Klasing and Brodberg 2006). According to Klasing and Brodberg (2006), screening values are defined by the US EPA as *"concentrations of target analytes in fish or shellfish tissue that are of potential public health concern and that are used as threshold values against which levels of contamination in similar tissue collected from the ambient environment can be compared. Exceedance of these SVs should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted"* (U.S. EPA, 2000). Table 1 presents the US EPA and current OEHHA screening values, as well as the proposed screening values. Examination of this table shows that for some chemicals there are significant differences. These differences are the result of several factors, including new information on the potential human health impacts of the chemicals (updated RfD-reference dose values), and changes in the assumed fish consumption rates and allowed cancer risk.

Examination of Table 1 shows that for several of the organochlorine legacy pesticides the OEHHA proposed fish screening value has been increased, in some cases, significantly. If these values are adopted, this could have significant impact on waterbodies' being listed as Clean Water Act 303(d) impaired due to excessive concentrations of a chemical of concern in edible fish/shellfish tissue.

Examination of the basis for OEHHA's 2006 proposed screening values shows that there are a number of important policy issues that need to be considered in adoption of these values as values upon which 303(d) listings would be based. The current screening value allowed cancer risk is one additional cancer case in 100,000 people (10^{-5}) who consume an average of 21g per day of fish at the screening value over a 70-year lifetime. The average person is assumed to weigh 70kg. OEHHA's proposed screening value is based on an allowed cancer risk of one additional cancer case in 10,000 people (10^{-4}) who consume an average of 12 meals per month (90g per day) of fish at the screening value over a 70-year lifetime. A meal is assumed to consist of eight ounces (227g) of fish (uncooked). In raising the allowed cancer risk from 10^{-5} to 10^{-4}, Brodberg (pers. comm. 2006) has indicated that the allowable range of cancer risk used by regulatory agencies across the country is 10^{-4} to 10^{-6}; therefore, the 10^{-4} value is within the allowable range. He indicated that increasing the allowed cancer risk to 10^{-4} reflects a position that there are significant health benefits from eating fish, even those fish that contain potentially hazardous chemicals at less than the proposed screening value.

One of the issues of controversy today in establishing fish screening values for potential carcinogens is the assumption about the amount of fish consumed. Increasing the fish consumption from the current 21g per day to the new 90 g/day (12 meals per month) is a step toward providing greater protection for those who consume more fish from a local waterbody than the average person in the US. However, there are still individuals (subsistence fishermen) in economically disadvantaged and minority populations who are projected to consume more than 12 meals per month of locally-caught contaminated fish. Adjusting the screening values to protect these individuals would require that the values be decreased in proportion to the increased amount of fish consumed. In some areas this can become an important environmental justice issue.

Brodberg (pers. comm. 2006) indicated that OEHHA's adoption of these proposed screening values would not in itself become a regulatory limit upon which 303(d) listings would be based. He indicated that it would be up to the State and Regional Water Quality Control Boards to decide the allowable cancer risk and the fish consumption rates that would be used to establish a revised screening value for a particular waterbody or region. This approach would mean that the State and Regional Water Quality Control Boards could become more involved in establishing screening values than they have been in the past.

As discussed the 2005 adoption of the OEHHA proposed screening value would eliminate the exceedances of fish tissue concentrations for the Delta thereby providing a basis for delisting the Delta waterbodies as Clean Water Act 303(d) listing and eliminate the need to conduct a TMDL to control the excessive bioaccumulation organochlorine legacy pesticides in edible fish. If however the CVRWQCB/SWRCB determine that the OEHHA use of 10^{-4} should be lowered to 10^{-5} or 10^{-6} cancer risk more typical of normally used cancer risks and/or want to provide public health protection than that proposed by OEHHA as the fish consumption rate by those who consume local fish as a larger part of their food supply then the screening values assumed in this review would be decreased and fish from some areas of the Delta would continue to be found to have excessive organochlorine legacy pesticides. This could become an important environmental justice issue that will need to be addressed. The CVRWQCB current efforts in developing a TMDL to reduce excessive bioaccumulation of mercury in Central Valley fish which includes consideration of environmental justice issues of fish consumption rates in establishing screening values for mercury fish tissue residues could be important in addressing appropriate fish consumption rates for Central Valley fish to protect public health.

The OEHHA (2006) proposed screening values are according to Brodberg (personal communication under review by OEHHA. Further information is available at http://www.oehha.ca.gov/fish/gtlsv/gtlsv1.html.

Future Studies

This review of the 2005 organochlorine Delta fish tissue data should be of value in helping the CVRWQCB select those areas where additional fish tissue data should be collected to confirm the appropriateness of delisting Delta and other Central Valley waterbodies from the CWQ 303(d) listing and thereby element the need to develop a TMDL to control the excessive bioaccumulation of organochlorine legacy pesticides. As mentioned an effort should be made to collect white catfish from the Sacramento River. Also fish should be taken from the Port of Stockton and the Deep Water Ship Channel near the Port to determine if these fish still contain excessive organochlorine legacy pesticides, PCBs and dioxins.

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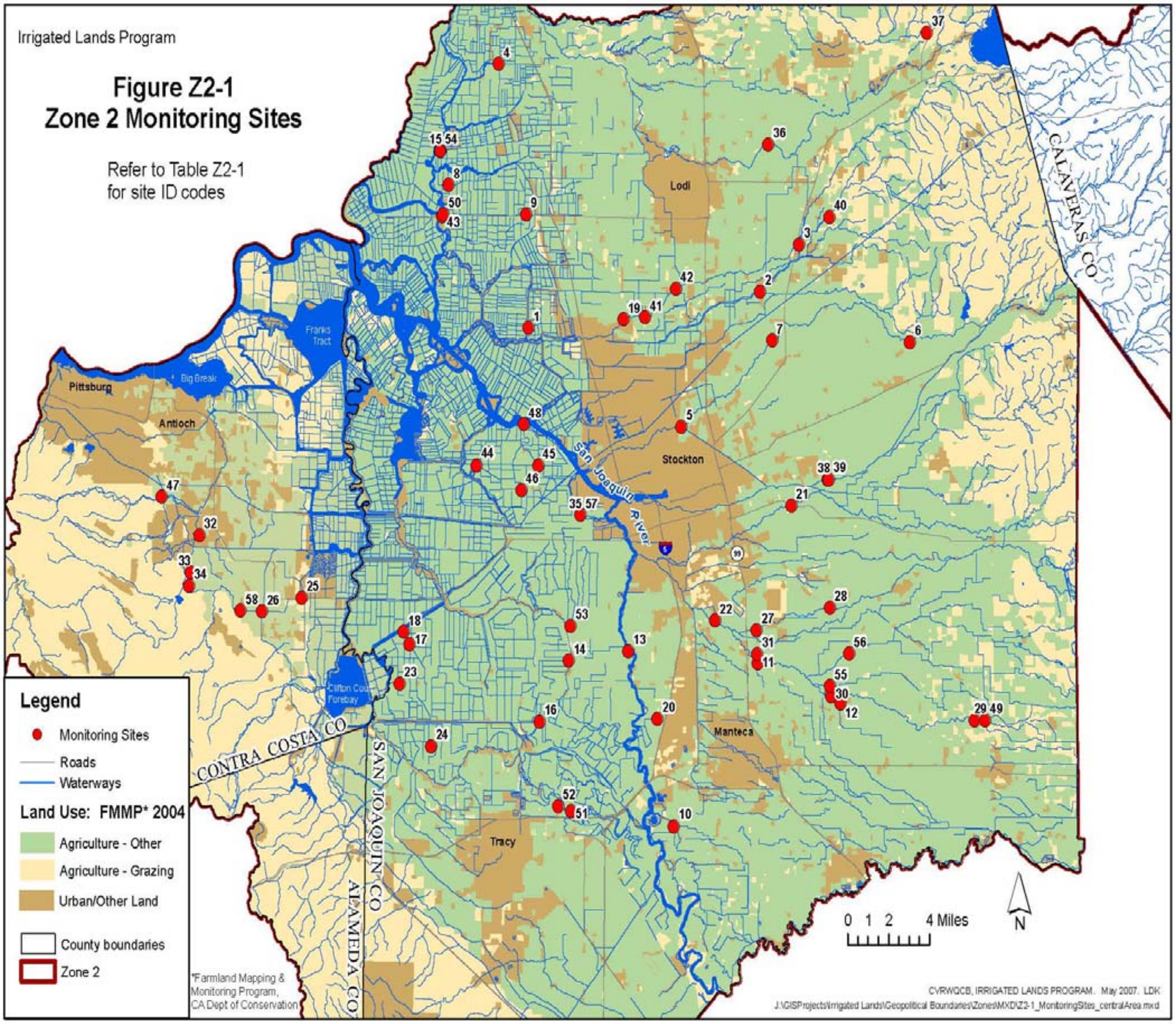
Appendix A Map of Delta and Near Delta Ag Waiver Collection Sites



Appendix B Listing Delta and Near Delta Ag Waiver Collection Sites

SiteNumber	SiteCode	SiteName	Latitude	Longitude	Samp
1	544EMARBR	8 Mile and Rio Blanco Rds.	38.0505	-121.41753	UCD A
2	531XNSJ32	Bear Creek at Alpine Rd	38.07402	-121.21093	UCD F
3	531XNSJ34	Bear Creek at Harney Ln.	38.101712	-121.176429	UCD F
4	544BSABRD	Beaver Slough at Blossom Rd.	38.20421	-121.44706	UCD A
5	531XCRABI	Calaveras River @ Belota Intake	37.9942	-121.2802	San Jo
6	531XNSJ04	Calaveras River at Clements Rd.	38.045627	-121.076605	UCD F
7	531XNSJ31	Calaveris River at Pezzi Rd	38.04536	-121.19982	UCD F
8	544XTTGLR	Delta Drain- Terminous Tract off Glascock Rd	38.1329	-121.4906	San Jo
9	544XTTGUR	Delta Drain- Terminous Tract off Guard Rd	38.1167	-121.4211	San Jo
10	531XXXD11	Drain 11 @ Walsal Slough (Top of Bank)	37.761	-121.2828333	South
11	544XXXD12	Drain 12 @ French Camp Rd Headwall/Southside of RR	37.85683333	-121.20967	South
12	544XXXD14	Drain 14 @ Lone Tree Ck (Top of Bank)	37.83433333	-121.1356667	South
13	544DABWMR	Drain at Bowman Rd.	37.86267	-121.32514	UCD A
14	544DRAWLR	Drain at Wing Levee Road	37.85659	-121.37801	UCD A
15	544XSED10	Drain to Brack Dr at Woodbridge Rd	38.1527	-121.4989	UCD F
16	544XXXD02	Drain to Grant Line Canal off Wing Levee Rd.	37.8205	-121.4035	UCD F
17	544XSED11	Drain to North Canal along Bonetti Drive	37.8643	-121.52	UCD F
18	544XXXD03	Drain to North Canal at South Bonetti Rd.	37.8715	-121.5256	UCD F
19	531XSED09	Drain to Pixley Slough at Davis Rd	38.0564	-121.3332	UCD F
20	544XXXD01	Drain to San Joaquin River off South Manthey Rd.	37.8234	-121.2985	UCD F
21	531XDCAHF	Duck Creek at Highway 4	37.9491	-121.181	San Jo
22	531SJC504	French Camp Slough @ Airport Way	37.8813	-121.2482	San Jo
23	544XGLCAA	Grant Line Canal @ Clifton Court Rd	37.8414	-121.5288	San Jo
24	544XGLCCR	Grant Line Canal near Calpack Rd	37.805	-121.4999	San Jo
25	544XKCHWF	Kellogg Creek @ Hwy 4	37.8904	-121.6172	San Jo
26	544XKCAHL	Kellogg Creek along Hoffman Ln	37.8819	-121.6522	San Jo
27	531LJCANR	Little John Creek at Newcastle Rd.	37.8763	-121.21068	UCD A
28	531XLCAJR	Littlejohns Creek @ Jacktone Rd	37.8898	-121.1459	San Jo
29	535XLTABR	Lone Tree Creek @ Bernnan Rd	37.82552	-121.01591	San Jo
30	531XLTCJR	Lone Tree Creek @ Jacktone Rd	37.8379	-121.1440	San Jo
31	531LTCANR	Lone Tree Creek at Newcastle Rd.	37.8622	-121.21009	UCD A
32	544XMCABA	Marsh Creek @ Balfour Ave	37.9256	-121.7091	San Jo
33	544XMCACA	Marsh Creek @ Concord Ave	37.9039	-121.7163	San Jo
34	544MCAMCR	Marsh Creek @ Marsh Creek Rd	37.89591	-121.7176	San Jo
35	544SJC517	Mid Roberts Island Drain at Woodsbro Road	37.94163	-121.3693	UCD F
36	531XMRABR	Mokelumne River @ Bruella Rd	38.1598	-121.2050	San Jo
37	531XMRAFH	Mokelumne River @ Fish Hatchery	38.22639	-121.0637	San Jo
38	544MSAJTR	Mormon Slough at Jack Tone Road	37.9647	-121.1488	San Jo
39	531XNSJ06	Mormon Slough on Jack Tone Rd	37.9650461	-121.147934	UCD F
40	531XNSJ38	Paddy Creek at Jack Tone Rd.	38.1178976	-121.149731	UCD F
41	531XNSJ28	Pixley Slough at Eightmile Rd	38.05765	-121.3135032	UCD F
42	531XNSJ36	Pixley Slough at Ham Ln	38.07474	-121.286298	UCD F

43	544XPSAHT	Potato Slough @ Hwy 12	38.1145	-121.4960	San Jo
44	544RIDAMR	Return Irrigation Drain at MCD Rd.	37.96983	-121.46227	UCD /
45	544RIDAHR	Roberts Island Drain along House Road	37.9702	-121.4074	San Jo
46	544RIDAHT	Roberts Island Drain at Holt Road	37.9556	-121.4223	San Jo
47	544SCAHFB	Sand Creek at Highway 4 Bypass	37.9475	-121.743	San Jo
48	544SJRSWC	SJR Source Water to Canal at Holt and Nueger Roads	37.99402	-121.42045	UCD /
49	535OAKSWL	Sweet Lateral	37.82556	-121.0061	Oakda
50	544XTTHWT	Terminous Tract Drain @ Hwy 12	38.1159	-121.4949	San Jo
51	544TPSELR	Tom Paine Slough at El Rancho Rd.	37.76898	-121.37445	UCD /
52	544XSED07	Tom Paine Slough at Paradise Rd.	37.7716	-121.386	UCD F
53	544SJC516	Unnamed Canal at Howard Road	37.87696	-121.37656	UCD F
54	544XNSJ03	Unnamed canal at west end of Woodbridge Rd	38.152657	-121.498601	UCD F
55	531UDLTAJ	Unnamed Drain to Lone Tree Creek at Jack	37.8442	-121.145	San Jo
56	531XSED08	Unnamed Slough at Wildwood Rd	37.8633	-121.1282	UCD F
57	544USAWR	Unnamed Slough at Woodsbro Rd. and Burns cutoff Levee	37.94174	-121.36912	UCD /
58	544UKCAHL	Upstream Kellogg Creek @ Hoffman Ln	37.8819	-121.67132	San Jo

Code & Qualifier Key:

Code	Meaning
-88	Null (Usually Equals No Result Available)
- (Any Number)	Non Detect (Negative Method Detection Level)
>	Greater Than (Bacteria Analysis Only)
<	Less Than (Bacteria Analysis Only)
=	Equal to (Bacteria Analysis Only)
ND	Non Detect
NR	No Result
E	Estimated - Calculated, Greater Than Method Detection Maximum
DNQ	Detected, Not Quantified (Same a EPA "J" Flag)

Appendix C   2005 Fish Tissue Delta and Near Delta Data

Appendix C SJR and Its Tributaries Fish Tissue Data

Appendix D Sacramento River and Its Tributaries Fish Tissue Data