2002-2004 SOUTHERN CALIFORNIA

COASTAL MARINE FISH CONTAMINANTS SURVEY

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Long Beach, California
on behalf of the Natural Resource Trustees

U.S. Environmental Protection Agency - Region IX
San Francisco, California

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The Natural Resources Trustees are National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, National Park Service, California Department of Fish and Game, California State Lands Commission, and California Department of Parks and Recreation.

Cover Photograph: Ken Nielsen of Seaventures, LLC holding a string of white croaker. The Palos Verdes peninsula is in the background.

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Attachments to this report are available from the Montrose Settlements Restoration Program (http://www.montroserestoration.gov/)

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LIST OF ACRONYMS

AWHL	Alpha Woods Hole Laboratory
CCAL	Continuing Calibration
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFCP	Coastal Fish Contamination Program
COC	Chain of Custody
COPC	Chemical of Potential Concern
CVAA	Cold Vapor Atomic Absorption
DDTs	Dichlorodiphenyltrichloroethane and its common metabolites and derivatives
EDD	Electronic Data Deliverable
EPA	United States Environmental Protection Agency
GC/MS-SIM	Gas Chromatography/Mass Spectrometry with Single Ion Monitoring
ICAL	Initial Calibration
IDP	Initial demonstration of proficiency
IQR	Inter-quartile range
JWPCP	Joint Water Pollution Control Plant
CSDLAC	County Sanitation Districts of Los Angeles County
LCS	Laboratory Control Sample
LOC	Level of Chlorination
MDL	Method Detection Limit
MQOs	Measurement Quality Objectives
MS	Matrix Spike
MSRP	Montrose Settlements Restoration Program
NIST	National Institute for Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council of Canada
OEHHA	Office of Environmental Health Hazard Assessment
PCBs	Polychlorinated Biphenyls
PV Shelf	Palos Verdes Shelf
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RecFIN	Recreational Fishing Network
RM	Reference Material
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SCB	Southern California Bight
SRB	Scientific Review Board
SRM	Standard Reference Material
TAL	Target Analyte List
TEO	Total Extractable Organics

LIST OF SCIENTIFIC NAMES

Common Name	Latin Name
Atlantic chub mackerel	*Scomber colias*
Barred sand bass	*Paralabrax nebulifer*
Barred surfperch	*Amphistichus argenteus*
Bat ray	*Myliobatis californica*
Black croaker	*Cheilotrema saturnum*
Black perch	*Embiotoca jacksoni*
Bocaccio	*Sebastes paucispinis*
Calico surfperch	*Amphistichus koelzi*
California corbina	*Menticirrhus undulates*
California halibut	*Paralichthys californicus*
California scorpionfish	*Scorpaena guttata*
California sheephead	*Semicossyphus pulcher*
Dwarf perch	*Micrometrus minimus*
Jacksmelt	*Atherinopsis californiensis*
Kelp bass	*Paralabrax clathratus*
Kelp perch	*Brachyistius frenatus*
Lingcod	*Ophiodon elongatus*
Opaleye	*Girella nigricans*
Pacific barracuda	*Sphyraena argentea*
Pacific bonito	*Sarda chiliensis*
Pacific chub mackerel	*Scomber japonicus*
Pile perch	*Rhacochilus vacca*
Queenfish	*Seriphus politus*
Rainbow seaperch	*Hypsurus caryi*
Rubberlip seaperch	*Rhacochilus toxotes*
Sargo	*Anisotremus davidsonii*
Shiner perch	*Cymatogaster aggregata*
Shovelnose guitarfish	*Rhinobatos productus*
Silver surfperch	*Hyperprosopon ellipticum*
Spotfin croaker	*Roncador stearnsii*
Spotfin surfperch	*Hyperprosopon anale*
Striped mullet	*Mugil cephalus*
Striped seabass	*Embiotoca lateralis*
Topsmelt	*Atherinops affinis*
Vermilion rockfish	*Sebastes miniatus*
Yellowfin croaker	*Umbrina roncador*
Yellowtail jack	*Seriola lalandi*
Walleye surfperch	*Hyperprosopon argenteum*
White croaker	*Genyonemus lineatus*
White seabass	*Atractoscion nobilis*
White seaperch	*Phanerodon furcatus*

EXECUTIVE SUMMARY

Millions of pounds of DDTs and PCBs were discharged in the past from industrial sources through wastewater outfalls into the ocean at White Point, near Los Angeles.[1] The DDTs and PCBs released through the County Sanitation Districts of Los Angeles County (CSDLAC) outfalls dispersed throughout the Southern California Bight (SCB) marine environment. The highest sediment and fish concentrations occur over the Palos Verdes Shelf (PV Shelf), the coastal region offshore of Los Angeles where the outfalls discharge (Figure ES-1).

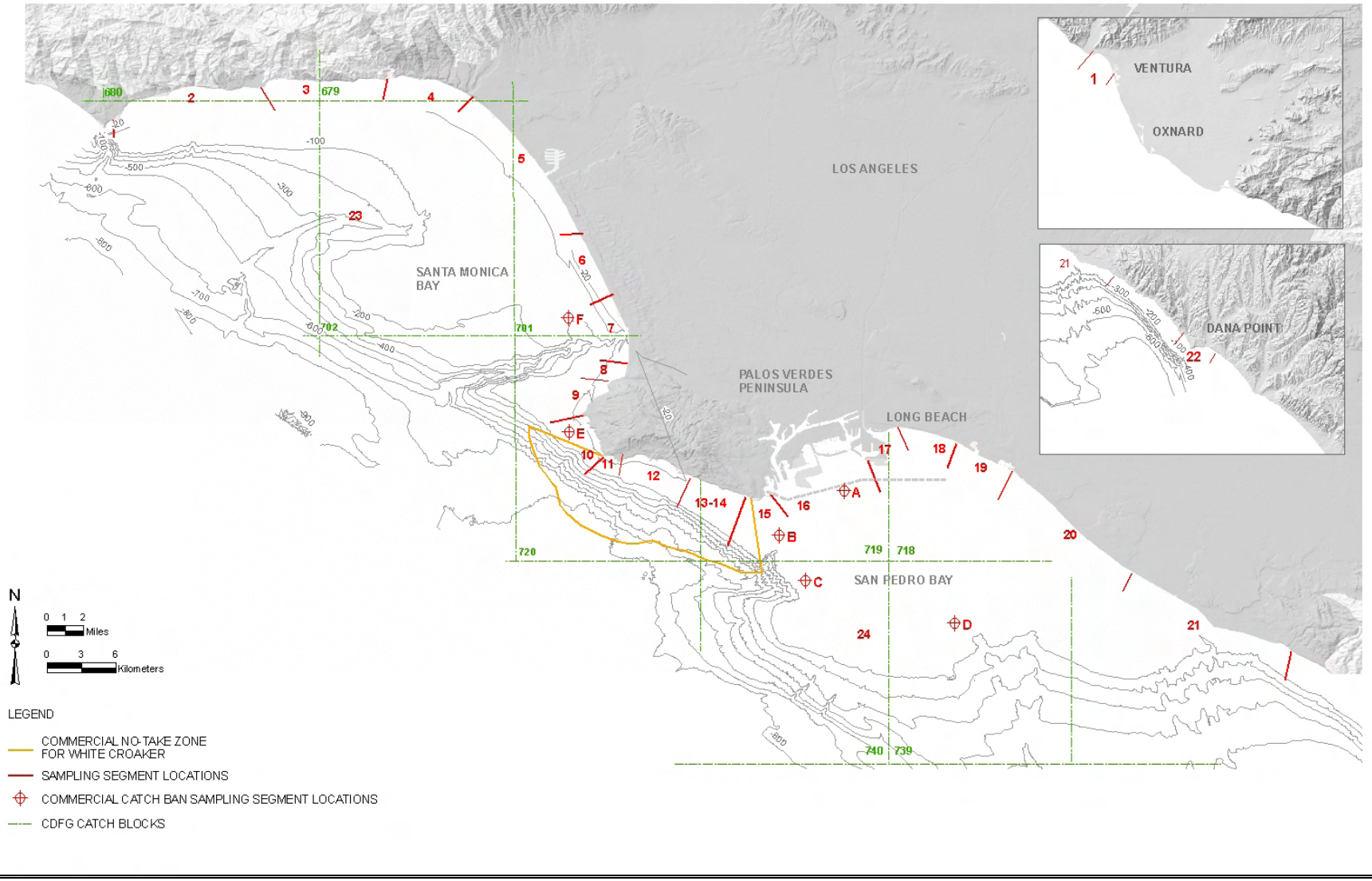
The primary source of DDTs was industrial waste from the Montrose Chemical Corporation, which manufactured the pesticide DDT at its facility in Los Angeles from 1947 to 1982.[2] PCBs have been found in sediments from the Southern California marine environment dated to the late 1930s, with peak inputs into the SCB from 1965 to 1970 (Horn *et al.* 1974, Mearns *et al.* 1988). The CSDLAC wastewater outfalls on the Palos Verdes Shelf were a principal source of releases of DDTs to the Southern California marine environment (Young and Heeson 1980, NOAA *et al.* 1991, Chartrand *et al.* 1985) and were one of several significant sources of PCBs, in addition to ocean dumping and other wastewater discharges such as the Orange County Sanitation Districts (SCCWRP 1973).

Even today, large amounts of DDTs and PCBs persist in ocean water and sediments, and certain fish, birds, and other wildlife continue to accumulate DDTs and PCBs in harmful amounts. The State of California Office of Environmental Health Hazard Assessment (OEHHA) completed a study of contaminants in fish collected from Point Dume to Dana Point in 1987 (Pollock *et al.* 1991), which resulted in fishing advisories for 11 sites and 8 fish species. In addition, because of especially high levels of DDTs and PCBs in white croaker, the State of California has imposed bag limits for this fish and has banned commercial fishing for white croaker in the vicinity of the PV Shelf. The state and federal governments investigated these problems and in 1990 filed an action in U.S. District Court against several parties responsible for the discharges of DDTs and PCBs. In October 2000, after ten years of litigation, the federal and state governments and the remaining defendants signed the last of a series of settlements. The court approved the final settlement in March 2001. These settlements provide funding to the U.S. Environmental Protection Agency (EPA) to respond to the ecological and human risks posed by the DDTs and PCBs of the case, and to the six federal and state natural resource trustee agencies (Trustees) to restore injured natural resources and compensate for the loss of the services they provide. The Trustees are National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service, National Park Service, California Department of Fish and Game, California State Lands Commission, and California Department of Parks and Recreation. The Trustees' restoration efforts are known as the Montrose Settlements Restoration Program (MSRP). The EPA refers to the site as the Palos Verdes Shelf Superfund site.

[1] In addition to the CSDLAC wastewater discharge, DDTs from the Montrose Chemical Corporation were dumped into San Pedro Basin between Santa Catalina Island and Palos Verdes Shelf or discharged in storm water runoff directly from the plant or inadvertently in storm runoff from soil around the plant into Los Angeles Harbor (NOAA *et al.* 1991).

[2] The Montrose Chemical Corporation was banned from discharging industrial waste to the CSDLAC sewers in 1972.

Figure ES-1
Ocean Fish Contaminants Survey Sampling Locations



In 2002, EPA and the Trustees agreed to jointly undertake a multi-purpose survey of contaminants in marine fish along the Southern California Coast between Ventura and Dana Point. An overarching goal of this survey is to provide comprehensive information that complements available historical data and other ongoing ocean fish sampling programs. The specific objectives of the study are as indicated below:

- Generate reliable information on contaminants of concern in fish caught by subsistence and sport fishers in the study area;

- Provide data to support State's assessment of the existing commercial no-take ("commercial catch ban") zone for white croaker in the vicinity of the Palos Verdes Shelf;

- Identify suitable locations for artificial reef project to restore lost fishing services to the public; and

- Support ongoing EPA Superfund PV Shelf cleanup program.

With the assistance of a scientific review board (SRB), the Trustees and EPA designed and implemented an extensive fish sampling and analysis program to address these objectives. The SRB included nearly two dozen public- and private-sector individuals with expertise specific to the Southern California coastal areas and experience in key technical areas necessary to the development of the plan. Overall, the Trustees and EPA implemented a plan that collected 2,676 fish, including individuals from 30 locations between Ventura and Dana Point (Figure ES-1), representing 23 different species. This report summarizes the methodology and results of the 2002-2004 Southern California Coastal Marine Fish Contaminants Survey. Evaluation of these data for risk assessment, fish consumption advisory, or other purposes is beyond the scope of this report.

Locations and species were targeted for collection based on several factors relevant to project objectives, including current fishing advisories in Southern California, available data on recreational and subsistence fishing, historical fish contamination data, and considerations regarding artificial reef implementation. Most fish were collected between August and November 2002. White croaker were collected in 2002, 2003, 2004. Table ES-1 presents a matrix that shows the number of fish caught, by location and species, and identifies those analyzed for contamination. Not all collected fish were analyzed; in some cases initial rounds of testing eliminated the need for further testing of certain species-location combinations. The laboratory analysis program included five contaminants of potential concern (COPCs): DDTs, PCBs (on a congener basis), mercury, chlordane, and dieldrin. The rationale for expanding beyond the scope of the contaminants covered by the litigation (*i.e.*, DDTs and PCBs) was to address the possibility that fish with low levels of those contaminants might have high levels of other contaminants, which may affect restoration decision-making and/or management of the fishery. Factors in the COPC selection process included bioaccumulation, persistence, and regional detection history.

Table ES-1
Overview of Fish Collection and Analysis

Segment	Description	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand Bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific Chub Mackerel	Pacific Barracuda	Pacific Sardine	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
1	Ventura: Emma Wood Beach to San Buenaventura Beach																	1						
2	Pt. Dume to Malibu Bluff		2	1	1		2		1						1C			1						1
3	Malibu Bluff to Las Flores																	1						1
4	Las Flores to W. End of Santa Monica Beach																	1						1
5	Santa Monica Beach to El Segundo	2			2				3	2		2						1		1C		1		
6	El Segundo to S. End of Manhattan Beach											2						1						3
7	King Harbor Area: Manhattan Beach to Redondo Beach	1	2	1	1	2			1					1	3		1C	1			1			1
8	Redondo Beach to Flat Rock Pt.	2		3	2				2	1C,2			1C				1C		1					
9	Flat Rock Pt. to Palos Verdes Pt.								2															
10	Palos Verdes Pt. to Pt. Vicente																							
11	Pt. Vicente to Long Pt.																							
12	Long Pt. to Bunker Pt.			3			2		1			1			1C			1						
14	Royal Palms to Pt. Fermin	2		1	1		1		2			1			1C			1						
15	Cabrillo/LA Breakwater: Ocean Side	2	1C	1,2	1	1	1		2			1					1C	1						1
16	Cabrillo/LA Breakwater: Inland Side			2	1	1			2	1C,2		1					1C	1	1		1	1	1	1
	Port of Los Angeles			2	2			2	2			2												
17	Pier J to Finger Piers at Shoreline Park	1			1	1												1				1	1	1
18	Belmont Pier/Seaport Village		1C		1													1		1	1		1	1
19	Seal Beach: Alamitos Bay jetties to Anaheim Bay	1		2	1	1			2			1C						1		1C				3
20	W. End of Sunset Beach to Huntington Beach (Hwy. 39)			2					2									1						
21	Huntington Beach (Hwy. 39) to Pelican Pt.														3			1						
22	Dana Pt.: Mussel Cove to Doheny Beach														1C	1C		1						
23	Short Bank																	1						
24	Horseshoe Kelp			2												1C		1						
A	Middle Breakwater			2	1				2									1						1
B	Approx. 2 miles offshore of Segment 15																	1						
C	Approx. 5 miles SE of Pt. Fermin																	1						
D	Approx. 7 miles S/SE of Segment A																							
E	West of Palos Verdes Pt. before Redondo Canyon																							
F	West of Station E on north side of Redondo Canyon																	1						
		1-4 fish caught at location																						
		5-9 fish caught at location																						
		10 or greater fish caught at location																						

Number in box represents round of analysis. Colored boxes with no number indicate that fish were caught but not analyzed.
A number followed by a C indicates that the organic analysis (DDTs, PCBs, chlordane, dieldrin) was conducted on a composite. Only first round of Commercial Catch Ban is included in this table.
Round 1: Initial Analysis at Battelle (organic analysis as individuals unless otherwise specified and mercury analysis as composites on all samples)
Round 2: Second Round at AWHL (PCB and DDT analysis on all, mercury on some samples, all as individual samples, no chlordane or dieldrin)
Round 3: Third Round at AWHL (mercury analysis only, all as individual samples)

For most organochlorine contaminant analysis (*i.e.*, PCBs, DDTs, chlordane, and dieldrin), contaminant levels were measured for each individual fish, with a sample size of ten fish per species-location combination. Transient pelagic species (*e.g.*, Pacific chub mackerel, Pacific sardine, Pacific barracuda), expected to have lower, more uniform contaminant levels relative to resident species, as well as a few other species were analyzed as composites, generally of ten fish.[3] For mercury analysis, all species were initially analyzed as 10-fish composites due to expected lower variability within a species. Where composite results indicated that spatial differences in mercury concentrations might be significant within a species, individual fish were subsequently analyzed for mercury at the individual level.

Most samples were analyzed as a skin-off fillet (*i.e.*, muscle tissue, with the belly flap removed). However, angler studies indicate that fish are consumed in a variety of preparations besides skin-off fillet, and results from a 1996 Heal the Bay study (Gold *et al.* 1997) generally indicate a trend of higher DDT levels in whole, gutted fish compared to fillets or muscle tissue. The entire body was analyzed in parts for 15 samples from each of two species representative of different feeding modes (*i.e.*, white croaker (bottom-feeder) and kelp bass (water column feeder)). These samples were selected based on catch location and skin-off fillet DDT and PCBs contaminant levels. The skin-off fillet from one side, the skin-on fillet with belly flap from the other side, the remaining tissue and skeleton ("remainder"), and the viscera were each weighed and analyzed, providing the ability to estimate the concentrations of contaminants in various permutations (*e.g.*, whole, gutted fish; whole fish; skin-on fillet with belly flap) for fish with just the skin-off fillet analyzed.

Organochlorine contaminant analysis was conducted by GC/LRMS-SIM. This method was selected because it provided the greatest advantages and flexibility for quantifying both the DDT isomers and PCB congeners at a reasonable cost. The results for total PCBs presented in this report are calculated as a sum of congeners analyzed. A list of 45 congeners was selected by the Trustees for individual quantitation based on past work in the SCB and in consultation with State of California Office of Environmental Health Hazard Assessment (OEHHA). In addition to identification and measurement as individual congeners, PCBs were quantitated by homologue group (*i.e.*, level of chlorination or LOC). Both target and non-target PCB congeners were included in the summation for each homologue. By summing the homologue groups, the total PCB concentration as a sum of all 209 congeners can be estimated. The remaining organochlorine analytes were analyzed by the same methodology as the PCB congeners. These analytes were DDT isomers (*p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD); the principal components of technical chlordane *(cis/trans* chlordane, oxychlordane, and *cis*/*trans* nonachlor); and dieldrin. Total mercury was analyzed in the fish tissue by cold vapor atomic absorption spectroscopy. Analysis of percent lipid and moisture content for each sample was also performed. The Trustees and EPA conducted an extensive data validation program, which is documented in the report and accompanying appendices.

Overall, with respect to organochlorine contamination, concentrations of PCBs, DDTs, and chlordane varied broadly throughout the species and segments. In contrast, almost all

[3] Other species analyzed as composites (see Table ES-1) represented species or locations of lower priority or significant unknown; composites provide an economical look at general contaminant level for a species and location.

dieldrin concentrations were below the detection limit. Concentration data presented below are expressed as mean concentrations for a given species and segment, which includes up to ten fish. For each contaminant, the range and distribution of mean concentrations are based on a log-normal distribution of mean concentrations, divided into quartile ranges (the "lower range", up to the 25th percentile; the "interquartile range" from the 25th percentile to the 75th percentile; and the "higher range", above the 75th percentile). The designations of "higher" and "lower" indicate the relative contaminant levels in groups of fish; they do not indicate absolute contaminant levels or that particular sites or species are recommended for consumption. From evaluation of "higher" and "lower" contaminant means for different species, segments, and contaminants, key factors determining relative contaminant levels emerge.

For DDTs, the lowest mean concentration was found in opaleye from King Harbor (Segment 7, 0.9 ppb) and the highest mean concentration in white croaker from the ocean side of the Los Angeles Breakwater near Cabrillo Pier (Segment 15, 3180 ppb). The interquartile range of the species/segments was roughly between 60 and 200 ppb. Species most commonly found in the higher quartile range for DDTs included white croaker, kelp bass, California scorpionfish, and barred sand bass. Species that were consistently below the 75th percentile included black croaker, California corbina, California halibut, jacksmelt, Pacific barracuda, Pacific chub mackerel, queenfish, shovelnose guitarfish, surfperches, white seabass, and yellowfin croaker.

Mean concentration of total PCBs varied broadly among species and locations, but less so than DDTs. The lowest mean PCB concentration was found in opaleye from the Seal Beach area (Segment 19, 3.06 ppb) while the highest mean PCB concentration was found in white croaker from the ocean side of Cabrillo Pier (Segment 15, 347 ppb). The inter-quartile range for mean PCB concentrations was roughly between 20 and 70 ppb. No species had mean PCB concentrations consistently above the inter-quartile range throughout the area. Species that were consistently below the 75th percentile were black croaker, California corbina, California halibut, California sheephead, jacksmelt, Pacific barracuda, Pacific chub mackerel, queenfish, rockfishes, shovelnose guitarfish, water-column-feeding surfperches, white seabass, and yellowfin croaker.

The mean concentration of chlordane also varied broadly among species and locations. Jacksmelt from inside the Los Angeles Breakwater at Cabrillo Pier (Segment 16, 0.18 ppb) had the lowest mean concentration, while the highest mean concentrations were found in white croaker from Santa Monica Bay (Segment 5, 71 ppb). The inter-quartile range for mean chlordane concentrations was 4.27 to 11.2 ppb. This range represented most species and segments. While nine species had a segment mean in the "higher" range, most of these species also had segments with mean chlordane concentrations in the "intermediate" or "low" range. Two exceptions, which only had concentrations in the "higher" category, were California halibut, for which there was only a single collection, and Pacific sardines, for which there were four collections and whole bodies were analyzed. Species that were consistently below the 75th percentile were barred sand bass, black croaker, California scorpionfish, kelp bass, opaleye, Pacific mackerel, rockfishes, shovelnose guitarfish, white seabass, and yellowfin croaker.

With a few exceptions, the spatial and interspecies variability in organochlorine concentrations found in this survey were largely consistent with those from previous surveys. White croaker was generally found to be the most highly contaminated species. Fish caught in locations closest to the Palos Verdes Shelf (*i.e.*, southern Santa Monica Bay, Palos Verdes Shelf,

San Pedro Bay) tended to have higher contaminant levels that those caught further north or south. White croaker followed this trend, with contaminant concentrations that were greatest in the vicinity of the Palos Verdes shelf. White croaker collected from segments in Orange County and parts of Long Beach Harbor had lower levels of contamination that were similar to white croaker collected from the more northerly segments (Point Dume, Ventura).

Variation in organochlorine concentrations did not follow a clear pattern of higher concentrations in fish that occupy higher trophic levels or larger sizes. In most cases, DDT concentrations were higher than PCB concentrations, particularly close to the Palos Verdes shelf. This DDT/PCB ratio is consistent with the reported sediment concentrations of DDTs and PCBs, which have approximately a 10 to 1 ratio in the sediments (CSDLAC 2006). Opaleye were an exception to this general trend, and were consistently found to have higher PCB concentrations than DDTs. The PCB concentrations in opaleye are similar to those of other reef/surf zone fish species, but opaleye DDT concentrations were much lower. While opaleye is the only herbivore among the species analyzed, it is not clear if this could explain the lower DDT concentrations. Further analysis/study is needed to understand DDT/PCB ratios in opaleye.

Mean concentrations of mercury were lowest in Pacific sardine from inside the Los Angeles Breakwater at Cabrillo Pier (segment 16, 18.6 ppb) and highest in black croaker from inside the Los Angeles Breakwater (Commercial catch ban Segment A, 582 ppb). Interestingly, while black croaker mean organochlorine concentrations were at or below averages found in other species, black croaker had the three highest mean mercury concentrations. The inter-quartile range (based on log-normal distribution) for average mercury concentrations was roughly 75 to 180 ppb. Most species had segments with means within the interquartile range; notable exceptions, with all segment means “higher”, were all collections of black croaker (4 segments), Pacific barracuda (2 segments), and white seabass (1 segment). Overall, segments with mean concentrations of mercury above the interquartile range were found in 11 species (barred sand bass, kelp bass, black croaker, California scorpionfish, Pacific barracuda, sargo, California halibut, rockfishes, shovelnose guitarfish, white croaker, and white seabass). Ten of the species with mean mercury concentrations in the “higher” range did not have any samples that were in the “lower” range, suggesting a more species dependent pattern for mercury than was found for the organochlorines. The exception was white croaker, with mean mercury concentrations primarily in the “lower” (6 segments) and “intermediate” (16 segments) ranges and one segment in the “higher” range. Species that were consistently either “intermediate” or “lower” in mean mercury concentrations were benthic-feeding surfperches, California corbina, California sheephead, jacksmelt, opaleye, Pacific chub mackerel, queenfish, topsmelt, water-column-feeding surfperches, and yellowfin croaker. Outlier mean concentrations were found only on the low concentration end (below 19.9 ppb), for Pacific sardines from segments 7, 8, 15, and 16.Variation in mercury concentrations among the fish collected in this survey appears to be driven by differences between species and fish size, as has been generally found in other surveys. No consistent hot spots for mercury were identified. Larger, higher trophic level species (kelp bass, barred sand bass) were generally higher in mercury concentrations than smaller, lower

trophic level species. Pacific chub mackerel had some of the lowest mercury concentrations of all the species analyzed.[4]

In addition to the skin-off fillet data described above, multiple body components were analyzed for a subset of kelp bass and white croaker. These results enabled the estimation of quantitative relationships between contaminant concentrations in the different body components, as well as the total contaminant levels in a whole, ungutted fish. These relationships may be specific to particular species and locations, as well as to specific contaminant types and levels (*e.g.*, organic contaminants, which may be higher in lipid-rich tissues, and mercury, which may be higher in muscle-rich tissues). An analysis of covariance was used to quantify relationships between contaminant levels (PCBs, DDTs) in three body components (skin-on fillets, viscera, and "remainder") and skin-off fillets. The effect of species (kelp bass, white croaker) on these relationships also was investigated.

All of the body component concentrations were significantly correlated with the fillet concentrations, with higher fillet concentrations associated with higher component concentrations. In most cases, the relationship between fillet concentration and the concentration in other body parts was not significantly affected by species. Skin-on fillets had the lowest increase in PCB and DDT concentrations compared to skin-off fillets, averaging approximately 6 to 7 times the DDTs and PCBs found in associated skin-off fillets. Skin-on fillet DDT and PCB concentrations for individual fish ranged between a factor of 1 and 20 times the skin-off fillet. Viscera and "remainder" samples had similar, but greater, increases in PCB and DDT concentrations compared to skin-off fillets, averaging approximately 11 to 17 times the DDTs and PCBs found in associated skin-off fillets, depending on contaminant and component. For individual fish, DDT and PCB concentrations in viscera and "remainders" ranged between a factor of 1 and approximately 40 times the skin-off fillet.

Component concentration data also were used to develop equations that estimate the PCB or DDT concentration in a whole, ungutted fish based on the concentration in a skin-off fillet. First, equations were developed to estimate the PCB or DDT concentration in the three additional body components (skin-on fillets, viscera, and "remainder") of a fish based on its fillet concentration. These concentrations, in combination with estimated component proportions (based on the laboratory weight of each of the four components), were then summed to estimate concentrations in a whole, ungutted fish. The results suggest that whole fish have concentrations of PCBs and DDTs that are generally 8 to 10 times higher than the fillet concentrations.

[4] While the "mackerel" is often associated with higher mercury content (see EPA/FDA warnings associated with tuna and king mackerel, USEPA/USFDA 2004), the warnings refer to species of the genus *Scomberomberus*. Pacific chub mackerel, as well as Atlantic chub mackerel, belong to the genus *Scomber* and tend to be smaller, shorter-lived species.

1 INTRODUCTION AND STUDY OBJECTIVES

Portions of the Southern California marine environment are contaminated with elevated levels of DDTs and PCBs.[5] In 2002 the U.S. Environmental Protection Agency (EPA) and six federal and state natural resource trustee agencies ("Trustees")[6] agreed to jointly undertake a multi-purpose survey of contaminants in marine fish along the Southern California Coast from Ventura to Dana Point. The effort resulted in the 2002-2004 Southern California Coastal Marine Fish Contaminants Survey, referred to in this report as the Ocean Fish Contaminants Survey. It includes several subcomponents focused on characterizing certain contaminants in fish for specific purposes described below. This section of the report describes the need for the survey and its objectives.

1.1 Background

Millions of pounds of DDTs and PCBs were discharged in the past from industrial sources through wastewater outfalls into the ocean at White Point, near Los Angeles. The Montrose Chemical Corporation manufactured the pesticide DDT at its facility in Los Angeles from 1947 to 1982. It was the only producer of DDTs in Southern California, and for much of that time it was the largest manufacturer of DDTs in the United States.

The releases of industrial waste containing DDTs from the Montrose plant entered the County Sanitation Districts of Los Angeles County (CSDLAC) sewer collection system, which discharged the contaminants through the CSDLAC Joint Water Pollution Control Plant (JWPCP) outfalls offshore of White Point beginning in 1953. Chartrand *et al.* (1985) estimated that 1,800 metric tons of DDTs were discharged from these outfalls between 1953 and 1970. Montrose was banned from discharging industrial waste to the CSDLAC sewers in 1972. In addition to the CSDLAC wastewater discharge, DDTs from the Montrose Chemical Corporation were dumped into San Pedro Basin between Santa Catalina Island and Palos Verdes Shelf or discharged in storm water runoff directly from the plant or inadvertently in storm runoff from soil around the plant into Los Angeles Harbor (NOAA *et al.* 1991).

PCBs have been found in sediments in the Southern California marine environment dated to the late 1930s, with peak inputs into the Southern California Bight (SCB) from 1965 to 1970 (Horn *et al.* 1974, Mearns *et al.* 1988). The CSDLAC wastewater outfalls on the Palos Verdes Shelf were a principal source of releases of PCBs to the Southern California marine environment, in addition to ocean dumping and other wastewater discharges such as the Orange County Sanitation Districts (SCCWRP 1973, Young and Heeson 1980, NOAA *et al.* 1991). Annual mass emissions of PCBs in 1972 exceeded 116 metric tons (NOAA *et al.* 1991).

[5] The pesticide DDT is referred to in this report as DDTs since the pesticide is present in the environment as a mixture of several chemicals.

[6] The Trustees are National Oceanic and Atmospheric Administration (NOAA); U.S. Fish and Wildlife Service; National Park Service; California Department of Fish and Game; California State Lands Commission; and California Department of Parks and Recreation

The DDTs and PCBs released from the CSDLAC outfalls dispersed throughout the SCB marine environment. The highest sediment and fish concentrations occur over the Palos Verdes Shelf (PV Shelf), the coastal region offshore of Los Angeles where the outfalls discharge (Figure 1-1).

Even today, large amounts of DDTs and PCBs persist in ocean water and sediments, and certain fish, birds, and other wildlife continue to accumulate DDTs and PCBs in harmful amounts. The state and federal governments investigated these problems and in 1990 filed an action in U.S. District Court against several parties responsible for the discharges of DDTs and PCBs. In October 2000, after ten years of litigation, the federal and state governments and the remaining defendants signed the last of a series of settlements. The court approved the final settlement in March 2001. These settlements provide funding to EPA to respond to the ecological and human risks posed by the DDTs and PCBs of the case, and to the Trustees to restore injured natural resources and compensate for the loss of the services they provide. The Trustees' restoration efforts are known as the Montrose Settlements Restoration Program (MSRP). The EPA refers to the site as the Palos Verdes Shelf Superfund Site, or PV Shelf site.

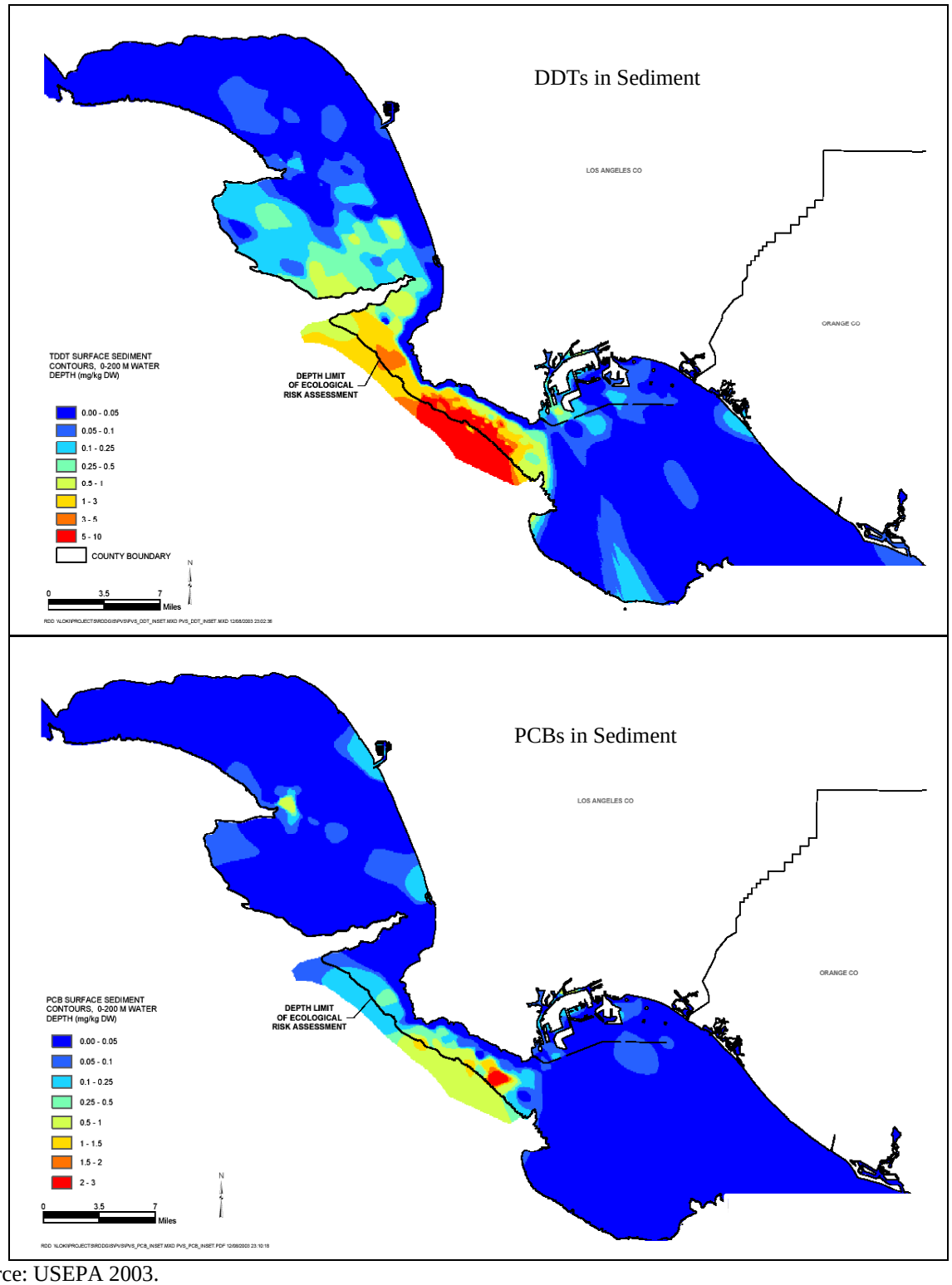
The principal statutory authority governing these settlements is the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund"). CERCLA provides authorities for both response and restoration actions.

- Under CERCLA, EPA and authorized state agencies may respond to releases of hazardous substances in several ways. For the Palos Verdes Shelf Superfund Site, EPA and its partners are currently implementing a multi-faceted institutional controls program aimed at reducing human exposures to the DDTs and PCBs in contaminated fish related to PV Shelf. EPA is also investigating potential actions to cleanup the contaminated sediments on the PV Shelf.

- CERCLA also provides for the designation of natural resource trustees – federal, state, or tribal authorities that represent the public interest in natural resources. The Trustees seek damages from polluters for injury, destruction, or loss of natural resources resulting from releases of hazardous substances, and use the damages collected to restore the injured natural resources and compensate for the loss of services they provide. In late 2005 the Trustees for this case completed a restoration plan that identifies a series of natural resource restoration actions to be taken over the next several years.

The Ocean Fish Contaminants Survey described in this report supports several response and restoration action objectives of EPA and the Trustees as described below.

Figure 1-1
Sediment Concentrations near Palos Verdes Shelf



Source: USEPA 2003.
Note: The depicted sediment concentrations are based on interpolated data; as a result, the actual locations of contamination gradients may vary from this depiction.

1.2 Need for Characterizing Contaminants in Southern California Coastal Ocean Fish

The coastal ocean habitats of southern California are home to a diverse assemblage of marine fishes, many of which are targeted by recreational and commercial anglers (Love 1996). In 2002, when study implementation began, recreational anglers caught roughly 9 million fish within 3 miles of shore, consisting of 120 species and weighing approximately 4,500 metric tons. Certain species were numerically dominant, while others were dominant by weight. Pacific chub mackerel was by far the numerically dominant species with an estimated 365,000 fish collected in 2002, approximately 17 percent of the total recreational catch by number. However, Pacific chub mackerel only made up approximately 8 percent of the catch by weight. By weight, barred sand bass was the dominant species, followed by California halibut and kelp bass; combined, the three species made up roughly 40 percent of the catch.

Previous work has evaluated contaminant levels in fish in the SCB. The State of California Office of Environmental Health Hazard Assessment (OEHHA) completed a study of contaminants in fish collected from Point Dume to Dana Point in 1987 (Pollock *et al.* 1991). The study examined tissue concentrations of DDTs and PCBs in 16 fish species from 24 locations as well as chlordane, mercury and tributyltin in selected species from selected locations. As a result of the study, OEHHA issued fishing advisories for 11 sites and 8 fish species.[7] In addition, because of especially high levels of DDTs and PCBs in white croaker, the State of California has imposed bag limits for this fish and has banned commercial fishing for white croaker in the vicinity of the PV Shelf.

Since the 1987 survey, additional data on contaminants in fish in the southern California coastal region have been gathered, but through several studies having objectives different from those of the EPA and Trustees (*e.g.*, Allen *et al.* 2002). While these data generally indicated that the DDT and PCB contamination in fish continued to be widespread and above health-based levels of concern, they did not provide the comprehensive data set that EPA and the Trustees needed for fish commonly caught in the study area.

Several factors were considered in the design of this Ocean Fish Contaminants Survey:

- The need for greater species and area resolution and coverage than prior studies;
- The need for more comprehensive data for contaminants other than DDTs and PCBs;
- The need for a high level of confidence in the analytical quality of the data;
- The need for contaminant information on whole fish, whole gutted fish, skinless fillet, and skin-on fillet to enable risk exposure estimation from various fish consumption scenarios; and
- The need for a design that lends itself to iterative study, *i.e.*, a design that would support further studies to explore patterns that more significantly affect the level of risk

[7] The fishing advisories are available on-line at http://www.oehha.ca.gov/fish/so_cal/socalpddp.html.

experienced by anglers. Such patterns could include, but are not limited to, patches of lesser-contaminated fish nested within areas characterized by higher levels of contamination, relationships between size and contamination level, and effects of gender and seasonality on level of contamination.

At the outset of this effort, EPA and the Trustees understood that in general, the levels of DDTs and PCBs vary among fish species and locations where they are caught in the study area. However, existing data provided a limited ability to examine how contaminant levels are correlated with the various factors (location, fish size, species, foraging behavior, ecology, life history, etc.) that may explain the variability in contamination.

Past studies show that the most contaminated fish commonly caught by local anglers is the white croaker, a fish found in soft-bottom habitats (Allen *et al*. 1996). This fish feeds on worms, crustaceans and other organisms living in the contaminated bottom sediments. White croaker is a "mainstay" of anglers fishing from piers, jetties, and small boats along the Southern California coast (Allen *et al*. 1996).[8] Fishing statistics show that it is the third most commonly caught fish in Los Angeles County, with a high consumption rate relative to catch rate.[9]

Fish that forage in reef habitats, such as kelp bass and some surfperch, reside in the contaminated area but do not feed on prey living in bottom sediments. In previous studies they were generally found to be less contaminated than white croaker; however, in certain locations sampled in the 1987 OEHHA survey, these species had high enough levels of DDTs and PCBs that the State included them in the fish consumption advisories (Pollock *et al*. 1991).

Pelagic fish, such as Pacific chub mackerel and Pacific bonito, do not reside full time in the contaminated area and do not feed on mud-dwelling organisms. Previous studies found that concentrations of DDTs and PCBs in pelagic species generally were low, and no such species were included in the State consumption advisories for southern California coastal waters. However, these previous analyses were generally limited to DDTs and PCBs; little data existed on the levels of mercury and other potential contaminants of concern across all the species targeted by subsistence and sport fishers.

While noting these general trends identified in past studies, EPA and the Trustees jointly embarked on the 2002-2004 Southern California Coastal Marine Fish Contaminants Survey to provide a more current, comprehensive data set that would allow more detailed, robust evaluation of contamination trends by species, location and fish preparation (*e.g.*, skin-off fillet, skin-on fillet, whole fish, whole-gutted fish).

[8] Allen *et al.* (1996) identify white croaker as the second most commonly caught fish from piers, jetties, and private boats in Santa Monica Bay (Point Dume to Cabrillo Pier), behind Pacific chub mackerel.

[9] Catch and consumption data summarized from RecFin data obtained from http://www.recfin.org. See Sampling and Analysis Plan for additional catch data.

1.3 Survey Objectives

An overarching goal of this survey is to provide comprehensive information that complements available historical data and other ongoing ocean fish sampling programs, while also addressing the needs and data gaps identified above.

Based upon the information needs/data gaps summarized in Section 1.2, with discussion from a Scientific Review Board (see Section 2.1), EPA and the Trustees developed the following specific objectives for the Fish Contaminants Survey:

- Generate reliable information on contaminants of concern in fish caught by subsistence and sport fishers in the study area:
    - To inform the public on how to reduce their health risk by avoiding or limiting consumption of more contaminated fish, and/or modifying fish preparation methods, and
    - To provide information to the public on fish species and locations considered safer for fish consumption;
- Assess the adequacy of the existing commercial no-take ("commercial catch ban") zone for white croaker in the vicinity of the PV Shelf;
- Identify suitable locations for artificial reef projects to restore the lost fishing services to the public; and
- Provide information for evaluation of current and future risks related to the PV Shelf Superfund investigation and the potential cleanup action for the contaminated sediment.

1.4 Survey Components

EPA and the Trustees are using the results of this survey to evaluate and design projects that allow the public to both avoid consuming contaminated fish and specifically target fish with low contamination levels. The types of response and restoration actions that will be supported by data generated by the Ocean Fish Contaminants Survey include the following:

- **State fish consumption advisories.** The results of the survey are being provided to OEHHA to update the existing fish consumption advisories for Southern California marine waters. Survey results on contaminant levels in 23 fish species and species groups in 22 coastal segments provide data for this purpose.
- **State white croaker commercial catch ban.** The California State Department of Fish and Game (CDFG) established a commercial catch ban for white croaker in a zone of the PV Shelf in 1990. As a component of the overall survey, ten white croakers were analyzed from five specific locations in four sampling events over two years to evaluate the adequacy of the existing commercial catch ban.

- **Public information.** EPA and the Trustees are collaborating with numerous state and community organizations and health agencies to give the public information about reducing exposures to contaminated fish and how they may take advantage of alternative opportunities to target low-contaminant fish along the coast of Southern California. The survey results will help provide meaningful information about the specific nature of the fish contamination problems and preferable fishing opportunities along the coasts of Los Angeles and Orange Counties. This information will enable the public to make informed decisions about where to fish, what fish to eat, and how best to prepare the fish (*i.e.*, skinning, filleting) to reduce contaminant exposure.

- **Restoration of lost fishing opportunities.** The Trustees, as part of their natural resources restoration plan, are preparing to construct artificial reefs in locations where such a change in habitat would displace the most highly contaminated soft-bottom fish species and increase the availability of less contaminated fish. Survey results on contaminant levels in skinless fillets from 23 fish species and species groups in 22 coastal segments provide data for this purpose.

- **Site remediation.** Most of the DDTs and PCBs causing the fish contamination are in the seafloor sediments. EPA is using the survey results as one of the scientific bases to design its cleanup action to reduce the extent to which DDTs and PCBs are released into the environment from the sediments.

The following sections of the report describe the study design, fish collection, laboratory analysis and quality assurance/quality control, and summarize study results.

2 STUDY DESIGN

This section describes the development of the Ocean Fish Contaminant Survey. This information provides a summary of the more detailed Sampling and Analysis Plan (SAP) developed by the Trustees as well as the process followed in its design.[10] The following two sections then discuss the implementation of the Plan (Section 3, Fish Collection, and Section 4, Laboratory Analysis).

2.1 Process Overview

The Trustees, with NOAA as lead Federal Trustee, initiated planning for the Ocean Fish Contaminant Survey by convening a scientific review board (SRB) in late 2001 to identify the best way to survey contaminants (primarily, but not limited to, DDTs and PCBs) in marine fish commonly caught in the study area. The SRB comprised nearly two dozen public- and private-sector individuals with expertise specific to the Southern California coastal areas and experience in key technical areas necessary to the development of the plan.[11] The SRB was tasked with addressing several crucial design aspects for a survey that would meet the needs of the Trustees, EPA, and other potential data users. Specific data use objectives identified for the SRB at the outset of the project included the planning and design of fishing restoration projects (*e.g.*, constructed reefs) and providing reliable information about contaminant levels in fish that could be used to update public fishing advisories for shore based and boat based anglers. Members of the SRB met at several plenary sessions to discuss the overall approach and also worked in smaller groups by technical field to address particular questions between plenary meetings.

The survey design recommendations of the SRB were used to develop the full SAP for the Ocean Fish Contaminant Survey. NOAA and EPA developed the SAP jointly, with assistance from those agencies' consultants (Industrial Economics, EcoChem Inc., and CH2M Hill). Thus, the SAP for the Ocean Fish Contaminant Survey was developed both for the specific natural resource restoration data needs of the Trustees and for EPA's needs to update the Institutional Controls program, including information on current white croaker commercial catch ban and sports fishing consumption advisories, and evaluate human and ecological risks and potential cleanup actions associated with the Palos Verdes Shelf Superfund Site.

The SRB met several times and discussed major design issues including target species, locations, chemical analytes, sample statistical requirements, field and laboratory quality assurance requirements, and laboratory selection guidelines. An adaptive approach was developed that involved a large initial fish collection effort, followed by multiple phases of contaminant analysis. This allowed for the consolidation of collection efforts (which have large

[10] The Sampling and Analysis Plan is Attachment 1 to this document.

[11] The SRB represented public and non-profit entities including the State of California (Department of Fish and Game, Office of Environmental Health Hazard Assessment, Department of Health Services), County Sanitation Districts of Los Angeles County, Port of Los Angeles, Heal the Bay, Santa Monica Bay Restoration Project, Southern California Coastal Water Research Program, and Pacific States Marine Fisheries Commission, as well as various private and academic consultants.

start-up costs) and resulted in the collection of most fish in a short time period. The phasing of laboratory analysis of fish allowed for iterative refinement of numbers, species, and locations of fish to be analyzed based on initial laboratory results. Thus, an initial set of fish was selected to be analyzed soon after most of the fish were collected to provide information on levels of contaminants in key species and locations, based on documented injury, prior fishing advisories, other historical fish contamination data, prior fish contamination history and applicability to the Trustees' and EPA's restoration and remediation purposes. After reviewing the early analytical results, NOAA and EPA identified a subsequent additional set of fish samples to be analyzed to fill remaining data gaps for the Survey (laboratory analysis results are discussed in Section 5).

2.2 Overall Sampling Design

2.2.1 Identification of Chemicals of Potential Concern

Several factors were considered as part of the COPC selection process:

(a) *Relevance to litigation* – DDTs and PCBs were the basis for the injuries to fishing services identified in the Montrose litigation and resulting settlement and are also the basis for current fishing advisories in the study area. For these reasons, DDTs and PCBs are a central focus of this project.

(b) *Bioaccumulation potential in fish* – Anglers and people who consume the fish they catch may have greater exposures to contaminants that bioaccumulate through the food web.

(c) *Persistence in the environment* – Contaminants that are persistent within the environment (*e.g.*, organochlorines and inorganics) have a greater potential impact on anglers and people who consume fish over long periods of time.

(d) *Detection history of other contaminants in the study area* – Other chemicals (*e.g.*, mercury, chlordane) have been detected in fish (and other biota and media) in the study area and may accumulate to levels of concern. Analyses for these contaminants provide important, current information to the public about their potential exposures to these contaminants regardless of their direct connection to the case. An understanding of these other contaminants in fish is particularly important for the Trustees' fishing restoration purposes, so that anglers are not misdirected to alternative fishing locations and species where levels of DDTs and PCBs are lower but other contaminants exceed levels of concern.

(e) *Contaminant thresholds for human health effects from consumption pathways* – To assist in the evaluation of whether other contaminants are likely to be present at levels of concern, contaminant levels in fish from historical studies were compared to various human-health based effects thresholds.

Several sources of information were analyzed as part of the evaluation of these factors. The Coastal Fish Contamination Program (CFCP 2001) tested fish collected in 1999 and 2000 in

some portions of the study area for a variety of contaminants (see SAP for additional information). Other sources for area-specific contaminant data in fish tissue include Pollock *et al.* 1991, Allen and Cross 1994, TSMP 1995, Allen *et al.* 1998, and CSDLAC 2000. Information about human health effects thresholds was obtained from EPA's IRIS database. Estimated fish consumption rates (*i.e.*, grams of fish consumed per unit of time) for study area anglers were obtained from several sources, including Puffer 1982, Allen *et al.* 1996, U.S. EPA 2000, and OEHHA 2001.

Based on comparison of CFCP data and screening values for human health effects, several contaminants (mercury, arsenic, chlordane, hexachlorobenzene, toxaphene and dieldrin) show at least one exceedance. However, exceedances were rare for toxaphene and hexachlorobenzene. Only one percent of CFCP samples showed an exceedance for toxaphene (this exceedance occurred for subsistence consumption rates at or above 142.4 g/day). Two percent of hexachlorobenzene samples exceeded screening values (also based on at least 142.4 g/day consumption). Approximately five percent of samples exceeded dieldrin screening values, with half of those exceeding at the lowest consumption rate. This evaluation was complicated, however, by the relatively high (2 ppb) method detection limit (MDL) for dieldrin in the CFCP study, which is higher than the screening value for all but the lowest consumption rate. Thus, dieldrin analysis requires a more sensitive detection method (*i.e.*, one with an MDL near 0.1 ppb) due to its relatively high toxicity. For arsenic, screening values for human health effects were based on inorganic arsenic, while the CFCP data measure total arsenic. The arsenic in fish primarily consists of organic arsenic compounds, which have minimal toxicity relative to inorganic arsenic. Given the above considerations and after discussion with OEHHA, the Trustees and USEPA selected DDTs, PCBs (on a congener basis), mercury, chlordane, and dieldrin for contaminant analysis.

2.2.2 Determination of Sample Size and Type

The SRB recommended analyzing individual fish, rather than composites of multiple fish, for organochlorines in most situations. While resulting in higher analysis costs for a given number of fish, this approach was recommended because individual-based analysis allows for within-segment estimation of the variance structure and magnitude for a given species. Estimates of variance structure identifies critical elements for understanding the nature of the contamination in the fish such as the impact of outlier individual(s) (*i.e.*, unusually “clean” or contaminated), the degree of modality in the distribution (single mode or multiple modes, indicating a single or multiple sources of contaminated fish), and the relationship be between body size and contaminant concentration. Estimation of the magnitude of variation within a segment and species provides the critical information needed for evaluating the confidence one can place on the mean value. Given individual-based data, it is possible to estimate the level of confidence with which reported means and distributions of contamination, derived from the sampling program, accurately reflect the populations of fish from which they were taken through the use of statistical power analyses and similar calculations. Finally, information that quantifies within segment variation is essential for interpreting between segment differences in contaminant concentrations. This final feature is a fundamental component for developing the geographic distribution of fish consumption advisories.

A sample size of ten was identified for testing DDTs and PCBs for each location and species. As described above, each fish sample was analyzed individually (*i.e.*, not in composite form), except for a small number of transient pelagic species expected to have uniform and lower contaminant levels relative to more resident species throughout the study area. These pelagic species were analyzed as 10-fish composites. In addition, all species were initially analyzed for mercury as 10-fish composites due to expected lower variability within a species. Homogenized material for individual fish was retained and in some cases subsequently analyzed for mercury at the individual level to evaluate spatial differences in mercury concentrations that emerged in a few species.

The choice of ten samples per species per location for analysis reflects a balance between analytical costs and the need for sufficient samples to provide a reasonable level of confidence in the decisions and recommendations made from the data. Prior to sampling, a statistical power analysis based on historical data was conducted to estimate the sample size required to adequately characterize a segment. However, this analysis was limited or not possible for many target species, and in other cases did not reflect current contamination levels and distributions. Choices concerning the number of fish samples to analyze in future testing should take into account results from this study.

2.2.3 Specification of Matrix

The SRB recommended that samples from the field be preserved as whole, gutted fish. Viscera were removed to prevent contamination of surrounding tissues during freeze/thaw processes. For analysis, a skin-off fillet (muscle tissue, with the belly flap removed) preparation was proposed for the initial analysis phase. This preparation is used by the state of California to determine fishing advisories; is a preparation method commonly used by anglers; and is relatively simple to prepare, and so less likely than other preparations (*e.g.*, whole body) to generate analytical results that vary due to sample homogenization or similar preparation issues.

However, angler studies indicate that fish are consumed in a variety of preparations besides skin-off fillet, and results from a 1996 Heal the Bay study (Gold *et al.* 1997) generally indicate a trend of higher DDT levels in whole, gutted fish compared to fillets or muscle tissue. For white croaker, Allen *et al.* (1996) indicate that a large percentage (68 percent) of the population consuming white croaker eat whole, gutted fish. Therefore, a comparison of concentrations between skin-off fillets and whole gutted fish was envisioned as a second phase of analysis. Preparations used in other studies (*e.g.*, skin-on fillet) and ecological risk assessment considerations (*e.g.*, whole fish) led to an expansion of the initial analysis to a four-part comparative analysis (skin-off fillet, skin-on fillet with belly flap, whole gutted fish, and viscera). For two representative species (white croaker and kelp bass), viscera were preserved from one or both species at seven segments. Following the initial analysis of skin-off fillets, thirty analyzed white croaker and kelp bass were selected to represent a range of locations and skin-off fillet contaminant levels. These fish were further resected and analyzed to provide comparison within an individual fish of the different preparations. The skin-off fillet from one side (previously analyzed), the skin-on fillet from the other side, the remaining tissue and skeleton (“remainder”), and the viscera were each weighed and analyzed, providing the ability to

estimate the concentrations of contaminants in the four desired preparations (skin-off fillet, skin-on fillet with belly flap, whole gutted fish, whole fish) from the skin-off fillet concentration.

2.2.4 Species Selection Process

The following factors were considered as part of the fish species selection process, with associated rationale for inclusion:

(a) *Shore-based and boat-based biomass of each species caught by recreational and subsistence anglers* – Target species include those frequently caught by anglers in general;

(b) *Biomass of each species caught per angler trip* – Consideration was given to species that may rank low in total biomass caught, but represent a high proportion of the catch for sub-populations of anglers targeting these species (*i.e.*, fewer anglers catch these species, but those that do catch large numbers of the species);

(c) *Fishing advisories* – Collection of species included in DDT- and/or PCB- based consumption advisories allows for current assessment of contaminant levels in these fish and evaluation of spatial gradients in contamination;

(d) *Historical fish contamination data* – Historical data from the study area were evaluated to identify additional species (other than those included in fishing advisories) likely to have elevated levels of DDTs and PCBs (and species for which data are lacking); and

(e) *Likelihood that the species would be attracted to artificial reefs* – For this study, it is important to determine contaminant levels in the types of species that would inhabit newly constructed reefs.

Sources of information on fishing patterns and contamination were analyzed as part of the evaluation of these factors. Data compiled from the Pacific States Marine Fisheries Commission's Recreational Fishing Information Network (RecFIN) were used to estimate the angler trips and biomass of various species caught from shore and by boat (within three miles of shore) by anglers at each RecFIN sampling site within the study area. Angler intercept studies and population-level fishing estimates were analyzed over the 1996-2000 period. Further detail is provided in the SAP.

Fish advisories established by the state of California, along with historical fish contamination data sets in the study area (*e.g.*, Pollock *et al.* 1991, SCCWRP *et al.* 1992, Allen and Cross 1994, TSMP 1995, CSDLAC 2000, QEA 2000, and CFCP 2001), provided information considered in the species selection process. Input from experienced fishermen and biologists familiar with the study area was utilized to help address limitations associated with available data.

Twenty-five species and/or species groups were selected for collection and analysis, based on current fishing advisories in Southern California, available data on recreational and

subsistence fishing, historical fish contamination data, and the likelihood that a particular species would be attracted to an artificial reef. For reporting purposes, the selected species were divided into four different general dwelling characteristics: hard bottom, hard and soft bottom, soft bottom, and pelagic (Table 2-1).[12] In order to be representative of normal angler catch, a size range was specified for each species. The ranges were determined from the catch examined by survey personnel in RecFIN angler intercept studies. Minimum and maximum lengths are based on the middle 80 percent of observed catch from these studies, to exclude potential outlier sizes. Modifications were anticipated to this size range based on actual catch experience during the collection effort. Changes to the initial size ranges are documented in the field summary (Chapter 3) and noted in Table 2-1.

Three species groups were designated, due to similarities in appearance among members of each group, which can lead to difficulties in angler identification beyond the general level: water-column feeding surfperch, benthic-feeding surfperch, and rockfish. The benthic-feeding surfperch complex includes the following species: white seaperch, barred surfperch, calico surfperch, pile perch, black perch, rainbow seaperch, dwarf perch, striped seaperch and rubberlip seaperch. The water-column feeding surfperch complex includes the following species: walleye surfperch, silver surfperch, spotfin surfperch, shiner perch and kelp perch. Any members of the genus *Sebastes* were included as rockfish. All three of these species groups were included in the hard-bottom dwelling category; however, individual species within each group may actually be pelagic or soft-bottom dwelling.

2.2.5 Selection of Sampling Area and Segments

Sampling locations were generated within the coastal area bounded by Ventura to the north and Dana Point to the south (see Exhibit 2-1).[13] Scientific studies, including those conducted as part of the Montrose litigation (*e.g.*, QEA 2000), determined that fish (and other biota) within this area are exposed to DDT and PCB contamination released by Montrose and other defendants of the case. While elevated levels of DDTs and PCBs may exist in other regions, sampling of those areas is outside the scope of this effort. The sampling area was divided into segments, with target species identified for each segment.

[12] Dwelling characteristics do not necessarily represent foraging habits, which may also significantly affect contaminant levels.

[13] Multi-page exhibits are located at the end of each chapter.

Table 2-1
Fish Species Overview and Specified Lengths

Species (Common Name)	Species Code	Scientific Name	Minimum Total Length (in mm)[4]	Maximum Total Length (in mm)[4]
HARD-BOTTOM SPECIES				
Opaleye	OP	*Girella nigricans*	165	400 (330)
Sargo	SA	*Anisotremus davidsonii*	170	350
Kelp bass	KB	*Paralabrax clathratus*	305[3]	500 (420)
Surfperch – BF[1]	BF	*Embiotocidae* spp.	150	360
Surfperch – WCF[1]	WCF	*Embiotocidae* spp.	100[2]	200[2]
Rockfish[1]	RO	*Sebastes* spp.	200	350
California sheephead	CS	*Semicossyphus pulcher*	305[3]	540
HARD/SOFT-BOTTOM SPECIES				
Topsmelt	TO	*Atherinops affinis*	130	240
Barred sand bass	BS	*Paralabrax nebulifer*	230[3]	500 (400)
Halfmoon	HA	*Medialuna californiensis*	210	330
California scorpionfish	SC	*Scorpaena guttata*	255[3]	
White seabass	WS	*Atractoscion nobilis*	200	500
Black croaker	BC	*Cheilotrema saturnum*	180	360 (260)
PELAGIC SPECIES				
Pacific chub mackerel	CM	*Scomber japonicus*	130	460
Pacific sardine	PS	*Sardinops sagax*	150	220
Pacific barracuda	PB	*Sphyraena argentea*	720	900
SOFT-BOTTOM SPECIES				
White croaker	WC	*Genyonemus lineatus*	160	300 (260)
Jacksmelt	JA	*Atherinopsis californiensis*	220	390 (350)
Yellowfin croaker	YC	*Umbrina roncador*	200	380 (340)
California corbina	CC	*Menticirrhus undulatus*	260 (280)	520
California halibut	CH	*Paralichthys californicus*	560[3]	820
Shovelnose guitarfish	SG	*Rhinobatos productus*	500 (560)	1100 (1020)
Queenfish	QU	*Seriphus politus*	120	260 (240)

[1]BF= benthic feeding; WCF= water column feeding. Note that all three species groups contain both species that dwell over had bottom and species that may be more appropriately classified as soft-bottom dwelling or pelagic. To the extent possible, fish collected in the field were identified to the species level.
[2]Values are based on available data for walleye and shiner perch. Other water-column feeding surfperch were kept regardless of size.
[3]Minimum lengths are truncated at the State of California legal size limits.
[4]Values originally specified in the Sampling and Analysis Plan and Field SOPs are listed in parentheses.

Several factors were considered as part of the segment identification and selection process:

(a) *Fishing pressure at shore-based fishing locations* – Among other considerations, it is important to define and include segments that capture locations frequently used by recreational and subsistence anglers.

(b) *Biomass of target species caught at shore-based fishing locations* – RecFIN data indicate substantial differences between sites in the types and amounts of fish caught by shore-based anglers. Selected sites include those with historically large catches of targeted species.

(c) *Site-specific fishing advisories* – The state of California has established several site-specific fishing advisories in the study area based on DDT and PCB contamination levels in fish. Sites specified in these advisories (along with neighboring sites) were included to provide updated data on fish contaminant levels in these areas.

(d) *Fishing pressures and catch rates at offshore locations* – Data on fishing pressures and catch rates from commercial passenger fishing vessels from RecFIN and the California Department of Fish and Game (CDFG) was used to identify locations commonly fished by boat-based anglers.

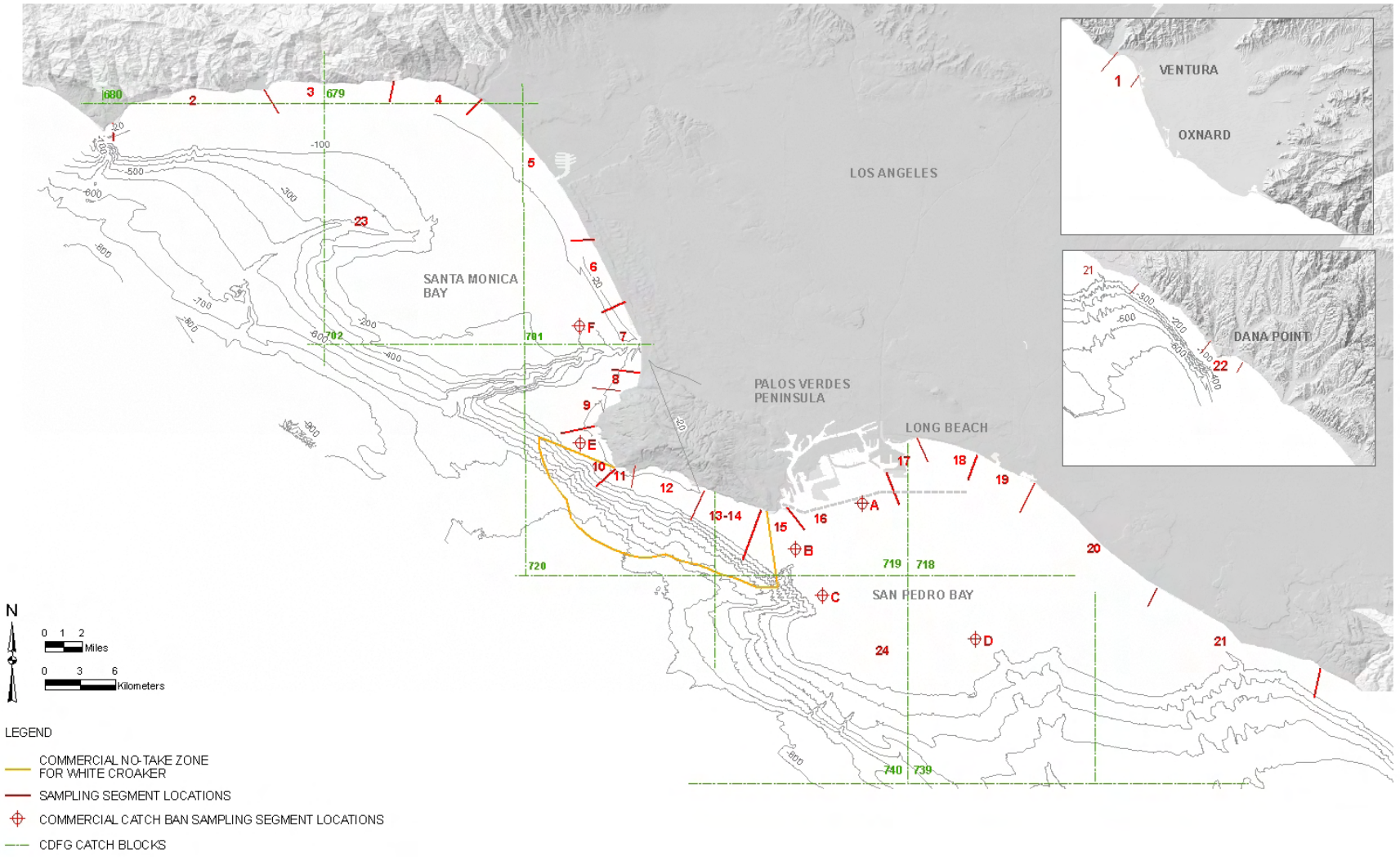
(e) *Historical DDT and PCB contamination data* – Historical gradients in DDT and PCB contamination within the study area were considered to help determine the sampling density needed for shoreline fishing locations. Areas characterized by relatively constant or slight changes in contamination levels require a lower sampling density than areas characterized by variable or rapid monotonic changes in levels. Evaluation of historical information also helped identify spatial gaps in fish contamination data and additional areas with elevated DDT and PCB levels.

(f) *White Croaker Commercial Catch Ban* – The State of California Department of Fish and Game has established a commercial catch ban area for white croaker on the Palos Verdes Shelf (Figure 1-1). A component of EPA's institutional controls program is aimed to enforce the commercial catch ban area as a part of the Palos Verdes Shelf Superfund response actions. As part of the Ocean Fish Contaminant Survey, the edges of this commercial catch ban zone, both nearshore and offshore, were tested to determine whether the current ban area is adequate.

Several sources of information were analyzed as part of the evaluation of these factors. RecFIN data were used to estimate site-specific fishing pressure, species, and biomass catch from shore-based locations (piers/man-made structures, beaches, and banks) in the study area. Information on catch and fishing location from commercial passenger fishing vessels obtained from the CDFG was used to identify offshore fishing locations. Contaminant studies performed in previous years (*e.g.,* Pollock *et al.* 1991, SCCWRP *et al.* 1992, Allen and Cross 1994, TSMP 1995, CSDLAC 2000, QEA 2000, and CFCP 2001) provide information about historical spatial gradients of DDT and PCB contamination in fish (and other media). As described above, information from state of California fishing advisories in the study area was included in the site selection process.

Figure 2-1 provides maps of the targeted segments. Exhibit 2-1 describes the segments and their boundaries, as well as indicating current fishing advisories and rationale for targeting particular segments.

Figure 2-1
Ocean Fish Contaminants Survey Sampling Locations



2.2.6 Fish Collection Requirements

Given the decision to analyze ten samples for each target species/location combination in the initial analysis phase, a collection minimum of 15 fish for each target was set, and up to 30 samples were kept. Additional fish were kept in order to allow for repeat chemistry analysis as needed, to replace samples that were damaged or lost, to increase sample size if it is later determined that additional precision is necessary, and for other QA/QC considerations.

The SAP did not specify fish collection methods to be used by fish collectors, choosing instead to rely on the judgement of the collection contractor and site-specific considerations. However, all methods used by fish collectors conformed to federal, state, and local regulatory requirements and did not damage the physical integrity of the fish (*i.e.*, no puncture or gouging of skin of fish). The collection method for each fish sample was clearly noted in a field logbook. Sampling locations were recorded by latitude and longitude or by reference to appropriate permanent markers. Details on the collection methods are documented in the field summary (Chapter 3).

2.2.7 Collection and Analysis Overview

Exhibit 2-2 presents the combined collection goals by species and location, taking into account priorities and information from the species and location selection processes. Selected samples are marked as primarily relevant for reef planning or related restoration purposes, for public information or other EPA purposes, or for both purposes. Exhibit 2-3 presents the analysis plan for the initial round of analysis. The plan for the initial round of analysis was used to prioritize the effort made for particular species at each location. The actual collection results (and fish selected for the various rounds of analysis) are discussed in Chapter 3.[14] In the first round, all samples/segments containing white croaker or representative of current fishing advisories were evaluated. Pelagic fish, due to the presumed low contaminant levels and thus likelihood of recommendation for consumption, and fish from potential reef sites closest to the Palos Verdes Shelf were also analyzed in the first round. Subsequent rounds of analysis addressed whole body analyses on kelp bass and white croaker (following the apportionment described in Section 2.2.3) and further investigation into areas of interest based on first-round results. This included individual checks on some previous composites (both organic and mercury), analysis of species of interest at segments where fewer than ten specimens were collected, and analysis of additional species in areas of interest.

2.3 Analytical QA/QC

The Trustees and EPA developed stringent quality assurance/quality control (QA/QC) requirements, due to the broad implications of the work for restoration efforts and human

[14] Table 3-2 presents the actual catch results and analysis decisions for each round of analysis.

consumption advisories. The QA/QC requirements were designed to meet high standards for accuracy and precision, and reflected SRB members' knowledge and experience with state of the art laboratory techniques. The QA/QC approach relied on performance-based standards, rather than method-based. This section outlines the analytical QA/QC procedures that provided the basic guidance for laboratory protocols to ensure that the quality of the data met the needs of its users. Specific reference material and measurement quality objectives (MQOs) for target analytes and methods (*e.g.*, DDTs and PCBs by GC/MS-SIM) are included. The laboratories' implementation of these QA/QC requirements, including QAPPs and SOPs (Attachment 2), is discussed in Section 4.

2.3.1 Analysis Methods

Several laboratory methods are available to characterize organochlorine analytes; each has different advantages and disadvantages. PCBs in particular present a special characterization challenge due to the high number of congeners (209). Several methods have been employed to estimate the sum of PCBs present in a sample (Aroclors, congeners, homologues, and variations in approaches for summing these components). To achieve a desirable balance between the representativeness of total PCB characterization and the cost of analysis, the Trustees and EPA suggested GC/LRMS-SIM as a likely analytical method to potential laboratories. This method was suggested because it provided the greatest advantages and flexibility for quantifying both the DDT isomers and PCB congeners at a reasonable cost.

The results for total PCBs presented in this report are calculated as a sum of congeners analyzed. A list of 45 congeners was selected by the Trustees for individual quantitation based on past work in the California Bight, in consultation with OEHHA.[15] If a congener was reported as non-detected, then zero was used in the summation. In addition to quantitation as individual congeners, PCBs were quantitated by homologue group (*i.e.*, level of chlorination or LOC). Both target and non-target PCB congeners were included in the summation for each homologue. The sum of the homologue groups (which includes all 209 congeners) provides an alternative method of estimating the total PCB concentration. Details regarding the quantitation methods employed are provided in the laboratory SOPs (Attachment 2).

The remaining organochlorine analytes were analyzed by the same methodology as the PCB congeners. These analytes were DDT isomers (*p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD); the principal components of technical chlordane *(cis/trans* chlordane, oxychlordane, and *cis*/*trans* nonachlor); and dieldrin. Total mercury was analyzed in fish tissue by cold vapor atomic absorption spectroscopy.

Analysis of percent lipid and moisture content for each sample was also performed. Percent lipid (or "total extractable organics") was determined using a gravimetric method on an aliquot of the solvent extract used for the organochlorine analysis. Moisture content was determined by drying a sample aliquot at 105 °C.

[15] PCB analyte list: 8, 18, 28, 31, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 195, 201, 203, 206.

2.3.2 QC Procedures

Method detection limit targets were defined for each potential analyte to meet Trustee and EPA needs for risk assessment (Table 2-2). Laboratories verified reported detection limits in the tissue matrix following the methodology in 40 CFR Part 136 Appendix B.

Table 2-2
Specifications for Likely Analytical Methods

Method	Parameter	Analyte	Target Detection Limit (ng/g wet weight)
GC/MS-SIM (Gas Chromatography/ Mass Spectrometry with Single Ion Monitoring)	Organochlorine pesticides and PCBs	p,p' and o,p' isomers of DDT, DDE and DDD	1.0
		PCB Congeners	0.1
		Chlordane	1.0
		Dieldrin	0.1
Cold Vapor Atomic Absorption Spectroscopy	Mercury	Total mercury	15

As part of sample plan development, the Trustees developed MQOs for organochlorine compounds and for mercury. Details of the implemented MQOs are discussed in Chapter 4. The MQOs include the accuracy and precision criteria for calibration of equipment, tuning of the GC/MS, reference materials, method blanks, matrix spikes, spiked blanks, sample duplicates, internal standards, and surrogates. Explanations and rationale for the MQOs are provided below:

(a) *Calibration, Continuing Calibration, and GC/MS Tune* - For accuracy, the instrument was calibrated against standards traceable to a recognized organization for the preparation and certification of QA/QC materials (*e.g.*, NIST). Demonstration of stable instrument calibration provides the basis for both accuracy (*i.e.*, how close a measurement is to the "true" value) and precision (*i.e.*, how repeatable a measurement is).

(b) *Reference Materials* - Reference materials were used to assess the accuracy of the analytical method. Also, through control charting of the results from the reference materials across batches, on-going precision (from batch to batch) was evaluated.

(c) *Method Blanks* - Method or procedural blanks were used to assess the laboratory contamination during all stages of sample preparation and analysis. The method blank was processed through the entire analytical procedure in a manner identical to the samples processed. A blank may be either a true blank, using no matrix, or a matrix blank, using the target matrix (*i.e.*, fish tissue) or a reasonable facsimile.

(d) *Matrix Spikes* - Matrix spikes (*i.e.*, spiked sample matrix) were used to evaluate the effect of the sample matrix (in this case, fish tissue) on the recovery of the analyte. The matrix spike included all the analytes being measured, and the spike was introduced into an aliquot of a field tissue sample prior to extraction.

(e) *Sample Duplicate* - Duplicate samples were used to assess the homogeneity of the samples and the precision of the analytical method in quantifying target analytes. The relative percent difference (RPD) between the sample and sample duplicate was calculated as a measure of this precision. While matrix spike duplicates are the standard duplicate analysis, a sample duplicate was chosen for this project due to the expected elevated contaminant levels in the samples.

(f) *Surrogate Standards* - Surrogate standards or recovery surrogates are compounds chosen to simulate the analytes of interest in organic analyses. They can be used as a reference analyte against which the signal from the analytes of interest is compared directly for the purpose of quantification. Surrogate standards are also used to assess the extraction efficiency of the analytes of interest.

(g) *Internal Standards* - Internal standards were added to each sample extract just prior to instrumental analysis to enable optimal quantification, particularly of complex extracts subject to matrix effects or retention time shifts relative to the analysis of standards.

(h) *Laboratory Control Standard* - The LCS is a sample of the target matrix that contains known quantities of the analytes of interest. An LCS was run with each batch of samples for organic analysis to evaluate laboratory accuracy and precision between batches.

2.3.3 Reference Materials

Based on Trustee concerns about the variable accuracy of laboratory work conducted as part of past studies, the accurate and reliable extraction and analysis of fish tissue was a key QA concern. Reference materials are previously prepared and characterized samples of the target matrix of a study, used to assess the accuracy of the analytical method (*i.e.*, how close a measurement is to the "true" value) in the context of the specific matrix (*i.e.*, fish tissue). As opposed to QC samples that have been spiked with known amounts of various analytes (*e.g.*, the matrix spike or the LCS), the reference material contains independently verified quantities of target analytes naturally present in the matrix of interest. In essence, the reference material demonstrates the accuracy of measuring contaminant levels in a particular matrix. As such, it is the key indicator of extraction efficiency. Also, through control charting of the results from the reference materials across batches, on-going precision (from batch to batch) can be evaluated. The reference material is run with each batch of samples (15 field samples for organic analyses, 20 for inorganic).

Two reference materials (RMs) for organochlorine compounds were analyzed with the fish tissue samples. The first was a standard reference material, Lake Superior Fish Tissue SRM 1946, certified by the National Institute for Standards and Technology (NIST 2004). The reference material was analyzed with each batch (15 samples per batch) of fish tissues. This reference material is certified for 28 PCB congener concentrations, for four of the six DDT analytes, five chlordane analytes, dieldrin, and lipids. The results for these analytes were to be within specified control limits or the laboratory was required to re-analyze the batch of samples.

In order to evaluate accuracy, particularly for extraction in more highly contaminated fish tissue, the Trustees coordinated with NIST to develop a new reference material using white croaker. White croaker from the Palos Verdes shelf were filleted and then sent to NIST to develop a reference material for organochlorine analyses. The laboratory was provided this reference material for batches expected to have high concentrations of PCBs and DDTs based on results of prior analytical programs (greater than 1 ppm DDTs and greater than 1 ppm PCBs). Because the white croaker RM was not certified for the target analytes, the laboratory was not required to reanalyze if a target analyte were outside the control limits. Rather the white croaker control material was used to provide an on-going measure of extraction efficiency at high concentrations of target analytes.

A reference material from the National Research Council of Canada, NRC dogfish muscle tissue DORM-2, was used as the reference material with the total mercury analysis (NRC 1999). As for the organochlorine analyses, an analysis of the reference material was included with each batch of mercury analysis. The laboratory was required to obtain a result within the specified control limits or the analytical batch was to be re-analyzed.

2.3.4 Laboratory Selection

A request for proposals was sent to a set of laboratories that had recently provided strong technical proposals for another project that involves Total PCB/PCB congener work in biota or that had been recommended by SRB members from past experience. Candidate laboratories were not limited to California, but sample delivery logistics was considered in the selection process. Likewise, state certification in California was not required, but was a secondary consideration in the proposal evaluation process. The following criteria describe the requirements for potential laboratories recommended by the SRB members, and evaluated by the Trustees and EPA as part of the selection process:

(a) Fish dissection and tissue preparation experience and capabilities;

(b) Past laboratory experience with organochlorine analyses of fish tissue;

(c) Laboratory analysis of the standard reference material (SRM);

(d) Laboratory's proposed analytical methods for lipids, DDTs, PCBs, chlordanes, dieldrin, and total mercury in fish tissue as well as laboratory facilities and equipment;

(e) Laboratory staff experience and experience of proposed laboratory project manager;

(f) Adequacy of laboratory capacity;

(g) Laboratory information management system and electronic reporting experience;

(h) Laboratory quality assurance plan;

(i) Location and sample delivery logistics; and

(j) Cost proposal.

Each laboratory provided the Trustees and EPA with a description of their proposed technical approach (*e.g.*, equipment, project manager, and relationship with consultants and Trustees) and cost information (*e.g.*, a per-sample price quote for each chemical analysis). The Trustees and EPA then evaluated the proposals based on technical qualifications and price to make a final selection. The laboratory selection process proceeded through the following steps:

1. A request for qualifications and proposed methodology was sent to the suggested list of laboratories.

2. As part of their submission, each laboratory provided information to enable the performance of a Laboratory Cost Evaluation on the following issues:

(a) Charge per sample given the estimated minimum number of samples, and for additional larger ranges.

(b) Methods for meeting QC requirements.

(c) Sample reanalysis and MDL requirements.

3. After Trustee and EPA evaluation of submittals, laboratories that were judged most qualified were asked to submit a Laboratory Performance Evaluation which included the following information:

(a) Analysis of white croaker reference material prepared by NIST (and analyzed by NIST for DDTs and PCBs).

(b) Analysis of SRM 1946 ('low level' DDTs and PCBs, chlordane, and dieldrin).

(c) Full electronic and written deliverables from the SRM 1946/Croaker RM analysis. The full data package and electronic deliverables were required for reporting the results of the Laboratory Performance Evaluation. Each laboratory performed, and provided as part of the package, a detection limit study for the specific matrix being used.

Based on the above considerations, Battelle was selected to provide both organic and mercury analyses. During the analysis, a second organization, Alpha Woods Hole Laboratory, was added to deal with later rounds of analysis to increase sample throughput. Both laboratories responded to the original request for qualifications.

Exhibit 2-1
Segment Locations And Descriptions

Segment Number And Name		Description	Advisory Species
1	Ventura: Emma Wood Beach to San Buenaventura Beach	Includes Ventura Pier and Marina. Northernmost of all sampling areas in this study, approximately 50 kilometers northwest of the next closest segment (Pt. Dume to Coral Beach).	
2	Pt. Dume to West End of Malibu Lagoon Beach	Immediately west of the Malibu segment (Segment 3). Although angler activity in the Pt. Dume segment is low, historical data indicate relatively high DDT concentrations in white croaker caught in the Malibu area (OEHHA 1991). To allow for evaluation of contamination gradients in this region, Malibu and adjacent areas have been divided into distinct sampling segments.	White croaker
3	West End of Malibu Lagoon Beach to Las Flores	This sampling segment includes Malibu Pier and the Malibu region.	Queenfish
4	Las Flores to West End of Santa Monica Beach	This sampling segment is immediately east of the Malibu segment.	
5	Santa Monica Beach to El Segundo	This segment includes Santa Monica Pier and Marina del Rey and is the northernmost area for reef evaluation. Samples of reef fish are expected to be collected from the rocky habitat around Marina del Rey.	
6	El Segundo to the South End of Manhattan Beach	This segment includes Manhattan Beach Pier. Because of its relatively northern location and low fishing pressure, reef fish collected from this segment also will not be tested in the initial round of chemical analysis.	
7	King Harbor Area: South End of Manhattan Beach to Redondo Beach	This segment includes Hermosa Beach Pier, King Harbor Pier/Jetties and Redondo Beach Pier. Samples of reef fish are expected to be collected from the rocky habitat near the King Harbor breakwater.	California corbina
8	Redondo Beach to Flat Rock Point	Although this segment is low in fishing pressure, its location near Palos Verdes will provide important information about spatial contamination gradients in soft-bottom feeding fish and reef fish. Fish collected from this segment will not be tested in the initial phase of the adaptive analysis program.	
9	Flat Rock Point to Palos Verdes Point	This sampling segment has the same boundaries as CSDLAC Sample Zone 3 (although CSDLAC sampling takes place in deeper waters: 60 meters and 100 meters).	
10	Palos Verdes Point to Point Vicente	This sampling segment is between CSDLAC Sample Zones 2 and 3.	White croaker
11	Point Vicente to Long Point	This sampling segment has the same boundaries as CSDLAC Sample Zone 2.	White croaker

Exhibit 2-1 **Segment Locations And Descriptions**			
12	Long Point to Bunker Point	This sampling segment is between CSDLAC Sample Zones 1 and 2.	
13/14	Bunker Point to Point Fermin	This sampling segment (combination of segments 13 and 14 from the initial plan) encompasses CSDLAC Sample Zone 1 and the area immediately to the east of it, including White Point.	White croaker, California scorpionfish, rockfishes, kelp bass
15	Cabrillo/Los Angeles Breakwater: Ocean Side	This segment includes the nearshore waters on the ocean side of the breakwater. A separate segment has been established for the inland side of the breakwater (see segment described below). Habitat conditions, fish species and foraging patterns are expected to differ between these two areas.	Surfperches, black croaker, white croaker, queenfish
16	Cabrillo/Los Angeles Breakwater: Inland Side	Target fish for this segment will be collected from the inland side of the breakwater	Surfperches, black croaker, white croaker, queenfish
17	Pier J to Finger Piers at Shoreline Park	Nearshore waters off Long Beach, on the eastern side of Pier J.	Surfperches
18	Belmont Pier/ Seaport Village	This sampling segment is approximately three to four kilometers southeast of Pier J, and is the southernmost segment that will be tested for reef purposes during the initial round of the adaptive analysis program.	Surfperches
19	Seal Beach: Alamitos Bay Jetties to Anaheim Bay	Approximately one kilometer south of the Belmont Pier segment.	
20	West End of Sunset Beach to Huntington Beach (Hwy. 39)	This sampling segment includes Huntington Beach Pier. It extends approximately one kilometer to the east of the Pier, where Hwy. 39 intersects the Pacific Coast Highway.	
21	Huntington Beach (Hwy. 39) to Pelican Point	This sampling segment includes Newport. Fish collected from the Newport segment will be compared to those collected in the Huntington Beach and Dana Point segments to assess contamination gradients in this region.	California corbina
22	Dana Point: East End of Mussel Cove to East End of Doheny Beach	This sampling segment includes Dana Point, and is the southernmost of all sampling areas in this study.	
23	Short Bank	This sampling segment has boundaries similar to Segment 5, but is further offshore. While Short Bank is a large deepwater area, the sampling is centered near the location in Pollock *et al.* 1991.	White croaker
24	Horseshoe Kelp	This sampling segment is on the ocean side of the Cabrillo/Los Angeles Breakwater, several miles east of Segment 15.	White croaker, California scorpionfish

Exhibit 2-1 **Segment Locations And Descriptions**			
A	Middle Breakwater	This segment approximates location 17 from the Pollock *et al.* 1991 study. The segment covers the ocean side of the middle breakwater between Los Angeles and Long Beach.	Surfperches, black croaker, white croaker, and queenfish
B	Approximately 2 miles offshore of Segment 15	As specified, for evaluation of the white croaker commercial catch ban.	
C	Approximately 5 miles southeast of Pt. Fermin	As specified, for evaluation of the white croaker commercial catch ban.	
D	Approximately 7 miles south-southeast of Station A	As specified, for evaluation of the white croaker commercial catch ban.	
E	West of Palos Verdes Point before Redondo Canyon	As specified, for evaluation of the white croaker commercial catch ban.	
F	West of Station E on the north side of Redondo Canyon	As specified, for evaluation of the white croaker commercial catch ban.	

Exhibit 2-2
Summary of Target Species/Sampling Segment Collection Requirements (modified from Exhibit 2-6 of SAP)

		Hard-Bottom Species							Hard/Soft-Bottom Species						Pelagic Species					Soft-Bottom Species						
Segment	Segment Name	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific chub mackerel	Pacific Sardine	Pacific Bonito	Pacific Barracuda	Yellowtail jack	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
1	Ventura																			P						
2	Pt. Dume to West End of Malibu Lagoon Beach	P		P	P				P											P						P
3	West End of Malibu Lagoon Beach to Las Flores														P	P	P	P		P						P
4	Las Flores to West End of Santa Monica Beach																			P						P
5	Santa Monica Beach to El Segundo	B	B	B	R				B	B	B			B						B	R	B	B	B	R	B
6	El Segundo to the South End of Manhattan Beach	R		R	R				R	R - 2 of 5 species					P	P	P	P		B	R	R	B	R	R	R
7	King Harbor Area	R	B	R	R				B		B			B						B	B	R	B	B	R	R
8	Redondo Beach to Flat Rock Pt.	R		R	R				R	R - 2 of 5 species										B	R	R	B	R	R	R
9	Flat Rock Pt. to Palos Verdes Pt.								P											C/R						
10	Palos Verdes Pt. to Pt. Vicente								P											B						
11	Pt. Vicente to Long Pt.														P	P	P	P		C/R						
12	Long Pt. to Bunker Pt.			P			P					P								B						
13/14	Bunker Pt. to Pt. Fermin, including White Point	P		P	P	P	P	P	P		P	P		P						B						
15	Cabrillo/LA Breakwater: Ocean Side[1]	R		B	B	B	B		B	B - 1 of 4 species				B	P	P	P	P		C/R	R	R	R	R	R	R
16	Cabrillo/LA Breakwater: Inland Side	B		B	B	B			B	B	B	B	B	B						C/R	B	R	R	B	B	B

Exhibit 2-2
Summary of Target Species/Sampling Segment Collection Requirements (modified from Exhibit 2-6 of SAP)

		Hard-Bottom Species							Hard/Soft-Bottom Species						Pelagic Species					Soft-Bottom Species						
Segment	Segment Name	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific chub mackerel	Pacific Sardine	Pacific Bonito	Pacific Barracuda	Yellowtail jack	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
17	Pier J to Finger Piers at Shoreline Park	R		R	B	B			R	B		B	B	B						C/R	B	R	R	B	R	B
18	Belmont Pier /Seaport Village	R		R	B	B			B	B			B	B						C/R	B	B	B	R	B	B
19	Seal Beach	R		B	B	B			B	B - 2 of 5 species										B	R	R	R	B	R	R
20	West End of Sunset Beach to Huntington Beach (Hwy. 39)								P						P	P	P	P		C			P			
21	Huntington Beach (Hwy. 39) to Pelican Pt.																			C			P			
22	Dana Pt.								P											C			P			
23	Short Bank			P				P	P			P	P							P						
24	Horseshoe Kelp			P				P	P			P	P							C						
A	Middle Breakwater				P	P								P						C						P
B	Approx. 2 miles offshore of Segment 15																			C						
C	Approx. 5 miles SE of Pt. Fermin																			C						
D	Approx. 7 miles S/SE of station A																			C						
E	West of Palos Verdes Pt. before Redondo Canyon																			C						
F	West of Station E on north side of Redondo Canyon																			C						

Collection key: P: for Public Information Purposes; R: for Reef purposes; C: for Commercial Catch Ban purposes; B: for both Public Information and Reef Purposes.
Shading indicates that a fishing advisory is in effect for that species in that segment or in an adjacent segment. Advisories at Segment 15 are based on the Los Angeles/Long Beach Harbor and Los Angeles/Long Beach Breakwater (ocean side) advisories from OEHHA. Segment 15 is located on the Palos Verdes shelf side of the Breakwater advisory and thus is expected to have similar or higher contamination levels.

Exhibit 2-3
Segment/Species Combinations to be tested for DDTs and PCBs in first phase of analysis (modified from Exhibit 2-10 of SAP)

		Hard-Bottom Species							Hard/Soft-Bottom Species						Pelagic Species					Soft-Bottom Species						
Segment	Segment Name	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific chub mackerel	Pacific Sardine	Pacific Barracuda	Yellowtail jack	Pacific Bonito	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
1	Ventura: Emma Wood Beach to San Buenaventura Beach																			P						
2	Pt. Dume to Malibu Bluff	P		P	P				P											P						P
3	Malibu Bluff to Las Flores														P^C	P^C	P^C	P^C	P^C	P						P
4	Las Flores to W. End of Santa Monica Beach																			P						P
5	Santa Monica Beach to El Segundo																			B						
6	El Segundo to S. End of Manhattan Beach																			B			B			
7	King Harbor Area: S. End of Manhattan Beach to Redondo Beach	R		R	R				B											B	B	R	B	B	R	R
8	Redondo Beach to Flat Rock Pt.																			B			B			
9	Flat Rock Pt. to Palos Verdes Pt.																			P						
10	Palos Verdes Pt. to Pt. Vicente																			P						
11	Pt. Vicente to Long Pt.														P^C	P^C	P^C	P^C	P^C	P						
12	Long Pt. to Bunker Pt.			P			P					P								P						
14	Royal Palms to Pt. Fermin			P	P	P	P					P		P						P						P
15	Cabrillo/LA Breakwater: Ocean Side	R		B	B	B	B		B			P		B						B	R	R	R	R	R	B
16	Cabrillo/LA Breakwater: Inland Side	B		B	B	B			B					B						B	B	R	R	B	B	B
17	Pier J to Finger Piers at Shoreline Park	R		R	B	B			R					B						B	B	R	R	B	R	R
18	Belmont Pier/Seaport Village	R		R	B	B			B											B	B	B	B	R	B	B
19	Seal Beach: Alamitos Bay jetties to Anaheim Bay				B	B														B						

Exhibit 2-3
Segment/Species Combinations to be tested for DDTs and PCBs in first phase of analysis (modified from Exhibit 2-10 of SAP)

		Hard-Bottom Species							Hard/Soft-Bottom Species						Pelagic Species					Soft-Bottom Species						
Segment	Segment Name	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific chub mackerel	Pacific Sardine	Pacific Barracuda	Yellowtail jack	Pacific Bonito	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
20	W. End of Sunset Beach to Huntington Beach (Hwy. 39)								P											P			P			
21	Huntington Beach (Hwy. 39) to Pelican Pt.														P[C]	P[C]	P[C]	P[C]	P[C]	P			P			
22	Dana Pt.: East End of Mussel Cove to East End of Doheny Beach	P		P	P				P											P			P			
23	Short Bank								P			P								P						
24	Horseshoe Kelp								P											P						
A	Middle Breakwater				P	P								P						C						P
B	Approx. 2 miles offshore of Segment 15																			C						
C	Approx. 5 miles SE of Pt. Fermin																			C						
D	Approx. 7 miles S/SE of station A																			C						
E	West of Palos Verdes Pt. before Redondo Canyon																			C						
F	West of Station E on north side of Redondo Canyon																			C						

Collection key: P: for Public Information Purposes; R: for Reef purposes; C: for Commercial Catch Ban purposes; B: for both Public Information and Reef Purposes.
Shading indicates that a fishing advisory is in effect for that species in that segment or in an adjacent segment. Advisories at Segment 15 are based on the Los Angeles/Long Beach Harbor and Los Angeles/Long Beach Breakwater (ocean side) advisories from OEHHA. Segment 15 is located on the Palos Verdes shelf side of the Breakwater advisory and thus is expected to have similar or higher contamination levels.

3 FISH COLLECTION

3.1 Collection Overview

The fish collection activities took place along the southern California coast between Ventura and Dana Point. An overview map of the sampling segments is located in Figure 2-1. Latitude and longitude coordinates for the segments are in available in the Field SOPs (Attachment 3). Brief descriptions of each segment are provided in the following sections of this document.

Seaventures, LLC performed the sampling with the M/V Earlybird. Initial sampling took place in fall 2002. A second collection effort was conducted in June 2003 to collect samples from segment/species combinations missed in the initial collection. A third effort specifically for barracuda was conducted in August 2003. In total, approximately 75 days were spent on collection, including travel and specimen handling. Four rounds of white croaker commercial catch ban sampling took place: August to November 2002; June 2003; November 2003; and June 2004. In June 2004, a collection was also undertaken at a potential reef construction site, under consideration by the Port of Los Angeles. This site is near segment 15, north of the breakwater. These fish have been combined with the prior collections, and included additional target fish from Segment 15. Table 3-1 provides a detailed list of sampling dates.

Table 3-1
Dates for Fish Collection Activities

Collection Dates	Purpose
August 21, 2002 to November 26, 2002	General Collection
June 6, 2003 to June 25, 2003	Follow-up Collection
August 4, 2003	Barracuda Collection
June 2, 2004 to June 4, 2004	Port of Los Angeles Collection
September 7 to November 15, 2002	Commercial Catch Ban Collection - Round 1
June 6 to June 25, 2003	Commercial Catch Ban Collection - Round 2
November 7 to November 11, 2003	Commercial Catch Ban Collection - Round 3
June 1 to June 8, 2004	Commercial Catch Ban Collection - Round 4

3.1.1 Fish Storage

All fish were packaged and frozen on-board of the M/V Earlybird. After freezing, samples were transferred to a locked freezer cage at the P&O Cold Logistics facility in Dominguez Hills, California. Fish were stored in coolers containing between 50 and 200 fish, depending on the size of the fish.

3.1.2 Chain of Custody

Seaventures personnel initiated chain of custody on the boat. Copies of the chain of custody (COC) forms were included inside each cooler and taped to the outside of each cooler for storage at the P&O Cold Logistics facility. Copies were also sent to Industrial Economics. During the initial field audit, it was determined that the packing lists specified in the SOPs were unnecessary given the detail on the COCs, and the packing lists were omitted. (See Overall Audit Report in Attachment 3).

After selection of an initial laboratory, Seaventures personnel retrieved designated fish and sent them to the Battelle Duxbury facility. New chain of custody forms were created at this point, because the fish were combined in different coolers for shipping. Samples were shipped from Long Beach, California to Duxbury, Massachusetts on dry ice via Federal Express. Of the 732 fish specified for shipping, 728 were received at Duxbury. The four missing fish (two benthic feeding surfperches, both from Segment 7, and two California scorpionfish, from Segments 16 and 19) did not create a significant problem in the analysis and were omitted. Additionally, two Pacific mackerel were not the samples specified in the analysis list given to Seaventures, but were fish from the same segments and were acceptable substitutes.

Additional fish were shipped from P&O Logistics to Battelle under COC as requested, for replacement and second round analyses. Seaventures personnel also shipped samples as necessary to AWHL. All specified fish were received at AWHL. Samples were also transferred between Battelle's facilities in Duxbury, Massachusetts and Sequim, Washington; between Battelle and AWHL; and between Battelle and CSDLAC for additional analyses. All samples were shipped under COC.

3.2 Collection Results

3.2.1 Overall Catch

Overall, 22 species and 3 species groups were targeted for collection. This includes 7 soft-bottom species, 7 hard-bottom species, 6 hard- or soft-bottom species, and 5 pelagic species. During the collection from August 2002 to June 2004, 2,676 fish were collected for the Trustees and EPA. These fish represent 183 segment/species combinations.

The SAP contained two target fish lists. The first (Exhibit 2-2) was a list of what would be kept and potentially analyzed, based on recreational fishing data for southern California and prior fish studies. The second (Exhibit 2-3) was a tentative first-round analysis guide and was used to target the collection effort, given the limited number of collection days available. Day-to-day collection decisions were made in consultation with NOAA and EPA, based on fishing conditions at the time. Of the 124 non-pelagic site/segment combinations listed in Exhibit 2-3, 56 were considered “successful” (greater than 15 fish, to allow for the initial analysis of 10 fish and provide extra fish for additional analysis, if needed). At an additional 14 target sites, ten or more

fish were obtained, allowing for analysis of the desired number of fish. At four sites, between five and ten fish were caught, and the sites were deemed of sufficient importance to analyze the reduced number. An additional 13 locations were selected as substitutes for locations at which targeted fish could not be collected. Overall, of the 124 initial planned analyses, 87 were conducted in full during the first round. Table 3-2 shows the total catch, as well as analyses completed in each round of analysis, color-coded to number of fish for each species and location.[16] Only the first round of the white croaker commercial catch ban analysis is shown in this exhibit.

Three of the pelagic species targeted were caught. Sufficient Pacific chub mackerel, Pacific sardine, and Pacific barracuda were caught to allow for analysis of Pacific chub mackerel from three regions and Pacific sardines and Pacific barracuda from two regions each.

Six sites (EPA A-F) were targeted for white croaker specifically to evaluate whether there was a need to expand the existing commercial catch ban area for white croaker (California Fish and Game Code § 7715(a) & (b); California Code of Regulations, Title 14, Section 104). These sites were located beyond the current boundaries of the commercial catch ban area (Figure 2-1). By design these sites were to be sampled up to four times each, twice during the spring and twice during the fall, to obtain data not only on geographic differences in concentrations but also on potential seasonal variations. Site F was determined to be an inappropriate collection site after the first collection event in the fall of 2002 and was not sampled thereafter. For two of the remaining sites, EPA D and EPA E, white croaker were not found at the locations in 2002 despite several days of effort. Thus four collections were made from EPA A, B, and C over two years and two seasons (fall 2002, spring 2003, fall 2003, and spring 2004), and three collections were made from modified EPA D and E sites (spring 2003, fall 2003, and spring 2004).

In an attempt to make sure that fish caught by the methods in the SOPs were representative of fish caught by recreational and subsistence fishers, average size ranges were specified. Size ranges were specified in the SAP and Field SOPs based on the middle 80 percent of reported fish lengths in the Pacific States Marine Fisheries Commission's recreational fishing database (RecFIN). In general, if a species were present at a location, sufficient numbers were found within the designated size range. However, some of the ranges were adjusted to accommodate the fish found at the locations. These changes are shown in Table 2-1. In most cases, the upper- or lower-bound was expanded by 10 to 20 percent. The original values from the SOPs are shown in parentheses next to the revised value. In all cases, fish kept were within the State of California Department of Fish and Game legal collection limits.

[16] This table provides a summary of the collection and analysis data. For a complete listing of analyses completed by individual fish or by species and segment, see the sample lists in the Data Quality Assurance Reports (Attachment 4).

Table 3-2
Overview of Completed Fish Collection and Analyses

Segment	Description	Opaleye	Sargo	Kelp Bass	Surfperches - BF	Surfperches-WCF	Rockfishes	California Sheephead	Barred Sand Bass	Topsmelt	Halfmoon	California Scorpionfish	White Seabass	Black Croaker	Pacific Chub Mackerel	Pacific Barracuda	Pacific Sardine	White Croaker	Jacksmelt	Yellowfin Croaker	California Corbina	California Halibut	Shovelnose Guitarfish	Queenfish
1	Ventura: Emma Wood Beach to San Buenaventura Beach																	1						
2	Pt. Dume to Malibu Bluff		2	1	1		2		1						1C			1						1
3	Malibu Bluff to Las Flores																	1						1
4	Las Flores to W. End of Santa Monica Beach																	1						1
5	Santa Monica Beach to El Segundo	2			2				3	2		2						1		1C		1		
6	El Segundo to S. End of Manhattan Beach											2						1						3
7	King Harbor Area: Manhattan Beach to Redondo Beach	1	2	1	1	2			1					1	3		1C	1			1			1
8	Redondo Beach to Flat Rock Pt.	2		3	2				2	1C,2			1C				1C		1					
9	Flat Rock Pt. to Palos Verdes Pt.								2															
10	Palos Verdes Pt. to Pt. Vicente																							
11	Pt. Vicente to Long Pt.																							
12	Long Pt. to Bunker Pt.			3			2		1			1			1C			1						
14	Royal Palms to Pt. Fermin	2		1	1		1		2			1			1C			1						
15	Cabrillo/LA Breakwater: Ocean Side	2	1C	1,2	1	1	1		2			1					1C	1						1
16	Cabrillo/LA Breakwater: Inland Side			2	1	1			2	1C,2		1					1C	1	1		1	1	1	1
	Port of Los Angeles			2	2			2	2			2												
17	Pier J to Finger Piers at Shoreline Park	1			1	1												1				1	1	1
18	Belmont Pier/Seaport Village		1C		1													1		1	1		1	1
19	Seal Beach: Alamitos Bay jetties to Anaheim Bay	1		2	1	1			2			1C						1		1C				3
20	W. End of Sunset Beach to Huntington Beach (Hwy. 39)			2					2									1						
21	Huntington Beach (Hwy. 39) to Pelican Pt.														3			1						
22	Dana Pt.: Mussel Cove to Doheny Beach														1C	1C		1						
23	Short Bank																	1						
24	Horseshoe Kelp			2												1C		1						
A	Middle Breakwater			2	1				2									1						1
B	Approx. 2 miles offshore of Segment 15																	1						
C	Approx. 5 miles SE of Pt. Fermin																	1						
D	Approx. 7 miles S/SE of Segment A																							
E	West of Palos Verdes Pt. before Redondo Canyon																							
F	West of Station E on north side of Redondo Canyon																	1						

1-4 fish caught at location
5-9 fish caught at location
10 or greater fish caught at location

Number in box represents round of analysis. Colored boxes with no number indicate that fish were caught but not analyzed.
A number followed by a C indicates that the organic analysis (DDTs, PCBs, chlordane, dieldrin) was conducted on a composite. Only first round of Commercial Catch Ban is included in this table.
Round 1: Initial Analysis at Battelle (organic analysis as individuals unless otherwise specified and mercury analysis as composites on all samples)
Round 2: Second Round at AWHL (PCB and DDT analysis on all, mercury on some samples, all as individual samples, no chlordane or dieldrin)
Round 3: Third Round at AWHL (mercury analysis only, all as individual samples)

At seven segments, viscera were kept from kelp bass and/or white croaker. Kelp bass viscera were kept at segments 2, 7, 13/14 and 17. White croaker viscera were kept at segments 2, 5, 7, 10, 13/14, and EPA A. Selection of individual samples for further analysis was made following initial skin-off fillet results. Based on contaminant levels and geographic spread, twelve kelp bass from segments 2, 7, and 13/14 and 18 white croaker from segments 5, 13/14, and EPA A were analyzed by constituent parts. As described in Section 2.2.3, the viscera and remaining body tissues were used to reconstruct whole body concentrations and other consumption scenarios and to estimate contaminant ratios between different body sections (see Section 5.3.)

For the three species groups (water-column and benthic feeding surfperch and rockfish), individual species was noted at collection for most samples. Water-column-feeding surfperch included walleye and shiner surfperch. Benthic-feeding surfperch included black, rubberlip and pile surfperch and white seaperch.[17] Rockfish included treefish and grass, kelp, olive, vermillion, and gopher rockfish.

3.2.2 Targeted Species-Location Combinations not Collected

During the fall 2002 sampling, several of the pelagic species were not found at any of the specified locations. Yellowtail jack, Pacific bonito, and Pacific barracuda were not located. Seaventures personnel also consulted with other commercial fishermen, and these fish were not reported to be in the target areas during the collection periods. In June and September 2003, Seaventures personnel caught Pacific barracuda from party boats at two locations (24/ Horseshoe Kelp and just south of 22/Dana Point, respectively).[18]

Barred sand bass were not in abundance in the southern portion of the collection range. South of Segment 15 (Cabrillo Pier), no more than four barred sand bass were caught at any given location. Kelp bass were similarly missing in the more southern regions. Black croaker were also targeted between Segments 13/14 and 19, and were not found in significant numbers there during the initial collection phase.

In the soft-bottom species, queenfish and white croaker were generally abundant at target locations. White croaker were caught at all segments except 8 through 11. These are rocky bottom areas on the northern side of the Palos Verdes Shelf. The white croaker used for the site-specific reference material were caught offshore near these areas. Between Segments 5 and 8, the other soft-bottom fish were fairly scarce. The fishermen noted the very low numbers of California corbina, which were very abundant in the 1987 OEHHA study (Pollock *et al*. 1991).

[17] The initial sampling design classified all surfperch as hard-bottom dwelling species. The white seaperch (benthic feeding), walleye surfperch (water-column feeding), and shiner perch (water-column feeding) are more appropriately designated as soft-bottom dwelling species. The overall classification of the surfperch has not been modified in order to maintain consistency with the structure of the sampling plan.

[18] Based on local fishing reports of barracuda availability, Seaventures personnel paid a party boat fee and fished for barracuda from a sport-fishing boat. This option was chosen rather than mobilizing the regular Seaventures vessel due to timing and mobilization expenses

3.2.3 Changes to Target Plan

Only minor changes were made to the collection requirements. Segment 1 was initially chosen as the northern end for "baseline" contaminant level, and several hard and hard/soft-bottom fish were targeted at that location. Greater interest in the northern Santa Monica Bay region and concern that Segment 1 (Ventura) was too far north to be applicable to the study resulted in the movement of these targeted species to Segment 2.

3.3 Locations

Proposed segment boundaries are described in Exhibit 2-1. Latitude-longitude boundaries by segment and maps of segment locations are included in Attachment 3. All fish are coded with the actual latitude and longitude coordinates from the location where they were caught.

EPA sites were modified when white croaker were not found at the initially specified locations. Segments C, D, E, and F were amended. Figure 2-1 specify the final locations where white croaker were collected for the EPA commercial catch ban effort.

3.4 Timing

White croaker were caught at Segments 1 through 24 from August 23 to October 31, 2002. Most of these samples (16 segments) were caught between August 23 and September 14, as an effort was made to catch these fish earlier in the fall, in order to catch the majority of the croaker before they spawned. At segments B thought F, white croaker collection took place between October 31, 2002 and November 15, 2002, since these sites were identified later.

Certain targeted fish that were the subject of current advisories were not found in the first round of collection at designated sites (Table 3-3). These fish were targeted again during June 2003, when the second round of collection for EPA's Catch Ban evaluation took place. At that time, five of the eight targets were achieved, although only five California scorpionfish were caught at Segment 24/ Horseshoe Kelp. White croaker were still not found at Segments 10 and 11 and barracuda were only caught at one location. In September 2003, additional Pacific barracuda from San Mateo Point, south of Segment 22/Dana Point, were substituted for Segment 22.

Table 3-3
Species not Collected in the Fall 2002 Collection That Were Targeted in Later Collection Rounds

Location	Species	Caught in Later Collection Round?
Various	Pacific barracuda	Yes, two locations – 24/ Horseshoe Kelp and San Mateo Point, south of 22/ Dana Point.
21/ Newport Pier	California corbina	Yes
24/ Horseshoe Kelp	California scorpionfish	Yes (5 samples)
16/ Cabrillo Pier inland of Breakwater	Black croaker	Yes
A/ Outside Los Angeles Breakwater	Black croaker	Yes
10/ Palos Verdes Pt. to Pt. Vicente	White croaker	No
11/ Pt. Vicente to Long Pt.	White croaker	No

3.5 Fishing Methods

All fish were caught by the standard methods mentioned in the SAP and described in greater detail in the SOPs. Minor modifications were made to these methods during collection; the final methodology is described below. Changes were made to reflect realistic fishing and processing conditions, and were evaluated by the QA manager.

(a) *Gill net*: The gill net was anchored at each end and marked with surface buoys. The net was left during the day, and overnight when necessary for collecting target species, and pulled daily to retrieve fish. The fish were picked out of the net by hand; suitable fish were kept in an ice chest with refrigerant gel packs for up to 24 hours until proper packaging and labeling. Other fish were returned to the sea.

(b) *Trawl net*: The trawl net was towed along the bottom for 5 to 30 minutes, with care taken to avoid snagging the net on the bottom. A trawl data sheet was filled out for each trawl. Most fish were alive when caught. Desired fish were stored on refrigerant gel packs in an ice chest for up to 24 hours until packaging, others were returned to the sea.

(c) *Fish traps*: Traps were baited and left on the bottom for up to 24 hours, then pulled and checked. Fish were alive when caught. Desired fish were stored on refrigerant gel packs in an ice chest for up to 24 hours until packaging, others were returned to the sea.

(d) *Hook and Line*: This method was also used. Individual fish were caught; desired fish were kept and others were returned to the sea.

3.6 Gutting/Storage Methods

Specimens were initially noted on a Collection Data Sheet and given a unique identifier. Each species and location had a separate data sheet. The total and standard length were measured as described in the Field SOPs, and noted on the data sheet. The measuring board was rinsed between fish.

Fish were then gutted as described in the Field SOPs, with a few modifications. During the initial audit, it was determined that the aluminum foil covering on the fish-processing table was unnecessary. Personnel were instructed to rinse the area and all fish processing implements thoroughly with seawater between fish. Implements were scrubbed with an Alconox-sea water solution between samples, and stored wrapped in aluminum foil overnight to prevent contamination. Additionally, in the initial field audit, the decision was made to leave topsmelt and Pacific sardines ungutted, based on discussion with field personnel.

Seaventures personnel rinsed all fish before and after cleaning. The appropriate pre-printed label was attached to the tail of the fish with stainless steel staples. The fish was then wrapped in aluminum foil, the middle portion of the label was taped to the package, and it was then sealed in plastic.

3.7 Quality Assurance

In addition to extensive quality assurance methods described in the Field SOPs (Attachment 3), both an independent assessor (from SAIC), as well as the overall QA manager, evaluated the collection process. The independent assessor spent several days on the boat throughout the collection period, overseeing all aspects of the effort. The QA reports are included in Attachment 3. Copies of all forms used by Seaventures during the collection are in the Field SOPs in Attachment 3.

3.7.1 Species Identification

Species identification was verified by in-survey audits and on-going verification of a voucher collection. During the survey, the Collection QA Officer audited taxonomic identifications during vessel visits. The Chief Field Scientist also prepared a digital voucher collection, which includes a photograph of a specimen from each target species. The Collection QA Officer evaluated the collection to ensure its accuracy. Standard fish field guides, including Miller and Lea (1976) and Love *et al.* (2002), were used for reference purposes. The initial field audit determined that the digital voucher collection could be substituted for the formalin-preserved voucher collection described in the SAP.

3.7.2 Sample Processing

All fish that were kept for the analysis effort were tagged and identified. Since this was a targeted collection process, rather than a population study, non-target fish were not catalogued.

Complete details of the procedures for processing and storing fish are included in the Field SOPs (Attachment 3).

Each fish was labeled with a unique identification code that included the species and a sequential number. Each fish was gutted, gilled, and rinsed on board the boat, and then an identification tag was stapled to the tail. Fish were wrapped in aluminum foil, another identical tag was taped to the foil, and the package was sealed in plastic. Fish were then frozen on board the boat, and taken to a long-term freezer storage facility as needed. The field logbook detailed the location, time, and method of each collection, as well as the fish kept from that site.

The Collection QA Officer and the Overall QA Officer evaluated the sample processing on several occasions. Their reports are included with Attachment 3.

4 EVALUATION OF DATA QUALITY

The Ocean Fish Contaminants Survey included an extensive evaluation of data quality. An independent contractor (EcoChem) reviewed and validated the data provided by the laboratories for organic and mercury analyses (Section 4.1). The validation process determined whether the specified measurement quality objectives (MQOs) were met and applied qualifiers to any data point that had a quality control (QC) parameter outside of the specified limits. Section 4.2 discusses the method verification procedures implemented after the review of the initial organochlorine and lipid quality control results; Section 4.3 discusses issues related to extended storage time; and Section 4.4 discusses lipid measurement. Inter-laboratory comparisons between the primary laboratory (Battelle) and CSDLAC are discussed in Section 4.5.[19]

4.1 Data Validation

This section summarizes the methods for and results of data validation on the overall dataset. Data are validated relative to the measurement quality objectives (MQOs) for precision, accuracy, and completeness. Data Quality Assurance Reports, which include data validation reports and are grouped by laboratory, are included in Attachment 4. The summaries provide a quantitative and qualitative assessment of the data and identify potential sources of error, uncertainty, and bias that may affect the overall usability.

4.1.1 Validation Process and Procedures

The data validation process and MQOs were based on requirements and guidance from the *Palos Verdes Shelf "Fish in Ocean" Sampling and Analysis Project Quality Assurance Plan,* Version 1.0, April 2003 (QAPP); the USEPA *National Functional Guidelines for Organic Data Review,* October 1999; and the USEPA *National Functional Guidelines for Inorganic Data Review,* February 1994. Final MQOs are presented in Tables 4-1 and 4-2. Method performance criteria are documented in the QAPP and the laboratory SOPs described in Table 4-3. Definitions and explanations of quality control procedures are provided in Section 2.3.2.

[19] CSDLAC conducts annual monitoring of fish near the White Point outfalls on the Palos Verdes shelf. The monitoring includes analysis of DDTs and PCB in white croaker and kelp bass, among other species.

Table 4-1: Measurement Performance Criteria for DDTS, PCBS, and Other Organochlorines by GC/MS-SIM		
Element or Sample Type	**Minimum Frequency**	**Acceptance Criteria**
Calibration	Initially and when CCAL fails	*Battelle:* Six point quadratic curve with $r^2 \geq 0.995$ *AWHL:* Five point curve with standard curve percent relative standard deviation (%RSD) < 20% for all analytes.
Continuing Calibration [1]	At the beginning and end of each analytical sequence, and every 10 analyses.	%Difference < 20% for each PCB analyte %Difference < 25% for each Pesticide analyte
GC/MS Tune	At the beginning and end of each analytical sequence, and every 10 analyses.	Within acceptance criteria [2]
Certified Reference Material (SRM1946)	One RM with every batch (max 15 field samples)	Values must be within <15% of 95% confidence interval for the true or reference value
Method Blank	Every batch (max 15 field samples)	No analytes to exceed 3x MDL unless analyte not detected in associated sample(s) or analyte concentration > 10x blank value.
Matrix Spike [3]	Every batch (max 15 field samples)	%Recovery = 50% to 125% if sample concentration is < 4X the matrix spike concentration.
Laboratory Control Sample	Every batch (max 15 field samples)	%Recovery = 50% to 125%
Sample Duplicate [4]	Every batch (max 15 field samples)	RPD <30% if > 10x MDL for fillets; RPD < 40% if > 10x MDL for whole body
Internal standards	Every sample (added just prior to analysis)	Area of internal standard must be within –50% to +100% of the internal standard from the CCAL at the beginning of the 12 hour sequence.
Surrogates	Every sample (added prior to extraction)	*Battelle:* % Recovery = 60% to 110% *AWHL*: % Recovery = 50% to 125%
DDT Breakdown	At the beginning and end of each analytical sequence and every 10 analyses	≤15% (as defined in Section 8.4.6 of USEPA Method 8081A)

[1] %D calculated as follows:

$$\%D = \left(\frac{TrueValue - CalculatedValue}{TrueValue} \right) \times 100$$

[2] Check instrument tune with a tuning compound (such as DFTPP or PFTBA). Three to six ions should be checked against appropriate acceptance criteria. The laboratory should specify the criteria in their SOP.

[3] Spiking solutions will contain, at a minimum, one congener from each homologue group.

[4] RPD calculated as follows: $RPD = \left(\frac{C1 - C2}{(C1 + C2)/2} \right) x100$

where C1 is the larger of the duplicate results for a given analyte and C2 is the smaller

Table 4-2: Measurement Quality Objectives for Mercury Determination by Cold Vapor Atomic Absorption Spectroscopy		
Element or Sample Type	**Minimum Frequency**	**Acceptance Criteria**
Calibration	Initially	Minimum one blank and three calibration standards; linear correlation coefficient ≥ 0.995
Initial Calibration Verification	Every batch (max 20 samples)	%D ≤ 10% (or %R = 90% – 110%)
Continuing Calibration	Must start and end analytical sequence and every 12 hours	%D ≤ 20% (or %R = 80% – 120%)
Calibration Blank	10%	< MDL. If > MDL, run two more times, the average must be < MDL. If average > MDL, reanalyze.
Certified Reference Material (DORM-2)	Every batch (max 20 field samples)	Values must be within ±15% of 95% confidence interval for the certified reference value for total mercury.
Method Blank	Every batch (max 20 field samples)	No analytes to exceed 3x MDL unless analyte not detected in associated sample(s) or analyte concentration > 10x blank value.
Matrix Spike	Every batch (max 20 field samples)	%R = 75% to 125% if sample concentration is < 4x the matrix spike concentration.
Spike Blank	Every batch (max 20 field samples)	%R = 75% to 125%
Sample Duplicate	Every batch (max 20 field samples)	RPD ≤ 35%, if > 10x MDL
Target Detection Limit	N/A	0.015 ug/g (wet weight)

Table 4-3: Standard Operating Procedures for Organic Analyses			
SOP Number	**Title**	**Revision**	**Date**
Battelle			
Montrose 001-01	Pre-Extraction Tissue Processing	1	5/09/03
Montrose 002-05	Identification and Quantitation of Polychlorinated Biphenyl Congeners (PCBs), Chlorinated Pesticides, and PCB Homologues by Gas Chromatography/Mass Spectrometry in the Select Ion Monitoring Mode	5	4/28/05
Montrose 003-01	Tissue Compositing	1	7/21/03
3-112-01	Operation of the Omni Homogenizer	1	6/4/91
5-307-03	Soil/Sediment and Tissue Extraction for Semi-Volatile Contaminant Analysis Using the Accelerated Solvent Extractor	3	2/15/05
MSL-C-003-03	Percent Dry Weight and Homogenizing Dry Sediment, Soil, and Tissue	3	4/24/00
MSL-I-024-04	Mixed Acid Tissue Digestion	4	4/17/02
MSL-I-016-05	Total Mercury in Tissues and Sediments by Cold Vapor Atomic Absorption (CVAA)	5	9/10/02
Project 004778	Battelle Work/Quality Assurance Project Plan	5	4/28/05
AWHL			
OP-016	Microscale Solvent Extraction	1.1	4/22/04
O-015	Determination of PCB Homologues, Individual Congeners and Pesticides by GC/MS-SIM	1	10/10/05
OP-015	Percent Lipid Determination	1	8/26/02
W-001	Percent Solids Determination	2	9/25/02
M-006	Mercury Determination in Solids by Cold Vapor Atomic Absorption Technique (CVAA)	3	4/15/04
OP-003	Tissue Preparation and Homogenization	0	4/25/02

Sample results and related QC data were received in both electronic and hard copy format as data packages, which each covered results for one batch (15 field samples plus QC samples). The laboratory electronic data deliverable (EDD) was verified against the hard copy data package. Most data packages received a summary validation, while approximately 15 percent of packages received full validation. For each data package, the QC elements described in Table 4-4 were reviewed. Specific information for each data package is provided in the Data Quality Assurance Reports (Attachment 4).

Table 4-4: Data Aspects Considered for Validation Process
• Chain of custody and sample handling
• GC/MS tune verification (from summary forms) – *Organic compounds only*
• Method blank contamination (from summary forms)
• Initial and continuing calibration (from summary forms)
• Rinsate blank contamination (from sample result summaries)
• Analytical accuracy: surrogates (*organic compounds only*), matrix spike samples, laboratory control samples, and standard reference material results (from summary forms)
• Analytical precision: laboratory duplicate samples (from summary forms)
• Internal standard areas (from summary forms) – *Organic compounds only*
• Reported detection limits (from sample result summaries).
• Compound identification evaluated from raw data - *Full Validation, Organic compounds only*
• Compound quantitation, transcription and calculation checks performed at a frequency of 10 percent from raw data. If an error was noted, 100 percent of the calculations and transcriptions for that data package were verified - *Full Validation Only*.

Laboratory QC samples were used to assess the effectiveness of homogenization procedures and to evaluate laboratory-derived contamination, laboratory performance, and sample matrix effects.[20] Quality control samples included method blanks, laboratory control samples (LCS), matrix spike (MS) samples, laboratory duplicate samples, and standard reference material (SRM) analyses. Surrogates were added to each sample analyzed for PCB congeners and pesticides to further assess the effects of sample matrix on accuracy. As part of QC measures, rinsate samples from homogenization and processing equipment (rinsate blanks) were analyzed to verify lack of cross-contamination.

Data were qualified when associated QC sample and instrument performance results were outside the QC limits. Table 4-5 provides explanation of the qualifiers used in the data validation.

[20] An overview and explanations of the quality control samples are provided in Section 2.3.

Table 4-5: Explanation of Data Qualifiers		
Qualifier	**Definition**	**Explanation**
J	Estimated	The associated numerical value is an estimated quantity. The analyte was detected, but the reported value may not be accurate or precise. The "J" qualification indicates results were outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.
UJ	Estimated/ Not detected	An analysis was performed for the compound or analyte, but it was not detected and the sample quantitation or detection limit may be inaccurate or imprecise. The associated numerical result is the detection limit.
U	Not detected	An analysis was performed for the compound or analyte, but it was not detected. This includes results qualified because of laboratory blank contamination. The associated numerical result is the detection limit.
NJ	Tentatively Identified/ Estimated	An analysis was performed for the compound or analyte, however the results are inconclusive and the identification may be incorrect or inaccurate. The associated numerical result is an estimated quantity.

For each qualifier, one or more reason codes were added to indicate which QC element(s) did not meet the relevant MQOs. These codes describe the various reasons for which data do not meet MQOs and allow end users to evaluate whether the data meet their particular needs. Table 4-6 provides explanation of the reason codes used in the data validation.

Table 4-6: Explanation of Reason Codes	
Reason Code	**Definition**
5A	Initial calibration (ICAL) percent relative standard deviation (%RSD) value is outside the specified control limit
5B	Continuing calibration (CCAL) standard percent difference value is outside the specified control limit
7	Analyte concentration is within five times the preparation blank result
8	Matrix spike (MS) recovery value is outside the specified control limit
9	Precision (relative percent difference between analytical duplicates) exceeds the specified control limit
10	Laboratory control sample (LCS) recovery value is outside the specified control limit
13	Surrogate recovery value is outside the specified control limit
12A	Reference Material concentration is greater than ±15 percent, but less than ± 30 percent, of the 95 percent confidence interval
12B	Reference Material concentration is greater than ±30 percent of the 95 percent confidence interval
14	Other (discussed in data validation report)
19	Internal Standard area is outside the specified control limit
21	Result was less than the laboratories method detection limit (MDL) value, indicating a potential false positive

4.1.2 Summary of Data Validation Results for Organic Contaminants

Samples were analyzed by Alpha Woods Hole Laboratory (AWHL), Raynham, Massachusetts and Battelle Laboratories (Battelle), Duxbury, Massachusetts. Battelle commenced analysis in late 2003; however results from quality control (QC) check samples revealed inconsistencies in analytical results (see discussion in Section 4.2.1). After additional method development and method validation, Battelle restarted analysis in 2005 and reanalyzed all previously analyzed samples. Only the analyses performed subsequent to method refinement (2005/2006) are discussed in this section.

The data set consists of 1,029 skin-off fillet samples; 19 sample composites (from skin-off fillets or whole fish [Pacific sardines]); 30 whole-body fish samples (topsmelt); and 30 fish that were each partitioned into four sub-samples, yielding 120 samples.[21] The sub-samples were skin-off fillet, skin-on fillet, viscera, and remainders (the "remainder" refers to all leftover tissue, skin, and bones not analyzed as a fillet or viscera). All 1,198 samples were analyzed for the target analyte list (TAL) including 45 PCB congeners, 10 PCB homologue groups, 6 DDT isomers, percent solids and percent lipids. Battelle also analyzed 880 of the skin-off fillet samples for chlordane and dieldrin (specific analytes are alpha-chlordane, gamma chlordane, cis-nonachlor, trans-nonachlor, oxychlordane, and dieldrin). The number of samples for each matrix and reported target analyte group are listed in Table 4-7. It should be noted that AWHL reported eight additional congeners and Battelle reported one additional congener due to co-eluting congener pairs. A list of the target PCB congeners and the co-eluting pairs are included in Table 4-7 for reference. In addition, total DDT (sum of six isomers) and total PCB homologues (sum of ten homologue groups) were calculated and reported by EcoChem during the validation process.

Of the 78,585 data points, 12,431 were qualified. The qualified data represent 15.8 percent of all data points. No data were rejected as a result of validation. Of the qualified data, a total of 10,817 data points (13.8 percent of all results) were estimated (J/UJ), and 1,741 data points (2.2 percent of all results) were qualified as not detected (U).[22] The overall quality of the data is acceptable and all results, as qualified, are considered usable. The qualifiers assigned are summarized in Table 4-8.

[21] An analytical database for the project is available as Attachment 5.

[22] Note that some results were qualified for more than one reason, so the total of the qualifiers is greater than the number of qualified sample results.

Table 4-7: Number of Samples Analyzed by Matrix and Analyte Group						
Sample Matrix	**PCB Congeners (45)**	**PCB Homologues[1] (10)**	**DDT Isomers[2] (6)**	**Additional Pesticides[3] (6)**	**Lipids**	**Percent Solids**
Battelle						
Skin-off fillet	831 [4]	831	831	831	831	831
Sub-samples of whole fish (4 ea.)						
- Skin-off sub-sample	30 [4]	30	30	30	30	30
- Skin-on sub-sample	30 [4]	30	30		30	30
- Viscera sub- sample	30 [4]	30	30		30	30
- Remainder sub-sample (everything else)	30 [4]	30	30		30	30
Composites	19 [4]	19	19	19	19	19
AWHL						
Skin-off fillet	197 [5]	197	197		197	197
Whole Topsmelt	30 [5]	30	30		30	30

[1] Total PCB homologues also reported.

[2] The 6 DDT isomers are: 2,4′-DDT, 4,4′-DDT, 2,4′-DDE, 4,4′-DDE, 2,4′-DDD, 4,4′-DDD. Total DDT isomers also reported.

[3] The 6 additional pesticides are alpha-chlordane, gamma chlordane, cis-nonachlor, trans-nonachlor, dieldrin, and oxychlordane.

[4] Two (2) pair of co-eluting congeners are reported which result in 1 additional congener reported for a total of 46 (**bold** indicates TAL congener):
PCB-83 & **119** and PCB-**153** & **168**

[5] Nine (9) pair of co-eluting congeners are reported, which result in 8 additional congeners reported for a total of 53 (bold indicates TAL congener):
PCB-5 & 8**, PCB-43 &** 49**, PCB-84 &** 101**, PCB-**128 **&** 167**, PCB-132 &** 168**, PCB-**138 **& 163, PCB-**170 **& 190, PCB-182 &** 187 AND **PCB-192 &** 203
TAL PCB Congeners: **8, 18, 28, 31, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138,149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 195, 201, 203, and 206**

Table 4-8: Percent of Pesticide/PCB Data Points Qualified by Laboratory and QC Element			
QC Element	**Battelle**	**AWHL**	**Total**
Calibration	0.0%	0.01%	0.01%
Continuing Calibration	1.09%	0.07%	1.2%
GC/MS Tune	0.0%	0.0%	0.0%
SRM	5.5%	2.2%	7.8%
Method Blank	2.15%	0.06%	2.2%
Matrix Spike	0.26%	0.01%	0.3%
LCS	0.5%	0.0%	0.5%
Sample Duplicate	0.03%	0.04%	0.1%
Internal Standards	0.7%	0.05%	0.8%
Surrogates	2.5%	0.0%	2.5%
DDT Breakdown	0.0%	0.0%	0.0%
Other Reasons	1.9%	0.1%	2.0%

4.1.3 Summary of Data Validation Results for Mercury

A total of 500 fish tissue samples were submitted for total mercury analysis, as follows:

- 106 fish tissue composites from skin-off fillets and 4 whole fish composites were submitted in October 2003, and 6 additional skin-off fillet composites were submitted in March 2004 to Battelle Marine Science Laboratory, Sequim, Washington (Battelle-Sequim).

- 384 tissues from individual fish were submitted in July 2006 to Alpha Woods Hole Laboratories, Raynham, Massachusetts (AWHL) for mercury analysis. All of these samples were prepared as skin-off fillets.

Of the 500 data points, 20 were qualified as estimated (J). This qualified data represents four percent of all data points. The overall quality of the data is acceptable and all results, as qualified, are considered usable. The qualifiers assigned are summarized in Table 4-9.

Table 4-9: Percent of Mercury Data Points Qualified by Laboratory and QC Element			
QC Element	**Battelle**	**AWHL**	**Total**
Calibration	0%	0%	0%
Initial Calibration Verification	0%	0%	0%
Continuing Calibration	0%	0%	0%
Calibration Blank	0%	0%	0%
Reference Material	0%	0%	0%
Method Blank	0%	0%	0%
Matrix Spike	0%	4%	4%
Spike Blank	0%	0%	0%
Sample Duplicate	0%	0%	0%

4.2 Method Development and Verification

There are no standardized procedures for analysis of organochlorine compounds and lipids in fish tissue. The initial quality assurance objectives were based on the input from the SRB and then finalized after discussions with the selected laboratories. Review of the initial analytical results from Battelle indicated that the data quality assurance objectives set for the project were not being met. The following sections discuss some of the investigations and adjustments performed during the development of the data set.

4.2.1 Initial Organochlorine and Lipid Reference Material Results

As discussed in Section 2.3.3, the Trustees and EPA considered results from the analyses of the reference materials (RMs) as a key component in assessing the accuracy and precision of analytical results. QC samples that consist of spiked matrices do not fully demonstrate the extraction efficiency and potential interferences as well as RMs, which have contaminants naturally incorporated into the matrix. Therefore the results from the RM analyses were examined closely as a means to monitor the accuracy and precision of the data.

The fish tissue RM results for organochlorine compounds and lipids provided with the initial batches of fish fillet results indicated that the goals for accuracy and precision were not being met. The laboratory submitted the initial sample results to the Trustees and EPA because most quality control results (other than the RM) met the project MQOs, and similar methodology had been used by the laboratory for past tissue evaluations. However, review of the variability from batch to batch of analyte recovery in the reference material matrix indicated that the method did not perform consistently in fish tissue. Discussions with the laboratory staff and chemists from NIST led to modifications in the analytical method. Several iterations of method validation exercises were performed using the reference materials. After accuracy and precision of the method was improved, the laboratory undertook an initial demonstration of proficiency (IDP) to document method performance. The IDP, as described in Section 8.4 of USEPA SW846 Method 8000B, involved performing four replicate analyses of spiked samples in a tissue matrix and assessing overall accuracy and precision. The laboratory SOPs were revised to reflect the

changes to the laboratory procedures, and the measurement quality objectives were re-assessed and adjusted for expected method performance. Previously run samples, as well as all new samples, were extracted and analyzed under the revised procedures.

4.2.2 Changes in the Laboratory SOPs

The most substantial changes to the laboratory's analytical procedures were made to the tissue extraction procedure using the accelerated solvent extractor. These method changes included improved extract drying procedures; increased temperature, cycles and pressure during extraction; and substitution of Florisil for alumina in the post-extraction column cleanup. These changes were incorporated into the laboratory's SOPs. All data presented in this report used the final SOPs listed in Table 4-3.

4.2.3 Changes to MQOs

The tables of analytical data quality objectives from the QAPP were reviewed with the laboratories during the initial laboratory audits. The following adjustments were made to the MQOs to be used during data validation after discussion with the laboratories:

DDTs, PCBs, and additional organochlorines:

- The acceptance range for the internal standard areas was widened to match criteria used by USEPA Method 8270C.

- The use of quadratic curves was found to improve quantitation across the calibration range. Acceptance criteria for quadratic curves were not specified in the QAPP, and the criterion that the coefficient of determination (r^2) value be greater than 0.995 was adopted.

- Continuing calibration acceptance limits were increased for all pesticide compounds to have percent difference values of ±25 percent.

- Surrogate recovery acceptance range was adjusted to agree with the laboratory's standard acceptable recovery range of 60 - 110 percent for Battelle-Duxbury and 50 - 125 percent for AWHL.

- Criteria for LCS and DDT breakdown were not specified in the QAPP. The MQO for MS were applied to the LCS and the DDT breakdown limit of 15 percent from USEPA method 8081A was used.

Total mercury:

- Batch size for analysis was increased from 15 samples to 20 samples for mercury to improve laboratory throughput.

In addition, following the implementation of the changes to the SOPs and evaluation of the accuracy and precision results from the IDP, it was determined that the MQO for the organochlorine RM analysis was not consistently achievable. Although the analytical results produced after method development had demonstrated significant improvement in accuracy and precision, a significant number of analytes were still not consistently achieving the $\pm$ 15 percent criteria. Acceptance ranges for the RM were widened to $\pm$ 30 percent of the 95 percent confidence interval. Based on the wider range of recovery results allowed by similar analytical programs, a 30 percent criteria was deemed acceptable. All data presented in this report are validated using the MQOs presented in Tables 4-1 and 4-2.

4.3 Storage Time

Recommended holding times for samples for the Ocean Fish Contaminant Survey were initially set at one year, based on general recommendations in EPA guidance and elsewhere. Delays resulted in tissue samples for the Survey being kept beyond that period, for up to three years before final analysis. Based on literature studies, fish tissue samples maintained at -20 ^{o}C, as these have been, should maintain stable concentrations of halogenated organic contaminants for periods significantly longer than one year. For DDTs, four-year studies on fish tissues at -20 ^{o}C showed no change in concentration; for PCBs, either no change or slight declines (Kiriluk *et al.* 1996). In a two-year study at -20 ^{o}C, no change in DDT or PCB level in either fish liver or muscle tissue was detected (DeBoer and Smedes 1997). Most research studies do not provide the limit where degradation begins, but rather indicate a point up to which degradation has not been detected. Moisture levels were measured in samples, in addition to visual inspections, to evaluate general tissue degradation and oxidation. No significant variance in moisture level was identified. Samples did appear to have surface desiccation following three years of holding, but with limited penetration.

4.4 Lipid Measurement

Lipid concentration in fish can be measured and reported in various ways. Lipid measurements as generally reported in fish sampling are perhaps more accurately called total extractable organics. Frequently, total extractable organics (TEO) is determined as a gravimetric measurement of an aliquot of the regular chemical extraction. For this project, TEO is determined from the dichloromethane extraction solution used for organochlorine measurements. A second common method of lipid determination is the Bligh-Dyer method (modified). Using a new aliquot of sample (approximately 5 g), the sample is treated with chloroform and methanol.

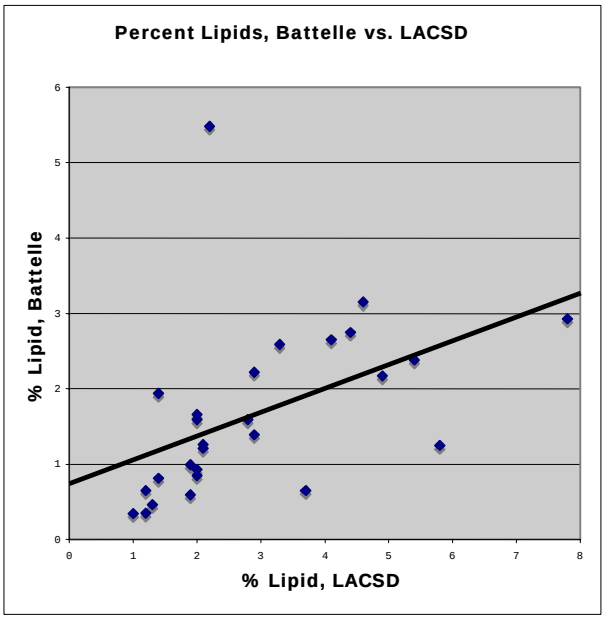
Values obtained by the two methods will differ. Randall *et al*. (1998) describes determination of lipid content in white croaker fillets by a chloroform/methanol extraction (modified Bligh-Dyer) and by a hexane extraction. Lipid content by Bligh-Dyer is 1.25 percent, and by hexane is 0.31 percent. EPA's fish advisory guidance (EPA 2000) recommends that dichloromethane be used as the extraction solvent in all lipid analyses. They note that "[o]verestimation of total lipids may occur if a solvent such as alcohol is used, which results in substantial coextraction of nonlipid material." (Volume 1, Section 8.2.1).

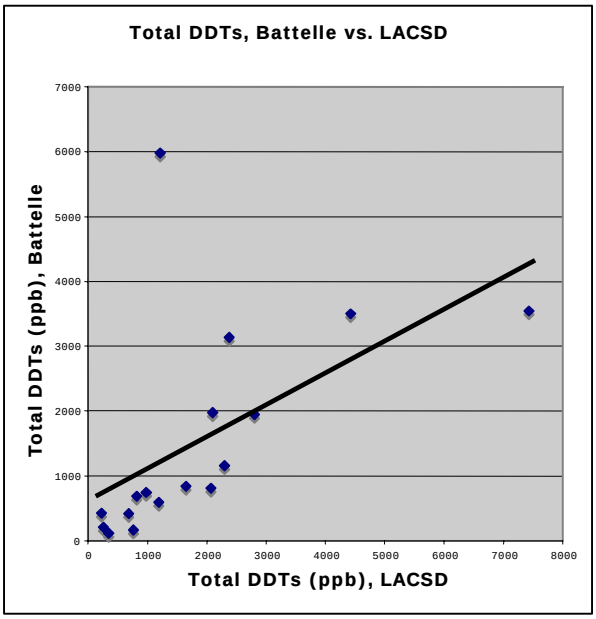
Method of lipid determination should be carefully reviewed when comparing data between studies, particularly if lipid normalization is employed. Randall *et al*. (1998) evaluated DDTs and PCBs results from different extraction methods. The researchers note that while the lipid values differ significantly, contaminant concentrations are much closer, and for p,p'-DDE are not significantly different between chloroform/methanol and hexane. At the very low lipid values identified in fish fillets, significant variability will appear in lipid normalized data, even if the same extraction methods is used, that may not be reflective of significant differences in contamination. The section below presents a comparison of lipid data for this project, analyzed under both the TEO and Bligh-Dyer methods.

4.5 Inter-laboratory Comparison

Two batches of samples were analyzed at both Battelle-Duxbury and CSDLAC. The first batch was homogenate from 21 fillet and remainder samples which were transferred from Battelle to CSDLAC. Each laboratory used the same container of homogenate. The second batch consisted of 15 skin-off fillets that were sent from CSDLAC to Battelle. For the second batch, the matching skin-off fillet was analyzed at CSDLAC prior to shipment. Comparison of the data between the two laboratories for the second batch led us to eliminate one sample from analysis as an outlier. The moisture was low, and the lipids high, relative to all of the other samples, and a significant variation from the normal contaminant ratio between the two laboratories (Figure 4-1). All analyses below omit this data point.

Figure 4-1
Lipids and DDTs in Tissues Analyzed by CSDLAC and Battelle





Note: Value in upper left quadrant in each graph is the "outlier".

For organic analysis, the laboratory for CSDLAC used GC-ECD, while Battelle and AWHL both used GC-MS-SIMS. For TEO (lipids), CSDLAC used the Bligh-Dyer method (as discussed in the previous section) and both Battelle and AWHL determined TEO from the organic analysis extract.

The values from the Battelle and CSDLAC are compared using the relative percent difference between the results for each sample. The calculation for RPD is shown in footnote 4 of Table 4-1. The RPD for this project for duplicate samples (sampled from the same homogenate and analyzed by the same laboratory in the same batch) is 30 percent for fillets and 40 percent for other tissues. Average RPDs between Battelle and CSDLAC values were generally around 50 percent for lipids, total DDTs, and total PCBs, which is considered reasonable for inter-laboratory variability. Most individual RPD values were significantly below 100 percent except for a few values up to 140 percent. A higher RPD is expected for inter-laboratory comparisons, given the large number of variables between the two laboratories (extraction method, analytical method, tissue sub-sampling) but also indicates caution in comparing values from different laboratories.

4.5.1 Lipids

From the first batch, 21 samples (nine remainder, twelve fillet) were analyzed for TEO at each laboratory. The average RPD was 44 percent and the CSDLAC value was on average 1.6 times the Battelle value. For the second batch of samples, TEO results are available for 14 samples. The average RPD was 55 percent and the CSDLAC value was on average 1.8 times the Battelle value. For both data sets, the overall RPD was 50 percent and the CSDLAC value was on average 1.7 times the Battelle value.

4.5.2 DDTs

From the first batch, ten samples (eight remainder, two fillet) were analyzed for DDTs at each laboratory. The average RPD was 44 percent and the CSDLAC value was on average 1.6 times the Battelle value. For the second batch of samples, DDT results are available for 14 samples. The average RPD was 55 percent and the CSDLAC value was on average 1.8 times the Battelle value. For both data sets, the overall RPD was 50 percent and the CSDLAC value was on average 1.7 times the Battelle value. The concentration of DDTs in the tissue did not have a significant effect on the RPD.

4.5.3 PCBs

The second batch of inter-laboratory samples was the only one for which PCB analyses were performed by CSDLAC. CSDLAC used an Aroclor-based methodology (Method 8082 by GC-ECD) while Battelle performed a congener-based method, which provided PCBs as a sum of homologues or a sum of congeners. The Aroclor and homologue methods are both designed to estimate total PCBs, while the sum of congeners represents only the specific targeted list, which is intended to represent the majority of the PCBs present. The Aroclor (CSDLAC) and homologue (Battelle) methods have an RPD of 34 percent, and the CSDLAC value was on

average 1.15 times the Battelle value. The Aroclor and congener methods have an RPD of 50 percent, and the CSDLAC value was on average 1.5 times the Battelle value. The concentration of PCBs in the tissue did not have a significant effect on the RPD.

5 STUDY RESULTS AND DISCUSSION

This section summarizes the analytical results for the Ocean Fish Contaminants Survey conducted by EPA and the Trustees. It also provides an overview of how contaminant concentrations vary among species and locations. The data from this survey will be used by EPA and the Trustees for remediation and restoration planning purposes as described in Section 1. They will also be provided to the State of California for use in updating fish consumption advisories and commercial catch ban boundaries. Interpretation of the data, such as its potential implications for existing public health guidance or regulatory actions, is beyond the scope of this report. Health risk assessments to be generated by the State of California and USEPA (for the purpose of its site cleanup decisions) will be based on the established protocols and methodologies appropriate to the specific programs. Fish consumption guidance will be generated by OEHHA based on these and other data (*e.g.*, CSDLAC monitoring data, CSDLAC 2006).

Analytical results are summarized at the end of this section in Exhibit 5-1, sorted by sampling segment, and in Exhibit 5-2, sorted by fish species.

5.1 Species and Habitat Synopses

The Ocean Fish Contaminants Survey collected and analyzed a broad range of fish species, representing 13 families (23 species and species groups) and nearly all the habitat types that are characteristic of the inshore waters of southern California (Allen *et al.* 2006).[23] These habitats included rocky reef (*e.g.*, rockfishes, kelp bass, opaleye), coastal pelagic (*e.g.*, Pacific sardine), soft bottom (*e.g.*, white croaker, corbina, halibut), and nearshore generalists (*e.g.*, topsmelt). Among the soft-bottom fish are species that occupied both coarse sandy areas of the surf zone (*e.g.*, California corbina) and the more organic-rich sediments that are more typical of deeper water or areas that are protected from wave action (*e.g.*, white croaker). Collected fish reflect a broad range of life history characteristics, including species with a maximum age that may exceed 50-60 years (*e.g.*, California sheephead, vermilion rockfish) and others that live no more than 6-8 years (*e.g.*, topsmelt and several surfperches). Prey preferences of the fish collected also are varied, and include herbivores (*e.g.*, opaleye), planktivores (*e.g.*, topsmelt), piscivores (*e.g.*, barracuda, kelp bass) and species that prey primarily on benthic infauna (*e.g.*, white croaker).

The survey successfully collected the vast majority of the targeted species and sizes outlined in Section 3. This suite of species made up approximately 63 percent of the recreational near shore landings of fish in southern California from 2004-2005, as reported in the RecFin database. In addition, our survey collected and analyzed 11 of the top 20 species (by weight) captured and consumed by anglers from the inshore waters of the southern California (boat mode and shore mode combined). The 9 species not collected were either (a) not targeted by this

[23] Actual species caught for the three species groups (water-column feeding surfperch, benthic-feeding surfperch, and rockfish) are described at the end of Section 3.2.1. Throughout this section in discussions of contaminant levels, these species groups are simply referred to as species for comparative purposes.

survey because they are primarily caught by boat fishing modes (lingcod, bocaccio); (b) targeted by the survey, but were difficult or impossible to find during the collection phase (Pacific bonito, yellowtail jack); (c) were represented by other species or species groups that were analyzed (barred surfperch, spotfin croaker, bat ray); or (d) have historically not been a major component of the recreational catch (striped mullet). Our sampling provided better species coverage for shore-mode fishing, which is of greater interest to EPA and the Trustees for remediation and restoration purposes.

5.2 Contaminant Concentrations in Fish Tissue

This section provides an overview of spatial and inter-species differences in average concentrations of DDTs, PCBs, chlordane, dieldrin, and mercury. All results in this section are for skin-off fillets, with the exception of Pacific sardines and topsmelt, which were analyzed as whole fish (with viscera) due to their small size. More detailed analysis of inter-segment differences in contaminant concentrations and the impacts of individual differences (*e.g.*, body size, lipid content) are not addressed in this document. The intent of this summary is to broadly describe the range and structure of contaminant concentration variability among segments and species. Specific differences between segments or species can be a result of several factors and should therefore be interpreted cautiously. As stated previously, evaluations for human health risk and fish consumption advisory purposes are not be addressed in this report.

The range and distribution of contaminant concentrations among species and segments are described using a standardized approach. First the contaminant concentrations (DDTs, PCBs, chlordane, and mercury) were characterized for each site and sampling segment using the arithmetic mean. Dieldrin was excluded at this point since values were generally either near or below detection limits, limiting the utility of statistical analysis. The distribution summary for each contaminant is based on log-distribution of mean values. The terms quartile, inter-quartile range, and outlier are used to distinguish outlier, higher, intermediate, and lower concentrations. These characterize the overall distribution of contaminant concentrations and identify any species and/or segments that are particularly high or low in concentrations relative to other species and/or segments. Quartiles are the values that represent the 25^{th}, 50^{th}, and 75^{th} percentile of the distribution. The 25^{th} and 75^{th} percentiles are generally used to represent the majority of the distribution. The inter-quartile range (IQR) is the difference between the 75^{th} and 25^{th} percentile. To characterize values relative to the overall distribution, the term "lower" applies to non-outlier values that are below the 25^{th}, "higher" to non-outlier values that are higher than the 75^{th} percentile, and "intermediate" to values that are within the inter-quartile range. Outlier values are typically identified as those that are either 1.5*IQR less than the 25^{th} percentile or 1.5*IQR more than the 75^{th} percentile. These designations are a way of identifying species and/or segments that may be particularly high or low in contaminants relative to the overall distribution. Given that mean concentrations are used in this analysis, outliers are not interpreted as mistakes or analytical errors, but rather as species or locations for which particularly high or low uptake is occurring relative to the overall distribution. In addition, concentrations that are identified as "higher" or high outliers may not mean that they represent significant health risk. The designations of "higher" and "lower" indicate the relative contaminant levels in groups of fish; they do not indicate absolute contaminant levels or that particular sites or species are recommended for consumption. From evaluation of "higher" and "lower" contaminant means

for different species, segments, and contaminants, key factors determining relative contaminant levels emerge.

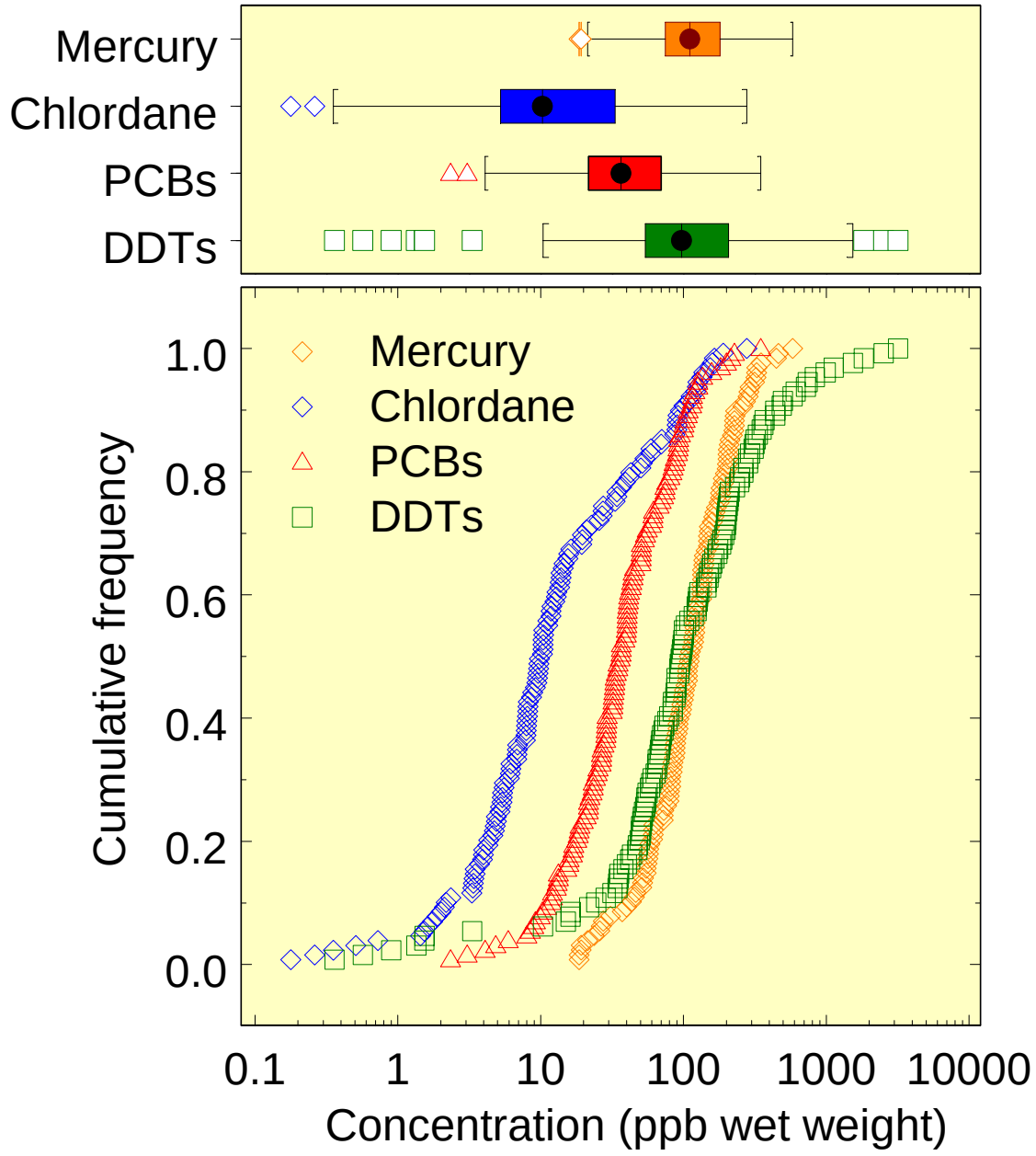
5.2.1 Organochlorines

Organochlorine analyses were conducted on at least one species from every segment (Exhibit 5-2, Figure 5-1). The number of species for which organochlorine analyses were conducted varied from a single species in segments 1 (white croaker), 9 (barred sand bass), and 25 (Pacific barracuda) to 13 species in segment 16. Analysis at commercial catch ban sites generally focused on one species (white croaker), with the exception of EPA "A". Concentrations of PCBs, DDTs, and to some extent chlordane varied broadly both geographically and among species (Exhibits 5-1 and 5-2, Figure 5-1). As noted above, concentrations of dieldrin were generally either near or below detection limits for all fish measured and therefore are not discussed in detail.

Mean concentration of total DDTs had the broadest range among species and segments (Figure 5-2) with the lowest mean concentration in opaleye from segment 7 (0.9 ppb) and the highest concentrations in white croaker from segment 15 (3,180 ppb). The inter-quartile range (based on log-normal distribution) for average DDT concentrations was 58.2 to 204 ppb. This range included most species and segments. "Higher" mean concentrations (as defined above) of DDTs were found in nine species (white croaker – 8 segments; kelp bass, California scorpionfish, and barred sand bass – 5 segments; Pacific sardine and rockfishes – 2 segments; and topsmelt, sargo, and California sheephead – 1 segment). All of these species (except California sheephead for which there is only a single collection) have DDT concentrations in the "intermediate" and/or "low" range in other segments, so there is no species that is consistently in the "higher" range for DDTs. Twelve species were consistently either "intermediate" or "lower" in DDTs. These were benthic-feeding surfperches, black croaker, California corbina, California halibut, jacksmelt, Pacific barracuda, Pacific chub mackerel, queenfish, shovelnose guitarfish, water-column-feeding surfperches, white seabass, and yellowfin croaker. Outlier mean concentrations were found on both the high and low concentration ends. Low mean concentration outliers (below 8.86 ppb) for DDTs comprised the entire opaleye collection, which had average concentrations for each segment lower than 4 ppb. Outliers on the high end (greater than 1,340 ppb) included white croaker (segments 12, 24, and 15) and barred sand bass (segment 13-14).

Figure 5-1
Collection locations for all species and segments analyzed for PCBs, DDTs, Chlordane, Dieldrin and mercury.
Segment regions and the CDFG commercial catch ban zone are indicated.

Figure 5-2
Mean Concentrations of DDTs, PCBs, Chlordane, and Mercury



Notes: Dieldrin concentrations are not shown because they were all at or near the minimum detection limit.
Upper panel – summary statistics for the four contaminants. Whiskers indicate 150% of (1.5x) the inter-quartile range (IQR, 25th to 75th percentile), box represents the inter-quartile range, solid circle represents the median value, and outliers (points that lie beyond 1.5 x IQR) are indicated with symbols that match those used in the cumulative distribution plot.
Lower panel – cumulative distribution (note log scale) for chlordane, PCBs, DDTs, and mercury

Mean concentration of total PCBs also varied broadly among species and locations (Figure 5-2), but less so than DDTs. The lowest mean PCB concentration was in opaleye from segment 19 (3.06 ppb) and the highest concentrations in white croaker from segment 15 (347 ppb). The inter-quartile range (based on log-normal distribution) for average PCB concentrations was 21.7 to 69.9 ppb. This range included most species and segments. "Higher" mean concentrations (as defined above) of PCBs were found in 10 species (white croaker, barred sand bass, kelp bass, California scorpionfish, benthic-feeding surfperches, Pacific sardine, topsmelt, opaleye, and sargo). All of these species have mean PCB concentrations in the "intermediate" and/or "low" range in other segments; therefore, no species had mean PCB concentrations consistently in the "higher" range. Thirteen species were consistently either "intermediate" or "low" in mean PCB concentrations. These were black croaker, California corbina, California halibut, California sheephead, jacksmelt, Pacific barracuda, Pacific chub mackerel, queenfish, rockfishes, shovelnose guitarfish, water-column-feeding surfperches, white seabass, and yellowfin croaker. Outlier mean concentrations were found only on the low concentration end (below 3.75 ppb) for PCBs and comprised opaleye from segment 19 (3.06 ppb) and jacksmelt from segment 8 (2.34 ppb).

The mean concentration of chlordane also varied broadly among species and locations, with the lowest mean concentration in jacksmelt from segment 16 (0.18 ppb) and the highest in white croaker from segment 5 (71 ppb). The inter-quartile range (based on log-normal distribution) for average chlordane concentrations was 4.27 to 11.2 ppb. This range included most species and segments. "Higher" mean concentrations (as defined above) of chlordane were found in 9 species (benthic-feeding surfperch, California corbina, California halibut, Pacific barracuda, Pacific sardine, queenfish, sargo, water-column-feeding surfperch, white croaker). Most of these species also have mean chlordane concentrations in the "intermediate" and/or "low" range in other segments; therefore, most species did not have consistently higher mean chlordane concentrations throughout the area sampled. Two exceptions, which only had concentrations in the "higher" category, were California halibut, for which there was only a single collection, and Pacific sardines, for which there were four collections and whole bodies were analyzed. Ten species were consistently either "intermediate" or "low" in mean chlordane concentrations. These were barred sand bass, black croaker, California scorpionfish, kelp bass, opaleye, Pacific mackerel, rockfishes, shovelnose guitarfish, white seabass, and yellowfin croaker. Outlier mean concentrations were found on both the high (above 51.8 ppb) and low concentration end (below 0.801 ppb) for chlordane. The single high outlier was white croaker from segment 5 (70.7 ppb). Low outliers were jacksmelt from segment 16 and 8 (0.178 and 0.725 ppb), California halibut from segments 5 and 16 (0.263 and 0.508 ppb), and opaleye from segment 19 (0.354 ppb).

With a few exceptions, the broader spatial and interspecies patterns in organochlorine concentrations found in this survey were largely consistent with those from previous surveys (*e.g.* Pollock *et al*. 1991, CSDLAC 2006).[24] White croaker was generally the most highly contaminated species in the vicinity of the Palos Verdes shelf (*i.e.*, southern Santa Monica Bay, Palos Verdes Shelf, San Pedro Bay). White croaker collected from segments in Orange County

[24] These patterns refer to generally higher values near Palos Verdes shelf and to DDT/PCB ratios, rather than to specific concentration levels or to specific locations.

and parts of Long Beach Harbor had levels of contamination that were similar to white croaker collected from the more northerly segments (Point Dume, Ventura). Variation in organochlorine concentrations appeared to be primarily driven by differences between locations and did not follow a clear pattern of higher concentrations in fish that occupy higher trophic levels or reach larger sizes. In most cases, DDT concentrations were higher than PCB concentrations, particularly close to the Palos Verdes shelf. This DDT/PCB ratio is consistent with the reported sediment concentrations of DDTs and PCBs, which have approximately a 10 to 1 ratio in the sediments (CSDLAC 2006). One exception from this rule was found in opaleye, which consistently had higher concentrations of PCBs than DDTs. The PCB concentrations in opaleye were similar to those of other reef/surf zone fish species, while opaleye DDT concentrations were much lower. While opaleye is the only herbivorous species analyzed, it is not clear if this could explain the lower DDT concentrations. Further study and analysis is needed to understand DDT/PCB ratios in opaleye.

The Ocean Fish Contaminants Survey and the 2002 CSDLAC annual monitoring program collected kelp bass and white croaker from comparable locations on Palos Verdes shelf (Figures 5-3, 5-4).[25] For kelp bass, detailed comparisons of laboratory results (presented in Section 4.5) have shown that the chemical results from this survey and those for the CSDLAC monitoring program are comparable. In 2002, the CSDLAC monitoring program collected kelp bass from three zones in the Palos Verdes Shelf region. They were collected from zones comparable to this study's segments 13-14 (similar to CSDLAC's Zone 1), 12 (similar to CSDLAC's Zone 2), and 9 (similar to CSDLAC's Zone 3). Combined, these collections allow for a comparison of two collections of kelp bass from the segment 13-14 area to additional collections from CSDLAC's Zone 2 and 3, which fills gaps in the data due to the lack of collections in segments 9 and 12 by this study. This analysis revealed no significant effects of body size or location among the four collections (13-14, Zone 1, Zone 2, and Zone 3) for either DDTs or PCBs. This analysis, combined with the analysis in Section 4.5, suggests that the CSDLAC collections in the Zone 2 area are providing similar results for DDTs and PCBs as those from segment 13-14 collection and that kelp bass from the region encompassing Southern Santa Monica Bay to San Pedro Bay outside the Los Angeles Breakwater could be considered to have similar concentrations of PCBs and DDTs.

For white croaker, concentrations of DDTs and PCBs are an order of magnitude lower than those from comparable locations in the 2002 CSDLAC survey conducted on the Palos Verdes shelf. The difference in contaminant results between CSDLAC's Zone 1 collection in 2002 and the current surveys segment 13-14 is particularly striking, given the proximity of the two stations (Figure 5-4). Various potential drivers for this pattern were explored: (1) inter-laboratory variability in contaminant results; (2) seasonal differences in contaminant concentrations; (3) general size differences in collected fish; and (4) small-scale differences in habitat and/or location.

[25] Note that Zone 1 and segment 13-14 both straddle the outfall pipes. As a result, for kelp bass, the segment 13-14 collection is on the west side of the pipes and Zone 1 is on the east side; conversely for white croaker, the segment 13-14 collection is on the east side of the pipes and Zone 1 is on the west side.

Figure 5-3
PCB/DDT (ppb) Results from Trustees/EPA 2002 Palos Verdes kelp bass sample (13-14) and CSDLAC 2002 kelp bass (Zones 1 2 and 3).

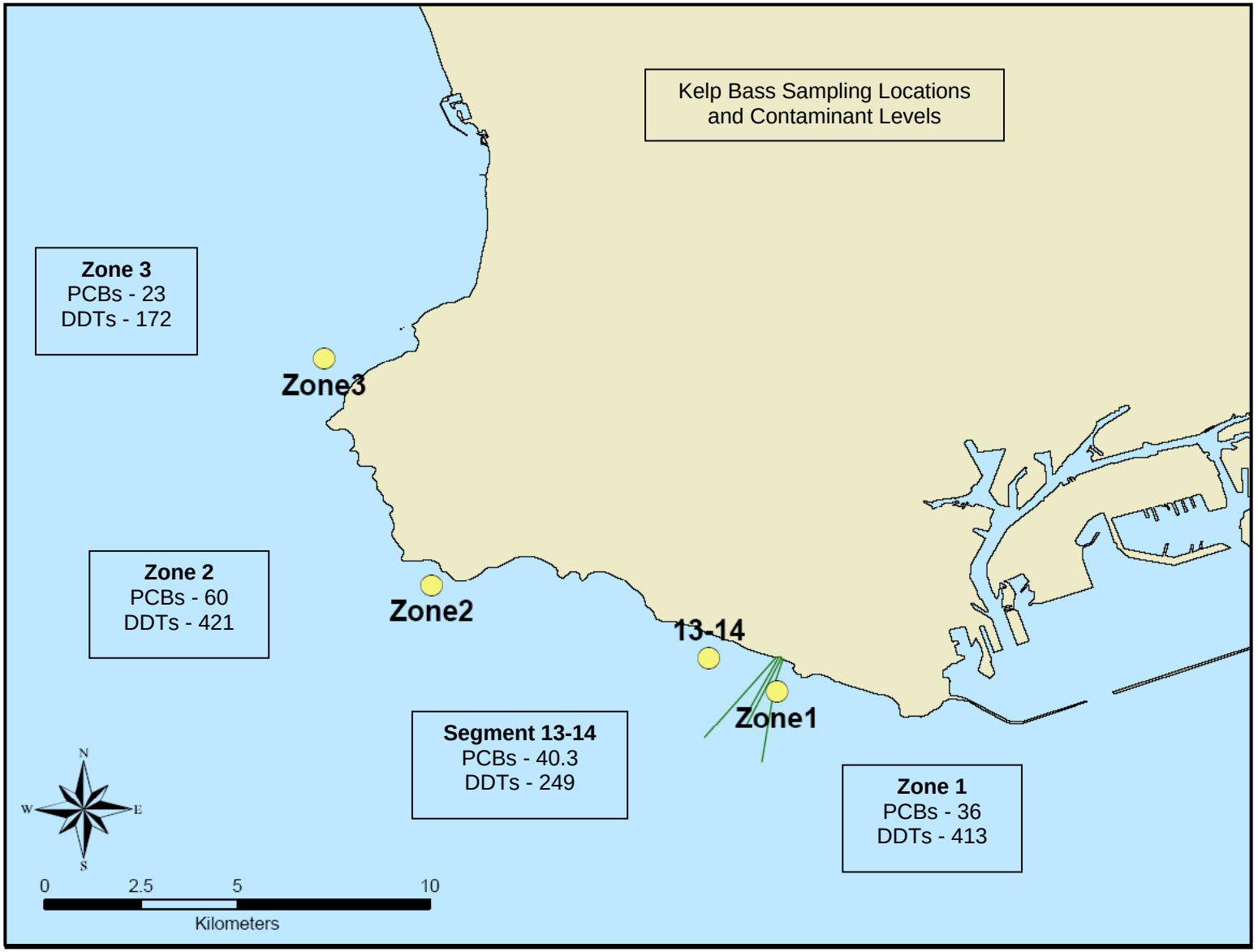
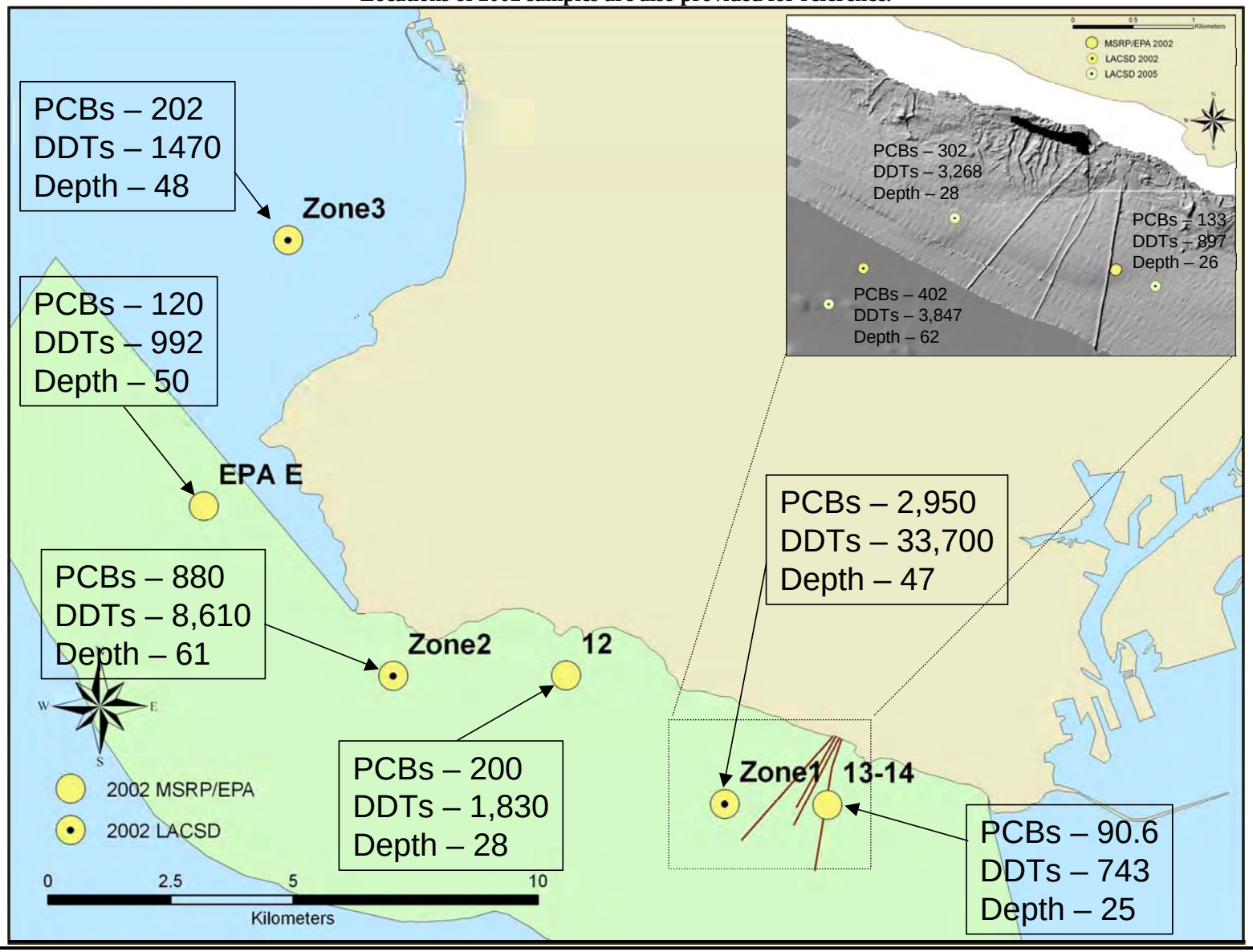


Figure 5-4
PCB/DDT (ppb) Results and sampling depths (m) from Trustees/EPA 2002 Palos Verdes white croaker samples (Segments EPA E, 12, and 13-14) and CSDLAC 2002 white croaker (Zones 1, 2, and 3). Inset panel show PCB/DDT results (ppb) for CSDLAC's 2005 white croaker samples. Locations of 2002 samples are also provided for reference.



The first three explanations were eliminated based on the study of interlaboratory variability described in Section 4.5 and on the timing and size of the fish collected in the two studies. Section 4.5 indicates that differences between the two laboratories, while potentially responsible for a two-fold difference in concentration results, are unlikely to explain the orders-of-magnitude difference between CSDLAC Zone 1 and segment 13-14. Both collections were made within a month of each other in fall 2002, so it is unlikely that timing drove the differences in contaminant results between the two collections. White croaker collected from CSDLAC Zone 1 were significantly smaller than those collected from segment 13-14. However, in order for this size difference to drive contaminant values, an inverse relationship between size and contamination level in the fish is necessary. No statistically significant inverse relationship between organochlorine concentrations and size was found for white croaker, so it is unlikely that size differences are the source of the differences in PCB and DDT concentrations between Zone 1 and segment 13-14.

The CSDLAC Zone 1 and segment 13-14 collections have two key differences in microhabitat: separation by depth differential and by a hard substrate. First, the CSDLAC Zone 1 collection was made from a deeper water depth than the segment 13-14 collection (47 m versus 25 m). Sediments in the deeper areas in the PV shelf tend to have higher organochlorine concentration than the shallow areas (CSDLAC 2006). Thus, if particular white croaker spend the majority of their time in either deep or shallow water, the shallow-water-associated individuals would tend to have lower concentrations of organochlorines than the deep-water-associated individuals. Second, the two collections (CSDLAC Zone 1 and segment 13-14) were made in different areas relative to the CSDLAC wastewater outflow pipes (Figure 5-4). While the CSDLAC Zone 1 collection was located near the end of the pipes and to the west, where the highest sediment concentrations of PCBs and DDTs exist, the segment 13-14 collection was made inshore of the ends of the pipes and on the east side, where sediment concentrations are much lower (CSDLAC 2006). White croaker will actively avoid hard substrates under some conditions (Allen 2001), so the outfall pipes may act as a barrier to along-shore movement of white croaker.

To test for differences between fish collected at different depths and sides of the outflow pipes, CSDLAC conducted a revised sampling survey in 2005. This survey collected ten white croaker in their traditional Zone 1 location, ten white croaker from the west side of the pipe in 25 meters of water, and ten white croaker on the east side of the pipe in 25 meters of water, close to where the original segment 13-14 white croaker were collected (Figure 5-4 inset). CSDLAC captured and filleted these fish using the same protocol used in this study. These 30 white croaker were analyzed for DDTs and PCBs at the CSDLAC laboratory.

The concentrations of PCBs and DDTs in the white croaker collected off of White Point in 2005 by CSDLAC were consistent with the hypothesis that the more highly contaminated fish on the west side of the outfall were blocked from moving along shore by the outfall pipes and provided no support for the hypothesis that contamination was related to the depth differential. Concentrations of PCBs and DDTs were not significantly different between the deep and shallow location on the west side of the pipe. However, the concentrations of DDTs and PCBs on the east side of the pipe were significantly lower than either collection on the west side of the outfall pipes (Table 5-1; values indicating a statistically significant difference are highlighted). The results from CSDLAC's 2005 sampling suggest that differences between the east and west sides

of the pipe, and the inability of certain fish to cross areas of hard substrate, are the most likely driver of local differences.

Table 5-1: Results from Analysis of Variance (ANOVA) that tested for between site variation in concentrations of Total DDTS and PCBs. The R^2 for this ANOVA was 0.28 and 0.27 for DDTs and PCBs, respectively.

Source of Variation	DF	SS	MS	F	p
Site (Total DDTs)	2	48864606.7	24432303	5.25	0.0119
Deep vs. shallow (west side of pipes)	1	1676205	1676205	0.36	0.5535
East vs. west	1	47188401.7	47188402	10.13	0.0036
Error (individuals within site)	27	125715180	4656118		
Site (Total PCBs)	2	369740	184870	5	0.0142
Deep vs. shallow (west side of pipes)	1	50000	50000	1.35	0.255
East vs. west	1	319740	319740	8.65	0.0066
Error (individuals within site)	27	998130	36968		

Notes: DF=Degrees of Freedom; SS=Sum of Squares; MS=Mean Square; F=F statistic (ratio of variances); p=Significance. Highlighted values are for $p<0.05$, indicating that the differences are statistically significant for that variable.

5.2.2 Mercury

Mean concentration of mercury had a slightly smaller range of values among segments and species than that of chlordane and PCBs (roughly 1.3 order of magnitude, versus two). The lowest mean concentration was in Pacific sardine from segment 16 (18.6 ppb) and the highest mean concentration was in black croaker from commercial catch ban site "A" inside the LA Breakwater (582 ppb). While black croaker were relatively low or intermediate in mean organochlorine concentrations, they had the three collections with the highest mean mercury concentrations. The inter-quartile range (based on log-normal distribution) for average mercury concentrations was 74.5 to 180 ppb. This range included most species and segments with the notable exceptions of all collections of black croaker (4 segments), Pacific barracuda (2 segments) and white seabass (1 segment). "Higher" mean concentrations of mercury (as defined above) were found in 11 species (barred sand bass, kelp bass, black croaker, California scorpionfish, Pacific barracuda, sargo, California halibut, rockfishes, shovelnose guitarfish, white croaker, and white seabass). White croaker had both "lower" (6 segments) and "intermediate" (16 segments) mean mercury concentrations along with the single segment with "higher" mean mercury concentrations. The remaining 10 species with "higher" mean concentrations did not have any samples that were in the "lower" range, suggesting a more species-dependent pattern for mercury than what was found for organochlorines. Ten species were consistently either "intermediate" or "lower" in mean mercury concentrations. These were benthic-feeding surfperches, California corbina, California sheephead, jacksmelt, opaleye, Pacific chub mackerel, queenfish, topsmelt, water-column-feeding surfperches and yellowfin croaker. Outlier mean concentrations were found only on the low concentration end (below 19.9 ppb) for mercury and comprised only Pacific sardines from segments 7, 8, 15, 16.

Variations in mercury concentrations among the fish collected in this survey were generally driven by differences between species and fish size, as has been found in other surveys throughout the nation. No consistent hot spots for mercury were identified and larger, higher trophic level species (kelp bass, barred sand bass) were generally higher in mercury

concentrations than smaller, lower trophic level species. One important point is that Pacific chub mackerel (of the *Scomber* genus) had some of the lowest mercury concentrations of all the species analyzed, while mackerel species that belong to the *Scomberomerus* genus are often associated with higher mercury content (see federal warnings associated with king mackerel, USEPA/USFDA 2004). This is likely due to the fact that Pacific chub mackerel feed on zooplankton and small fish, grow fast, and are not particularly long-lived relative to the larger tunas and mackerel that occupy a higher trophic level. Black croaker are an exception to the rule that predicts higher mercury concentrations in higher trophic level species. The species is generally believed to consume similar food to other demersal croakers (benthic invertebrates such as rock-dwelling crabs, shrimp, and amphipods and some small fish; Limbaugh 1961). Despite their trophic similarity to other croakers, they consistently had the highest mercury concentrations of all species analyzed. One possible explanation for this is that black croaker are known to be slower growing and longer-lived than other croakers (Love 1996), which may result in greater bioaccumulation potential. However, they had higher mercury concentrations than other species that are also known to be long-lived and slow growing (*e.g.*, rockfish). Previous research has noted that detritus feeders, such as crabs, may have much higher concentrations of bioaccumulative contaminants than predicted by their assumed trophic level, depending on the trophic level of the carcasses consumed (Isaacs 1972). Therefore, black croakers may be accumulating high levels of mercury through their detrivorous prey.

5.2.3 White croaker commercial catch ban collection data

As described under study design in Section 2 of this report, white croaker were collected at six sites (EPA A-F) specifically to provide data for the evaluation of the existing commercial catch ban area for white croaker (California Fish and Game Code § 7715(a) & (b); California Code of Regulations, Title 14, Section 104). These sites were located beyond the current boundaries of the commercial catch ban area (Figure 5-5). By design these sites were to be sampled up to four times each, twice during the spring and twice during the fall, to obtain data not only on geographic differences in organochlorine concentrations but also on potential seasonal variations. Section 3 describes the results of the fish collection and notes changes to the sampling locations made because of difficulties in finding white croaker in some of the original locations. Not every site was sampled in every year and season (Figure 5-6). In particular, Site F was determined to be an inappropriate collection site after the first collection event in the fall of 2002, due its rocky substrate, and was not sampled thereafter. For two of the remaining sites, EPA D and EPA E, a fall collection did not occur in 2002. Thus four collections were made from EPA A, B, and C over two years and two seasons (fall 2002, spring 2003, fall 2003, spring 2004), and 3 collections were made from EPA D and E (spring 2003, fall 2003, spring 2004).[26]

The purpose of the multi-year/multi-season approach is to determine if seasonal variation in contaminant concentrations exist that would be missed by the single-season sampling strategy used for the larger survey. Seasonally dependent spawning patterns may influence organochlorine contamination levels due to the link between egg production and lipid content in the females. Spawning occurs in white croaker in the late winter and spring, with peak spawning

[26] The spring collections of white croaker took place in June; the fall collections took places between September and November.

activity in January and February (Love *et al*. 1984). Thus it is possible that female fish will build up high concentrations of lipids in the fall and early winter during the period that they are producing eggs, and then release the bulk of those lipids during the final stages of egg production and spawning, releasing large amounts of DDTs and PCBs at the same time. The expectation is that this pattern would result in higher concentrations of organochlorines in the fall than in the spring. Male fish in some areas also have a seasonal cycle in lipid content that is more associated either with migration or building up resources for cold winters. Such a seasonal variation was observed in white croaker PCB concentrations in a monitoring program conducted in San Francisco Bay in 2000 (Greenfield *et al*. 2004).[27]

The white croaker collected from these locations surrounding the existing "commercial catch ban area" exhibited DDT and PCB contamination levels that were generally in the higher range of values found in fish through the entire Ocean Fish Contaminants Survey, particularly at EPA B and E, and to a lesser extent at EPA C (Figure 5-6, see also Figure 5-4 and values in Exhibit 5-2 for comparison). While concentrations of DDTs and PCBs in this commercial catch ban area evaluation are somewhat elevated, they are considerable lower than concentrations found in white croaker collected from the deeper waters adjacent to the White Point wastewater outflow (CSDLAC 2005). Evaluation of the need to modify the boundaries of the white croaker commercial catch ban area is beyond the scope of this report; thus, discussion focuses on the results of temporal sampling and whether contamination results indicate interseasonal variability.

The results from this survey did not detect a consistent difference between spring and fall collections in PCB/DDT concentrations in the muscle tissue of white croaker. Other studies have found some seasonality in white croaker contaminant concentrations; however as in this survey no consistent pattern has emerged. In one study (Pollock *et al*. 1991), peak DDT and chlordane concentration in the muscle tissue of white croaker occurred in the summer months, whereas peak PCB concentrations occurred in the winter months. Another study, which examined concentrations in the liver and gonads of white croaker, demonstrated a clearer pattern where contaminant concentrations varied with season and reproductive cycles (SCCWRP 1986).The SCCWRP (1986) survey did not examine muscle tissue concentrations.

In the current survey, three locations had two consecutive years of collections in the fall and following spring (EPA A, B, and C, 2002-2003, 2003-2004). PCB and DDT concentrations were highly correlated (R^2= 0.92) suggesting that unlike results from Pollack *et al*. 1991, high DDT concentrations were correlated with high PCB concentrations. Lipid concentration explained 38% of the variation in DDT concentration and 45% of the variation in PCBs among these samples. However, lipid concentration did not appear to have a significant influence on seasonal differences in contaminant concentrations. No significant differences between spring and fall collections were found before or after contaminant concentrations were adjusted for lipid levels. There were significant differences between sampling locations in both lipid-adjusted and raw contaminant concentrations, and a significant interaction between season and sampling year. This latter effect highlights the variance in seasonal differences from year to year. This is best seen in EPA A and B where fall 2002 concentrations were higher than those from spring 2003, but fall 2003 concentrations were lower than those from spring 2004 (Figure 5-6).

[27] Greenfield *et al*. (2004) defined Spring/Summer/Fall/Winter as March/June/September/December.

Figure 5-5
Locations for collections designed to evaluate that CDFG commercial catch ban zone, also indicated.
CSDLAC wastewater outflows are indicated in red.

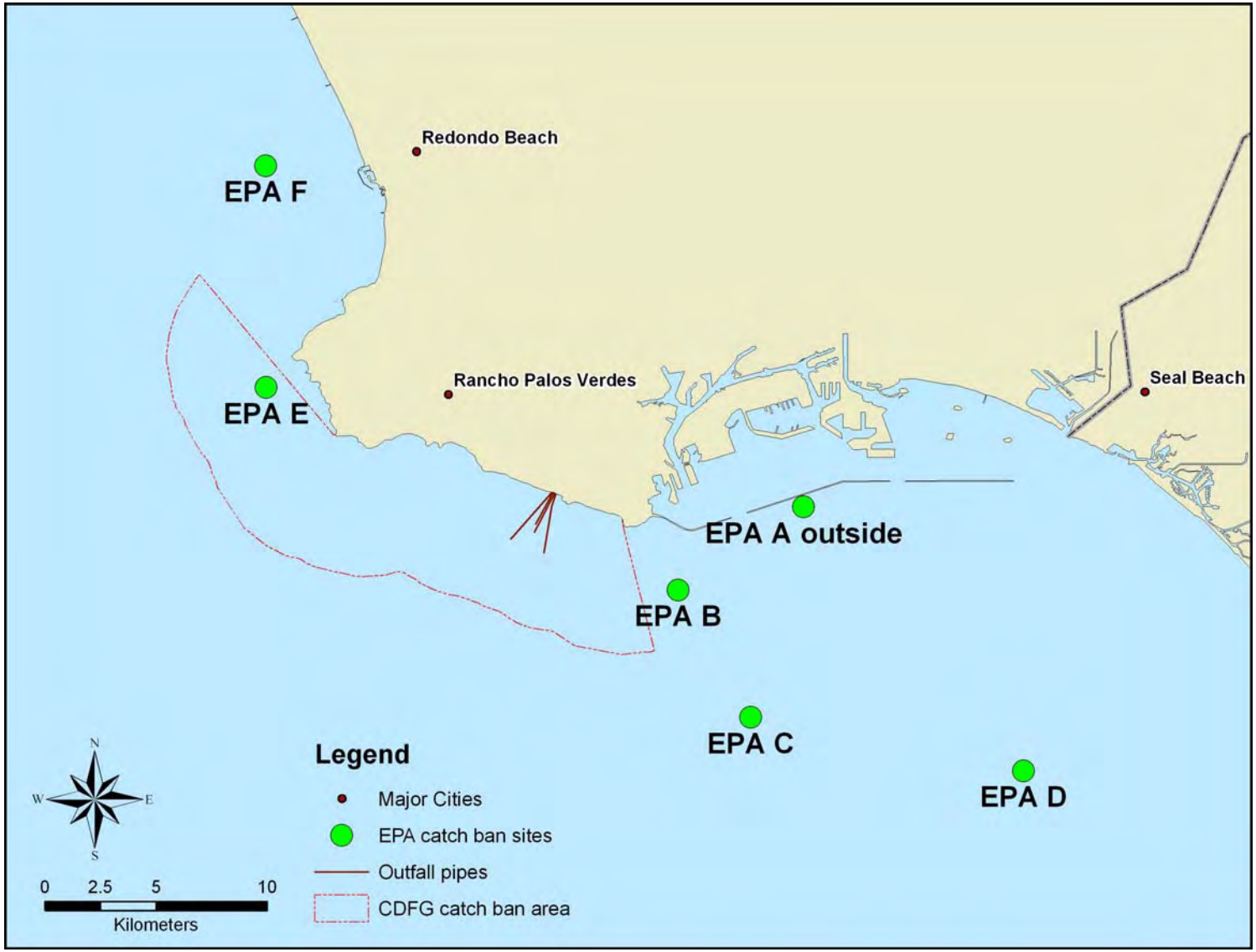
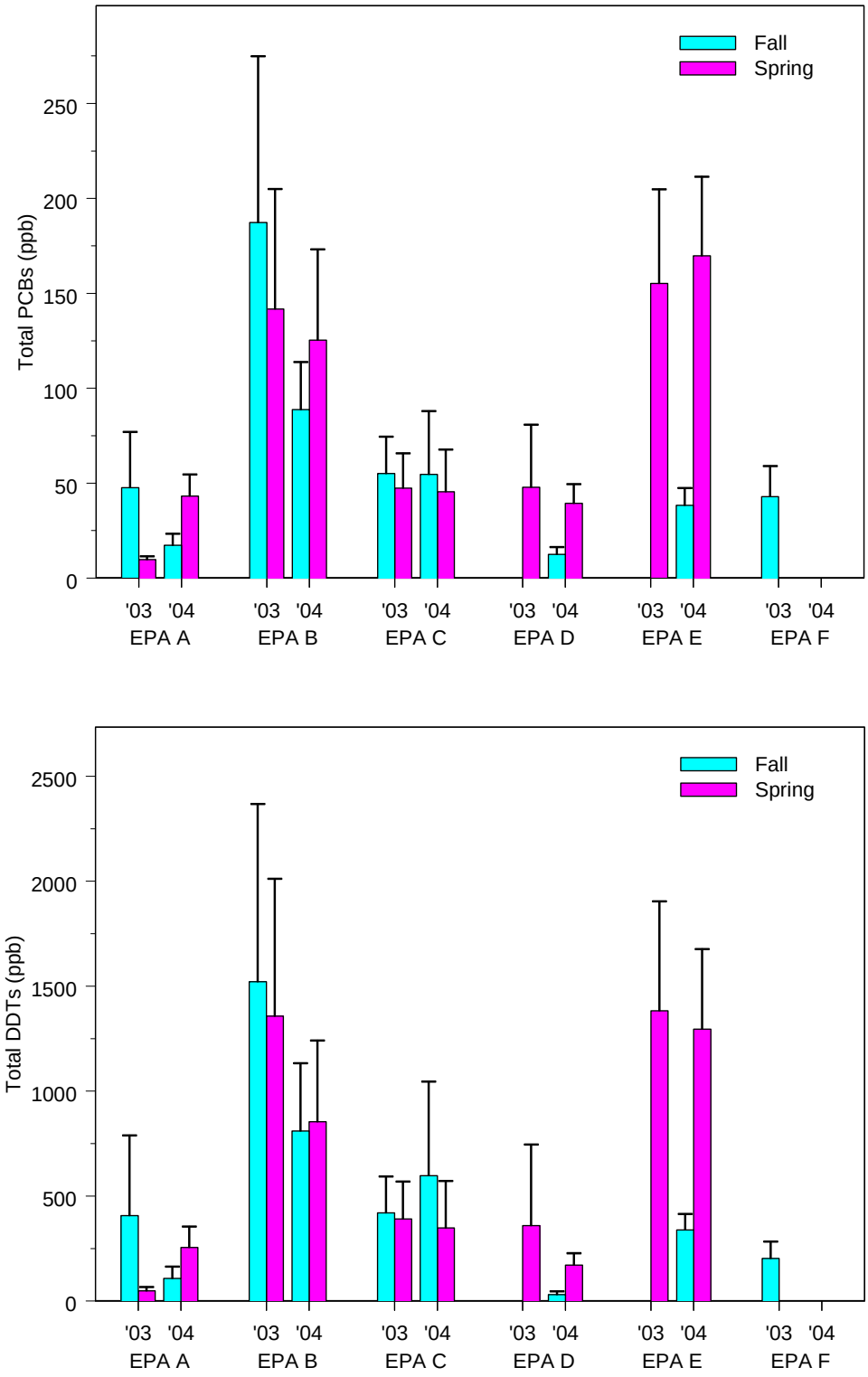


Figure 5-6
Average concentrations of DDTs and PCBs in white croaker collected as part of the evaluation of the commercial catch ban zone. Error bars indicate standard deviations of the means.



Several possible explanations exist for the absence of a consistent pattern of higher organochlorine concentrations in white croaker in the fall season:

1. A seasonal or annual pattern simply does not exist (*i.e.*, the seasonal spawning does not have a significant influence on contaminant levels).

2. The seasonal variability is smaller than the study can detect within the overall data variability. Given the sample size of 10 fish per location, the total number of samples, and variation in results, the minimum statistically significant difference detectable for this study is 112 percent, based on a post hoc power of the test analysis.

3. A seasonal pattern may be masked by the confounding influences of gender. Gender was not recorded for the fish that were collected, but a large number of the samples may have been males or the gender ratio may have varied significantly among collections.

4. The temporal resolution used in the sampling may be too coarse to resolve a pattern that may occur in the span of a few weeks, or may occur at very different times within a season. While spawning may ultimately result in a release of organochlorines for an individual, this release happens to each individual at a different time point during the spawning season. Given that the spawning season is typically several months long and varies in timing from year to year, the two spring collections may have occurred prior to the bulk of the population releasing their eggs, or the collections in the later fall may have occurred after fish had already released their eggs. Sampling a few months or even weeks prior could have resulted in higher concentrations in pre-spawned adults. Sampling too late (*i.e.*, June) may have resulted in fish that had rebuilt their lipid/organochlorine concentrations.

5. Finally, the movement patterns of the fish may affect contamination results. White croaker are known to exhibit seasonal inshore-offshore migrations, spending much of the winter in deeper water and much of the summer in shallower water. Sediments in the deeper offshore water are more heavily contaminated with PCBs and DDTs. If fish collected in the spring have spent a greater proportion of their recent past over the highly contaminated sediments than those collected in the fall, they may have higher concentrations of organochlorines in their tissues regardless of their lipid content.

Other factors may explain the lack of consistently higher fall season organochlorine concentrations in white croaker from this study, or several explanations may interplay. If further sampling is planned to explore seasonal variation in white croaker contamination, these and other considerations should be included during the sampling design.

5.3 Contamination Relationships for Multiple Body Components for White Croaker and Kelp Bass

5.3.1 Analysis of Contamination Relationships between Different Body Components

Fish are consumed as various body components, as discussed in Section 2.2.3.[28] Available literature regarding the relationships between contaminant concentrations in the different body components is generally limited and complex. The relationships may be specific to particular species and locations, as well as to specific contaminant types and levels (*e.g.*, organic contaminants, which may be higher in lipid-rich tissues, and mercury, which may be higher in muscle-rich tissues). Additionally, many variations on the preparation of each component may exist. However, measuring contaminant levels in all body components would substantially limit the total number of individual fish analyzed in cases where budgets or other resources are finite.

One approach to developing a better understanding of body-component-specific contaminant concentrations while balancing the constraints associated with finite funding resources is to analyze a single, commonly consumed, tissue or body component from all fish collected, and multiple tissues or body components from a subset of fish. Ideally, the subset will represent a range of contaminant concentrations that span the total range of contamination concentrations observed in the total dataset and represent species of key concern. This subset of fish can then be used to determine relationships among body components. The relationships between components can then be used to estimate body component concentrations in fish for which only a single body component or tissue (*i.e.*, skin-off fillet) was analyzed.

An analysis of covariance (ANCOVA) was used to determine (1) the degree to which contaminant levels (PCBs, DDTs) in three body components (skin-on fillets, viscera, and "remainder") can be estimated by contamination levels in skin-off fillets and (2) whether species (kelp bass, white croaker) significantly affects these relationships. The second goal relates to the degree to which data from one or two species might be generalized to other species. If major differences between species are found, then one might conclude that development of such relationships would be required for every species. However, if no consistent differences are found between species, then it is possible that the relationship can be generalized at least to species that are taxonomically and morphologically similar to those tested. The following standard ANCOVA model was used:

$$y = \alpha \cdot s + m \cdot x + b \qquad \textbf{Equation 5-1}$$

where *x* is the log-transformed fillet concentration, b is the slope of the regression, α is the effect of species on the regression, and s is the species. The species variable is either a 1 for kelp bass or a 0 for white croaker, hence the parameter α specifically addresses the degree to which body component values (y) for kelp bass are higher ($\alpha > 0$) or lower ($\alpha < 0$) than those of white croaker. A t-test is used to test against the null hypothesis that each parameter is equal to zero.

[28] Fish for this whole body analysis were resected to remove three portions: skin-off fillet, skin-on fillet with belly flap, and viscera. The "remainder" portion contained all tissue, skin, and bones remaining after resection.

All body component concentrations were significantly correlated with the skin-off fillet concentrations (Table 5-2), with higher skin-off fillet concentrations associated with higher component concentrations (Figure 5-7). The R^2 (proportion of variation explained) for the ANCOVAs ranged from 0.52 to 0.79. Variation in contamination levels that are not explained may be, in part, driven by within-body component variation in lipid levels, a factor that was not included in this analysis.

Table 5-2: Results from Analyses of Covariance (ANCOVA) testing for relationships between skin-off fillet PCB and DDT concentrations and three other body components

			Parameter		
Analyte	Material type	R^2	intercept (b)	slope (m)	Species (α)
PCBs	Skin-on fillet	0.68	1.40 **	0.63 **	-0.27 *
	Viscera	0.63	1.39 **	0.74 **	0.03 ns
	Remainder	0.52	1.56 **	0.64 **	0.12 ns
DDTs	Skin-on fillet	0.79	1.03 **	0.90 **	-0.14 ns
	Viscera	0.61	1.81 **	0.69 **	-0.34 ns
	Remainder	0.77	0.98 **	1.02 **	0.26 ns

Note: The R^2 for the ANCOVA is provided as well as the parameter estimates for the intercept, slope, and species affect. Statistical significance of each parameter is indicated with a * ($p<0.05$), ** ($p<0.01$), and ns (not significant).

In most cases, species was not a significant determinant of the relationship between skin-off fillet concentration and the concentration in other body parts. Skin-on fillets had the lowest increase in DDT/PCB concentrations over skin-off fillets, averaging approximately 6 to 7 times the DDTs and PCBs of skin-off fillets. Skin-on fillet DDT/PCB concentrations ranged among individuals from as low as the skin-off fillets to more than 20 times the skin-off fillet.[29] Viscera and "remainder" samples had similar and higher increases in DDT/PCB concentrations over skin-off fillets, approximately 11 to 17 times the DDTs and PCBs as skin-off fillets depending on contaminant and component. DDT/PCB concentrations in these two components ranged among individuals from as low as the skin-off fillets to more than 40 times the skin-off fillet. The one exception to species independence is the case of PCBs in the skin-on fillets, where PCB concentrations in the skin-on fillets relative to skinless fillets of kelp bass were significantly lower than white croaker. Future studies may include a further evaluation of the effect of species on these relationship to clarify any inter-species differences.

[29] A comparison between composites of skin-on and skin-off fillets from white croaker in San Francisco Bay indicated a much lower ratio of roughly 1.75:1 (Davis *et al.* 2002). However, that study had significantly higher lipid concentrations in both skin-on and skin-off portions (6-9 percent skin-on, 4-6 percent skin-off) and did not use the entire fillet from the fish. The study did not indicate whether belly flap tissue was included in the skin-on fillet composite. Across multiple species, the ratios vary widely between fillet and whole body samples, and in many cases the definition of the fillet is not precise (e.g. inclusion of skin, subcutaneous fats, belly flaps). An analysis of PCB ratios in various species (including various salmon, trout, bass, and perch) indicated ratios varying from 1 to 25 between whole fish and fillets (Connolly *et al.* 1992, Parkerton 1993, Amrheim *et al.* 1999).

The ANCOVA model provided a good fit to the observed values with R^2 values ranging from 0.52 to 0.67. Observed values plotted against predicted values tended to fall along the one-to-one line over most of the concentrations tested (Figure 5-8). For samples with the highest concentrations, the predicted values tended to under-estimate the observed values. Using the parameters in Table 5-2 and skin-off fillet concentrations from other fish, additional body component concentrations can be estimated as needed.

Figure 5-7
Correlation of Total PCB and Total DDT Concentration Between Skin-off Fillet and Other Body Components

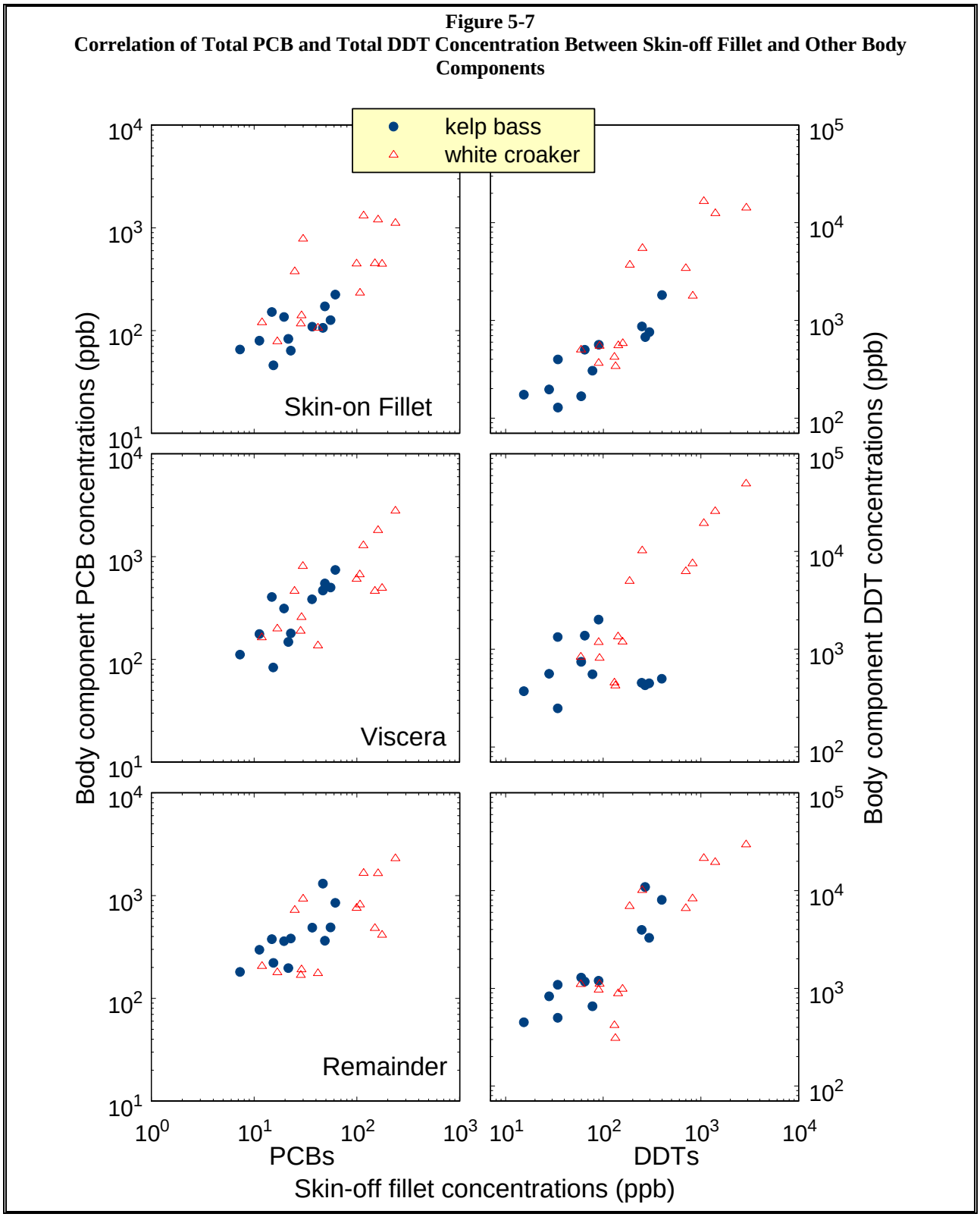
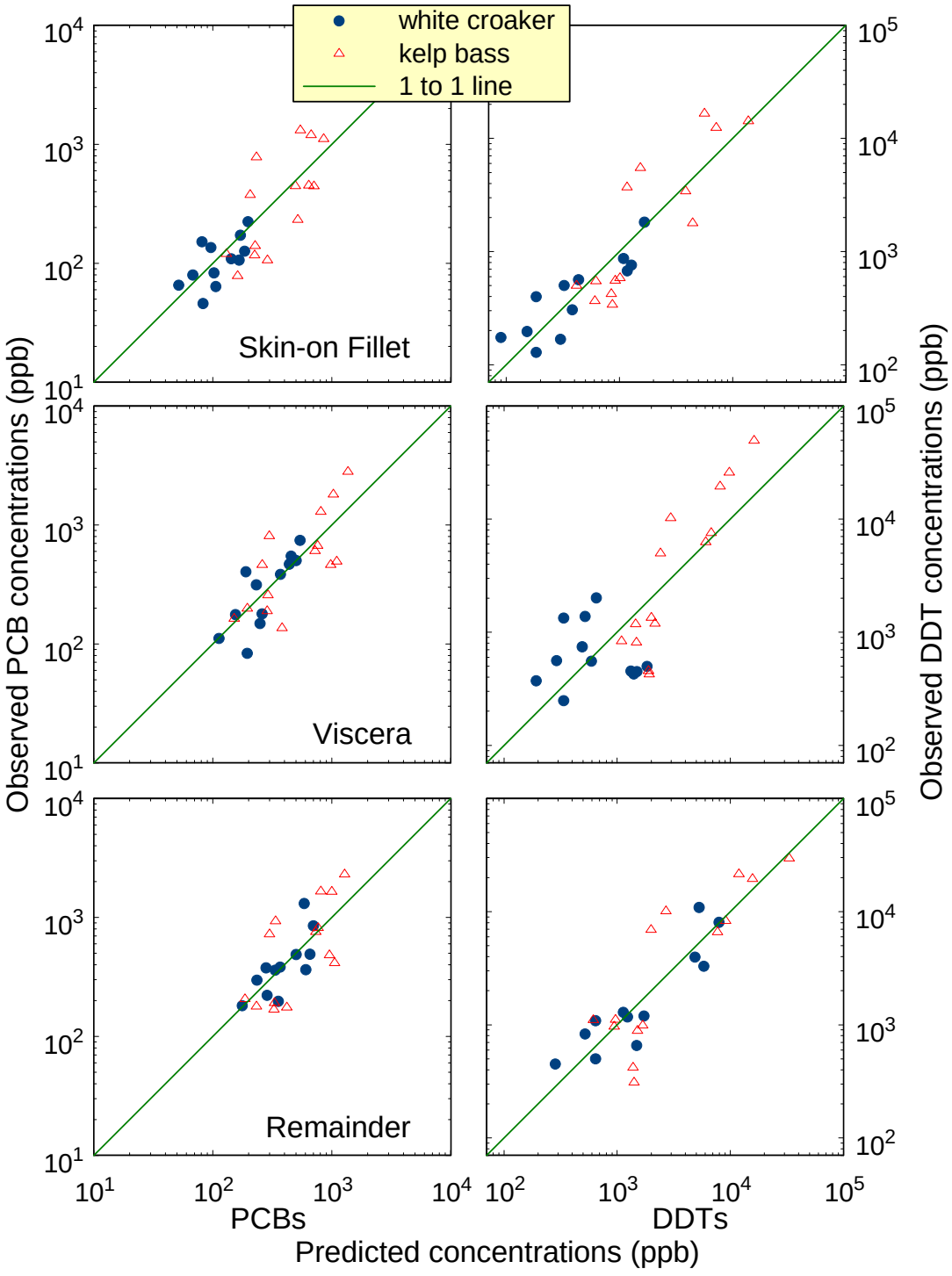


Figure 5-8
Correlation of Observed Total PCB and Total DDT Concentration to Predicted Total PCB and Total DDT Concentration, Based on ANCOVA Model. One-to-one line indicated in green.



5.3.2 Estimating Concentrations in Whole Fish or Other Combined Body Components from Measurements in Fillets

Relationships between contaminant concentrations in non-measured preparations (*e.g.*, whole fish, whole gutted fish) and skin-off fillet concentrations can be developed by combining the body component concentration relationships in the previous section with the weights of those components. While the majority of data in this study are for skin-off fillets, contaminant levels in other body components may also be needed for comparison to other data sets and for risk assessments. Contaminant levels in whole, ungutted fish are useful for ecological risk assessment, in order to calculate the dosage that predators would receive consuming whole prey. For comparison with other data sets, estimates of concentration in whole, gutted fish may be useful.

Using the component relationships developed in the previous section and the weight of each component, any combination of the four body components (skin-off fillet, skin-on fillet, viscera, and remainder) can be combined to create a partial or whole body estimate of PCB or DDT concentration. With the regression model described in the previous section, one can estimate the PCB or DDT concentration in any of the three body components of a fish based on its skin-off fillet concentration. These different components are then combined with body proportions (Table 5-3) as:

$$C = \frac{\sum_i \left(p_i \cdot c_i\right)}{\left(\sum_i p_i\right)} \qquad \textbf{Equation 5-2}$$

where c_i is the concentration in body component ***i*** and p_i is the proportion (by wet weight) that the body component ***i*** represents relative to the entire body. The concentrations in the skin-on fillet, viscera, and "remainder" body components are estimated from the skin-off fillet concentrations based on Equation 5-1 with the parameters listed in Table 5-2. Estimates of whole body PCB and DDT concentrations were then generated for the 26 fish in the body component analysis (Table 5-4). These estimates suggest that whole fish have concentrations of PCBs and DDTs that are generally 8 to 10 times higher than the skin-off fillet concentrations, with whole body/skin-off fillet ratios ranging from as low as 4 to as high as 12 (Table 5-4). Kelp bass tend to have higher whole fish:fillet ratios (*i.e.*, whole fish is more contaminated relative to skin-off fillet) than white croaker. The DDT ratio is less variable than the PCB ratio. For kelp bass, the whole fish:fillet ratio for DDTs is roughly 12, while it ranges from 8 to 15 for PCBs. For white croaker, the whole fish:fillet ratio for DDTs is 7 to 8, while it ranges from 4 to 10 for PCBs.

Table 5-3: Proportion of Total Weight for Each Body Component									
		Skin-off Fillet		Skin-on Fillet		Remainder		Viscera	
Sample ID	**Segment**	**Weight (g)**	**Proportion**	**Weight (g)**	**Proportion**	**Weight (g)**	**Proportion**	**Weight (g)**	**Proportion**
KB 001	7	99.89	0.09	390.27	0.37	525.35	0.85	131.47	0.11
KB 002	7	91.72	0.12	245.18	0.35	345.02	0.78	104.62	0.13
KB 023	2	141.27	0.20	186.66	0.33	276.82	0.64	101.99	0.14
KB 026	2	109.99	0.10	379.24	0.39	446.91	0.69	156.21	0.14
KB 027	2	133.44	0.14	321.57	0.40	342.79	0.58	131.68	0.14
KB 028	2	88.15	0.12	290.7	0.43	290.41	0.62	90.17	0.12
KB 034	7	126.77	0.17	243.98	0.41	279.03	0.62	78.15	0.11
KB 036	7	86.33	0.10	268.63	0.35	365.53	0.75	130.83	0.15
KB 046	13/14	134.67	0.21	106.12	0.21	307.27	0.91	95.75	0.15
KB 048	13/14	99.43	0.15	175.37	0.31	301.94	0.82	94.29	0.14
KB 055	13/14	148.13	0.17	240.07	0.34	373.07	0.78	89.36	0.11
KB 058	13/14	56.27	0.15	110.15	0.34	149.86	0.66	61.04	0.16
WC 126	5	23.5	0.20	41.35	0.44	21.17	0.22	32.05	0.27
WC 135	5	36.64	0.16	82.99	0.44	76.41	0.51	28.93	0.13
WC 361	13/14	29.04	0.13	82.5	0.43	72.01	0.48	38.00	0.17
WC 369	13/14	26.46	0.15	51.24	0.33	63.84	0.54	40.30	0.22
WC 373	13/14	23.81	0.17	58.18	0.49	28.04	0.24	32.58	0.23
WC 374	13/14	20.82	0.11	43.48	0.25	89.39	0.84	42.19	0.22
WC 376	13/14	27.36	0.14	43.99	0.25	95.21	0.89	35.89	0.18
WC 384	13/14	23.1	0.12	57.89	0.36	74.02	0.66	30.32	0.16
WC 693	A	21.6	0.14	45.79	0.34	56.03	0.56	32.65	0.21
WC 696	A	18.79	0.14	47.15	0.39	45.73	0.49	27.31	0.20
WC 700	A	13.88	0.12	28.75	0.27	50.44	0.73	26.20	0.22
WC 701	A	24.77	0.13	48.74	0.30	72.34	0.63	40.98	0.22
WC 710	A	14.54	0.16	28.25	0.36	39.36	0.75	10.04	0.11
WC 712	A	15.67	0.14	28.84	0.30	47.93	0.74	20.14	0.18
Average	KB	109.67	0.14	246.50	0.35	333.67	0.73	105.46	0.13
	WC	22.86	0.14	49.22	0.35	59.42	0.59	31.26	0.19

Table 5-4: Estimates of Whole Body PCB and DDT Concentrations Based on Body Component Concentrations (All concentrations are in ppb; ratios are unitless)

		Skin-off fillet		Skin-on fillet		Remainder		Viscera		Whole body		Whole body/fillet	
Sample ID	**Segment**	**DDTs**	**PCBs**	**DDTs**	**PCBs**	**DDTs**	**PCBs**	**DDTs**	**PCBs**	**DDTs**	**PCBs**	**DDTs**	**PCBs**
KB 023	2	34.3	15.4	129	45.9	499	222	248	83.2	407	185	12	12
KB 036	7	59.5	22.8	167	63.6	1290	382	743	179	703	240	12	11
KB 027	2	15.4	7.31	174	65.3	450	181	371	111	185	113	12	15
KB 026	2	27.9	11.3	196	79.4	827	297	559	176	332	151	12	13
KB 002	7	77.6	21.6	306	82.8	656	197	555	148	915	231	12	11
KB 028	2	34.3	14.9	398	151	1080	377	1340	404	407	181	12	12
KB 001	7	64.7	19.6	501	135	1170	360	1380	313	764	217	12	11
KB 034	7	89.7	49	563	172	1190	363	2010	548	1060	399	12	8
KB 055	13/14	269	46.7	675	106	10900	1310	426	468	3170	387	12	8
KB 046	13/14	296	55.6	758	126	3290	490	448	501	3490	434	12	8
KB 048	13/14	248	36.8	867	109	3960	487	454	384	2920	330	12	9
KB 058	13/14	399	61.7	1820	223	8050	850	499	740	4710	466	12	8
WC 126	5	133	176	339	444	310	416	424	494	1040	761	8	4
WC 693	A	89.5	16.8	366	78.4	967	179	1180	199	723	155	8	9
WC 135	5	130	150	422	452	419	482	456	463	1020	682	8	5
WC 696	A	59	11.9	501	120	1110	206	835	163	494	123	8	10
WC 701	A	91.6	41.9	548	106	1110	176	811	136	738	287	8	7
WC 710	A	142	28.9	555	140	889	191	1350	257	1110	223	8	8
WC 700	A	158	28.4	586	117	989	169	1190	189	1220	221	8	8
WC 384	13/14	822	107	1780	232	8300	816	7560	671	5780	542	7	5
WC 374	13/14	698	99.4	3420	446	6610	759	6260	605	4940	515	7	5
WC 361	13/14	186	24.8	3700	377	6910	725	4980	463	1420	201	8	8
WC 369	13/14	251	29.9	5500	781	10100	935	10200	808	1880	228	7	8
WC 376	13/14	1400	161	12400	1200	19600	1650	25800	1810	9640	716	7	4
WC 712	A	2900	237	14300	1110	29600	2310	49500	2800	19500	934	7	4
WC 373	13/14	1070	116	16600	1310	21500	1660	19500	1290	7440	572	7	5
Average		375	61.2	2600	318	5450	623	5350	554	2920	365	10	8

Note: Only 26 fish are listed in this table. A reanalyzed skin-off fillet concentration was not available for the remaining four from Table 5-3 (WC 139, 142, 144, and 150 from Segment 5) and so the overall ratios could not be calculated for those fish.

Exhibit 5-1
Analytical Results Sorted by Sampling Segment

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
Ventura	1	White croaker	184 (168-206)	84.0(44.2-115)	21.7(8.86-31)	19.4 (ND-33.4)	ND	2.99 (0.54-4.7)	95.9 (c)	9 /9
SMB	2	Barred sand bass	427 (389-480)	31.9(ND-77.9)	8.93(3.81-17.2)	1.44 (ND-3.32)	2.78 (ND-3.94)	0.1 (0.06-0.19)	349 (220-480)	10 /10
SMB	2	Benthic-feeding surfperches	309 (260-345)	15.0(6.62-40.3)	4.08(1.2-6.69)	1.87 (ND-4.96)	ND	0.38 (0.13-0.72)	120 (94-160)	10 /7
SMB	2	Kelp bass	425 (359-476)	34.6(10.4-90.2)	9.91(5.02-15.4)	4.8 (1.84-10)	ND	0.4 (0.01-2.89)	230 (98-370)	10 /10
SMB	2	Pacific chub mackerel	312 (265-395)	58.2(c)	18.3(c)	7.89 (c)	ND (c)	1.93 (c)	83.7 (54-140)	10 /10
SMB	2	Queenfish	171 (162-182)	84.3(29.4-173)	17.9(6.79-35.9)	3.93 (ND-11.3)	ND	0.85 (0.55-1.16)	152 (c)	10 /10
SMB	2	Rockfishes	281 (228-335)	40.2(20.6-95.7)	12.1(4.63-20.4)			1.34 (0.78-2.5)	88.2 (52-160)	6 /6
SMB	2	Sargo	322 (287-366)	66.0(34.5-111)	24.9(12.3-44)			1.28 (0.57-3.3)	228 (89-380)	10 /10
SMB	2	White croaker	218 (190-244)	110.0(74.6-145)	31.7(22.7-42.4)	11.2 (9.24-13.6)	ND	1.8 (1.29-2.28)	167 (c)	5 /5
SMB	3	Queenfish	166 (147-186)	79.3(22.4-206)	28.6(3.58-95.6)	12 (2.62-31.2)	ND	0.99 (0.46-2.69)	108 (c)	10 /6
SMB	3	White croaker	202 (173-230)	101.0(26.5-195)	39.8(13.4-68.4)	15.7 (11.7-18.5)	ND	1.21 (0.28-2.46)	163 (c)	10 /10
SMB	4	Queenfish	162 (150-185)	50.5(18.1-116)	16.7(ND-44.6)	3.98 (ND-11.1)	ND	0.74 (0.46-1.26)	97.3 (c)	10 /4
SMB	4	White croaker	194 (177-225)	97.9(0.99-276)	39.9(4.87-97.3)	5.57 (ND-22.4)	ND	1.88 (0.25-3.72)	135 (c)	10 /10
SMB	5	Benthic-feeding surfperches	286 (247-362)	156.0(44.9-269)	76.4(34.6-124)			1.91 (0.59-3.2)	112 (63-200)	10 /10
SMB	5	California halibut	616 (563-770)	54.8(24-124)	13.3(2.92-35.5)	0.263(ND-0.98)	ND	0.46 (0.25-0.64)	202 (c)	8 /8
SMB	5	California scorpionfish	275 (253-301)	197.0(67.9-702)	50.7(28.5-75.8)			2.95 (1.8-4.1)	121 (83-150)	10 /10
SMB	5	Opaleye	324 (290-376)	1.4(0.478-3.5)	61.1(19.5-153)			3.02 (0.63-9.7)		10 /0
SMB	5	Topsmelt	177 (147-208)	310.0(37.5-1430)	215(77.4-670)			7.29 (5.5-10)		10 /0
SMB	5	White croaker	238 (219-269)	129.0(87.1-189)	182(132-292)	70.7 (39.4-115)	0.818 (ND-4.91)	4.86 (4.15-5.83)	79.4 (c)	6 /6
SMB	5	Yellowfin croaker	261 (233-311)	35.5(c)	42(c)	7.8 (c)	ND (c)	0.42 (c)	170 (c)	10 /10
SMB	23	California scorpionfish	289 (260-328)	352.0(240-562)	116(47.6-231)			2.34 (0.79-4.3)	293 (180-570)	10 /10
SMB	23	White croaker	223 (207-244)	230.0(70-469)	95.4(15.1-227)	6.19 (ND-12)	0.257 (ND-2.57)	1.27 (0.42-2.31)	150 (c)	10 /10
SMB	6	California scorpionfish	291 (260-329)	722.0(215-1810)	126(47.6-267)			4.9 (2.4-8.2)	232 (130-400)	10 /10
SMB	6	White croaker	207 (169-230)	200.0(97.9-292)	59.6(32.2-75)	9.42 (ND-16.1)	ND	1.34 (0.57-2.78)	123 (c)	10 /10
SMB	EPA F	White croaker	211 (183-228)	204.0(90.4-368)	42.9(18.6-72)	7.92 (2.56-11.9)	ND	1.02 (0.27-2.33)	134 (c)	5 /5
SMB	7	Barred sand bass	429 (346-466)	99.1(45.3-269)	26.5(8.17-58.7)	4.27 (ND-9.42)	1.07 (ND-3.88)	0.25 (0.14-0.59)	284 (150-420)	10 /10
SMB	7	Benthic-feeding surfperches	217 (184-260)	88.6(ND-351)	32.3(5-138)	8.02 (ND-26.5)	ND	0.85 (0.29-2.98)	84.4 (c)	10 /8
SMB	7	Black croaker	314 (242-351)	73.7(25.5-141)	28.7(8.58-55.5)	4.33 (ND-10.1)	ND	0.2 (0.06-0.28)	462 (c)	10 /10
SMB	7	California corbina	284 (265-310)	16.2(6.01-30.5)	12.1(4.64-19.9)	6.19 (2.68-9.96)	ND	0.34 (0.18-0.73)	136 (c)	10 /10

Exhibit 5-1
Analytical Results Sorted by Sampling Segment

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SMB	7	Kelp bass	425 (383-465)	101.0(11.5-230)	23.4(4.55-51.6)	4.91 (1.85-7.96)	ND	0.51 (0.01-1.47)	182 (95-290)	10 /10
SMB	7	Opaleye	260 (214-351)	0.9(ND-4.9)	25.2(4.37-62.6)	10.5 (5.92-17.2)	ND	0.96 (0.38-2.41)	55.5 (c)	10 /10
SMB	7	Pacific sardine	215 (197-225)	262.0(c)	92.6(c)	19.6 (c)	ND (c)	12.98(c)	19.2 (c)	5 /5
SMB	7	Queenfish	177 (165-186)	21.9(7.71-33.9)	5.93(1.9-8.46)	3.73 (ND-14)	ND	0.74 (0.24-1.52)	124 (c)	9 /9
SMB	7	Sargo	322 (278-355)	211.0(39.6-551)	114(23.6-233)			2.74 (1-6.5)	205 (110-310)	8 /8
SMB	7	Water-column-feeding surfperches	128 (114-171)	60.9(36.9-96.2)	24.3(16.3-39.9)			2.86 (1.7-4.9)		10 /0
SMB	7	White croaker	182 (153-215)	283.0(60.1-874)	74.3(18.9-209)	14.4 (8.65-23.1)	ND	2.28 (0.54-4.81)	72.2 (c)	10 /10
SMB	8	Barred sand bass	325 (325-325)	65.4(65.4-65.4)	19.9(19.9-19.9)			0.62 (0.62-0.62)	220 (220-220)	1 /1
SMB	8	Benthic-feeding surfperches	295 (260-411)	51.4(18.6-82.9)	7.99(2.72-14.4)			1.1 (0.52-1.8)	102 (52-140)	10 /10
SMB	8	Jacksmelt	251 (223-308)	10.4(2.51-29.7)	2.34(ND-7.27)	0.725(ND-3.33)	ND	0.41 (0.12-0.59)	51 (c)	10 /10
SMB	8	Opaleye	338 (293-379)	0.4(ND-1.09)	4.86(1.53-9.85)			1.63 (0.93-2.9)		10 /0
SMB	8	Pacific sardine	210 (197-236)	262.0(c)	92.6(c)	19.6 (c)	ND (c)	12.98(c)	19.2 (c)	5 /5
SMB	8	Topsmelt	173 (155-191)	198.0(83.1-347)	36.5(19.7-74.6)			2.09 (1.2-3.7)	23.7 (c)	10 /10
SMB	8	White seabass	840 (723-1205)	65.6(c)	12.9(c)	5.38 (c)	ND (c)	0.23 (c)	203 (c)	9 /9
PV	9	Barred sand bass	376 (337-402)	363.0(81.8-586)	45.5(12.1-80.4)			0.58 (0.22-0.98)	205 (140-260)	4 /4
PV	EPA E	White croaker	215 (184-254)	992.0(127-3590)	120(15.3-356)	8.81 (ND-29.9)	0.0279(ND-0.81)	1.03 (0.17-3.53)		29 /0
PV	12	Barred sand bass	409 (315-467)	487.0(46.2-1540)	61.6(5.47-157)	2.18 (ND-5.56)	ND	0.24 (0.14-0.34)	209 (120-340)	10 /10
PV	12	California scorpionfish	305 (279-336)	321.0(111-901)	44.5(19.4-108)	6.13 (2.09-11.9)	ND	0.49 (0.12-1.18)	212 (c)	8 /8
PV	12	Rockfishes	274 (222-301)	285.0(229-333)	32(29.5-35.5)			0.58 (0.36-0.79)	139 (42-320)	3 /3
PV	12	White croaker	258 (225-280)	1830.0(589-6770)	200(72.3-619)	11.2 (7.61-18.3)	ND	0.93 (0.46-1.35)	116 (c)	9 /9
PV	13-14	Barred sand bass	406 (309-499)	1540.0(262-4320)	158(56.4-294)			1.49 (0.53-2.2)	228 (69-410)	6 /6
PV	13-14	Benthic-feeding surfperches	295 (227-335)	173.0(72.7-430)	21.7(7.59-60)	3.38 (1.9-6.92)	ND	0.21 (0.07-0.63)	110 (29-240)	10 /9
PV	13-14	Black croaker	296 (246-322)	127.0(22.9-185)	22.2(4.68-29.5)	3.3 (ND-8.71)	ND	0.25 (0.17-0.33)	325 (c)	5 /5
PV	13-14	California scorpionfish	331 (266-371)	833.0(38.1-2630)	84.6(8.9-243)	6.03 (ND-13.3)	ND	0.41 (0.09-1.03)	136 (40-230)	10 /7
PV	13-14	Kelp bass	388 (306-455)	249.0(65.9-605)	40.3(15-71.5)	1.62 (ND-3.95)	ND	0.35 (0.19-0.49)	271 (110-480)	10 /10
PV	13-14	Opaleye	320 (320-320)	1.5(1.53-1.53)	16.9(16.9-16.9)			1.6 (1.6-1.6)		1 /0
PV	13-14	Pacific chub mackerel	312 (234-423)	28.6(c)	9.19(c)	5.23 (c)	ND (c)	1.16 (c)	79.7 (19-190)	10 /10
PV	13-14	Rockfishes	270 (242-291)	207.0(77.1-427)	27.8(12.8-48.5)	3.41 (ND-7.57)	ND	0.46 (0.16-1.22)	81.3 (23-250)	10 /10
PV	13-14	White croaker	265 (244-290)	742.0(186-1400)	90.8(24.8-161)	7.95 (6.57-9.06)	ND	0.59 (0.25-0.88)	196 (c)	7 /7

Exhibit 5-1
Analytical Results Sorted by Sampling Segment

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SPB-out	EPA B	White croaker	219 (150-267)	1130.0(65.5-6450)	136(10.1-663)	9.81 (ND-21.2)	ND	1.16 (0.27-2.54)	83.2 (c)	39 /10
SPB-out	15	Barred sand bass	367 (308-532)	583.0(68.9-3350)	72.7(18-222)			1 (0.26-2.8)	166 (82-440)	15 /15
SPB-out	15	Benthic-feeding surfperches	311 (250-345)	187.0(36.8-600)	26.7(11-74.3)	2.14 (ND-7.6)	ND	0.92 (0.19-2.6)	72.9 (50-98)	20 /10
SPB-out	15	California scorpionfish	302 (260-325)	246.0(21.6-1880)	26.7(5.68-142)	3.37 (1.56-6.18)	ND	0.5 (0.05-1.3)	118 (55-340)	14 /14
SPB-out	15	California sheephead	351 (324-395)	609.0(397-869)	67.6(44.3-93.4)			2.7 (2.4-3.2)	107 (100-110)	3 /3
SPB-out	15	Kelp bass	381 (312-510)	200.0(29.8-658)	41.4(10.1-103)	1.87 (ND-2.56)	ND	1.2 (0.18-3.4)	152 (71-330)	22 /22
SPB-out	15	Opaleye	308 (286-330)	3.3(2.32-4.26)	88(13.2-159)			2.43 (1.4-3.7)		3 /0
SPB-out	15	Pacific sardine	198 (191-210)	145.0(c)	40.5(c)	13.9 (c)	ND (c)	8.36 (c)	18.6 (c)	9 /9
SPB-out	15	Queenfish	190 (184-201)	97.1(50.2-130)	15.2(8.96-19.4)	2.01 (1.52-2.79)	ND	0.7 (0.34-1.13)	127 (c)	3 /3
SPB-out	15	Rockfishes	285 (266-300)	193.0(34.7-567)	55.8(12.3-124)	6.81 (2.04-12.6)	ND	0.82 (0.27-1.7)	261 (46-440)	10 /10
SPB-out	15	Sargo	309 (290-345)	52.1(c)	40.8(c)	6.86 (c)	ND (c)	0.39 (c)	121 (c)	10 /10
SPB-out	15	Water-column-feeding surfperches	116 (110-119)	69.3(51.3-102)	11.9(9.47-17)	1.53 (ND-2.12)	ND	0.5 (0.39-0.65)		5 /0
SPB-out	15	White croaker	219 (191-262)	3180.0(5.49-11100)	347(41.5-1120)	14.6 (7.1-29.3)	ND	2.63 (0.64-5.73)	79.1 (c)	9 /8
SPB-out	EPA C	White croaker	233 (217-273)	440.0(1.97-3130)	50.5(2.58-232)	5.55 (ND-18.3)	ND	0.89 (0.09-3.6)	135 (c)	39 /9
SPB-out	24	California scorpionfish	321 (275-357)	56.1(ND-142)	17.1(ND-33.4)	2.12 (ND-3.69)	ND	0.37 (0.1-0.6)	87.4 (48-110)	5 /5
SPB-out	24	Kelp bass	308 (304-311)	151.0(144-157)	36.8(34.6-38.9)			4.25 (3.4-5.1)	118 (96-140)	2 /2
SPB-out	24	Pacific barracuda	831 (743-940)	100.0(100-100)	54.2(54.2-54.2)	11.8 (11.8-11.8)	ND	1.4 (1.4-1.4)	327 (c)	10 /10
SPB-out	24	White croaker	241 (206-268)	2520.0(94.1-12700)	228(9.39-1090)	9.7 (ND-32)	ND	1.39 (0.47-4.82)	135 (c)	8 /8
SPB-out	EPA A out	Barred sand bass	424 (359-488)	370.0(337-402)	91.7(72.4-111)			2.85 (2.8-2.9)	97 (84-110)	2 /2
SPB-out	EPA A out	Benthic-feeding surfperches	254 (234-280)	124.0(72.1-264)	34.7(17.8-68.8)	9.51 (7.28-12.4)	ND	0.99 (0.25-2.86)	61 (c)	10 /10
SPB-out	EPA A out	Black croaker	317 (281-361)	34.9(10.2-126)	13.1(5.18-49)	5.36 (ND-10.2)	ND	0.22 (0.06-0.47)	447 (c)	10 /10
SPB-out	EPA A out	Kelp bass	378 (342-400)	498.0(137-1430)	82.9(33-127)			2.2 (1.4-3.2)	206 (83-320)	6 /6
SPB-out	EPA A out	Queenfish	175 (152-199)	94.2(46.6-232)	33.2(17-74.3)	10.5 (3.42-15.3)	ND	0.87 (0.01-1.95)	61.7 (c)	8 /6
SPB-out	EPA A out	White croaker	217 (184-255)	203.0(17.3-2900)	29.1(5.26-237)	4 (ND-13.6)	ND	0.58 (0.19-1.29)	91.8 (c)	39 /10
SPB-out	EPA D	White croaker	208 (183-245)	175.0(1.97-2270)	32.2(2.26-207)	5.18 (ND-18.1)	ND	0.8 (0.09-2)		28 /0
SPB-in	16	Barred sand bass	319 (305-345)	118.0(60.7-197)	40.3(24.3-56.5)			1.7 (0.98-2.2)	90.5 (52-130)	4 /4
SPB-in	16	Benthic-feeding surfperches	225 (174-280)	70.9(23.1-110)	32.9(13-50.4)	6.85 (1.74-11.8)	ND	0.96 (0.42-1.63)	61.5 (c)	10 /10
SPB-in	16	California corbina	408 (339-461)	95.9(9-324)	44.2(0.46-174)	9.59 (ND-22.8)	ND	1.43 (0.18-4.36)	87.3 (c)	10 /10
SPB-in	16	California halibut	665 (585-820)	89.5(35.4-171)	15.8(5.61-25)	0.508(ND-1.5)	ND	0.34 (0.18-0.42)	110 (c)	6 /6

Exhibit 5-1
Analytical Results Sorted by Sampling Segment

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SPB-in	16	California scorpionfish	281 (257-320)	47.4(12.7-200)	11(3.13-23.1)	3.48 (ND-10.7)	ND	0.29 (0.14-0.62)	136 (c)	10 /9
SPB-in	16	Jacksmelt	337 (304-383)	42.4(9.25-69.7)	8.49(ND-25.7)	0.178(ND-0.72)	ND	0.92 (0.35-1.34)	101 (c)	10 /10
SPB-in	16	Kelp bass	388 (385-390)	208.0(146-270)	69.9(41.9-97.9)			1.35 (1-1.7)	150 (120-180)	2 /2
SPB-in	16	Pacific sardine	205 (205-205)	145.0(c)	40.5(c)	13.9 (c)	ND (c)	8.36 (c)	18.6 (c)	1 /1
SPB-in	16	Queenfish	195 (185-210)	89.6(21.8-249)	33.1(9.39-77.4)	5.42 (ND-13.8)	ND	0.75 (0.32-1.33)	107 (c)	10 /10
SPB-in	16	Shovelnose guitarfish	616 (503-813)	43.6(22.7-126)	18.9(12.4-25.8)	3.35 (ND-7.14)	ND	0.34 (0.27-0.45)	86.5 (c)	10 /10
SPB-in	16	Topsmelt	148 (135-175)	151.0(93.8-204)	86.3(57.1-116)			2.96 (2-5.4)	26.6 (c)	10 /10
SPB-in	16	Water-column-feeding surfperches	126 (109-142)	89.0(49.2-131)	33.9(16.4-53.7)	6.9 (ND-11.4)	ND	1.21 (0.57-2.2)	25.9 (c)	8 /1
SPB-in	16	White croaker	220 (173-252)	439.0(84.9-2520)	103(58.5-279)	13.6 (8.84-21.1)	ND	3.01 (1.38-4.98)	56.4 (c)	10 /10
SPB-in	EPA A in	Black croaker	308 (271-366)	47.9(8.04-119)	20.8(3.17-59.8)	4.89 (ND-10.7)	ND	0.2 (0.05-0.44)	582 (c)	10 /10
SPB-in	17	Barred sand bass	359 (332-386)	293.0(217-369)	116(53.2-178)			2.2 (1.1-3.3)	88.5 (37-140)	2 /2
SPB-in	17	Benthic-feeding surfperches	295 (240-345)	35.2(13.2-102)	18.6(9.05-49.8)	2.35 (ND-7.6)	ND	0.31 (0.12-0.54)	107 (c)	10 /10
SPB-in	17	California halibut	656 (550-895)	165.0(15.5-765)	61.2(14.6-188)	13.7 (5.06-26.7)	ND	0.46 (0.2-1.32)	104 (c)	10 /10
SPB-in	17	Kelp bass	375 (375-375)	332.0(332-332)	126(126-126)			3.1 (3.1-3.1)	150 (150-150)	1 /1
SPB-in	17	Opaleye	312 (278-345)	1.5(0.41-3.1)	10.3(1.85-40.5)	1.75 (0.12-8.78)	ND	1.32 (0.47-3.12)	46.3 (c)	10 /10
SPB-in	17	Queenfish	190 (161-215)	55.0(6.78-187)	34.8(1.96-84.4)	11.8 (ND-18.6)	ND	0.42 (0.23-0.99)	91.5 (c)	10 /9
SPB-in	17	Shovelnose guitarfish	885 (690-1075)	68.1(23.3-117)	53.3(23.8-106)	4.74 (0.888-11.6)	ND	0.33 (0.23-0.43)	182 (c)	10 /10
SPB-in	17	Water-column-feeding surfperches	143 (135-151)	37.9(12.5-57.8)	50.7(25.6-76.6)	21 (15.5-27.2)	0.66 (ND-3.3)	0.92 (0.42-1.6)		5 /0
SPB-in	17	White croaker	236 (214-256)	72.5(32.9-165)	108(55-187)	36.9 (20.9-62.1)	4.18 (ND-7.89)	1.77 (0.52-3.06)	27.5 (c)	10 /10
SPB-in	18	Benthic-feeding surfperches	261 (241-285)	93.7(65-122)	74.4(50.6-106)	15.5 (13.2-17.5)	ND	1.75 (0.51-2.79)	61.9 (c)	10 /10
SPB-in	18	California corbina	271 (233-305)	53.9(6.63-206)	36.8(4.08-145)	12.9 (ND-26.2)	ND	0.81 (0.24-2.7)	45.3 (c)	10 /10
SPB-in	18	Queenfish	177 (153-220)	16.3(ND-57)	13.3(6.23-39.9)	3.47 (ND-11.4)	ND	0.38 (0.23-0.56)	54.9 (c)	9 /9
SPB-in	18	Sargo	309 (278-346)	63.8(c)	50.4(c)	13 (c)	ND (c)	0.99 (c)	81.5 (c)	10 /10
SPB-in	18	Shovelnose guitarfish	740 (646-911)	59.5(24-136)	38.9(21.6-72.3)	8.1 (ND-13.1)	ND	0.29 (0.16-0.36)	120 (c)	10 /10
SPB-in	18	White croaker	207 (178-249)	126.0(81.9-202)	106(57.9-190)	22.7 (13.7-31.2)	ND	1.97 (0.84-2.84)	54.7 (c)	10 /10
SPB-in	18	Yellowfin croaker	225 (212-240)	24.5(5.45-46)	15.7(8.28-21)	8.14 (ND-16.5)	ND	0.44 (0.29-0.58)	43.2 (c)	10 /10

Exhibit 5-1
Analytical Results Sorted by Sampling Segment

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
OC	19	Barred sand bass	0 (0-0)	50.6(50.6-50.6)	23.4(23.4-23.4)			0.36 (0.36-0.36)	100 (100-100)	1 /1
OC	19	Benthic-feeding surfperches	285 (253-340)	77.3(25.6-186)	50.5(13.1-121)	10.3 (5.86-20.7)	ND	0.72 (0.13-3.59)	140 (c)	10 /9
OC	19	California scorpionfish	285 (260-297)	49.3(c)	32.6(c)	10.4 (c)	ND (c)	0.83 (c)	159 (c)	7 /7
OC	19	Kelp bass	402 (383-430)	184.0(82.9-285)	101(58.4-144)			1.92 (0.57-2.9)	323 (240-550)	4 /4
OC	19	Opaleye	294 (278-325)	0.6(ND-2.83)	3.06(0.45-6.24)	0.354(ND-0.7)	ND	0.78 (0.35-1.29)	37.2 (c)	10 /10
OC	19	Water-column-feeding surfperches	170 (143-199)	68.4(28.3-124)	28.8(10.9-51.4)	9.74 (ND-12.9)	ND	1.3 (0.63-2.9)	52.5 (c)	8 /1
OC	19	White croaker	179 (161-197)	93.3(34.9-186)	43.4(14.9-74.5)	12.6 (9.21-15.8)	0.208 (ND-1.87)	1.69 (1.02-2.51)	40.1 (c)	9 /9
OC	19	Yellowfin croaker	242 (220-269)	52.9(c)	29.2(c)	8.18 (c)	ND (c)	0.48 (c)	56.8 (c)	10 /10
OC	20	Barred sand bass	422 (422-422)	124.0(124-124)	80.3(80.3-80.3)			3.9 (3.9-3.9)	190 (190-190)	1 /1
OC	20	Kelp bass	411 (410-411)	315.0(275-355)	100(79.9-121)			3.7 (3.2-4.2)	225 (220-230)	2 /2
OC	20	White croaker	182 (165-206)	104.0(35.6-188)	41.1(5.41-72.4)	10.4 (ND-20.3)	ND	1.73 (0.35-2.94)	51.7 (c)	10 /10
OC	21	California corbina	270 (245-309)	50.2(23.2-104)	27(11.3-47.7)	8.06 (6.58-9.77)	ND	1.26 (0.6-2.02)	76.2 (c)	10 /10
OC	21	White croaker	247 (228-266)	87.8(19.2-479)	22.9(5.94-56.1)	4.62 (ND-13.5)	ND	0.69 (0.34-1.46)	139 (c)	10 /10
OC	22	Pacific chub mackerel	314 (280-340)	70.0(c)	21.6(c)	8.62 (c)	ND (c)	1.72 (c)	81.3 (35-140)	10 /8
OC	22	White croaker	251 (221-269)	159.0(19.6-527)	36.1(3.77-123)	16.3 (2.99-41.3)	ND	1.74 (0.38-4.22)	178 (c)	8 /8
OC	25	Pacific barracuda	799 (725-880)	84.6(84.6-84.6)	28.9(28.9-28.9)	10.4 (10.4-10.4)	ND	0.34 (0.34-0.34)	288 (c)	10 /10

Notes: (c) indicates that analysis was run on a composite sample; therefore no range of values is available. Lipids were calculated as total extractable organics on a weight basis.
N (org/Hg) indicates number of samples included in the organic and mercury analysis, respectively for that sample. The number of organic analyses refers only to DDTs and PCBs; dieldrin and chlordane were not run for all organic samples.

Exhibit 5-2
Analytical Results Sorted by Species

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SMB	2	Barred sand bass	427 (389-480)	31.9 (ND-77.9)	8.93 (3.81-17.2)	1.44 (ND-3.32)	2.78 (ND-3.94)	0.1 (0.06-0.19)	349 (220-480)	10 /10
SMB	7	Barred sand bass	429 (346-466)	99.1 (45.3-269)	26.5 (8.17-58.7)	4.27 (ND-9.42)	1.07 (ND-3.88)	0.25 (0.14-0.59)	284 (150-420)	10 /10
SMB	8	Barred sand bass	325 (325-325)	65.4 (65.4-65.4)	19.9 (19.9-19.9)			0.62 (0.62-0.62)	220 (220-220)	1 /1
PV	9	Barred sand bass	376 (337-402)	363 (81.8-586)	45.5 (12.1-80.4)			0.58 (0.22-0.98)	205 (140-260)	4 /4
PV	12	Barred sand bass	409 (315-467)	487 (46.2-1540)	61.6 (5.47-157)	2.18 (ND-5.56)	ND	0.24 (0.14-0.34)	209 (120-340)	10 /10
SPB-out	15	Barred sand bass	367 (308-532)	583 (68.9-3350)	72.7 (18-222)			1 (0.26-2.8)	166 (82-440)	15 /15
SPB-in	16	Barred sand bass	319 (305-345)	118 (60.7-197)	40.3 (24.3-56.5)			1.7 (0.98-2.2)	90.5 (52-130)	4 /4
SPB-in	17	Barred sand bass	359 (332-386)	293 (217-369)	116 (53.2-178)			2.2 (1.1-3.3)	88.5 (37-140)	2 /2
OC	19	Barred sand bass	0 (0-0)	50.6 (50.6-50.6)	23.4 (23.4-23.4)			0.36 (0.36-0.36)	100 (100-100)	1 /1
OC	20	Barred sand bass	422 (422-422)	124 (124-124)	80.3 (80.3-80.3)			3.9 (3.9-3.9)	190 (190-190)	1 /1
PV	13-14	Barred sand bass	406 (309-499)	1540 (262-4320)	158 (56.4-294)			1.49 (0.53-2.2)	228 (69-410)	6 /6
SPB-out	EPA A out	Barred sand bass	424 (359-488)	370 (337-402)	91.7 (72.4-111)			2.85 (2.8-2.9)	97 (84-110)	2 /2
SMB	2	Benthic-feeding surfperches	309 (260-345)	15 (6.62-40.3)	4.08 (1.2-6.69)	1.87 (ND-4.96)	ND	0.38 (0.13-0.72)	120 (94-160)	10 /7
SMB	5	Benthic-feeding surfperches	286 (247-362)	156 (44.9-269)	76.4 (34.6-124)			1.91 (0.59-3.2)	112 (63-200)	10 /10
SMB	7	Benthic-feeding surfperches	217 (184-260)	88.6 (ND-351)	32.3 (5-138)	8.02 (ND-26.5)	ND	0.85 (0.29-2.98)	84.4 (c)	10 /8
SMB	8	Benthic-feeding surfperches	295 (260-411)	51.4 (18.6-82.9)	7.99 (2.72-14.4)			1.1 (0.52-1.8)	102 (52-140)	10 /10
SPB-out	15	Benthic-feeding surfperches	311 (250-345)	187 (36.8-600)	26.7 (11-74.3)	2.14 (ND-7.6)	ND	0.92 (0.19-2.6)	72.9 (50-98)	20 /10
SPB-in	16	Benthic-feeding surfperches	225 (174-280)	70.9 (23.1-110)	32.9 (13-50.4)	6.85 (1.74-11.8)	ND	0.96 (0.42-1.63)	61.5 (c)	10 /10
SPB-in	17	Benthic-feeding surfperches	295 (240-345)	35.2 (13.2-102)	18.6 (9.05-49.8)	2.35 (ND-7.6)	ND	0.31 (0.12-0.54)	107 (c)	10 /10
SPB-in	18	Benthic-feeding surfperches	261 (241-285)	93.7 (65-122)	74.4 (50.6-106)	15.5 (13.2-17.5)	ND	1.75 (0.51-2.79)	61.9 (c)	10 /10
OC	19	Benthic-feeding surfperches	285 (253-340)	77.3 (25.6-186)	50.5 (13.1-121)	10.3 (5.86-20.7)	ND	0.72 (0.13-3.59)	140 (c)	10 /9
PV	13-14	Benthic-feeding surfperches	295 (227-335)	173 (72.7-430)	21.7 (7.59-60)	3.38 (1.9-6.92)	ND	0.21 (0.07-0.63)	110 (29-240)	10 /9
SPB-out	EPA A out	Benthic-feeding surfperches	254 (234-280)	124 (72.1-264)	34.7 (17.8-68.8)	9.51 (7.28-12.4)	ND	0.99 (0.25-2.86)	61 (c)	10 /10
SMB	7	Black croaker	314 (242-351)	73.7 (25.5-141)	28.7 (8.58-55.5)	4.33 (ND-10.1)	ND	0.2 (0.06-0.28)	462 (c)	10 /10
PV	13-14	Black croaker	296 (246-322)	127 (22.9-185)	22.2 (4.68-29.5)	3.3 (ND-8.71)	ND	0.25 (0.17-0.33)	325 (c)	5 /5
SPB-in	EPA A in	Black croaker	308 (271-366)	47.9 (8.04-119)	20.8 (3.17-59.8)	4.89 (ND-10.7)	ND	0.2 (0.05-0.44)	582 (c)	10 /10
SPB-out	EPA A out	Black croaker	317 (281-361)	34.9 (10.2-126)	13.1 (5.18-49)	5.36 (ND-10.2)	ND	0.22 (0.06-0.47)	447 (c)	10 /10
SMB	7	California corbina	284 (265-310)	16.2 (6.01-30.5)	12.1 (4.64-19.9)	6.19 (2.68-9.96)	ND	0.34 (0.18-0.73)	136 (c)	10 /10

Exhibit 5-2
Analytical Results Sorted by Species

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SPB-in	16	California corbina	408 (339-461)	95.9 (9-324)	44.2 (0.46-174)	9.59 (ND-22.8)	ND	1.43 (0.18-4.36)	87.3 (c)	10 /10
SPB-in	18	California corbina	271 (233-305)	53.9 (6.63-206)	36.8 (4.08-145)	12.9 (ND-26.2)	ND	0.81 (0.24-2.7)	45.3 (c)	10 /10
OC	21	California corbina	270 (245-309)	50.2 (23.2-104)	27 (11.3-47.7)	8.06 (6.58-9.77)	ND	1.26 (0.6-2.02)	76.2 (c)	10 /10
SMB	5	California halibut	616 (563-770)	54.8 (24-124)	13.3 (2.92-35.5)	0.263 (ND-0.98)	ND	0.46 (0.25-0.64)	202 (c)	8 /8
SPB-in	16	California halibut	665 (585-820)	89.5 (35.4-171)	15.8 (5.61-25)	0.508 (ND-1.5)	ND	0.34 (0.18-0.42)	110 (c)	6 /6
SPB-in	17	California halibut	656 (550-895)	165 (15.5-765)	61.2 (14.6-188)	13.7 (5.06-26.7)	ND	0.46 (0.2-1.32)	104 (c)	10 /10
SMB	5	California scorpionfish	275 (253-301)	197 (67.9-702)	50.7 (28.5-75.8)			2.95 (1.8-4.1)	121 (83-150)	10 /10
SMB	6	California scorpionfish	291 (260-329)	722 (215-1810)	126 (47.6-267)			4.9 (2.4-8.2)	232 (130-400)	10 /10
PV	12	California scorpionfish	305 (279-336)	321 (111-901)	44.5 (19.4-108)	6.13 (2.09-11.9)	ND	0.49 (0.12-1.18)	212 (c)	8 /8
SPB-out	15	California scorpionfish	302 (260-325)	246 (21.6-1880)	26.7 (5.68-142)	3.37 (1.56-6.18)	ND	0.5 (0.05-1.3)	118 (55-340)	14 /14
SPB-in	16	California scorpionfish	281 (257-320)	47.4 (12.7-200)	11 (3.13-23.1)	3.48 (ND-10.7)	ND	0.29 (0.14-0.62)	136 (c)	10 /9
OC	19	California scorpionfish	285 (260-297)	49.3 (c)	32.6 (c)	10.4 (c)	ND (c)	0.83 (c)	159 (c)	7 /7
SMB	23	California scorpionfish	289 (260-328)	352 (240-562)	116 (47.6-231)			2.34 (0.79-4.3)	293 (180-570)	10 /10
SPB-out	24	California scorpionfish	321 (275-357)	56.1 (ND-142)	17.1 (ND-33.4)	2.12 (ND-3.69)	ND	0.37 (0.1-0.6)	87.4 (48-110)	5 /5
PV	13-14	California scorpionfish	331 (266-371)	833 (38.1-2630)	84.6 (8.9-243)	6.03 (ND-13.3)	ND	0.41 (0.09-1.03)	136 (40-230)	10 /7
SPB-out	15	California sheephead	351 (324-395)	609 (397-869)	67.6 (44.3-93.4)			2.7 (2.4-3.2)	107 (100-110)	3 /3
SMB	8	Jacksmelt	251 (223-308)	10.4 (2.51-29.7)	2.34 (ND-7.27)	0.725 (ND-3.33)	ND	0.41 (0.12-0.59)	51 (c)	10 /10
SPB-in	16	Jacksmelt	337 (304-383)	42.4 (9.25-69.7)	8.49 (ND-25.7)	0.178 (ND-0.72)	ND	0.92 (0.35-1.34)	101 (c)	10 /10
SMB	2	Kelp bass	425 (359-476)	34.6 (10.4-90.2)	9.91 (5.02-15.4)	4.8 (1.84-10)	ND	0.4 (0.01-2.89)	230 (98-370)	10 /10
SMB	7	Kelp bass	425 (383-465)	101 (11.5-230)	23.4 (4.55-51.6)	4.91 (1.85-7.96)	ND	0.51 (0.01-1.47)	182 (95-290)	10 /10
SPB-out	15	Kelp bass	381 (312-510)	200 (29.8-658)	41.4 (10.1-103)	1.87 (ND-2.56)	ND	1.2 (0.18-3.4)	152 (71-330)	22 /22
SPB-in	16	Kelp bass	388 (385-390)	208 (146-270)	69.9 (41.9-97.9)			1.35 (1-1.7)	150 (120-180)	2 /2
SPB-in	17	Kelp bass	375 (375-375)	332 (332-332)	126 (126-126)			3.1 (3.1-3.1)	150 (150-150)	1 /1
OC	19	Kelp bass	402 (383-430)	184 (82.9-285)	101 (58.4-144)			1.92 (0.57-2.9)	323 (240-550)	4 /4
OC	20	Kelp bass	411 (410-411)	315 (275-355)	100 (79.9-121)			3.7 (3.2-4.2)	225 (220-230)	2 /2
SPB-out	24	Kelp bass	308 (304-311)	151 (144-157)	36.8 (34.6-38.9)			4.25 (3.4-5.1)	118 (96-140)	2 /2
PV	13-14	Kelp bass	388 (306-455)	249 (65.9-605)	40.3 (15-71.5)	1.62 (ND-3.95)	ND	0.35 (0.19-0.49)	271 (110-480)	10 /10
SPB-out	EPA A out	Kelp bass	378 (342-400)	498 (137-1430)	82.9 (33-127)			2.2 (1.4-3.2)	206 (83-320)	6 /6
SMB	5	Opaleye	324 (290-376)	1.35 (0.478-3.5)	61.1 (19.5-153)			3.02 (0.63-9.7)		10 /0

Exhibit 5-2
Analytical Results Sorted by Species

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SMB	7	Opaleye	260 (214-351)	0.897 (ND-4.9)	25.2 (4.37-62.6)	10.5 (5.92-17.2)	ND	0.96 (0.38-2.41)	55.5 (c)	10 /10
SMB	8	Opaleye	338 (293-379)	0.361 (ND-1.09)	4.86 (1.53-9.85)			1.63 (0.93-2.9)		10 /0
SPB-out	15	Opaleye	308 (286-330)	3.32 (2.32-4.26)	88 (13.2-159)			2.43 (1.4-3.7)		3 /0
SPB-in	17	Opaleye	312 (278-345)	1.54 (0.41-3.1)	10.3 (1.85-40.5)	1.75 (0.12-8.78)	ND	1.32 (0.47-3.12)	46.3 (c)	10 /10
OC	19	Opaleye	294 (278-325)	0.568 (ND-2.83)	3.06 (0.45-6.24)	0.354(ND-0.7)	ND	0.78 (0.35-1.29)	37.2 (c)	10 /10
PV	13-14	Opaleye	320 (320-320)	1.53 (1.53-1.53)	16.9 (16.9-16.9)			1.6 (1.6-1.6)		1 /0
SPB-out	24	Pacific barracuda	831 (743-940)	100 (100-100)	54.2 (54.2-54.2)	11.8 (11.8-11.8)	ND	1.4 (1.4-1.4)	327 (c)	10 /10
OC	25	Pacific barracuda	799 (725-880)	84.6 (84.6-84.6)	28.9 (28.9-28.9)	10.4 (10.4-10.4)	ND	0.34 (0.34-0.34)	288 (c)	10 /10
SMB	2	Pacific chub mackerel	312 (265-395)	58.2 (c)	18.3 (c)	7.89 (c)	ND (c)	1.93 (c)	83.7 (54-140)	10 /10
OC	22	Pacific chub mackerel	314 (280-340)	70 (c)	21.6 (c)	8.62 (c)	ND (c)	1.72 (c)	81.3 (35-140)	10 /8
PV	13-14	Pacific chub mackerel	312 (234-423)	28.6 (c)	9.19 (c)	5.23 (c)	ND (c)	1.16 (c)	79.7 (19-190)	10 /10
SMB	7	Pacific sardine	215 (197-225)	262 (c)	92.6 (c)	19.6 (c)	ND (c)	12.98(c)	19.2 (c)	5 /5
SMB	8	Pacific sardine	210 (197-236)	262 (c)	92.6 (c)	19.6 (c)	ND (c)	12.98(c)	19.2 (c)	5 /5
SPB-out	15	Pacific sardine	198 (191-210)	145 (c)	40.5 (c)	13.9 (c)	ND (c)	8.36 (c)	18.6 (c)	9 /9
SPB-in	16	Pacific sardine	205 (205-205)	145 (c)	40.5 (c)	13.9 (c)	ND (c)	8.36 (c)	18.6 (c)	1 /1
SMB	2	Queenfish	171 (162-182)	84.3 (29.4-173)	17.9 (6.79-35.9)	3.93 (ND-11.3)	ND	0.85 (0.55-1.16)	152 (c)	10 /10
SMB	3	Queenfish	166 (147-186)	79.3 (22.4-206)	28.6 (3.58-95.6)	12 (2.62-31.2)	ND	0.99 (0.46-2.69)	108 (c)	10 /6
SMB	4	Queenfish	162 (150-185)	50.5 (18.1-116)	16.7 (ND-44.6)	3.98 (ND-11.1)	ND	0.74 (0.46-1.26)	97.3 (c)	10 /4
SMB	7	Queenfish	177 (165-186)	21.9 (7.71-33.9)	5.93 (1.9-8.46)	3.73 (ND-14)	ND	0.74 (0.24-1.52)	124 (c)	9 /9
SPB-out	15	Queenfish	190 (184-201)	97.1 (50.2-130)	15.2 (8.96-19.4)	2.01 (1.52-2.79)	ND	0.7 (0.34-1.13)	127 (c)	3 /3
SPB-in	16	Queenfish	195 (185-210)	89.6 (21.8-249)	33.1 (9.39-77.4)	5.42 (ND-13.8)	ND	0.75 (0.32-1.33)	107 (c)	10 /10
SPB-in	17	Queenfish	190 (161-215)	55 (6.78-187)	34.8 (1.96-84.4)	11.8 (ND-18.6)	ND	0.42 (0.23-0.99)	91.5 (c)	10 /9
SPB-in	18	Queenfish	177 (153-220)	16.3 (ND-57)	13.3 (6.23-39.9)	3.47 (ND-11.4)	ND	0.38 (0.23-0.56)	54.9 (c)	9 /9
SPB-out	EPA A out	Queenfish	175 (152-199)	94.2 (46.6-232)	33.2 (17-74.3)	10.5 (3.42-15.3)	ND	0.87 (0.01-1.95)	61.7 (c)	8 /6
SMB	2	Rockfishes	281 (228-335)	40.2 (20.6-95.7)	12.1 (4.63-20.4)			1.34 (0.78-2.5)	88.2 (52-160)	6 /6
PV	12	Rockfishes	274 (222-301)	285 (229-333)	32 (29.5-35.5)			0.58 (0.36-0.79)	139 (42-320)	3 /3
SPB-out	15	Rockfishes	285 (266-300)	193 (34.7-567)	55.8 (12.3-124)	6.81 (2.04-12.6)	ND	0.82 (0.27-1.7)	261 (46-440)	10 /10
PV	13-14	Rockfishes	270 (242-291)	207 (77.1-427)	27.8 (12.8-48.5)	3.41 (ND-7.57)	ND	0.46 (0.16-1.22)	81.3 (23-250)	10 /10
SMB	2	Sargo	322 (287-366)	66 (34.5-111)	24.9 (12.3-44)			1.28 (0.57-3.3)	228 (89-380)	10 /10

Exhibit 5-2
Analytical Results Sorted by Species

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SMB	7	Sargo	322 (278-355)	211 (39.6-551)	114 (23.6-233)			2.74 (1-6.5)	205 (110-310)	8 /8
SPB-out	15	Sargo	309 (290-345)	52.1 (c)	40.8 (c)	6.86 (c)	ND (c)	0.39 (c)	121 (c)	10 /10
SPB-in	18	Sargo	309 (278-346)	63.8 (c)	50.4 (c)	13 (c)	ND (c)	0.99 (c)	81.5 (c)	10 /10
SPB-in	16	Shovelnose guitarfish	616 (503-813)	43.6 (22.7-126)	18.9 (12.4-25.8)	3.35 (ND-7.14)	ND	0.34 (0.27-0.45)	86.5 (c)	10 /10
SPB-in	17	Shovelnose guitarfish	885 (690-1075)	68.1 (23.3-117)	53.3 (23.8-106)	4.74 (0.888-11.6)	ND	0.33 (0.23-0.43)	182 (c)	10 /10
SPB-in	18	Shovelnose guitarfish	740 (646-911)	59.5 (24-136)	38.9 (21.6-72.3)	8.1 (ND-13.1)	ND	0.29 (0.16-0.36)	120 (c)	10 /10
SMB	5	Topsmelt	177 (147-208)	310 (37.5-1430)	215 (77.4-670)			7.29 (5.5-10)		10 /0
SMB	8	Topsmelt	173 (155-191)	198 (83.1-347)	36.5 (19.7-74.6)			2.09 (1.2-3.7)	23.7 (c)	10 /10
SPB-in	16	Topsmelt	148 (135-175)	151 (93.8-204)	86.3 (57.1-116)			2.96 (2-5.4)	26.6 (c)	10 /10
SMB	7	Water-column-feeding surfperches	128 (114-171)	60.9 (36.9-96.2)	24.3 (16.3-39.9)			2.86 (1.7-4.9)		10 /0
SPB-out	15	Water-column-feeding surfperches	116 (110-119)	69.3 (51.3-102)	11.9 (9.47-17)	1.53 (ND-2.12)	ND	0.5 (0.39-0.65)		5 /0
SPB-in	16	Water-column-feeding surfperches	126 (109-142)	89 (49.2-131)	33.9 (16.4-53.7)	6.9 (ND-11.4)	ND	1.21 (0.57-2.2)	25.9 (c)	8 /1
SPB-in	17	Water-column-feeding surfperches	143 (135-151)	37.9 (12.5-57.8)	50.7 (25.6-76.6)	21 (15.5-27.2)	0.66 (ND-3.3)	0.92 (0.42-1.6)		5 /0
OC	19	Water-column-feeding surfperches	170 (143-199)	68.4 (28.3-124)	28.8 (10.9-51.4)	9.74 (ND-12.9)	ND	1.3 (0.63-2.9)	52.5 (c)	8 /1
Ventura	1	White croaker	184 (168-206)	84 (44.2-115)	21.7 (8.86-31)	19.4 (ND-33.4)	ND	2.99 (0.54-4.7)	95.9 (c)	9 /9
SMB	2	White croaker	218 (190-244)	110 (74.6-145)	31.7 (22.7-42.4)	11.2 (9.24-13.6)	ND	1.8 (1.29-2.28)	167 (c)	5 /5
SMB	3	White croaker	202 (173-230)	101 (26.5-195)	39.8 (13.4-68.4)	15.7 (11.7-18.5)	ND	1.21 (0.28-2.46)	163 (c)	10 /10
SMB	4	White croaker	194 (177-225)	97.9 (0.99-276)	39.9 (4.87-97.3)	5.57 (ND-22.4)	ND	1.88 (0.25-3.72)	135 (c)	10 /10
SMB	5	White croaker	238 (219-269)	129 (87.1-189)	182 (132-292)	70.7 (39.4-115)	0.818 (ND-4.91)	4.86 (4.15-5.83)	79.4 (c)	6 /6
SMB	6	White croaker	207 (169-230)	200 (97.9-292)	59.6 (32.2-75)	9.42 (ND-16.1)	ND	1.34 (0.57-2.78)	123 (c)	10 /10
SMB	7	White croaker	182 (153-215)	283 (60.1-874)	74.3 (18.9-209)	14.4 (8.65-23.1)	ND	2.28 (0.54-4.81)	72.2 (c)	10 /10
PV	12	White croaker	258 (225-280)	1830 (589-6770)	200 (72.3-619)	11.2 (7.61-18.3)	ND	0.93 (0.46-1.35)	116 (c)	9 /9
SPB-out	15	White croaker	219 (191-262)	3180 (5.49-11100)	347 (41.5-1120)	14.6 (7.1-29.3)	ND	2.63 (0.64-5.73)	79.1 (c)	9 /8
SPB-in	16	White croaker	220 (173-252)	439 (84.9-2520)	103 (58.5-279)	13.6 (8.84-21.1)	ND	3.01 (1.38-4.98)	56.4 (c)	10 /10
SPB-in	17	White croaker	236 (214-256)	72.5 (32.9-165)	108 (55-187)	36.9 (20.9-62.1)	4.18 (ND-7.89)	1.77 (0.52-3.06)	27.5 (c)	10 /10

Exhibit 5-2
Analytical Results Sorted by Species

Region	Segment	Common Name	Total Length (mm) mean (range)	Total DDTs (ppb) mean (range)	Total PCBs (ppb) mean (range)	Chlordane (ppb) mean (range)	Dieldrin (ppb) mean (range)	Lipid (%TEO) mean(range)	Mercury (ppb) mean (range)	N (Org/Hg))
SPB-in	18	White croaker	207 (178-249)	126 (81.9-202)	106 (57.9-190)	22.7 (13.7-31.2)	ND	1.97 (0.84-2.84)	54.7 (c)	10 /10
OC	19	White croaker	179 (161-197)	93.3 (34.9-186)	43.4 (14.9-74.5)	12.6 (9.21-15.8)	0.208 (ND-1.87)	1.69 (1.02-2.51)	40.1 (c)	9 /9
OC	20	White croaker	182 (165-206)	104 (35.6-188)	41.1 (5.41-72.4)	10.4 (ND-20.3)	ND	1.73 (0.35-2.94)	51.7 (c)	10 /10
OC	21	White croaker	247 (228-266)	87.8 (19.2-479)	22.9 (5.94-56.1)	4.62 (ND-13.5)	ND	0.69 (0.34-1.46)	139 (c)	10 /10
OC	22	White croaker	251 (221-269)	159 (19.6-527)	36.1 (3.77-123)	16.3 (2.99-41.3)	ND	1.74 (0.38-4.22)	178 (c)	8 /8
SMB	23	White croaker	223 (207-244)	230 (70-469)	95.4 (15.1-227)	6.19 (ND-12)	0.257 (ND-2.57)	1.27 (0.42-2.31)	150 (c)	10 /10
SPB-out	24	White croaker	241 (206-268)	2520 (94.1-12700)	228 (9.39-1090)	9.7 (ND-32)	ND	1.39 (0.47-4.82)	135 (c)	8 /8
PV	13-14	White croaker	265 (244-290)	742 (186-1400)	90.8 (24.8-161)	7.95 (6.57-9.06)	ND	0.59 (0.25-0.88)	196 (c)	7 /7
SPB-out	EPA A out	White croaker	217 (184-255)	203 (17.3-2900)	29.1 (5.26-237)	4 (ND-13.6)	ND	0.58 (0.19-1.29)	91.8 (c)	39 /10
SPB-out	EPA B	White croaker	219 (150-267)	1130 (65.5-6450)	136 (10.1-663)	9.81 (ND-21.2)	ND	1.16 (0.27-2.54)	83.2 (c)	39 /10
SPB-out	EPA C	White croaker	233 (217-273)	440 (1.97-3130)	50.5 (2.58-232)	5.55 (ND-18.3)	ND	0.89 (0.09-3.6)	135 (c)	39 /9
SPB-out	EPA D	White croaker	208 (183-245)	175 (1.97-2270)	32.2 (2.26-207)	5.18 (ND-18.1)	ND	0.8 (0.09-2)		28 /0
PV	EPA E	White croaker	215 (184-254)	992 (127-3590)	120 (15.3-356)	8.81 (ND-29.9)	0.0279 (ND-0.81)	1.03 (0.17-3.53)		29 /0
SMB	EPA F	White croaker	211 (183-228)	204 (90.4-368)	42.9 (18.6-72)	7.92 (2.56-11.9)	ND	1.02 (0.27-2.33)	134 (c)	5 /5
SMB	8	White seabass	840 (723-1205)	65.6 (c)	12.9 (c)	5.38 (c)	ND (c)	0.23 (c)	203 (c)	9 /9
SMB	5	Yellowfin croaker	261 (233-311)	35.5 (c)	42 (c)	7.8 (c)	ND (c)	0.42 (c)	170 (c)	10 /10
SPB-in	18	Yellowfin croaker	225 (212-240)	24.5 (5.45-46)	15.7 (8.28-21)	8.14 (ND-16.5)	ND	0.44 (0.29-0.58)	43.2 (c)	10 /10
OC	19	Yellowfin croaker	242 (220-269)	52.9 (c)	29.2 (c)	8.18 (c)	ND (c)	0.48 (c)	56.8 (c)	10 /10

Notes: (c) indicates that analysis was run on a composite sample; therefore no range of values is available. Lipids were calculated as total extractable organics on a weight basis.
N (org/Hg) indicates number of samples included in the organic and mercury analysis, respectively for that sample. The number of organic analyses refers only to DDTs and PCBs; dieldrin and chlordane were not run for all organic samples.

6 REFERENCES

Allen, L. G., M. H. Horn, and D.J. Pondella, II (eds.). 2006. Ecology of Marine Fishes: California and Adjacent Areas. University of California Press, Berkeley, CA. 660 pp.

Allen, M. J. 2001. Review of habitat information on white croaker (*Genyonemus lineatus*) and nearshore soft- and hard-bottom assemblages of southern California. White paper prepared for National Oceanic and Atmospheric Administration, Damage Assessment Center, Long Beach, CA. Southern California Coastal Water Research Project, Westminster, CA. 46 p.

Allen, M. J., and J. N. Cross. 1994. Contamination of recreational seafood organisms off Southern California. pp. 100-110 *in* J. N. Cross, C. Francisco, and D. Hallock (eds.), Southern California Coastal Water Research Annual Project Report 1992-1993. Southern California Coastal Water Research Project, Westminster, CA.

Allen, M. J., P. V. Velez, D. W. Diehl, S. E. McFadden, and M. Kelsh. 1996. Demographic variability in seafood consumption rates among recreational anglers of Santa Monica Bay, California in 1991-1992. Fishery Bulletin (U. S.) 94:597-610.

Allen, M. J., S. L. Moore, K. C. Schiff, S. B. Weisberg, D. Diener, J. K Stull, A. Groce, J. Mubarak, C. L. Tang, and R. Gartman. 1998. Southern California Bight 1994 Pilot Project: V. Demersal fishes and megabenthic invertebrates. Southern California Coastal Water Research Project, Westminster, CA. Technical Report 308. 365 p.

Allen, M. J., A. K. Groce, D. Diener, J. Brown, S. A. Steinert, G. Deets, J. A. Noblet, S. Moore, D. Diehl, E. T. Jarvis, V. Raco-Rands, C. Thomas, Y. Ralph, R. Gartman, D. Cadien, S. B. Weisberg, and T. Mikel. 2002. Southern California Bight 1998 Regional Monitoring Program: V. Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project, Westminster, CA. 572 p.

Amhreim, J., C. Stow, and C. Wible, 1999. Whole fish versus fillet polychlorinated biphenyl concentrations: An analysis using classification and regression tree models. Environmental Toxicology and Chemistry. 18(8):1817–1823.

CFCP (Coastal Fish Contamination Program). 2001. Personal communication from Dr. Robert Brodberg, Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency: Oakland, California.

Chartrand, A.B., S. Moy, A.N. Safford, T. Yoshimura and L.A. Schinazi. 1985. Ocean dumping under Los Angeles Regional Water Quality Board permit: A review of past practices, potential adverse impacts and recommendations for future action. California Reg. Water Quality Control Board, Los Angeles Region, March 1985. 47 pp.

Connolly, J., T. Parkerson, J. Quadrini, S. Taylor, and A. Thuman, 1992. Development and Application of a Model of PCBs in the Green Bay, Lake Michigan Walleye and Brown Trout and Their Food Webs. October 2.

CSDLAC (County Sanitation Districts of Los Angeles County). 2000, 2005, 2006. Annual Data Reports for levels of PCBs and DDTs in white croaker, kelp bass, and black perch. CSDLAC, Whittier, California.

Davis, J.A., M.D. May, B.K. Greenield, R. Fairey, C. Roberts, G. Ichikawa, M.S. Stoelting, J.S. Becker, and R.S. Tjeerdema. 2002. Contaminant concentrations in sport fish from San Francisco Bay, 1997. Marine Pollution Bulletin. 44:1117-1129.

De Boer, J., F. Smedes (1997). Effects of Storage Conditions of Biological Materials on the Contents of Organochlorine Compounds and Mercury. Marine Pollution Bulletin, Volume 35, pp. 93-108.

Gold, M., J. Alamillo, S. Fleisch, J. Forrest, R. Gorke, L. Heibshi, R. Gossett. 1997. Let the Buyer Beware: A Determination of DDT and PCB Concentrations in Commercially Sold White Croaker. Heal the Bay, Santa Monica, California.

Greenfield, B.K., J.A. Davis, R. Fairey, C. Roberts, D. Crane, G. Ichikawa. 2004. Seasonal, interannual, and long-term variation in sport fish contamination, San Francisco Bay. Science of the Total Environment. 336: 25-43.

Horn, W., R. W. Riseborough, A. Soutar, and D. R. Young. 1974. Deposition of DDT and polychlorinated biphenyls in dated sediments of the Santa Barbara Basin. Science. 184: 1197-1199.

Isaacs, J. D. 1972. Unstructured marine food webs and pollutant analogues. Fishery Bulletin (U.S.) 70:1053-1059.

Kiriluk, R.M., W.H. Hyatt, M.J. Keir, and D.M. Whittle (1996). Fluctuations in levels of total PCB, organochlorine residues, lipid, and moisture in whole lake trout homogenate samples during four years of frozen storage. Canadian Technical Report for Fisheries and Aquatic Science, Report 2091, 32 pp.

Limbaugh, C. 1961. Life-history and ecological notes on the black croaker. California Fish and Game 47(2):163-174.

Love, M. 1996. Probably more than you want to know about the fishes of the Pacific coast. Santa Barbara, California: Really Big Press. 386 pp.

Love, M. S., G. E. McGowen, W. Westphal, R. J. Lavenberg, and L. Martin. 1984. Aspects of the life history and fishery of the white croaker, *Genyonemus lineatus* (Sciaenidae), off California. Fish. Bull. 82(1):179-198.

Love, M., M. Yoklavich, L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press. 416 pp.

Mearns, A. J., M. B. Matta, D. Simecek-Beatty, M. F. Buchman, G. Shigenaka, and W. A. Wert. 1988. PCB and Chlorinated pesticide Contamination in U.S. Dish and Shellfish: A Historical Assessment Report. NOAA Technical Memorandum NOS OMA 39. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Ocean Service. Seattle, WA. 140 pp.

Miller D. J., R. N. Lea. 1976. Guide to the coastal marine fishes of California. California Department of Fish and Game Bulletin 157. 249 pp.

National Institute of Standards and Technology (NIST). 2004. Certificate of Analysis: Standard Reference Material 1946: Lake Superior Fish Tissue. Available on-line from NIST at http://ts.nist.gov/MeasurementServices/ReferenceMaterials/232.cfm.

National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Interior, and State of California. 1991. Injury Determination Plan, Damage Assessment: Los Angeles/Long Beach Harbors, Palos Verdes Shelf and Ocean Dump Sites. Draft PDX062 1639. 117 pp.

NRC. 1999. DORM-2 and DOLT-2: Dogfish Muscle and Liver Certified Reference Materials for Trace Metals. National Research Council of Canada, Institute for National Measurement Standards: Ottawa, Ontario.

OEHHA. 2001. Chemicals in Fish: Consumption of Fish and Shellfish in California and the United States. Final Report. Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency: Oakland, California.

Parkerton, T. F., 1993. Do aquatic effects or human health end points govern the development of sediment-quality criteria for nonionic organic chemicals? Environmental Toxicology and Chemistry. 12:507–523.

Pollock, G.A., I. J. Uhaa, A.M. Fan, J. A. Wisniewski, I. Witherell. 1991. A Study of Chemical Contamination of Marine Fish from Southern California: II. Comprehensive Study. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency: Sacramento, CA.

Puffer H.W., S.P. Azen, M.J. Duda, D.R. Young. 1982. Consumption Rates of Potentially Hazardous Marine Fish Caught in the Metropolitan Los Angeles Area. EPA-600/3-82-070. University of Southern California School of Medicine, Departments of Pathology and Preventive Medicine: Los Angeles, CA.

QEA (Quantitative Environmental Analysis, LLC) 2000. Total DDT Levels in Fish from the Palos Verdes Shelf: Proportions Exceeding the FDA Action Level and the California State Trigger Level. Testimony submitted as part of litigation against the Montrose Chemical Company: Syracuse, NY.

Randall, R. C., D.R. Young, H. Lee II, and S.F. Echols (1998). Lipid Methodology and Pollutant Normalization Relationships for Neutral Nonpolar Organic Pollutants. Environmental Toxicology and Chemistry, Volume 17, pp. 788-791.

SCCWRP (Southern California Coastal Water Research Project). 1973. The ecology of the Southern California Bight: Implications for water quality management. SCCWRP TR 104. El Segundo, CA: Southern California Coastal Water Research project. 499 pp.

SCCWRP 2002. Southern California Bight 1998 Regional Monitoring Program:V. Demersal Fishes and Megabenthic Invertebrates. Available online at http://www.sccwrp.org/regional/98bight/bight98_trawl_report.html

SCCWRP and MBC Applied Environmental Sciences, University of California Santa Cruz Trace Organics Facility. 1992. Santa Monica Bay Seafood Contamination Study. Report submitted to Santa Monica Bay Restoration Project: Monterey Park, CA. 179 pp.

TSMP (Toxic Substances Monitoring Program). 1995. State Water Resources Control Board, California Environmental Protection Agency. Data available at http://www.swrcb.ca.gov/programs/smw. Latest available full report 1994-1995.

U.S. EPA (Environmental Protection Agency). 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. EPA 823/B-00-007. Office of Water: Washington, D.C.

U.S. EPA and Montrose Settlements Restoration Program (MSRP). 2003. Palos Verdes Shelf "Fish in Ocean" Sampling & Analysis Project Quality Assurance Project Plan. April 10, 2003.

U.S. EPA and U.S. FDA. 2004. 2004 FDA/EPA Consumer Advisory: Mercury in Fish and Shellfish Available on-line at http://www.epa.gov/waterscience/fishadvice/advice.html. March 2004.

U.S. EPA. 2003. Ecological Risk Assessment for the Palos Verdes Shelf. U.S. EPA Region IX. San Francisco, CA.

Young, D. R., and T. C. Heeson. 1980. Synoptic Survey of Chlorinated Hydrocarbon Inputs to the Southern California Bight. Final Report, Grant #R803707. U.S EPA and the Southern California Coastal Water Research Project. Newport , OR and Long Beach, CA.