

CHEMICAL CONTAMINANTS IN EDIBLE, NON-SALMONID
FISH AND CRABS FROM COMMENCEMENT BAY, WASHINGTON

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ABSTRACT

A survey of chemical contaminants in fish and crabs from Puget Sound's Commencement Bay area was initiated following reports by various agencies that certain waterways in the area contained relatively high levels of potentially toxic chemicals. Information was collected to provide the Tacoma-Pierce County Health Department with chemical data needed to begin a preliminary assessment of any health risk possibly faced by persons eating fish and crabs from Commencement Bay and adjacent waters.

Sampling was conducted from July 1981 to January 1982. Eighty-six non-salmonid fish and six Dungeness crabs were collected from popular sport fishing locations in the vicinity of Commencement Bay and from a remote reference area, Discovery Bay. Muscle tissue from these specimens was chemically analyzed for selected metals and organic compounds (EPA priority pollutants).

Specimens from the Commencement Bay area generally had higher contaminant levels than did the specimens collected from Discovery Bay. The pollutant concentrations in the fish and crabs varied considerably, depending on the species and their location. The highest concentrations of polychlorinated biphenyls (PCB's) and pesticides were measured in fish from the Hylebos Waterway, while the highest total metal concentrations measured in fish were found in flatfish from the Point Defiance Dock. Regardless of where the crabs were collected, they contained total metal concentrations several times higher than the highest levels detected in fish.

The mercury, PCB, and DDT concentrations measured were always well below the tolerance or action levels established by the U.S. Food and Drug Administration (FDA). However, few specific guidelines are available to assist in the direct assessment of the potential toxicity of many individual chemicals detected. The existing guidelines also do not address possible combinations of chemicals and metabolites. No attempt was made in this report to conduct an overall assessment based on these data.

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CONCLUSIONS

The edible muscle tissues of most of the fish and crabs collected contained several potentially toxic chemical contaminants. The degree of contamination varied considerably, depending on the species and the location from which the specimens were collected. Specimens from the Commencement Bay area generally had higher contaminant levels than did specimens from the Discovery Bay reference site.

The highest total metal concentrations measured in fish were found in "bottom" fish from the Point Defiance Dock. Total metal concentrations in "off-bottom" fish from the Commencement Bay area were similar to those measured in "off-bottom" fish from the Discovery Bay reference area. Crabs from both the Commencement Bay area and Discovery Bay contained total metal concentrations that were substantially higher than levels measured in fish from the same sites. The levels of mercury measured were always well below the action level of 1.0 ppm established by the FDA for fish and shellfish.

Fish taken from the Hylebos Waterway contained the highest concentrations of PCB's averaging approximately 0.5 ug/g wet weight, or about one-tenth the FDA tolerance level of 5.0 ppm, and one-fourth the proposed tolerance level of 2.0 ppm.

No chlorinated butadienes were found in any of the specimens at the limit of detection reached in this study. However, hexachlorobenzene (HCB) was detected in fish and crabs from the Hylebos Waterway, but not in specimens collected at other locations. The chlorinated hydrocarbon pesticides DDT, DDD, and DDE were the only pesticides detected. These compounds were found in all but one of the fish and crab samples analyzed. Relatively high levels of one or more of these pesticides were detected in individual fish from both the Commencement Bay area and the Discovery Bay reference site. However, the highest average total pesticide level was measured in specimens from the Hylebos Waterway. Specimens from Discovery Bay had the lowest average total pesticide level. Concentrations of DDT and its metabolites never exceeded the FDA action level of 5.0 ppm in fish.

Phthalates were commonly found in many of the fish. In addition, a limited number of volatile organic compounds were detected in a few of the fish and crabs collected.

Although most of the contaminants detected in the edible muscle tissues appeared to be present at relatively low levels, efforts should continue to be directed at assessing their human health significance. The potential toxicity of combinations of these and other contaminants and their metabolites must be considered in the risk assessment process.

INTRODUCTION

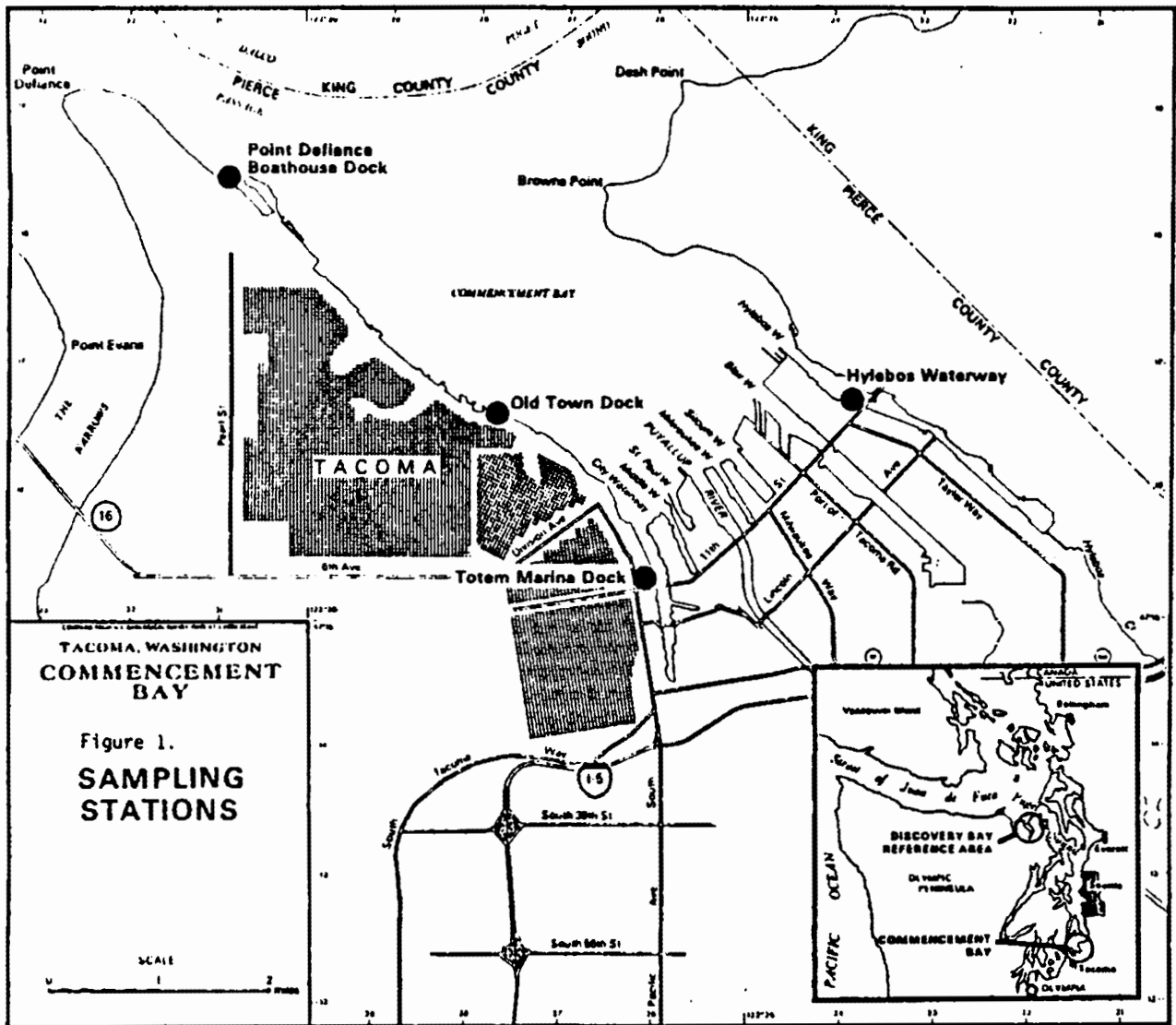
The potential for Puget Sound and adjacent waters to be adversely affected by expanding urban and industrial development has been known for some time. However, the possible extent and nature of some of these effects were not recognized until recently. In 1980, the National Oceanic and Atmospheric Administration (NOAA), Office of Marine Pollution Assessment (OMPA), reported on studies which described the distribution and possible biological effects of selected chemical contaminants in Puget Sound (6,11). Water, suspended matter, sediments, and aquatic organisms collected from several locations in Puget Sound were found to have measureable concentrations of one or more of the following groups of chemicals: metals, polychlorinated biphenyls (PCB's), petroleum hydrocarbons, and chlorinated organic compounds. Selected waterways in the Commencement Bay area generally appeared to be the most polluted.

In addition to the chemical contaminants observed, some of the fish, crabs, shrimp, and clams collected from a few of the contaminated areas were found by Malins and his associates (6) to have a variety of lesions of the liver or other organs. These observations raised questions about not only the relationship between the chemical contaminants and the health of associated aquatic organisms, but also about the possible influence of these chemicals on the health of those persons eating the contaminated seafoods. Considering the general lack of chemical and toxicological information on the chemical contaminants present in edible portions of aquatic organisms inhabiting the Commencement Bay area, the Tacoma-Pierce County Health Department issued warnings advising people not to eat fish and shellfish caught in certain waterways. Since this work has been completed, Malins and his associates (7) have published chemical and biological data on livers taken from 85 fish throughout Puget Sound. They presented data on organic compounds in liver and muscle tissue from 13 fish caught in Commencement Bay. These included five English sole, five salmon, and three cod.

To provide more complete information on which to assess the human health significance of the chemical contamination described, EPA Region 10 initiated a chemical survey in July 1981, to determine if potentially toxic organic compounds and metals were present in edible muscle tissues of non-salmonid fish and crabs from Commencement Bay and nearby waters.

The synergistic or antagonistic effects of the contaminants and their metabolites found in the fish are generally unknown at the present time.

The effect of the cooking methods used by the public was not considered in this report.



Final Preparation

Before removing any tissues for analysis, each specimen was identified, weighed, measured, and inspected for grossly visible lesions, parasites, and other features of possible significance. Fish samples were first skinned (Note 3), then edible muscle tissue (the fillet) was removed from both sides of each specimen using stainless steel scalpels, scissors, and forceps (Note 4). As much edible muscle tissue as possible was picked from the crab samples using the same stainless steel instruments. The tissues collected were cut or torn into small pieces before being placed in glass jars having teflon-lined screw caps (Note 5), then weighed and stored at 1°C until processing for chemical analysis was begun.

Following the collection of the muscle tissues, fish livers were removed with stainless steel scissors and forceps, placed in glass jars fitted with aluminum foil-lined screw caps (Notes 1,5), and stored at -12°C for possible future chemical analysis. All the livers were weighed and visually inspected before being frozen.

Finally, the sex of the fish was confirmed by inspection of the gonads under a microscope, and otoliths were collected to provide information on the ages of the fish collected.

The gross visual inspection of the fish and livers for such things as lesions and parasites was included in the sampling procedures to compliment the chemical information being collected. These general observations were not intended to constitute an independent investigation of biological abnormalities. However, the observations were considered appropriate in light of recent studies identifying possible links between chemical contamination and diseases of fish and crustaceans from certain Puget Sound waters (6,7).

- Notes:
1. The aluminum foil, used to line the tissue sample jar lids, and to wrap the whole fish and crabs, was cleaned in the following manner:
 - a. Rinsed twice with pesticide-grade acetone.
 - b. Rinsed twice with pesticide-grade methylene chloride.
 - c. Dried 10 minutes in a drying oven at 100°C.
 2. The decision to preserve the samples for analysis by refrigeration rather than freezing was based on concerns about the poorly defined effects of freezing, coupled with possible thawing and refreezing, on the concentrations of volatile organic compounds in edible muscle tissues. The procedure of analyzing refrigerated tissues was also believed to be consistent with the way in which many of the sport fish catches were preserved before being prepared for consumption.

ANALYTICAL METHODS

Fish and crab samples were analyzed for the priority pollutant organic compounds and metals, which are listed in Table E-1. Additional metals and organic compounds previously detected in Commencement Bay by other investigators were included. Tentative identifications were made for those compounds showing response in the gas chromatography/mass spectrometer (GC/MS) chromatograms.

Analytical methods for the priority pollutants, other organic compounds, and metals, followed EPA procedures as much as possible. However, modifications were needed to remove interferences so that lower detection limits were achievable. This section briefly outlines the procedures followed. Details of the procedures and detection limits are indicated in Tables F-3 and F-4.

Procedures for Organic Compounds

The edible muscle tissues of the fish and crab samples were extracted into a methylene chloride/methanol mixture three times with a Brinkman Polytron homogenizer. After filtering, the extracts were reduced in volume and combined with organic-free water at a pH of ≤ 2 . The water/extract mixtures were extracted again with methylene chloride, reduced in volume and divided for pesticide/chlorinated hydrocarbon analysis and acid/neutral (A/N) analysis.

The fractions used for pesticide, PCB, and polychlorinated butadiene (PCBD) analyses were further cleaned on a Florisil column; pentane was used to elute the PCBD, PCB, and some of the chlorinated pesticide compounds. Mixtures of diethylether/pentane were used to elute the other pesticides. These fractions were analyzed by GC/EC (gas chromatography/electron capture) with dual column confirmation. When the concentrations of chlorinated species were sufficiently high, confirmation was obtained by a halogen - specific detector and/or fused silica capillary chromatography/mass spectrometry/data system (FSCC/MS/DS). The A/N fraction was further cleaned by gel permeation chromatography before FSCC/MS/DS analysis. Volatile organic compounds were analyzed by the gas purge, GC/MS procedure as modified by the Region 10 Laboratory (3). A detailed description of the analytical methods is presented in Appendix E.

Procedures for Metals

Samples of tissues were digested with a mixture of nitric acid and hydrogen peroxide until the tissue was destroyed. The metals were determined by atomic absorption spectrometry using a graphite furnace or flame following EPA methods (8). Mercury was determined by the manual cold vapor technique, similar to that described by EPA Method 245.5 (8).

Table 1. Distribution of Fishes and Crabs from Commencement Bay, Adjacent Waterways, and the Discovery Bay Reference Area
July 15, 1982 - January 7, 1982

		Hylebos Waterway	City Waterway (Totem Marina Dock)	Old Town Dock	Point Defiance Dock	Discovery Bay (Reference Area)	Totals
OFF-BOTTOM FISH	Walleye Pollock <u>Theragra chalcogramma</u>		5	5	5	5	20
	Pacific Hake <u>Merluccius productus</u>		5	5			10
	Pacific Tomcod <u>Microgadus proximus</u>		3			1	4
	Pacific Cod <u>Gadus macrocephalus</u>		2	1			3
	English Sole <u>Parophrys vetulus</u>	5	5	3	3	5	21
BOTTOM FISH	Rock Sole <u>Lepidopsetta bilineata</u>			2	3		5
	Flathead Sole <u>Hippoglossoides elassodon</u>				1	1	2
	Starry Flounder <u>Platichthys stellatus</u>			1		1	2
	C-O Sole <u>Pleuronichthys coenosus</u>				1		1
	Pacific Staghorn Sculpin <u>Leptocottus armatus</u>	3		1	3	5	12
MIXED FISH	Whitespotted Greenling <u>Hexagrammos stelleri</u>	3					3
	Buffalo Sculpin <u>Enophrys bison</u>			1	1		2
	Rockfish <u>Sebastes sp.</u>			1			1
	Dungeness Crab <u>Cancer magister</u>	2	2			2	6
CRAB	Rock Crab <u>Cancer productus</u>					1	1
Totals		13	22	20	17	21	93

The average PCB concentrations in the various species of fish at the various sampling sites are depicted in Figures A-1 through A-14. Specific data are shown in Tables A-1 through A-3.

Chlorinated Butadienes (PCBD's)

Detectable levels of polychlorinated butadienes were not found in any of the muscle tissues analyzed. The limit of detection was 0.001 ug/g.

Hexachlorobenzene (HCB)

Hexachlorobenzene was detected only in fish and crab muscle tissue samples taken from the Hylebos Waterway. The HCB levels in the fish ranged from 0.014 ug/g to 0.15 ug/g with an average of 0.078 ug/g which was 2 to 6 times higher than in crab. The limit of detection for HCB by GC/EC was 0.001 ug/g. The presence of HCB in Hylebos Waterway samples was confirmed both with a halogen-specific detector and GC/MS.

Chlorinated Pesticides

Although a search was made for all of the chlorinated hydrocarbon pesticides listed in Table E-1, the only pesticides found were DDT, DDD and DDE. These three compounds were detected in all but one of the samples of fish and crab muscle tissue analyzed. Total pesticide levels (sum of the concentrations of DDT, DDD, and DDE) ranged from less than 0.001 ug/g to 0.059 ug/g, and were much lower than the PCB concentrations measured (Tables A-1, A-2, and A-3). The highest average total pesticide level was measured in species from the Hylebos Waterway, with specimens from Discovery Bay having the lowest average total pesticide level. Concentrations of DDT and its metabolites were always well below the FDA action level of 5.0 ppm.

Volatile, Acidic, and Neutral Organic Compounds

A variety of volatile, acidic, and neutral organic compounds were found by GC/MS in fish and crab muscle tissues taken from the five sampling stations. Although attempts were made to characterize several hundred compounds detected in tissue extracts by mass spectral matching techniques, only 56 compounds were identified. Comparison of retention times and mass spectra data generated from authentic substances was possible for 17 compounds found on the priority pollutant list. Tentative identifications based on mass spectral matching results were assigned to the remaining 43 substances. Both tetrachloroethylene and trichloroethylene were detected in fish tissue sampled at the Hylebos Waterway. Both chemicals were detected in water from the Hylebos in previous EPA surveys. This may be the first time volatile organics have been shown to accumulate in fish. The results of GC/MS analyses are compiled in Tables C-1, C-2, and C-3.

Several other unidentified chlorinated substances were present in all Hylebos Waterway tissue samples. These peaks were not present in samples taken from other stations.

Metals

The fish and crab tissue samples were analyzed for 13 metals. Arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc were found in low to moderate concentrations. Antimony, beryllium and thallium were not detected. All concentrations are presented on a wet weight basis.

The highest average total metal concentrations were found in the tissues of the "bottom" fish and the "mixed" fish. The "off-bottom" fish had lower average total metal concentrations regardless of station location.

"Bottom" fish had the highest average total metal concentration at the Point Defiance Dock station (27.6 ug/g). The average total metal concentrations in "bottom" fish at the other four stations are arrayed as follows: Hylebos Waterway 12.3 ug/g, Old Town Dock 11.4 ug/g, City Waterway 11.1 ug/g and Discovery Bay 9.4 ug/g (Figure B-1).

While "mixed" fish contained higher average total metal concentrations than did the "off-bottom" fish, there were no remarkable differences in "mixed" fish averages between stations. The highest average in this "mixed" fish category was in fish from the Old Town Dock area (12.8 ug/g). The second highest average was in fish from the Point Defiance Dock area (12.0 ug/g). The lowest averages in this group were found in fish from the Hylebos Waterway and Discovery Bay. "Mixed" fish from both of these areas had average total metal concentrations of 10.0 ug/g. No "mixed" fish were sampled at the City Waterway (Figure B-2).

The "off-bottom" fish had the lowest average total metal concentrations, and the smallest differences between these values at the different stations. "Off-bottom" fish from the Point Defiance Dock area actually contained less total metals, (8.4 ug/g) than did "off-bottom" fish from the reference station (8.5 ug/g). "Off-bottom" fish from the Old Town Dock area averaged 8.0 ug/g, and "off-bottom" fish from the City Waterway averaged 7.6 ug/g. Unfortunately no "off-bottom" fish from the Hylebos Waterway were sampled (Figure B-3).

Crab muscle tissues contained several times more total metal than the fish muscle tissues from the same sampling stations. Differences between station averages were small. The reference station Dungeness crab contained only slightly less total metal than did crab from the Hylebos Waterway (Figure B-14).

Total and individual metal concentrations found in the various fish and crab species are presented graphically in Figures B-4 through B-14. Averages of metal concentrations by species are compared in Table B-1 and the means and ranges by station are tabulated in Table B-2. Data describing metal concentrations for individual fish and crabs are presented in Table B-3.

The different metals are discussed individually with respect to station, species, and fish category occurrences.

Copper

Copper concentrations were relatively high in fish from the Point Defiance Dock area and the Old Town Dock area. Fish from Discovery Bay, and the Hylebos and City Waterways contained less copper.

"Off-bottom" fish from the Point Defiance Dock area contained the most copper of any group of fish from any station. Copper concentrations in these fish averaged 0.82 ug/g. "Mixed" fish from the Point Defiance Dock area had the second highest average concentration at 0.76 ug/g. "Mixed" fish from the Old Town Dock area had the third highest average concentration of copper at 0.6 ug/g, followed by "off-bottom" fish from that same station with an average of 0.52 ug/g.

"Mixed" and "off-bottom" fish consistently contained more copper on the average than the "bottom" fish collected from any of the sampling stations.

Lead

Lead levels were highest in fish caught in the Point Defiance Dock area, the Old Town Dock area, and the City Waterway. Lead levels were lower in fish from Discovery Bay and the Hylebos Waterway.

"Bottom" fish from the Point Defiance Dock area contained the highest average lead concentration at 1.98 ug/g. This average includes a concentration of 10.4 ug/g lead found in an English sole. If this sole were excluded as an outlier from the averaging, the average for this group would be 0.58 ug/g lead. The second highest lead concentrations were found in the "mixed" fish from the Old Town Dock area. They averaged 0.63 ug/g lead. "Off-bottom" fish from the Point Defiance Dock station were third highest in lead concentration with an average of 0.61 ug/g.

Average levels of lead detected in the Hylebos Waterway samples were actually lower than those averages found in Discovery Bay samples.

Mercury

The Hylebos Waterway and the Old Town Dock area produced fish with the highest average mercury concentrations. "Off-bottom" fish at Discovery Bay also contained relatively high concentrations.

The highest concentrations of mercury were found in whitespotted greenling caught in the Hylebos Waterway. The average mercury content of these fish was 0.17 ug/g. The second highest concentrations were found in "off-bottom" fish from the Old Town Dock area. These fish averaged 0.010 ug/g mercury. Walleye pollock caught at the Discovery Bay station also contained higher mercury concentrations with an average of 0.008 ug/g.

At all stations, where comparisons could be made, the "mixed" fish and the "off-bottom" fish contained higher average levels of mercury than the "bottom" fish. Levels of mercury measured were always below the action level of 1.0 ppm established by the FDA for fish and shellfish.

(Crab Tissue)

Metal concentrations detected in Dungeness crabs, caught in the Hylebos and City Waterways and Discovery Bay, were generally high. Zinc, copper, nickel, and silver concentrations were especially high.

Zinc concentrations were consistently high in crabs from all stations (49.3 ug/g to 52.6 ug/g). These averages are 5 to 12 times higher than zinc concentrations found in the fish tissue. Commencement Bay crabs contained 3 to 4 times the copper (12.7 ug/g to 15.0 ug/g) that Discovery Bay crabs contained (4.3 ug/g).

Lead concentrations in crabs from Commencement Bay were twice as high (0.69 ug/g to 0.82 ug/g) as those found in Discovery Bay crabs (0.36 ug/g). Mercury and cadmium levels in crabs from Commencement Bay were similar to levels found in crabs from the reference station.

Arsenic and nickel concentrations in crabs from the Commencement Bay area were actually lower than concentrations detected in crabs from the reference station.

Condition of Samples

General Condition

The external condition of the crabs appeared to be good with only one Dungeness crab missing a leg and another having a "scar" on its carapace. Although no tumor-like growths were seen on any of the fish samples, approximately 13% of all the fish collected were observed to have some type of external abnormal condition. The abnormalities appeared to have been caused by such things as disease, predation, parasitism, abrasion, or hook and line fishing. The abnormal conditions recorded are listed in Table D-1 and summarized below.

The erosion or loss of portions of various fins was observed in an English sole and a whitespotted greenling from Hylebos Waterway, in an English sole and a rock sole from the Point Defiance Dock, and in a walleye pollock from City Waterway. Hemorrhaging along the dorsal, anal, and caudal fins was seen in a starry flounder from City Waterway, while "raw looking" pink/red splotches were observed on the blind side of a flathead sole from the same area. An open tear was noted in the flesh along the caudal peduncle of a walleye pollock from City Waterway, with a bleeding wound observed on the caudal peduncle of a rock sole from the Point Defiance Dock. In addition, a buffalo sculpin from Old Town Dock was missing a portion of its left maxillary, and a starry flounder from Discovery Bay had small lesions on its blind side that appeared to be associated with the presence of crustacean parasites.

The highest incidences of abnormality were in fish from City Waterway (20%), Point Defiance Dock (19%), and Hylebos Waterway (18%). Only 6% of the fish from Old Town Dock and the Discovery Bay reference area were observed to have external abnormalities.

Abnormalities in the fish from the Commencement Bay stations were most prevalent in flatfish (60%), with the remainder of the abnormalities (40%) being observed in walleye pollock, whitespotted greenling, and buffalo sculpin.

Inspection of the fish livers did not result in the detection of any grossly visible lesions or abnormal growths. The most striking feature of the livers examined, however, was the wide variation in their coloration from station to station. For example, the livers of English sole collected from the Hylebos Waterway ranged in color from yellowish/brown to yellowish/beige with pink or red/brown splotches, while the livers of English sole taken from Discovery Bay ranged from pink/beige to gray/brown with gray/white splotches.

Although the significance of the color differences was not known, they may have been linked to such factors as size, age, sex, diet, or physiological state. It is also possible that in some cases they were associated with a degenerative condition, or the presence of microscopic lesions, as reported by Malins and his associates (6).

Size and Age of Samples

The estimated ages of the fish collected ranged from 1 year to 11 years, with most of the fish being from 3 years to 6 years of age. The average lengths and estimated ages of the most frequently collected fish species (English sole, walleye pollock, and Pacific hake) are presented in Table 4. For more detailed information on the length, age, total weight, fillet weight, liver weight, and sex of these and other fish collected refer to Table D-1.

The average length of the English sole collected ranged from 246 mm (Old Town Dock) to 289 mm (City Waterway). The average estimated ages of English sole collected from these same stations ranged from 3 years at Old Town Dock to 5 years at City Waterway. Walleye pollock ranged in length from an average of 333 mm (Old Town Dock) to an average of 409 mm (City Waterway); the average estimated age of these fish also ranged from 3 years to 5 years, respectively. The average length of Pacific hake collected from Old Town Dock was 435 mm, with specimens collected from City Waterway averaging 448 mm in length.

Regardless of the species listed in the table, the smallest (and youngest) fishes were collected from Old Town Dock, with the largest (and oldest) specimens being taken from City Waterway. Considering the small sample sizes involved (3-5 samples), it was not possible to explain this size and age distribution. It is important to note that although most of the fish species collected were not characterized by large differences in size or age, the differences that did exist could have accounted for at least some of the variation observed in the result of the chemical analyses.

No effort was made to estimate the ages of the crabs collected. The Dungeness crabs ranged in carapace width (excluding spines) from 118 mm (Hylebos Waterway, female) to 186 mm (Discovery Bay, male).

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APPENDIX A.

Comparison of Concentrations of PCB's and Pesticides Among Fish Species and Sampling Sites

NOTE: "u" denotes concentration is less than detection limit

"^" denotes quantifiable concentrations have been averaged together with "u" concentrations

For more information concerning detection limits see Appendix F page 115.

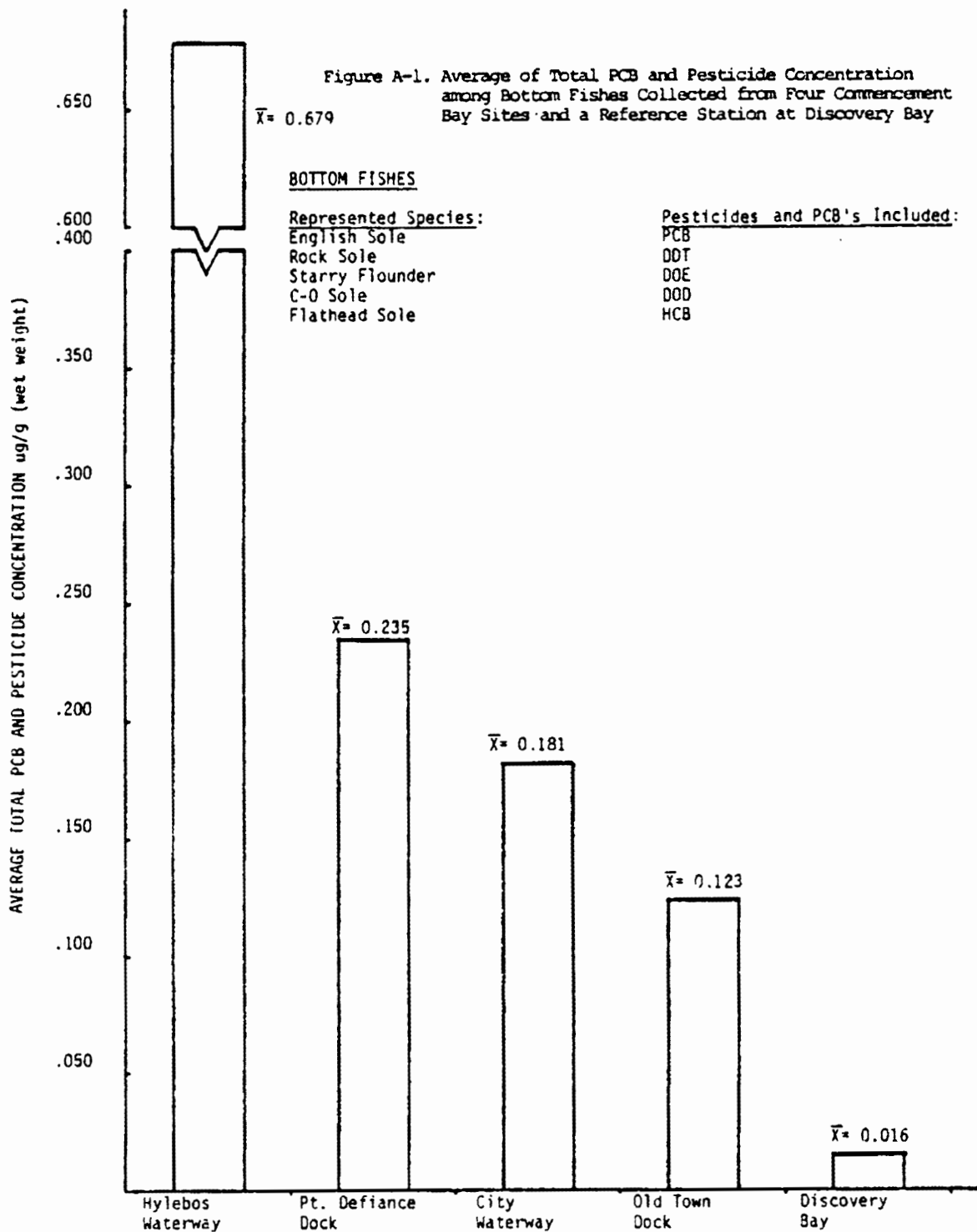
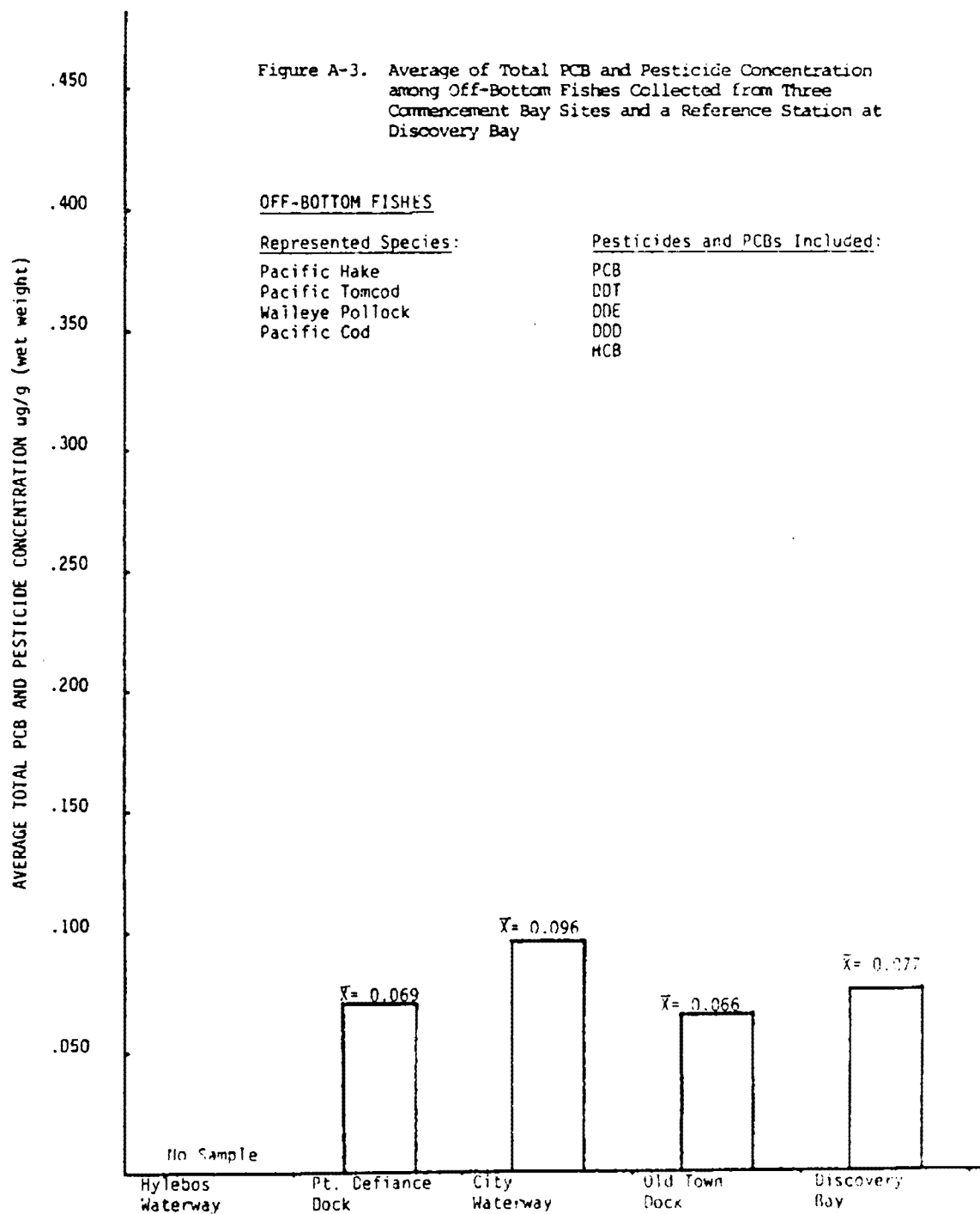


Figure A-3. Average of Total PCB and Pesticide Concentration among Off-Bottom Fishes Collected from Three Commencement Bay Sites and a Reference Station at Discovery Bay



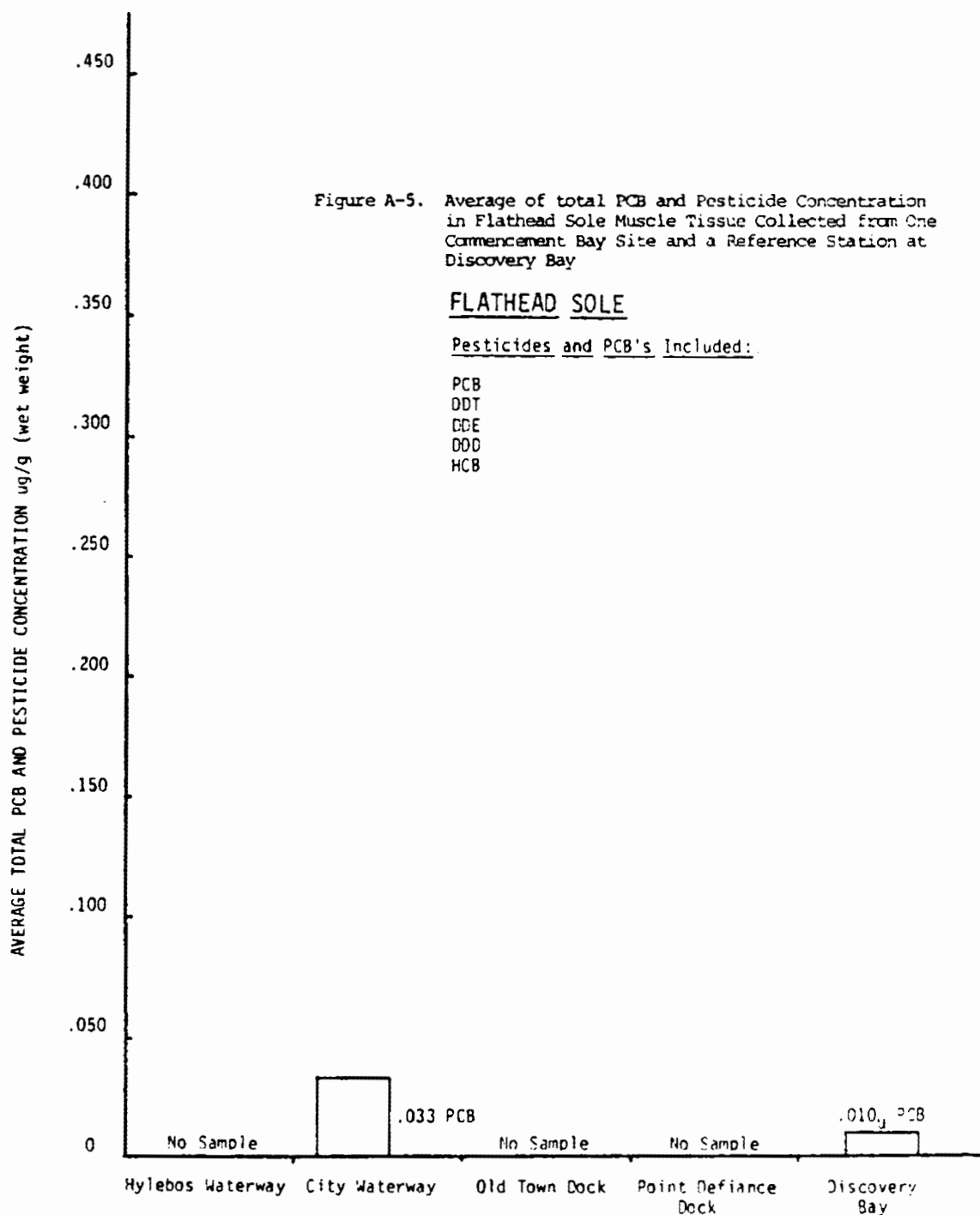


Figure A-7. Average of Total PCB and Pesticide Concentration in Starry Flounder Muscle Tissue Collected from One Commencement Bay Site and a Reference Station at Discovery Bay

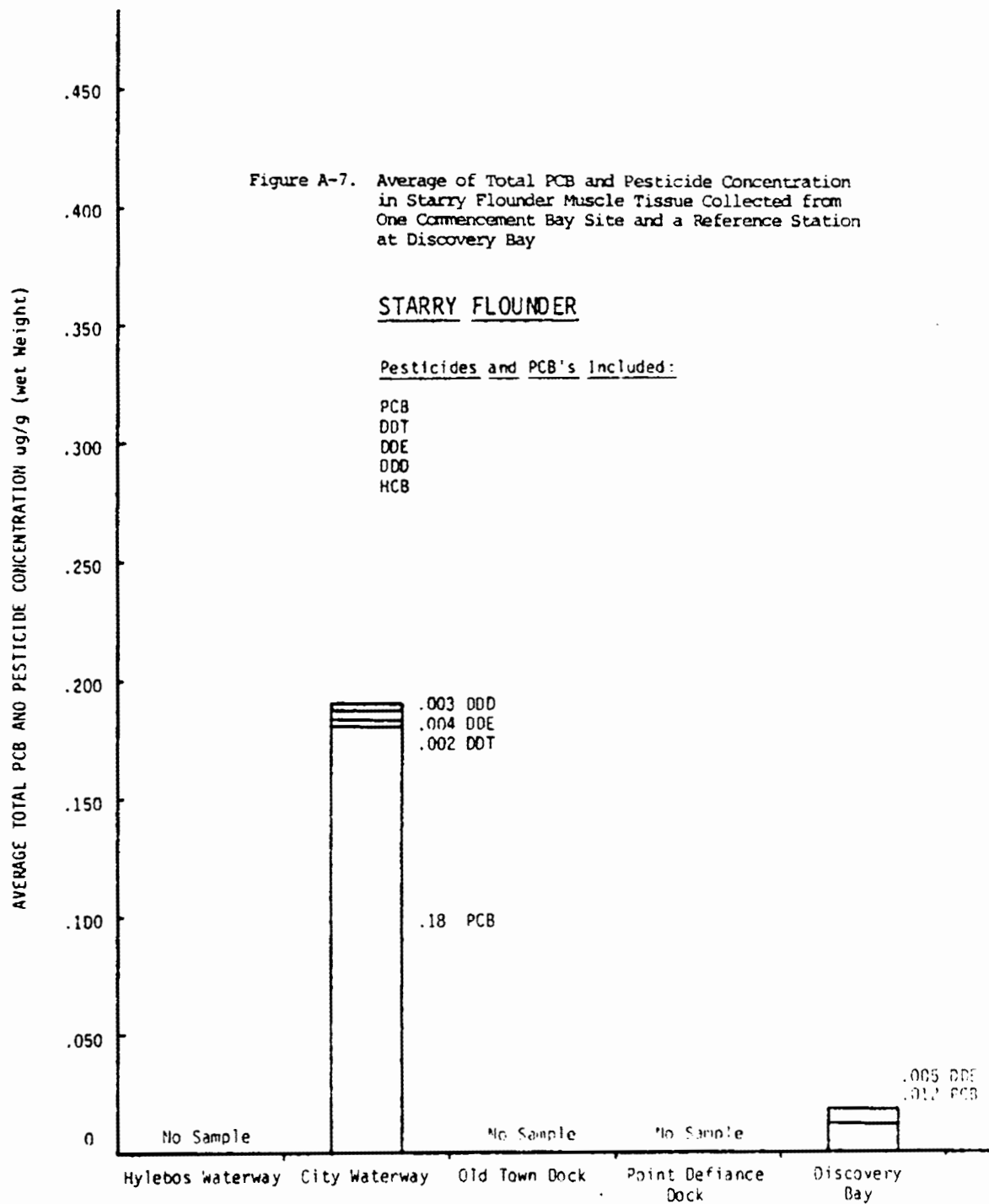


Figure A-9. Average of Total PCB and Pesticide Concentration in Pacific Staghorn Sculpin Muscle Tissue Collected from Three Commencement Bay Sites and a Reference Station at Discovery Bay

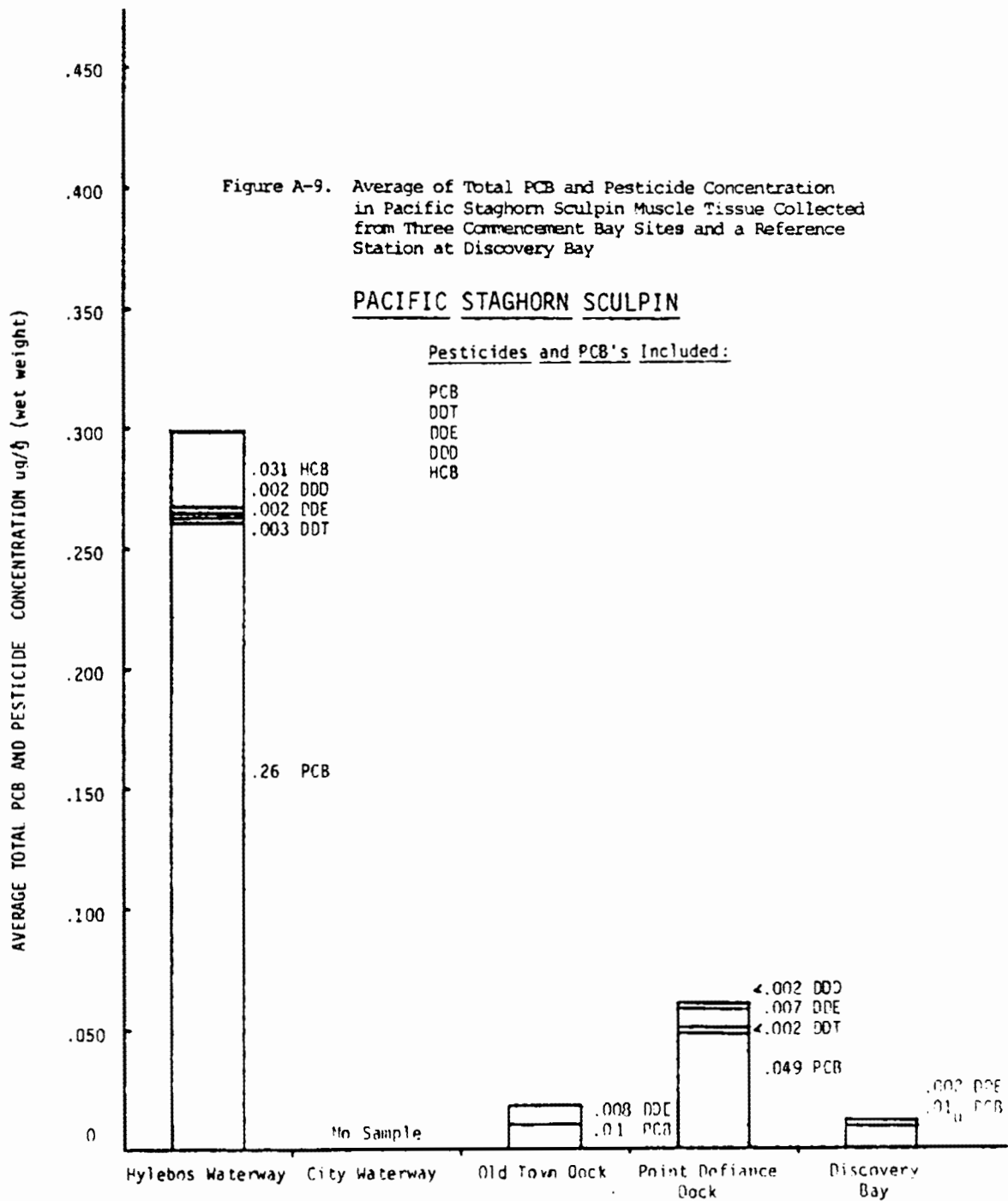


Figure A-11. Average of Total PCB and Pesticide Concentration in Pacific Hake Muscle Tissue Collected from Two Commencement Bay Sites.

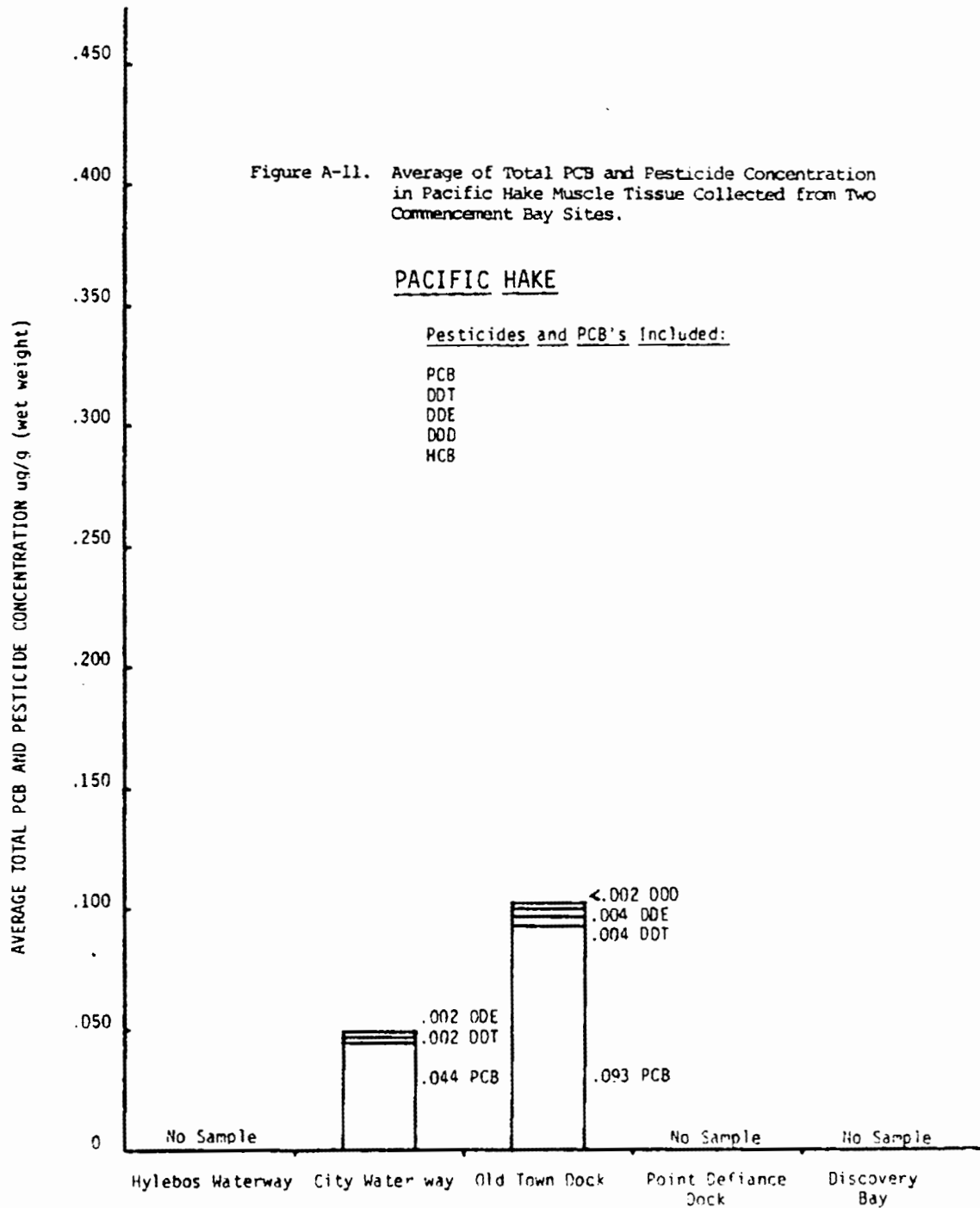


Figure A-13. Average of Total PCB and Pesticide Concentration in Walleye Pollock Muscle Tissue Collected from Three Commencement Bay Sites and a Reference Station at Discovery Bay

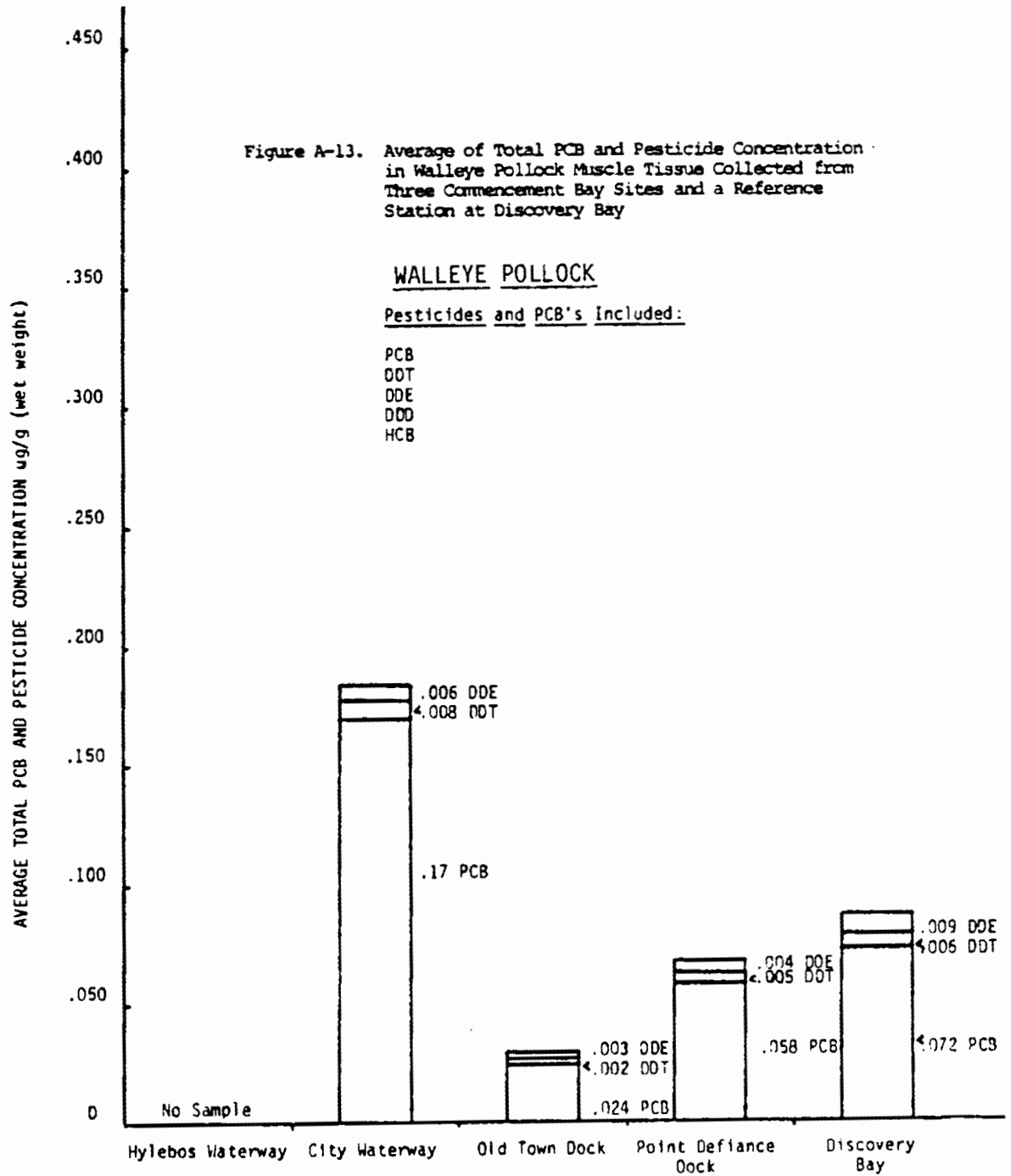


Table A-1.
Average PCB and Pesticide Concentrations Found in Fish Muscle Tissue Sampled in the Commencement Bay Area and Discovery Bay ug/g wet weight

Station	Species	(N)	PCB		DDT		DDE		DDD		HCB	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Hylebos	Whitespotted Greenling	3	0.86	0.45-1.12	0.025	0.014-0.037	0.006	0.002-0.01	0.005	0.002-0.01	0.059	0.014-0.096
Waterway	English Sole	5	0.55	0.13-1.03	<0.008 (4/5)	0.001u-0.015	0.005	0.002-0.007	<0.008 (4/5)	0.001u-0.013	0.11	0.056-0.15
	Pacific Staghorn Sculpin	2	0.26	0.17-0.34	0.003	0.002-0.004	0.002	-	0.002	-	0.031	0.028-0.034

Point Defiance	English Sole	3	0.33	0.10-0.64	<0.002 (1/3)	0.001u-0.005	0.004	0.003-0.005	<0.003 (2/3)	0.001u-0.006	0.001u	-
Dock	Rock Sole	2	0.12	0.06-0.19	<0.004 (1/2)	0.001u-0.006	0.026	0.003-0.049	<0.001 (1/2)	0.001u-0.001	0.001u	-
	C-O Sole	1	0.07	-	0.001u	-	0.001	-	0.001u	-	0.001u	-
	Walleye Pollock	5	0.058	0.017-0.13	<0.005 (2/5)	0.001u-0.005	0.004	0.001-0.011	<0.001 (1/5)	0.001u-0.001	0.001u	-
	Pacific Staghorn Sculpin	3	0.049	0.045-0.052	<0.002 (2/3)	0.001u-0.005	0.007	0.004-0.011	<0.002 (2/3)	0.001u-0.003	0.001u	-
	Buffalo Sculpin	1	0.011	-	0.001u	-	0.001u	-	0.001u	-	0.001u	-

Fraction represents the number of samples with detectable values over the number of samples analyzed

Table A-1. cont.

Average PCB and Pesticide Concentrations Found in Fish Muscle Tissue Sampled in the Commencement Bay Area and Discovery Bay ug/g wet weight

Station	Species	(N)	PCB		DDT		DDE		DDD		HCB	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Discovery Bay	Walleye Pollock	5	<0.072(2/5)	0.01u-0.27	<0.006(2/5)	0.001u-0.024	0.009	0.001-0.035	<0.001(1/5)	0.001u-0.002	0.001u	-
	English Sole	5	<0.013(2/5)	0.01u-0.01	<0.001(1/5)	0.001u-0.002	0.003	0.002-0.003	0.001u	-	0.001u	-
	Starry Flounder	1	0.012	-	0.001u	-	0.005	-	0.001u	-	0.001u	-
	Pacific Staghorn Sculpin	5	0.010u	-	0.001u	-	0.002	0.002-0.004	0.001u	-	0.001u	-
	Pacific Tomcod	1	0.010u	-	0.001u	-	0.002	-	0.001u	-	0.001u	-
	Flathead Sole	1	0.010u	-	0.001u	-	0.001	-	0.001u	-	0.001u	-

Fraction represents the number of samples with detectable values over the number of samples analyzed

Table A-2.cont.
PCB and Pesticide Concentrations*Found in Fish Muscle Tissue Sampled at the City waterway .

Lab. No.	Species	PCB 1254	Average	DDT	Average	DDE	Average	DDD	Average	HCB	Average
29005	Pacific Tomcod	-	-	-	-	-	-	-	-	-	-
46051	Pacific Tomcod	0.032	0.030	0.001u	0.001u	0.002	0.002	0.001u	0.001u	0.001u	0.001u
46052	Pacific Tomcod	0.028		0.001u		0.003		0.001u		0.001u	
46050	Pacific Cod	0.038	0.037	0.001	0.006	0.001	0.002	0.001u	0.001u	0.001u	0.001u
46058	Pacific Cod	0.036		0.011		0.002		0.001u		0.001u	
38022	Starry Flounder	0.18	0.18	0.002	0.002	0.004	0.004	0.003	0.003	0.001u	0.001u
38026	Flathead Sole	0.033	0.033	0.001u	0.001u	0.001	0.001	0.001u	0.001u	0.001u	0.001u
36050	English Sole	0.054		0.005		0.005		0.006		0.001u	
38021	English Sole	0.16		0.002		0.004		0.002		0.001u	
38023	English Sole	0.23	0.19	0.002	0.004	0.006	0.005	0.013	0.008	0.001u	0.001u
38024	English Sole	0.15		0.004		0.005		0.002		0.001u	
38025	English Sole	0.36		0.005		0.006		0.016		0.001u	
46053	Walleye Pollock	0.53		0.004		0.007		0.001		0.001u	
46054	Walleye Pollock	0.017		0.002		0.003		0.001u		0.001u	
46055	Walleye Pollock	0.20	0.17	0.026	<0.008	0.015	0.006	0.001	< 0.001	0.001u	0.001u
46056	Walleye Pollock	0.036		0.001u		0.002		0.001u		0.001u	
46057	Walleye Pollock	0.066		0.009		0.005		0.001u		0.001u	
46060	Pacific Hake	0.020		0.002		0.001		0.001u		0.001u	
46061	Pacific Hake	0.073		0.003		0.003		0.002		0.001u	
46062	Pacific Hake	0.038	0.044	0.002	0.002	0.001	0.002	0.001u	< 0.001	0.001u	0.001u
46063	Pacific Hake	0.036		0.002		0.002		0.001u		0.001u	
46059	Pacific Hake	0.053		0.003		0.002		0.001		0.001u	

* Concentrations Expressed in ug/g Wet Weight

Table A-2. cont.
PCB and Pesticide Concentrations*Found in Fish Muscle Tissue Sampled at the Point Defiance Dock

Lab. No.	Species	PCB 1254	Average	DDT	Average	ODE	Average	DDD	Average	HCB	Average
28000	Rock Sole	0.19		0.006		0.049		0.001		0.001u	
29000	Rock Sole	0.060	0.12	0.001u	<0.004	0.003	0.026	0.001u	<0.001	0.001u	0.001u
29001	Rock Sole	-	-	-	-	-	-	-	-	-	-
29002	English Sole	0.10		0.001u		0.003		0.001u		0.001u	
29003	English Sole	0.64	0.33	0.001u	<0.002	0.005	0.004	0.001	<0.003	0.001u	0.001u
38027	English Sole	0.25		0.005		0.005		0.006		0.001u	
29004	C-O Sole	0.070	0.070	0.001u	0.001u	0.001	0.001	0.001u	0.001u	0.001u	0.001u
38028	Buffalo Sculpin	0.011	0.011	0.001u	0.001u	0.001u	0.001u	0.001u	0.001u	0.001u	0.001u
01000	Walleye Pollock	0.085		0.008		0.006		0.001		0.001u	
01001	Walleye Pollock	0.031		0.001u		0.001		0.001u		0.001u	
01002	Walleye Pollock	0.027	0.058	0.001u	<0.005	0.001	0.004	0.001u	<0.001	0.001u	0.001u
01003	Walleye Pollock	0.017		0.001u		0.002		0.001u		0.001u	
01005	Walleye Pollock	0.13		0.015		0.011		0.001u		0.001u	
01004	Pacific Staghorn Sculpin	0.045		0.001u		0.004		0.001		0.001u	
01006	Pacific Staghorn Sculpin	0.050	0.049	0.001	<0.002	0.011	0.007	0.001u	<0.002	0.001u	0.001u
01007	Pacific Staghorn Sculpin	0.052		0.005		0.006		0.003		0.001u	
	* Concentration Expressed in ug/g Wet Weight										

Table A-3.

PCB and Pesticide Concentrations*Found in Crab Muscle Tissue Sampled at the Hylebos Waterway, City Waterway and Discovery Bay

[illegible]

APPENDIX B.

Comparison of Concentration of Metals Among Fish Species and Sampling Sites

NOTE: "u" denotes concentration is less than detection limit

" < " denotes quantifiable concentrations have been averaged together with "u" concentrations

For more information concerning detection limits see Appendix F page 115.

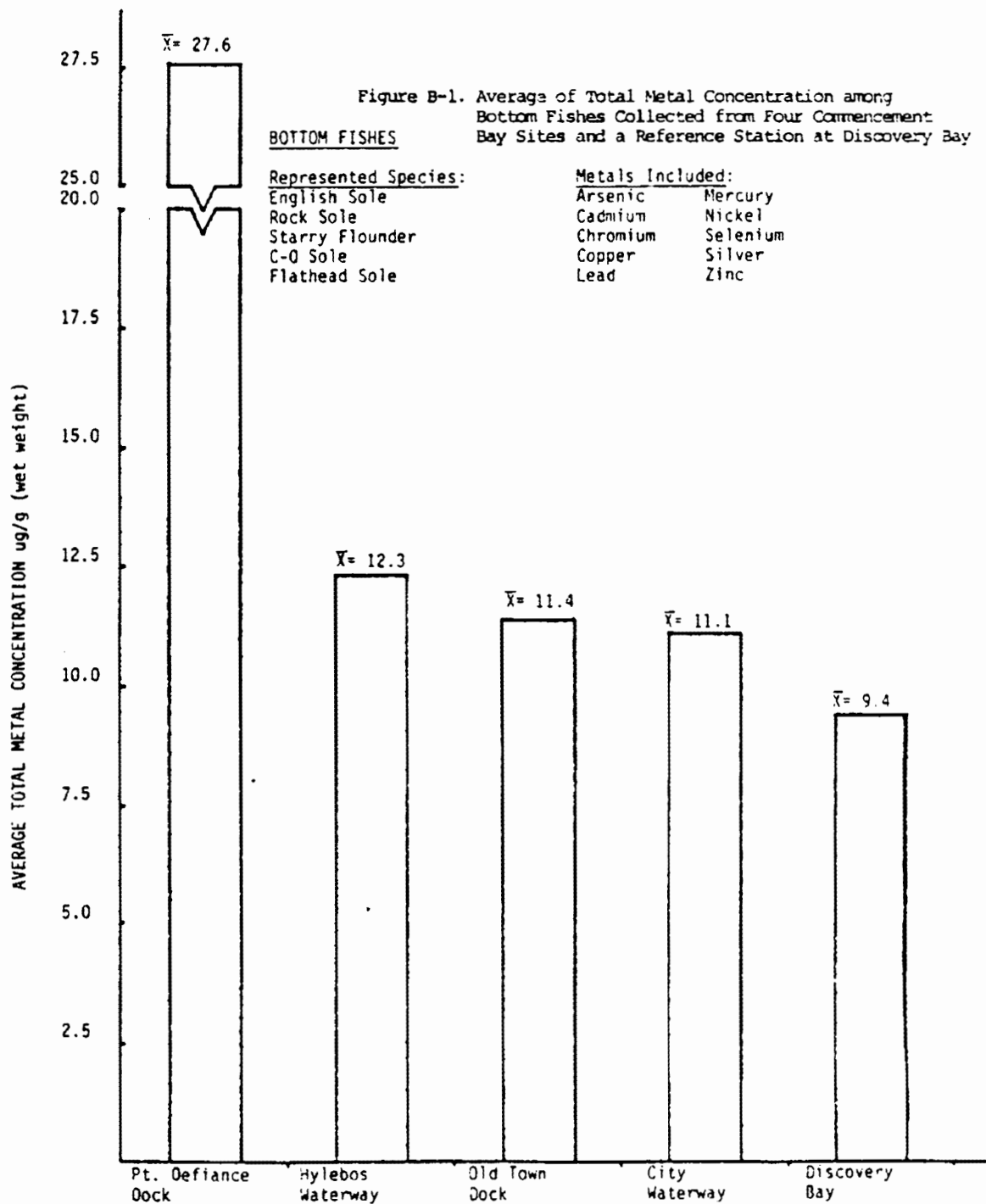


Figure B-3. Average of Total Metal Concentration among Off-Bottom Fishes Collected from Three Commencement Bay Sites and a Reference Station at Discovery Bay

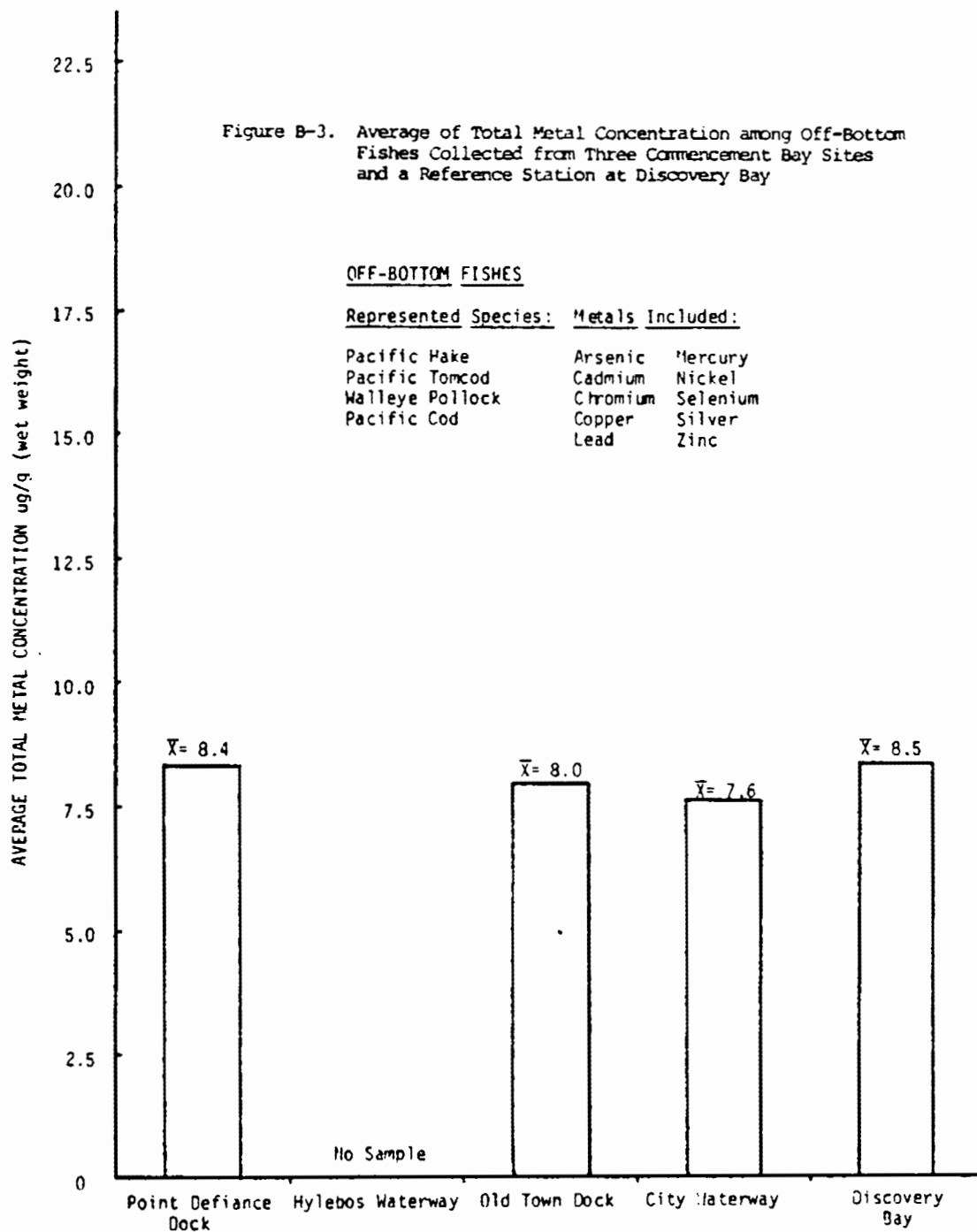


Figure B-5 Average of Total Metal Concentration in Flathead Sole Muscle Tissue Collected from One Commencement Bay Site and a Reference Station at Discovery Bay

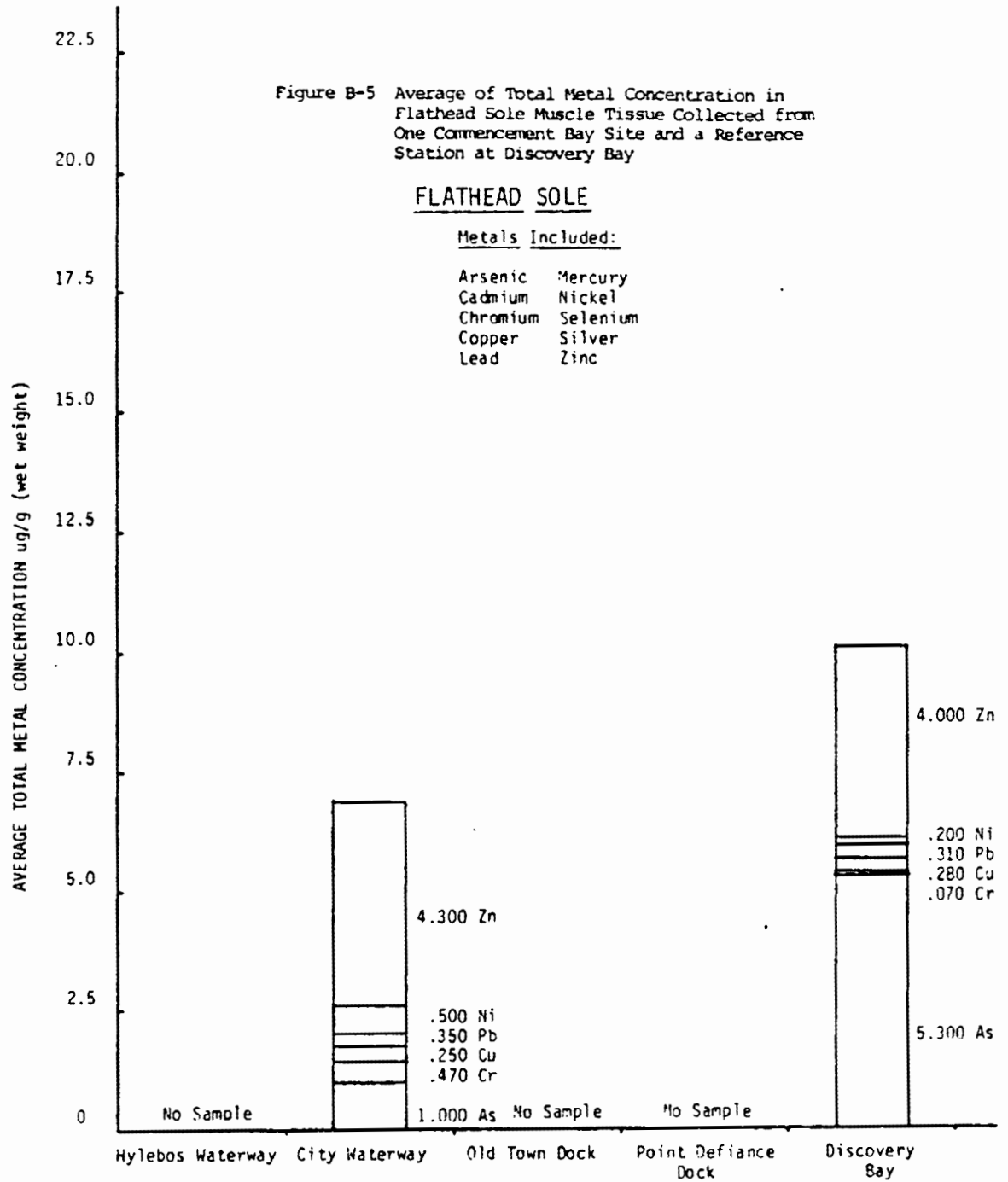


Figure B-7 Average of Total Metal Concentration in Starry Flounder Muscle Tissue Collected from One Commencement Bay Site and a Reference Station at Discovery Bay

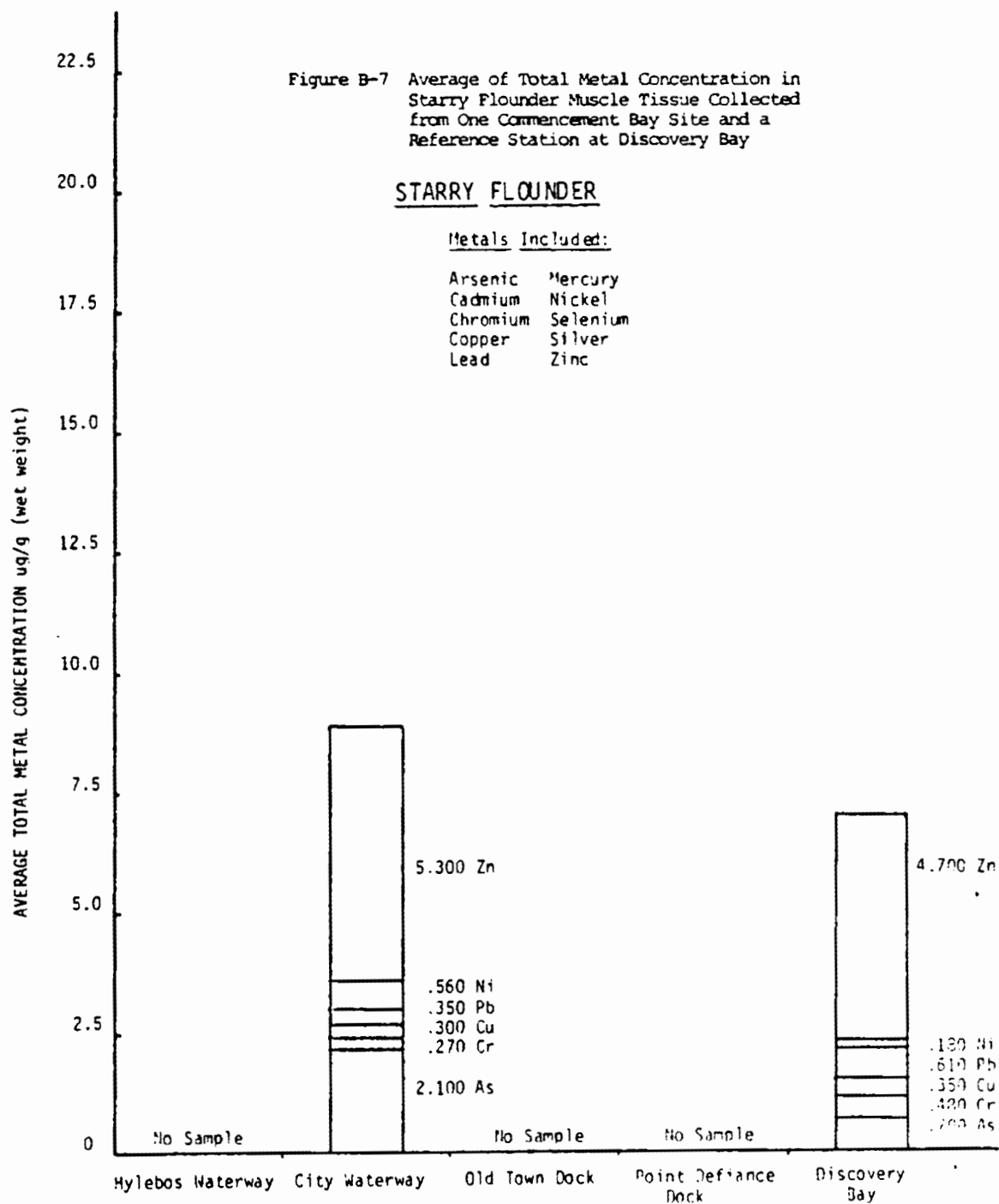


Figure B-9. Average of Total Metal Concentration in Pacific Staghorn Sculpin Muscle Tissue Collected from Three Commencement Bay Sites and a Reference Station at Discovery Bay

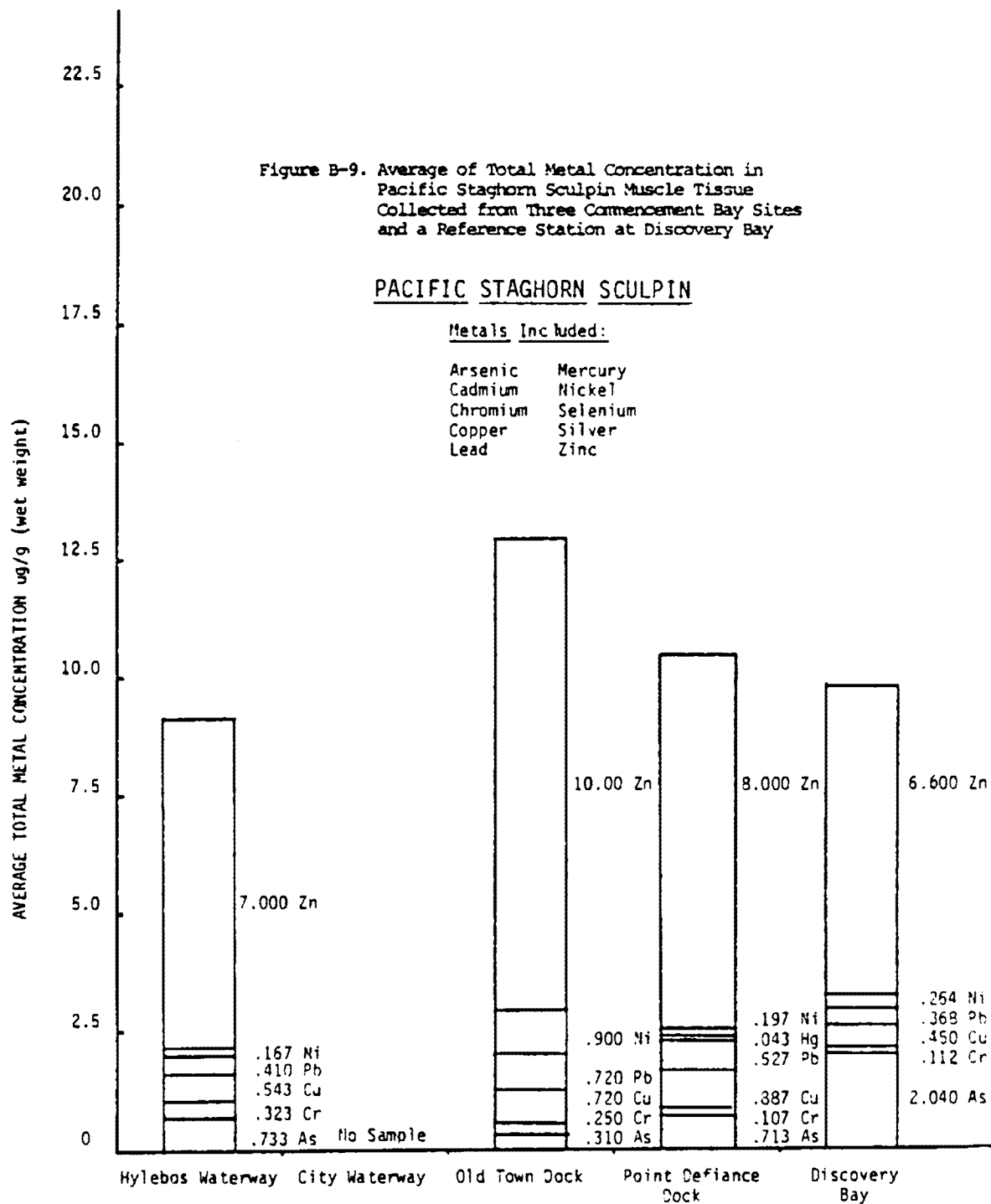
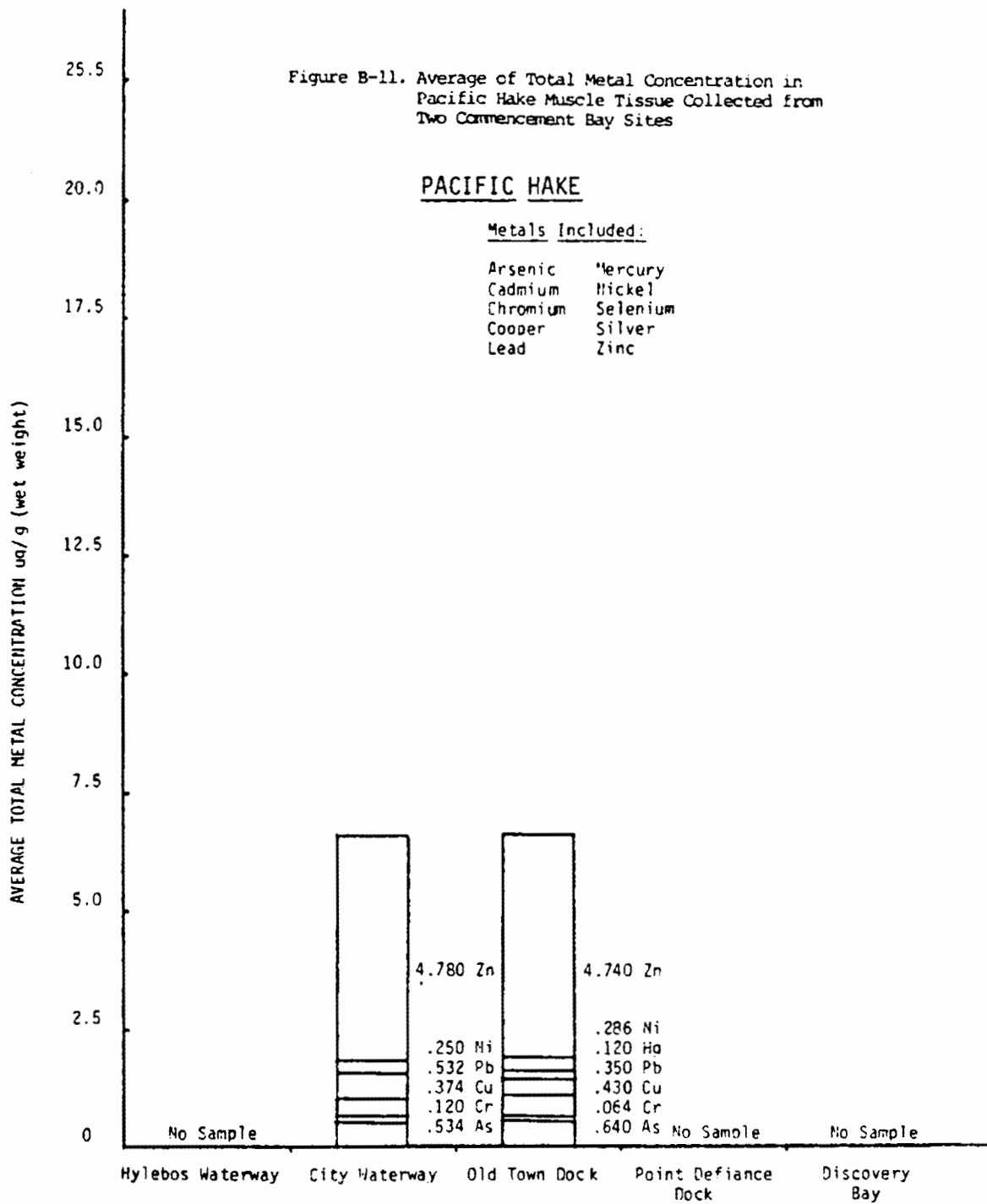


Figure B-11. Average of Total Metal Concentration in Pacific Hake Muscle Tissue Collected from Two Commencement Bay Sites



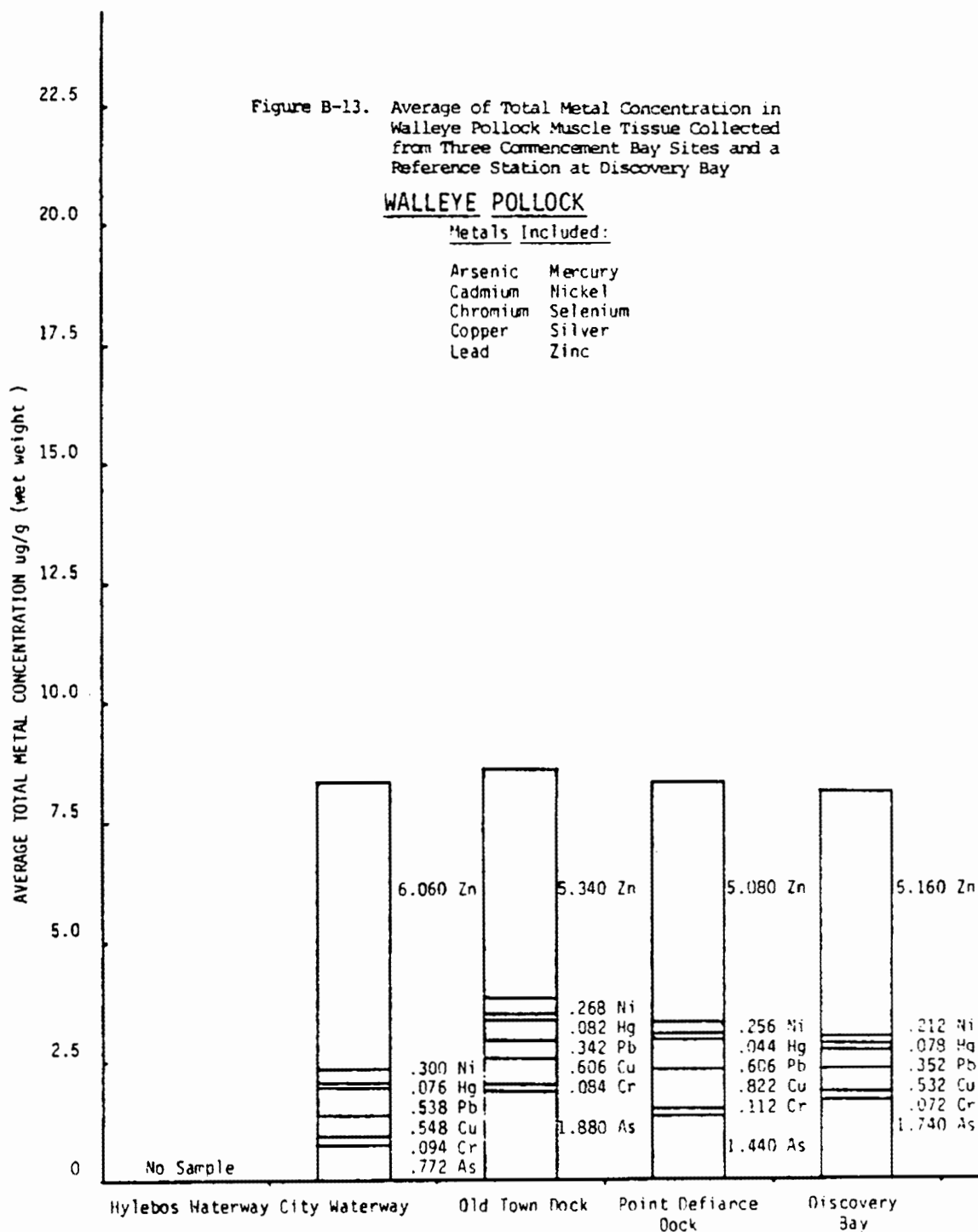


Table B-1.

Average Metal Concentrations Found in Fish Species Sampled in the Commencement Bay Area and a Reference Station at Discovery Bay ug/g wet weight

C-O SOLE	(N)	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Hylebos Waterway											
City Waterway											
Old Town Dock											
Point Defiance Dock (1)		37.8	0.006	0.18	0.44	0.65	0.02	0.50	0.06	0.006u	10.7
Discovery Bay											
ENGLISH SOLE	(N)										
Hylebos Waterway (5)		4.9	0.008	0.23	0.28	0.25	0.03	1.3	< 0.14	0.07u	5.1
City Waterway (5)		5.1	0.005u	0.31	0.32	0.32	0.04	0.65	0.07u	0.01u	5.5
Old Town Dock (3)		2.9	0.007	0.14	0.38	0.58	0.03	0.46	0.12	0.006u	5.9
Point Defiance Dock (3)		8.6	0.007	0.28	0.39	3.9	0.03	0.52	< 0.13	0.006u	6.5
Discovery Bay (5)		3.2	< 0.006	0.06	0.42	0.46	0.04	0.23	0.07u	0.01u	5.2
FLATHEAD SOLE	(N)										
Hylebos Waterway											
City Waterway (1)		1.0	0.005u	0.47	0.25	0.35	0.04	0.50	0.30u	0.007u	4.3
Old Town Dock											
Point Defiance Dock											
Discovery Bay (1)		5.3	0.004u	0.07	0.28	0.31	0.04	0.20	0.07u	0.01u	4.0

Table B-1. cont.

Average Metal Concentrations Found in Fish Species Sampled in the Commencement Bay Area and a Reference Station at Discovery Bay ug/g wet weight

PACIFIC STAGHORN SCULPIN (N)	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Hylebos Waterway (3)	0.73	0.021	0.32	0.54	0.41	0.02	0.17	0.08u	0.010u	7.0
City Waterway										
Old Town Dock (1)	0.31	0.012	0.25	0.72	0.72	0.03	0.90	0.12	0.006u	10.0
Point Defiance Dock (3)	0.71	0.004u	0.11	0.89	0.53	0.04	0.20	0.07u	0.007u	8.0
Discovery Bay (5)	2.0	< 0.004	0.11	0.45	0.37	0.03	0.26	0.07u	0.010u	6.6
ROCKFISH (N)										
Hylebos Waterway										
City Waterway										
Old Town Dock (1)	0.55	0.012	0.28	0.66	0.58	0.03	0.48	0.14	0.006u	9.8
Point Defiance Dock										
Discovery Bay										
WHITESPOTTED GREENLING (N)										
Hylebos Waterway (3)	0.71	0.010	0.49	0.42	0.31	0.17	0.18	0.08u	0.010u	8.3
City Waterway										
Old Town Dock										
Point Defiance Dock										
Discovery Bay										

Table B-1. cont.

Average Metal Concentrations Found in Fish and Crab Species Sampled in the Commencement Bay Area and a Reference Station at Discovery Bay ug/g wet weight

WALLEYE POLLOCK (N)	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc	
Hylebos Waterway											
City Waterway (5)	0.77	0.015	0.09	0.55	0.54	0.08	0.30	0.07u	0.010u	6.1	
Old Town Dock (5)	1.9	0.006	0.08	0.61	0.34	0.08	0.27	0.07u	0.010u	5.3	
Point Defiance Dock (5)	1.4	0.004u	0.11	0.82	0.61	0.04	0.26	0.07u	0.007u	5.1	
Discovery Bay (5)	1.7	<0.005	0.07	0.53	0.35	0.08	0.21	0.07u	0.010u	5.2	
DUNGENESS CRAB (N)											
Hylebos Waterway (2)	2.8	0.027	0.19	12.7	0.82	0.08	0.76	< 0.11	0.235	49.3	
City Waterway (2)	5.8	0.032	0.32	15.0	0.69	0.08	0.88	0.26	0.330	49.7	
Old Town Dock											
Point Defiance Dock											
Discovery Bay (2)	7.2	0.021	0.06	4.3	0.36	0.07	1.6	0.07u	0.195	52.6	

Table B-2 cont. Average Metal Concentrations Identified in Fish Muscle Tissue Sampled in the Commencement Bay Area and a Reference Station at Discovery Bay, ug/g wet weight

Station	Species	(N)	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
			Mean Range	Mean Range	Mean Range	Mean Range	Mean Range	Mean Range	Mean Range	Mean Range	Mean Range	Mean Range
Old Town Dock	Pacific Staghorn Sculpin	1	0.31 -	0.012 -	0.25 -	0.72 -	0.72 -	0.03 -	0.90 -	0.12 -	0.006u -	10.0 -
	Buffalo Sculpin	1	0.13 -	0.004 -	0.15 -	0.43 -	0.58 -	0.02 -	0.43 -	0.06u -	0.009 -	11.0 -
	Rock Sole	2	4.6 1.5-7.8	0.008 0.006-0.009	0.21 0.14-0.28	0.40 0.39-0.41	0.57 0.33-0.81	0.02 0.01-0.03	0.38 0.27-0.50	0.07u 0.06u-0.08u	0.008u 0.006u-0.01u	6.4 6.0-6.8
	Rockfish	1	0.55 -	0.012 -	0.28 -	0.66 -	0.58 -	0.03 -	0.48 -	0.14 -	0.006u -	9.8 -
	Pacific Cod	1	3.1 -	0.004 -	0.07 -	0.52 -	0.42 -	0.12 -	0.40 -	0.07u -	0.01u -	6.0 -
	English Sole	3	2.9 2.1-3.4	0.007 0.006-0.008	0.14 0.13-0.15	0.38 0.35-0.40	0.58 0.49-0.69	0.03 0.02-0.04	0.46 0.44-0.48	0.12 0.09-0.15	0.006u -	5.9 5.5-6.3
	Walleye Pollock	5	1.9 1.1-3.4	0.006 0.004-0.006	0.08 0.07-0.12	0.61 0.41-0.81	0.34 0.31-0.42	0.08 0.04-0.12	0.27 0.17-0.37	0.07u -	0.01u -	5.3 4.7-6.0
	Pacific Hake	5	0.64 0.50-0.90	0.006 0.004-0.016	0.06 0.05-0.08	0.43 0.33-0.67	0.35 0.31-0.39	0.01 0.07-0.13	0.29 0.17-0.40	0.07u -	0.01u -	4.7 4.0-5.7
City Waterway	English Sole	5	5.1 2.8-8.6	0.005u -	0.31 0.20-0.64	0.32 0.26-0.50	0.32 0.20-0.45	0.04 0.01-0.09	0.65 0.48-1.2	0.07u -	0.01u -	5.5 4.3-7.7
	Starry Flounder	1	2.1 -	0.005u -	0.27 -	0.30 -	0.35 -	0.04 -	0.56 -	0.30u -	0.007u -	5.3 -
	Walleye Pollock	5	0.77 0.43-0.97	0.015 0.013-0.016	0.09 0.07-0.12	0.55 0.44-0.71	0.54 0.42-0.68	0.08 0.06-0.09	0.30 0.15-0.40	0.07u -	0.01u -	6.1 5.3-6.7
	Pacific Cod	2	1.8 1.8-1.9	0.014 0.013-0.016	0.12 0.07-0.16	0.32 0.29-0.35	0.38 0.33-0.42	0.04 0.04-0.05	0.26 0.25-0.28	0.07u -	0.01u -	5.2 5.0-5.3
	Pacific Tomcod	3	0.70 0.30-1.3	0.013 0.006-0.019	0.19 0.12-0.27	0.46 0.36-0.54	0.50 0.45-0.55	0.03 0.02-0.05	0.31 0.25-0.41	< 0.07 0.06-0.07u	0.009u 0.006u-0.01u	5.3 5.0-5.5
	Flathead Sole	1	1.0 -	0.005u -	0.47 -	0.25 -	0.35 -	0.04 -	0.50 -	0.30u -	0.007u -	4.3 -
	Pacific Hake	5	0.53 0.33-0.90	0.012 0.011-0.013	0.12 0.06-0.23	0.37 0.27-0.53	0.53 0.36-0.78	0.07 0.02-0.13	0.25 0.15-0.30	0.07u -	0.01u -	4.8 4.3-5.3

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[illegible]

Table B-3. cont.
Metal Concentrations Found in Fish Muscle Tissue Sampled at the Point Defiance Dock, ug/g wet weight

Lab. No.	Species	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
28000	Rock Sole	.07u	2.5	.003	.006	.28	.40	.45	.05	.36	.25	.006u	.05u	8.8
29000	Rock Sole	.07u	11.9	.003	.008	.24	.47	.45	.03	.60	.18	.006u	.05u	8.8
29001	Rock Sole	.07u	34.1	.003	.008	.20	.35	.55	.02	.50	.29	.006u	.03u	9.8
29002	English Sole	.07u	14.6	.003	.012	.20	.49	.72	.03	.43	.17	.006u	.03u	7.0
29003	English Sole	.07u	3.2	.003	.004	.22	.42	10.4	.03	.40	.17	.006u	.03u	7.3
38027	English Sole	.07u	7.9	.003	.004	.41	.27	.67	.02	.73	.06u	.007u	.04u	5.3
29004	C-O Sole	.07u	37.8	.003	.006	.18	.44	.65	.02	.50	.06	.006u	.03u	10.7
38028	Buffalo Sculpin	.07u	3.6	.005u	.005u	.19	.37	.40	.02	1.0	.06u	.007u	.04u	10.7
01000	Walleye Pollock	.07u	2.2	.004u	.004u	.14	.71	.53	.08	.25	.07u	.007u	.04u	4.7
01001	Walleye Pollock	.06u	1.4	.004u	.004u	.11	.85	.61	.02	.40	.07u	.007u	.04u	4.7
01002	Walleye Pollock	.06u	1.9	.004u	.004u	.08	.85	.63	.02	.22	.07u	.007u	.04u	4.7
01003	Walleye Pollock	.06u	1.3	.004u	.004u	.11	.85	.63	.02	.19	.07u	.007u	.04u	5.3
01005	Walleye Pollock	.06u	.40	.004u	.004u	.12	.85	.63	.08	.22	.07u	.007u	.04u	6.0
01004	Pacific Staghorn Sculpin	.06u	.87	.004u	.004u	.12	1.2	.67	.03	.22	.07u	.007u	.04u	8.3
01006	Pacific Staghorn Sculpin	.06u	.67	.004u	.004u	.12	.66	.42	.03	.12	.07u	.007u	.04u	8.7
01007	Pacific Staghorn Sculpin	.06u	.60	.004u	.004u	.08	.80	.49	.07	.25	.07u	.007u	.04u	7.0

Table 8-3. cont.
Metal Concentrations Found in Fish Muscle Tissue Sampled at Discovery Bay, ug/g wet weight

Lab. No.	Species	Sb	As	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Tl	Zn
40000	Starry Flounder	.07u	.70	.005u	.013	.48	.35	.61	.05	.18	.17	.007u	.04u	4.7
48005	Flathead Sole	.07u	5.3	.005u	.004u	.07	.28	.31	.04	.20	.07u	.01u	.04u	4.0
48014	Pacific Staghorn Sculpin	.07u	2.8	.005u	.004	.12	.52	.27	.02	.30	.07u	.01u	.04u	6.7
48015	Pacific Staghorn Sculpin	.07u	1.7	.005u	.006	.12	.44	.45	.04	.30	.07u	.01u	.04u	6.7
48016	Pacific Staghorn Sculpin	.07u	1.7	.005u	.004u	.09	.33	.42	.04	.23	.07u	.01u	.04u	5.0
48017	Pacific Staghorn Sculpin	.07u	3.1	.005u	.004u	.14	.48	.39	.04	.36	.07u	.01u	.04u	7.3
48018	Pacific Staghorn Sculpin	.07u	.9	.005u	.004	.09	.48	.31	.02	.13	.07u	.01u	.04u	7.3
48019	Pacific Tomcod	.07u	3.4	.005u	.006	.08	.40	.42	.04	.13	.07u	.01u	.04u	5.0
48000	English Sole	.07u	2.3	.005u	.006	.07	.40	.49	.04	.20	.07u	.01u	.04u	5.3
48001	English Sole	.07u	2.1	.005u	.006	.05	.44	.61	.05	.26	.07u	.01u	.04u	7.0
48002	English Sole	.07u	4.1	.005u	.004u	.05	.40	.46	.02	.33	.07u	.01u	.04u	4.3
48003	English Sole	.07u	3.6	.005u	.008	.07	.44	.31	.05	.17	.07u	.01u	.04u	4.7
48004	English Sole	.07u	4.0	.005u	.004u	.07	.40	.45	.04	.17	.07u	.01u	.04u	4.7
48007	Walleye Pollock	.07u	.9	.005u	.004u	.12	.93	.31	.03	.26	.07u	.01u	.04u	4.7
48008	Walleye Pollock	.07u	1.3	.005u	.006	.05	.33	.31	.09	.17	.07u	.01u	.04u	4.7
48010	Walleye Pollock	.07u	.9	.005u	.004	.05	.48	.39	.11	.17	.07u	.01u	.04u	4.7
48012	Walleye Pollock	.07u	4.1	.005u	.004u	.07	.59	.33	.08	.23	.07u	.01u	.04u	6.7
48013	Walleye Pollock	.07u	1.5	.005u	.006	.07	.33	.42	.08	.23	.07u	.01u	.04u	5.0

APPENDIX C.

Comparison of Organic Compounds Among Fish Species and Sampling Sites

NOTE: "m" indicates that a concentration falls between the detection level and the quantitation level for that compound

" < " denotes that quantifiable concentrations have been averaged together with "m" concentrations

For more information concerning detection limits see Appendix F page 115.

Table C-1. The Average Concentrations of Priority Pollutant Organics Identified in Fish Muscle Tissues
 Sampled at Four Commencement Bay Sites and a Reference Station at Discovery Bay
 * = ug/kg wet weight ** = ug/g wet weight

Compound	Point Defiance Dock					City Waterway					Old Town Dock					Hylebos Waterway					Discovery Bay				
	Nd/Na	\bar{X}	B	M	O	Nd/Na	\bar{X}	B	M	O	Nd/Na	\bar{X}	B	M	O	Nd/Na	\bar{X}	B	M	O	Nd/Na	\bar{X}	B	M	O
hexachlorobenzene *																4/9	<48.25	3	1	0					
isophorone *											1/12	920m	0	1	0										
naphthalene*						1/11	510	1	0	0															
n-nitrosodiphenylamine *											1/12	64	0	0	1										
bis(2-ethylhexyl) phthalate*	6/10	281	5	1	0	6/11	111.67	6	0	0	7/12	122.14	1	2	4	6/9	62.67	2	4	0	2/5	125	2	0	0
butylbenzyl phthalate *	2/10	385	1	1	0											2/9	54.5	0	2	0					
di-n-butyl phthalate *	2/10	595	1	1	0	5/11	598	5	0	0	5/12	342.4	1	0	4	6/9	266.7	3	3	0	2/5	120	2	0	0
diethyl phthalate *	6/10	87.5	5	0	1	8/11	< 33.38	7	0	1	10/12	67.9	4	3	3	7/9	35.29	5	2	0	2/5	<54	2	0	0
dimethyl phthalate *																					1/5	8	1	0	0
phenol *	2/10	141.5	0	0	2	3/11	22.67	0	0	3															
1,1,1-trichloroethane **	2/16	0.04	0	1	1																				
1,2-trans-dichloroethylene **						2/22	0.01m	0	0	2															
ethyl benzene **						1/22	0.01m	0	0	1	1/19	0.01m	1	0	0										
methylene chloride **	8/16	0.48	0	3	5	2/22	0.18	0	0	2	3/19	0.53	0	0	3						1/18	0.1	0	0	1
tetrachloroethylene **																7/11	<0.033	4	3	0					
toluene **	1/16	0.03	0	0	1																1/18	0.01m	1	0	0
trichloroethylene **																6/11	<0.043	4	2	0					

(Nd/Na)= No. Fish with Detectible Values over No. Fish Analyzed (B)=Bottom Fishes (M)=Mixed Fishes (O)=Off-Bottom Fishes

Table C-2. cont.
Concentrations of Priority
Pollutants Found in Fish
Muscle Tissue Sampled at:

City Waterway

Lab. No.	sp. Code	Base Neutral Extractables	hexachlorobenzene *	isophorone *	naphthalene*	n-nitrosodiphenylamine *	bis(2-ethylhexyl) phthalate *	butylbenzyl phthalate *	di-n-butyl phthalate *	diethyl phthalate *	dimethyl phthalate *	Acid Extractables	phenol *	Volatiles	1,1,1- trichloroethane**	1,2- trans-dichloroethylene**	ethylbenzene**	methylene chloride**	tetrachloroethylene**	toluene**	trichloroethylene**
29005	(12)		0	0	0	0	0	0	0	0	0		0								
46051	(12)		0	0	0	0	0	0	0	0	0		0								
46052	(12)		0	0	0	0	0	0	0	0	0		0			0.01m	0.01m				
38022	(5)						160		580	35											
46050	(10)		0	0	0	0	0	0	0	0	0		0								
46058	(10)		0	0	0	0	0	0	0	0	0		0								
38026	(3)								430	30											
36050	(2)						170		580	45											
38021	(2)						180		700	50											
38023	(2)						60			30											
38024	(2)						80		700	35											
38025	(2)				510		20			25											
46053	(13)		0	0	0	0	0	0	0	0	0		0								
46054	(13)												35					0.3			
46055	(13)		0	0	0	0	0	0	0	0	0		0								
46056	(13)		0	0	0	0	0	0	0	0	0		0			0.01m		0.07			
46057	(13)																				
46059	(11)												21								
46060	(11)		0	0	0	0	0	0	0	0	0		0								
46061	(11)									17m			12								
46062	(11)		0	0	0	0	0	0	0	0	0		0								
46063	(11)		0	0	0	0	0	0	0	0	0		0								

(2)= English Sole , (3)= Flathead Sole , (5)= Starry Flounder , (10)= Pacific Cod , (11)= Pacific Hake , (12)= Pacific Tomcod , (13)= Walleye Pollock

Table C-2. cont.
Concentrations of Priority
Pollutants Found in Fish
Muscle Tissue Sampled at:

Point Defiance Dock

[illegible]

(1)= C-O Sole, (2)= English Sole, (4)= Rock Sole, (6)= Buffalo Sculpin, (7)= Pacific Staghorn Sculpin, (13)= Walleye Pollock

Table C-2A.

Concentrations of Priority
Pollutants in Dungeness
Crab Muscle Tissue Sampled
at the Hylebos and City
Waterways and Discovery
Bay

[illegible]

Lab Number

[illegible]

Table C-3.
cont.
Old Town Dock

Lab. Number	butenoic acid, 2-methyl, methyl ester	butanoic acid, 2-methyl, methyl ester	butanoic acid, ethyl ester	pentenoic acid, methyl ester	2-pentanoic acid, methyl ester	hexanoic acid, methyl ester	hexanedioic acid, dihexyl ester	2-piperidine-carboxylic acid, 1-acetyl, ethyl ester	furan, 2-pentyl-	2(5H)-furanone, 5-ethyl-	acetone	2-butanone	2-pentanone	2-pentanone, 3-methyl-	2-pentanone, 4-methyl-	3-pentanone, 2,4-dimethyl-	3-hexanone	3-hexen-2-one	heptanone	2 heptanone	propanal, 2-methyl-	butanal	butanal, 2-methyl-	butanal, 3-methyl-
28001																								
28002																								
29007																								
29006																								
44006			0					0	0	0						0		0						
29008																								
29009																								
29040																								
49075			0				0	0	0	0						0		0						
49076			0				0	0	0	0						0		0						
49077			0				0	0	0	0						0		0						
49078																								
49079																								
49080																								
49081																								
49082			0				0	0	0	0						0		0						
49083																								
49084			0				0	0	0	0						0		0						
49085			0				0	0	0	0						0		0						

Table C-3. cont.
Non-Priority Pollutant Organic
Compounds Tentatively Identified
in Fish Muscle Tissue Sampled at:

Lab. Number	Species	Point Defiance Dock	trimethylamine	propanamine	benzaldehyde	benzeneethanol	1,3-benzodioxol-one, hexahydro,-trans- benzoic acid, methyl ester	benzene, (1-methylethyl)-	benzene, 1,2-dimethyl-	benzene, 1,3-dimethyl	benzene, 1,2,3-trimethyl-	benzene, ethyl-	benzene, 1-ethyl-2- methyl-	benzene, 1-ethyl-4-methyl	benzene, 1-ethyl-4- (1-methylethyl)-	benzene, 1,2-diethyl-	benzene, 1,3-diethyl-	benzene, 1,4-diethyl-	benzene, ethenyl-	benzene, 1-ethenyl-3- ethyl-	benzene, 1-ethenyl-4- ethyl-
28000	Rock Sole																				
29000	" "																				
29001	" "																				
29002	English Sole																				
29003	" "																				
38027	" "																				
29004	C-O Sole																				
38028	Buffalo Sculpin																				
01000	Walleye Pollock		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01001	" "		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01002	" "		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01003	" "																				
01005	" "																				
01004	Pac. Stag. Sculpin		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01006	" " "		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01007	" " "		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Compound Detected



Compound Not Detected



Base Neutral or Acid Extractable Compound Not Determined

Lab. Number	Point Defiance Dock	Table C-3, cont.
28000		ethane,1,1,2-trichloro-
29000		1,2,2-trifluoro-
29001		ethane,1,1,2,2-tetrachloro-
29002		hexane,2,4,4-trimethyl-
29003		ethanol,2-(2-ethoxyethoxy)-
38027		cyclohexene,3-(bromoethyl)-
29004		2-cyclohexen-1-ol
38028		2-cyclohexen-1-one
01000	0	1,4-hexadiene,3-ethyl-
01001	0	2H-pyran-2-one
01002	0	2H-pyran-2-carboxaldehyde,5,6-dihydro-
01003		dimethyl, disulfide
01005		ethanethiol
01004	0	pyrazine,2,5-dimethyl-
01006	0	
01007	0	

Table C-3.
cont.

Discovery Bay

[illegible]

Table D-1. Collection and Biological Data for Fish and Crab Specimens Taken in Commencement and Discovery Bays.

E.P.A. Lab. No.	Station	Date of Collection	Time of Collection	Method of Collection	Species	Sex	Fork Length (mm)	Total Weight (g)	Total Fillet Weight (g)	Liver Weight (g)	Estimated Age (yrs)	Remarks
28000	Point Defiance Dock	7/15/81	1135	Hook + Line	Rock Sole <u>Lepidopsetta bilineata</u>	F	372	549.90	128.84	5.56	9	Posterior margin of caudal fin eroded.
28001	Old Town Dock	7/16/81	1840	Hook + Line	Rockfish sp. <u>Sebastes</u> sp.	F	195	136.64	33.77	3.08	3	
28002	Old Town Dock	7/16/81	1945	Hook + Line	Pac. Stag. Sculpin <u>Leptocottus armatus</u>	F	224	167.38	34.75	6.64	4	
29000	Point Defiance Dock	7/20/81	1230	Trawl	Rock Sole	M	198	76.02	23.91	1.00	4	Lesion on caudal peduncle, bleeding with opaque area surrounding it (blind side)
29001	Point Defiance Dock	7/20/81	1230	Trawl	Rock Sole	F	195	101.32	32.43	0.91	3	Blind side with bloodworms.
29002	Point Defiance Dock	7/20/81	1230	Trawl	English Sole <u>Parophrys vetulus</u>	M	280	162.03	43.73	2.71	4	Eyed and blind sides with embedded bloodworms.
29003	Point Defiance Dock	7/20/81	1230	Trawl	English Sole	F	234	113.41	30.30	2.52	4	Blind side with embedded bloodworms.
29004	Point Defiance Dock	7/20/81	1230	Trawl	C-O Sole <u>Pleuronichthys coenosus</u>	M	187	82.11	28.74	1.23	2	
29005	City Waterway (Totem Marina)	7/24/81	1145	Hook + Line	Pacific Tomcod <u>Microgadus proximus</u>	F	179	46.21	12.88	0.54	2	
29006	Old Town Dock	7/24/81	1015	Trawl	Rock Sole	M	226	151.17	49.60	3.36	3	
29007	Old Town Dock	7/24/81	1015	Trawl	Buffalo Sculpin <u>Enophrys bison</u>	F	285	615.75	65.97	22.46	-	Part of left maxillary appeared torn away

Table D-1.cont. Collection and Biological Data for Fish and Crab Specimens Taken in Commencement and Discovery Bays.

E.P.A. Lab. No.	Station	Date of Collection	Time of Collection	Method of Collection	Species	Sex	Fork Length (mm)	Total Weight (g)	Total Fillet Weight (g)	Liver Weight (g)	Estimated Age (yrs)	Remarks
36059	Hylebos Waterway	9/10/81	1430	Trawl	Dungeness Crab	F	140	376.45	59.01	-	-	Appearance good. Frozen before processing.
38020	City Waterway (Totem Marina)	9/23/81	1100	Trawl	Dungeness Crab	M	178	778.50	-	-	-	Appearance good. Small "scar" on left posterior portion of carapace.
38021	City Waterway (Totem Marina)	9/23/81	1100	Trawl	English Sole	M	263	148.70	36.43	2.60	6	Liver dark pink/purple.
38022	City Waterway (Totem Marina)	9/23/81	1130	Trawl	Starry Flounder <u>Platichthys stellatus</u>	M	271	184.46	53.8	2.96	5	Apparent hemorrhaging along dorsal, ventral and caudal fins. Liver yellowish/rust with purple veins.
38023	City Waterway (Totem Marina)	9/23/81	1130	Trawl	English Sole	M	261	159.90	51.96	3.82	3	Liver cream/pink.
38024	City Waterway (Totem Marina)	9/23/81	1130	Trawl	English Sole	M	281	160.23	47.41	2.10	3	Bloodworms embedded on blind sides. Liver cream/pink.
38025	City Waterway (Totem Marina)	9/23/81	1130	Trawl	English Sole	M	289	178.27	48.00	2.98	5	Blind side with red (raw) tinge. Liver yellow/brown.
38026	City Waterway (Totem Marina)	9/23/81	1130	Trawl	Flathead Sole <u>Plippoglossoides</u> <u>platessodon</u>	F	240	125.80	46.09	2.83	3	Blind side with raw-looking pink/red splotches. Liver light cream brown.
38027	Point Defiance Dock	9/23/81	1400	Trawl	English Sole	F	276	160.90	47.43	3.08	6	Some erosion of dorsal and ventral fin membranes. Liver brownish purple.
38028	Point Defiance Dock	9/23/81	1400	Trawl	Buffalo Sculpin	F	210	235.87	34.76	8.93	3	Liver yellow/orange
40000	Discovery Bay	10/6/81	1100	Trawl	Starry Flounder	F	471	1455.0	396.03	28.48	11	Several small lesions appearing red on blind side possibly associated with copepod parasites. Liver light yellow.
44000	Hylebos Waterway	11/5/81	1000- 1300	Hook + line	Whitespotted Greenling <u>Hexagrammos stelleri</u>	F	331	501.36	147.21	27.42	3	Stomach full of shrimp parts and one shrimp. Liver pink brown with surface white splotch-es

Table D-1. cont. Collection and Biological Data for Fish and Crab Specimens Taken in Commencement and Discovery Bays.

E.P.A. Lab. No.	Station	Date of Collection	Time of Collection	Method of Collection	Species	Sex	Fork Length (mm)	Total Weight (g)	Total Fillet Weight (g)	Liver Weight (g)	Estimated Age (yrs)	Remarks
46055	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Walleye Pollock	F	408	442.65	97.98	5.00	5	Caudal fin with flap of tissue above caudal peduncle. Upper lobe of caudal fin smaller. Open wound opposite flap. Liver thin, gray.
46056	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Walleye Pollock	F	389	381.29	92.68	11.24	4	Liver light gray.
46057	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Walleye Pollock	F	362	260.40	46.88	3.09	4	Upper lobe of caudal fin damaged. Liver purple/brown with a few coiled (worm) cyst-like structures on surface.
46058	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Cod	M	442	913.00	227.70	12.45	2	Liver light brown with pink splotches.
46059	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Hake <u>Merluccius productus</u>	F	486	529.75	136.08	31.14	-	Liver light beige with purple veins in places.
46060	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Hake	F	437	536.89	132.80	40.60	-	Liver light beige.
46061	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Hake	F	437	411.72	121.51	17.32	-	Liver light beige with pink tinged splotches. Coiled round- worms on liver.
46062	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Hake	F	420	454.91	75.52	11.03	-	Liver light beige with pink tinge.
46063	City Waterway (Totem Marina)	11/20/81	2030- 2330	Hook + Line	Pacific Hake	F	458	454.84	104.37	28.79	-	Liver light beige.
48006	Discovery Bay	12/1/81	1000	Trawl	English Sole	M	281	209.51	67.61	4.64	5	Blind side with red flecks. Liver gray/brown with gray/ white splotches.
48001	Discovery Bay	12/1/81	1000	Trawl	English Sole	M	314	240.42	56.89	4.21	-	Blind side with red flecks. Liver pink/beige.

Table 0-1. cont. Collection and Biological Data for Fish and Crab Specimens Taken in Commencement and Discovery Bays.

E.P.A. Lab. No.	Station	Date of Collection	Time of Collection	Method of Collection	Species	Sex	Fork Length (mm)	Total Weight (g)	Total Fillet Weight (g)	Liver Weight (g)	Estimated Age (yrs)	Remarks
48013	Discovery Bay	12/1/81	1000- 1230	Trawl	Walleye Pollock	F	437	677.28	180.64	50.37	4	Liver light pink/beige with coiled (worm-like) cysts on surface.
48014	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Staghorn Sculpin	M	285	390.45	73.83	8.63	3	Liver pink/beige.
48015	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Staghorn Sculpin	F	260	233.45	38.11	4.33	3	Liver pink/beige with scarlet edges.
48016	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Staghorn Sculpin	M	301	446.16	66.48	8.38	2	Liver pink/beige with scarlet edges and tint.
48017	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Staghorn Sculpin	F	313	413.17	63.29	6.98	4	Liver brown/pink.
48018	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Staghorn Sculpin	F	224	150.82	29.60	3.51	2	Liver pink/brown.
48019	Discovery Bay	12/1/81	1000- 1230	Trawl	Pacific Tomcod	-	200	72.71	19.18	2.14	3	Liver light gray/pink.
49075	Old Town Dock	12/10/81	2030- 2330	Hook + Line	Walleye Pollock	M	364	392.43	104.72	18.35	3	Liver pink/beige with red splotches. A few worm-like cysts on surface.
49076	Old Town Dock	12/10/81	2030- 2330	Hook + Line	Walleye Pollock	M	358	407.93	111.67	17.67	2	Liver light cream with red splotches. Some worm-like cysts on surface.
49077	Old Town Dock	12/10/81	2030- 2330	Hook + Line	Walleye Pollock	M	273	208.37	55.17	13.27	1	Liver pink/light beige.
49078	Old Town Dock	12/10/81	2030- 2330	Hook + Line	Walleye Pollock	M	272	171.58	48.30	5.81	2	Liver pink/beige.
49079	Old Town Dock	12/10/81	2030- 2330	Hook + Line	Walleye Pollock	F	397	595.49	181.08	30.05	7	Liver pink/beige.

Table 0-1.cont. Collection and Biological Data for Fish and Crab Specimens Taken in Commencement and Discovery Bays.

E.P.A. Lab. No.	Station	Date of Collection	Time of Collection	Method of Collection	Species	Sex	Fork Length (mm)	Total Weight (g)	Total Fillet Weight (g)	Liver Weight (g)	Estimated Age (yrs)	Remarks
01005	Point Defiance Dock	1/7/82	1930- 2130	Hook + Line	Walleye Pollock	F	402	378.19	82.58	4.09	5	Liver small, brown/beige with coiled worm-like cysts on surface.
01006	Point Defiance Dock	1/7/82	1930- 2130	Hook + Line	Pacific Staghorn Sculpin	F	264	236.92	43.35	6.67	-	Liver peach with red splotches.
01007	Point Defiance Dock	1/7/82	1930- 2130	Hook + Line	Pacific Staghorn Sculpin	F	277	279.14	57.85	10.23	2	Liver peach with red splotches.

ANALYTICAL METHODS

Organic Analysis

Tissue Extraction Procedure

Approximately 30 g of fish muscle tissue was placed in a 100-mL fluted Virtis extraction flask with acid/neutral (A/N) and pesticide surrogate spikes and 100 mL of methylene chloride/methanol (2:1) solution. The tissue was ground for 1 minute with a Brinkman Polytron homogenizer. After filtering through a Whatman #1 filter using a Buchner funnel pre-rinsed with methylene chloride (CH_2Cl_2), the tissue was returned to the Virtis flask and the procedure was repeated twice. The residue was discarded after the final filtration.

The filtrate was filtered again by gravity through another Whatman #1 filter into a Kuderna-Danish (KD) concentrator, the solvent volume was reduced on a steam bath using a Snyder column to approximately 10 mL or until foaming occurred and persisted. The organic concentrate was transferred to a 1-L separatory funnel containing 500 mL of 2% Na_2SO_4 solution, whose pH was adjusted to 2. After the contents were shaken for 1 minute, the CH_2Cl_2 layer was allowed to separate and then drained into a second 500-mL separatory funnel. The extraction of the aqueous portion in the large separatory funnel was repeated twice, with two 50-mL portions of CH_2Cl_2 , and the organic extracts combined in the 500-mL separatory funnel. The organic phase was washed twice with 25-mL portions of 2% Na_2SO_4 solution, pH adjusted to 2. Centrifugation was used, when necessary, to remove any emulsion. The aqueous portion was discarded.

The CH_2Cl_2 fraction was transferred to a KD flask fitted with a Snyder column, and the volume reduced to approximately 5 mL. The samples that were extracted prior to 3 December 1981 were evaporated to 4.0 mL with a nitrogen (N_2) evaporator and divided in half for A/N and pesticide analysis. Samples extracted after 3 December 1981 were reduced to 5.0 mL; 4.0-mL and 1.0-mL portions were taken for A/N and pesticide analysis, respectively.

Pesticide Extraction Procedure

Approximately 5 mL of hexane was added to the ampule containing the pesticide fraction. The ampule was then fitted with a micro-Snyder column and refluxed on a steam bath to remove the CH_2Cl_2 . A Florisil column was prepared, rinsed with petroleum ether, and the hexane extract was transferred to the top of it. Two hundred milliliters of pentane was passed through the column and collected. This fraction was used for the analysis of polychlorinated butadienes (PCBD's) and PCB's. Next, 200 mL each of the 6%, 15%, and 50% diethyl ether/pentane mixtures were passed through the column, collected and combined. The ether/pentane solvent was replaced by iso-octane by use of a N_2 evaporator, and the volume was reduced to 2.0 mL before injection.

Gas Chromatography/Mass Spectrometry Analysis---Volatile Organic Analysis (VOA)

Every sample was analyzed for VOA compounds. Approximately 1 g of finely sliced tissue was placed in a 40-mL screw cap vial and held at -12°C until ready for analysis. Just prior to purging, 10 mL of organic-free water containing the internal standards was added to the vial containing the thawed sample. The vial was connected to a Tekmar purge and trap instrument, heated in a 60°C water bath and sparged onto a trap containing 2/3 Tenax and 1/3 silica gel. The volatile compounds were desorbed at 180°C onto a 0.2% CW1500 stainless steel column (80-100 mesh, Carbopack C) held at 30°C. After desorption, the GC oven temperature was raised to 60°C and held for 2 minutes, and then programmed at 8°C/minute to 180°C and held for 19 minutes. The GC/MS used was a Finnigan 3100D with a Riber SADR data system.

APPENDIX F.

Quality Assurance

QUALITY ASSURANCE

The purpose of quality assurance in a laboratory is to ensure the reliability and validity of data generated and help maintain control of the quality of data. Through the use of quality control (QC) samples and procedures, a more definite evaluation of the precision and accuracy of a determination can be obtained. The variations in data can then be attributed to real differences among samples, and trends in the data can be identified better.

Organic Parameters

Quality assurance (QA) for the tissue samples was measured through the use of surrogate spiking compounds in both tissue and quality control (QC) samples. QC samples comprised 28% of all samples analyzed. Table F-1 summarizes the QC work.

Table F-1 Quality Control Samples Analyzed

Fraction	Tissue Samples Analyzed	Blanks	Duplicates	Spikes
Base-Neutral/ Acid	49	5	6	3
VOA	92	27	6	6
Pesticide/ CB/PCBD	83	5	8	-

Acid/Neutral Fraction

The compounds used for surrogate spikes for the A/N fraction were decafluorobiphenyl, 2-fluorophenol, and pentafluorophenol. The average recovery ($\bar{x} + \delta$) for the surrogate spikes for 63 samples was 10% \pm 24%, 37% \pm 23%, and 3% \pm 30%, respectively.

The average recovery for spiked acid and neutral compounds from three spiked samples, a total of 50 values, was 57% \pm 44%. Di-n-butylphthalate and bis (2-ethyl-hexyl) phthalate were present in all samples and blanks at low levels. All data were reported uncorrected. In the six duplicate samples for the A/N fraction, only one sample had any target compounds that were detected. Six compounds were detected in sample 36050, but their concentrations were below the limit of quantitation. Only one of the six compounds was detected in the duplicate.

DETECTION LIMITS

The limit of detection of a compound is defined as an analyte signal 3 standard deviations above the peak to peak noise level of the instrument in the region of the expected analyte peak. Any signal not exceeding this minimum response would be judged as not indicating the presence of the analyte. The limit of quantitation is defined as the analyte signal that is 10 standard deviations above the noise level of the instrument. Between these two limits is a region of detection in which a compound can be identified, but whose concentration is too low to allow an accurate estimate of its value (1).

The symbol "u" is used when the value preceding it is the quantitation limit for the particular substance. It means that the concentration, if any, falls below the detection limit. The symbol "m" indicates that the concentration of the substance falls between its detection limit and its quantitation limit. The symbol "<" is used in tables and bar graphs throughout the appendices, and is an artifact of averaging. When quantifiable values are averaged together with indeterminate "u" or "m" values the quotient is preceded by the "<" symbol.

The quantitation limits of all the target compounds and metals are listed in Table F-3 and F-4. The quantitation limits of the VOA compounds are generally lower than the A/N compounds because the purge and trap procedure eliminates many matrix problems.

Table F-3 cont.

Detection Limits of Organic Compounds Analyzed in
Commencement Bay Tissue *

		<u>VOA Compounds (ppb)</u>	
Acrolein	200.	Chloroethane	10.
Acrylonitrile	100.	Chloroform	10.
Benzene	10.	1,1-Dichloroethylene	10.
Carbon Tetrachloride	10.	1,2-trans-Dichloroethylene	10.
Chlorobenzene	10.	1,2-Dichloropropane	10.
1,2-dichloroethane	10.	cis-1,3-Dichloropropene	10.
1,1,1-Trichloroethane	10.	trans-1,3-Dichloropropene	10.
1,1-Dichloroethane	10.	Ethylbenzene	10.
1,1,2-Trichloroethane	10.	Methylene Chloride	10.
1,1,2,2-Tetrachloroethane	10.	Methyl Chloride	10.
		Methyl Bromide	10.
		Bromoform	10.
		Bromodichloromethane	10.
		Trichlorofluoromethane	10.
		Dibromochloromethane	10.
		Tetrachloroethylene	10.
		Toluene	10.
		Trichloroethylene	10.
		Vinyl Chloride	10.
		2-Chloroethyl Vinyl Ether	10.

*wet weight basis