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POTENTIAL TOXICANT EXPOSURE AMONG CONSUMERS OF RECREATIONALLY CAUGHT FISH FROM URBAN EMBAYMENTS OF PUGET SOUND

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PREFACE

This document reports the results of the first year of a two-year study of the potential exposure of recreational anglers to toxic chemicals through consumption of fish caught in bays near urban centers along Puget Sound. The objectives of the study are two-fold: 1) to determine the patterns of fish consumption; and 2) to determine the concentration and types of toxic chemicals in the fish consumed. Calculations of exposure or dose required that these two objectives be satisfied.

The study focuses on recreational anglers in the urban bays since they are likely to represent the greatest possibility of the greatest possible exposure to toxins through fish consumption. Next year, a final report will be prepared on the basis of additional and extensive chemical analyses of fish tissue samples. More thorough estimates of exposure will be included in that report; however estimates of risk will not be included. The Contracting Officer's Technical Representative from NOAA for this study was Edward R. Long.

POTENTIAL TOXICANT EXPOSURE AMONG CONSUMERS OF RECREATIONALLY CAUGHT FISH FROM URBAN EMBAYMENTS OF PUGET SOUND

by

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EXECUTIVE SUMMARY

The presence of organic and inorganic contaminants in fish and shellfish collected from urban embayments in Puget Sound, Washington, has resulted in growing public concern regarding the consumption of fish from these places. This study was conducted to produce a demographic characterization of the population of anglers fishing in these embayments and to determine contaminant levels in the edible portions of the most commonly caught species.

This report outlines the first-year findings of a two-year study of Puget Sound urban shoreside recreational anglers' fish catch and consumption. The overall objective of the study was to determine potential for exposure to contaminants through consumption of fish caught by recreational anglers. For this purpose we used two types of data: 1) estimates of catch and consumption on a daily basis of fish exposed to these toxins in their urban habitats, 2) an estimate of the concentration of selected organic and inorganic contaminants. This document reports the results of the first year of study in which consumption patterns were determined and limited chemical analyses were performed.

During the first year of the study, 4181 anglers were interviewed at four embayments: Commencement Bay, Elliott Bay, Sinclair Inlet, and Edmonds (Figure 1). The results show that daily fishing activity peaked between 6:00 p.m. and midnight at all locations. Fishing activity was greatest during the autumn. At Sinclair Inlet (Bremerton) anglers were fairly evenly distributed

among the age groups 3-16 years, 17-26 years, and 27-34 years. At the other embayments, anglers in the 27-34 year age-class were the most strongly represented. At all embayments the anglers were primarily Caucasian; the largest number of Asian anglers were encountered at Elliott Bay and Edmonds. Over 80% of all the anglers were born in the United States. Of the foreign-born anglers, the largest number were from Korea, the Philippines, and Southeast Asia.

The total catch of those anglers who permitted examination of their catch for all locations and over the course of the first year study was 7,933 organisms weighing a total of 4,013.6 kilograms. Squid, hake, tomcod, pollock, and Pacific cod were the species most commonly taken. Flatfish (all species of flounder and sole) constituted 5.8% (by numbers) and 2.5% (by weight) of the catch. Successful anglers caught 1 to 4 fish per trip weighing an average of 2 kilograms. Usually the catch was consumed by more than one person. Most people ate only fillets. Baking and frying were the most common methods of preparation.

Three trace metals and total PCB were measured in 43 individual fish muscle samples of four species; sablefish, squid, English sole, and Pacific cod (Figure 2). An additional 38 samples were analyzed for trace metals only. The highest concentration of PCB was found in Pacific cod and squid, and the highest arsenic concentration was found in squid and flatfish.

The estimated PCB dose per person per day taken, based upon observed mean catch and mean PCB values from tissue analysis were, sablefish, 1.98 ug; Pacific cod, 4.2 ug; squid, 6.0 ug; and English sole (overall), 0.78 ug. Similar estimates for mean trace metal doses (in micrograms) were, for the leading species: sablefish--arsenic 54.9, cadmium 0.06, lead 0.36; tomcod--arsenic 26.6, cadmium 0.05, lead 0.02; squid--arsenic 326, cadmium 2.1, lead 0.35; English sole--arsenic 71.8, cadmium 0.001, lead 0.2; and Pacific cod--arsenic 125.6, cadmium 0.25, lead 0.95.

These doses were calculated based on two sets of assumptions relative to consumption patterns and fishing interval:

Consumption

a) fish were cleaned, with the edible portion comprising about 49% of total animal weight for squid and crab and 30% for finfish;
b) catch was evenly distributed among eaters in the household;
c) these people actually ate the fish;
d) personal fish consumption was evenly distributed over the interval since the last successful trip.

Fishing Interval

Fishing frequency (days) was based on interview responses which tended to focus on a particular seasonal fishery. Thus the daily dose rates apply only to the period of time each species was present in the fishery (Appendix E), not to the entire year.

The second year's effort will focus on chemical analyses of tissue specimens caught during the first year. We also will attempt to assess the catch and consumption patterns of boating anglers. We do not expect to observe significant changes in either population demographics or catch levels, except that boaters, so far, appear somewhat more successful than shoreside anglers both economically and as anglers.

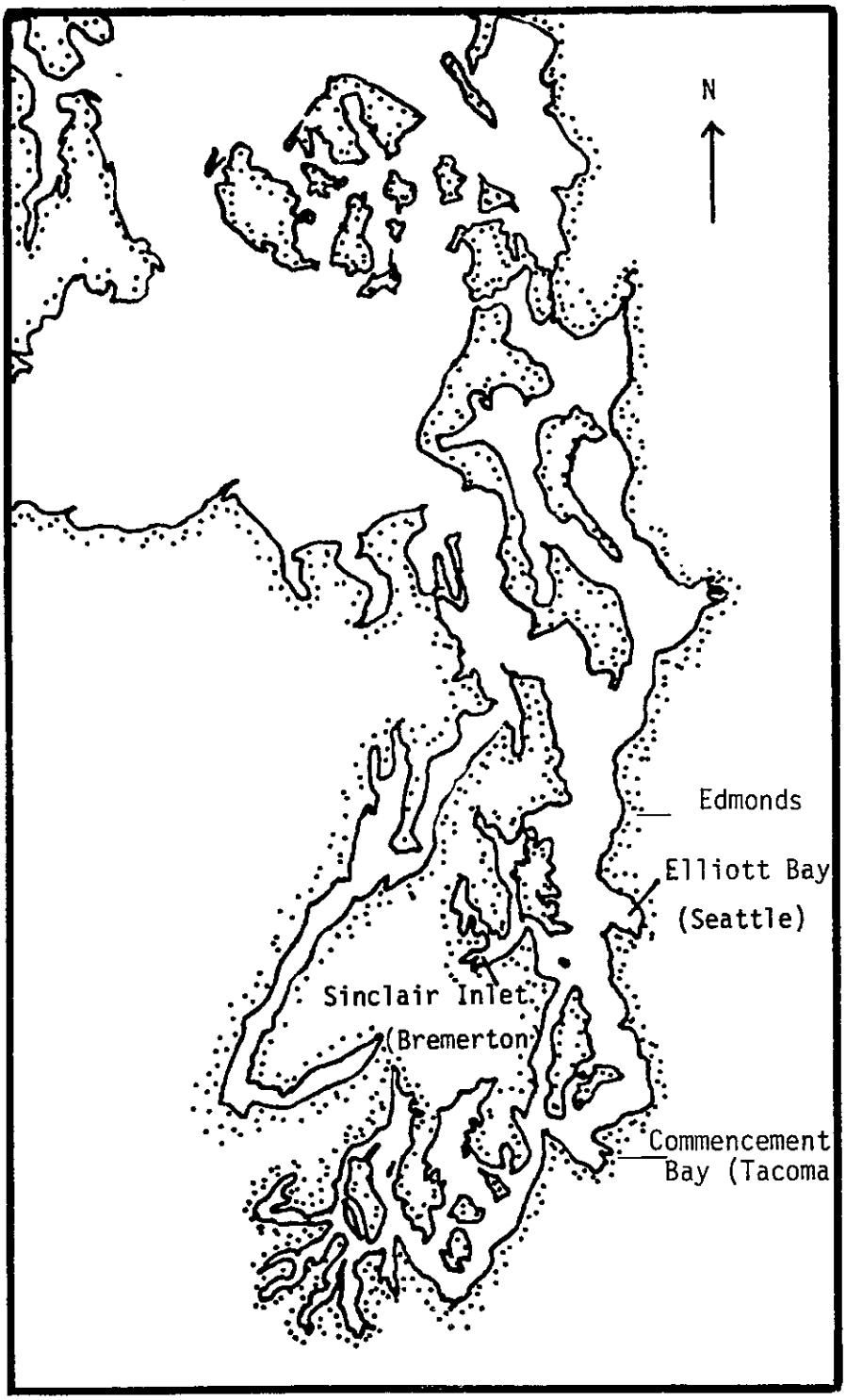


Figure 1. Location of study areas.

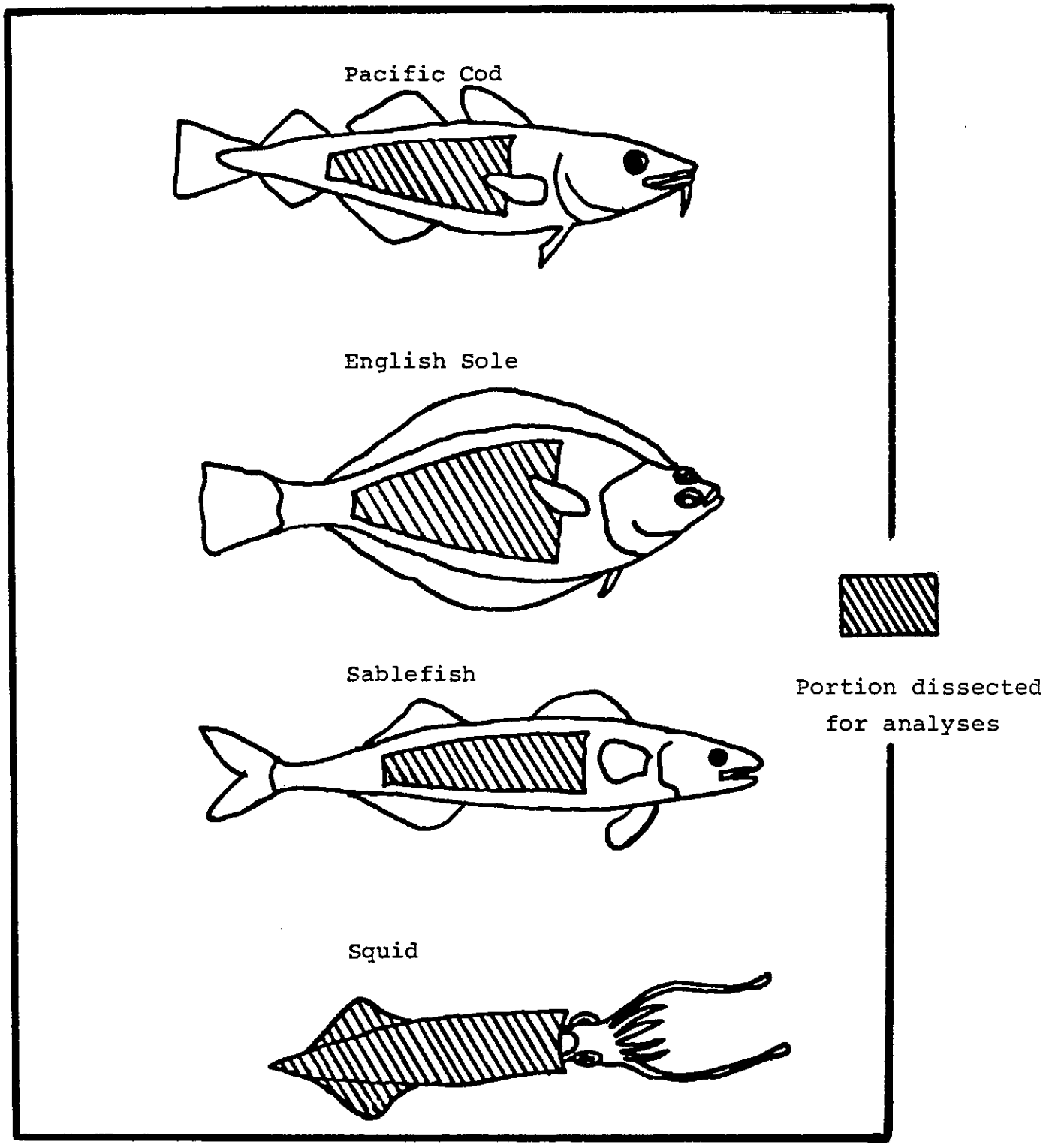


Figure 2. Specific parts of each species that were dissected for chemical analyses.

1. INTRODUCTION

Studies of trace metal and trace organic levels in Puget Sound sediments have shown that the concentrations of polychlorinated biphenyls (PCB), chlorinated pesticides and other chlorinated organic compounds, petroleum hydrocarbons, and some trace metals (e.g., arsenic, lead) are highest in two areas: Commencement Bay and Elliott Bay (Malins et al., 1982). The studies also report that high concentrations of these chemicals can be found in the tissues of some fish caught in these areas and that some of the fish inhabiting the bays have elevated incidences of various proliferative, neoplastic, and degenerative lesions (Malins et al., 1980; Dexter et al., 1981). In addition, newly acquired information indicates that top predators in Elliott and Commencement Bay areas (e.g. marine mammals and birds) have high levels of PCB in their tissue (Riley et al., 1983; Calambokidis et al., 1984). These areas, as well as other places near metropolitan areas of Puget Sound are heavily used for recreational fishing (Noviello, 1982); however, little quantitative information is available regarding consumption of tissues of these creatures by recreational anglers.

The overall objective of this study was to determine the potential for exposure of a certain group of anglers to contaminants that may be present in fish caught by recreational anglers. The contaminants selected for analysis (As, Cd, Pb, and PCB) were most frequently reported to be present in fish and shellfish from different areas of Puget Sound (Malins et al., 1982; Gahler et al., 1982). The specific objectives of this study were (1) to identify the species of fish (and selected shellfish) most commonly caught by anglers in urban areas of Puget Sound; (2) to identify demographically the population of anglers who catch those fish; (3) to characterize the fish consumption patterns of the anglers (i.e., fishing frequency, amount of fish consumed, tissues eaten, method of preparation); (4) to assess the concentration of principle contaminants in the various edible portions; (5) to estimate the quantity of selected chemicals consumed by anglers and their families; and (6) to attempt to document other possible routes of human exposure to Puget Sound contaminants. The study was designed as a two-year project, with the first year focusing primarily on the collection of demographic data and the second year primarily on the collection of chemical data. This report summarizes first year findings.

2. METHODS

2.A. Geographic Sites

This study focused on four urban embayments (Fig. 1) in Puget Sound, Washington:

a) Seattle (Elliott Bay)
b) Tacoma (Commencement Bay)
c) Bremerton (Sinclair Inlet)
d) Edmonds

These embayments are near or within the metropolitan areas of Puget Sound, have abundant bottom fish, and are used heavily by anglers. In terms

of contaminants present in sediment and biota, Commencement and Elliott Bays appear to be the worst cases, whereas Edmonds represents the least contaminated area among the four embayments.

The Elliott Bay region extended from Smith Cove to Duwamish Head; the major fishing areas that were surveyed included Piers 48,56,70, and 86, the Spokane Street Bridge, and the Armeni boat ramp in West Seattle. The Commencement Bay study area extended from Point Defiance to Dash Point where heaviest fishing pressure occurred at the Les Davis public fishing pier, with lighter fishing activity at Point Defiance, Old Tacoma, Brown's Point, and Dash Point. The Bremerton study area extended throughout Sinclair Inlet, from Retsil to the Port Washington Narrows; popular fishing areas included Annapolis, Port Orchard, the First Street dock (Bremerton), and Illahee State Park. The Edmonds study site extended from the Edmonds ferry dock to the Union 76 oil dock; most fishing occurs on the public fishing pier, with very little activity on either the ferry dock or the oil dock. Other sites (Everett, Mukilteo, Bellingham), assessed in September-October 1983, were found to have insufficient angling activity to justify their inclusion in this study.

2.B. Demographic Studies

Demographic studies of urban anglers were conducted over a 13-month period (November 1, 1983 - November 30, 1984) at each of the four urban embayments. Interviewers surveyed anglers and examined their catches. Because of public concerns in the Puget Sound area regarding possibly high fish consumption by certain demographic groups, we solicited data on race, education and employment status, which are included here. Specifically, the concern was that various recently arrived Asian immigrant groups known to include much fish in their diets might be using the local marine resource to supply a large proportion of their dietary protein. Education and employment data could show whether a particular economically deprived segment of society was predominant among urban embayment anglers, affording them an increased potential for exposure to toxins.

At the beginning of each interview period interviewers recorded the date, weather, and tidal conditions, and provided general comments about the degree and type of fishing activity (Appendix A). They then interviewed as many anglers as possible and recorded responses on a standardized form (Appendix B)

2.C. Selection and Training of Interviewers

All interviewers had completed at least the undergraduate fisheries programs at the University of Washington or elsewhere. Thus, they already were familiar with Puget Sound marine fishes. Interviewers were tested on ability to identify local marine fishes and also briefed on characteristic features of all resident species. Three training sessions for the interviewers were conducted in the first eight months of the study.

Meetings with interviewers, held at least monthly, provided continuous feedback on changes in fishing conditions, fishing activity, etc., which was

taken into account for the next month's field schedule. Survey and site description forms were turned in every 2-3 weeks. These forms were checked for uniformity and completeness before computer processing of data as a quality control for individual interviewers and to provide another form of feedback on fishing activity.

2.C.1. Scheduling of field interviews

After a trial period fieldwork schedules were set as determined based on feedback from interviewers. Initially, we scheduled 72 person-hours of field coverage per week (12 hours per location per week at Bremerton and Edmonds, 24 hours per location per week at Commencement and Elliott Bays). Most interviews were conducted by two people.

Elliott Bay was covered in two 6-hour shifts per week, later reduced to 4-hour shifts. We then worked three 4-hour shifts per week to account for temporal changes in fishing activity. Commencement Bay and Bremerton were covered twice weekly in 6-hour shifts, a schedule maintained throughout the study, largely because of the added travel time (about 1 hour) to and from each of these sites. Initially, Edmonds was surveyed in six 2-hour shifts per week. However, we found that 2 hours were insufficient to interview all anglers adequately; thus we changed to three 4-hour shifts per week. All of these schedule changes were instituted by late January 1984.

At the outset of the study, we employed a random approach to the scheduling of field surveys by day and hour (Tables 1, 2). Each week was divided into time blocks such as: 12:00-6:00 am, 6:00am -12:00 pm, 12:00-6:00 pm, and 6:00 pm - 12 am, for Sunday through Saturday (28 blocks per week), with 2-hour time blocks at Edmonds (84 per week). Time schedules for each site were generated from random number tables. We employed a stacked random approach, such that no time block was repeated until all others were used once. This approach was used to avoid presampling bias and to determine for ourselves when fishing activity was at a peak. In addition to the formal questions on the interview form, all anglers were asked if they decided to fish according to tidal cycle, time of day, day of the week, or by seasonal preference; these points were summarized on the Site Description Form (Appendix A). By mid-January 1984, we had enough indication of fishing preferences to abandon the random approach, and thereafter field schedules were designed according to expected maximum fishing activity (Tables 1 and 2).

2.C.2. The interview

All interviews were conducted shoreside, since we knew from previous information that less than 4% of anglers use boats. In most cases, anglers were interviewed only if they had been fishing at least one hour, unless they had already caught fish. After this one-hour period, anglers were surveyed regardless of fishing success. All interviews were strictly voluntary and anonymous. Interviewers wore specially marked caps and carried University of Washington identification cards to avoid being mistaken for state fisheries enforcement officials. We informed police, marina and bait shop operators of the aims of our study, and all agreed to handle questions from concerned

anglers. Although, some anglers were at first wary of our interviewers, the interviewers were quickly accepted by the fishing population. In spite of the large number of Asian immigrants among the anglers, language did not prove to be a serious barrier. In most cases with an apparent language barrier, the angler evidently feared that he/she was fishing illegally. In all cases, the interviewer assured the angler that our study was for the University of Washington School of Fisheries, with no interest in enforcing fisheries regulations.

The field survey form used in this study is shown in Appendix B. The interviewer noted the age, sex, and race of each angler, and the type of fish sought. When anglers were fishing as a group, one interview was conducted if the catch was being pooled in one bucket; if anglers separated their catch in individual buckets, anglers were interviewed individually. Anglers were asked how often they fished in the area, when they last caught and ate fish from that area, and what type(s) of fish were caught. City of residence, ethnic background, occupation, and educational background of the anglers were also determined in order to assess the concern that some ethnic groups rely heavily on a fish diet. A site description form (Appendix A) was completed for each location surveyed within a study site. This form summarized weather and tidal conditions, number and ethnic characteristics of groups of anglers, percentage of regular anglers, and most common target species.

All fish caught were identified to the species level using field guides by Hart (1973) and Somerton and Murray (1976). Fork length of each fish was measured in cm and recorded on the survey form. Squid length was measured from the anterior tip of the beak to the posterior tip of the mantle, excluding the tentacles. Crabs were measured by the maximum width of the carapace. Anglers were asked which species would be consumed, what body parts of those species would be consumed, and the mode of preparation for eating.

2.C.3. Interview data analysis

Angler interview data were entered into and analyzed on the Washington State Department of Social and Health Services, Epidemiology Laboratories, PRIME computer using SPSS Version 7.3 (Nie et al., 1975). Statistical tests employed chi-square with Yates' correction and F test of means, with alpha (two-tailed) = .05.

2.D. Chemical Analyses of Tissues

2.D.1. Sample collection

Fish samples were caught off the piers and other locations where interviews were conducted (for exact locations see Table 56). The fish were caught with hook and line by the interviewers, were obtained from anglers, or were collected by trawling and beach seining. To prevent contamination of the samples, collectors avoided excess handling and unnecessary contact of the fish with plastic bags, buckets, rags, docks, or fishing piers.

If the fish was caught by the interviewer, the catch was pulled out of the water, placed in a glass jar, the line was cut leaving the hook in, and the lid was put back on the jar. If the fish was caught by anglers, the interviewers would sample only those fish that were caught in their presence. As soon as the fish was pulled out of the water, it was unhooked and placed in a glass jar to avoid contact with the pier surface, the angler's bag, or bucket.

Some demersal fish were collected by a 7.3-m otter trawl at 50-m depth on board the Research Vessel Kittiwake. Nearshore specimens were collected by sinking (set 30 m from the shore) and floating (set 60 m from the shore) beach seines. Individual fish samples were hand picked from the nets and placed immediately in glass jars without touching the ship's deck or the beach.

In the field, the glass jars containing fish samples were kept cool on ice. Upon arrival in the laboratory, the jars were drained of excess water and placed in a freezer until dissection and analysis.

All the glass jars used as fish containers were precleaned in the laboratory with detergent and water, acid rinsed, rinsed with dichloromethane and dried at 200°C. The lids of the jars were sealed with a Teflon lining.

2.D.2. Sample preparation

At time of analysis, the samples were thawed in their original glass jars and then transferred to solvent-rinsed aluminum foil. After species identification, the weight (in grams) and total length (in millimeters) of the organism were recorded along with any other pertinent information.

The fish skin was cut with a solvent-rinsed scalpel blade and pulled back with forceps to expose the muscle tissue. To avoid contamination, a new scalpel blade and forceps were used to remove approximately 30 g of tissue. Since the specimens varied greatly in size and conformation, specific sites were chosen to be dissected for each species (Fig. 2). Approximately 10 g of muscle tissue were used for trace organic analysis, while two 2 g subsamples were obtained for trace metal analysis and for calculating the wet/dry ratio. All samples and subsamples were stored frozen in solvent-cleaned vials and jars with Teflon-lined lids. In some cases the liver was dissected and stored frozen in solvent-cleaned aluminum foil. All analyses were performed on uncooked samples.

2.D.3. PCB measurement

Sample preparation and analysis for PCB was a modification of standard NOAA procedures (Malins et al., 1980). The schematic of sample preparation is shown in Figure 3, and the details are as follows.

A 10 $\pm$ 0.5 g tissue sample was homogenized for about 20 seconds. One milliliter of the recovery standards, C18 naphthalene and o.p.-DDT (dissolved in methanol), were added. Fifty milliliters of dichloromethane/methanol (2/1 v/v) were added, and the sample was extracted for one minute at medium speed

using a Kinematica Polytron. The probe was washed with 2% sodium chloride in water in the 150-ml centrifuge tube and the sample was centrifuged for 10 minutes at 2,500 rpm. The aqueous and organic layers were decanted into a 250-ml separatory funnel, leaving the pellet in the centrifuge tube. Another 50 ml of dichloromethane/methanol (2/1 v/v) were added to 150-ml centrifuge tube containing the pellet. The sample was again extracted for one minute on the Polytron at medium speed, washing the probe, this time with dichloromethane/methanol (2/1). This mixture was centrifuged for 10 minutes at 2,500 rpm, and the liquid layer decanted into the separatory funnel containing the previous extracts.

Fifty milliliters of 2% sodium chloride in water were added to the 250-ml separatory funnel containing the extracts. The funnel was inverted and swirled gently for 2 minutes with frequent venting. The phases were allowed to separate, and the lower (dichloromethane) layer was drained into a second 250-ml separatory funnel. Ten milliliters of dichloromethane were added to the separatory funnel containing the aqueous layer. The funnel was then swirled for one minute with frequent venting. The layers were allowed to separate, and the lower (dichloromethane) layer was drained into the second separatory funnel containing the previous dichloromethane extract. One hundred milliliters of 2% sodium chloride in water were added to the separatory funnel containing the dichloromethane extracts. The funnel was inverted and swirled for 2 minutes with frequent venting, and then the layers were allowed to separate. The lower (dichloromethane) layer was drained into a dichloromethane-rinsed eight-ounce sample jar, and another 20 ml of dichloromethane were added to the separatory funnel. The funnel was swirled for one minute. The phases were allowed to separate, and then the lower (dichloromethane) phase was drained into the sample jar containing the previous extract. The jars were covered with Teflon-lined lids until Florisil cleanup.

2.D.4. Lipid determination

Ten percent of the extracted material was pipetted into a preweighed aluminum dish and allowed to evaporate 4-6 hrs at room temperature. The residue was then weighed and the percent lipid content of the sample was calculated. Approximately 2-3 grams of anhydrous sodium sulfate were added to the remaining extract material to remove any excess water or methanol. After 2 hours the extract was ready for Florisil cleanup.

2.D.5. Florisil cleanup

The remaining extracted material in dichloromethane/methanol (2/1 v/v) was transferred to a Kuderna-Danish concentrator and placed in a 75°C water bath. The solvent was then exchanged to hexane with the final volume being 10 ml. The column recovery standards, tetrachlorobiphenyl and decachlorobiphenyl, were added. A 10.5 mm ID x 250 mm column was washed thoroughly with dichloromethane, then hexane, plugged with glass wool, then filled with 4 g of activated Florisil and topped off with one 2.5 cm of anhydrous sodium sulfate. About 3.3-5.0 ml of the sample was applied to the column allowing the sample level to fall just below the sodium sulfate surface. Then, 20 ml of 10% ethyl

ether in petroleum ether were added and allowed to elute through the columm. The eluate was collected in a scintillation vial and allowed to evaporate until dry. This fraction contained all the PCBs. The column was then eluted with 20 ml of dichloromethane which was collected in a scintillation vial and stored for future analysis. Twenty milliliters of methanol were finally added, eluted, and also stored for further analysis. After drying, one milliliter of hexane was added to the scintillation vial containing the PCB fraction. At this stage the sample was ready for analysis.

2.D.6. Gas chromatography analysis

Before analysis, a known amount of decafluorobenzophenone was added to each sample to serve as an internal standard. The samples were loaded on a Hewlett-Packard 7677A auto sampler, and the analysis was performed using a splitless injector on a Hewlett-Packard 5880A gas chromatograph. A J&W Scientific DB-5 fused silica capillary column, 30 m x 0.25 mm ID was employed with hydrogen as the carrier gas and 95% argon-methane as the make-up gas. The detector temperature was set at 330°C, and the injector at 250°C. The initial oven temperature was 30°C; after one minute the temperature increased at a rate of 15°C/min until it reached 150°C; then the rate decreased to 4°C/min until the final value of 300°C was obtained.

A Ni-63 electron capture detector was used, while the chromatographs were plotted on a Hewlett-Packard 5880A GC terminal Level-Four integrator.

2.D.7. Method of quantification

Standards of Aroclor mixtures 1248, 1254, and 1260 were run in duplicate at five different concentrations (Figs. 4-6). Standard curves were drawn by plotting the amount of the PCB Aroclor versus the summation of the area units corresponding to selected major peaks (Fig. 7). Sixteen PCB isomer standards were run at three different concentrations and standard curves were obtained for each compound. As an example, the response curves of 2,3,3',4',6 pentachlorobiphenyl and decafluorobenzophenone are shown in Figure 8 and 9 respectively. The retention times of each compound were identified making quantification possible for their concentration in standards and samples. Fifty peaks were chosen to be used for quantification including the 16 known isomer compounds. When sample retention times were within $\pm$ 0.03 minutes of a reference peak, the compound was categorized as a PCB. When it appeared that the retention times of the internal standard and the recovery compounds had shifted by a uniform amount, the difference in time was corrected for all the remaining peaks of the chromatogram.

The initial estimates of the total amount of PCB present in the fish tissue were done using the assumption that the ratio of Aroclor mixtures was 1:2:6 for Aroclor 1248, 1254, and 1260, respectively, in all samples.

2.D.8. Estimating Aroclor ratios

By comparing the chromatographs from each of the four fish species analyzed (squid, sole, cod, and sablefish, see Fig. 10), with chromatographs

of Aroclors 1248, 1254, and 1260 standards, a general trend of interspecies distribution of Aroclor mixtures could be estimated.

The estimated Aroclor ratio was obtained by looking at the standards of the three Aroclor mixtures at equal concentration and calculating the area units of peaks shared by two or more Aroclors (Table 3). A percent contribution from each Aroclor was then determined for each shared peak. Thus, for a given peak, it is either all from one Aroclor, or it is present as a percentage of the different Aroclor mixtures. Adding together the portion of each Aroclor in the fish sample peaks produced a ratio based on the final total amounts. Once the ratio 1:2:6 was ascertained, a standard was made in those proportions and run at four concentrations to develop a response curve (Fig. 11). The schematic of the PCB quantification is shown in Figure 12.

After PCB total was determined, it was divided by the wet weight of the tissue analyzed. Data were corrected internally for injection variation using a known concentration of decafluorobenzophenone (Fig. 9). Extraction recovery was determined using C18 naphthalene and column recovery using decachlorobiphenyl. Recovery experiments using these recovery compounds alone resulted in recoveries of 99.2% and 94.2%, respectively. A more accurate quantification method is presently being applied to the data so that a precise measurement of Aroclor combinations can be determined.

2.D.9. Quality control

2.D.9.a. Duplicate samples. Muscle tissue samples were taken from dissected fish and split into two equal portions of 10 g each. Each portion was extracted and cleaned up separately. Data from these duplicate analyses are presented in ppm wet weight, not corrected for recovery compounds:

Species	Sample I.D. #	PCB Duplicate Analyses of (ppm, wet weight) (1)	(2)
A. Pacific cod	#161	0.413*	0.360
B. English sole	#155	0.025	0.026
C. Squid	#38	0.105	0.137

* Not corrected for recovery compounds.

Further experiments on replicate sample analyses yet to be completed include increasing the number of replicates per sample and taking subsamples from a homogenized mixture.

2.D.9.b. Recovery Compounds. Due to the relatively poor recovery of the late-eluting compounds off the Florisil column, o.p.-DDT and the tetrachloro biphenyl were not used when considering recovery calculations. However, the early eluting octachloronaphthalene and decachlorobiphenyl gave more consistent recoveries; thus, these were chosen as the extraction and column recovery compounds respectively.

The percent recovered of each compound in the total sample group:

Compound	$\bar{X}$	SE	Range	n
Octachloronaphthalene	87.42	18.5	28.0 - 145.0	48
Decachlorobiphenyl	74.96	20.4	49.0 - 144.0	48

2.D.10. Measurement of trace metals

A portion of each tissue sample was weighed and dried at 100°C to constant weight. The dried samples were used for measuring the dry/wet ratio and then for analysis of arsenic, cadmium, and lead. Also, a portion of each wet sample was set aside for mercury determination.

For As measurement, 0.3 to 1.0 g of dried sample was accurately weighed and transferred to a polyethylene vial. The samples together with NBS Standard Reference Materials were neutron irradiated in the University of Washington's nuclear reactor for 2 hrs. The induced gamma energy of As-76 at 559 KeV was measured, compared with the corresponding value of standards, and the arsenic concentration of the samples was determined.

After As determination, the samples were transferred into glass vials and digested using Ultrex HNO_3 and $HClO_4$. The samples were finally diluted to 0.5 M HNO_3, and Pb and Cd were measured using flameless atomic absorption spectrophotometry (Fig. 13).

3. RESULTS

3.A. Demographic Studies

Over the course of the study 4,181 (96% shoreside) anglers were interviewed (Table 4). The results of the interviews are summarized below.

3.A.1. Time, location, and mode of activity

At Commencement Bay and Sinclair Inlet fishing activity was heaviest on weekends; the reverse was true at the other two locations (Table 5). At all locations fishing activity peaked between 6:00 pm and midnight (Table 6) and, seasonally, was heaviest during the autumn (Table 7). Most anglers fished from dockside; however, 13.2% of fishermen utilized bridges in the Elliott Bay area (Table 8).

3.A.2. Demographic characteristics of anglers

The majority of anglers were males (Table 9). At Sinclair Inlet anglers were fairly evenly distributed over the age groups 3-16 years, 17-26 years,

and 27-34 years. At the other embayments, many of the anglers were in the 27-34 year-old age-class (Table 10). At all embayments the fishermen were primarily Caucasian; the largest number of Asian anglers was encountered at Elliott Bay and Edmonds (Table 11). Over 80% of anglers were born in the United States (Figure 14). Of the foreign-born fishermen the largest numbers were from Korea, the Philippines, and Southeast Asia (Figure 15).

Seventy percent of the anglers had 12 or more years of education (Table 12). The majority of fishermen were employed (Table 13a) with the largest percentage classified as blue-collar workers (Table 13b, Figure 16). Most of the anglers arrived at the fishing site by private automobile (Figure 17), and most fished close to their homes (Table 14).

3.A.3. Fishing activity

The majority of anglers were involved in fishing rather than clamming, crabbing, or other activities (Table 15). Some anglers fished alone (Table 16), while others fished in groups of 2 to 15 persons (Table 17). The average fishing trip lasted between four and five hours (Table 18) with most successful anglers catching one to four fish per trip (Tables 19 and 20). The frequency with which people fished was highly variable (Table 21), but in three of the embayments the median number of days between trips was about one week (Table 22). Many of the anglers expressed no preference when asked what species of fish they sought (Table 23). Among those expressing a preference, Pacific cod, salmon, and squid ranked high (Table 23).

3.A.4. Interview success

Most of the anglers agreed to be interviewed (Table 24) and to have their catch examined (Table 25). Most people interviewed could speak and understand English adequately for purposes of the interview (Table 24). Overall, about one-fourth of the interviewed anglers reported having been interviewed more than once as part of this study(17.9%-28.1%; Table 24).

3.A.5. Fish caught

The actual catch of those anglers who permitted examination was 7,933 organisms (Table 26) weighing a total of 4,013.6 kilograms (Table 27) in all locations over the course of the study. Squid, hake, tomcod, pollock and cod were the species most commonly taken (Table 26). Squid, salmon, hake, cod, and pile perch yielded the most weight (Table 27). Bottom-dwelling flatfish (all species of flounder and sole combined) which have been shown to have high levels of idiopathic hepatic neoplasms and which have been a source of public concern relative to their safety for consumption, constituted 5.8% (by numbers) and 2.5% (by weight) of the catch (Tables 26 and 27).

Successful anglers caught an average of 1 to 4 fish per trip (Table 19) weighing an average of 2 kilograms (Fig. 18). The median number of days between meals of urban-caught fish was approximately seven (Table 28). Usually the catch was consumed by more than one person (Table 29). Most

people ate only fillets (Table 30). Baking and frying were the most common methods of preparation (Table 31).

3.A.6. Ethnic differences

Based on 1980 census counts (Table 32), Blacks and Asians were predominant in our sample of anglers (Table 11). Because of concern that certain ethnic groups might rely on urban embayments for a major source of protein, we examined some of our variables based on ethnicity. The following findings were significant.

Ethnicity of anglers was correlated with mode of fishing (Table 33) with more Blacks using bridges and more Caucasians using boats ($p < .001$). Asian anglers were most likely to fish on weekdays (Table 34) and at night (Table 35) ($p < .001$) and with their families (Table 36) ($p < .001$). They also had a more even distribution by age, with more younger and older people compared to Caucasians or Blacks (Table 37) ($p < .01$). Asians also were more likely to have a language barrier or to refuse the interview. More Caucasians were interviewed repeatedly (Table 38) ($p < .001$). Asians had larger numbers of fish eaters per household (Table 39) ($p < .001$) and were more successful at catching fish (Tables 40 and 41). Asian and Caucasian anglers were more likely to be employed (Table 42). Blacks were less likely to have more than a high school education (Table 43) ($p < .001$). Blacks fished more in spring and less in winter than Caucasians or Asians (Table 45) ($p < .001$). Asians and Caucasians were more likely ($p < .001$) to have higher status occupations (manager, skilled, professional) (Table 46).

In regard to preparation of catch, Asians were more likely to eat parts of the fish other than the muscle (Table 47) and to boil it as broth or to eat it raw ($p < .001$) (Table 48), but U.S.-born and non-U.S.-born Asians did not differ significantly on these variables ($p < .001$) (Tables 47, 49, 50). Blacks fried their fish more often than did members of other ethnic groups (Table 48).

Regarding species taken, only the proportion of the total catch made up of Pacific cod, squid, dogfish, and shiner perch differed between ethnic groups (in terms of number of individuals), with Caucasians taking more cod and squid and Asians taking more dogfish and shiner perch ($p < .05$). Because of their higher success rate, Asian anglers showed a significantly greater proportion of both refusal to allow inspection of catch and agreement with inspection than did the other ethnic groups. Significant ethnic differences were not noted for other parameters tested (Tables 51-55).

3.B. Chemical Analyses

Trace metals and PCBs were measured in 43 individual fish muscle samples of four fish species; sablefish, squid, English sole, and Pacific cod. An additional 38 samples were analyzed for trace metals only with a subsample set aside for future measurement of trace organics (Table 56). The overall range of concentrations for all areas together with the mean and standard deviations for the species analyzed are shown in Table 57. The highest concentrations of

PCBs were found in Pacific cod and squid.

The overall range of concentration of trace metals and PCBs of fish species from different embayments together with the corresponding mean values and standard deviations are given in Table 58. The number of samples per fish species and per embayment is too small to make a general conclusion. However, the effect of embayment is evident in the concentration of As in rock sole and English sole from Commencement Bay. Total PCB content as related to lipid content is given in Table 59 and in Figure 19. The results of PCB and trace metals measurements in Puget Sound reported by other selected authors are summarized in Tables 60 and 61, respectively. Due to differences in analytical methodology, the type and size of species analyzed, and location and seasonal variations, a direct comparison of the results of different studies is not feasible.

According to our data, feeding habits of fish and location of fishing have a more powerful influence on how much PCB is accumulated in muscle tissue than the percent of lipid content (Table 59). The concentration of total PCB versus percent lipid content in muscle tissue of different fish species is shown in Figure 19. Although there may seem to be some correlation between the PCB content and the percent lipid, this trend is not clear at this time due to the sparcity of data.

A summary of prey types and life history of each species is listed below (Hart, 1973).

Species: Pacific Cod, Gadus macrocephalus (Bargmann, 1980).
Prey items: worms, crabs, molluscs, shrimp, herring, sand lance, walleye pollock, flatfish. Benthic feeders until larger than 60 cm.

Habitats: schooling, midwater and bottom oriented, with a tendency to have seasonal migrations.

Species: Sablefish, Anoplopoma fimbria (Pasquale, 1964).
Prey items: saury, blue lantern fish, crustaceans, worms, small fishes, siphonophores, ctenophores. Primarily pelagic feeders.
Habitats: schooling, midwater, pelagic, with a tendency to be extensively migratory. Juveniles migrate out of Puget Sound at approximately three years of age.

Species: English sole, Parophrys vetulus (Day, 1976).
Prey items: clams and clam siphons, small molluscs, marine worms, small crabs, shrimps, brittle stars.
Average size and age at maturity: 10-12 inches, 3 years.
Habitats: sand to mud bottoms in shallow waters. Somewhat migratory, with seasonal movements to deepwater for spawning in winter, and to shallow waters in the spring.

Species: Squid, Loligo opalescens (Maupin, 1984).
Prey items: crustaceans (euphasiids, mysids, megalops larvae), juvenile gastropods, nereid polychaetes.
Average size and age at maturity: dorsal mantle length (110-180mm), 9 months-two years.
Habitats: schooling, pelagic. Migrate seasonally inshore to spawn and lay eggs.

Previous studies (Malins et al. 1982) have shown that the PCB concentrations in the English sole are high in the areas that have high concentrations of this contaminant in sediment such as Commencement Bay (Table 61). The location at which these benthic fish are caught is important since there is a strong association between sediment concentrations and flat fish concentrations (Conner, 1984). English sole analyzed from Elliott Bay were caught near Pier 91 and show a sharp contrast to the high contaminant levels reported from Duwamish Head sole (Malins et al., 1982). The low contaminant levels of our Elliott Bay English sole may be attributed to the relatively low PCB levels of the sediments located near Pier 91.

The English sole feeds primarily on clam siphons and polychaetes and is potentially prone to bioaccumulate the contaminants associated with the sediments in its feeding area.

The Pacific cod and sablefish are free-ranging species whose life histories and eating habits are quite different from flatfish and from each other (Allen, pers. comm.). The Pacific cod juveniles feed mostly on benthic organisms, e.g., gammarid amphipods, polychaetes. When they reach 50 to 60 cm in length, the cod switch from the benthic-feeding mode to pelagic food consisting mostly of hake, herring, and walleye pollock.

The sablefish juveniles feed on pelagic food such as shrimp, euphasiids, siphonophores, and ctenophores. When a sablefish reaches 20 to 40 cm, it will still be pelagic but will tend to go to the bottom of deeper waters since it has no swim bladder. After reaching the size of 50 cm, the fish tends to stay in deeper waters and will continue to feed on pelagic organisms. Usually, the sablefish does not consume as much benthic prey as the Pacific cod. This difference in feeding strategies may account for the relatively lower contamination levels of the pelagic-feeding sablefish when compared to the benthic-feeding Pacific cod. In addition, because adult sablefish tend to migrate out of Puget Sound, their exposure to contaminants is reduced further.

The relatively high concentration of PCBs in squid is primarily due to its consumption of crustaceans which contain a substantial amount of lipid. Their early life history in Puget Sound is uncertain, but their high contaminant levels suggest that they spend a good deal of feeding time in the sound rather than the open ocean.

3.C. Consumption Rates

The ideal way to calculate personal fish consumption would be to post observers at each meal where fish from Puget Sound were eaten and weigh the

amount consumed. A nearly ideal method would be to follow the same group of anglers/fisheaters over a year's time and to survey and record their catch and consumption habits at frequent and regular intervals. This method would serve especially well for partially overlapping fishing seasons such as those for salmon (July-October), squid (September-November), and cod (November-March). Cost and guarantees of privacy prohibited both of these approaches.

The dose (geometric mean grams of contaminants consumed per person per day) for each subcategory (embayment, ethnic group) was calculated by means of several steps and assumptions. First, for each successful angler trip the grams of fish taken per species were computed, based on quantities (fishcount) and lengths (fishlength) recorded on the interview forms and using weight-length regression coefficients (a=intercept; b=slope) for each Puget Sound species (Wildermuth, 1982). In cases when more than one fish per species was taken, the mean fish length was used to compute weight and then multiplied by the number (fishcount) in that catch. Interviewers saw very little size variance among the same species of fish in a given catch, and anglers usually caught one to three or four fish per species.

Next, this total weight of fish caught was divided by the number of people reportedly eating fish in the angler's household (eaters), and by the days (days) elapsed since fish caught at the same site were last eaten. That value was then multiplied by a cleaning factor (cf: 0.49 for squid, crab; 0.3 for finfish) to obtain the mean daily grams of available edible portion (edfishwt) consumed per person. The values reflect two sets of assumptions:

1) consumption
   a) fish were cleaned, with the edible portion comprising about 49% of total animal weight for squid and crab and 30% for finfish;
   b) catch was evenly distributed among eaters in the household;
   c) these people actually ate the fish;
   d) personal fish consumption was evenly distributed over the interval since the last successful trip;

2) fishing interval: fishing frequency (days) was based on interview responses which tended to focus on a particular seasonal fishery (Appendix E). The values represent seasonal consumption rates and therefore should not be extrapolated to a yearly basis. This value was set conservatively at unity if unreported.

The above calculations are depicted by the following expression:

$$\text{Edfishwt} = \frac{\text{fishcount} \times a \times \text{fishlength}^{b} \times \text{cf}}{\text{eaters} \times \text{elapsed days}}$$

Because SPSS computes data on an individual basis per interview, fish mass available for consumption was calculated per successful trip. Obviously tables of these numbers would have thousands of entries and would be uninterpretable, thus the data were summarized as follows.

Using the following formula, geometric means of the results obtained per angler were computed for each embayment (Table 63) and ethnic group (Table 62) to yield mean consumption of fish tissue per day:

$$\text{geometric mean grams} = \sqrt[n]{\prod_{1}^{n} \text{Edfishwt}}$$

Where n is the number of anglers in a given embayment or ethnic group who caught fish of the species in question.

This value was multiplied by the means and by the lower and upper ranges of contaminant concentrations (from Tables 57 and 58) to provide an estimate of the dose of PCB (Table 64) or heavy metals (Table 65) consumed by persons eating the fish. For example, to calculate the mean PCB dose for Pacific cod consumers at all locations, 27g (from Table 63) was multiplied times 0.156ug (from Table 57), yielding a total of 4.2ug PCB/day. This calculation derives from mean PCB levels and mean consumption rates.

Dose (ug) = geometric mean grams x contaminant concentration (ug/g)

Lower and higher doses were calculated by using the extreme values of contaminant concentrations and consumption figures. For example, a higher dose results from multiplying the mean of 27g for cod times the Edmonds upper PCB concentration in cod (0.548ug/g) for a loading of 14.8ug/person/day. However, this latter value is unrealistic, since the 0.548ug/g was unusual relative to the other values observed. Moreover, Pacific cod are only available to pier anglers in the colder months and hence do not represent a continual contaminant source.

It is important to note that the daily consumption/dose rates reported in Tables 62-65 reflect consumption/dose per day only for the period of time that each species was present in the fishery (Appendix E). For example, squid were taken by shoreside anglers during winter months only. Thus for squid, the daily consumption/dose rates apply to that period of time only, not to the entire year.

4. DISCUSSION

To the extent that our interviewers were able to sample randomly the entire angling population, we believe our data represent fairly the characteristics of the population. However, in the event that people who were observed fishing but who were not interviewed differ in their fishing success rate from the population interviewed, their estimated dose could differ. We do not know how persons who were not interviewed differ from interviewed anglers.

Tables 26 and 27 contain reference to unidentified species. Lack of identification resulted from a variety of circumstances. For example, some anglers already had cleaned and iced their fish; thus weights could be estimated, but precise species identification was difficult. In other cases anglers were willing to report the number, size, and species group caught, but they refused to allow visual inspection of their catch. Lack of species

estimates of catch and consumption probably bias our findings downward for those species controlled by bag limits (e.g., trout, salmon).

The higher success rate found for Asian anglers (Table 41) could have resulted from their occasionally larger-sized fishing groups (Table 52). Alternatively, the shorter duration of their fishing trips could mean greater angling expertise.

For the purpose of this interim report, we listed metal and PCB levels, but we confined our estimates of contaminant consumption rates to only three metals: As, Cd, and Pb. More extensive studies of consumption rates will appear in the final report. It should be noted that the values in Tables 64 and 65 reflect the potential for human exposure as a result of sport fish consumption. These values should be compared with the total ingestion dose received from daily diet. The latter can be calculated from the mean grams of food consumed and the corresponding contaminant concentrations. The ingestion dose can be further compared to other exposure doses, such as inhalation and physical contact, from Puget Sound area contaminants. A thorough treatment of these issues will be included in the final report.

5. SUMMARY

In contrast to the report entitled Assessment of Human Health Risk from Ingesting Fish and Crabs from Commencement Bay (Versar Inc., 1985), the present study was not undertaken to estimate risk. Rather, we attempted to measure exposures to certain metals and organic contaminants by first tallying the number of people catching given amounts and kinds of fish and then analysing tissue samples from such fish to assess levels of contaminant(s) present.

We interviewed 4,212 anglers, with 4,189 interviews completed in the period November, 1983, through November, 1984. Given our interview scheduling methods outlined above, we estimate that from 3,000 (observed) to 10,500 (=3000 x 7 days/week/2 days interviewed/week) anglers fished urban areas of Puget Sound during the period of our study. From 10,000 to 35,000 people ate what these anglers caught. Without positive angler identification per interview, it is not possible to narrow these limits of these estimates.

Our interviewers reported several findings not included in their questionnaires that bear directly on the estimation of number of anglers. First, the most important species tend to be highly seasonal, with salmon and squid in autumn, and gadoids in winter and spring. Perch, rockfish, and flatfish are caught year-round but more so in the absence of the previously mentioned species. Second, the angling population fishes in response to the seasonality of their "favorite" species, with some anglers fishing all seasons but many more only during their species' runs. Thus, one should think of anglers seeking the currently available species group(s), then not fishing much until the next seasonal appearance of a favored species. Although angling may occur dialy during the fishing season for a given species,very few anglers who report fishing daily do so for the entire year, or after they have accumulated quantities of fish sufficient for several large meals. Third, a

handful of anglers may fish (illegally) for profit or barter their catch. Finally, the 28% repeat interviews conducted include a few multiple repeats, but as a rule anglers tended to avoid being interviewed more than once or twice. With all these reservations, we find the 2,900 Commencement Bay anglers of Pierce (1981) to be a reasonable estimate.

According to the (1981) report of Puffer et al., Sportfishing Activity and Catches in Polluted Coastal Regions of Metropolitan Los Angeles, California, anglers fished more often (the majority of anglers surveyed fished once per week or more often) than we found for Puget Sound (about one third of the anglers surveyed fished once per week or more often), perhaps due to demographic and/or climatic differences. Their estimate of 31,351 anglers based on 1,059 interviews reflects the greater population of the Los Angeles area compared to Puget Sound. Anglers here in Puget Sound were somewhat more successful on a per-trip basis than those in Los Angeles, but the Los Angeles group ate somewhat more grams per person per day, albeit of quite different species. Methods of preparation or cooking were quite similar in both Los Angeles and Puget Sound. Puffer et al. (1981) did not report parts of fish eaten. They did attempt to identify and follow a select sample of anglers, whereas we did not.

Heatwole and West (1984), in Shore-Based Fishing in New York City, found even heavier fishing activity (81,000 anglers) and, paradoxically, both more fishing trip failure (69%) and more quantitative success (estimated total catch of 15 million fish/year) than observed here in Puget Sound or in Los Angeles. This greater number may reflect their research design, which relied in part on a telephone survey. They gathered household income data, but we did not. Both in New York and Puget Sound, anglers tend to fish near home, but in Puget Sound they are much more likely to commute to their fishing site by automobile and to come from greater distances. Unlike the New York study (4-page questionnaire), ours (one page) did not assess site preferences. Puget Sound had fewer Blacks, more Native Americans, and more Asian anglers than New York.

We suggest that future studies should address the following problem areas of both substance and methodology:

1. Relation of number of anglers present at a site to the proportion interviewed;
2. Practical means of identifying unique (non-repeat) interviews;
3. Practical means of determining repeat interviews with the same anglers at several times and locations;
4. Practical means of estimating socioeconomic status.
5. Appropriate statistical methodology for point and interval estimates of amount of contaminant(s) consumed per day on the basis of the observed data.

We did not attempt here to estimate channels or media other than sport fish for potential exposure to organic or metallic toxicants. We analyzed fish muscle tissue only because of the overwhelming angler preference for eating this tissue. Higher organic contaminant levels could be expected in fat, liver, and skin and higher levels of metals in bone and kidney tissue compartments.

References

Bargmann, G. 1980. Studies on Pacific cod in Agate Pass, Washington. Washington Dept. of Fisheries Progress Report No. 123.

Butler, P. and R. Schutzmann. 1978. Residues of pesticides and PCBs in estuarine fish: 1972-1976. Nat'l Pest. Mon. Prog., Pest. Mon. J. 12(2):51-59.

Calambokidis, J., J. Peard, G.H. Stiger, J.C. Cubbage, and R.L. DeLong. 1984. Chemical contaminants in marine mammals from Washington State. NOAA Technical Memorandum NOS, OMS 6.

Conner, M.S. 1984. Fish/sediment concentration ratios for organic compounds. Environ. Sci. Technol. 18(1):31-35.

Day, D. 1976. Homing behavior and population stratification in central Puget Sound English sole. J. Fish. Res. Bd. Canada 33(2):278-282.

Dexter, R.N., D.E. Anderson, E.A. Quinlan, L.S. Goldstein, R.M. Strickland, S.P. Pavlou, J.R. Clayton, R.M. Kocan and M.L. Landolt. 1981. A Summary of Knowledge of Puget Sound Related to Chemical Contaminants. NOAA Technical Memorandum OMPA-13. 435 pp.

Finch, R. 1970. Fish protein for human foods. Critical Reviews in Food Technology 1:519-580.

Gahler, A.R., J.M. Cummins, J.N. Blazevich, R.H. Rieck, R.L. Arp, C.E. Gangmark, S.W. Pope and S. Filip. 1982. Chemical Contaminants in Edible, Nonsalmonid Fish and Crabs from Commencement Bay, Washington. Seattle, Washington. U.S. Environmental Protection Agency. Environmental Services Division. EPA-910/9-82-093.

Hart, J.L. 1973. Pacific Fishes of Canada. Fish. Res. Board of Canada, Ottawa, Canada.

Heatwole, C.A. and N.C. West. 1984. Shore based fishing in New York City. Unpublished report.

Malins, D.C., B.B. McCain, D.W. Brown, A.K. Sparks and H.O. Hodgins. 1980. Chemical contaminants and biological abnormalities in central and southern Puget Sound. NOAA Technical Memorandum. OMPA-2. 186 pp + app.

Malins, D.C., B.B. McCain, D.W. Brown, A.K. Sparks, H.D. Hodgins and S.L. Chan. 1982. Chemical Contaminants and Abnormalities in Fish and Invertebrates from Puget Sound. Boulder, CO. NOAA, OMPA-19.

Malins, D.C., B.B. McCain, D.W. Brown, S-L. Lam, M.S. Myers, J.T. Landahl, P.G. Prohaska, A.J. Friedman, L.D. Rhodes, D.G. Burrows, W.D. Gronlund and H.O. Hodgins. 1982. Chemical pollutants in sediments and diseases of bottom-dwelling fish in Puget Sound, Washington. Environm. Sci. Technol. 18:705-713.

Maupin, S. 1984. International recruitment investigations in the subarctic species Schematica (Market squid, Loligo opalescens). NMFS, NOAA. Unpublished data.

Nelson, R. 1985. Northwest and Alaska Fisheries Center, NMFS, Seattle, WA. Personal Communication.

Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrunner and D.H. Bent. 1975. Statistical Package for the Social Sciences. New York: McGraw-Hill.

Noviello, D. 1982. Commencement Bay fish/shellfish consumption study - interim report. Pierce County Health Authority, Tacoma, Washington.

Pasquale, N. 1964. Notable migrations of sablefish tagged in Puget Sound. Washington Dept. of Fisheries. Fisheries Research Papers. Vol. 2, No. 3. p. 68.

Pierce, D., D. Noviello and D. Rogers. 1981. Commencement Bay seafood consumption study-preliminary report. Tacoma, Washington: Tacoma-Pierce County Health Department.

Puffer, H.W., S.P. Azen, and D.R. Young. 1981. Consumption rates of potentially hazardous marine fish caught in the metropolitan Los Angeles area. U.S. Environmental Protection Agency, Final Report, Grant No. R807120010, Corvallis, Oregon.

Riley, R.G., E.A. Crecelius, R.E. Fitzner, B.L. Thomas, G.M. Gurtisen and N.S. Bloom. 1983. Organic and inorganic toxicants in sediments and marine birds from Puget Sound. U.S. NOAA Tech. Memo. NOS OMS 1. 125 pp.

Romberg, G.P., et al. 1984. Toxicant pretreatment planning study technical report C:1; Presence, Distribution and Fate of Toxicants in Puget Sound and Lake Washington. Municipality of Metropolitan Seattle.

Somerton, D. and C. Murray. 1976. Field guide to the fish of Puget Sound and the Northwest Coast. pp. 76. Seattle: University of Washington Press.

Stober, Q.J., et al. 1984. Renton sewage treatment plant project: Seahurst Baseline study. Vol. IX. pp. 125. Seattle: University of Washington, Fisheries Research Institute.

Versar, Inc.1985. Assessment of human health risk from ingesting fish and crabs from Commencement Bay. US EPA Report EPA 910/9-85-129 (prepared under contract 68-03-3149).

Wildermuth, D. 1982. Length-weight regression analysis for thirty-seven species of sport caught marine fishes. Seattle: Washington Marine Recreational Fishes Statistical Survey.

Table 1. Interview coverage for each day of the week. Values indicate the total number of hours spent during Year 1 (Nov. 1983-Nov. 1984).

Day:	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Commencement Bay	89	85	89	26	131	195	116	723
Elliott Bay	90	88	73	75	90	127	74	617
Sinclair Inlet	31	45	25	24	109	120	67	421
Edmonds	82	50	80	82	78	126	86	584

Table 2. Interview coverage by location and hour of the day. Values indicate the total number of hours spent during Year 1 (Nov. 1983-Nov. 1984).

Hour:	Midnight-4:00 pm	4:00 am-8:00 am	8:00 am-Noon	Noon-4:00 pm	4:00 pm-8:00 pm	8:00 pm-Midnight	Total
Commencement Bay	84	60	91	100	142	246	723
Elliott Bay	42	65	48	68	134	242	617
Sinclair Inlet	41	37	57	42	101	121	421
Edmonds	40	44	33	84	155	218	584

Table 3. Percent distribution of Aroclors in individual peaks, based on the area units obtained from the three Aroclor mixtures (Aroclor 1248, Aroclor 1254, and Aroclor 1260 standards) run at the same concentration (0.5 ppm).

Retention time	% Composition			Retention time (continued)	% Composition		
	1248	1254	1260		1248	1254	1260
13.50		100		27.33		14	86
16.92	65	35		27.43	22	78	
17.75	64	36		28.45	2	18	80
18.96	100			28.60		100	
19.75	100			28.67	27	73	
19.96	100			29.04		23	77
20.51	59	41		29.11			100
20.71	77	23		29.74		28	72
20.86	78	22		30.10			100
21.45	74	26		30.48			100
22.02	100			30.73		59	41
22.39	100			31.01			100
23.09	76	24		31.20			100
23.26	67	33	23	31.56			100
23.44	43	34	23	31.82			100
23.75		100		32.03			100
24.23	69	31		32.08		100	
24.52	18	49	33	32.53			100
24.76	38	62		32.83		2	98
25.52	38	65		34.18		5	95
25.76	27	73		34.55			100
25.96	49	51		34.59		100	
26.07			100	34.77			100
26.22	21	59	20	36.13			100
26.75	10	19	71	37.01			100
26.98		23	77				

Table 4. Number of anglers interviewed at each of four urban embayments.

Location	Number	Percent
Commencement Bay	1207	28.9
Elliott Bay	1356	32.4
Sinclair Inlet	228	5.5
Edmonds	1390	33.2
Total	4181	100.0

Table 5. Percentage of anglers fishing on weekends versus weekdays.

Location	Weekend (5 p.m. Fri-6 p.m. Sun)	Weekday
Commencement Bay	61.6	38.4
Elliott Bay	36.7	63.3
Sinclair Inlet	61.4	38.6
Edmonds	45.3	54.7

Table 6. Time of fishing activity at each of four urban embayments. Values expressed in percent.

Location	00:00 to 05:59	06:00 to 11:59	12:00 to 17:59	18:00 to 24:00
Commencement Bay	6.9	11.7	29.6	51.8
Elliott Bay	3.8	10.1	17.3	68.8
Sinclair Inlet	3.1	20.6	26.3	50.0
Edmonds	7.6	9.9	28.2	54.4

Table 7. Seasonal fishing activity at each of four urban embayments. Values expressed in percent of anglers interviewed.

Location	Spring (March-May)	Summer (June-Aug)	Autumn (Sept-Nov)	Winter (Dec-Feb)
Commencement Bay	1.6	24.6	42.0	17.8
Elliott Bay	7.6	34.1	42.2	16.1
Sinclair Inlet	4.4	31.1	40.8	23.7
Edmonds	12.1	29.7	42.2	15.9

Table 8. Mode of fishing activity at each of four urban embayments. Values expressed in percent of anglers interviewed.

Location	Dock	Beach	Bridge	Boat
Commencement Bay	97.1	0.6	0.2	2.2
Elliott Bay	79.4	2.6	13.2	4.7
Sinclair Inlet	95.6	3.5	0.0	0.9
Edmonds	95.7	0.1	0.0	4.2

Table 9. Age and sex of anglers at each of four urban embayments. Values expressed in percent of anglers interviewed.

Location	Male	Female
Commencement Bay	91.8	8.2
Elliott Bay	91.0	9.0
Sinclair Inlet	90.7	9.3
Edmonds	93.1	6.9

Table 10. Age of anglers at each of four embayments. Values expressed in percent.

Location	3-16	17-26	27-34	35-44	45-64	65-84 years
Commencement Bay	5.9	22.6	29.0	23.4	17.2	1.8
Elliott Bay	6.2	20.3	29.0	20.0	17.5	7.2
Sinclair Inlet	21.4	33.3	15.2	13.3	14.8	1.9
Edmonds	10.5	27.1	23.9	18.7	16.3	3.4

Table 11. Ethnic origin of anglers at each of four embayments. Values expressed in percent.

Location	Caucasian	Black	Asian	American Indian	Hispanic	Pacific Islander	Other
Commencement Bay	69.3	11.2	17.3	0.6	1.3	0.1	0.2
Elliott Bay	51.4	15.2	30.1	1.7	1.4	0.2	0.2
Sinclair Inlet	83.3	4.4	10.1	0.4	1.8	0.0	0.0
Edmonds	70.9	1.7	26.1	0.4	0.6	0.3	0.0

Table 12. Educational background of anglers in each of four urban embayments. Values expressed in percent.

Number of Years Of Education:	1-8	9-11	12	13-15	16	17+
Commencement Bay	4.5	11.3	51.8	21.4	7.3	3.7
Elliott Bay	8.2	13.0	35.6	24.1	12.3	6.8
Sinclair Inlet	14.6	15.7	36.8	22.2	8.1	2.7
Edmonds	12.4	13.6	24.0	29.3	9.5	11.4

Table 13a. Employment status of anglers fishing at each of four urban embayments. Values expressed in percent.

	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
Employed	55.2	58.1	54.4	61.3
Unemployed	44.8	41.9	45.5	38.7

Table 13b. Occupational groupings of anglers fishing at each of four urban embayments irrespective of current employment status. Values expressed in percent.

	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
Professional	4.9	10.3	3.8	10.0
Manager, proprietor	6.0	4.7	5.4	7.1
Clerical	5.7	9.0	7.7	6.1
Skilled	14.1	19.6	12.3	18.0
Military	18.6	1.4	16.9	1.9
Semi-skilled	2.2	1.9	2.3	3.9
Unskilled	16.1	17.3	7.7	12.6
Homemaker	9.6	9.0	7.7	7.4
Student $\geq$18 yr old	4.9	10.3	3.8	10.0
Student $\leq$18 yr old	5.0	6.4	13.9	16.3
Retired	9.2	9.8	4.6	7.4
Other	3.1	4.6	3.2	0.8

Table 14. City of residence for anglers at each of four urban embayments. Values expressed in percent.

City	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
Seattle	1.4	81.7	4.6	27.3
Everett	0.1	0.3	0.0	6.4
Bremerton	0.2	0.0	51.5	0.2
Bremerton-Navy	0.1	0.0	1.0	0.0
Port Orchard	0.0	0.0	27.5	0.1
Tacoma	75.4	0.7	1.0	0.5
Federal Way	4.3	0.6	0.0	0.0
Edmonds	0.0	0.6	0.0	19.2
Richmond Beach	0.0	0.0	0.0	0.6
Stanwood	0.0	0.0	0.0	0.1
Olympia	0.5	0.0	0.0	0.0
Other King Co.	4.0	10.7	0.5	15.3
Other Snohomish Co.	0.4	0.8	0.5	25.8
Other Kitsap Co.	0.0	0.1	2.5	0.3
Other Pierce Co.	10.6	0.2	2.0	0.0
Other Washington Co.	1.8	1.5	5.6	2.1
Other USA States	0.9	0.3	3.1	1.5
Other Country	0.2	0.5	0.0	0.3

Table 15. Types of fishing activity at each of four urban embayments. Values expressed in percent of total anglers interviewed at each site. Cumulative percentage may exceed 100 since more than one answer was possible.

Location	Fishing	Clamming	Crabbing	Other
Commencement Bay	99.9	0.0	0.4	0.6
Elliott Bay	99.3	0.0	0.8	0.3
Sinclair Inlet	96.5	0.0	4.4	0.9
Edmonds	99.4	0.1	0.6	0.0

Table 16. Types of fishing groups at each of four urban embayments. Values expressed in percent of anglers reporting.

Location	Alone	Family	Friends	Family & Friends
Commencement Bay	30.9	29.3	33.2	6.4
Elliott Bay	45.0	24.1	27.2	3.4
Sinclair Inlet	31.3	26.8	33.9	8.0
Edmonds	36.0	26.3	32.1	5.6

Table 17. Fishing group size at each of four urban embayments. Values are expressed in percent of anglers reporting.

	Number of Persons Per Group				
Location	2	3	4	5	6-15
Commencement Bay	54.9	24.2	12.1	5.3	3.0
Elliott Bay	55.2	24.2	13.4	3.0	4.3
Sinclair Inlet	49.7	27.9	10.9	7.5	4.4
Edmonds	57.9	20.3	12.8	4.1	5.0

Table 18. Number of hours angler spent fishing during current trip. Values expressed in percent of anglers reporting.

Number of Hours (to the nearest hour)	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1	1.6	3.9	2.2	2.5
2	8.9	19.4	26.3	19.1
3	24.1	26.0	28.5	25.0
4	27.4	20.8	17.9	20.6
5	15.9	14.4	12.8	12.0
6	7.8	5.8	6.1	6.0
7	4.4	3.3	2.8	3.4
8+	9.9	6.3	3.3	11.4
Mean Number of Hours/Trip	4.7	4.1	3.7	4.3

Table 19. Number of fish caught by successful anglers during last fishing trip at interview site. Values expressed in percent of anglers reporting.

Number of Fish Caught	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1-4	69.2	64.6	60.4	67.8
5-9	16.4	16.5	15.3	12.0
10-14	6.9	7.9	5.4	5.6
15-19	4.2	3.3	6.3	3.2
20-29	2.0	3.3	7.2	5.3
30-39	0.8	1.6	0.9	2.1
40-49	0.0	1.8	1.8	1.3
50+	0.5	1.0	2.7	2.5

Table 20. Number of fish caught by successful anglers during current fishing trip to interview site. Values expressed in percent of anglers reporting.

Number of Fish caught	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1-4	74.4	71.3	67.4	69.6
5-9	15.8	16.8	15.2	15.3
10-14	5.2	4.6	7.6	6.6
15-19	2.5	3.6	2.2	1.5
20-29	1.1	2.4	3.3	3.2
30-39	0.5	0.7	3.3	1.9
40-49	0.5	0.2	1.1	1.1
50+	0.0	0.4	0.0	0.8

Table 21. Frequency (trips/period) with which anglers fish in each of four urban embayments. First-seventh timers report no frequency. Values expressed in percent of anglers reporting.

Frequency	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1st Time	17.4	19.3	27.7	17.8
2nd Time	10.8	7.0	11.8	6.3
3rd Time	1.2	0.4	1.5	1.5
4th - 7th Time	0.2	0.4	0.5	0.6
1/Week	17.3	13.9	9.2	13.3
2/Week	11.9	15.2	11.8	13.8
3/Week	5.1	9.8	3.6	5.7
4/Week	2.0	4.1	3.1	3.3
5/Week	0.5	3.7	4.1	2.0
6/Week	0.5	0.6	1.5	1.0
7/Week	2.4	4.7	1.5	3.3
1/Month	11.3	5.5	6.1	9.5
2/Month	10.8	5.4	9.7	9.2
3/Month	2.0	1.7	0.5	2.2
5-10/Month	0.3	0.7	1.0	0.7
1/Year	0.1	1.3	1.0	1.1
2/Year	1.3	2.0	1.0	1.9
3/Year	1.0	0.6	1.0	1.7
4/Year	0.0	0.0	0.0	0.0
5/Year	0.9	1.5	0.5	1.6
6/Year	0.4	0.3	0.0	0.4
7/Year	1.3	0.1	1.0	1.2
8/Year	0.3	0.4	0.0	0.3
9/Year	0.0	0.3	0.0	0.6

Table 22. Time elapsed (days) since angler last fished in the embayment where interview was conducted. Values expressed in percent of anglers reporting.

# Days	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1	13.9	29.4	18.9	25.5
2	6.4	13.3	11.5	10.0
3	8.4	6.4	8.8	4.9
4	6.1	4.6	3.4	3.9
5	4.5	3.3	2.7	3.6
6	5.5	1.2	2.0	2.9
7	11.6	13.9	12.8	15.0
8	1.3	1.0	1.3	1.2
9	0.4	0.2	0.0	0.4
10	2.9	1.5	1.3	1.2
11-13	1.0	0.4	0.0	0.1
14	9.0	5.6	14.2	5.4
15-20	1.9	0.8	0.0	0.8
21	4.0	2.7	2.7	4.7
22-29	0.2	0.4	0.0	0.4
30	11.3	4.6	6.8	6.2
31-364	11.3	7.5	13.5	10.7
365+	0.4	3.2	0.0	2.9
Median # Days	6.9	3.7	6.8	6.2

Table 23. Species sought by anglers at each of four urban embayments. Values expressed in percent of anglers reporting. Cumulative percentage may exceed 100 since more than one answer was possible.

Species Sought	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
No Preference	47.6	34.0	35.5	36.4
Pacific Cod	23.9	15.1	21.9	8.1
Perch	1.7	2.0	4.4	7.2
Flounder	1.6	1.2	0.0	1.7
Rockfish	0.2	0.9	0.4	3.2
Sablefish	0.2	1.0	0.4	0.1
Salmon today only	1.5	0.6	0.4	1.0
Salmon	17.9	18.7	8.3	27.5
Squid	4.8	17.8	18.0	17.3
Crab	1.4	1.2	7.9	1.2
Shrimp	0.0	1.2	0.4	0.0
Trout(cutthroat, Dolly Varden)	0.0	1.4	4.4	0.2
Herring	0.2	0.3	0.4	0.3
Ling Cod	0.0	0.2	0.0	0.0
Clam	0.0	0.0	0.4	0.0
Hake	0.2	0.7	0.0	3.5
Other Species	0.3	0.7	2.6	0.3

Table 24. Interview status of anglers at each of four urban embayments. Values expressed in percent. More than one response is possible.

Location	Agreed to be Interviewed	Refused to be Interviewed	Language Barrier	Previously Interviewed
Commencement Bay	93.4	2.6	2.6	28.1
Elliott Bay	58.1	12.7	4.5	26.3
Sinclair Inlet	92.9	1.8	1.3	17.9
Edmonds	74.4	14.5	7.4	25.6

Table 25. Willingness of successful anglers at each of four urban embayments to have their catch examined. Values expressed in percent of responses to question with more than one response possible.

Location	Nothing Caught	Agree to Inspection	Refuse Inspection	Catch Not Available
Commencement Bay	47.6	43.9	0.9	7.6
Elliott Bay	51.0	36.7	5.2	7.1
Sinclair Inlet	56.5	39.9	1.8	1.8
Edmonds	51.8	31.8	4.3	12.1

Table 26. The twenty species most commonly taken in all bays (in terms of numbers of fish) by urban anglers. Total catch = 7,933 animals.

Species	Number Caught	% of Total Catch
1. Market squid	3,104	39.1
2. Pacific hake	797	10.0
3. Pacific tomcod	400	5.0
4. Walleye pollock	400	5.0
5. Pacific cod	387	4.9
6. Striped perch	259	3.3
7. Shiner perch	227	2.9
8. Red rock crab	208	2.6
9. Pile perch	202	2.5
10. Sablefish	176	2.2
11. Coho salmon	169	2.1
12. Unidentified sole	162	2.0
13. Rock sole	150	1.9
14. English sole	149	1.9
15. Unidentified rockfish	127	1.6
16. Dogfish shark	111	1.4
17. Chinook salmon	110	1.4
18. Copper rockfish	95	1.2
19. Brown rockfish	90	1.1
20. Unidentified salmon	79	1.0

Table 27. The twenty species most commonly taken in all bays (in terms of kilograms) by urban anglers. Total = 4013.6 kilograms.

Species	Kilograms	% of Total Kg
1. Market squid	503.2	12.5
2. Chinook salmon	497.2	12.4
3. Coho salmon	331.6	8.3
4. Unidentified salmon	282.9	7.0
5. Pacific hake	261.6	6.5
6. Pacific cod	261.3	6.5
7. Pile perch	182.4	4.5
8. Walleye pollock	126.2	3.1
9. Striped perch	102.5	2.5
10. Sablefish	96.3	2.4
11. Unidentified flatfish	47.1	1.2
12. Unidentified rockfish	40.8	1.0
13. Pacific tomcod	40.7	1.0
14. Dogfish	36.7	0.9
15. Rock sole	29.8	0.7
16. Copper rockfish	26.5	0.7
17. English sole	26.4	0.6
18. Brown rockfish	25.3	0.6
19. Steelhead trout	21.9	0.5
20. Red rock crab	21.0	0.5
21. Other species	1052.6	26.2

Table 28. Time elapsed (days) since angler last ate fish that were caught in the embayment where the interview was conducted. Values expressed in percent of anglers reporting.

# Days	Commencment Bay	Elliott Bay	Sinclair Inlet	Edmonds
1	13.1	21.9	16.9	15.9
2	6.3	12.3	12.7	8.5
3	8.1	5.6	6.8	5.4
4	5.3	3.4	5.9	3.1
5	4.2	4.1	0.8	3.3
6	5.0	1.0	2.5	3.1
7	10.0	12.5	11.9	12.4
8	1.1	0.7	1.7	1.1
9	0.5	0.6	0.0	0.3
10	3.4	1.6	1.7	1.6
11-13	0.6	0.4	0.0	0.3
14	8.7	7.5	12.7	6.8
15-20	1.1	0.4	0.0	0.8
21	2.9	3.1	3.4	4.1
22-29	0.2	0.3	0.0	0.7
30	12.3	5.0	7.6	8.4
31-364	17.0	13.4	14.4	17.1
365+	0.2	6.2	0.8	7.0
Mean # Days	33.5	49.1	27.8	55.7
Median # Days	7.3	6.6	6.9	7.4

Table 29. Number of people who eat the fish caught by anglers at each of four urban embayments. Values expressed in percent of anglers reporting.

Number of Consumers	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
1	10.2	20.4	7.7	12.9
2	23.0	24.4	30.0	24.3
3	20.1	17.2	17.3	22.5
4	17.9	16.9	24.4	19.7
5	17.3	8.9	8.9	18.7
6-9	10.4	8.8	11.3	1.9
>10	0.7	3.3	2.4	0.0
Mean Number Consumers/Angler	3.5	3.3	3.8	3.4

Table 30. Parts of animal eaten by anglers at each of four urban embayments. Values expressed in percent. More than one response possible.

Parts eaten	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
Skinned fillet	75.4	72.1	78.9	73.0
Unskinned fillet	19.2	19.3	14.6	20.6
Broth	1.0	1.0	0.8	1.9
Head	2.2	2.0	0.8	1.7
Crab hepatopancreas	0.0	0.3	0.8	0.1
Whole	1.9	5.2	3.2	1.7
Other	0.3	0.1	0.8	0.9

Table 31. Mode of preparation used by anglers at each of four urban embayments. Values expressed in percent. More than one response possible.

Mode of Preparation	Commencement Bay	Elliott Bay	Sinclair Inlet	Edmonds
Raw	2.5	2.3	3.1	1.0
Boiled	13.0	9.3	13.9	8.1
Baked	18.5	18.3	13.2	17.3
Fried	50.5	56.5	55.8	50.0
Barbequed	4.3	4.6	3.9	9.9
Smoked	2.9	2.7	0.8	4.4
Steamed	6.8	2.4	3.9	2.5
Broiled	0.9	3.7	2.3	5.9
Pickled	0.4	0.3	3.1	0.8

Table 32. The 1980 U.S. census counts and 1984 population estimates by ethnic categories, as percents of total population.*

Place (row %)	Ethnic Origin						
	Total (col.%)	Cauc.**	Black	Indian, Esk. & Aleut.	Asian & Pac. Isl.	Other	Hispanic
WA State							
1980	100.0	91.46	2.55	1.47	2.66	1.85	2.90
1984	100.0	90.48	2.86	1.50	3.27	1.90	2.96
King Co.							
1980	30.73	88.36	4.41	0.98	4.92	1.33	2.10
1984	30.65	87.01	4.85	1.03	5.97	1.14	2.00
Seattle City							
1980	11.95	79.53	9.47	1.27	7.41	2.32	2.56
Kitsap Co.							
1980	3.56	92.38	1.84	1.38	3.17	1.26	2.57
1984	3.75	91.70	2.13	1.32	3.70	1.15	2.54
Greater Bremerton							
1980	1.72	90.39	2.94	1.24	3.93	1.51	3.11
Pierce Co.							
1980	11.75	87.71	6.14	1.22	3.18	1.75	2.65
1984	11.89	86.46	6.78	1.23	4.03	1.49	2.51
Greater Tacoma							
1980	7.63	85.70	7.22	1.39	3.65	2.03	2.71
Snohomish Co.							
1980	8.17	95.67	0.67	1.23	0.63	0.83	1.61
1984	8.47	95.28	0.83	1.15	2.02	0.72	1.54
Greater Edmonds							
1980	3.15	95.09	0.70	0.82	2.25	1.14	1.65

* Source: 1980 U.S. Bureau of Census figures, extrapolated to 1984 by Washington State Office of Financial Management.

**Including Hispanic

Table 33. Mode of fishing activity, all sites, for selected ethnic groups. Values expressed in percent of anglers interviewed.

Ethnic Origin	Dock	Beach	Bridge	Boat
Caucasian	90.3	1.7	3.1	4.8
Black	87.9	0.8	10.2	1.1
Asian	92.6	1.3	5.2	1.0

Table 34. Percentage of anglers in selected ethnic groups fishing on weekends versus weekdays.

Ethnic Origin	Weekend (5 p.m. Fri-6 p.m. Sun)	Weekday
Caucasian	48.7	51.3
Black	50.0	50.0
Asian	41.3	58.7

Table 35. Time of fishing activity for selected ethnic groups. Values expressed in percent.

Ethnic Origin	00:00 to 05:59	06:00 to 11:59	12:00 to 17:59	18:00 to 24:00
Caucasian	5.1	11.4	27.4	56.0
Black	4.3	12.6	26.3	56.7
Asian	8.9	8.6	17.2	65.3

Table 36. Types of fishing groups for selected ethnic groups. Values expressed in percent of anglers reporting.

Ethnic Origin	Alone	Family	Friends	Family & Friends
Caucasian	36.5	24.4	33.6	5.5
Black	36.3	29.0	31.0	3.7
Asian	39.1	32.6	23.0	5.3

Table 37. Age of anglers for selected ethnic groups. Values expressed in percent of anglers reporting.

Ethnic Origin	1-14	15-29	30-39	40-49	50-59	60-69	70+
Caucasian	7.8	40.2	25.3	12.1	6.8	6.2	1.6
Black	3.1	36.7	30.5	12.1	13.7	3.1	0.8
Asian	2.3	30.6	30.3	19.3	9.7	7.0	0.6

Table 38. Interview status for selected ethnic groups, all locations. Values expressed in percent of anglers interviewed.

Ethnic Origin	Agree to be Interviewed	Refuse to be Interviewed	Language Barrier	Previously Interviewed
Caucasian	69.9	6.8	0.5	22.8
Black	61.0	11.6	0.0	27.4
Asian	51.7	12.2	15.6	20.5

Table 39. Number of people who eat the fish caught by anglers in selected ethnic groups all locations. Values expressed in percent of anglers interviewed.

Number of Consumers	Caucasian	Black	Asian
1	15.3	15.1	8.9
2	24.9	20.0	24.1
3	21.8	16.9	14.7
4	18.2	21.8	17.9
5-9	18.2	26.2	30.5
10-14	1.1	0.0	2.7
15+	0.4	0.0	1.1

Table 40. Number of fish caught by successful anglers of selected ethnic groups during previous fishing trip at interview site. Values expressed in percent of anglers interviewed.

Number of Fish caught	Caucasian	Black	Asian
1-4	72.2	69.9	49.1
5-9	14.3	18.8	15.9
10-14	5.3	5.9	11.8
15-19	2.8	2.7	7.2
20-29	2.4	1.6	7.2
30-39	0.8	1.1	3.6
40-49	1.0	0.0	1.9
50+	1.2	0.0	3.1

Table 41. Number of fish caught by successful anglers of selected ethnic groups during current fishing trip. Values expressed in percent of anglers interviewed.

Number of Fish caught	Caucasian	Black	Asian
1-4	77.0	82.0	54.7
5-9	14.6	14.7	20.0
10-14	3.9	2.0	10.7
15-19	1.6	0.0	5.7
20-29	1.6	0.0	4.6
30-39	0.7	0.7	2.2
40-49	0.4	0.0	1.3
50+	0.1	0.7	0.9

Table 42. Employment status of anglers in selected ethnic groups. Values expressed in percent of anglers reporting.

Employment Status	Caucasian	Black	Asian
Employed	57.1	54.2	61.2
Unemployed	42.9	45.8	38.8

Table 43. Educational background of anglers in selected ethnic groups. Values expressed in percent of anglers reporting.

Number of years of education	Caucasian	Black	Asian
1-11	22.8	23.0	16.3
12	36.2	45.9	36.4
13+	41.0	31.1	47.2

Table 44. Mode of transportation to fishing site used by selected ethnic groups. Values expressed in percent of anglers reporting.

Mode of Transportation	Caucasian	Black	Asian
Car	89.5	84.7	95.9
Bus	3.3	6.7	1.4
Bicycle	2.0	2.3	1.2
Walk	5.1	6.3	1.4

Table 45. Seasonal fishing activity by anglers of selected ethnic groups. Values expressed in percent of anglers interviewed.

Season	Caucasian	Black	Asian
Spring (March-May)	11.8	14.8	7.9
Summer (June-Aug)	33.4	37.4	16.4
Autumn (Sept-Nov)	38.6	33.9	56.1
Winter (Dec-Feb)	16.1	14.0	19.5

Table 46. Occupation of successful anglers in selected ethnic groups. Values expressed in percent of anglers reporting.

Occupation	Caucasian	Black	Asian
Professional	8.5	9.3	6.6
Student (18+)	6.2	3.3	12.2
Student (5-17)	11.7	8.0	4.1
Manager/Proprietor	5.2	3.3	9.9
Clerical	7.7	4.7	6.1
Skilled	16.9	14.7	16.2
Military	8.0	14.0	3.8
Semi-skilled	2.5	2.7	3.3
Unskilled	13.2	16.7	19.3
Homemaker	8.8	10.7	7.1
Disabled	0.7	2.7	0.8
Unemployed	1.5	2.7	3.3
Retired	8.9	7.3	7.4

Table 47. Portions of animal consumed by anglers of selected ethnic groups. Values expressed in percent of all responses. More than one response possible.

Tissues eaten	Caucasian	Black	Asian
Skinned fillet	77.7	79.8	60.7
Unskinned fillet	18.1	18.2	23.2
Broth	0.7	0.5	3.0
Head	1.5	1.0	3.3
Crab "butter" (hepato pancreas)	0.1	0.0	0.2
Whole	1.3	0.5	9.1
Other	0.5	0.0	0.6

Table 48. Method of cooking used by anglers of selected ethnic groups. Values expressed as percent of responses. More than one response possible.

Method of cooking	Caucasian	Black	Asian
Raw	0.7	0.0	6.4
Boiled	6.7	7.5	22.7
Baked	21.8	12.9	8.8
Fried	53.3	71.5	43.5
Barbequed	7.4	1.6	3.4
Smoked	4.1	2.7	0.9
Steamed	2.1	1.6	10.1
Broiled	3.5	2.1	2.8
Pickled	0.4	0.0	1.3

Table 49. Portions of animals consumed by foreign-born (70.2% of) Asian anglers. Values expressed in percent of all responses.

Tissues eaten	Filipino	S.E. Asian	Chinese-Japanese
Skinned fillet	62.2	61.2	43.5
Unskinned fillet	30.6	20.1	21.7
Broth	0.9	4.0	4.3
Head	1.8	3.6	6.5
Crab "butter" (hepato pancreas)	0.0	0.9	0.0
Whole	4.5	8.9	23.9
Other	0.0	1.3	0.0

Table 50. Method of preparation used by foreign-born Asians, all locations. Values expressed in percent of all responses.

Cooking method	Filipino	S.E. Asian	Chinese-Japanese
Raw	2.0	7.3	16.3
Boiled	18.2	30.2	20.9
Baked	7.1	6.0	4.6
Fried	50.5	38.4	41.9
Barbequed	5.0	2.6	2.3
Smoked	1.0	0.9	0.0
Steamed	10.1	12.5	9.3
Broiled	5.0	1.7	9.3
Pickled	1.0	0.4	4.6

Table 51. Sex of anglers for selected ethnic groups. Values expressed in percent of anglers interviewed.

Ethnic Origin	Male	Female
Caucasian	92.4	7.6
Black	90.9	9.1
Asian	90.9	9.1

Table 52. Fishing group size for selected ethnic groups, all locations. Values expressed in percent of anglers reporting.

Ethnic Origin	Number of persons per group				
	2	3	4	5	6-15
Caucasian	56.9	24.0	11.8	4.0	3.2
Black	56.5	20.8	13.5	3.9	5.3
Asian	51.2	22.7	13.8	6.5	5.9

Table 53. Willingness of anglers from selected ethnic groups to have their catch examined. Values expressed in percent of anglers reporting.

Ethnic Origin	Nothing Caught	Agree to Inspection	Refuse Inspection	Catch not Available
Caucasian	54.2	33.2	2.5	10.1
Black	53.6	37.9	1.7	6.8
Asian	37.8	50.8	7.4	4.0

Table 54. Time elapsed (days) since anglers in selected racial groups last fished at site of interview. Values expressed in percent of anglers reporting.

# Days	Caucasian	Black	Asian
1	25.0	23.2	25.5
2	12.9	8.0	11.9
3	6.7	6.2	9.3
4	5.5	6.2	3.2
5	3.9	1.8	5.2
6	4.2	2.7	2.9
7	13.3	14.3	16.5
8	0.8	1.8	1.4
9	0.3	0.0	0.6
10	2.0	2.7	1.4
11-13	0.4	0.9	0.6
14	2.3	10.7	6.1
15-20	0.9	0.9	1.7
21	4.0	6.2	3.2
22-29	0.3	0.0	0.6
30	7.3	8.9	7.2
31-364	2.8	2.7	1.1
365+	2.3	2.7	1.4
Median # Days	6.1	6.9	5.8

Table 55. Time elapsed (days) since anglers in selected ethnic groups ate fish that were caught at the interview site. Values expressed in percent of anglers reporting.

# Days	Caucasian	Black	Asian
1	18.1	16.7	21.4
2	10.9	8.8	10.4
3	7.0	3.9	7.7
4	4.5	5.9	3.0
5	4.0	3.0	3.0
6	4.0	2.9	4.2
7	12.1	12.7	11.0
8	0.9	1.0	1.5
9	0.2	0.0	0.6
10	1.5	2.9	2.1
11-13	0.1	1.0	0.6
14	7.3	10.8	5.6
15-20	0.6	0.0	1.5
21	3.2	3.9	2.1
22-29	0.4	0.0	0.3
30	6.8	10.8	6.8
31-364	13.7	7.8	8.9
365+	4.5	8.8	9.2

Table 56. Concentration of trace metals and PCB in Puget Sound fish muscle. Values are in ug/g (PPM) of wet tissue.

Sample Number	Species	Site*	Length (cm)	Weight (g)	Dry/wet ratio	As (ppm)	Cd (ppm)	Pb (ppm)	PCB (ppm)	% Lipid of net weight
8	Sablefish	A-3	37.4	241.52	0.140	0.5	0.002	0.013	0.024	0.8
9	Hake	D-1	28.7	305.57	0.178	4.05	0.001	0.013	--	--
16	Tomcod	B-7	26.0	296.97	0.172	0.82	0.005	0.028	--	--
18	Striped perch	D-1	30.3	407.66	0.216	0.6	0.006	0.18	--	--
19	Rock sole	D-1	24.1	117.40	0.148	3.4	0.001	0.016	--	--
20	Striped perch	D-8	29.2	263.18	0.193	0.4	0.001	<0.01	--	--
29	Sablefish	A-2	30.0	297.14	0.175	1.6	0.008	0.014	0.042	0.7
32	Rockfish	A-5	20.6	156.73	0.216	1.2	0.003	<0.012	--	--
33	English sole	D-1	19.5	81.30	0.169	3.9	0.002	<0.008	0.029	0.9
34A	Rockfish	D-1	14.0	78.18	0.199	2.4	<0.001	0.016	--	--
34	"	D-1	"	"	"	1.7	--	--	--	--
35	Rockfish	D-1	12.7	40.74	0.189	1.1	0.002	<0.01	--	--
38	Squid	D-1	16.1	97.43	0.206	4.4	0.005	<0.01	0.196	2.6
39	Squid	D-1	16.0	101.23	0.223	8.7	0.037	<0.01	0.133	2.7
41	Squid	B-12	16.3	107.21	0.218	6.9	0.004	<0.01	--	2.8
42	Squid	D-1	18.2	118.75	0.211	5.4	0.002	0.002	0.215	2.9
43	Tomcod	B-7	20.1	224.78	0.225	4.02	0.004	0.03	--	--
44	Squid	B-7	18.2	120.03	0.225	6.4	0.063	<0.01	0.177	2.0
45	Squid	D-1	14.1	103.11	0.240	22.1	0.012	<0.012	0.024	1.4
46	Squid	D-1	17.2	110.13	0.228	4.6	0.25	<0.01	0.175	3.2
48A	English sole	B-12	19.0	74.03	0.159	14.03	0.003	0.022	0.106	0.7
48	"	B-12	"	"	"	16.5	--	--	--	--
49	English sole	B-12	20.2	58.55	0.172	20.4	0.002	0.048	0.190	0.8
50	Rockfish	D-1	20.1	73.18	0.180	1.84	0.018	0.03	--	--

Table 56 (cont.)

Sample Number	Species	Site*	Length (cm)	Weight (g)	Dry/wet ratio	As (ppm)	Cd (ppm)	Pb (ppm)	PCB (ppm)	% Lipid of net weight
51	English sole	B-7	19.0	62.84	0.102	20.24	0.001	0.037	0.115	0.9
59	Pacific cod	A-10	40.2	580.46	0.135	2.0	0.066	0.015	0.271	0.6
65	English sole	B-11	24.0	113.20	--	--	--	--	0.068	0.9
72	Pac. sanddab	B-12	18.1	47.44	0.189	20.7	0.002	0.047	--	--
73	Buffalo sculpin	B-12	16.0	110.47	0.094	1.0	0.002	0.018	--	--
74	Rock sole	B-11	30.4	366.7	0.128	7.7	<0.0006	<0.006	--	--
75	Rock sole	B-12	21.0	138.03	0.182	20.6	0.001	0.1	--	--
85A	Rock sole	C-14	30.8	253.23	0.124	5.34	<0.0006	<0.006	--	--
85	"	C-14	"	"	"	5.0	--	--	--	--
88	English sole	C-14	18.1	56.52	0.188	5.9	<0.001	0.032	0.039	0.9
89	English sole	C-14	24.4	125.32	0.193	7.1	<0.001	<0.01	0.100	0.9
90	English sole	C-14	25.0	148.43	0.182	5.7	<0.001	<0.01	0.047	0.8
95	English sole	C-14	36.3	493.96	0.197	11.1	<0.001	0.022	0.259	2.7
97	Flathead sole	C-14	37.4	--	--	--	--	--	--	--
98	Rock sole	C-14	30.7	373.12	0.20	19.6	<0.001	<0.01	--	--
99	Rock sole	C-14	29.8	366.46	0.205	6.5	<0.001	<0.01	--	--
100	Rock sole	C-14	31.6	407.08	0.202	16.3	<0.001	0.083	--	--
104	Rock sole	C-14	23.8	366.46	0.205	6.5	<0.001	<0.01	--	--
118A	English sole	D-1	39.8	561.05	0.162	1.8	<0.0008	<0.008	0.021	1.2
118	"	D-1	"	"	"	1.3	--	--	--	--
123	Rock sole	A-6	24.2	165.62	0.203	2.1	<0.001	<0.01	--	--
124	Rock sole	A-6	18.2	68.66	0.186	4.4	<0.001	0.017	--	--
125	Rock sole	A-6	25.2	187.82	0.196	2.6	<0.001	<0.01	--	--
126	Rock sole	A-6	21.2	114.73	0.193	2.2	<0.001	<0.01	--	--
145	Rock sole	A-13	26.4	224.84	0.193	2.9	<0.001	<0.01	--	--

Table 56 (cont.)

Sample Number	Species	Site*	Length (cm)	Weight (g)	Dry/wet ratio	As (ppm)	Cd (ppm)	Pb (ppm)	PCB (ppm)	% Lipid of net weight
154	English sole	D-1	36.2	444.84	0.179	1.0	<0.001	<0.01	0.032	1.0
155	English sole	D-1	40.9	561.50	0.160	1.4	<0.0008	<0.008	0.081	1.0
157	Rock sole	D-1	33.0	508.96	0.212	1.2	<0.001	0.015	--	--
158	Rock sole	D-1	9.5	364.97	0.203	3.6	<0.001	<0.01	--	--
159A	Rock sole	D-1	24.1	189.92	0.199	2.7	<0.001	0.058	--	--
159	"	D-1	"	"	"	3.1	--	--	--	--
161	Pacific cod	D-1	45.4	742.56	0.164	3.6	<0.0008	0.2	0.548	0.5
173	English sole	D-1	35.3	352.38	0.121	1.9	<0.001	<0.006	0.048	0.8
175	Pacific cod	D-1	43.4	775.74	0.174	2.0	<0.001	<0.01	0.030	0.6
182	Rock sole	D-1	34.8	504.52	0.190	3.2	0.001	0.01	--	--
183	Rock sole	D-1	29.4	313.82	0.177	1.2	<0.001	<0.01	--	--
185	English sole	A-13	19.7	71.02	0.194	1.8	<0.001	--	0.022	1.0
186	English sole	A-13	21.7	103.12	0.191	6.5	0.002	<0.01	0.026	1.4
187	English sole	A-13	25.8	147.57	0.183	3.8	0.001	0.013	0.047	0.9
188A	English sole	A-13	30.1	226.50	0.181	3.4	<0.001	0.045	0.023	0.8
188	"	A-13	"	"	"	4.2	--	--	--	--
189	English sole	A-13	18.0	56.93	0.194	3.02	<0.001	<0.01	0.020	1.2
103	English sole	C-14	12.9	23.53	0.153	2.1	<0.0008	0.028	--	--
DSHS-2	Pacific cod	C-9	40.8	770.55	0.179	3.6	<0.001	<0.01	0.030	0.6
DSHS-10	Pacific cod	C-9	43.3	1125.00	0.186	5.4	<0.001	<0.01	--	0.4
DSHS-14	Pacific cod	C-9	49.8	1228.10	0.152	12.6	0.002	<0.008	0.091	0.5
DSHS-20	Sablefish	A-5	28.5	176.12	0.177	0.5	0.003	<0.01	0.025	0.8
DSHS-21	Sablefish	A-5	31.9	314.67	0.183	0.6	0.001	<0.01	0.030	1.2
DSHS-24	Sablefish	A-4	35.2	324.83	0.176	1.3	0.001	<0.01	0.044	1.1
DSHS-28	Pacific cod	C-15	41.9	774.78	0.175	5.8	<0.001	<0.01	0.048	0.5

Table 56 (cont.)

Sample Number	Species	Site*	Length (cm)	Weight (g)	Dry/wet ratio	As (ppm)	Cd (ppm)	Pb (ppm)	PCB (ppm)	% Lipid of net weight
DSHS-29A	Sablefish	A-4	35.2	429.25	0.192	2.9	<0.001	0.013	0.089	2.0
DSHS-29	"	A-4	"	"	"	3.9	--	--	--	--
DSHS-30	Sablefish	A-4	33.3	300.58	0.167	1.0	0.001	<0.008	0.027	1.1
DSHS-31	Sablefish	A-4	39.5	528.47	0.194	2.5	<0.001	0.02	0.360	3.6
DSHS-32	Sablefish	A-4	34.8	314.07	0.173	2.3	0.001	<0.01	0.046	1.2
DSHS-34	Sablefish	A-3	33.6	323.40	0.179	0.8	<0.001	<0.01	0.042	1.4
DSHS-35	Sablefish	A-3	34.2	362.38	0.175	5.3	0.002	<0.01	0.041	0.9
DSHS-36	Sablefish	A-3	33.5	293.09	0.173	0.6	0.002	<0.01	0.023	1.2

Quality Control:

Lead:
Precision: c.v. 8.5% at .09 ug/gR
Spike Recovery: 100%
Bovine Liver NBS 1577 = 0.34 .08 ug/gR
Analyzed 0.37, 0.30 ug/gR

Cadmium:
Precision: c.v. 5.5% at 0.050 ug/gR
Recovery Test: 107% (spike)
Accuracy: Bovine Liver NBS 1755 = 0.27 0.04
Analyzed 0.31, 0.24 ug/gR

*Site Locations:

A = Elliott Bay
B = Commencement Bay
C = Sinclair Inlet
D = Edmonds

1 = Public Fishing Pier
2 = Pier 56
3 = Pier 57
4 = Pier 70
5 = Pier 86
6 = Pier 91
7 = Les Davis Pier
8 = Ferry Dock
9 = 1st Street Dock
10 = Spokane Street Bridge
11 = Old Tacoma
12 = Point Defiance
13 = Smith Cove
14 = Sinclair Inlet
15 = Port Orchard

Table 57. Overall range, mean, and standard deviation (SD) of trace metal and PCB values in ug/g of wet tissue of fish groups from Table 56; N.A. = not applicable.

Species	As (ppm)				Cd (ppm)				Pb (ppm)				PCB (ppm)			
	n	Range	Mean	SD(s)	n	Range	Mean	SD(s)	n	Range	Mean	SD(s)	n	Range	Mean	SD(s)
Sablefish	13	0.5-5.3	1.831	1.494	12	0.001-0.008	0.002	0.002	12	0.008-0.02	0.012	0.003	12	0.023-0.360	0.066	0.094
Tomcod	2	0.82-4.02	2.42	2.263	2	0.004-0.005	0.0045	0.0007	2	0.028-0.03	0.0014	0.0014	0	--	--	--
Striped perch	2	0.04-0.6	0.5	0.141	2	0.001-0.006	0.0035	0.0035	2	0.01-0.018	0.095	0.12	0	--	--	--
Rock sole	20	1.2-20.6	5.587	5.01	18	0.006-0.001	0.001	0.00013	18	0.006-0.1	0.0227	0.0277	0	--	--	--
Squid	7	4.4-22.1	8.357	6.238	7	0.002-0.25	0.0533	0.0896	7	0.002-0.012	0.0091	0.0032	6	0.024-0.215	0.153	0.069
English sole	21	1.0-20.4	6.528	6.206	18	0.0008-0.003	0.000124	0.0006	17	0.006-0.048	0.0192	0.014	18	0.02-0.259	0.071	.0648
Pacific cod	8	2.0-12.6	4.65	3.532	8	0.0008-0.066	0.0092	0.023	8	0.008-0.2	0.035	0.0667	7	0.03-0.548	0.156	0.192
Rockfish	5	1.1-2.4	1.648	0.526	4	0.001-0.018	0.006	0.008	4	0.01-0.03	0.017	0.009	0	--	--	--
Pacific sanddab	1	20.7	20.7	N.A.	1	0.002	0.002	N.A.	1	0.047	0.047	N.A.	0	--	--	--
Buffalo sculpin	1	1.0	1.0	N.A.	1	0.002	0.002	N.A.	1	0.018	0.018	N.A.	0	--	--	--
Hake	1	4.05	4.05	N.A.	1	0.001	0.001	N.A.	1	0.013	0.013	N.A.	0	--	--	--

Table 58. Range, mean and standard deviation (SD) of trace metal and PCB values in ug/g of wet tissue of fish groups from Table 56 according to embayment.

Species	Location	As (ppm) n	As (ppm) Range	As (ppm) Mean	As (ppm) SD(s)	Cd (ppm) n	Cd (ppm) Range	Cd (ppm) Mean	Cd (ppm) SD(s)	Pb (ppm) n	Pb (ppm) Range	Pb (ppm) Mean	Pb (ppm) SD(s)	PCB (ppm) n	PCB (ppm) Range	PCB (ppm) Mean	PCB (ppm) SD(s)
Sablefish	B	13	0.5-5.3	1.831	1.494	12	0.001-0.008	0.002	0.002	12	0.008-0.02	0.012	0.003	12	0.023-0.36	0.066	0.094
Hake	A	1	4.05	4.05	N.A.	1	0.001	0.001	N.A.	1	0.013	0.013	N.A.	0	--	--	--
Tomcod	C	2	0.82-4.02	2.42	2.263	2	0.004-0.005	0.0045	0.0007	2	0.028-0.03	0.029	0.0014	0	--	--	--
Striped perch	A	2	0.4-0.6	0.5	0.141	2	0.001-0.006	0.0035	0.0035	2	0.01-0.18	0.095	0.12	0	--	--	--
Rock sole	A	7	1.2-3.6	2.63	1.014	6	0.001	0.001	0	6	0.01-0.058	0.02	0.019	0	--	--	--
Rock sole	C	2	7.7-20.6	14.15	9.122	2	0.0006-0.001	0.0008	0.0003	2	0.006-0.1	0.053	0.067	0	--	--	--
Rock sole	D	6	5.0-16.3	8.473	4.206	5	0.0006-0.001	0.00092	0.00018	5	0.006-0.083	0.0252	0.0326	0	--	--	--
Rock sole	B	6	2.1-4.4	2.84	0.929	5	0.001	0.001	0	5	0.01-0.017	0.0114	0.00313	0	--	--	--
Rockfish	B	1	1.2	1.2	N.A.	1	0.003	0.003	N.A.	1	0.012	0.012	N.A.	0	--	--	--
Rockfish	A	4	1.1-2.4	1.76	0.534	3	0.001-0.018	0.007	0.0095	3	0.01-0.03	0.0187	0.01	0	--	--	--
Squid	A	5	4.4-22.1	9.04	7.503	5	0.002-0.25	0.0612	0.1064	5	0.002-0.012	0.0088	0.0039	5	0.024-0.215	0.1486	0.076
Squid	C	2	6.4-6.9	6.65	0.354	2	0.004-0.063	0.0335	0.0417	2	0.01	0.01	0	1	0.177	0.177	N.A.
English sole	A	6	1.0-3.9	1.883	1.042	5	0.0008-0.002	0.001	0.0005	5	0.006-0.01	0.008	0.0014	5	0.021-0.081	0.0422	0.0238
English sole	C	4	14.03-20.4	17.793	3.089	3	0.001-0.003	0.002	0.001	3	0.022-0.048	0.0357	0.013	4	0.068-0.19	0.12	0.051
English sole	D	5	2.1-11.1	6.38	3.233	5	0.0008-0.001	0.00096	0.00009	5	0.01-0.032	0.0204	0.01	4	0.039-0.259	0.113	0.1022
English sole	B	6	1.8-6.5	3.787	1.563	5	0.001-0.002	0.0012	0.000454		0.01-0.045	0.0195	0.017	5	0.02-0.047	0.0276	0.011
Pacific cod	B	1	2.0	2.0	N.A.	1	0.066	0.066	N.A.	1	0.015	0.015	N.A.	1	0.271	0.271	N.A.
Pacific cod	A	3	2.0-3.6	2.6	0.872	3	0.0008-0.001	0.00086	0.00012	3	0.01-0.2	0.076	0.1075	3	0.03-0.548	0.218	0.287
Pacific cod	E	4	3.6-12.6	6.85	3.951	4	0.001-0.002	0.0013	0.0005	4	0.008-0.01	0.0095	0.001	3	0.03-0.091	0.0563	0.0313
Pacific sanddab	C	1	20.7	20.7	N.A.	1	0.002	0.002	N.A.	1	0.047	0.047	N.A.	0	--	--	--
Buffalo sculpin	C	1	1.0	1.0	N.A.	1	0.002	0.002	N.A.	1	0.018	0.018	N.A.	0	--	--	--

Legend: Location =
A = Edmonds
B = Elliott Bay
C = Commencement Bay
D = Bremerton
E = Sinclair Inlet

Table 59. Mean total PCB concentration by species and embayment as related to lipid content.

Species	Total PCB (ppm) $\bar{x}$	(SD)	% lipid (wet weight) $\bar{x}$	(SD)	n
Sablefish	0.066	.09	1.32	0.80	12
Pacific cod	0.156	.19	0.53	0.08	7
Squid	0.153	.07	2.50	0.61	7
English sole	0.071	.07	1.04	0.47	18
English sole by embayment:					
Edmonds	0.0415	.02	0.97	0.16	5
Commencement Bay	0.120	.05	0.81	0.11	4
Bremerton	0.111	.05	1.32	0.90	4
Elliott Bay	0.028	.01	1.06	0.23	5

Table 60. Reported Cd, Pb, and As concentrations in fish muscle samples from Puget Sound areas. Values in ug/g (PPM) of wet weight.

Species (N)		Cd	Pb	As	Location	Ref.
Rock sole (5)	$\bar{x}$	0.004	0.05	2.0	Seahurst area	Stober, et al.
	S.D.	0.002	0.01	2.3		1984
	Range	0.002-0.006	0.04-0.08	0.4-5.3		
Rock sole (5)	$\bar{x}$	0.008	0.52	11.6	Commencement Bay	Gahler, et al.
	S.D.	0.001	0.18	13.3		1982
	Range	0.006-0.009	0.33-0.81	1.5-34		
Sole (6)	$\bar{x}$	0.004	0.03	7.4	Elliott Bay & Central Puget Sound	Romberg, et al.
	S.D.	0.001	0.02	6.1		1984
	Range	0.003-0.004	0.008-0.06	0.4-18		

Table 61. Reported PCB concentrations in fish samples from Puget Sound. Values in ppm of wet weight. Previous Studies.

Species	Butler & Schutzmann, 1978 Juvenile fish, whole average of 2 samples of 25 pooled fish Duwamish River	Calambokidis et al., 1978 Collected 1977 South Puget Sound Whole fish	Gahler, 1982 Collected 1981 Muscle tissue Commencement Bay	Malins, et al., 1982 Collected 1978-81. Muscle tissue Elliott Bay (EB) Commencement Bay (CB)
English sole (*Parophrys vetulus*)	Fall 72 3346ppb Spring 73 2111 Fall 73 1683 Spring 74 1927 Fall 74 1733 Spring 75 2541 Spring 76 2129	1 sample 154 ppb	16 samples 350 mean ppb 90-1030 range	5 samples EB 5 CB 1000 mean 500 mean 270-2100 range 160-850 range
Pacific Staghorn Sculpin (*Leptocottus armatus*)	Fall 72 2202ppb Spring 73 2065 Fall 73 1129 Spring 74 1477 Fall 74 -- Spring 75 1832 Spring 76 998	5 samples 77ppb 14-97 range	7 samples 103 40-340 range	9 samples only liver data
Pacific tomcod (*Microgadus proximus*)	-----	1 sample 224ppb	2 samples 28 & 30ppb	1 sample liver only
Pacific cod (*Gadus microcephalus*)	-----	----	3 samples 40ppb 35-50 range	8 samples (8 livers also) 28 (EB & CB) 14-46 range
Starry flounder (*Platichthys stellatus*)	-----	1 sample 97ppb	1 sample 180ppb	----
Whitespotted greenling (*Hexogrammos stelleri*)	-----	----	3 samples 860ppb (450-1120 range)	----

Table 62. Daily fish consumption rates for selected ethnic groups. (Values are expressed as the geometric mean grams of cleaned fish available for consumption per person per day during the period of time each species was present in the fishery. Season lengths for each species are presented in Appendix E.)

Species	Over All Races	Over All Non-U.S. Asians	Non-U.S. Asians			U.S. Races		
			Filip.	S.E. Asia	China-Jpn.	Cauc.	Black	Asian
Pacific cod	23 *	19	17	20	12	29	27	23
Tomcod	11	11	4	18	4	11	5	13
Pacific hake	19	16	10	19	8	21	15	19
Walleye pollock	16	17	5	23	3	17	10	18
English sole	11	9	9	9		12	11	8
Starry flounder	18	7	6	8		20	14	16
Sablefish	30	8	19	5	4	30	47	12
Squid	40	34	25	31	60	33	41	47
Overall Mean	11	10	7	11	8	11	9	10
Mean Values of Top 7 Spp. Groups**	11	10	8	11	8	11	9	11

*For each successful trip the mean daily grams per person of available edible portion (Edfishwt) was calculated by the following formula:

$$\text{Edfishwt} = \frac{(\text{fishcount})(a)(\text{fishlength}^{b})(cf)}{(\text{eaters})\ (\text{days})}$$

From these results obtained per angler a geometric mean was computed using the following formula: $\text{Geometric mean grams} = \sqrt[n]{\prod_{i}^{n}} \text{Edfishwt}$

For an explanation of symbols refer to Section 3.c.

**Gadids, flatfish, squid, rockfish, salmon, crab, perch.

Table 63. Daily fish consumption rates for each of four urban embayments. (Values are expressed as the geometric mean grams of cleaned fish available for consumption per person per day during the period of time each species was present in the fishery. Season lengths for each species are presented in Appendix E).

Species Taken	Over All Group	Commencement Bay	Elliott Bay	Bremerton	Edmonds
Pacific cod	27 *	25	29	45	24
Tomcod	11	10	18		10
Pacific hake	20	11	34		25
Walleye pollock	16	15	20		20
English sole	11	11	12	5	12
Starry flounder	18	17	18	4	50
Sablefish	30	26	32		18
Squid	39	25	47	45	36
Overall Mean	11	8	10	14	14
Mean Value Across Top 7 Groups**	11	8	10	16	14

*For each successful trip the mean daily grams per person of available edible portion (Edfishwt) was calculated by the following formula:

$$\text{Edfishwt} = \frac{(\text{fishcount})(a)(\text{fishlength}^b)(cf)}{(\text{eaters})\ (\text{days})}$$

From these results obtained per angler a geometric mean was computed using the following formula:

$$\text{Geometric mean grams} = \sqrt[n]{\prod_{i}^{n} \text{Edfishwt}}$$

For an explanation of symbols refer to Section 3c.

** Gadids, flatfish, squid, rockfish, salmon, crab, perch.

Table 64. Estimated PCB dose (µg) per person per day. (Values are calculated based upon observed mean catch and upon PCB values from tissue analysis. Values are expressed as ug PCB per person per day during the period of time each species was present in the fishery. Season lengths for each species are presented in Appendix E.)

Species	Mean**	SD	Range** Low	High
Sablefish	1.98*	2.7	0.69	10.8
Pacific cod	4.2	5.1	0.81	14.8
Squid	6.0	2.7	0.94	8.4
English sole (overall)	0.78	0.77		
English sole by location:				
Commencement Bay	1.3	0.55	0.75	2.1
Elliott Bay	0.31	0.12	0.20	0.56
Bremerton	0.56	0.25	0.20	1.3
Edmonds	0.50	0.24	0.25	0.97

*PCB dose was calculated from the geometric mean consumption rates (Table 63) and measured PCB levels (Table 57) using the following formula:

Dose (µg) = (geometric mean grams) x (contaminant conc µg/g)

For further information refer to Section 3.c.

**Based upon means and low/high ranges in PCB concentrations.

Table 65. Estimated heavy metals dose (µg) per person per day. (Values are calculated based upon observed mean catch and upon metal levels from tissue analysis. Values are expressed as µg heavy metals per person per day during the period of time each species was present in the fishery.) Season lengths for each species are presented in Appendix E.

Species	Mean**	SD	Range** Low	High
Sablefish				
As	54.9*	44.8	15.0	159.0
Cd	0.06	0.06	0.03	0.24
Pb	0.36	0.09	0.24	0.60
Tomcod				
As	26.6	24.9	9.0	44.2
Cd	0.05	0.008	0.044	0.055
Pb	0.015	0.015	0.31	0.33
Squid				
As	325.9	243.3	171.6	861.9
Cd	2.1	3.5	0.08	9.8
Pb	0.35	0.12	0.08	0.47
English sole				
As	71.8	68.3	11.0	224.4
Cd	0.001	0.007	0.000	0.0033
Pb	0.21	0.15	0.07	0.53
Pacific cod				
As	125.6	95.4	54.0	340.2
Cd	0.25	0.25	0.02	1.78
Pb	0.95	1.80	0.22	5.40

*Heavy metals dose was calculated from the geometric mean consumption rates (Table 63) and measured heavy metals levels (Table 57) using the following formula:

Dose (µg) = (geometric mean grams) x (contaminant conc. µg/g)

For further explanation refer to Section 3.c.

**Based upon means and low/high ranges in heavy metal concentrations.

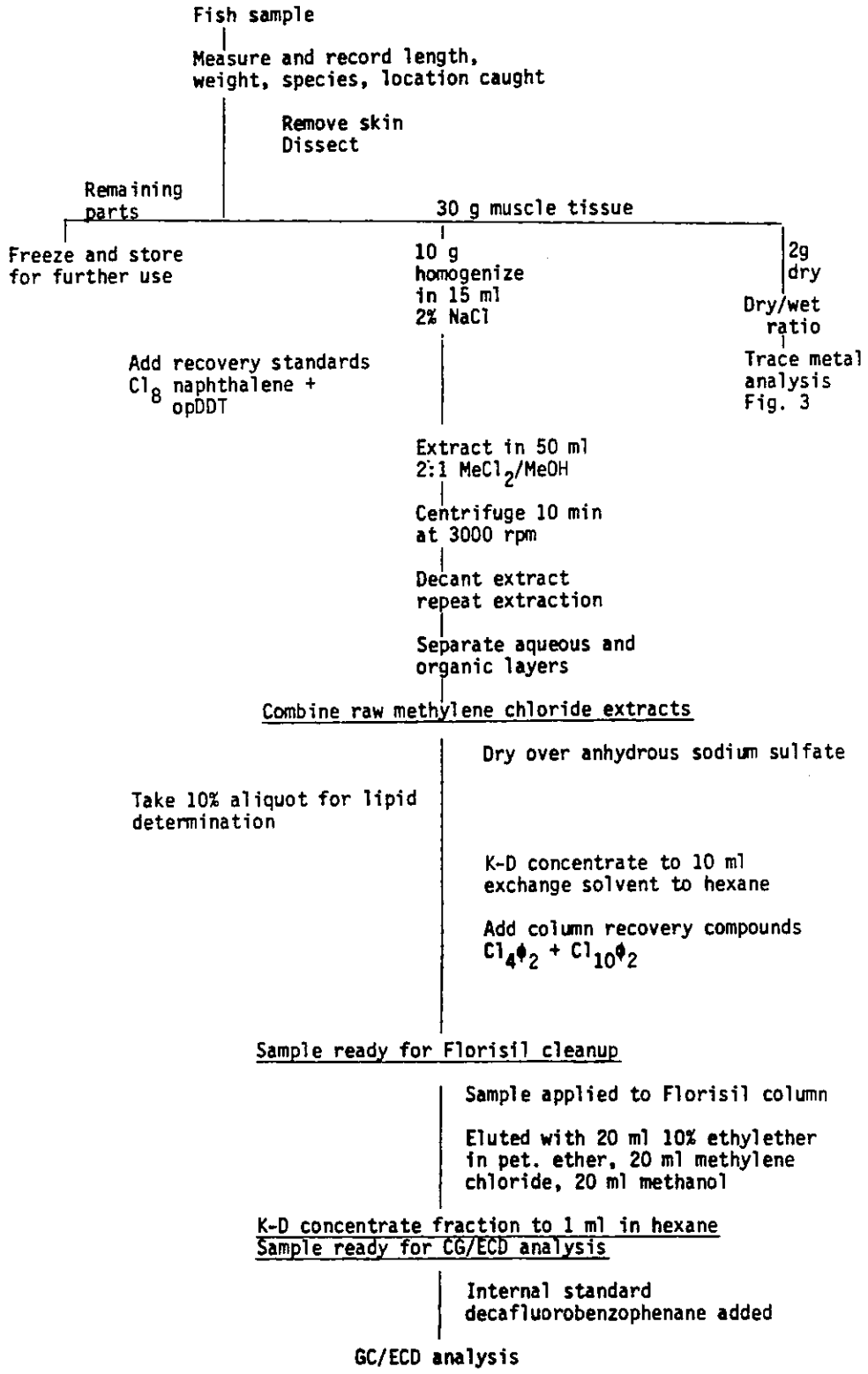


Figure 3. Schematic of sample preparation for PCB analysis.

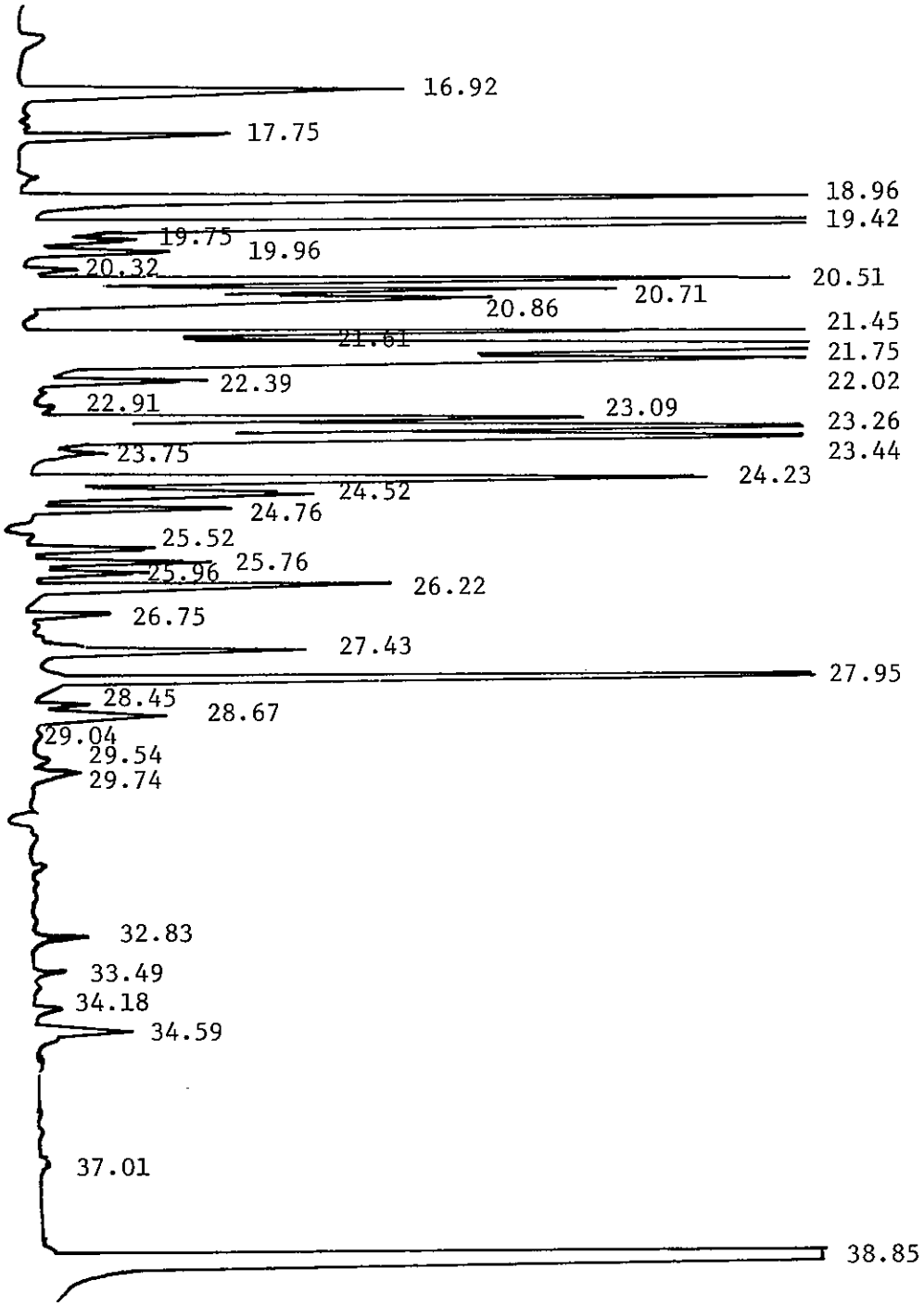


Figure 4. Chromatograph of Aroclor 1248 standard at 0.5 ppm.

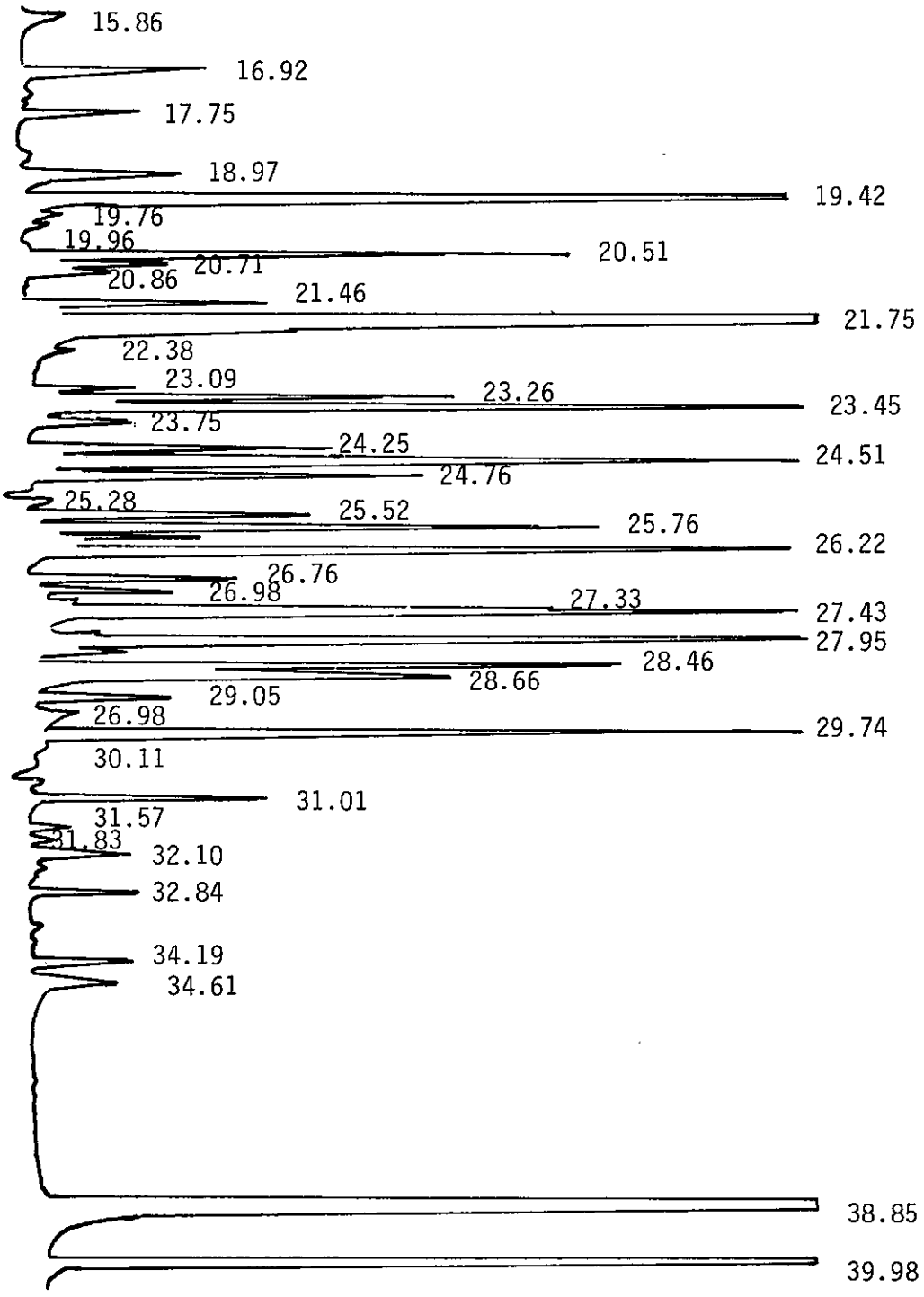


Figure 5. Chromatograph of Aroclor 1254 standard at 0.5 ppm.

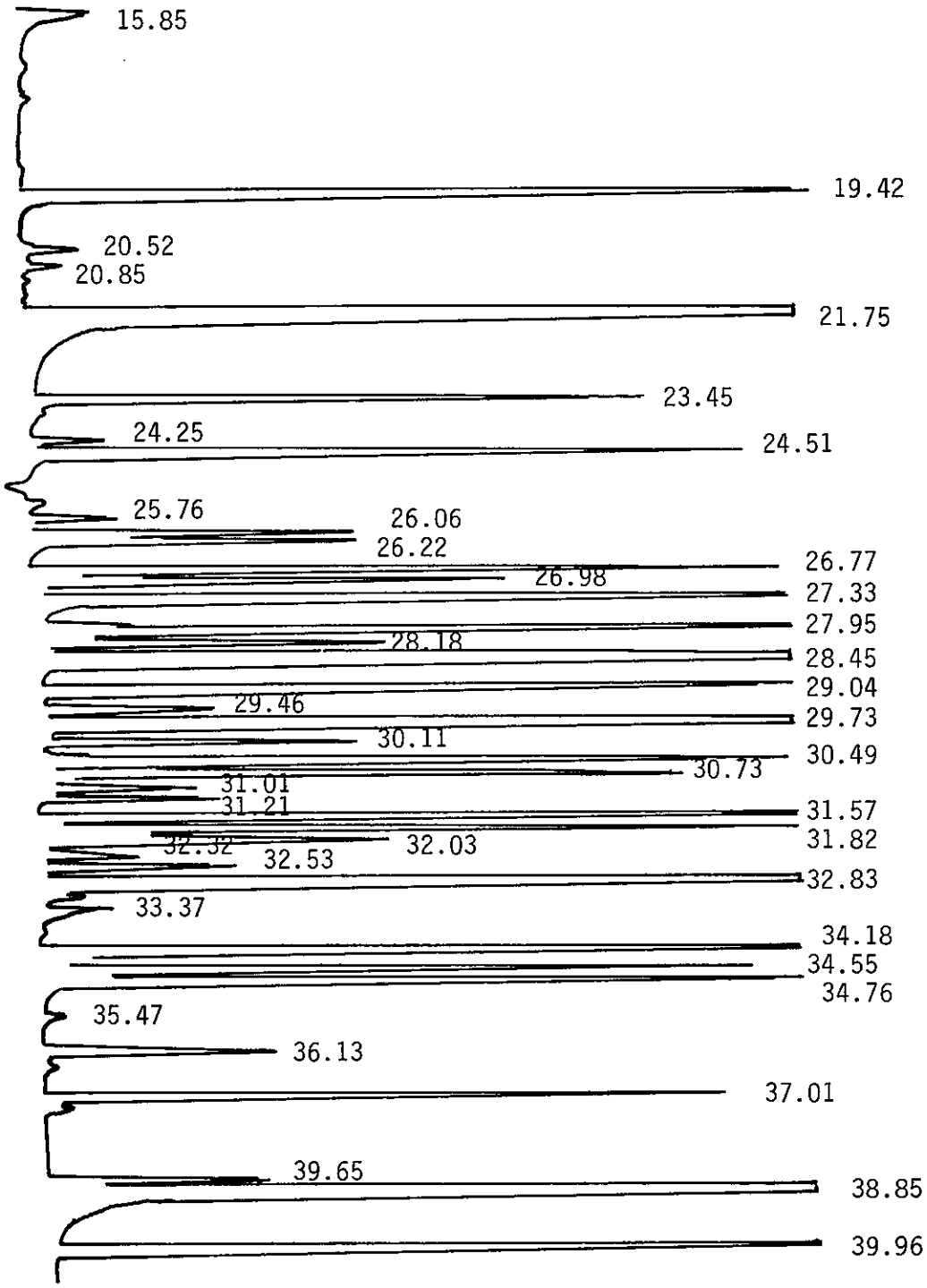


Figure 6. Chromatograph of Aroclor 1260 standard at 0.5 ppm.

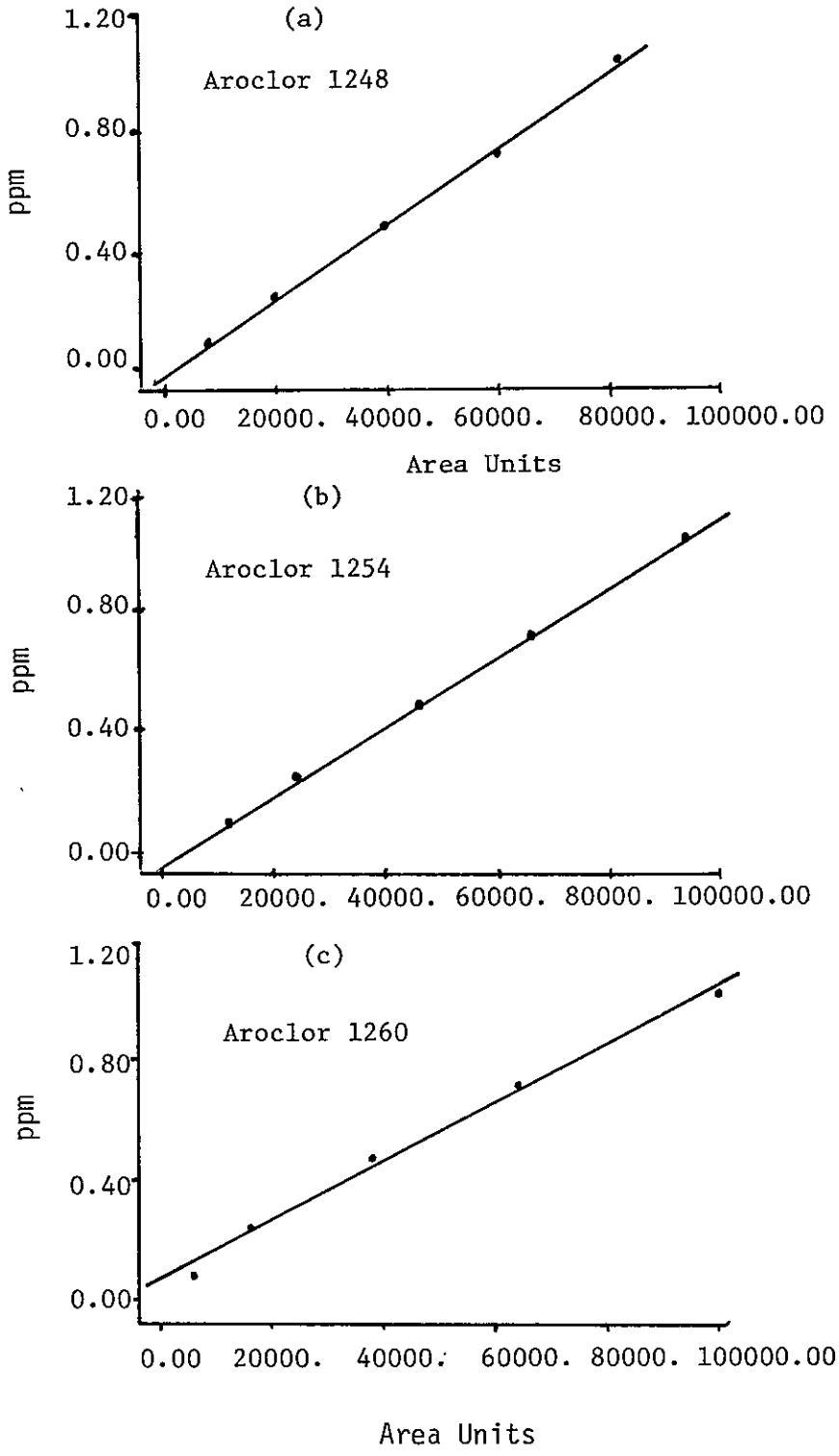


Figure 7. Standard curves for Aroclor mixtures. Curves are drawn by plotting the amount of PCB Aroclor versus the summation of the area units corresponding to selected major peaks from chromatographs in Figure 2. (a) Aroclor 1248, (b) Aroclor 1254, (c) Aroclor 1260.

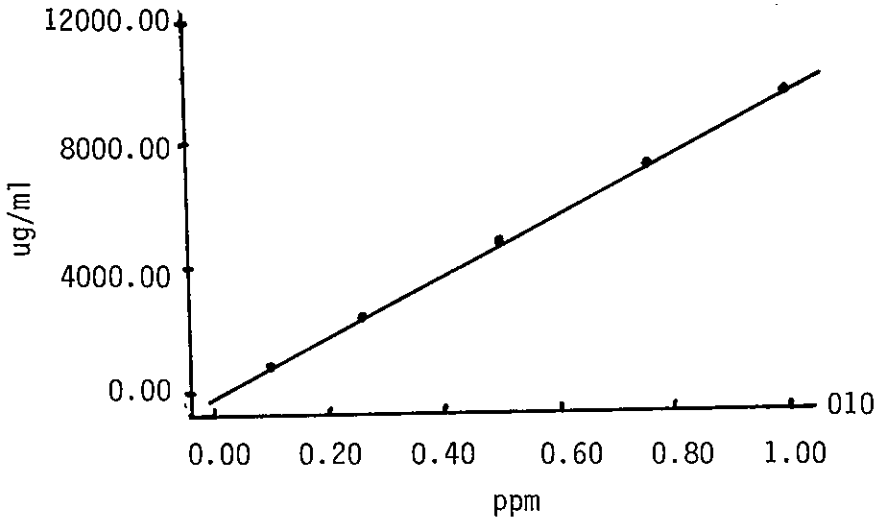


Figure 8. 2,3,3',4',6 pentachloro biphenyl response curve. Retention time, 26.22 minutes. Compound from a standard mixture of PCB isomers and pesticides.

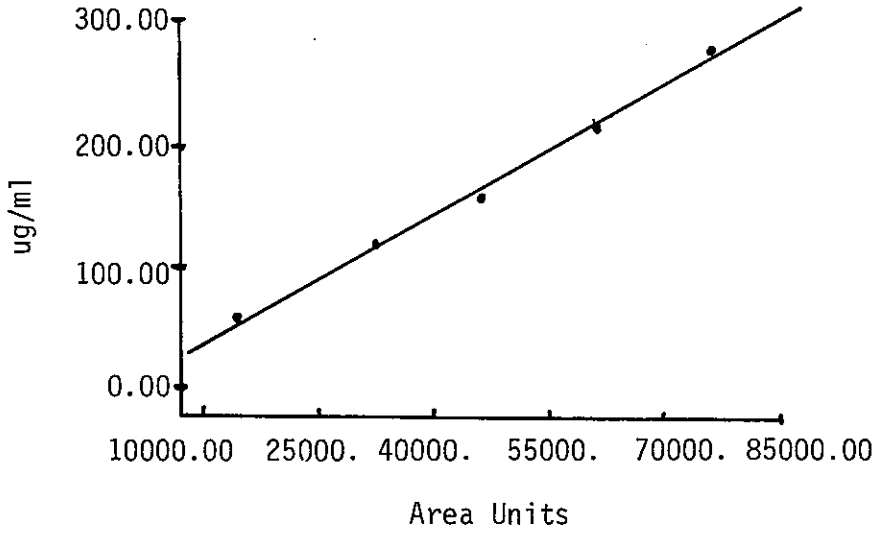


Figure 9. Decafluorobenzophenone (internal standard) response curve.

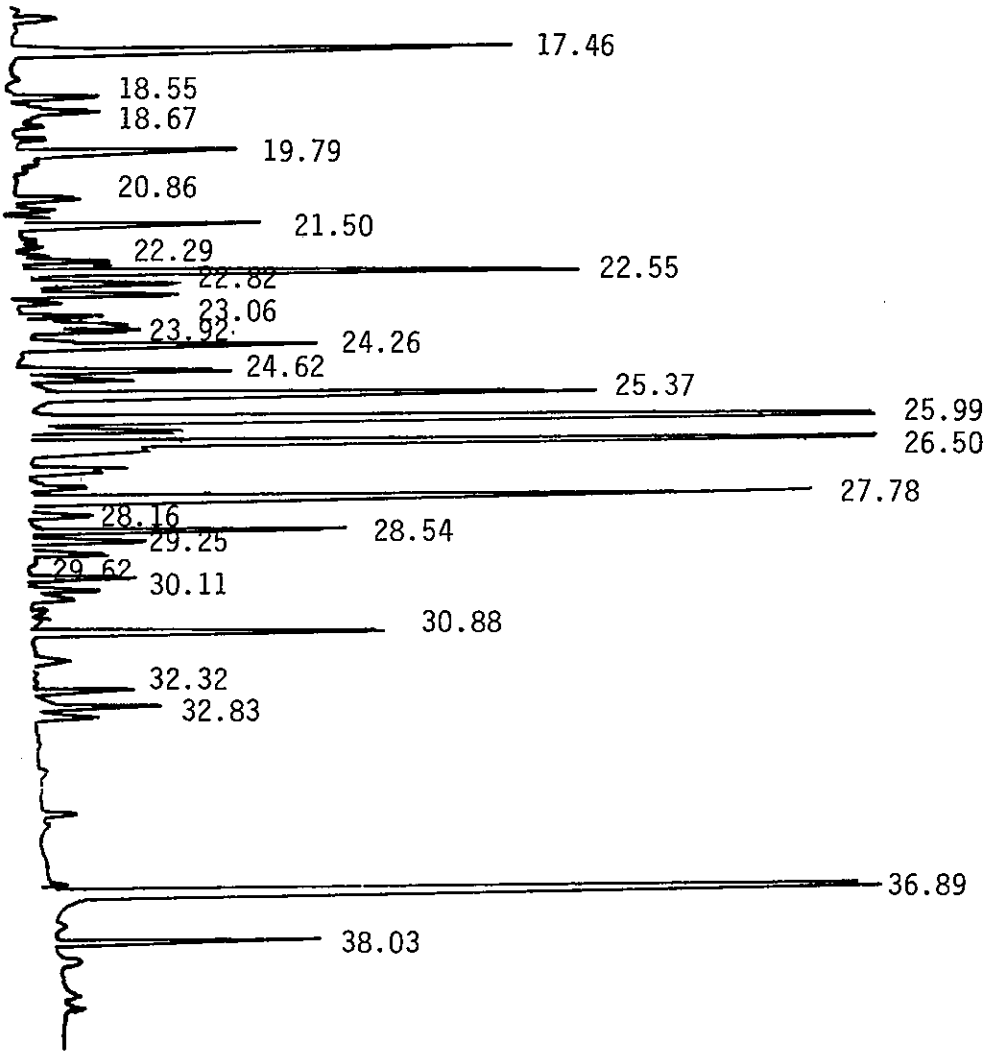


Figure 10. Typical sample chromatograph of squid.

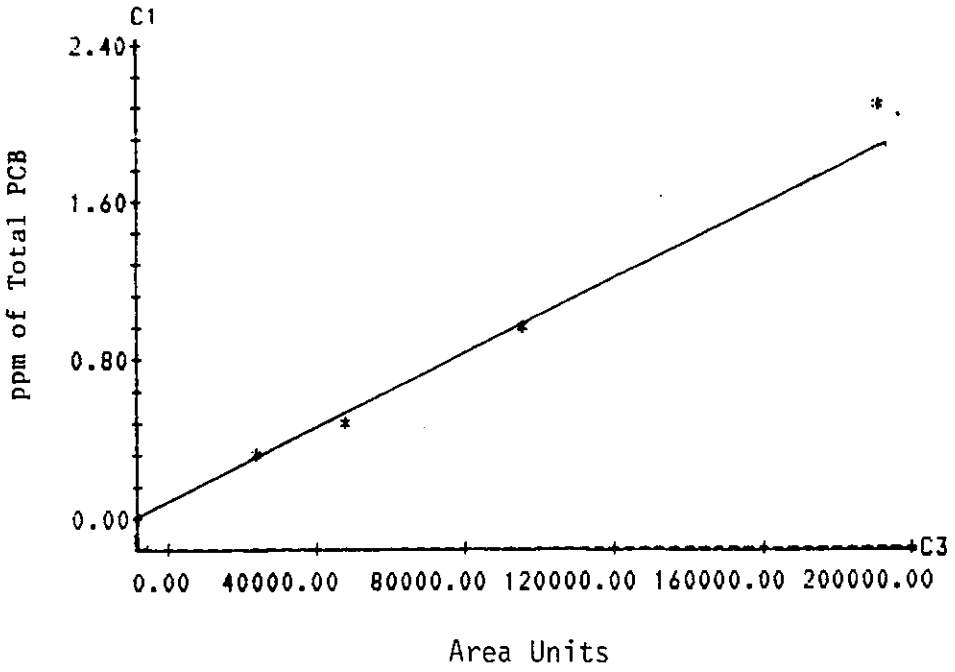


Figure 11. Standard curve for 1:2:6 ratio of Aroclors 1248:1254:1260.

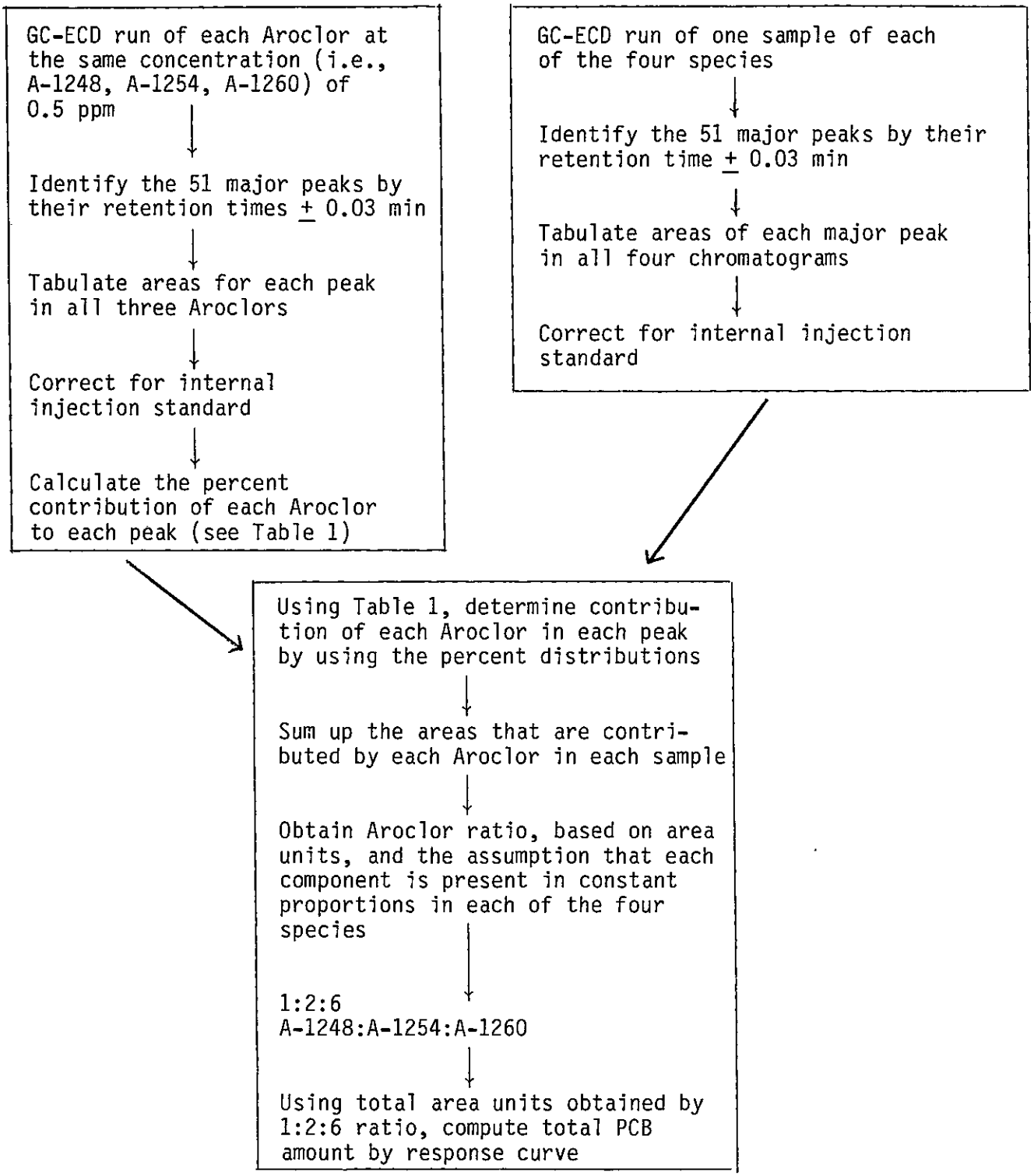


Figure 12. Schematic of PCB quantification.

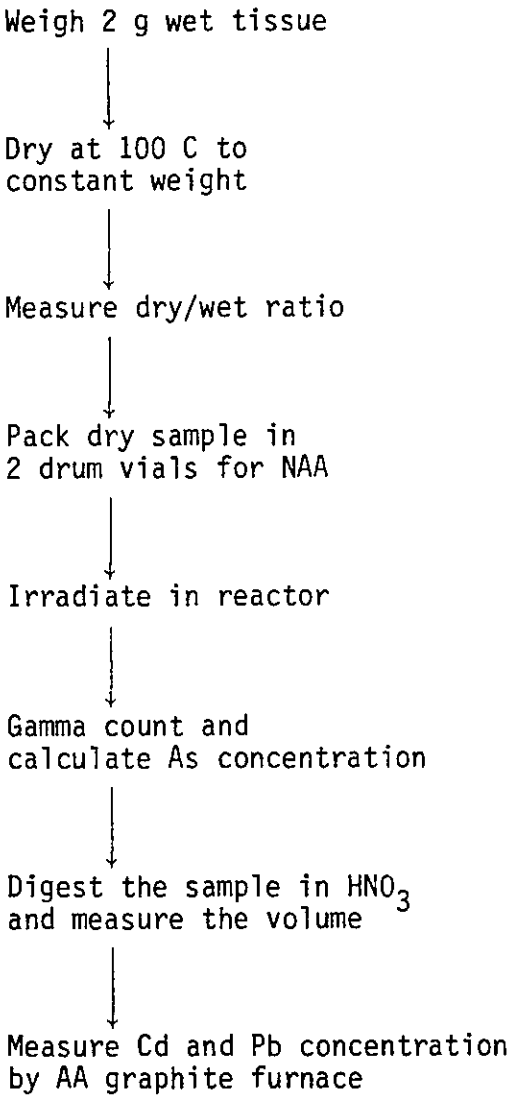


Figure 13. Schematic of sample preparation for As, Cd, and Pb measurments.

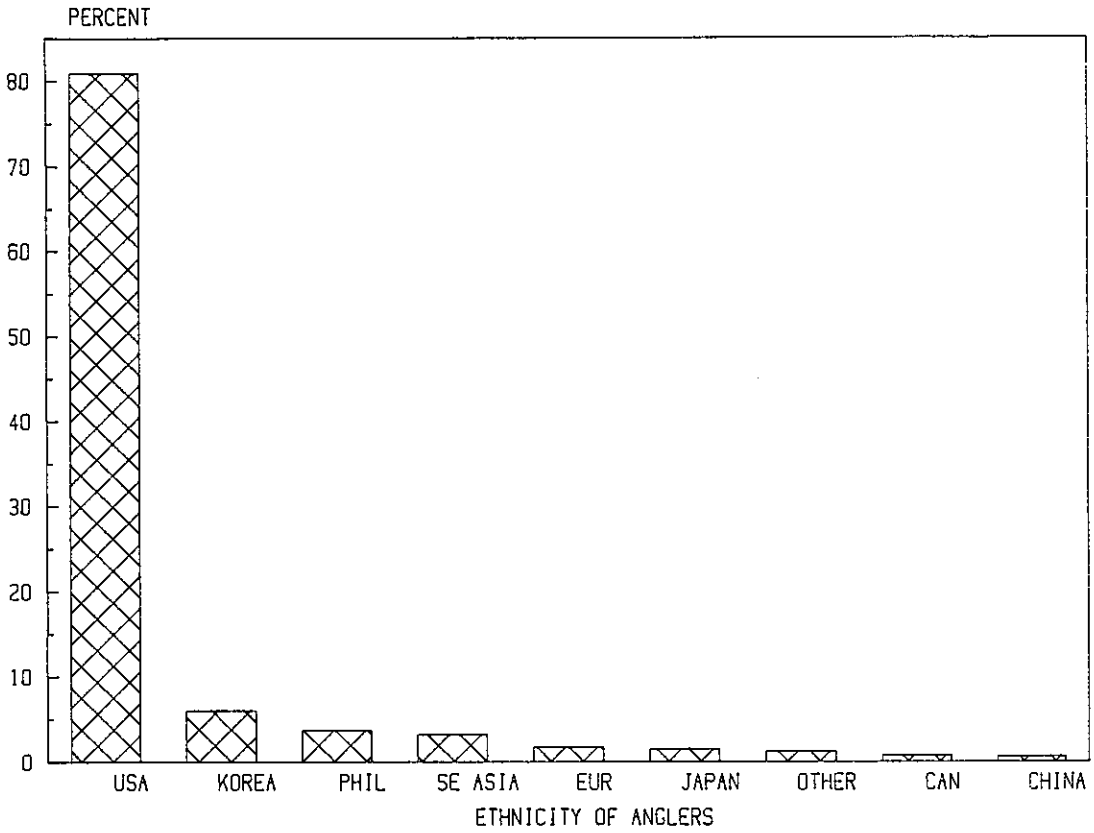


Figure 14. Distribution of anglers by ethnic group. Values are summarized for all four embayments.

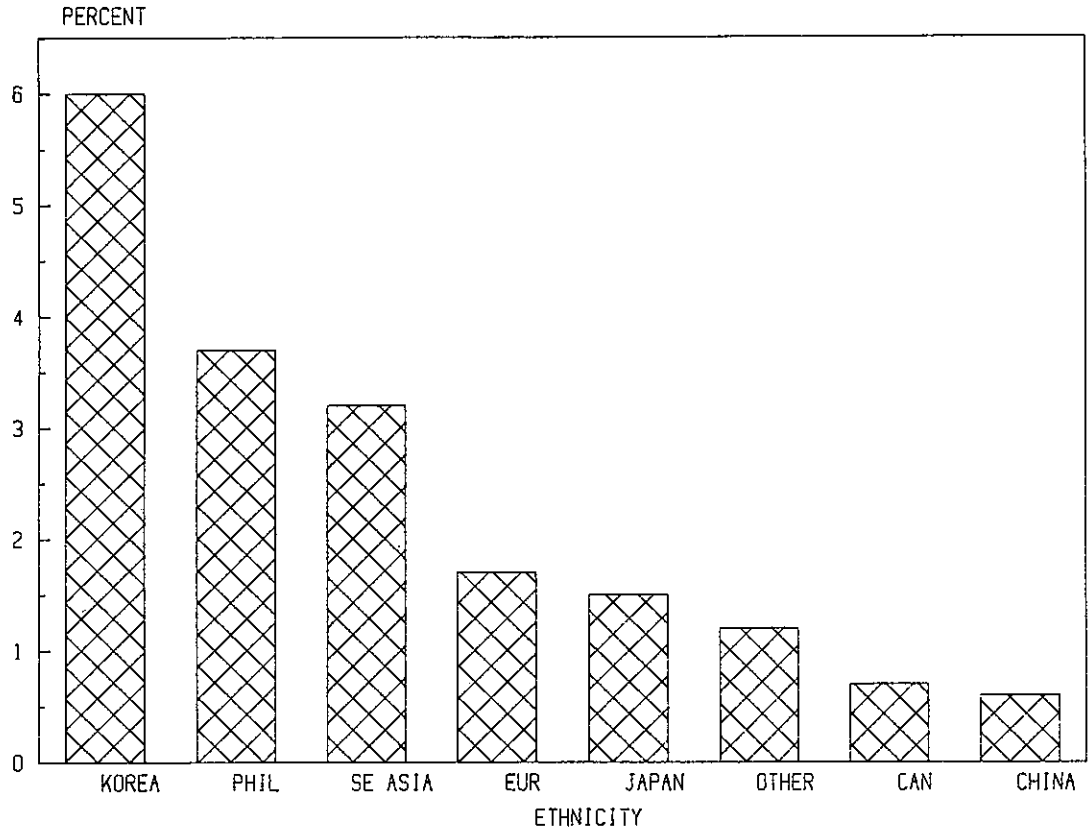


Figure 15. Ethnic distribution of non-U.S. born anglers. Values summarized for all four embayments.

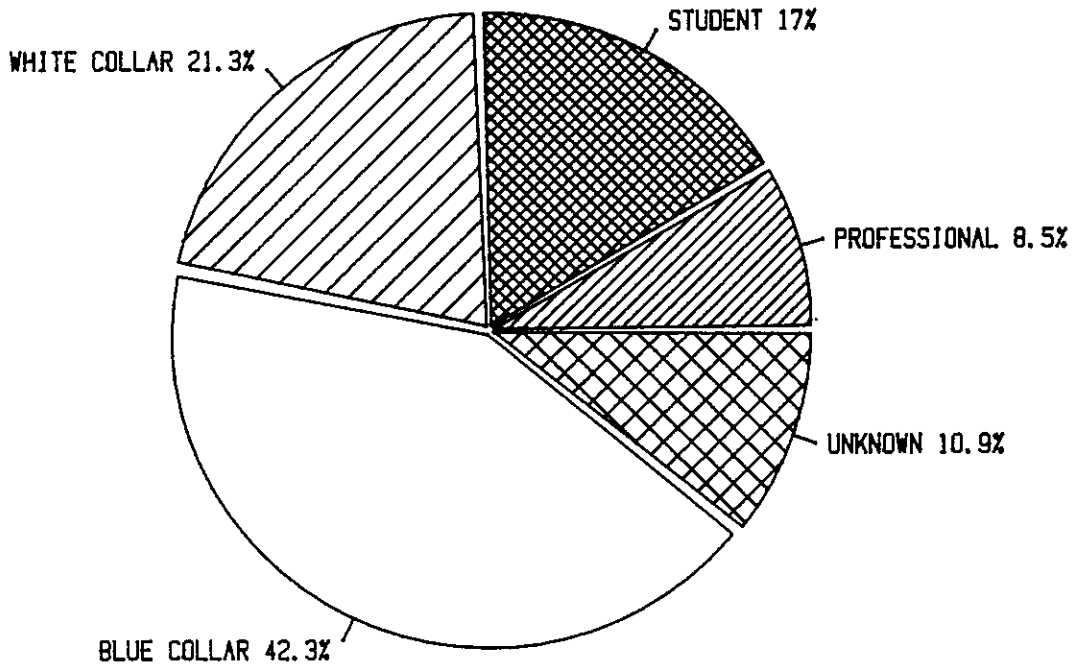


Figure 16. Occupation of those anglers who were employed (Table 13) for all four embayments.

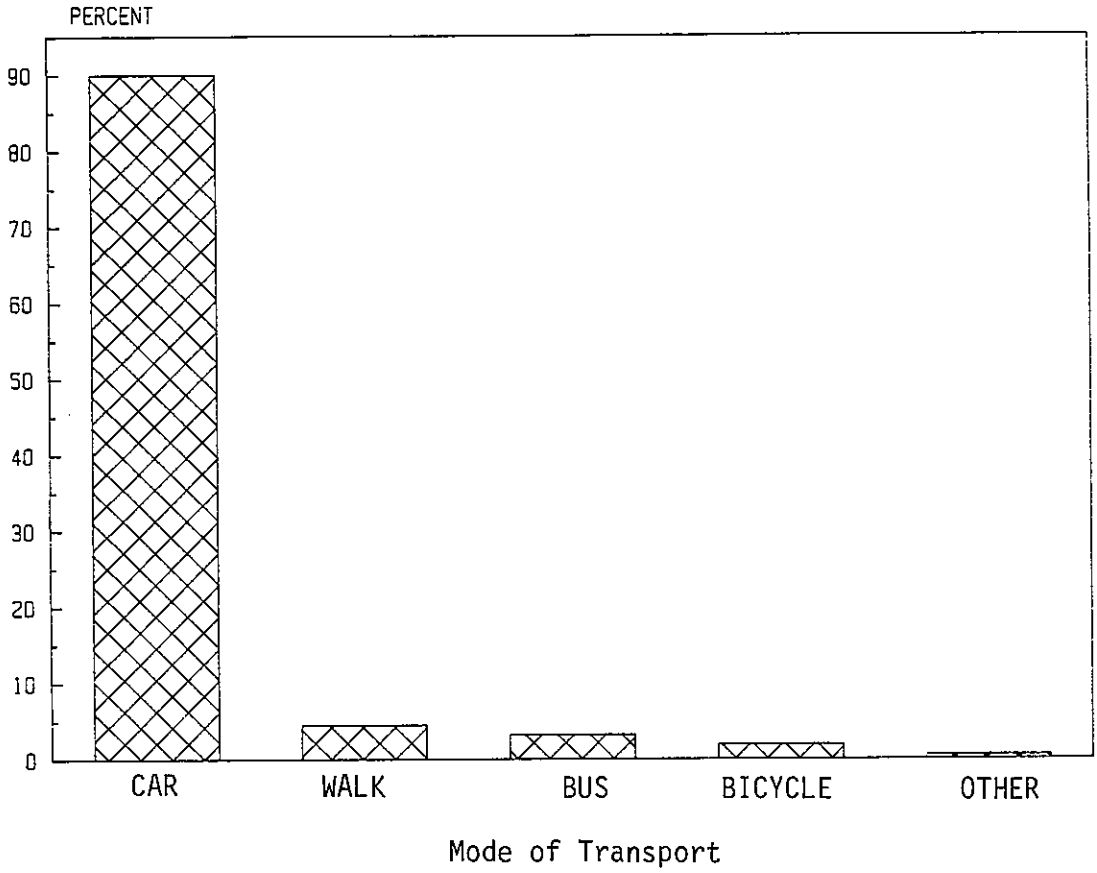


Figure 17. Mode of transportation to angling site. Values are summarized for all four embayments.

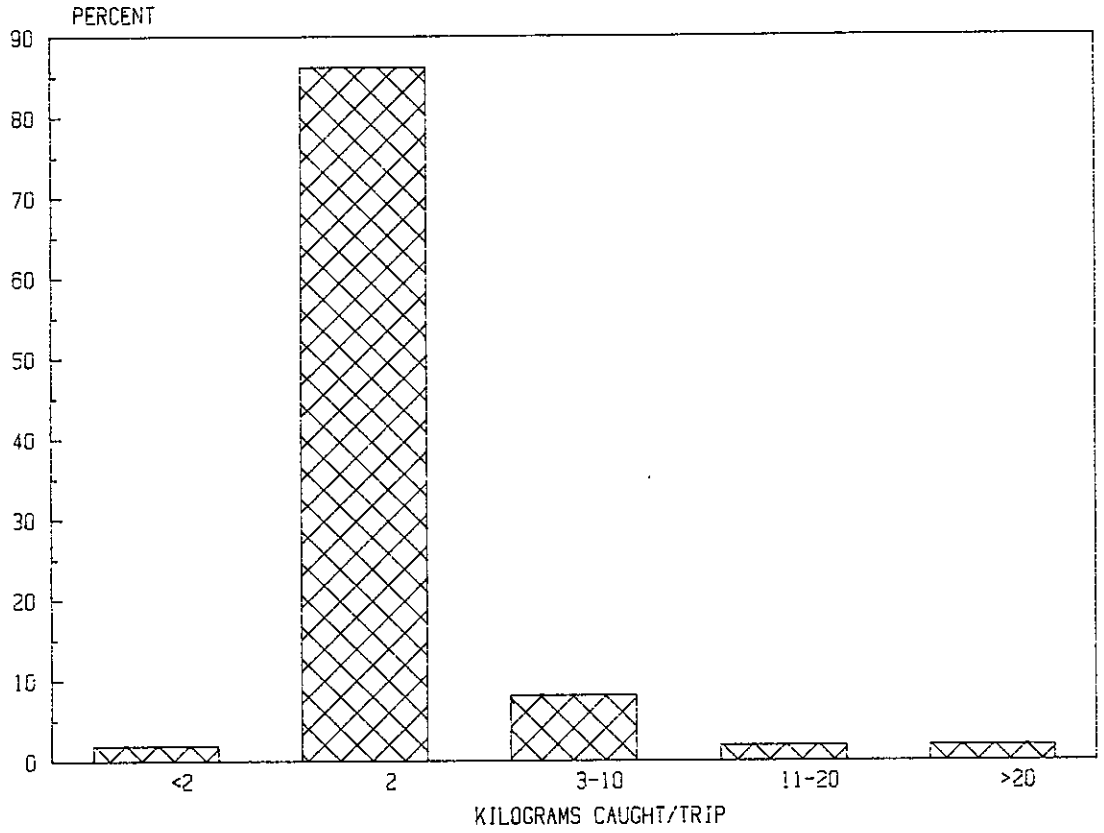


Figure 18. Number of kilograms taken by successful anglers per trip. Values summarized for all four embayments.

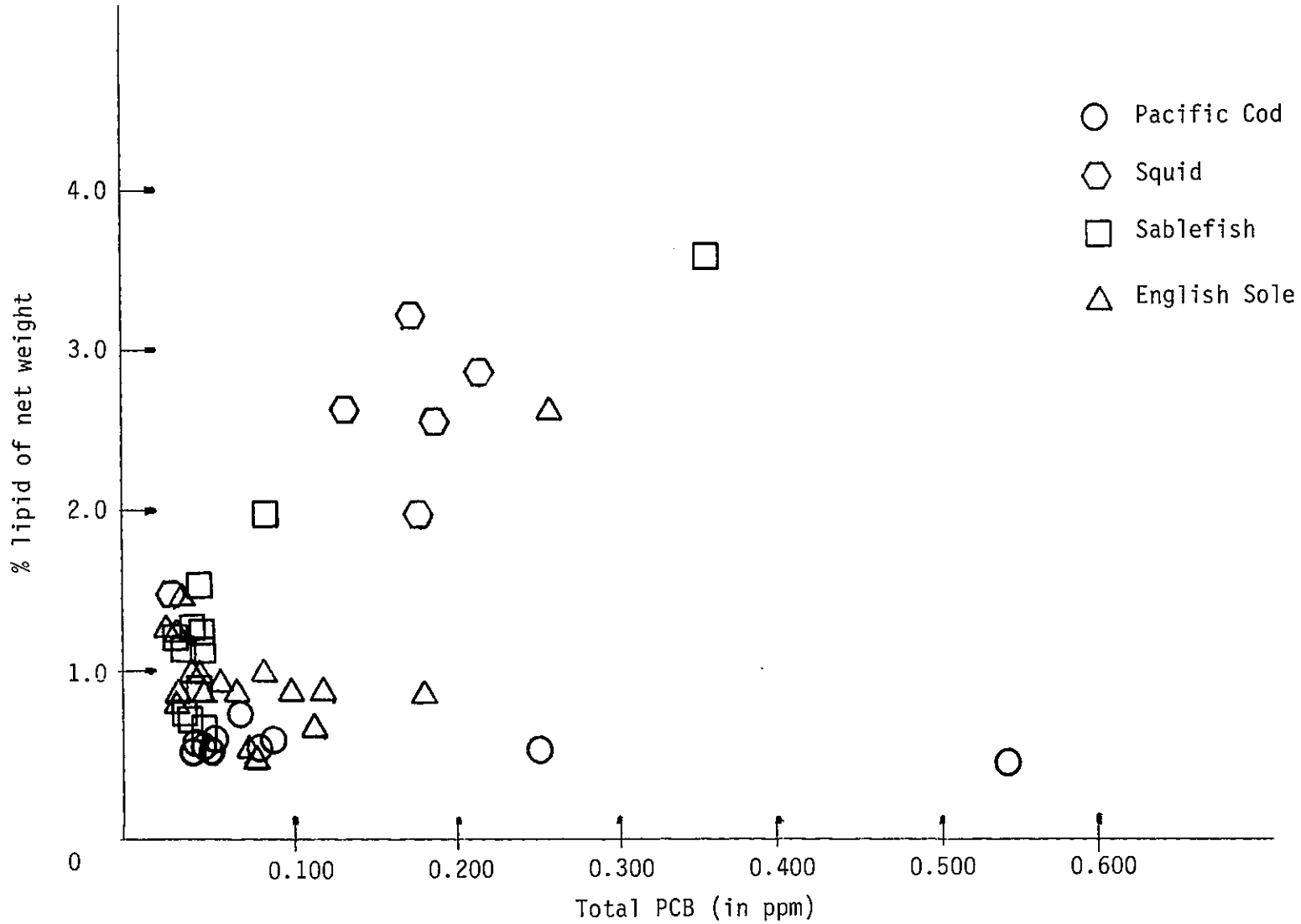


Figure 19. Concentration of PCB versus percent lipid content in muscle tissue of different fish species.

FISHING SITE DESCRIPTION

Site _____ Location _____

Interviewer _____ Interview nos. _____ - _____

Date __/__/__ Time _____A.M./P.M. Day of week _____

Tide: High/Low Time _____A.M./P.M. Peak high/low _____ (ft.)

Weather: Temperature (°F) _____ Rain/Snow/Wind/Fog/Clear/Partly cloudy/Overcast

Comments _____

****

No. of anglers _____ % regulars _____

Predominant group type (families, friends, alone, etc.) _____

Predominant race _____ Predominant age _____

What are most people fishing for? _____

Fishing preference:

Tide _____

Time of day _____

Day of week _____

Season/Species _____

Weather _____

Other _____

Comments:

5/21/84

APPENDIX B

Field Survey Form

Date: ___/___/___ Day . . . . . Time: ___:___ am/pm Interview # _____

Site: . . . . . Location: . . . . . Surveyor: . . . . . .

Mode: 1. Dock 2. Beach 3. Bridge 4. Boat 5. . . . . (_)

Race: . . . . . Sex: Male/Female Age: (___)

Previous interview? Yes/No Interview status: 1. Agree 2. Disagree 3. Language barrier

Group type: 1. Alone 2. Family 3. Friends 4. Both 2&3 (_) Group size (___) Person # ____

What are you trying for? . . . . . (_____)

May I examine your catch? 1. Nothing caught 2. Yes 3. No 4. Not available (_)

****

WEIGH FISH ONLY IF GREATER THAN 99 cm.

Species	No.	Length (cm) or Weight (kg)	Will eat?	Parts consumed*	Preparation method**
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)
. . . . .	(___)	_____	. . .(_)	. . . . . (_)	. . . . . .(_)

* 1. Entire 2. Muscle 3. Skin 4. Entrails 5. Broth 6. Other

** 1. Raw 2. Boil 3. Bake 4. Fry 5. Smoke 6. BBQ 7. Steam 8. Broil 0. Stir-fry

****

How often do you fish here? (___1st) (___2nd) (___per week) (___per month) (___per year)

When did you last use this area? (___days) How long were you out? (___hrs,___min)

When did you last catch and eat something from this area? (___days)

	Species	No.	Species	No.	Species	No.
What did you get?	. . . . .	(__)	. . . . .	(__)	. . . . .	(__)

How many people will eat these fish? (_____)

City of residence: . . . . . .(____) Zip code: (_____)

Country of origin: . . . . . (_____)

How did you get here? 1. Car 2. City bus 3. Walked 4. Bicycle 5. . . . . (__)

What time did you arrive? ___:___am/pm When will you leave? ___:___am/pm

Occupation: (_____) Currently employed? Yes/No Years of schooling (____)

English Sole

PCB concentrations expressed as chlorine content of isomer group (2= isomers of dichlorobiphenyl, 3= etc.) Values in ppm and percent.

Elliott Bay

Sample I,D,		2	3	4	5	6	7	8
185		0	.0007	,0010	.0041	.0025	.0009	.0008
	%	0	6.6	9.8	41.4	25.0	8.8	8.3
186		0	.0008	.0010	.0051	.0032	.0049	.0011
	%	0	4.7	6.5	31.6	19.8	30.8	6.7
187		0	.0011	.0045	.0125	.0112	.0140	.0028
	%	0	2.3	9.5	26.6	23.9	29.8	8.0
188		0	.0031	.0005	.0060	.0023	.0018	.0014
	%	0	20.6	3.0	40.0	15.1	11.7	9.5
189		0	.0010	.0008	.0034	.0019	.0010	.0008
	%	0	10.8	9.2	38.2	21.5	11.4	9.0

Appendix C cont.

English Sole — PCB concentration expressed as chlorine content of isomer group(2= isomers of dichlorobiphenyl, 3= etc.)
Values in ppm and percent.

Commencement Bay

Sample I.D.		2	3	4	5	6	7	8
48		0	.0014	.0089	.0364	.0194	.0089	.0021
	%	0	1.8	11.6	47.3	25.2	11.5	2.7
49		0	.0033	.0131	.0563	.0335	.0151	.0036
	%	0	2.6	10.5	45.0	26.8	12.1	2.9
51		0	.0042	.0092	.0236	.0166	.0073	.0011
	%	0	6.8	14.8	38.0	26.8	11.8	1.8
65		0	.0004	.0035	.0130	.0103	.0061	.0017
	%	0	1.1	10.1	37.2	29.5	17.3	4.8
Edmonds								
33		0	.0004	.0009	.0081	.0067	.0043	.0006
	%	0	2.0	4.3	38.4	31.9	20.7	2.7
118		0	0	.0006	.0069	.0045	.0024	.0015
	%	0	0	4.0	43.4	28.4	14.7	9.5
154		0	.0004	.0006	.0058	.0040	.0027	.0005
	%	0	3.1	4.3	41.2	28.8	19.2	3.4
155		0	.0025	.0018	.0101	.0058	.0030	.0011
	%	0	9.5	7.3	42.0	24.1	12.6	4.5
155-I		0	.0007	.0020	.0109	.0066	.0033	.0006
	%	0	2.9	8.4	45.4	27.5	13.7	2.3
173		0	.0005	0	.0028	.0040	.0063	.0035
	%	0	2.8	0	16.2	23.5	37.1	20.5
Bremerton								
88		0	.0004	.0004	.0052	.0073	.0063	.0026
	%	0	2.0	1.6	23.5	33.3	28.0	11.7
89		0	.0009	.0037	.0192	.0203	.0080	.0029
	%	0	1.6	6.8	34.9	36.9	14.6	5.3
90		0	.0032	.0023	.0161	.0109	.0089	.0055
	%	0	6.9	4.8	34.2	23.2	19.0	11.7
95		0	.0016	.0077	.0647	.0493	.0180	.0077
	%	0	1.1	5.2	43.4	33.1	12.1	5.2

Sablefish

PCB concentration expressed as chlorine content of isomer group (2= isomers of dichlorobiphenyl, 3= etc.) Values in ppm and percent.

Sample I.D.		2	3	4	5	6	7	8
8		0	.0010	.0007	.0014	.0035	.0026	.0010
	%	0	9.7	7.1	13.6	34.5	25.5	9.5
29		0	.0004	.0008	.0080	.0106	.0055	.0018
	%	0	1.4	2.8	29.5	39.2	20.3	6.8
D-20		0	.0013	.0030	.0089	.0033	.0043	.0013
	%	0	5.7	13.7	40.5	14.9	19.4	5.7
D-21-I		0	.0029	.0017	.0067	.0028	.0017	.0002
	%	0	17.9	10.6	42.1	17.2	10.7	1.5
D-24		0	.0005	.0012	.0076	.0071	.0041	.0014
	%	0	2.2	5.4	34.7	32.4	18.7	6.5
D-29		0	.0010	.0062	.0186	.0167	.0103	.0021
	%	0	1.9	11.2	33.9	30.4	18.7	3.9
D-30		0	.0004	.0010	.0039	.0025	.0021	.0010
	%	0	4.0	8.8	35.3	23.1	19.3	9.5
D-31		0	.0018	,0139	.0467	.0418	.0409	.0060
	%	0	1.2	9.2	30.9	27.7	27.1	4.0
D-32		0	.0020	.0029	.0110	.0041	.0041	.0008
	%	0	8.0	11.6	44.4	16.2	16.5	3.3
D-34		0	.0014	.0029	.0072	.0090	.0017	.0009
	%	0	5.9	12.8	31.2	39.0	7.2	4.0
D-35		0	.0004	.0007	.0071	.0077	.0069	.0042
	%	0	1.3	2.5	26.3	28.5	25.7	15.6
D-36		0	.0007	.0014	.0056	.0033	.0022	.0007
	%	0	5.3	9.7	40.0	23.9	16.0	5.1

Appendix C cont.

Squid

PCB concentration expressed as chlorine content of isomer group (2= isomers of dichlorobiphenyl, 3= etc.)
Values in ppm and percent.

Sample I.D.		2	3	4	5	6	7	8
38		.0003	.0022	.0068	.0350	.0344	.0238	.0023
	%	0.3	2.1	6.5	33.3	32.8	22.7	2.2
39		0	.0011	.0041	.0177	.0167	.0091	.0022
	%	0	2.1	8.1	34.8	32.7	17.9	4.4
42		0	.0038	.0124	.0594	.0434	.0197	.0021
	%	0	2.7	8.8	42.1	30.8	14.0	1.5
44		0	.0019	.0059	.0352	.0340	.0193	.0038
	%	0	1.9	5.9	35,2	34.0	19.3	3.8
45		0	.0009	.0013	.0064	.0051	.0033	.0010
	%	0	5.1	7.1	35.8	28.4	18.2	5.4
46		.0005	.0022	.0085	.0555	.0515	.0335	.0063
	%	0.3	1.4	5.3	35.1	32.6	21.2	4.0

Appendix C cont.

Pacific Cod

PCB concentration expressed as chlorine content of isomer group (2=isomers of dichlorobiphenyl, 3= etc.) Values in ppm and percent.

Sample I.D.		2	3	4	5	6	7	8
59		0	0	.0030	.0542	.1233	.0799	.0103
	%	0	0	1.1	20.0	45.5	29.5	3.8
161		0	.0007	.0058	.0708	.1991	.1196	.0178
	%	0	0.18	1.4	17.1	48.1	28.9	4.3
161-I		0	.0006	.0046	.0674	.1335	.0896	.0121
	%	0	0.20	1.5	21.8	43.2	29.0	3.9
175		0	.0008	.0019	.0077	.0092	.0056	.0008
	%	0	2.9	7.4	29.6	35.5	21.5	3.2
176		0	.0009	.0027	.0148	.0314	.0183	.0040
	%	0	1.3	3.7	20.6	43.6	25.4	5.6
200		0	.0012	.0030	.0110	.0142	.0064	.0022
	%	0	3.1	7.8	29.0	37.3	16.8	5.9
201		0	0	0	.0083	.0150	.0074	.0028
	%	0	0	0	24.3	44.0	21.8	8.1
D-2		0	.0016	.0018	.0073	.0068	.0041	.0014
	%	0	6.9	7.8	31.6	29.8	17.8	6.1
D-14		0	.0015	.0033	.0160	.0347	.0170	.0055
	%	0	1.9	4.2	20.5	44.5	21.8	7.1
D-28		0	.0012	.0013	.0073	.0063	.0025	.0014
	%	0	5.9	6.5	36.7	31.4	12.7	6.8

APPENDIX D

Concentrations of specific PCB isomers with percent recoveries of Cl_8 Napthalene and Cl_{10} - biphenyl.

English Sole (1)

Retention Time(min)	PCB Isomer conformation	Area Units/ 1 ng	Sample Number 49	33	48	51	65	88	89	90	95	118
16.92	2,2',5	52	0.65	-	0.54	1.65	-	-	-		0.79	-
20.51	2,2',5,5'	57	18.96	0.21	10.35	10.85	6.82	-	3.27	4.06	6.04	0.44
21.46	2,2',3,5'	39	4.90	0.25	3.63	6.22	-	-	1.07	1.55	3.17	0.13
23.44	2,2',3,5',6	44	22.42	2.81	37.69	17.26	11.11	1.38	-	5.07	32.47	1.61
24.51	2,2',4,5,5'	43	71.28	6.49	57.51	30.95	20.51	6.05	28.35	12.86	65.67	5.67
25.75	2,3,4,5,6	72	13.83	1.73	11.91	4.85	4.44	1.29	5.02	2.82	11.00	1.84
26.23	2,3,3',4',6	42	75.77	9.74	61.68	24.64	17.52	5.99	26.92	18.05	67.38	8.58
27.43	2,3',4,4',5	29	140.86	11.06	149.45	59.59	-	8.73	41.75	20.27	125.03	10.07
28.45	2,2',4,4',5,5'	55	73.08	14.51	61.59	42.06	16.88	12.68	39.60	21.51	106.66	8.43
29.74	2,2',3,4,4',5'	47	103.41	17.61	84.96	46.42	20.47	18.14	50.72	26.41	144.98	9.77
30.73	2,2',3,4,4',5',6	72	5.46	1.74	4.05	2.89	2.82	1.80	3.30	3.65	9.80	0.84
31.01	2,2',3,3',4,4'	41	20.67	4.03	14.64	8.24	4.69	4.76	8.77	9.64	21.59	1.86
32.84	2,2',3,3',4,4',5,5'	49	24.00	8.06	23.04	15.88	8.45	8.86	10.84	12.73	34.55	3.71
34.19	2,2',3,3',4,4',5	46	11.02	3.00	8.70	5.35	3.31	5.00	7.14	8.18	22.99	1.67
37.01	2,2',3,3',4,4',5,5'	46	4.01	0.99	3.19	2.33	1.79	2.89	3.60	70.03	9.16	1.40
Total nanograms			590.32	82.24	532.93	279.18	118.8	77.55	230.33	153.86	661.30	56.02
(Not corrected) Estimated PCB in ppm			.195	.027	.184	.092	.039	.026	.074	.050	.220	.018
Using 1:2:6 ratio; (corrected) est. PCB in ppm			.190	.029	.106	.115	.068	.039	.100	.047	.259	.021
% Recovery (x100) during extraction (Cl_8 Napthalene)			.90	1.12	.73	1.03	.87	.89	.87	1.00	.81	1.06
% Recovery (x100) during column cleanup (Cl_{10} 02)			.73	.72	1.00	.54	.59	.64	.63	1.00	.71	.76
Total area units quantified for 1:2:6 ratio			37384	6287	33628	18530	10431	6372	17030	14542	44240	4929

Appendix D cont.

English Sole (2)

Retention Time(min)	PCB Isomer conformation	Area Units/ 1 ng	Sample Number 154	155	155-I	173	185	186	187	189	188
16.92	2,2',5	52	-	0.98	-	-	-	-	-	0.29	-
20.51	2,2',5,5'	57	-	1.86	1.91	-	0.42	1.82	2.77	1.08	0.16
21.46	2,2',3,5'	39	-	0.73	0.58	-	-	0.79	3.15	0.36	-
23.44	2,2',3,5',6	44	3.14	4.23	4.75	0.68	2.53	3.62	6.31	1.67	1.81
24.51	2,2',4,5,5'	43	8.05	13.51	15.79	3.91	4.12	4.63	8.93	4.37	-
25.75	2,3,4,5,6	72	1.60	2.36	2.70	0.48	1.26	2.19	2.82	0.94	1.48
26.23	2,3,3',4',6	42	8.00	10.53	13.24	2.79	6.18	7.28	13.92	-	5.65
27.43	2,3',4,4',5	29	9.28	19.31	21.03	4.34	4.69	4.49	13.29	5.14	4.21
28.45	2,2',4,4',5,5'	55	7.50	14.78	16.33	9.18	3.28	4.85	14.89	3.65	3.74
29.74	2,2',3,4,4',5'	47	11.04	17.39	19.38	10.49	3.05	7.01	21.25	4.05	4.96
30.73	2,2',3,4,4',5',6	72	0.95	1.14	1.31	2.02	0.56	-	3.47	0.49	0.98
31.01	2,2',3,3',4,4'	41	3.33	2.90	3.02	2.66	1.38	3.67	9.49	1.21	2.10
32.84	2,2',3,3',4,4',5,5'	49	4.14	5.49	6.63	15.20	1.29	5.31	16.45	1.41	2.29
34.19	2,2',3,3',4,4',5	46	1.58	2.19	2.73	4.05	0.56	6.84	11.15	0.63	1.10
37.01	2,2',3,3',4,4',5,5'	46	1.34	1.27	0.95	5.47	0.24	2.97	8.02	0.30	2.67
Total nanograms			59.98	98.69	110.36	59.00	29.56	55.47	135.91	25.58	31.15
(Not corrected) Estimated ΣPCB in ppm			.019	.033	.035	.019	.010	.019	.044	.009	.011
Using 1:2:6 ratio; (corrected) est. ΣPCB in ppm			.032	.081	.038	.048	.022	.026	.047	.020	.023
% Recovery (x100) during extraction (Cl_8 Napthalene)			.80	.56	1.05	.61	.79	.96	1.20	.90	.96
% Recovery (x100) during column cleanup (Cl_{10} $\emptyset_2$)			.57	.57	.63	.59	.60	.66	1.05	.51	.70
Total area units quantified for 1:2:6 ratio			4462	7795	7457	5046	3068	4831	12332	2474	4387

Appendix D cont.

Pacific Cod

Retention Time(min)	PCB Isomer conformation	Area Units/ 1 ng	Sample Number 161.I	59	161	175	176	190	191	D-2	D-14	D-28	D-10
16.92	2,2',5	52	-	-	-	-	-	-	-	-	-	-	-
20.51	2,2',5,5'	57	5.07	-	1.57	1.29	5.81	3.36	-	1.69	3.34	2.33	.90
21.46	2,2',3,5'	39	1.45	-	0.38	-	-	2.59	-	-	2.06	1.02	0.35
23.44	2,2',3,5',6	44	20.09	15.34	9.00	5.27	7.05	5.63	-	4.55	7.92	5.05	1.56
24.51	2,2',4,5,5'	43	147.12	93.23	59.34	10.67	20.05	17.56	6.79	9.47	24.12	8.84	5.09
25.75	2,3,4,5,6	72	16.15	9.54	7.12	2.79	4.74	2.87	-	3.65	3.55	2.02	0.77
26.23	2,3,3',4',6	42	107.79	87.64	49.95	12.38	27.19	15.38	15.17	-	18.68	11.75	3.12
27.43	2,3',4,4',5	29	523.37	274.25	253.80	25.51	69.66	38.12	21.51	28.01	88.63	27.67	10.75
28.45	2,2',4,4',5,5'	55	664.82	459.91	353.74	31.40	134.85	50.37	41.09	28.65	147.59	22.68	8.32
29.74	2,2',3,4,4',5'	47	876.19	531.06	460.55	31.19	97.95	50.38	28.18	26.08	149.83	26.95	10.63
30.73	2,2',3,4,4',5',6	72	77.71	50.13	37.45	2.93	12.56	3.74	4.06	3.13	11.12	1.86	1.66
31.01	2,2',3,3',4,4'	41	154.44	68.62	76.38	6.57	20.82	9.32	7.51	6.38	24.76	5.87	3.11
32.84	2,2',3,3',4,4',5,5'	49	540.82	340.18	288.39	13.24	68.92	21.51	19.18	9.67	81.24	8.69	2.96
34.19	2,2',3,3',4,4',5	46	201.71	126.04	105.45	5.97	27.71	7.32	7.38	5.37	31.99	4.88	1.38
37.01	2,2',3,3',4,4',5,5'	46	46.68	28.08	24.74	2.69	9.50	3.30	4.66	3.62	14.78	2.00	0.67
Total nanograms			3383.39	2084.03	1727.88	151.93	506.82	231.45	155.53	130.27	609.61	131.21	51.31
(Not corrected) Estimated ΣPCB in ppm			.692	.438	.559	.034	.109	.048	.050	.028	.127	.029	.017
Using 1:2:6 ratio; (corrected) est. ΣPCB in ppm			.431	.271	.548	.030	.075	.041	.063	.030	.091	.048	
% Recovery (x100) during extraction (Cl_8 Napthalene)			1.96	1.01	.94	.92	1.00	.94	.72	.77	.89	.66	
% Recovery (x100) during column cleanup (Cl_{10} $\emptyset_2$)			1.14	1.00	.70	.92	.96	.97	.75	1.05	.97	.63	
Total area units quantified for 1:2:6 ratio			197526	121439	94149	11586	32764	17941	10529	10278	36771	9120	4309

Appendix D cont.

Sablefish

Retention Time(min)	PCB Isomer conformation	Area Units/ 1 ng	Sample Number 8	29	D-20	D-21-1	D-24	D-29	D-30	D-31	D-32	D-34	D-35	D-36
16.92	2,2',5	52	0.52	-	0.79	0.90	-	-	-	-	-	-	-	-
20.51	2,2',5,5'	57	-	0.67	3.94	1.22	0.99	3.44	0.32	14.38	3.18	1.98	0.57	1.54
21.46	2,2',3,5'	39	-	0.15	1.57	0.96	0.63	1.68	-	10.68	1.45	1.19	0.18	0.58
23.44	2,2',3,5',6	44	-	1.56	6.36	5.23	3.89	12.85	3.30	40.34	5.41	5.79	1.36	3.19
24.51	2,2',4,5,5'	43	-	7.70	3.88	7.35	7.39	27.05	2.90	61.84	13.44	1.91	8.47	4.00
25.75	2,3,4,5,6	72	0.44	2.20	-	4.22	1.73	5.13	1.26	16.40	2.56	-	1.63	1.63
26.23	2,3,3',4',6	42	2.52	8.27	11.32	7.96	10.00	21.03	5.63	53.05	9.23	-	6.51	7.36
27.43	2,3',4,4',5	29	7.29	16.92	13.08	8.59	10.65	32.16	4.62	-	17.33	24.04	11.88	7.26
28.45	2,2',4,4',5,5'	55	8.23	22.04	10.31	4.45	12.43	45.64	4.64	97.50	-	24.51	18.52	7.65
29.74	2,2',3,4,4',5'	47	10.83	24.04	8.35	5.44	14.34	35.40	6.78	75.40	17.63	23.28	18.98	7.06
30.73	2,2',3,4,4',5',6	72	1.44	2.32	5.94	-	1.37	3.98	1.27	10.61	1.59	2.37	2.65	0.79
31.01	2,2',3,3',4,4'	41	2.78	5.85	3.38	2.12	4.61	6.62	2.44	24.90	3.74	5.22	4.73	2.29
32.84	2,2',3,3',4,4',5,5'	49	7.69	9.76	13.73	1.59	5.71	15.59	3.69	50.29	9.00	-	10.61	3.63
34.19	2,2',3,3',4,4',5	46	2.97	3.72	3.68	1.93	2.45	6.45	1.77	23.40	4.24	4.13	6.19	1.97
37.01	2,2',3,3',4,4',5,5'	46	1.75	2.09	_	0.19	1.47	2.28	0.60	13.12	2.13	2.35	6.03	1.88
Total nanograms			46.46	107.29	86.34	52.17	77.67	219.30	39.23	491.93	90.93	96.78	98.33	50.83
(Not corrected) Estimated PCB in ppm			.015	.035	.029	.017	.026	.071	.013	.159	.030	.029	.032	.017
Using 1:2:6 ratio; (corrected) est. PCB in ppm			.024	.042	.025	.030	.044	.089	.027	.360	.046	.043	.041	.023
% Recovery (x100) during extraction (Cl_8 Napthalene)			.86	.88	1.45	.88	.92	.89	.88	.42	.99	.91	.87	.89
% Recovery (x100) during column cleanup (Cl_{10} $\emptyset_2$)			.50	.74	.85	.59	.55	.70	.49	1.00	.54	.59	.76	.71
Total area units quantified for 1:2:6 ratio			3167	7980	6382	4892	6439	16749	3380	46114	7335	6818	8136	4093

Appendix D cont.

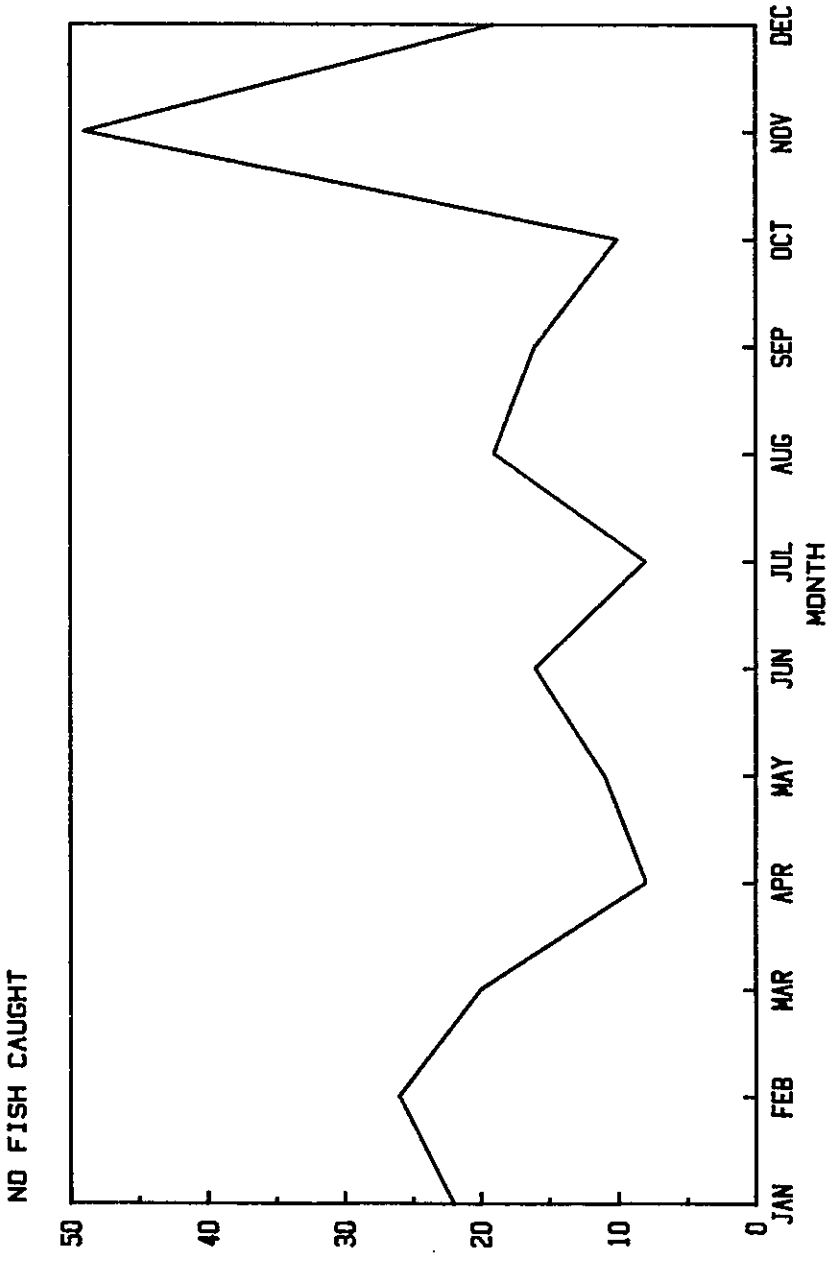
Squid

Retention Time(min)	PCB Isomer conformation	Area Units/ 1 ng	Sample Number 38	39	41	42	44	45	46
16.92	2,2',5	52	2.48	-	-	-	-	-	1.54
20.51	2,2',5,5'	57	7.69	4.70	4.13	13.00	4.40	2.75	10.34
21.46	2,2',3,5'	39	6.55	3.45	1.93	13.15	4.90	1.17	7.54
23.44	2,2',3,5',6	44	25.61	12.04	11.83	38.87	17.24	3.42	38.35
24.51	2,2',4,5,5'	43	48.74	27.05	26.23	76.35	39.63	8.02	84.09
25.75	2,3,4,5,6	72	7.36	3.71	3.26	10.54	6.04	1.66	11.81
26.23	2,3,3',4',6	42	41.39	15.55	14.59	59.20	35.31	8.13	68.75
27.43	2,3',4,4',5	29	-	38.77	-	108.46	71.09	11.75	-
28.45	2,2',4,4',5,5'	55	87.81	51.53	41.77	111.04	80.26	11.93	152.50
29.74	2,2',3,4,4',5'	47	81.84	37.35	32.54	109.96	82.84	9.92	136.20
30.73	2,2',3,4,4',5',6	72	8.18	3.20	3.39	9.17	5.23	1.33	9.90
31.01	2,2',3,3',4,4'	41	11.35	4.83	4.35	10.77	8.67	4.08	14.69
32.84	2,2',3,3',4,4',5,5'	49	27.94	17.12	12.78	33.35	32.16	4.45	45.63
34.19	2,2',3,3',4,4',5	46	11.75	5.71	5.47	11.86	10.41	1.39	42.84
37.01	2,2',3,3',4,4',5,5'	46	3.25	3.02	5.30	4.40	3.49	-	12.26
Total nanograms			371.96	228.03	167.59	610.12	401.69	70.00	636.84
(Not corrected) Estimated PCB in ppm			.124	.072	.057	.198	.134	.023	.200
Using 1:2:6 ratio; (corrected) est. PCB in ppm			.196	.133		.215	.177	.024	.175
% Recovery (x100) during extraction (Cl_8 Napthalene)			.80	.63	.28	.80	.94	.85	.90
% Recovery (x100) during column cleanup (Cl_{10} $\emptyset_2$)			.67	.61		.82	.60	.88	1.44
Total area units quantified for 1:2:6 ratio			30995	15827	13842	42736	29578	5372	49663

APPENDIX E

Monthly catch rate for eight commonly caught species.
Summation of catch based upon individual interviews.

PACIFIC COD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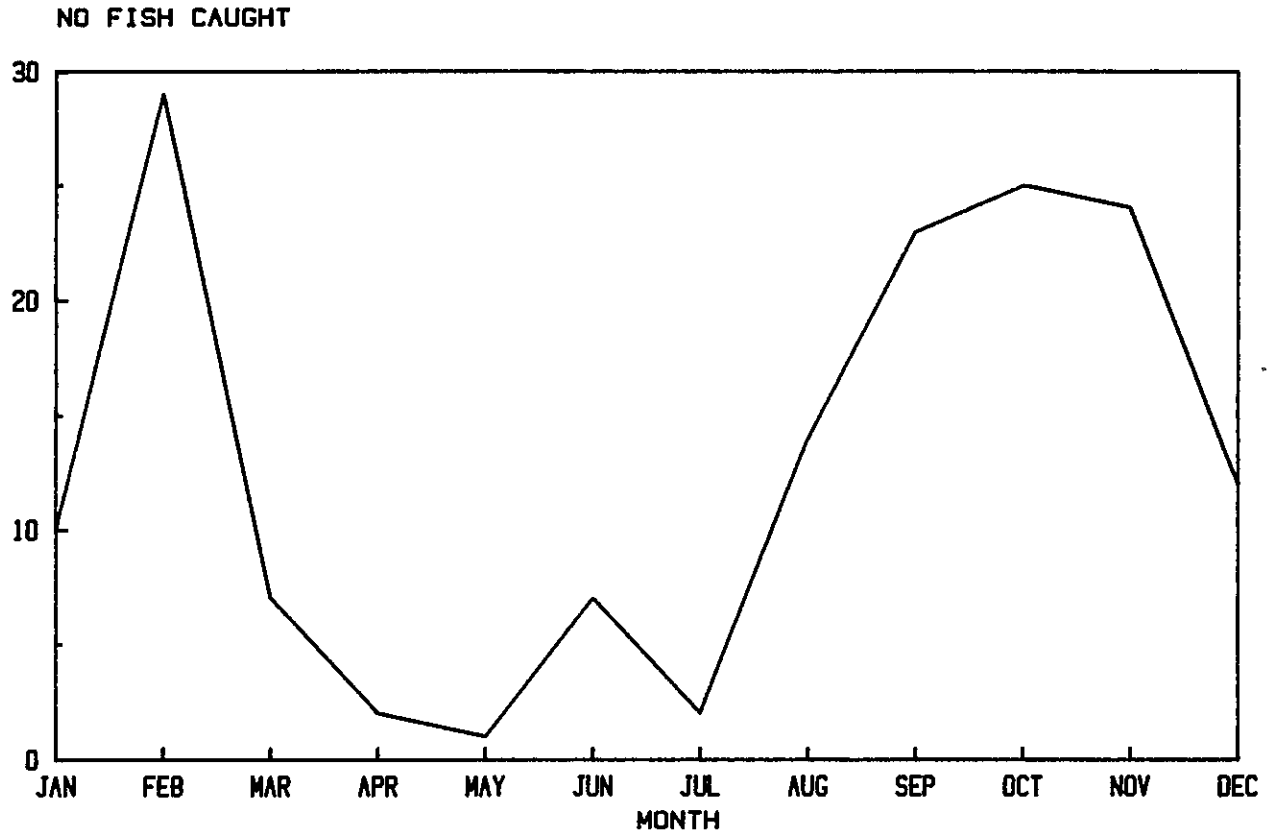
DEC
MONTH

TOMCOD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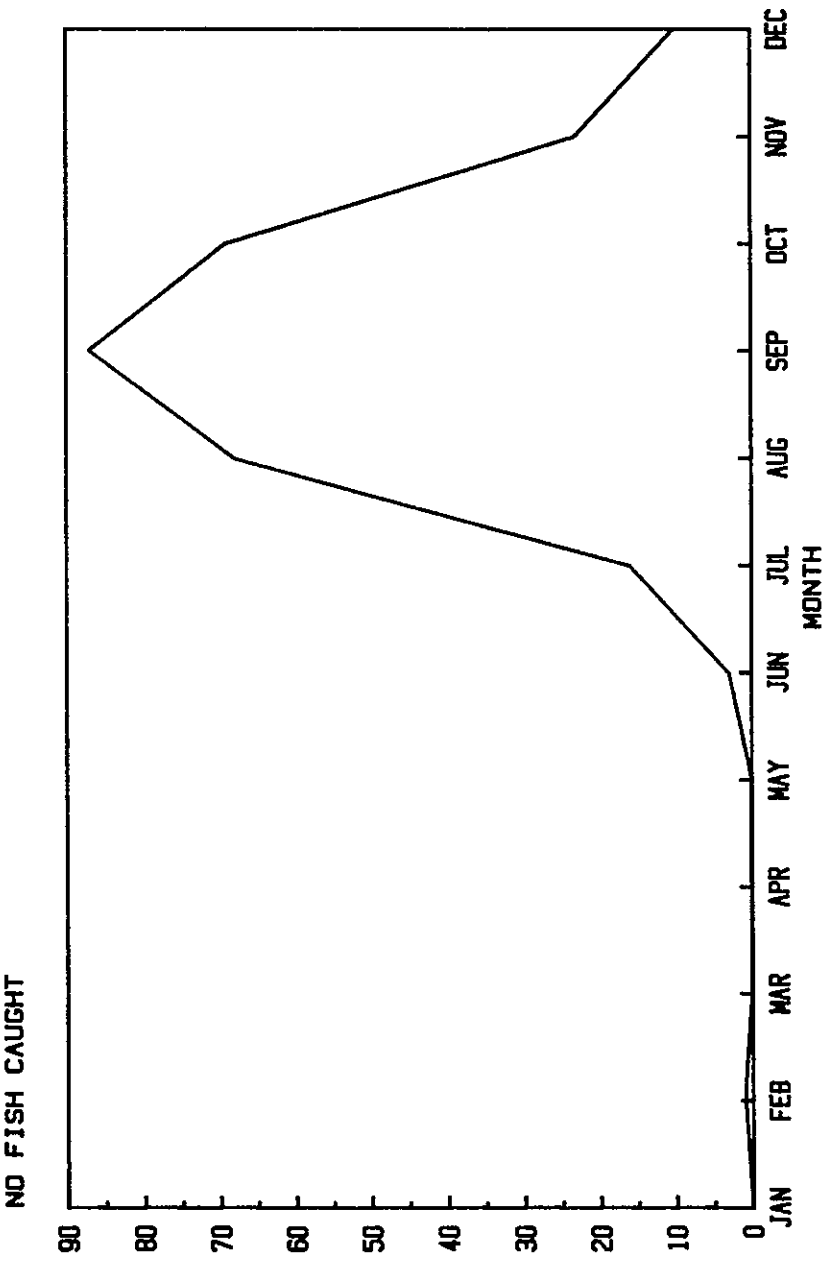
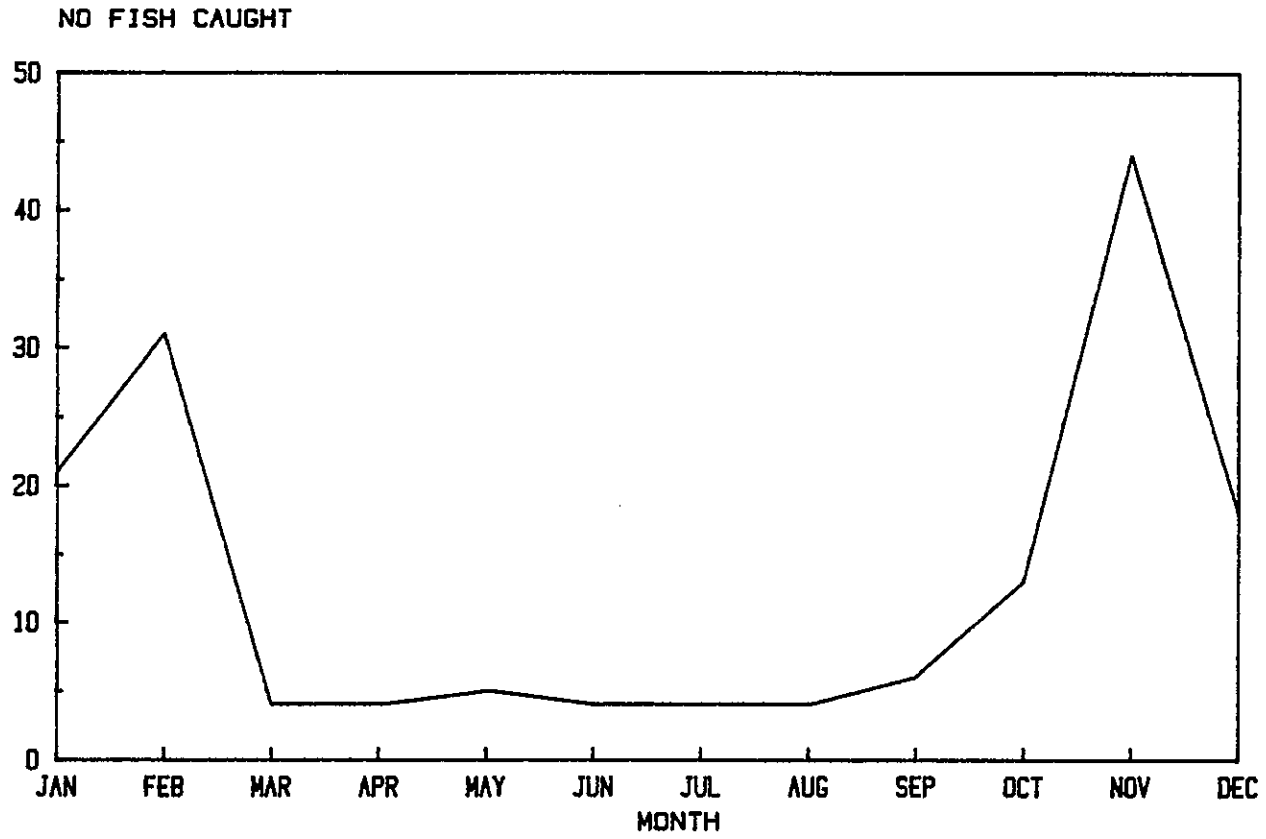
NOV
DEC
MONTH

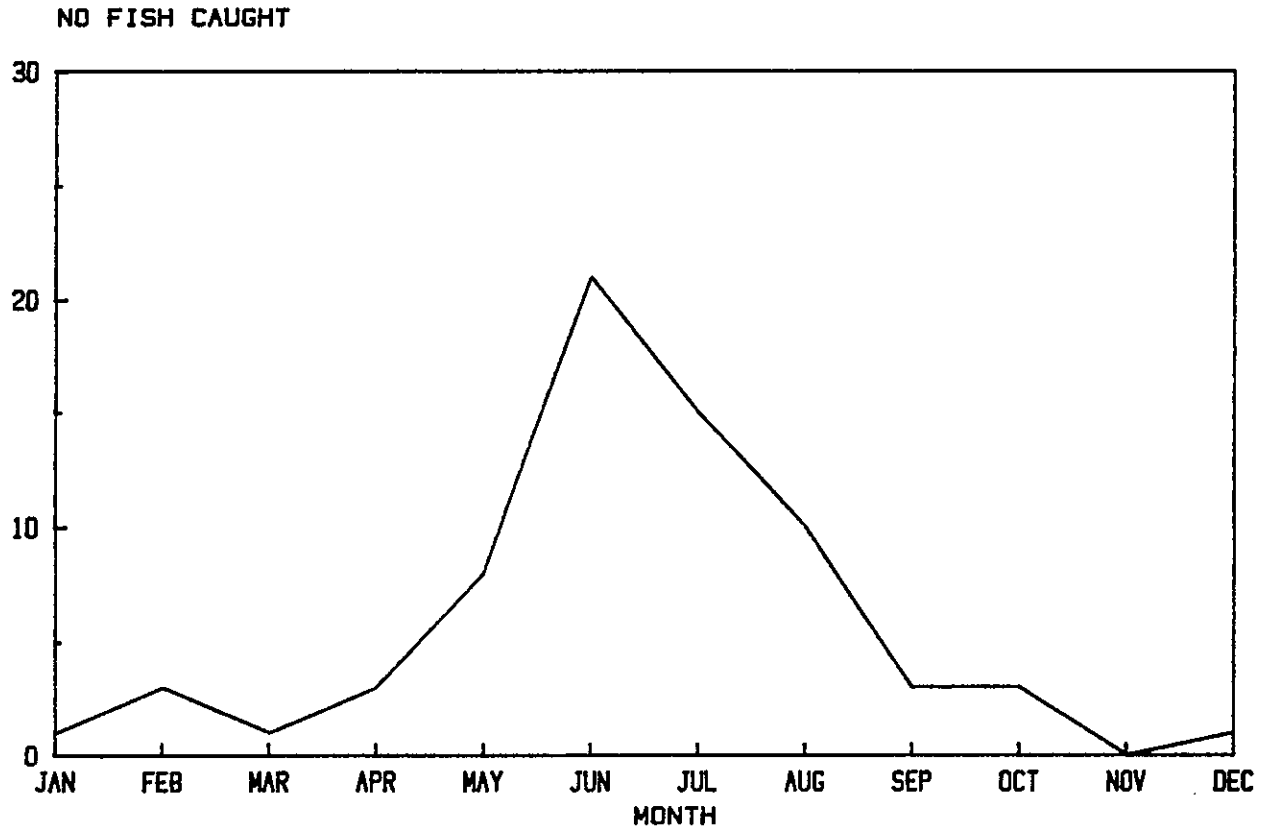
PACIFIC HAKE



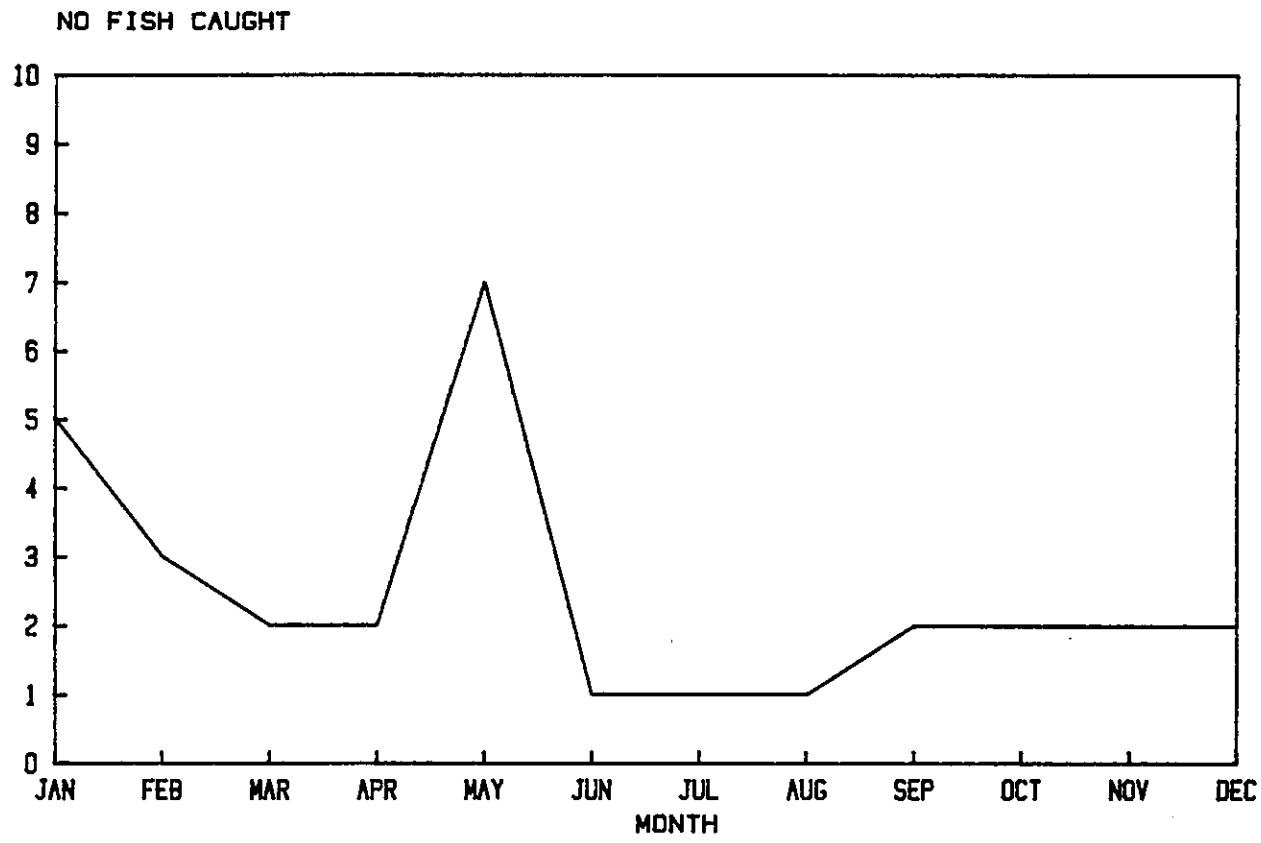
WALLEYE POLLOCK



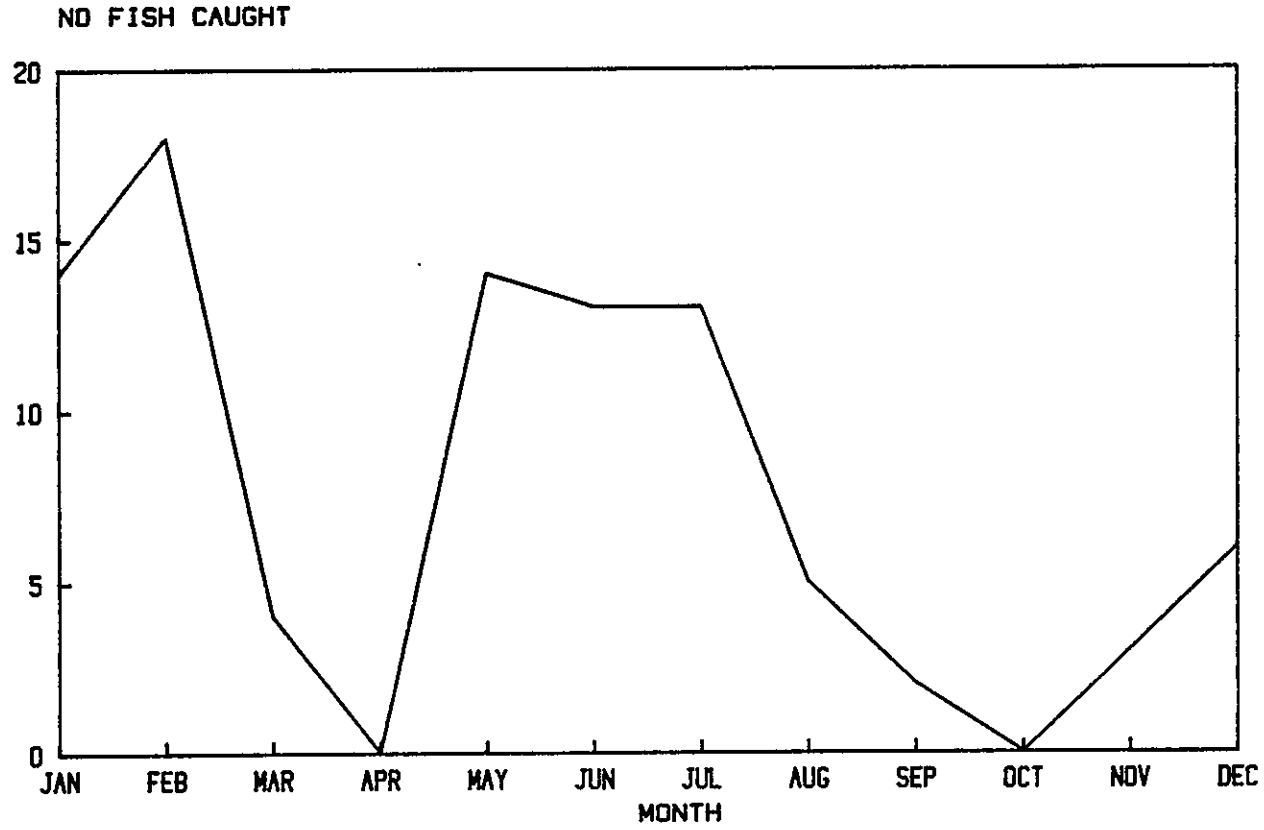
ENGLISH SOLE

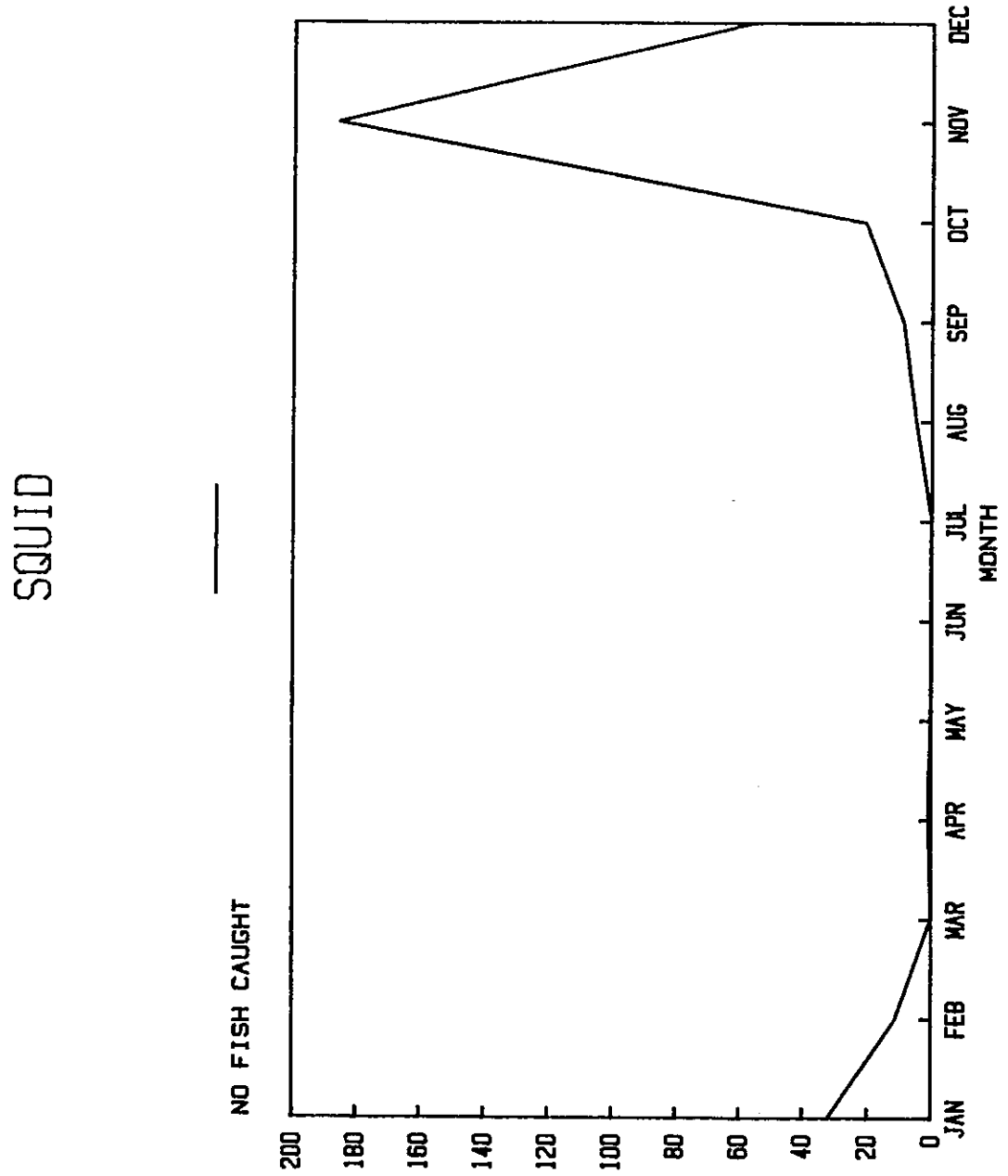


STARRY FLOUNDER



SABLEFISH


NO FISH CAUGHT
20
15
10
5
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTH



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