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MEMORANDUM
November 10, 1982

To: Dr. Claris Hyatt

Through: Joan Thomas

From: Dick Cunningham

Subject: Assessment of Toxic Pollutants in English Sole and Rock Sole: Everett Harbor and Port Gardner

INTRODUCTION

On September 15, 1982, the Washington State Department of Ecology (WDOE) and many other public agencies and individuals were alerted to recent observations made by Dr. Donald C. Malins[1] on Everett Harbor samples of English sole (*Parophrys vetulus*) and Rock sole (*Lepidopsetta bilineata*). As stated by Dr. Malins, "The prevalence of liver diseases we observed in [Everett Harbor] fish was generally higher than that found elsewhere in Puget Sound, including the highly polluted Duwamish Waterway (Malins, *et al.*, 1982). We are notifying you of these findings because of their relevance to the health of marine life and the consumer." (Malins, D.C., September 14, 1982). The question of public health was immediately of high concern both to the WDOE, other environmental agencies, and state and local public health agencies.

During the week of September 20, 1982, federal, state, and local environmental and health agencies met with Dr. Malins to further discuss his findings. It was decided that additional information was needed as Dr. Malins' survey locations did not coincide specifically with popular fishing sites in the Everett vicinity. Further, chemical analyses of the tissues had not yet been conducted which could be related specifically to the question of public health.

During the week of October 3, a survey was conducted by WDOE with two objectives: (1) to determine if diseased fish were likely to be taken at the popular fishing sites in the Everett vicinity; and (2) to identify and quantify any chemical contaminants in the edible portions of these fish. Collecting and analyzing these fish was given highest priority

[1] Director, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA.

with a target period of mid-October for reporting preliminary results -- an extremely short period as surveys dealing with priority pollutants (metals and exotic organic chemicals) routinely take at least three to four months to obtain preliminary results.

Assistance in carrying out the study was sought and obtained from the Washington State Department of Fisheries (WDF), Marine Ground Fisheries Division, to provide assistance and expertise in fish collection; National Marine Fisheries Service (NMFS), to provide assistance and expertise in pathological examination of the fish; and, the Environmental Protection Agency (EPA) to provide assistance and expertise in processing, pathological examination, and chemical analysis of fish tissues.

METHODS

Fish were collected during October 3 and 4, 1982.

Based on personal observations and information provided by the WDF staff, five sites were selected for for sampling (Figure 1). Station 1 is located in the East Waterway and coincides with work conducted by Dr. Malins. Station 2 is the waterway adjacent to Western Gear -- a popular fishing site. Station 3, adjacent to Pier #1 -- a popular fishing site and also coincides with work conducted by Dr. Malins. Station 4, mouth of the Snohomish River adjacent to the jetty -- a popular fishing site. Station 5, southwest side of Gedney Island -- a popular fishing site which is located some distance from Everett Harbor, allowing it to possibly serve as a reference or control station.

Target species were English sole and Rock sole. Survey design called for a total catch of 40 fish; four of each species per station. Collection methods consisted of rod and reel, long line, and TRY-NET trawl. Collected fish were immediately wrapped in foil, enclosed in a plastic bag, and stored on ice for shipment to the EPA Manchester laboratory. The wrapping foil was previously cleaned in the EPA laboratory by two rinses of acetone and methylene chloride. After cleaning, wrapping foil was dried for 10 minutes in a drying oven at 100°C. Wrapping foils were enclosed in larger foil envelopes until used. Samples were delivered to the EPA laboratory within 24 hours and stored in a cold room until examination and dissection.

Measurements were taken from each fish including sex, total length, total weight, total muscle weight, and total liver weight. Age was estimated from otoliths. Gross visual observations were made on the external appearance of the fish as well as the fish livers.

The muscle and liver were removed for chemical analysis. A representative sample of each tissue was used to determine trace metals on each fish collected. Tests for the remaining priority pollutants including pesticides, base/neutral extractables, acid extractables, and volatile organics were conducted on tissue composites. Muscle tissues at each station were composited to make a single sample and liver tissues at each station were composited to make a single sample (see Table 1).

RESULTS AND DISCUSSION

During the first day, hook-and-line and long-line collection methods were used. This met with partial success. Fish were collected at every station, but at no station did we collect more than one species. To reduce the apparent selectivity of our collection method and also to increase the number of organisms taken, a second day of fishing was conducted using a TRY-NET trawl. Fish collected the second day increased the number of fish taken per station and the number of species taken; however, we still failed to collect both species at stations 1, 2, and 3 (Table 2).

While we had not completed the task of fish collection after the first day, it was obvious that the fish collected at our reference station (station 5) were larger than fish collected at any of the other stations. Since this could complicate later interpretation of the data, a second reason for going to the TRY-NET trawl was to get uniform, larger-size fish at each station sampled. We failed to meet this objective as the fish collected remained smaller at stations 1 through 4 than at station 5 (Table 3).

Cursory observation at the time of collection revealed no abnormal exterior conditions on any of the fish collected. To a large degree, this was substantiated by later gross visual observations in the laboratory by Joe Cummins of EPA and Dr. Lee W. Harrell of NMFS. With the exception of blood worms, only one fish out of 26 or 3.9 percent showed any abnormal external condition. The abnormal condition was a hemorrhaging at the base of the dorsal fin of a Rock sole collected at station 1. By comparison, fish collected during recent Commencement Bay investigations had 13 percent external abnormalities. External conditions noted in fish collected in the Commencement Bay study included erosion of portions of fins, hemorrhaging around fins, hemorrhaging of tissue areas, open wounds, and lesions from parasites (Joe Cummins, personal communication).

Gross visual internal observations revealed various colorations of the liver, a small hemorrhage (fish number 40371); a friable condition (fish number 40373) at station 2; nodules on intestine, origin probably parasitic (fish number 40363); and a possible autolysis (fish number 40364) at station 4. The most recurring condition appeared to be liver discolorations. Liver discolorations had been noted previously by Malins (Malins, *et al.*, 1980). The importance of these observations during our survey is unknown. The lack of available facilities and personnel in this survey precluded immediate and complete examination of livers to determine if noted liver discolorations were indicative of diseased tissue.

As indicated above, our findings for the most part did not reveal either external or internal abnormal fish conditions (with the exception of questions regarding liver discolorations). Malins, on the other hand, observed substantial numbers of abnormalities.

Malins' recent observations were that 84 percent and 35 percent of the English sole and Rock sole, respectively, collected in Everett Harbor had one or more types of liver diseases (Malins, *et al.*, 1982). In addition to liver diseases, Malins observed that 30 percent of the English sole from Everett Harbor were found to have deformed fin rays (Malins correspondence, 1982).

The difference in findings regarding the occurrence of liver diseases is easily explained. Malins conducted both gross and histopathological (microscopic observations of cellular and subcellular perturbations) observations. Our observations were strictly gross examinations. The occurrence of liver abnormalities noted by Malins required histopathological techniques. As stated by Malins, "In some cases the lesions are grossly visible; however most were only microscopically detectable." (Malins, *et al.*, 1980, pg. 19).

With respect to deformed fin rays, the reasons for different findings is most likely due to sample size and sample location. During our survey a total of 4 English sole were collected in the vicinity of Malins' earlier fish collection station (Table 2). Given Malins' observations of 30 percent fin deformities in English sole, we might have expected to observe from 0 to 1 fish with this deformity. Had we collected a larger number of fish at stations 1 and 3, we might have observed the fin abnormality. Also, Dr. Malins observed the problem to occur most frequently in the area of our stations 1 and 3, less frequently near the industrial deep water outfall (south of our stations 1 and 3), even less approximately 1 mile southwest of our station 3, and, be absent west of the Snohomish River (Dr. Sin-Lam Chan, personal communication). Based on Dr. Malins' observations, we would not have observed it at our stations 2, 3, or 5.

Metals

Metal concentrations in both the English and Rock sole muscle tissue were generally less than 1 part per million (ppm). The exceptions to this were primarily with respect to arsenic and zinc, and also occasional values above 1 ppm of chromium and lead. Liver values were substantially higher, with many metals approaching or exceeding 1 ppm (Table 4).

There appears to be no substantial difference between metal concentrations in tissues from one station to the next, including the reference station 5 (Table 5). In some cases, the highest values were in fish tissues collected at the reference station. If additional sampling were to be conducted and fish at station 5 continued to show higher metal concentrations, it might be explained by their larger size or greater age (Table 6).

Generally, the United States Food and Drug Administration (FDA) does not have administrative guidelines for metal concentrations. The only official guideline (action level) is for mercury. Unofficial guidelines exist for cadmium and lead (Table 7). In all cases, muscle tissue metal concentrations for mercury, cadmium, and lead were equal to or less than

one-fifth of the FDA official or unofficial guideline. With few exceptions, measured metals concentrations in muscle tissue were less than one-tenth FDA guidelines.

In the case of the liver, not normally considered edible tissue, a different situation existed. A composite English sole liver and English sole and Rock sole liver samples were analyzed at stations 4 and 5, respectively. In all three cases, cadmium concentrations exceeded the FDA guideline. In addition, the station 4 English sole liver composite sample exceeded the guideline for lead.

It appears the liver is effective in bioaccumulating metals. Comparing muscle and liver data of stations 4 and 5, it appears that metal concentrations in liver are normally much higher than corresponding metal concentrations in muscle (Table 8).

Organic Priority Pollutants

Tissue samples were scanned for 114 organic priority pollutants (Table 9). Excluding volatiles, the results show that 14 compounds were found either in the muscle or the liver or both (Table 10). In addition, where other compounds were isolated, an attempt was made to tentatively identify these compounds as well (Table 11).

Volatile organics were tested on selected fish where, based on judgment, the highest probability of positive results would exist. Special analytical procedures were required. The results are shown in Table 12. Low levels of benzene and toluene and other compounds were detected in the Gedney liver sample while the Everett Harbor samples contained fewer compounds. A partial explanation may be that the detection limit for the tissue analysis of the Gedney sample was four times lower than for the other samples. For the muscle analyses, tentatively identified volatiles in the Everett Harbor area were greater in number than the Gedney Island sample. The detection limits were the same for all muscle samples.

Many compounds other than the priority pollutants existed in the tissue samples (Joe Blazevich, personal communication). Some compounds were detected, but could not be identified because of time constraints or the complexity of the sample mixture. It is also a good assumption that a number of priority pollutants listed on Table 9 were present but were not identified because detection limits were too high. The problem of detection limits is easily seen by comparing the number of chemicals found in the liver composites with the number of chemicals found in the muscle composites. One might expect the liver samples to have more compounds and at higher concentrations than muscle samples. While it was true that liver samples had higher concentrations than corresponding compounds in the muscle samples, it will be noted that fewer chemicals were detected. The lowest detection limit for the muscle sample was 1 ppb whereas the lowest detection limit for liver samples was generally 25 ppb or above.

Chlorinated Pesticides and PCBs

Compared to other industrialized areas in Puget Sound, the liver tissues of Everett vicinity English and Rock sole have relatively low chlorinated pesticide concentrations. A close similarity is found between Everett and an outer station of Elliott Bay (Table 13). All of the other industrialized areas show higher chlorinated pesticide concentrations. In addition to those shown in Table 13, Port Madison and Budd Inlet, two rather remote areas with relatively low industrialization had higher concentrations of chlorinated pesticides than the Everett fish.

Likewise, liver PCB concentrations in Elliott Bay fish compared reasonably well with those of Everett fish. Other industrial areas listed in Table 12 again showed fish with greater contamination than fish taken from Everett. With respect to other areas, Case Inlet, Port Madison, and Budd Inlet had mean PCB concentrations lower than Everett.

A comparison of muscle tissue with other areas of Puget Sound followed a similar pattern (Table 14).

Muscle composite sample concentrations were far below FDA action criteria for DDT and PCB (Table 7). They were also below the World Health Organization/Food and Agriculture Organization (WHO/FAO) recommended allowable daily intake levels of 0.005 mg/Kg body weight per day for DDT (Edwards, 1973) and EPA calculated allowable daily intake of 0.003 mg/Kg body weight per day for PCB (Anon., EPA, 1980).

Phthalates

Phthalate ester concentrations in the muscle tissues were far below the calculated EPA allowable daily intake levels of 0.6, 12.5, 10, and 1.26 mg/Kg body weight per day for DEHP, diethyl-, dimethyl-, and di-n-butyl phthalate (Anon., EPA, 1980).

Phthalate esters were also detected in many whole-fish samples taken by EPA throughout Washington State (Anon., EPA, 1981). One might expect whole-fish sample concentrations to be higher than in muscle samples because of possible gut content contamination. As a rough comparison, the Everett Harbor/vicinity muscle concentrations seem to fall within the lower part of the range of phthalate concentrations detected in the 10EPATOX whole-fish samples (Table 15).

Although phthalate esters are found primarily in fatty tissue, the composite liver sample at station 4 with very high DEHP concentrations seems unusual because no DEHP was detected in muscle tissue. Care must be exercised in interpreting these data since phthalates are used in plastic manufacturing and, as one might expect, are ubiquitous in our environment. Contamination of samples and/or extracts easily occurs and cannot be ruled out in this instance.

CONCLUSIONS

1. Gross visual observations of 26 fish collected at five locations revealed 3.9 percent external abnormalities. Internally, the most observable, possibly abnormal, condition was discoloration of the liver. No histopathological examination of cellular and subcellular structure was conducted as was done by Malins. Histopathological examination would probably be needed to observe most liver lesions. Deformed fin rays were not observed as reported by Malins. To a large degree, this is probably due to the fact that most of our stations (and the popular fishing areas) are west of the Snohomish River where this fish abnormality has not been observed.

2. Gross visual observations would not suggest that English and Rock sole caught by fishermen would be considered unfit to eat.

3. Metal concentrations in muscle tissue are generally less than 1 ppm and within applicable FDA administrative guidelines for edible tissue. It should be noted that guidelines exist only for cadmium, mercury, and lead. Administrative guidelines do not exist for most metals.

4. There were no substantial differences between tissue metal concentrations of fish collected at any of the five stations.

5. The bioaccumulation of metals in liver tissues is generally much higher than for muscle tissue (average 1,000 percent).

6. Of 114 organic priority pollutants, only 14 compounds were found in either the liver, the muscle, or both. Other compounds did exist but time constraints, sample complexities, or present detection levels would not allow their identification or quantification.

7. Organic pollutant concentrations detected in edible fish tissue are all below the applicable FDA administrative guidelines. They are below applicable WHO/FAO and EPA daily intake levels. It should be noted that guidelines do not exist for many organic pollutants and that many chemicals in the samples could not be identified or quantified.

8. There were no substantial differences detected in organic chemical contamination of fish at any of the five stations. It should again be noted that pollutant identification and quantification problems existed.

9. Everett English sole and Rock sole have lower chlorinated pesticide and PCB concentrations than similar organisms in most other industrialized (and some non-industrialized) areas of Puget Sound.

RKC:cp

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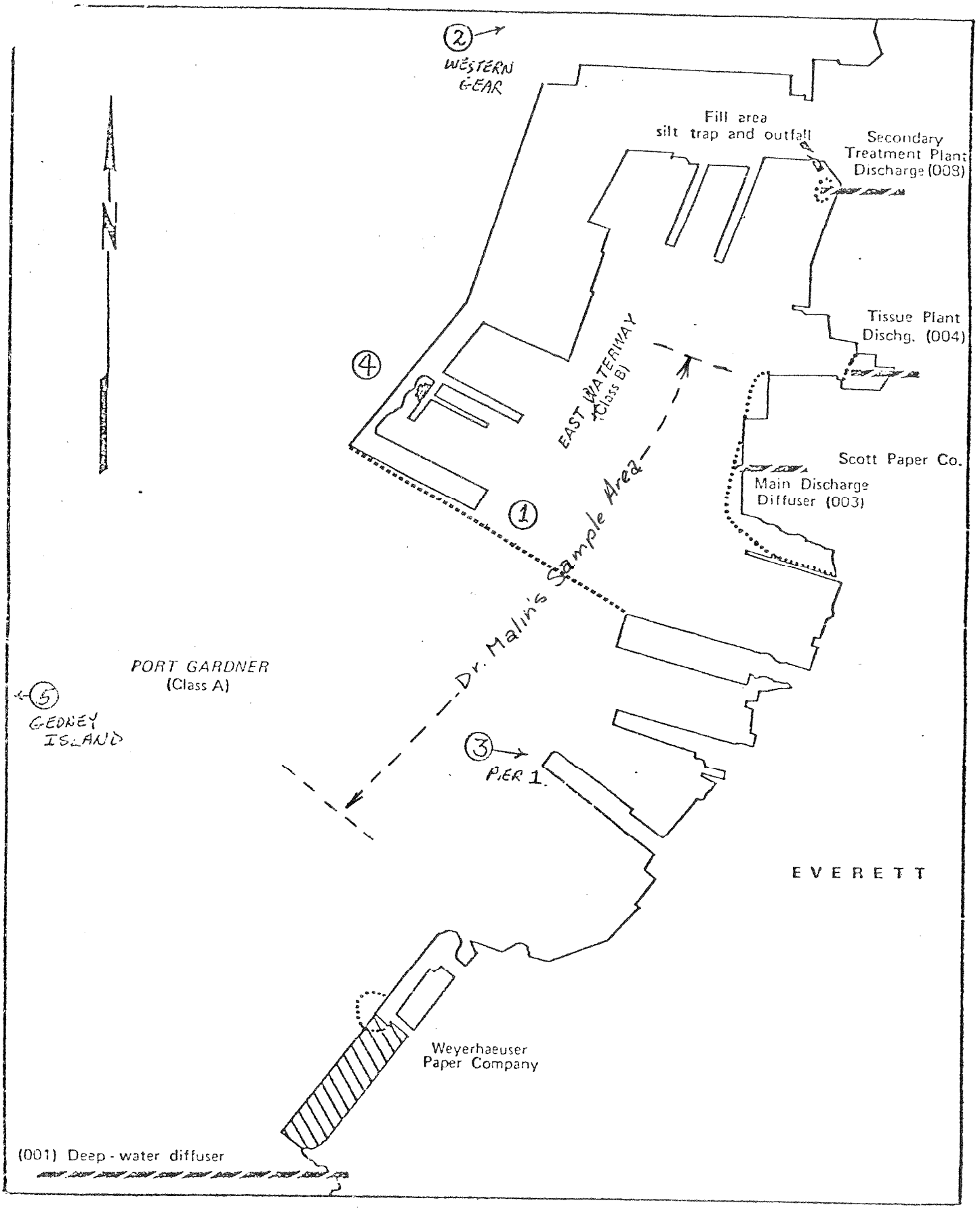

Figure 1. Map showing areas sampled by WDOE and WDF personnel in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Table 1. Analytical plan for tissue analysis of Everett vicinity fish collected by WDOE and WDF on October 3 and 4, 1982.

Analyses	Stations	Sample Types		Tissues Analyzed	
		Individual	Composite	Muscle	Liver
Metals	1 - 5	X		X	X*
Pesticides	1 - 5		X	X	X
Base/Neutral Extractables	1 - 5		X	X	X
Acid Extractables	1 - 5		X	X	X
Volatile Organics	1, 3, 5	X**		X	X

*Insufficient sample available to conduct chemical analysis on stations 1 - 3 and the Rock sole sample of station 4.

**Two individuals from each station (1, 3, and 5) were analyzed.

Table 2. Number of fish collected in the vicinity of Everett Harbor during October 3 and 4, 1982.

Station Number	Station Description	Species	3 Sunday	4 Monday	Sample Total	Priority of Analysis*
1	Inner Harbor	Rock	3	0	3	1
		English	0	0	0	
2	Western Gear Dock	Rock	0	0	0	4
		English	3	1	4	
3	Pier 1	Rock	0	0	0	1
		English	0	4	4	
4	Mouth of River	Rock	2	1	3	3
		English	0	4	4	
5	Gedney Island	Rock	4	0	4	2
		English	0	4	4	
	Total		12	14	26	

*Prioritization of sample analysis was required in the event that all analyses could not be completed by mid-October.

Table 3. Biological information on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) collected during October 3-4, 1982, from Everett Harbor and Port Gardner, Washington.

EPA Lab. Number	Station	Description	Date Collected	Method of Collection	Species	Sex	Total Length (mm)	Total Weight (g)	Total Muscle Weight (g)	Liver Weight (g)	Estimated Age (years)	Gross Visual Observations[a] (External)	(Liver)
40374	1	Log booms	10/3/82	Hook & Line	Rock Sole	Male	222.2	125.94	48.31	1.08	3	Unremarkable	Tan
40375	1	Log Booms	10/3/82	Hook & Line	Rock Sole	Female	247.6	170.12	59.90	1.41	3	Unremarkable	Mottled light brown
40376	1	Log Booms	10/3/82	Hook & Line	Rock Sole	Female	209.6	106.06	40.43	0.92	3	Hemorrhaging at base of dorsal fin	Brownish red
40370	2	Western Gear Dock	10/3/82	Hook & Line	English Sole	Male	222.2	104.28	41.43	1.13	5	Unremarkable	Mottled red/tan
40371	2	Western Gear Dock	10/3/82	Hook & Line	English Sole	Female	244.5	122.09	45.68	0.90	4	Unremarkable	Reddish brown with petechiae (small hemorhages)
40372	2	Western Gear Dock	10/3/82	Hook & Line	English Sole	Male	238.1	121.54	45.40	1.11	3	Unremarkable	Flesh beige with worm under capsule
40373	2	Western Gear Dock	10/4/82	Trawl	English Sole	Female	263.5	171.11	54.84	1.58	3	Unremarkable	Reddish brown; friable
40366	3	Pier No. 1	10/4/82	Trawl	English Sole	Male	212.7	86.57	24.02	1.02	5	Unremarkable	Light brown
40367	3	Pier No. 1	10/4/82	Trawl	English Sole	Female	225.4	103.14	28.34	0.95	3	Unremarkable	Light brown
40368	3	Pier No. 1	10/4/82	Trawl	English Sole	Female	254.0	131.47	44.52	1.15	3	Unremarkable	Light brown
40369	3	Pier No. 1	10/4/82	Trawl	English Sole	Male	209.6	77.77	21.07	1.04	2	Unremarkable	Light brown

[a]Observations made by Dr. Lee W. Harrell, Veterinary Medical Officer, National Marine Fisheries Service, Manchester, WA.

Table 3 - Continued. Biological information on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) collected during October 3-4, 1982, from Everett Harbor and Port Gardner, Washington.

EPA Lab. Number	Station	Description	Date Collected	Method of Collection	Species	Sex	Total Length (mm)	Total Weight (g)	Total Muscle Weight (g)	Liver Weight (g)	Estimated Age (years)	Gross Visual Observations[a] (External)	(Liver)
40359	4	Snohomish R. at End of Jetty	10/4/82	Trawl	English Sole	Female	304.8	257.45	78.45	3.2	3	Bloodworms along base of dorsal, anal, & caudal fins	Brown/red
40360	4	Snohomish R. at End of Jetty	10/4/82	Trawl	English Sole	Male	295.3	221.67	67.88	1.82	4	Unremarkable	Brown
40361	4	Snohomish R. at End of Jetty	10/4/82	Trawl	English Sole	Female	228.6	104.98	33.65	0.90	2	Unremarkable	Reddish brown
40362	4	Snohomish R. at End of Jetty	10/4/82	Trawl	English Sole	Male	266.7	169.34	44.04	2.58	4	Unremarkable	Yellow/beige Numerous white nodules on intestine - origin probably parasitic
40363	4	Snohomish R. at End of Jetty	10/3/82	Hook & Line	Rock Sole	Female	196.8	96.78	36.59	0.75	2	Unremarkable	Light brown
40364	4	Snohomish R. at End of Jetty	10/3/82	Hook & Line	Rock Sole	Female	196.8	91.93	30.69	0.53	2	Unremarkable	Reddish brown (Possible autolysis due to time since death)
40365	4	Snohomish R. at End of Jetty	10/4/82	Trawl	Rock Sole	Female	219.1	128.62	48.58	0.87	2	Bloodworm at base of dorsal fin	Pale reddish brown

[a]Observations made by Dr. Lee W. Harrell, Veterinary Medical Officer, National Marine Fisheries Service, Manchester, WA.

Table 3 - Continued. Biological information on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) collected during October 3-4, 1982, from Everett Harbor and Port Gardner, Washington.

EPA Lab. Number	Station	Description	Date Collected	Method of Collection	Species	Sex	Total Length (mm)	Total Weight (g)	Total Muscle Weight (g)	Liver Weight (g)	Estimated Age (years)	Gross Visual Observations[a] (External)	(Liver)
40351	5	Gedney Island	10/4/82	Trawl	English Sole	Male	342.9	329.15	97.08	6.18	4	Unremarkable	Creamy; milky white
40352	5	Gedney Island	10/4/82	Trawl	English Sole	Female	362.0	397.15	113.77	4.01	10	Unremarkable	Brown/red
40353	5	Gedney Island	10/4/82	Trawl	English Sole	Female	279.4	192.62	51.12	2.5	3	Unremarkable	Tan/red
40354	5	Gedney Island	10/4/82	Trawl	English Sole	Male	215.9	89.91	26.08	0.84	2	Unremarkable	Beige (gallbladder normal)
40355	5	Gedney Island	10/3/82	Hook & Line	Rock Sole	Female	314.3	399.35	110.71	4.49	11	Unremarkable	Reddish brown
40356	5	Gedney Island	10/3/82	Hook & Line	Rock Sole	Female	339.7	541.76	185.32	10.47	8	Unremarkable	Milky white (gallbladder normal)
40357	5	Gedney Island	10/3/82	Hook & Line	Rock Sole	Female	301.6	290.65	99.04	3.15	5	Unremarkable	Marbled light & dark brown
40358	5	Gedney Island	10/3/82	Hook & Line	Rock Sole	Male	266.7	235.72	83.18	1.91	-	Unremarkable	Yellowish brown

[a]Observations made by Dr. Lee W. Harrell, Veterinary Medical Officer, National Marine Fisheries Service, Manchester, WA.

Table 4. Summary of muscle and liver tissue metals data on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Station #1 - Rock sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40374	0.97	0.05	0.58	0.45	.011	0.42	0.61	<.05	4.0	.005		.011	<.03
40375	1.08	0.03	0.71	0.43	.011	0.26	0.56	<.05	4.5	.005		.006	<.03
40376	0.92	0.03	0.73	0.37	.011	0.82	0.29	<.05	5.1	.005		<.006	<.03
Average	0.99	0.04	0.67	0.42	.011	0.50	0.49	∿.03	4.5	.005		∿.007	∿.02

Station #2 - English Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40370	1.42	0.02	0.43	0.64	.017	0.44	0.70	<.05	4.5	.006		.006	<.03
40371	1.05	0.02	0.68	0.34	.019	0.33	0.28	<.05	6.6	.006		.006	<.03
40372	0.74	0.02	0.33	0.84	.026	0.48	0.43	<.05	3.9	.006		<.006	<.03
40373	0.41	0.02	0.66	0.49	.023	0.61	0.29	<.05	3.7	.005		.008	<.03
Average	0.91	0.02	0.53	0.58	.021	0.47	0.43	∿.03	4.7	.006		∿.006	∿.02

Station #3 - English Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40366	3.05	0.02	1.13	0.66	.016	0.53	1.00	<.05	4.5	.004		<.006	<.03
40367	1.40	0.01	0.79	0.52	.008	0.50	0.52	<.05	3.4	.005		.006	<.03
40368	1.42	0.03	0.83	0.70	.005	0.41	0.60	<.05	4.5	.004		.006	<.03
40369	2.57	0.02	0.70	0.66	.006	0.57	0.63	<.05	4.7	.004		.006	<.03
Average	2.11	0.02	0.86	0.64	.009	0.50	0.69	∿.03	4.3	.004		∿.005	∿.02

As - Arsenic
Cd - Cadmium
Cr - Chromium
Cu - Copper
Hg - Mercury
Ni - Nickel
Pb - Lead
Sb - Antimony
Zn - Zinc
Be - Beryllium
Se - Selenium
Ag - Silver
Tl - Thallium

*All concentrations are µg/g (ppm), wet weight.
**Individual fish

To determine averages, "less than" values assumed to be one-half of value shown (detection limit).

Table 4 - Continued. Summary of muscle and liver tissue metals data on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Station #4 - English Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40359	1.84	0.05	1.03	0.88	.020	0.54	0.58	<.05	5.7	<.003		.014	<.03
40360	1.08	0.01	0.90	0.78	.020	0.38	0.63	<.05	4.1	.004		.006	<.03
40361	1.05	0.02	0.43	0.68	.016	0.38	1.35	<.05	6.0	.006		<.006	<.03
40362	1.45	0.01	0.48	0.55	.014	0.60	0.52	<.05	4.7	.007		<.006	<.03
Average	1.36	0.02	0.71	0.72	.018	0.48	0.77	∿.03	5.1	∿.005		∿.007	∿.02

English Sole - Liver* Composite, 4 fish

EPA Lab. Number	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40382	1.54	0.53	3.6	14.4	--	2.1	9.47	<.26	65.2	<.003		.073	<.03

Rock Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40363	0.85	0.02	0.33	0.46	.020	0.53	0.60	<.05	3.7	.005		<.006	<.03
40364	0.74	0.02	0.75	0.72	.014	0.45	0.63	<.05	4.7	.004		.006	<.03
40365	0.67	0.02	0.46	0.60	.018	0.47	0.49	<.05	8.1	.005		<.006	<.03
Average	0.75	0.02	0.51	0.59	.017	0.48	0.57	∿.03	5.5	.005		∿.004	∿.02

As - Arsenic
Cd - Cadmium
Cr - Chromium
Cu - Copper
Hg - Mercury
Ni - Nickel
Pb - Lead
Sb - Antimony
Zn - Zinc
Be - Beryllium
Se - Selenium
Ag - Silver
Tl - Thallium

*All concentrations are µg/g (ppm), wet weight.
**Individual fish

To determine averages, "less than" values assumed to be one-half of value shown (detection limit).

Table 4 - Continued. Summary of muscle and liver tissue metals data on English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Station #5 - English Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40351	1.37	0.03	0.63	0.54	.021	0.24	0.28	<.05	5.0	.004		.019	<.03
40352	1.16	0.07	1.03	0.66	.062	0.33	0.56	<.05	4.0	.006		<.006	<.03
40353	1.26	0.02	1.45	0.82	.021	0.27	0.73	<.05	5.6	<.003		<.006	<.03
40354	2.25	0.02	0.76	0.87	.017	0.28	1.02	<.05	5.6	<.003		<.006	<.03
Average	1.50	0.04	0.97	0.72	.030	0.28	0.65	∿.03	5.1	∿.003		∿.007	∿.02

English Sole - Liver* Composite, 5 fish

EPA Lab. Number	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40380	1.98	1.9	0.82	14.8	--	0.58	2.71	<.12	75.3	.009		.19	<.03

Rock Sole - Muscle*

EPA Lab. Number**	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40355	1.13	0.02	0.54	0.80	.057	0.29	0.49	<.05	4.5	<.003		<.006	<.03
40356	2.36	0.02	0.88	0.82	.048	0.39	0.80	<.05	4.9	.004		.008	<.03
40357	2.31	0.03	1.05	0.83	.082	0.42	1.08	<.05	5.9	<.003		<.006	<.03
40358	3.52	0.02	1.00	0.74	.034	0.45	0.90	<.05	5.0	<.003		<.006	<.03
Average	2.33	0.02	0.87	0.80	.055	0.39	0.82	∿.03	5.1	∿.002		∿.004	∿.02

Rock Sole - Liver* Composite 5 fish

EPA Lab. Number	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn	Be	Se	Ag	Tl
40381	3.80	1.1	0.65	5.7	--	0.32	1.96	<.08	45.7	.006		.059	<.03

As - Arsenic
Cd - Cadmium
Cr - Chromium
Cu - Copper
Hg - Mercury
Ni - Nickel
Pb - Lead
Sb - Antimony
Zn - Zinc
Be - Beryllium
Se - Selenium
Ag - Silver
Tl - Thallium

*All concentrations are µg/g (ppm), wet weight.
**Individual fish

To determine averages, "less than" values assumed to be one-half of value shown (detection limit).

Table 5. Comparison of metals data by station for English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Sole - Muscle (average values for each species/station)

Station No.	1	2	3	4		5	
Station Name	East Waterway	Western Gear	Pier #1	Mouth/Snohomish River		Control, Gedney Island	
Fish Type	Rock	English	English	English	Rock	English	Rock
As	0.99	0.91	2.11	1.36	0.75	1.50	2.33
Cd	0.04	0.02	0.02	0.02	0.02	0.04	0.02
Cr	0.67	0.53	0.86	0.71	0.51	0.97	0.87
Cu	0.42	0.58	0.64	0.72	0.59	0.72	0.80
Hg	0.011	0.021	0.009	0.018	0.017	0.030	0.055
Ni	0.50	0.47	0.50	0.48	0.48	0.28	0.39
Pb	0.49	0.43	0.69	0.77	0.57	0.65	0.82
Sb	∿0.03	∿0.03	∿0.03	∿0.03	∿0.03	∿0.03	∿0.03
Zn	4.5	4.7	4.3	5.1	5.5	5.1	5.1
Be	0.005	0.006	0.004	∿0.005	∿0.005	∿0.003	∿0.002
Se							
Ag	∿0.007	∿0.006	∿0.005	∿0.007	∿0.004	∿0.007	∿0.004
Tl	∿0.02	∿0.02	∿0.02	∿0.02	∿0.02	∿0.02	∿0.02

Sole - Liver (composites)

Station No.	4	5	
Station Name	Mouth/ Snohomish River	Control, Gedney Island	
Fish Type	English	English	Rock
As	1.54	1.98	3.80
Cd	0.53	1.9	1.1
Cr	3.6	0.82	0.65
Cu	14.4	14.8	5.7
Hg	--		
Ni	2.1	0.58	0.32
Pb	9.47	2.71	1.96
Sb	<0.26	<0.12	<0.08
Zn	65.2	75.3	45.7
Be	<0.003	0.009	0.006
Se			
Ag	0.073	0.19	0.059
Tl	<0.03	<0.03	<0.03

*Parts per million (ppm).

All concentrations are $\mu g/g^{*}$, wet weight.

Table 6. Average length, weight, and age of Everett vicinity English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) collected by WDOE October 3 and 4, 1982.

Station Number	Total Length (mm)		Total Weight (g)		Age (years)	
	English	Rock	English	Rock	English	Rock
1		226.50		134.04		3.00
2	242.08		129.76		3.75	
3	225.43		99.74		3.25	
4	273.85	204.23	188.36	105.78	3.25	2.00
5	300.05	305.58	252.21	366.87	4.75	7.00*

*Includes a male Rock sole for which an age was not provided. The age of this specimen was estimated at four years based on length.

Table 7. U.S.F.D.A. - "Administrative Guidelines" (Action Levels)*: Edible tissue, concentrations in ppm, wet-weight basis.

Substance	"Administrative Guidelines" Fish	Shellfish	Notes
Total PCBs	5.0		This value is in Federal Register as a regulation.
Total Heptachlor and Heptachlor epoxide	0.3	0.3	Concentration of individual compounds must be ≥ 0.02 ppm to be included in total.
Endrin	0.3	0.3	
Aldrin	0.3	0.3	
Dieldrin	0.3	0.3	
Total Toxaphene	5.0		Includes all isomers of toxaphene.
Mirex	0.1		
Chlordecone (Kepone)	0.3	0.3	Shellfish value includes only crabs and oysters.
Total Chlordane	0.3		Includes cis and trans chlordane; cis and trans nonachlor; oxychlordane (octachlorepoxide); α, β, and γ chlordene and chlordene. Concentrations of individual compounds must be > 0.02 ppm to be included in total.
DDT and analogues	5.0		Includes DDT, DDE, & DDD (TDE). Individual compounds must be ≥ 0.2 ppm to be included in total.
Total BHC	0.1	0.1	α, γ, and Δ forms must be ≥ 0.02 ppm, β form ≥ 0.04 ppm to be included in total.
Mercury	1.0		
Cadmium	(0.5)	(0.5)	This is an "unofficial guideline" adopted from other types of food.
Lead	(7.0)	(7.0)	This is an "unofficial guideline" adopted from other types of food.

*Unless otherwise noted, these are concentrations which, when exceeded, trigger FDA to consider action to remove commercial foods from distribution. They are administrative and (unless noted) not coded into law.

( ) = "Unofficial guideline."

Table 8. Comparison of metal concentrations in liver tissue and corresponding muscle tissue of English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) collected in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Station No.	4			5			5		
Station Name	Mouth/Snohomish River			Control, Gedney Island			Control, Gedney Island		
Fish Type	English Sole			English Sole			Rock Sole		
	Muscle (ppm)	Liver (ppm)	Percent Liver / Muscle	Muscle (ppm)	Liver (ppm)	Percent Liver / Muscle	Muscle (ppm)	Liver (ppm)	Percent Liver / Muscle
Metal									
As	1.36	1.54	113	1.51	1.98	131	2.33	3.80	163
Cd	0.02	0.53	2,650	0.04	1.9	4,750	0.02	1.1	5,500
Cr	0.71	3.6	507	0.97	0.82	85	0.87	0.65	75
Cu	0.72	14.4	2,000	0.72	14.8	2,056	0.80	5.7	713
Ni	0.48	2.1	438	0.28	0.58	207	0.39	0.32	82
Pb	0.77	9.47	1,230	0.65	2.71	417	0.82	1.96	239
Zn	5.1	65.2	1,278	5.1	75.3	1,476	5.1	45.7	896
Ag	~0.007	0.073	1,043	0.007	0.19	2,714	0.004	0.059	1,475
Total			9,259			11,836			9,143
$\bar{X}$			1,157			1,480			1,143

Table 9. List of USEPA priority pollutants.

COMPOUND NAME

1. *acenaphthene
2. *acrolein
3. *acrylonitrile
4. *benzene
5. *benzidine
6. *carbon tetrachloride (tetrachloromethane)

*chlorinated benzenes (other than dichlorobenzenes)

7. chlorobenzene
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene

*chlorinated ethanes (including 1,2-dichloroethane, 1,1,1-trichloroethane and hexachloroethane)

10. 1,2-dichloroethane
11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,1,2-trichloroethane
15. 1,1,2,2-tetrachloroethane
16. chloroethane

*chloroalkyl ethers (chloromethyl, chloroethyl and mixed ethers)

17. bis(chloromethyl) ether
18. bis(2-chloroethyl) ether
19. 2-chloroethyl vinyl ether (mixed)

*chlorinated naphthalene

20. 2-chloronaphthalene

*chlorinated phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols)

21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. *chloroform (trichloromethane)
24. *2-chlorophenol

*dichlorobenzenes

25. 1,2-dichlorobenzene
26. 1,3-dichlorobenzene
27. 1,4-dichlorobenzene

*dichlorobenzidine

28. 3,3'-dichlorobenzidine

*dichloroethylenes (1,1-dichloroethylene and 1,2-dichloroethylene)

29. 1,1-dichloroethylene
30. 1,2-trans-dichloroethylene
31. *2,4-dichlorophenol

*dichloropropane and dichloropropene

32. 1,2-dichloropropane
33. 1,2-dichloropropylene (1,3-dichloropropene)
34. *2,4-dimethylphenol

*dinitrotoluene

35. 2,4-dinitrotoluene
36. 2,6-dinitrotoluene
37. *1,2-diphenylhydrazine
38. *ethylbenzene
39. *fluoranthene

*haloethers (other than those listed elsewhere)

40. 4-chlorophenyl phenyl ether
41. 4-bromophenyl phenyl ether
42. bis(2-chloroisopropyl) ether
43. bis(2-chloroethoxy) methane

*halomethanes (other than those listed elsewhere)

44. methylene chloride (dichloromethane)
45. methyl chloride (chloromethane)
46. methyl bromide (bromomethane)
47. bromoform (tribromomethane)
48. dichlorobromomethane
49. trichlorofluoromethane
50. dichlorodifluoromethane
51. chlorodibromomethane
52. *hexachlorobutadiene
53. *hexachlorocyclopentadiene
54. *isophorone
55. *naphthalene
56. *nitrobenzene

*nitrophenols (including 2,4-dinitrophenol and dinitrocresol)

57. 2-nitrophenol
58. 4-nitrophenol
59. *2,4-dinitrophenol
60. 4,6-dinitro-o-cresol

*nitrosamines

61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine
64. *pentachlorophenol
65. *phenol

*phthalate esters

66. bis(2-ethylhexyl) phthalate
67. butyl benzyl phthalate
68. di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate

*polynuclear aromatic hydrocarbons

72. benzo(a)anthracene (1,2-benzanthracene)
73. benzo(a)pyrene (3,4-benzopyrene)
74. 3,4-benzofluoranthene
75. benzo(k)fluoranthene (11,12-benzofluoranthene)
76. chrysene
77. acenaphthylene
78. anthracene
79. benzo(ghi)perylene (1,12-benzoperylene)
80. fluorene
81. phenanthrene
82. dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene)
83. indeno (1,2,3-cd)pyrene (2,3-o-phenylenepyrene)
84. pyrene
85. *tetrachloroethylene
86. *toluene
87. *trichloroethylene
88. *vinyl chloride (chloroethylene)

pesticides and metabolites

89. *aldrin
90. *dieldrin
91. *chlordane (technical mixture & metabolites)

*DDT and metabolites

92. 4,4'-DDT
93. 4,4'-DDE (p,p'-DDX)
94. 4,4'-DDD (p,p'-TDE)

*endosulfan and metabolites

95. a-endosulfan-Alpha
96. b-endosulfan-Beta
97. endosulfan sulfate

*endrin and metabolites

98. endrin
99. endrin aldehyde

*heptachlor and metabolites

100. heptachlor
101. heptachlor epoxide

*hexachlorocyclohexane (all isomers)

102. a-BHC-Alpha
103. b-BHC-Beta
104. r-BHC (lindane)-Gamma
105. g-BHC-Delta

*polychlorinated biphenyls (PCB's)

106. PCB-1242 (Arochlor 1242)
107. PCB-1254 (Arochlor 1254)
108. PCB-1221 (Arochlor 1221)
109. PCB-1232 (Arochlor 1232)
110. PCB-1248 (Arochlor 1248)
111. PCB-1260 (Arochlor 1260)
112. PCB-1016 (Arochlor 1016)
113. *toxaphene
114. *antimony (total)
115. *arsenic (total)
116. *asbestos (fibrous)
117. *beryllium (total)
118. *cadmium (total)
119. *chromium (total)
120. *copper (total)
121. *cyanide (total)
122. *lead (total)
123. *mercury (total)
124. *nickel (total)
125. *selenium (total)
126. *silver (total)
127. *thallium (total)
128. *zinc (total)
129. **2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

*Specific compounds and chemical classes as listed in the consent degree.

**This compound was specifically listed in the consent degree. Because of the extreme toxicity (TCDD), EPA recommends that laboratories *not* acquire analytical standard for this compound.

Table 10. Organic priority pollutants detected in English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Sole - Muscle (composites)*

Station No.	1	2	3	4		5	
Station Name	East Waterway	Western Gear	Pier #1	Mouth/Snohomish River		Control, Gedney Island	
Fish Type	Rock	English	English	English	Rock	English	Rock
napthalene	--	--	--	m	m	m	--
fluorene	--	--	--	--	--	2	--
bis(2-ethylhexyl) phthalate	46	170	12	24	--	13	5
butyl benzyl phthalate	--	--	--	--	--	11	--
di-n-butyl phthalate	--	--	--	63	--	80	--
diethyl phthalate	--	7	12	--	12	--	--
dimethyl phthalate	--	--	--	--	2	--	--
4,4' DDE	2	3	3	4	2	3	5
PCB 1254	26	58	41	130	26	39	68
PCB 1260	6	15	11	63	8	10	12
toluene	m	--	--	--	--	--	--

Sole - Liver (composites)*

Station No.	1	2	3	4		5	
Station Name	East Waterway	Western Gear	Pier #1	Mouth/Snohomish River		Control, Gedney Island	
Fish Type	Rock	English	English	English	Rock	English	Rock
bis(2-ethylhexyl) phthalate	--	--	--	--	6300	--	--
4,4' DDE	19	15	18	25	21	22	43
4,4' DDD	3	6	4	7	2	3	3
Alpha BHC	3	2	2	4	3	5	--
PCB 1254	470	330	450	1030	330	360	550
PCB 1260	--	110	90	430	100	100	170
benzene	m	--	--	--	--	3	--
toluene	m	--	--	--	--	m	--

Notes:

m = Identified but too low to quantify.
-- = None detected.
*Concentrations are µg/Kg (ppb), wet weight.

Table 11. Tentatively identified compounds (excluding volatiles) observed in English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) caught in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Sole - Muscle (composites)*

Station No.	1	2	3	4		5	
Station Name	East Waterway	Western Gear	Pier #1	Mouth/Snohomish River		Control, Gedney Island	
Fish Type	Rock	English	English	English	Rock	English	Rock
pyridene	TI	TI					
3-methyl-1-butanol		TI			TI		
benzene ethanol					TI		TI
2,2-diethyl-3-methyl-3-butenoic acid						TI	

Sole - Liver (composites)*

Station No.	1	2	3	4		5	
Station Name	East Waterway	Western Gear	Pier #1	Mouth/Snohomish River		Control, Gedney Island	
Fish Type	Rock	English	English	English	Rock	English	Rock
1,2,3,4-tetrahydro-1,1,6 trimethyl napthalene		TI				TI	

Notes:

TI = Tentatively identified.
*Concentrations are µg/Kg (ppb), wet weight.

Table 12. Volatile organics in English Sole (*Parophrys vetulus*) and Rock Sole (*Lepidopsetta bilineata*) from selected areas sampled in Everett Harbor and Port Gardner during October 3 and 4, 1982.

Muscle*

Station Number	1		3		5
Station Name	East Waterway		Pier #1		Gedney Is.
Sample Number	40374	40376	40366	40368	40351
Fish Type	Rock	Rock	English	English	English
Parameter					
toluene		m			
acetone	TI	TI	TI	TI	
2-propanol				TI	
2-methyl propanol	TI	TI		TI	
ethanol	TI	TI			
2-butanone	TI				
2-methyl-1-propanol		TI			

Liver*

Station Number	1	3	5
Station Name	East Waterway	Pier #1	Gedney Is.
Sample No.	40375	40368	40351
Fish Type	Rock	English	English
Parameter			
benzene	m		30
toluene	m		20
ethanol			TI
2-butanone			TI
3-ethoxy-1-propene			TI
3-methyl-1-butanol	TI		TI
hexanol			TI
3-methyl ketone			TI
3-methyl-1-butanol		TI	TI
acetone	TI	TI	
xylene		TI	

Notes:

m = Identified but too low to quantify.
TI = Tentatively identified.
*Concentrations are µg/Kg (ppb), wet weight.

Table 13. Comparison of chlorinated pesticides and PCB concentations in liver tissue from Everett Harbor/Port Gardner with English Sole and Rock sole collected in other areas*** of Puget Sound.

Location	Chlorinated Pesticides* Average	Range	PCBs** Average	Range
Everett	0.03	0.02 - 0.05	0.65	0.44 - 1.46
Outer Elliott Bay	0.05	0.03 - 0.06	0.58	0.32 - 0.92
Sinclair Inlet	0.11	0.06 - 0.14	1.4	0.90 - 1.9
Duwamish	0.46	0.05 - 1.4	3.9	0.53 - 8.0
Seattle Waterfront	0.16	0.07 - 0.23	1.5	0.85 - 2.1
Commencement Bay (Hylebos)	0.20	0.004 - 0.43	2.6	0.05 - 4.6
Commencement Bay (S.W.)	0.07	0.03 - 0.12	1.1	0.82 - 1.7

Notes:

*Summation of DDE, DDD, and Alpha BHC concentrations.
**Summation of all PCB compounds.
***Data from Malins, D.C., 1980.

Concentrations are µg/g (ppm), wet weight.

Table 14. Comparison of PCB concentrations in English sole muscle tissue from Everett Harbor/Port Gardner with English Sole collected in other areas** of Puget Sound.

Location	PCBs*
Everett	.05
Elliott Bay	1.03
Commencement Bay	.59

*Summation of all PCB compounds.
**Data from Malins, D.C., 1982.

Concentrations are µg/g (ppm), wet weight.