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PORT GAMBLE BAY:
A RECONNAISSANCE SURVEY OF SEDIMENT QUALITY

by

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ABSTRACT

Sediments collected in Port Gamble Bay and a reference site (Bywater Bay) were analyzed for a range of metals, semivolatile organic compounds, pesticides/PCBs, and ancillary parameters. This work was done in conjunction with an investigation into the cause of herring spawn mortality conducted cooperatively by the Point No Point Treaty Council, the Port Gamble Klallam Tribe, and the University of Washington School of Fisheries. The concentrations of metals, pesticides/PCBs, and many organic compounds in the Port Gamble Bay sediments were at or near background (reference) levels. Polynuclear aromatic hydrocarbon concentrations were somewhat elevated, but still well below concentrations associated with adverse biological effects.

INTRODUCTION

The Washington State Department of Fisheries (WDF) has conducted herring spawning surveys since 1972. Since 1978, weekly visits to spawning sites have been conducted during the spawning season to estimate egg mortalities and escapement (Pentilla, 1986a). Progress reports summarizing the findings of these surveys have been published annually (Gonyea, et al., 1982a, b; Pentilla, et al., 1985; Pentilla, 1986b). These reports document high mortalities in herring egg sets at certain locations in Puget Sound including Tulalip Bay, the east shore of Port Gamble Bay, the south shore of Port Madison, and an area near Dockton in Quartermaster Harbor. The Dockton area was the subject of an earlier reconnaissance survey of sediment quality by the Washington State Department of Ecology (Yake, 1986).

The Port Gamble herring spawn mortalities were of particular concern to the Port Gamble Klallam Tribe (Charles, 1986). Subsequent to a request by the Ecology's Northwest Regional Office (Ellison, 1986), representatives of Ecology, WDF, the Port Gamble Klallam Tribe, the Point No Point Treaty Council, and the University of Washington's School of Fisheries met to discuss the situation. As a result of these and related discussions, the tribe retained Dr. Richard Kocan of the School of Fisheries to conduct a herring embryo mortality study in Port Gamble Bay. Ecology agreed to collect sediment samples at mutually chosen study sites and analyze these sediments for a suite of pollutants. Additionally, Ecology conducted limited field analyses of the water column above these sites and assisted in the collection of water samples for Dr. Kocan's study. The sites chosen (with the exception of the Bywater Bay control) corresponded to long-term WDF herring spawn mortality assessment sites. The results of the Port Gamble Klallam/School of Fisheries study are reported by Kocan (1987).

This paper reports the results of Ecology's sediment and limited water column analyses.

SURVEY DESCRIPTION

The survey was conducted on March 23, 1987, six days after substantial mortalities of herring spawn were reported by WDF. The study area is shown in Figure 1, and the station descriptions and locations are given in Table 1.

Table 1. Station descriptions for samples collected by Ecology March 23, 1987, at Port Gamble, WA.

Station Number Ecology	Station Number WDF	Description	Latitude 47°	Longitude 122°
PG-1	33	Port Gamble east shore 2900 yds. fm mouth, depth = 5 meters	49' 24"	34' 40"
PG-2	30	Port Gamble midbay 4300 yds. fm mouth, depth = 5 meters	49' 17"	34' 22"
PG-3	25	Port Gamble west shore 4100 yds. fm mouth, depth = 5 meters	49' 58"	34' 00"
B-1	--	Bywater Bay midchannel at mouth, depth = 5 meters	52' 42"	37' 29"

Herring spawn mortalities noted by WDF on March 17 were: WDF #33 - 30 percent mortality; WDF #30 - 80 percent mortality; WDF #25 - 90 to 100 percent mortality. These were some of the last sets of the spawning season and among the first to show substantial mortalities in the bay during the 1987 season. Egg mortalities noted on March 17 were used to pick the sites used in the present study, as well as by Dr. Kocan in his study.

Field work was carried out by Dale Norton and Bill Yake of the Toxics Investigations Unit, Water Quality Investigations Section, with assistance by Lori Levander (Ecology, NWRO) and Steve Ralph (Point No Point Treaty Council).

All sites were located at five meters depth. Vertical profiles for temperature, salinity and conductivity were conducted using a Beckman Electrodeless Induction Salinometer. A water sample taken near the bottom was analyzed for dissolved oxygen.

Sediment samples were collected with a $0.1m^2$ VanVeen grab. The top 2 cm of sediment were removed and homogenized using stainless steel containers and spoons cleaned sequentially with Liquinox detergent, distilled water, 10 percent nitric acid, distilled water, pesticide-grade methylene chloride, and acetone. Aliquots for separate analyses were obtained from the homogenate.

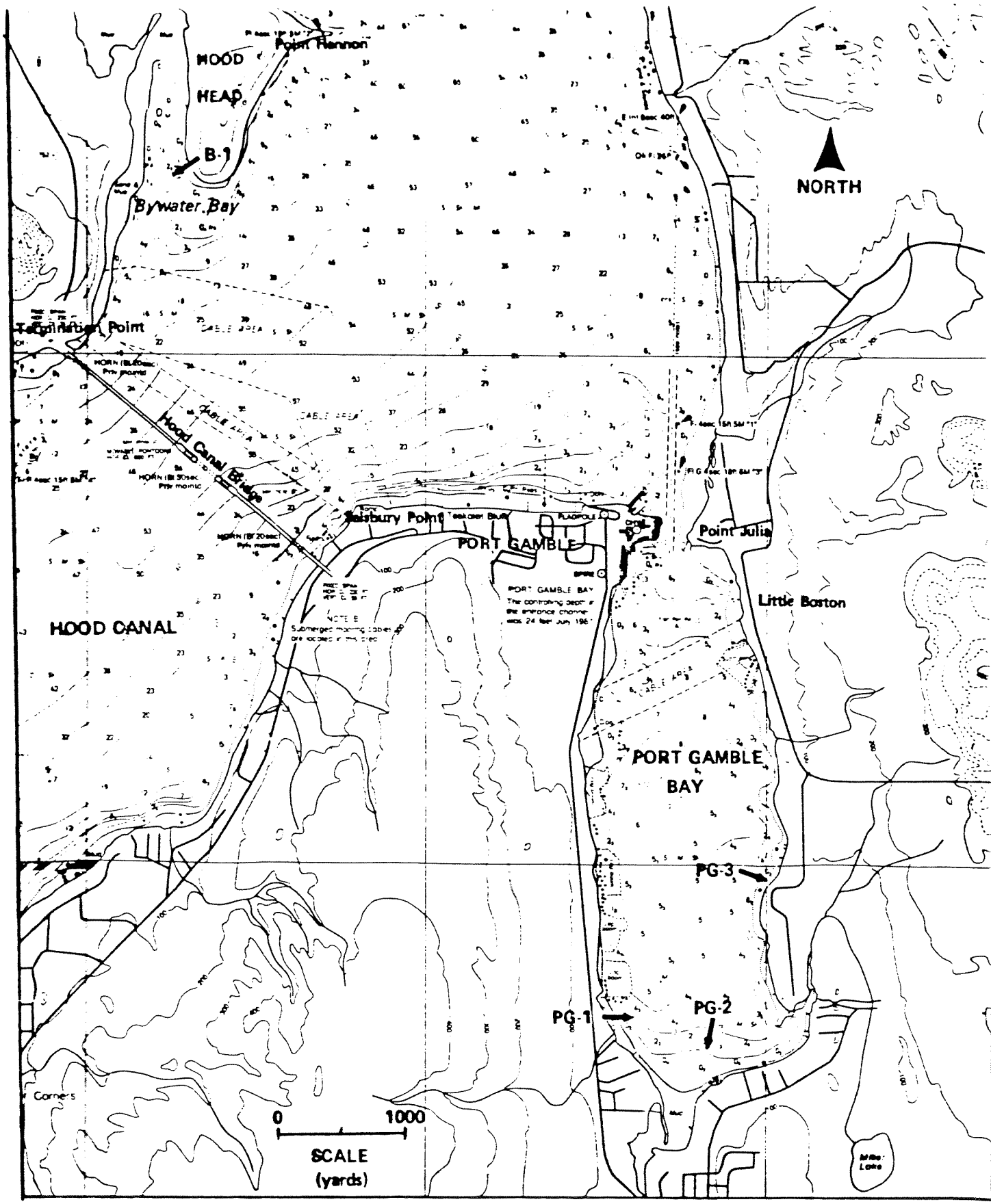

Figure 1. Study area and sampling locations.

Table 2 shows the sediment analyses performed at each site and the laboratories involved. Blind field duplicates were submitted for metals and organics at PG-2. Laboratories conducted replicate analyses for total organic carbon at B-1 and for grain size at B-1 and PG-1. Triplicate analyses were conducted for metals on one of the PG-2 field replicates, as well as for organics triplicate analyses at PG-3.

Table 2. Sediment analyses conducted.

Analyses	Sites				Laboratory/Location
	B-1	PG-1	PG-2	PG-3	
Percent solids	X	X	X	X	Ecology, Manchester; ARI, Seattle
Total organic carbon	X	X	X	X	Laucks, Seattle
Grain size	X	X	X	X	Parametrix, Bellevue
Metals	X		X	X	Ecology, Manchester
Semivolatile organics	X	X	X	X	ARI, Seattle
Pesticides/PCBs	X	X	X	X	ARI, Seattle

Field and laboratory methods used in these determinations are listed in Table 3. Additional information on the semivolatiles extraction and analysis methodology is given in the Appendix.

RESULTS AND DISCUSSION

Water Column

Table 4a shows the results of field measurements taken near the bottom of the water column (approximately 5 meters depth). Table 4b gives the results of vertical temperature and salinity gradients measured above each of the sediment sampling sites.

Table 4a. Port Gamble Bay water quality results.

Station Location	Bywater Bay	Port Gamble		
Station Number	B-1	PG-1	PG-2	PG-3
Date	3/23/87	3/23/87	3/23/87	3/23/87
Time	1215	1130	1050	1030
Depth (meters)	5	5	5	5
Dissolved oxygen* (mg/L)	8.7	8.8	8.4	8.6
(% saturation)	88.3	88.8	84.9	87.2
Salinity* (o/oo)	28.82	27.86	28.04	28.18
Spec. Cond.* (mmhos/cm)	31.26	30.35	30.38	30.42
Temperature* (^{o}C)	8.08	8.14	8.16	8.25

*Reading taken at bottom

Table 3. Analysis of Port Gamble Bay samples.

Analysis	Method	Method Number	Reference
- -water samples- -			
temperature (field)	Beckman induction salinometer	--	--
salinity (field)	Beckman induction salinometer	--	--
dissolved oxygen (field)	Winkler (azide modification)	421B	APHA (1985)
- -sediment samples- -			
grain size	seives & pipettes	--	Holmes & McIntyre (1971)
total organic carbon	combustion/gravimetric	--	Nelson (1985)
total solids	evaporation to dryness, 100°C	209F	APHA (1985)
metals (digestion)	nitric acid/hydrogen peroxide	SOW 787	EPA (1987)
analysis - Hg	cold vapor/AA	145.5	EPA (1987)
As	graphite furnace/AA	106.2	EPA (1987)
Cd	graphite furnace/AA	213.2	EPA (1987)
Cu	flame/AA	220.1	EPA (1987)
Pb	graphite furnace/AA	239.2	EPA (1987)
Zn	flame/AA	289.1	EPA (1987)
semivolatiles	stable isotope dilution, GC/MS	See App. I	
pesticides/PCBs	GC/EC	8080	EPA (1986)

Table 4b. Port Gamble Bay; water quality results, vertical profile data.

	Salinity (o/oo)				Temperature (°C)			
Station	B-1	PG-1	PG-2	PG-3	B-1	PG-1	PG-2	PG-3
Time	1203	1125	1055	1000	1203	1125	1055	1000
Depth (m)								
0	27.80	27.31	26.42	27.52	8.48	8.48	8.67	8.70
0.25	28.08	27.48	27.02	27.50	8.52	8.60	8.58	8.70
0.50	28.16	27.54	27.30	27.58	8.42	8.62	8.52	8.64
0.75	28.08	27.55	27.54	27.57	8.51	8.51	8.49	8.59
1.0	28.02	27.67	27.65	27.59	8.46	8.44	8.29	8.49
2.0	28.30	27.92	27.81	27.80	8.34	8.35	8.16	8.32
3.0	28.32	27.96	27.90	27.93	8.24	8.24	8.22	8.10
4.0	28.76	27.90	28.04	28.08	8.07	8.23	8.24	8.15
5.0	28.82	27.86	28.04	28.18	8.08	8.14	8.16	8.25

The water column results are generally unremarkable. Salinity in Port Gamble Bay was approximately 0.3 to 1.0 o/oo lower than at the Bywater Bay control site. The lowest surface salinities were recorded at PG-2. Temperatures at the control site were slightly lower than those in Port Gamble Bay. These findings most easily are explained by the differences in size, configuration, and freshwater input between Bywater and Port Gamble Bays. Bywater Bay is small and open with little freshwater input. Port Gamble Bay is relatively large with a restricted mouth and several freshwater creeks feeding the head of the bay. Bywater Bay water quality probably closely tracks that of Hood Canal and Admiralty Inlet, while that of Port Gamble Bay is somewhat modified by freshwater input, primarily at its southern end.

Dissolved oxygen concentrations were measured only near the bottom of the vertical transects and ranged from 8.4 to 8.8 mg/L (85 to 89 percent saturation). A comparison of dissolved oxygen results at the control site and the Port Gamble Bay sites reveals no obvious differences. In retrospect, it is unfortunate that vertical dissolved oxygen transects were not obtained as they might have provided some evidence in support or in contradiction to the possible involvement of "metabolites of natural algal blooms" raised by Kocan (1987).

Sediment Results

Conventionals

Table 5a summarizes conventional measurements of sediment characteristics and heavy metals concentrations. Table 5b summarizes the results of organic priority pollutants. Full organics results (including quantification limits) are tabulated in the appendix (Tables A-1 and A-2).

Table 5a. Port Gamble sediment results - conventionals, metals.

Station Location	Bywater Bay	Port Gamble				
Station Number	B-1	PG-1	PG-2			PG-3
Date	3/23/87	3/23/87	3/23/87			3/23/87
Time	1200	1130	1050	1050	1050	1030
Sample Number	8054	8050	8051	8052		8052
Additional Information				Field Dupl.	Mean	
Solids (% d.w., Manchester)	67.2	72.8	70.5	NA	70.5	74.1
(% d.w., ARI)	69.6	74.1	72.0	74.6	73.3*	78.7
T. organic carbon (% d.w.)	0.1*	0.2	0.1	NA	0.1	<0.1
Grain Size (%)						
Gravel (>2 mm)	0.12*	0.14*	1.98	NA	1.98	2.27
Sand (62 um - 2 mm)	84.98*	90.36*	83.36	NA	83.36	52.03
Silt (4 um - 62 um)	12.42*	7.06*	11.67	NA	11.67	39.18
Clay (<4 um)	1.50*	2.35*	2.58	NA	2.58	3.69
Metals (mg/kg, dry wt.)						
As	1.23	NA	0.67	0.91**	0.79*	0.89
Cd	0.65	NA	0.57	0.52**	0.54*	0.29
Cu	14.9	NA	13.3	17.0**	15.2*	19.3
Hg	0.025	NA	0.023	NA	0.023	0.027
Pb	1.17	NA	0.84	1.14**	0.99*	0.40
Zn	28.8	NA	24.5	66.7**	45.6*	35.4

NA = not analyzed
* = mean of two values
** = mean of three values

Table 5b. Port Gamble sediment results[1] - organics (ug/kg, dry weight).

Station Location	Bywater Bay	Port Gamble							
Station Number	B-1	PG-1	PG-2			PG-3			
Date	3/23/87	3/23/87	3/23/87			3/23/87			
Time	1200	1130	1050			1030			
Sample Number	8054	8050	8051	8053	Mean	8052			Mean
Additional Information			Field Duplicates			Laboratory Triplicates			
Solids (%, ARI)	69.6%	74.1%	72.0%	74.6%	73.3%	78.7%			78.7%
Acid Extractables									
Phenol	*	*	*	67u	--	*	*	*	*
4-Methylphenol	NC	&	NC	NC	NC	NC	*	*	*
2,4-Dimethylphenol	NC	NC	NC	NC	NC	NC	*	130u	--
Pentachlorophenol	33u	6.3J	35u	65u	32u	NC	36u	250u	ND
4-Chloro,3-methylphenol	200u	37u	*	NC	--	*	11u	*	--
Base/Neutral Extractables									
Hexachloroethane	27u	26u	10J	46u	10J	82u	38u	20u	47u
1,4-Dichlorobenzene	*	*	*	*	*	*	*	*	*
Diethylphthalate	2.0u	*	*	*	*	*	*	*	*
Di-n-Butylphthalate	*	*	*	*	*	*	*	*	*
bis(2-ethylhexyl)phthalate	*	*	*	*	*	*	*	*	*
Butylbenzylphthalate	3.8u	6.1	6.1	5	5.6	3.3u	2.8	1.7u	2.8J
Di-n-octylphthalate	1.6u	2.4u	2.5u	3	3J	1.5u	1.5u	1.0u	1.3u
Isophorone	6.8	3.2	2.1u	6	6J	0.6u	1.4u	1.1u	1.0u
Dibenzofuran	2.0	6.1	6.8	7	6.9	4.1	4.8	4.4	4.4
Naphthalene	6.0	120	120	150	135	110	130	96	112
2-Methylnaphthalene	2.3	4.2	4.2	4	4.1	2.2	3.5	3.3	3.0
Acenaphthylene	2.3	48	38	41	40	40	39	35	38
Acenapthene	1.8u	10	9	11	10	7.5	8.2	8.1	7.9
Fluorene	2.8	8.9	9	12	10	7.7	8.3	7.7	7.9
Anthracene	2.5	18	17	21	19	13	15	13	14
Phenanthrene	10	71	77	73	75	43	59	46	49
Fluoranthene	19	110	110	110	110	79	78	69	75
Pyrene	19	120	140	130	120	90	89	75	85
Chrysene	8.7	23	21	23	22	12	18	13	14
Benzo(a)anthracene	6.8	16	16	16	16	11	12	10	11
Benzo(b)fluoranthene	7.5	19	18	17	18	13	15	13	14
Benzo(k)fluoranthene	8.4	20	21	23	22	14	18	15	16
Benzo(a)pyrene	9.9	26	30	27	28	20	21	23	21
Benzo(ghi)perylene	14	28	38	33	36	24	40	29	31
Indeno(1,2,3-cd)pyrene	3.4u	17	44	16	30	13	19	18	17
Pesticides/PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1]See text for data caveats
* = detected; however also detected in method blank
NC = not calculated due to low surrogate recovery
ND = not detected; see appendix for individual detection limits
u = not detected at given quantification limit
J = estimated value; below quantification limit
-- = indeterminant
__ = detected

Sediments in both Port Gamble Bay and Bywater Bay (control site) can be characterized as sandy with low concentrations (<0.1 to 0.2 percent) of total organic carbon. The water content of sediment samples ranged from about 25 to 30 percent.

Metals

Metals concentrations in Port Gamble Bay and Bywater Bay sediments were similar. Table 6 compares these concentrations to concentrations found elsewhere in Puget Sound and to "apparent effects thresholds" (AETs) developed to estimate concentrations above which deleterious effects apparently occur (Tetra Tech, 1987). By any of these measurements, metals concentrations are very low. They generally fall near the minimum concentrations measured at reference locations in Puget Sound (Tetra Tech, 1986) and range from one to three orders of magnitude below the AETs.

Organics

Some problems were experienced with the organics analysis. SW-846 (EPA, 1986) recommends a maximum holding time of 14 days prior to extraction and 40 days between extraction and analysis. The Ecology laboratory has accepted these times as their holding time policy. The holding time prior to extraction was exceeded.

In addition, laboratory blanks showed trace contamination with several phenolic and phthalate compounds, and surrogate recoveries were in some cases too low to permit accurate calculation of concentrations of some pollutants. These problems were experienced primarily because the method employed (see Appendix) for semivolatile analysis was a new one intended to achieve improved precision at low contaminant concentrations. The method appeared to achieve this goal with the most important class of organic contaminants tested--the polynuclear aromatic hydrocarbons (see Table 5b).

Trace amounts of pentachlorophenol (estimated 6.3 ug/kg dw; Station PG-1) and hexachloroethane (estimated 10 ug/kg dw; one field duplicate; Station PG-2) were reported. Hexachloroethane is not presently identified as a "pollutant of concern" in Puget Sound; therefore, little information is available on typical concentrations in Puget Sound sediments. Additionally, there are no AETs for this compound. The AET for pentachlorophenol is >140 ug/kg dw. The single detected value for this compound was less than five percent of the AET.

The primary class of organic compounds detected in these sediments is the polynuclear aromatic hydrocarbons (PNA's). Concentrations of individual low-weight (2- to 3-ring) PNA's were 5 to 20 times higher in Port Gamble Bay sediments than in the Bywater

Table 6. Pollutants of concern: comparison of Port Gamble sediments, apparent effects thresholds, and reference values.

	Bywater Bay	Port Gamble	Reference Locations[A, 1] Minimum[2]	Median[3]	90%[4]	Non-Reference[B, 5] Minimum	Median	90%	Apparent Effects Thresholds[6] Amphipod[7]	Benthic[8]
Metals (mg/kg, dry wt.)										
As	1.23	0.79-0.89	1.9	5.6	19.5	1.2	11	39	93	85
Cd	0.65	0.29-0.54	0.1	0.7	1.48	<0.01	0.62	3.2	6.7	5.8
Cu	14.9	15.2-19.3	3.6	33	57	3.8	55	90	800	310
Hg	0.025	0.023-0.027	0.016	0.055	0.105	0.01	0.23	1.1	2.1	0.88
Pb	1.17	0.40-0.99	<0.1	9.6	19.5	4.4	48	220	700	300
Zn	28.8	35.4-45.6	15	76	95	18	100	320	870	260
Organics (ug/kg, dry wt.)										
Naphthalene	6.0	112-135	1.3	7.1	--	<1.6	200	1,200	2,400	2,100
Acenaphthalene	2.3	38-48	<2.7	<40	<100	1.7	56	350	560	640
Acenaphthene	<1.8	7.9-10	1.3	--	--	<1.3	71	460	980	500
Fluorene	2.8	7.9-10	2.5	--	--	<1.2	91	460	1,800	640
Phenantahrene	10	49-71	2.6	14	--	<1	290	1,300	5,400	3,200
Anthracene	2.5	14-19	2.7	6	--	<1	110	530	1,900	1,300
Low-weight Polynuclear Aromatics (total) (ug/kg d.w.)	24	228-289	2.5	24	160	1.3	850	4,400	5,500	6,100
Fluoranthene	19	75-110	9.6	24	91	<1	530	2,300	9,800	6,300
Pyrene	19	85-120	11	22	114	<1	630	2,200	11,000	>7,300
Benzo(a)anthracene	6.8	11-16	2.6	5.5	--	<1	530	2,300	3,000	4,500
Chrysene	8.7	14-23	3.9	10	--	<1	420	2,000	5,000	6,700
Total benzofluoranthenes	16.4	30-40	9.1	18	--	2.6	710	3,600	3,700	8,000
Benzo(a)pyrene	9.9	21-28	4.1	8.4	--	<1	350	1,700	2,400	6,800
Indeno(1,2,3-cd)pyrene	<3.4	17-30	6.6	--	--	1.6	170	840	880	>5,200
Dibenzo(a,h)anthracene	<3.2	<6.9-<9.6	<3.3	--	--	<1	52	450	510	1,200
Benzo(ghi)perylene	14	28-36	4.0	7.6	--	<1	180	1,300	860	5,400
High-weight Polynuclear Aromatics (total) (ug/kg d.w.)	94	284-402	22	76	200	1.3	3,400	4,400	38,000	>51,000
Other Organics										
Dibenzofuran	2.0	4.4-6.9	<5	<5	<5	<5	130	380	540	540
2-Methylnaphthalene	2.3	3.0-4.2							670	670

A & B = from Pollutants of Concern Matrix, Tetra Tech (1986)

1 = Reference Locations: sites within Puget Sound considered to be control (i.e., relatively pristine) sites
2 = Minimum reported concentration
3 = Median reported concentration
4 = Concentration below which 90 percent of values fell
5 = Non-reference Locations: all locations not included in "reference" definition
6 = From Tetra Tech (1987)
7 = Based on bioassay results using the marine amphipod *Rhepoxynius*
8 = Based on analysis of benthic infaunal communities

Bay control. By comparison, individual high-weight (4- to 6-ring) PNA's were 2 to 6 times higher in Port Gamble Bay sediments. Bywater Bay sediment results compare well with median Puget Sound reference site concentrations (see Table 6), while Port Gamble Bay sediments had PNA concentrations that (while elevated with respect to reference values) were well below both median non-reference site concentrations and AETs. Low-weight PNA concentrations were somewhat higher than concentrations detected near Dockton in a similar survey (Yake, 1986), while high-weight PNA concentrations were somewhat lower. Concentrations of PNA's and related compounds (dibenzofuran, 2-methylnaphthelene) were well below those associated with known adverse effects.

CONCLUSIONS AND RECOMMENDATIONS

Contaminant concentrations detected in sediments collected during this survey are in many cases (metals, pesticides, most organics) near background (reference) levels. Even those compounds that are elevated above background (PNA's), are well below concentrations where adverse biological impacts have been measured.

The initial biological study of Port Gamble Bay conducted by Kocan (1987) showed both elevated egg mortalities and frequency of abnormal larvae in water collected from the same three locations sampled in this survey. Seawater extracts of sediment from these sites produced no difference in embryo survival, but did result in significantly increased frequency of larval abnormalities. Kocan concludes, "Based on the data obtained from field and laboratory exposures of herring embryos to water and sediment extract, it appears that some type of water soluble toxic substance is present in Port Gamble Bay which can produce either embryo mortality or physical defects in those embryos which survive to hatching."

In reviewing the field data generated by the WDF, egg mortality appears to be spatially and temporally erratic, and, therefore, the result of non-continuous phenomena. Given the relatively undeveloped nature of the drainage area and generally low concentrations of contaminants measured in Port Gamble Bay sediments, a biologically based phenomenon (for instance, the metabolites or decomposition products of algae mentioned by Kocan, 1987) appears the most reasonable hypothesis.

Given these findings, we urge resource management entities (Department of Fisheries, Port Gamble Bay Klallam Tribe) to pursue the hypothesis of biologically based phenomena as the most likely explanation for herring spawn mortalities. In the interim, additional chemical analysis of water or sediment should await the identification of a likely causative agent.

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APPENDIX

Semivolatile Analytical Scheme
(re-typed from Analytical Resources, Inc., Seattle WA)

SAMPLE PREPARATION:

Washington Department of Ecology Port Gamble Sediments

The sediment samples were homogenized and extracted following EPA Method 3550 (SW 846: Test Methods for Evaluating Solid Waste, November 1986). Approximately 100g (wet weight) were extracted. The samples were spiked with stable isotope labelled surrogate standards at 8 ug/sample (~100 ppb dry weight). The primary, neutral extract was concentrated to about 50 mL and the acidic and basic compounds removed by aqueous partitioning. The neutral fraction was concentrated to 2 mL and cleaned up using Gel-Permeation Chromatography (GPC) (SW 846-Method 3640). Following GPC the neutral extract was concentrated to about 1 mL and subjected to Silica Gel Chromatography in order to remove additional interferences. The column was 2.5 cm ID x 60 cm long and contained 60-200 mesh Silica Gel (J.T. Baker #5-3405) which had been heated to 450°C for six hours. The neutral fraction from Silica Gel was concentrated to about 2 mL and shaken with metallic mercury in order to remove elemented sulfur. The base and neutral fractions were combined, then concentrated to approximately 400 uL. The acid fraction was concentrated to approximately 400 uL separately.

The base/neutral and acid fractions were analyzed by GC-MS following EPA Method 1625 B. Calibration standards were run containing 1, 5, 10, and 20 ng/uL of unlabelled standards along with 10 ng/uL labelled standards in each calibration mixture. In order to increase sensitivity, the mass spectrometer photomultiplier was operated at a higher voltage than normal. This limited the linear dynamic range to about 1 to 25 ng/uL for most target compounds.

Table A-1 (part 1) complete semivolatiles data.

Site	B-1	PG-1	PG-2		PG-3		
Laboratory Number	8054	8050	8051	8053	8052	8052D	8052T
Phenol	*	*	*	67u	*	*	*
bis(2-Chloroethyl)Ether	2.7u	4.6u	5.4u	5.7u	23u	4.4u	2.8u
2-Chlorophenol	65u	12u	NC	45u	NC	7.4u	6.8u
1,3-Dichlorobenzene	3.8u	6.8u	8.4u	9.3u	40u	8.2u	4.8u
1,4-Dichlorobenzene	*	*	*	*	*	*	*
Benzyl Alcohol	3.0u	3.7u	4.5u	3.5u	2.0u	2.7u	2.7u
1,2-Dichlorobenzene	3.8u	6.6u	8.0u	9.1u	27u	7.1u	4.4u
2-Methylphenol	NC	130u	NC	NC	NC	12u	20u
bis(2-chloroisopropyl)Ether	8.8u	15u	17u	17.3u	36u	14u	9.1u
4-Methylphenol	NC	*	NC	NC	NC	*	*
N-Nitroso-Di-n-Propylamine	2.4u	2.9u	3.5u	2.7u	1.6u	2.1u	2.1u
Hexachloroethane	27u	26u	10J	46u	82u	38u	20u
Nitrobenzene	6.2u	11u	13u	13u	42u	9.4u	6.5u
Isophorone	6.8	3.2	2.1u	6	2.0u	1.4u	1.1u
2-Nitrophenol	25u	7.4u	6.7u	8.6u	NC	10u	6.5u
2,4-Dimethylphenol	NC	NC	NC	NC	NC	*	130u
Benzoic Acid	31u	30u	37u	36u	28u	28u	28u
bis(2-Chloroethoxy)Methane	3.4u	5.7u	6.7u	6.2u	7.2u	4.4u	3.7u
2,4-Dichlorophenol	54u	20u	24u	87u	NC	10.1u	9u
1,2,4-Trichlorobenzene	4.5u	7.3u	8.5u	8.1u	11u	5.8u	4.6u
1,2,3-Trichlorobenzene	4.0u	6.6u	7.5u	7.1u	8.4u	5.1u	4.2u
Naphthalene	6.0	120	120	150	110	130	96
4-Chloroaniline	1.9u	2.3u	2.9u	2.2u	1.3u	1.7u	1.7u
Hexachlorobutadiene	9.9u	15u	18u	16u	24u	12u	9.5u
4-Chloro-3-Methylphenol	200u	37u	*	NC	*	11u	*
2-Methylnaphthalene	2.3	4.2	4.2	4	2.2	3.5	3.3
Hexachlorocyclopentadiene	NC	NC	NC	NC	NC	NC	26u
2,4,6-Trichlorophenol	34u	18u	27u	47u	22.1u	19u	11u
2,4,5-Trichlorophenol	26u	16u	21u	39u	11.1u	19u	10u
2-Chloronaphthalene	1.8u	3.4u	3.8u	3.7u	2.0u	2.0u	1.9u
2-Nitroaniline	4.3u	5.2u	6.4u	4.9u	2.9u	3.9u	3.9u
Dimethyl Phthalate	1.8u	2.4u	3.1u	1.9u	1.9u	1.7u	1.5u
Acenaphthylene	2.3	48	38	41	40	39	35
3-Nitroaniline	4.6u	5.6u	6.9u	5.3u	3.1u	4.2u	4.2u

D = laboratory duplicate
T = laboratory triplicate
* = present, but also present in method blank
u = not detected at given quantification limit
NC = not calculated due to no recovery of surrogate
J = estimated value

Table A-1 (part 2) complete semivolatiles data.

Site	B-1	PG-1	PG-2		PG-3		
Laboratory Number	8054	8050	8051	8053	8052	8052D	8052T
Acenaphthene	1.8u	10	9	11	7.5	8.2	8.1
2,4-Dinitrophenol	39u	41u	38u	NC	87u	NC	NC
4-Nitrophenol	9u	10u	14u	NC	12u	NC	16u
Dibenzofuran	2.0	6.1	6.8	7	4.1	4.8	4.4
2,4-Dinitrotoluene	6.9u	11u	14u	11.2u	6.7u	8.0u	7.0u
2,6-Dinitrotoluene	11u	13u	17u	32u	9.2u	12u	11u
Diethylphthalate	2.0u	*	*	*	*	*	*
4-Chlorophenyl-phenylether	3.4u	4.6u	5.9u	5.3u	3.4u	3.5u	3.6u
Fluorene	2.8	8.9	9.0	12	7.7	8.3	7.7
4-Nitroaniline	6.1u	7.5u	9.2u	7.1u	4.1u	5.6u	5.5u
4,6-Dinitro-2-Methylphenol	16u	20u	21u	31u	22u	NC	33u
N-Nitrosodiphenylamine(1)	3.0u	3.3u	4.6u	3.2u	3.1u	4.2u	4.2u
4-Bromophenyl-phenylether	6.7u	8.9u	12u	NC	7.1u	6.9u	7.1u
Hexachlorobenzene	6.7u	8.3u	10.1u	8.7u	5.7u	6.4u	6.7u
Pentachlorophenol	33u	6J	35u	65u	32u	NC	36u
Phenanthrene	10	71	77	73	43	59	46
Anthracene	2.5	18	17	21	13	15	13
Di-n-Butylphthalate	*	*	*	*	*	*	*
Fluoranthene	19	110	110	110	79	78	69
Pyrene	19	120	140	130	90	89	75
Butylbenzylphthalate	3.8u	6.1	6.1	5	2.8	3.3u	2.8
3,3'-Dichlorobenzidine	NC	NC	NC	NC	NC	NC	NC
Benzo(a)Anthracene	6.8	16	16	16	11	12	10
bis(2-Ethylhexyl)Phthalate	*	*	*	*	*	*	*
Chrysene	8.7	23	21	23	12	18	13
Di-n-Octyl Phthalate	1.6u	2.4u	2.5u	3	1.0u	1.5u	1.5u
Benzo(b)Fluoranthene	7.5	19	18	17	13	15	13
Benzo(k)Fluoranthene	8.4	20	21	23	14	18	15
Benzo(a)Pyrene	9.9	26	30	27	20	21	23
Indeno(1,2,3-cd)Pyrene	3.4u	17	44	16	13	19	18
Dibenzo(a,h)Anthracene	3.2u	7.4u	8.9u	10.3u	3.7u	9.0u	8.1u
Benzo(ghi)Perylene	14	28	38	33	24	40	29
Carbazole	3.6u	5.3u	4.9u	3.1u	1.8u	3.2u	4.0u

D = laboratory duplicate
T = laboratory triplicate
* = present, but also present in method blank
u = not detected at given quantification limit
NC = not calculated due to no recovery of surrogate
J = estimated value

Table A-2 complete pesticides/PCBs data.

Site	B-1	PG-1	PG-2		PG-3		
Laboratory Number	8054	8050	8051	8053	8052	8052D	8052T
Alpha-BHC	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Beta-BHC	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Delta-BHC	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Gamma-BHC (Lindane)	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Heptachlor	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Aldrin	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Heptachlor Epoxide	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Endosulfan I	1.0u	1.1u	1.5u	1.2u	1.1u	1.0u	1.0u
Dieldrin	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
4,4'-DDE	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
Endrin	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
Endosulfan II	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
4,4'-DDD	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
Endosulfan Sulfate	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
4,4'-DDT	2.1u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
Methoxychlor	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Endrin Ketone	21u	2.3u	2.9u	2.4u	2.1u	1.9u	2.0u
Chlordane	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Toxaphene	21u	23u	29u	24u	21u	19u	20u
Aroclor-1016	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Aroclor-1221	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Aroclor-1232	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Aroclor-1242	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Aroclor-1248	10.5u	11.4u	14.6u	11.9u	10.7u	9.7u	10.2u
Aroclor-1254	21u	23u	29u	24u	21u	19u	20u
Aroclor-1260	21u	23u	29u	24u	21u	19u	20u

D = laboratory duplicate
T = laboratory triplicate
u = not detected at given quantification limit