Publication Number 88-e15

Waterbody Number WA-CR-1010

SCREENING SURVEY FOR CHEMICAL CONTAMINANTS AND TOXICITY IN SEDIMENTS AT FIVE LOWER COLUMBIA RIVER PORTS SEPTEMBER 22-24, 1987

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December 1988

ABSTRACT

EPA priority pollutants/hazardous substances list compounds and resin acids were analyzed in 12 sediment samples collected at five lower Columbia River ports and an upstream reference area during September 22-24, 1987. Potential for sediment toxicity was assessed through bioassay with two crustacean species, *Hyalella azteca* (amphipod) and *Daphnia pulex* (cladoceran). Ports included in the survey were Camas, Vancouver, Kalama, Longview, and Ilwaco.

Results suggest the level of chemical contamination to be generally low. The sediments were not toxic in bioassay. Additional sampling is recommended to confirm the high concentration and evaluate the extent of polyaromatic hydrocarbons in sediments below the Reynolds aluminum smelter at Longview and possible elevated polychlorinated biphenyls below Reynolds and the VANALCO smelter in Vancouver.

INTRODUCTION

At the request of the Ecology Southwest Regional Office (SWRO), the Toxics Investigations/Ground Water Monitoring Section conducted a reconnaissance survey of sediment quality at five ports along the lower Columbia River during September 22-24, 1987. Survey objectives were to characterize the occurrence of toxic chemicals in the sediments and assess the potential for sediment toxicity. Based on discussions with Gary Bailey and Mike Morhous of SWRO and George Houck of the Ecology Industrial Section, the ports listed below in Table 1 were selected for sampling:

Table 1. Lower Columbia River ports selected for sediment sampling, September 22-24, 1987.

Location (approximate river mile)	Potential Sources
Reed Island (124)	reference station
Camas Slough (118)	pulp mill, urban runoff
Vancouver (105-102)	paper mill, aluminum smelter, chemical storage, STP, urban runoff
Kalama (75)	chemical manufacturer
Longview (67-56)	pulp mills, aluminum smelter, former Hg-cell chloralkali plant, log yards, light industry, STP, urban runoff
Ilwaco (3)	boatyards, fishing fleet

METHODS

Sampling--Four stations were sampled at Longview (including Coal Creek Slough), two at Vancouver, and one each at the remaining ports (see Figures 1 and 2). Sediments were collected with a 0.1 m2 van Veen sampler. An effort was made to locate deposits of fine grained sediments. Although several sampling sites are described as being below major industries, no samples were collected in the immediate vicinity of outfalls.

Two to three grabs were pooled for each station. Replicate samples were collected at Camas Slough and at Longview below the Weyerhaeuser pulp mill. The top 2 cm layer from the grabs was pooled and homogenized by stirring with stainless steel spoons in stainless steel beakers, and split into subsamples for analysis. Samples for volatiles analysis were collected by filling 40 mL glass vials (no head space) prior to homogenizing.

Sample handling equipment was cleaned with hot tap water, Liqui-Nox detergent, and sequential rinses of deionized water, dilute nitric acid, deionized water, and pesticide-grade acetone. Sample containers for chemical analyses and bioassays were priority pollutant-cleaned glass jars with teflon-lined lids (I-Chem, Hayward, CA). All samples were stored on ice for transport to the Ecology/EPA Manchester Environmental Laboratory.

Analysis--Table 2 shows the physical/chemical analyses and bioassays done on the sediments. All samples were analyzed for acid/base/neutral compounds and pesticides/PCBs classed as EPA priority pollutants or hazardous substances list (HSL) compounds, grain size, total organic carbon (TOC), and percent moisture. Selected samples were analyzed for priority pollutant/HSL volatiles, cyanide, and resin acids. Appendix A gives a complete list of target chemicals.

The EPA Environmental Research Laboratory in Corvallis, Oregon, conducted bioassays on subsamples from each station. Two acute bioassays were employed: 96-hour exposure of the amphipod *Hyalella azteca* and 48-hour exposure of the cladoceran (water flea) *Daphnia pulex*. Two 1000-mL beakers containing 200 mL sediment and 800 mL of well water were prepared for each sample. Fifteen *Hyalella* were put in each beaker on September 29, 1987; 20 *Daphnia* were placed in the same beakers on October 1, 1987. All animals were counted, and survival recorded on October 3, 1987. The water temperature was 20^{o}C; well water hardness was 20 mg/L. The water was gently aerated during testing (Nebeker, 1987).

Quality assurance for chemical analyses followed standard Manchester laboratory practice (including method blanks, matrix spike duplicates, and surrogate compound spikes) as described in Huntamer (1986). Holding times and spike recoveries were within EPA Contract Laboratory Program (CLP) limits for priority pollutant analysis except for volatiles which exceeded the 14-day holding time for analysis by seven days. The analyses for antimony and neoabietic acid (a resin acid) were of questionable accuracy as described later in this report. Chemical concentrations are reported in units of ug/g (parts per million) or ng/g (parts per billion) on a dry weight basis.

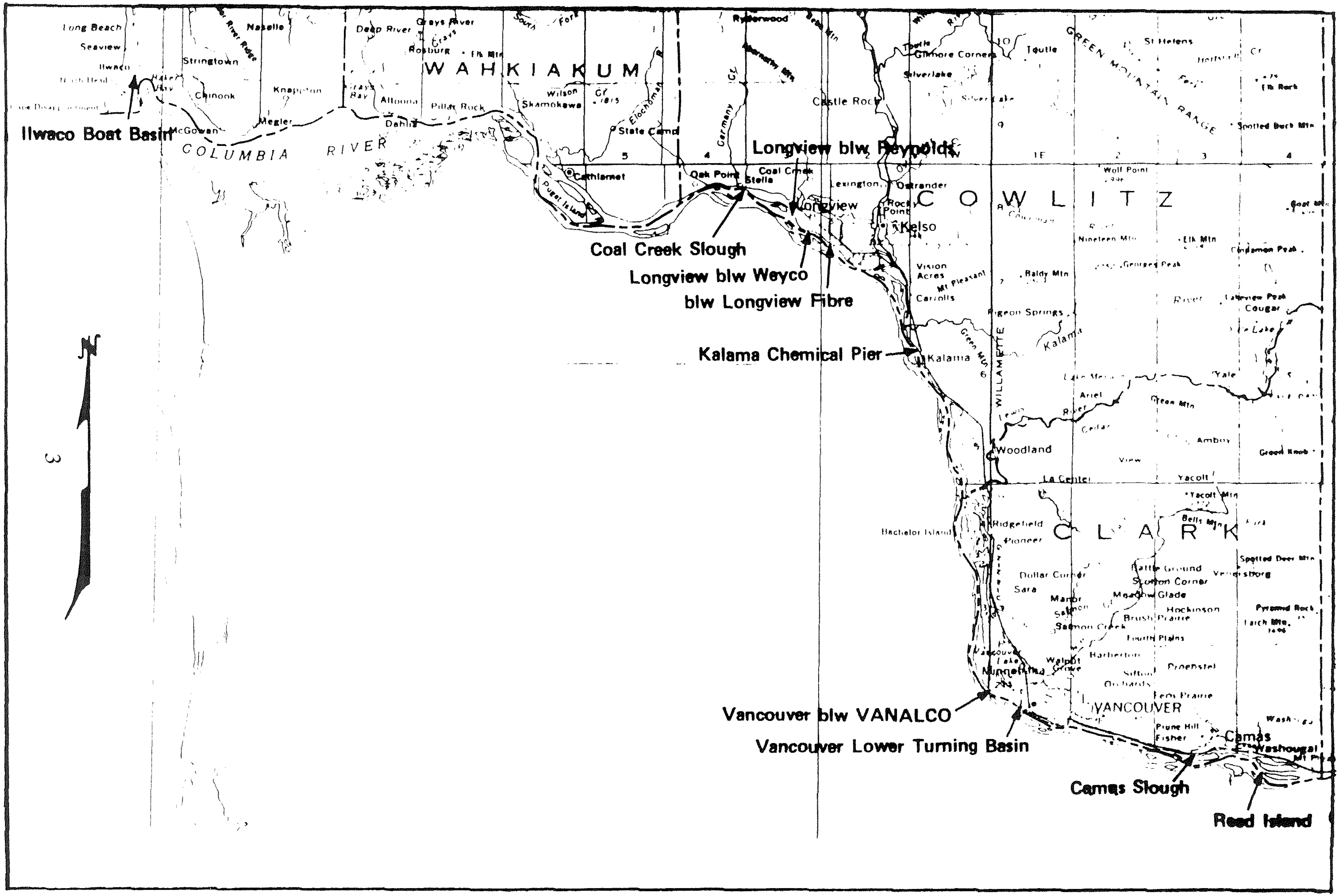

Figure 1. Lower Columbia River sampling sites, September 22-24, 1987

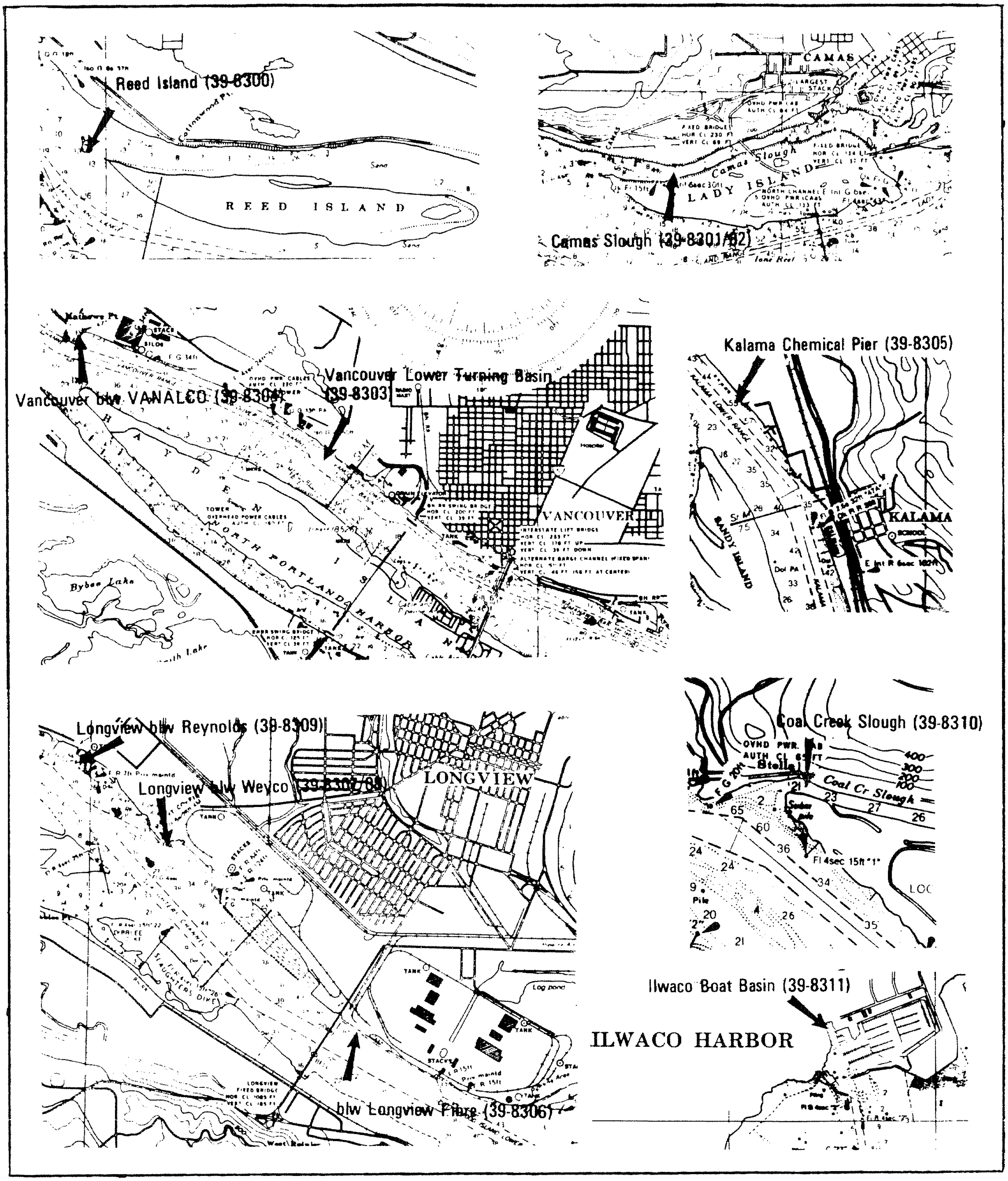

Figure 2. Locations of sediment samples collected at lower Columbia River ports, September 22-24, 1987

Table 2. Analytical methods for survey of sediment quality at lower Columbia River ports, September 22-24, 1987.

Analysis	Method	Reference	Laboratory
Ag, Al, As, Be, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Sb, Sn, Tl, Zn	atomic adsorption spectroscopy	EPA (1979)	Laucks Testing Labs, Inc. Seattle, WA
volatiles	purge and trap/gas chromatography/mass spectroscopy, method 624	EPA (1984)	Ecology/EPA Environmental Lab, Manchester, WA
acid/base/neutrals	gas chromatography/mass spectroscopy, method 625	EPA (1984)	Ecology/EPA Environmental Lab, Manchester, WA
organochlorine pesticides/ PCBs	gas chromatography/ electron capture, method 608	EPA (1984)	Ecology/EPA Environmental Lab, Manchester, WA
cyanide	colorimetric automated UV method 335.3	EPA (1979)	Ecology/EPA Environmental Lab, Manchester, WA
resin acids	gas chromatography/mass spectroscopy	NCASI (1986)	Ecology/EPA Environmental Lab, Manchester, WA
grain size	seives and pipettes	Holme & McIntyre (1971)	Parametrix, Inc. Bellevue, WA
total organic carbon	persulfate-UV, method 505	APHA (1985)	Laucks Testing Labs, Inc. Seattle, WA
Hyalella bioassay	96-hour exposure	Nebeker *et al*. (1986)	EPA Environmental Research Laboratory, Corvallis, OR
Daphnia bioassay	48-hour exposure	EPA (1985) - modified	EPA Environmental Research Laboratory, Corvallis, OR

RESULTS AND DISCUSSION

Physical Characteristics (Table 3)--Sandy sediments with low organic content were typical of most sampling sites. Only the Ilwaco boat basin and Camas Slough sediments were predominantly fine (< 62 um) material. These two sites, and perhaps Coal Creek Slough, appeared to be the only depositional environments encountered in the survey.

Metals (Table 3)--Metals concentrations were generally low. Antimony[1], selenium, silver, and thallium were not detectable. Concentrations of other metals were not appreciably elevated above those measured at Reed Island--considered a reference station for purposes of the present study--except for the following:

- Arsenic (9.1 ug/g), beryllium (0.8 ug/g), chromium (26 ug/g), copper (75 ug/g), mercury (0.18 ug/g), and zinc (140 ug/g) in sediments from the Ilwaco boat basin were from 4 to 12 times higher than at Reed Island. The boat basin had the highest concentrations of these five metals, as well as nickel (15 ug/g) and tin (21 ug/g), found in the survey.

- Beryllium and nickel concentrations in Camas Slough were equivalent to those at Ilwaco. Mercury concentrations (0.09 - 0.10 ug/g) were also moderately elevated compared to other sampling sites.

- The highest lead (140 ug/g) and second highest copper (54 ug/g) concentration--9 and 14 times reference levels, respectively--- occurred at the Vancouver lower turning basin.

Table 4 compares the metals concentrations measured at lower Columbia River ports with levels characteristic of the lower Columbia River drainage and other nearby estuaries. Also shown are interim criteria developed by the Wisconsin Department of Natural Resources (1985) for open-water disposal of sediments dredged from the Great Lakes. These criteria (which are limited to metals) are based on comparisons of current and historical concentrations of contaminants in Great Lakes sediments. Sediment criteria have not yet been established for Washington State freshwaters.

This comparison indicates that even the highest concentrations of arsenic, cadmium, chromium, and nickel observed in the present survey are not appreciably above background, including deep vibracore samples collected in the Columbia River by the U.S. Army Corps of Engineers (COE). Although most sampling sites also had relatively low copper, lead, mercury, and zinc concentrations, lead in the Vancouver lower turning basin, and mercury and zinc at the Ilwaco boat basin exceeded Great Lakes interim dredge disposal criteria. Copper

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1 Quality assurance samples analyzed at the Manchester Laboratory during the time the lower Columbia River samples from the present survey were being processed suggest the antimony data are suspect. Manchester measured only 0.5-0.8 ug/g in duplicate analyses of a NBS standard reference material (River Sediment 1645) containing 51 ug/g. These data have been reported in Johnson (1988).

Table 3. Metals analysis of sediments collected at lower Columbia River ports, September 1987 (µg/g, dry; ppm)

Location:	Reed Island	-Camas Slough-		Vanc. Lower Turning Basin	Vancouver below VANALCO	Kalama Chemical Pier	Below Longview Fibre	Longview --below Weyco--		Longview below Reynolds	Coal Creek Slough	Ilwaco Boat Basin
Depth (ft.):	7	36	36	48	30	36	49	19	18	25	21	8
Date:	4/22	4/22	4/22	4/22	4/22	4/22	4/23	4/23	4/23	4/23	4/23	4/24
Time:	1040	1130	1150	1410	1440	1700	1000	1020	1035	1050	1125	1000
Sample No.(88-398-):	300	301	302	303	304	305	306	307	308	309	310	311
% Fines[a]	**0.47**	**64.29**	**72.46**	**7.56**	**11.02**	**1.27**	**2.77**	**16.66**	**19.99**	**8.28**	**25.42**	**94.91**
% TOC	**0.3**	**1.6**	**2.8**	**0.7**	**0.3**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**1.6**
% Moisture	**26.9**	**52.3**	**54.9**	**27.5**	**30.3**	**28.7**	**26.6**	**31.0**	**29.4**	**28.3**	**34.8**	**61.8**
Antimony*	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)	(<2.5)
Arsenic*	**2.1**	**7.2**	**7.2**	**3.8**	**3.4**	**2.4**	**0.8**	**1.1**	**1.0**	**1.1**	**1.3**	**9.1**
Beryllium*	**0.1**	**0.8**	**0.8**	**0.2**	**0.2**	**0.2**	<0.1	<0.1	<0.1	<0.1	**0.1**	**0.8**
Cadmium*	<0.5	**0.9**	**0.8**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**0.6**
Tin	**6**	**17**	**15**	**12**	**10**	**8**	**9**	**8**	**10**	**12**	**8**	**21**
Chromium*	**12**	**22**	**22**	**13**	**16**	**11**	**8**	**7**	**8**	**11**	**9**	**26**
Copper*	**6**	**31**	**30**	**54**	**18**	**8**	**14**	**16**	**17**	**19**	**15**	**75**
Lead*	<10	**38**	**22**	**140+**	<10	<10	<10	<10	<10	<10	<10	**21**
Mercury*	<0.02	**0.09**	**0.10**	**0.03**	**0.03**	**0.06**	<0.02	<0.02	**0.02**	**0.09**	**0.03**	**0.18**
Nickel	**9**	**15**	**15**	**11**	**11**	**9**	**7**	**5**	**7**	**9**	**8**	**15**
Selenium*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Silver*	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Thallium*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Zinc*	**40**	**130**	**130**	**95**	**71**	**59**	**27**	**28**	**31**	**39**	**38**	**140**
Manganese	**160**	**330**	**330**	**280**	**290**	**230**	**110**	**130**	**130**	**170**	**180**	**200**
Aluminum	**7,800**	**23,000**	**23,000**	**10,000**	**11,000**	**8,300**	**5,500**	**7,000**	**6,600**	**6,900**	**8,300**	**28,000**
Iron	**12,000**	**25,000**	**24,000**	**16,000**	**17,000**	**13,000**	**14,000**	**13,000**	**16,000**	**19,000**	**14,000**	**28,000**

[a]silt and clay (<4µm-62µm)
*EPA priority pollutant
( ) accuracy suspect; see text
+possible anomalous value; see text

Table 4. Concentrations of selected metals measured in sediments at lower Columbia River ports compared to results of other studies and criteria for disposal of dredged material (µg/g, dry; ppm)

	Lower Columbia River Ports (present study)				
	80th Percentile[a]	Maximum Concentration	Lower Columbia River Background Concentrations[b]	Average Columbia River and Oregon Estuaries[c]	Freshwater Sediment Criteria[d]
Arsenic	3.8	9.1	9.7 ± 2.6	6.6 ± 0.7	10
Cadmium	<0.5	0.9	0.2 ± 0.04	0.4 ± 0.1	1.0
Chromium	16	26	16 ± 6.3	29 ± 5.8	100
Copper	31	75	16 ± 6.4	24 ± 3.4	100
Lead	21	140	12 ± 1.4	14 ± 1.4	50
Mercury	0.09	0.18	0.014 ± 0.006	0.05 ± 0.01	0.10
Nickel	11	15	NA[e]	29 ± 5.5	100
Zinc	95	140	63 ± 10	84 ± 10	100

[a] eighty percent of stations (i.e., 8 out of 10) had equal to or less than this concentration.

[b] U.S. Army Corps of Engineers deep vibracore samples (Festul, 1987).

[c] average of 150 samples in U.S. Army Corps of Engineers, Portland, database as reported in Festul (1987).

[d] interim criteria for open water disposal of dredged materials in the Great Lakes; cannot exceed 125 percent of criteria value (Wisconsin Department of Natural Resources, 1985).

[e] not analyzed.

concentrations at the Illwaco boat basin and Vancouver lower turning basin are above background but within the dredge disposal criteria.

In response to an Ecology compliance order, the Port of Vancouver recently conducted an investigation of impacts from copper concentrate ore spills at the loading facility bordering the lower turning basin (Century West Engineering Corp., 1988). They reported high concentrations of copper (to 54,200 ug/g) and, to a lesser extent, lead (to 796 ug/g), arsenic (to 365 ug/g), zinc (to 5,395 ug/g), and mercury (to 0.25 ug/g) in the immediate vicinity of the loading facility. Downstream of this site only copper concentrations appeared elevated compared to the background levels reported in the document.

Table 5 compares the Port's lower turning basin data (excluding samples at the loading facility) and background data with results from the present survey and previously cited COE data on metals in Columbia River background sediments. Except for lead, Port and Ecology data are in close agreement on metals concentrations in the turning basin. The lead concentration of 140 ug/g reported in the single sample analyzed for Ecology's survey may be an anomaly. The Port's analysis of lead in background sediments agrees well with both Ecology and COE results. Matrix spike recoveries for lead reported in the Port's study also suggest their analyses were accurate.

Except for arsenic and zinc, the Port's data on background concentrations are in line with present study and COE findings. The Port's arsenic data (<0.05 ug/g in all samples) are suspect. The zinc concentrations reported (134 +/- 33 ug/g) may reflect local background, the Port's samples having been collected not far upstream of the turning basin.

The data sources referenced in Table 4 did not include beryllium or tin. Beryllium has been detected in Puget Sound sediments at 0.16 - 1.1 ug/g; average levels in the earth's crust are 6 ug/g (Konasewich et al., 1982). On this basis, sediments at these lower Columbia ports (<0.1 - 0.8 ug/g) do not contain elevated concentrations of beryllium. Although the tin concentration at the Ilwaco boat basin (21 ug/g) was not much above the range at other ports (8-17 ug/g), the amount of organo-tin present would be the critical factor in determining its significance. Organo-tins were not analyzed for the present survey.

Volatiles--This analysis was limited to sites with potential pulp mill influence--Camas Slough, the Vancouver lower turning basin, Longview below Weyerhaeuser--and the Reed Island reference station. No compounds were detected at detection limits ranging from 1.4 to 15 ng/g. As already noted, the 14-day holding time for analysis was exceeded by one week for these samples.

Analysis for volatiles in sediments off the Kalama Chemical pier was recently done as part of an Ecology Class II inspection (Heffner, 1988). Only trace amounts (less than 1 ng/g) of two compounds, toluene and 1,1,1-trichloroethane, were detected near the pier. 1,1,1-Trichloroethane, however, was also detected (4.4 ng/g) upstream of the pier.

Acid/Base/Neutrals (Table 6)--Polyaromatic hydrocarbons (PAH) and phthalate acid esters (PAE) were detected at all sites. Dibenzofuran, an oxygen-containing 2-ring aromatic

Table 5. Comparison of metals concentrations measured by the Port of Vancouver, Ecology, and COE in sediments from the Vancouver lower turning basin and/or background sediments (ug/g, dry; ppm).

	Vancouver Lower Turning Basin		Lower Columbia River Background		
	Port Data[a]	Ecology Data[b]	Port Data[c]	Ecology Data[d]	COE Data[e]
Arsenic	2.7 ± 1.2	3.8	<0.05 ± 0	2.1	9.7 ± 2.6
Cadmium	NA[f]	<0.5	NA	<0.5	0.2 ± 0.04
Chromium	6.8 ± 4.0	13	8.0 ± 1.6	12	16 ± 6.3
Copper	49 ± 44	54	23.0 ± 5.5	6	16 ± 6.4
Lead	7.4 ± 7.6	140	16.7 ± 6.2	<10	12 ± 1.4
Mercury	0.035 ± 0.016	0.03	0.07 ± 0.03	<0.02	0.014 ± 0.006
Nickel	NA	11	NA	9	NA
Zinc	97 ± 62	95	134 ± 33	40	63 ± 10

[a]mean ± SD of 32 samples (Century West Engineering Corp., 1988)

[b]sample no. 85-398303, present survey

[c]mean ± SD of 5 samples (Century West Engineering Corp., 1988)

[d]sample no. 88-398300 (Reed Island), present survey

[e]deep vibracore samples (Festul, 1987)

[f]not analyzed

Table 6. Organic priority pollutants/hazardous substances list compounds detected in the acid-base/neutrals fraction of sediments collected at lower Columbia River ports, September 1987 ng/g dry)

Location:	Reed Island	-Camas Slough-		Vanc. Lower Turning Basin	Vancouver below VANALCO	Kalama Chemical Pier	Below Longview Fibre	Longview --below Weyco--		Longview below Reynolds	Coal Creek Slough	Ilwaco Boat Basin
Depth (ft.):	7	36	36	48	30	36	49	19	18	25	21	8
Date:	4/22	4/22	4/22	4/22	4/22	4/22	4/23	4/23	4/23	4/23	4/23	4/24
Time:	1040	1130	1150	1410	1440	1700	1000	1020	1035	1050	1125	1000
Sample No. (88-398-):	300	301	302	303	304	305	306	307	308	309	310	311
% Fines[a]	0.47	64.29	72.46	7.56	11.02	1.27	2.77	16.66	19.99	8.28	25.42	94.91
% TOC	0.3	1.6	2.8	0.7	0.3	0.2	0.1	0.2	0.2	0.2	0.3	1.6
% Moisture	26.9	52.3	54.9	27.5	30.3	28.7	26.6	31.0	29.4	28.3	34.8	61.8
Polyaromatic Hydrocarbons (PAH):												
naphthalene	120u	190u	840u	22J	9J	110J	130u	140u	130u	530u	140u	44J
2-methylnapthalene	120u	3J	14J	6J	4J	1J	4J	3J	6J	6J	4J	17J
acenaphthylene	120u	190u	840u	4J	2J	110u	130u	140u	130u	530u	140u	12J
acenaphthene	120u	190u	840u	5J	9J	110u	24J	6J	5J	94J	140u	14J
fluorene	120u	1J	9J	9J	9J	110u	15J	7J	5J	49J	2J	34J
phenanthrene	1J	8J	59J	65J	71J	3J	42J	41J	26J	580	17J	180J
anthracene	120u	190u	840u	12J	6J	110u	5J	6J	4J	460J	140u	1,500u
fluoranthene	0.5J	8J	72J	160J	96J	4J	40J	98J	46J	2,100	35J	1,500u
pyrene	120u	9J	80J	160J	78J	5J	50J	130J	50J	2,500	51J	590J
benzo(a)anthracene	120u	6J	50J	62J	45J	5J	21J	66J	26J	2,200	29J	180J
chrysene	120u	7J	58J	65J	66J	5J	15J	73J	23J	4,100	37J	200J
benzo(b)fluoranthene	2BJ	6BJ	32BJ	26BJ	31BJ	110BJ	10BJ	41BJ	14BJ	1,800B	22BJ	99BJ
benzo(k)fluoranthene	2BJ	190BJ	26BJ	20BJ	22BJ	3BJ	8BJ	31BJ	10BJ	910B	8BJ	120BJ
benzo(a)pyrene	120Bu	190Bu	840Bu	33BJ	47BJ	110Bu	13BJ	66BJ	21BJ	1,500B	140Bu	1,500u
indeno(1,2,3-cd)pyrene	120u	190u	840u	17J	33J	110u	10J	42J	12J	920	11J	76J
dibenzo(a,h)anthracene	120Bu	190Bu	840Bu	520Bu	12BJ	110Bu	7BJ	25BJ	130Bu	400BJ	140Bu	1,500Bu
benzo(g,h,i)perylene	120Bu	190Bu	37BJ	22BJ	39BJ	110Bu	8BJ	51BJ	17BJ	1,100B	140Bu	1,500Bu
Total PAH detected:	6	48	440	690	580	26	270	690	400	19,000	220	1,600
Other Aromatic Hydrocarbons:												
dibenzofuran	120u	190u	840u	7J	7J	110u	11J	5J	6J	28J	3J	28J

[a] silt + clay (<4μm-62μm)
u = not detected at detection limit shown
J = estimated concentration
B = also detected in laboratory blank (see text)

Table 6. (continued)

Location:	Reed Island	-Camas Slough-		Vanc. Lower Turning Basin	Vancouver below VANALCO	Kalama Chemical Pier	Below Longview Fibre	Longview --below Weyco--		Longview below Reynolds	Coal Creek Slough	Ilwaco Boat Basin
Depth (ft.):	7	36	36	48	30	36	49	19	18	25	21	8
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Sample No. (88-398-):	300	301	302	303	304	305	306	307	308	309	310	311
% Fines[a]	0.47	64.29	72.46	7.56	11.02	1.27	2.77	16.66	19.99	8.28	25.42	94.91
% TOC	0.3	1.6	2.8	0.7	0.3	0.2	0.1	0.2	0.2	0.2	0.3	1.6
% Moisture	26.9	52.3	54.9	27.5	30.3	28.7	26.6	31.0	29.4	28.3	34.8	61.8
Phthalate Acid Esters (PAE):												
diethylphthalate	3J	190u	4J	2J	2J	110u	130u	2J	130u	530u	140u	1,500u
di-n-butylphthalate	25J	9J	840J	41J	650u	15J	12J	32J	19J	530u	15J	1,500u
butylbenzylphthalate	2J	190u	840u	260u	130u	1J	130u	140u	10J	530u	140u	1,500u
bis(2-ethylhexyl)-phthalate	64BJ	16BJ	170BJ	33BJ	210B	1,900B	20J	27BJ	44BJ	47BJ	62BJ	570BJ
di-n-octylphthalate	7BJ	16BJ	72BJ	20BJ	9BJ	4BJ	4J	9BJ	14BJ	530Bu	63BJ	64BJ
Total PAE detected:	100	41	1,100	96	220	1,900	36	70	87	47	140	630
Miscellaneous Compounds:												
isophorone	120u	190u	840u	260u	4J	110u	130u	140u	130u	530u	140u	1,500u
Tentative Identifications:												
2,4,5,7-tetramethyl-phenanthrene	ND	900J	2,400J	4,200J	ND	ND	ND	ND	6,200J	ND	ND	ND
benzo(j)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	12,000J	ND	ND
benzo(b)triphenylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	3,100J	ND	ND
benzo(b)naphtho-(1,2-d)thiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND	6,100J	ND	ND
2,2-diethyl-1,1-biphenyl	ND	ND	ND	890J	580J	ND	ND	ND	ND	ND	ND	ND
d-friedoolean-14-en-one	ND	1,600J	1,200J	ND	ND	ND	ND	ND	510J	ND	1,000J	ND

[a] silt + clay (<4μm-62μm)
u = not detected at detection limit shown
J = estimated concentration
B = also detected in laboratory blank (see text)
ND = not detected

hydrocarbon was also detected at most sites except Reed Island, Camas Slough, and the Kalama Chemical pier. A trace (estimated at 4 ng/g) of isophorone (trimethylcyclohexenone), a solvent and intermediate in chemical synthesis, was detected at Vancouver below the VANALCO aluminum smelter.

In most cases concentrations of the above compounds were below detection limits and reported by the laboratory as estimates. One of the two method blanks analyzed in conjunction with these samples also had detectable amounts of five high molecular weight PAH (3-8 ng/g) and two PAE (5-10 ng/g). The data are so qualified in the table.

The primary result of interest in this analysis is the elevated concentrations of high molecular weight PAH (400-4,100 ng/g individual PAH; 19,000 ng/g total detected PAH) in the sediments collected at Longview below the Reynolds aluminum smelter. These concentrations are one to three orders of magnitude higher than found at the other ports and exceed some of the apparent effects thresholds (AET[2]) that have been determined for PAH in Puget Sound sediments (PTI Environmental Services, 1988). Similar concentrations of aromatic hydrocarbons not classed as EPA priority pollutants were also tentatively identified below Reynolds (and at several other sites).

According to Ted Mix and Dave Davies of the Ecology Industrial Section, PAH are released when anodes are consumed in the aluminum smelting process. PAH (monitored by way of benzo(a)pyrene) are among the constituents currently limited in Reynolds' NPDES permit. The extent of PAH contamination at this facility or its potential as a PAH source to the river has not been investigated. The Industrial Section has begun discussions with the aluminum industries and EPA on control of PAH released through air emissions, and will be requiring complete priority pollutant scans on effluents and stormwater discharges when Reynolds' NPDES permit comes up for renewal next year (Davies, personal communication).

The total PAH concentration at the Ilwaco boat basin (1,600 ng/g), although much lower than at Longview below Reynolds, was 2 to 6 times higher than at the other ports. PAH concentrations at Ilwaco do not, however, approach even the lowest of Puget Sound AET values for individual PAH (230 ng/g).

Chlorinated Pesticides--With one exception, pesticides were not detected in the Columbia ports sediments. The limit of detection was 2.0 ng/g (60 ng/g for toxaphene). These results are consistent with data reported by USGS for the lower Columbia River and nearby drainages which show organochlorines to be generally at or below limits of detection in the sediments

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2 An AET is the sediment concentration of a chemical above which a statistically significant biological effect (relative to reference sediments) is always observed. The biological indicators used include depressions in benthic infauna and results of amphipod (*Rhepoxynius abronius*), oyster larvae (*Crassostrea gigas*), and Microtox bioassays. The AET values cited in the present report are based on data from up to 284 stations in Puget Sound.

(Fuhrer, 1984: Fuhrer and Rinella, 1982). The Manchester laboratory reported 141 ng/g of endosulfan sulfate in sediments from Longview below Reynolds but encountered interferences in the analysis of this compound and qualified the result "presumptive evidence for presence of material."

Polychlorinated Biphenyls--PCBs (quantified as Aroclor-1254) were detected at two locations only--Longview below Reynolds (73 ng/g) and Vancouver below VANALCO (58 ng/g). Detection limits for other sites were 20 ng/g.

Neff et al. (1986) have proposed a freshwater sediment criterion of 290 ug/g (TOC normalized) for PCBs. This value, derived from field data, is the highest sediment concentration tolerated by 95 percent of benthic infauna. Although PCB concentrations of 58 and 73 ng/g (19 and 36 ug/g, respectively, when normalized to TOC) are within Neff's criterion and below Puget Sound AET values (130 - 3,100 ng/g), results of the present study and the above-referenced USGS analyses of Columbia River sediments suggest the concentrations measured below Reynolds and VANALCO are relatively high for the lower Columbia and may, therefore, indicate past or present sources.

One small discharge of PCBs is known to have occurred at VANALCO. According to Dave Davies, a 1982 inspection by the Department of Labor and Industries found evidence of air contamination with PCBs at the VANALCO wire mill (now owned by ACPC, a separate company). The source was traced to a 250,000-gallon tank of oil used to lubricate the wire-rolling machinery.

VANALCO used a filtration system to treat and re-use the oil. However, wastewater resulting from filtration became contaminated with PCBs. Between 1983 and 1984, in consultation with Ecology and EPA, this water was disposed of by bleeding into the plant's NPDES discharge to the Columbia River (5 MGD) at a rate calculated to result in conformance with the EPA health risk level of 10^{-5} (0.79 ng/L) after mixing with other process effluents. Ecology records indicate less than 10 grams of PCBs were discharged to the Columbia in this manner.

Cyanide--This analysis was limited to sediments near aluminum smelters and Reed Island. Cyanide was not detected at any of these sites at a detection limit of 5 ng/g.

Resin Acids (Table 7)--Only the three sites with potential pulp mill influence and Reed Island were analyzed for resin acids. The basic structure of the compounds considered here consists of a three-ring aromatic hydrocarbon (phenanthrene) with a carboxyl group (-COOH). Resin acids are naturally occurring compounds but are much concentrated through both chemical and mechanical pulping processes (Keith, 1976; Oikari and Holmbom, 1986). Chlorinated resin acids are unique to bleach mills using chlorine.

Resin acids were detected at each of the sampling sites below pulp mills, but not at Reed Island. A chlorinated resin acid, dichlorodehydroabietic acid, was detected in the Vancouver lower turning basin (60 ng/g, estimated) and at Longview below Weyerhaeuser (42 ng/g, estimated). Total resin acid concentrations were 2,000 ng/g at Camas Slough, 570 ng/g at the Vancouver lower turning basin, and 1,400 ng/g at Longview below Weyerhaeuser. Other sources of data

Table 7. Resin acids detected in sediments collected at selected lower Columbia River ports, September 1987 (ng/g, dry; ppb)

Location:	Reed Island	Camas Slough	Vancouver Lower Turning Basin	Longview bw Weyco
Depth (ft.):	7	36	48	19
Date:	4/22	4/22	4/22	4/23
Time:	1040	1130	1410	1020
Sample No. (88-398-):	300	301	303	307
% Fines[a]	**0.47**	**64.29**	**7.56**	**16.66**
% TOC	**0.3**	**1.6**	**0.7**	**0.2**
% Moisture	**26.9**	**52.3**	**27.5**	**31.0**
Abietic acid	120u	**500**	**110**	**300**
Neoabietic acid	(120u)	(300u)	(100u)	(130u)
Dehydroabietic acid	120u	**920**	**240**	**500**
Dichlorodehydro-abietic acid	120u	300u	**60J**	**42J**
Isopimaric acid	120u	**500**	**130**	**340**
Sandaracopimaric acid	120u	**130J**	**32J**	130u
Levopimaric acid	120u	300u	100u	130u
Palustric acid	120u	300u	100u	**170**
Total detected resin acids:	ND	**2,000**	**570**	**1,400**

[a]silt + clay (<4um-62µm)
u = not detected at detection limit shown
( ) = low matrix spike recoveries (1.4%-6.5%) for this compound
J = estimated concentration
ND = not detected

on resin acids in Columbia River sediments were not available to put these findings in perspective, but limited resin acid analyses have been done in Puget Sound. Recent analysis of Port Townsend Bay sediments by the Manchester laboratory suggests individual resin acid concentrations of 2,000 ng/g or more are not unusual in the vicinity of pulp mills (Johnson, 1988). In Everett Harbor's East Waterway, individual resin acid concentrations approach 100,000 ng/g (PTI Environmental Services and Tetra Tech, 1988). The significance of resin acid contamination of aquatic sediments has not been determined.

Bioassays (Table 8)--None of the sediments assayed appeared to have substantial toxicity toward *Hyalella* or *Daphnia*. Little or no mortality occurred among *Hyalella*. Although in most instances *Daphnia* experienced mortality in the range of 5 to 25 percent, the highest mortality--25 to 30 percent---occurred in Reed Island reference sediments. This suggests the *Daphnia* mortality observed for port sediments is probably not significant.

CONCLUSIONS

Results of this limited survey of sediment quality at lower Columbia River ports suggest the level of chemical contamination to be generally low. This may reflect the non-depositional character of most of the sites investigated, rather than the absence of contaminant sources. The sediments did not appear toxic in short-term bioassays with two species of crustaceans.

RECOMMENDATIONS

- Additional Columbia River sediment samples should be collected to confirm the high concentration of PAH at Longview below the Reynolds aluminum smelter, and determine the extent of contamination.

- Sampling to confirm elevated PCBs should also be done at the Reynolds site and at Vancouver below the VANALCO aluminum smelter.

- A few sediment samples from the Reynolds site should be analyzed for endosulfan sulfate to determine whether the tentative presence of this compound can be confirmed.

- Copper, mercury, zinc, and PAH appeared somewhat elevated at the Ilwaco boat basin but the value of focusing on this particular finding is questionable considering the widespread use of copper--and (historically) mercury--containing anti-fouling paints, sacrificial zinc anodes, gasoline, and diesel fuel at these types of facilities. Mercury is no longer registered for use in anti-fouling paints (EPA, 1980).

Table 8. Bioassay results on sediments collected at lower Columbia River ports, September 22-24, 1987 (duplicate samples).

Location	Sample No. (88-398-)	Hyalella (n = 15) No. Dead	Hyalella (n = 15) % Mortality	Daphnia (n = 20) No. Dead	Daphnia (n = 20) % Mortality
Laboratory control	A	2	13	0	0
	B	0	0	0	0
Reed Island	300A	1	7	6	30
	300B	1	7	5	25
Camas Slough	301A	2	13	3	15
	301B	0	0	1	5
	302A	0	0	1	5
	302B	0	0	1	5
Vancouver Lower Turning Basin	303A	0	0	1	5
	303B	0	0	3	15
Vancouver below VANALCO	304A	1	7	2	10
	304B	0	0	1	5
Kalama Chemical Pier	305A	1	7	3	15
	305B	1	7	3	15
Below Longview Fibre	306A	0	0	4	20
	306B	0	0	5	25
Longview below Weyco	307A	0	0	4	20
	307B	1	7	0	0
	308A	0	0	3	15
	308B	0	0	0	0
Longview below Reynolds	309A	0	0	4	20
	309B	0	0	5	25
Coal Creek Slough	310A	0	0	3	15
	310B	0	0	2	10
Ilwaco Boat Basin	311A	0	0	0	0
	311B	0	0	0	0

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Appendix A. Chemicals analyzed in sediments collected at lower Columbia River ports, September 22-24, 1987

Volatiles

Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Methylene chloride
Acetone
Carbon disulfide
1,1-Dichloroethene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Vinyl acetate
Bromodichloromethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
2-Chloroethylvinylether
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethene
1,1,2,2-Tetrachloroethane
Toluene
Chlorobenzene
Ethylbenzene
Styrene
Total Xylenes

Acid/Base/Neutrals

Phenol
bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
3-Nitroaniline
Guaiacol
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-Nitrosodiphenylamine(1)
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
di-n-Butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
bis(2-Ethylhexyl)pthalate
Chrysene
di-n-Octylphthalate
Benzo(b)fluoranthene &
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anthracene
Benzo(ghi)peylene

OC Pesticides/PCBs

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
p,p'-DDE
Endrin
Endosulfan II
p,p'-DDD
Endosulfan sulfate
p,p'-DDT
Methoxychlor
Endrin aldehyde
Chlordane
Toxaphene
PCB-1016
PCB-1242
PCB-1248
PCB-1254
PCB-1260

Resin Acids

Abietic acid
Neoabietic acid
Dehydroabietic acid
Dichlorodehydroabietic acid
Isopimaric acid
Levopimaric acid
Sandaracopimaric acid
Palustric acid

Metals

Antimony
Arsenic
Beryllium
Cadmium
Tin
Chromium
Copper
Lead
Mercury
Nickel
Selenium
Silver
Thallium
Zinc
Manganese
Aluminum
Iron

Miscellaneous

Cyanide