

INDUSTRIALLY-POLLUTED SEDIMENTS OF THE COLUMBIA RIVER
NEAR WENATCHEE, WASHINGTON

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Preliminary Report to
Environmental Protection Agency
(Interagency Agreement DW13931749-01.0)

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October 1986

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BACKGROUND

Ramifications of this investigation impact three regional fisheries and habitat priority issues: (1) dams and hydroelectric power generation; (2) point and non-point source industrial waste discharge; and (3) waterway development (including dredging, filling, and dredge disposal). The National Marine Fisheries Service (NMFS) has long been involved in research on these particular issues. In the Columbia River Basin, information **is** needed on industrially-discharged materials, particularly organic compounds, heavy metals, fluoride, and cyanide. This information will contribute directly toward improved salmonid and habitat management in the Basin by NMFS, Environmental Protection Agency, U.S. Army Corps of Engineers (COE), Department of Interior, Bonneville Power Administration, Northwest Power Planning Council, state fishery agencies, and interagency groups such as the Columbia River Inter-tribal Fish Commission.

In a fish-passage-delay study funded by the COE, recent observations by NMFS related the fluctuations in fluoride concentrations at John Day Dam (Columbia River Mile 216) to fluoride discharges from a primary aluminum-production plant (Fig. 1) (Damkaer 1983; Damkaer and Dey 1984, 1985, 1986). Further observations, including bioassay experiments on adult salmon behavior, attributed significant increased passage times and decreased survival of salmon to these fluoride concentrations. Fluoride seems to have a critical role during the migration of adult salmonids, especially in their willingness to negotiate fishways at dams. In addition, the researchers determined the concentrations of a large number of inorganic and organic compounds in the water and sediments of the John Day Dam region.

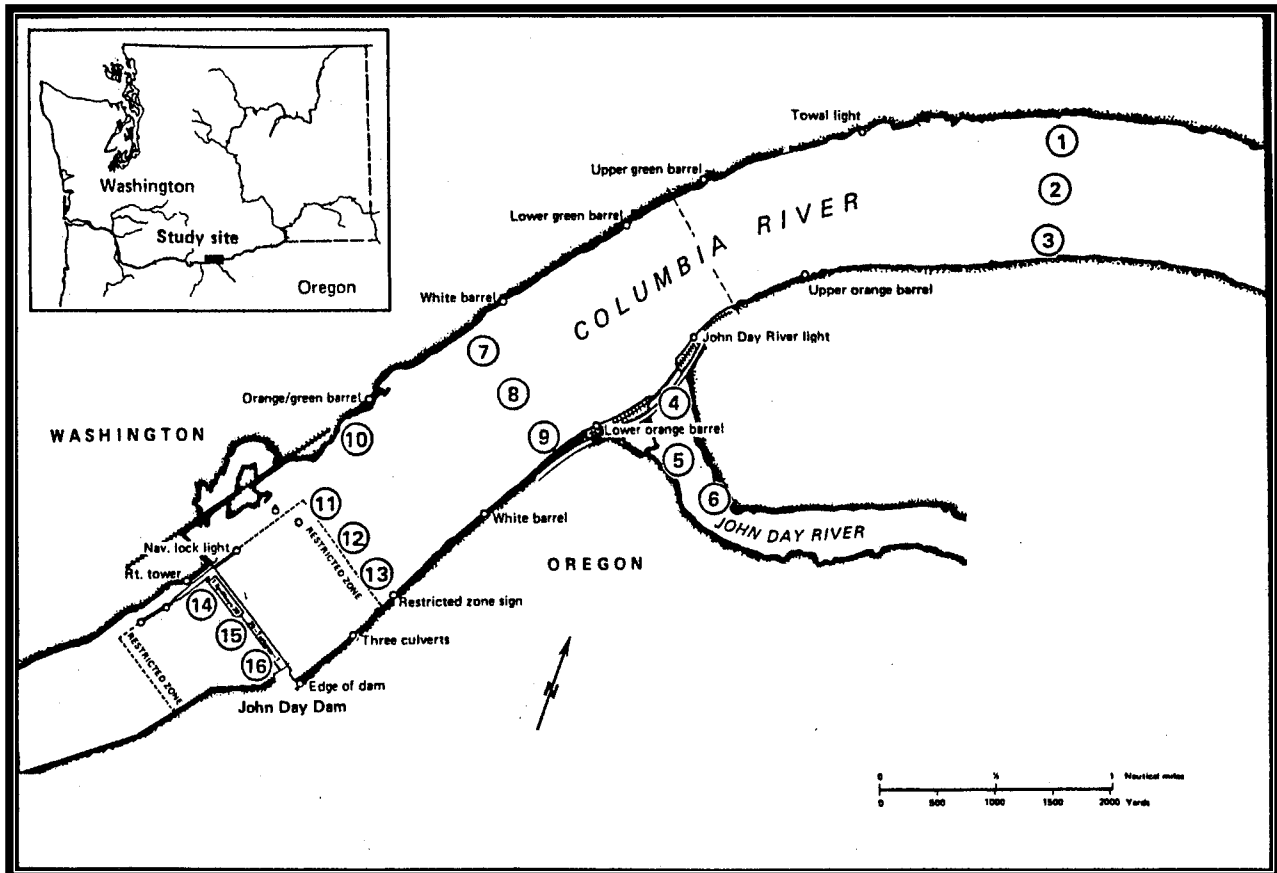


Figure 1.--Study area for adult salmonid passage-delay program, John Day Dam region, Columbia River. Circled numbers indicate sampling sites (sampling sites on downstream side of The Dalles and Bonneville Dams not shown).

While the fish-passage-delays appeared to have a large and critical component related to fluoride concentrations upstream from the dam, it is possible that lesser effects were due to some heavy metals (cadmium, copper, lead, and zinc) and some aromatic and chlorinated hydrocarbons. The concentrations of aromatic hydrocarbons were much higher in the river sediment collected near the aluminum plant outfall and in the nearby lagoon (Stations L1 and L2) than from upriver stations, thereby implicating the aluminum plant as a source of aromatic hydrocarbons (Table 1).

It is interesting to compare the concentrations of the aromatic hydrocarbons in sediment samples from the John Day Dam region with those from other Pacific Northwest sites. The average and the range of concentration are comparable to concentrations in sediments from the Duwamish Waterway (Seattle), and they approach the concentrations found in Hylebos Waterway (Tacoma) (Table 2). These latter sites are deemed among the most-polluted aquatic areas in the U.S.

It is apparent that a number of toxic compounds related to an aluminum-production plant are accumulating in the sediments in the forebay and associated areas of John Day Dam. Even though the aluminum plant generally meets the Washington State Department of Ecology (DOE) standards for specific discharges, the presence of pollutants in the nearby river sediments is undoubtedly due to the rapid adsorption of pollutants onto suspended particulates and the high rate of sedimentation in the reservoir of the dam.

There are seven primary aluminum-production plants on or near the main Columbia River (Fig. 2). Some of these, like the complex recently studied at John Day Dam, are associated with hydroelectric dams. The plant at John Day Dam is just upstream from the dam. The aluminum plant at Wenatchee,

Table 1.--Concentrations of aromatic compounds in sediment and water collected from the John Day Dam region, Columbia River.

Compound	Settling pond water (ng/ml) 6/11/82	Sediment (ng/g, dry weight)							
		Station 2 4/24/82	Station 4 4/24/82	Station 10 4/24/82-1	Station 10 4/24/82-2	Station 10+ 6/11/82	Station 10 6/11/82	L1 6/11/82	L2 6/11/82
isopropylbenzene	<.08	<.83	<.83	<.83	<.83	<.5	3.0	13	<1.0
n-propylbenzene	<.09	<.92	<.92	<.92	<.92	<.5	1.5	<1.1	(1.0)
indan	0.09	<.87	<.87	<.87	<.87	<.5	1.2	3.7	1.4
tetramethylbenzene	<.08	(.83	<.83	(.83	(.83	<.5	<.5	<1.0	(1.0)
naphthalene	<.07	<.76	<.76	13	12	<.5	0.5	42	29
benzothiophene	<.10	<1.1	<1.1	<1.1	(1.1	4.0	10	3.4	4.7
2-methylnaphthalene	(.08	<.85	<.85	5.7	6.1	18	13	20	9.7
1-methylnaphthalene	<.07	<.40	<.70	2.9	3.2	6.6	11	19	33
biphenyl	<.08	<.80	<.80	<.80	<.80	<.5	<.5	.8	6.3
2,6-dimethylnaphthalene	0.08	<.82	0.82	<.82	<.82	<.5	0.8	2.9	<.7
acenaphthene	<.07	<.73	<.73	16	13	8.0	5.6	110	55
trimethylnaphthalene	<.08	<.72	3.4	<.72	<.72	<.5	4.4	<.7	<.7
fluorene	<.07	<.82	<.82	23	20	13	8.2	78	44
dlbenzothiophene	<.08	<.80	<.80	10	10	1.1	(.5	39	22
phenanthrene	<12	16	14	230	230	100	66	830	460
anthracene	<.07	(.85	<.85	140	140	37	16	200	88
1-methylphenanthrene	0.64	<.5	<.84	30	30	27	22	59	43
3,6-dimethylphenanthrene	0.25	<2.3	<2.3	25	25	11	11	53	26
fluoranthene	0.69	49	13	1100	1200	340	140	2000	1400
pyrene	0.51	49	14	1100	1200	360	150	2300	1500
benz[ajanthracene	0.52	20	4.3	1500	2000	280	100	1200	720
chrycene	1.5	39	12	4000	5800	780	310	2100	1500
benzo[e]pyrene	0.93	23	6.9	1800	2400	330	180	1300	770
benzo[a]pyrene	0.37	19	4.7	1700	2100	270	150	1200	720
perylene	<0.07	28	13	400	460	83	78	320	180
dlbenzanthracene	0.10	7.4	<1.9	630	700	140	94	430	280

Table 2.--The sums of concentrations of selected 1 through 5-ring aromatic compounds in sediment samples from the Columbia River (near John Day Dam) and Puget Sound (ng/g dry weight).

	Columbia R. stations			Puget Sound sites		
	2	4	1(t ^a)	Duwamish Waterway ^{b1}	Hylebos Waterway ^c	Port Madison ^d
<u>Sums</u> of concentrations of selected 1-5 ring aromatic compounds listed in Table 3.	250	86	8,300 [range 1,300-16,000]	11,000 [range 4,100-22,000]	18,000 [range 5,000-39,000]	480 [range 200-640]
<u>Sums</u> of concentrations of 3-, 4-, and 5-ring compounds listed in Table 3.	240	82	8,000 [range 2,600-16,000]	10,000 [range 3,700-20,000]	13,000 [range 3,800-33,000]	340 [range 160-510]

a/ Average for four samples (Damkaer 1983).

b/ Duwamish Waterway ,, Seattle, WA, average for four samples (Malins et al. 1980, 1982).

c/ **Hylebos** Waterway, Tacoma, WA, average for six samples (Malins et al. 1980, 1982).

d/ Port Madison, Puget Sound, WA, average for two samples (Malins et al. 1980, 1982).

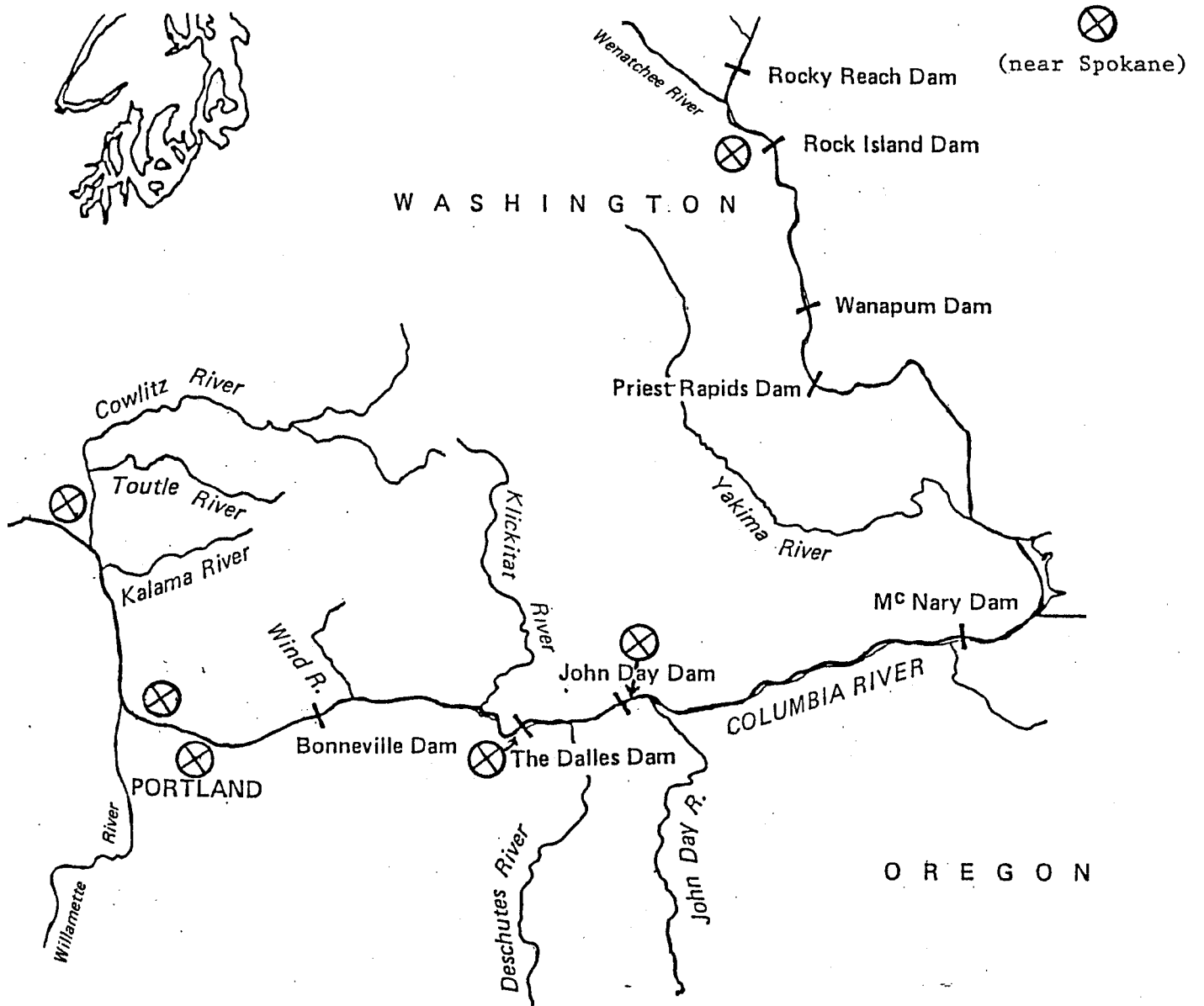


Figure 2.--Aluminum-production plants ⊗ on the Columbia River system.

Washington, is between two nearby dams. The aluminum plant at The Dalles, Oregon, is just downstream from The Dalles Dam. Other aluminum plants, near Spokane, Vancouver, and Longview, Washington, and Troutdale, Oregon, are not adjacent to major dams.. Undoubtedly the location of an aluminum plant's discharge, relative to an adjacent dam, would have important effects on the distribution of any pollutants in the water and in the sediments.

It **is** well known that sedimentation and siltation are occurring upstream from the major dams to such an extent that some dams in the Columbia River Basin will be non-functional in about 100 years unless the forebays (reservoirs) are dredged; obviously, these areas will be dredged. Because of the pollutant content, it is likely that this material would be resuspended on a large scale, and disposal on land would be required. The more that is known about the pollutants and their distributions in the Columbia River sediments, the more rationally will the problems be addressed.

In view of the likely critical situation of pollutant accumulation in the river sediments near aluminum plants, as described from the NMFS preliminary investigations at John Day Dam, it was proposed to examine other likely sites to document the nature and extent of these sedimented industrial pollutants. Our previous investigation centered on John Day Dam and particularly on fluorides. We related many organic pollutants to the aluminum-production process and have assumed that fluoride could be an index of this activity. Fluoride samples from the mouth of the Columbia River to Rocky Reach Dam (RM 474) (Fig. 2) showed relatively high fluoride concentrations adjacent to each aluminum plant. It is possible, therefore, that an assessment of river sediments would also show extraordinarily high concentrations of organic pollutants around these sites.

A proposed sampling site was the main Columbia River near Wenatchee, Washington (RM 465). The Aluminum Company of America (ALCOA) primary aluminum smelter is located about 10 miles south of Wenatchee on the west bank of the Columbia River (Fig. 3). The plant is situated 1.8 miles upstream from Rock Island Dam and 19 miles below Rocky Reach Dam. Built in 1952 and capable of producing 625 tons of aluminum per day, the ALCOA plant has been in operation about 20 years longer than the Commonwealth Aluminum plant (production capacity: 500 tons per day) at John Day Dam. Over the past 33 years, the aluminum plant at Wenatchee has been discharging 10–15 million gallons of wastewater per day directly into the Columbia River (compared to 9 million gallons per day at the John Day facility). Because of the location of the ALCOA plant between the two dams, it was believed that organic pollutants, particularly aromatic hydrocarbons, would be in high concentrations in the river adjacent to the aluminum plant.

The specific objectives of this study were to: 1) collect sediments and general environmental data from the Columbia River near Wenatchee, John Day Dam, and other sites of active sedimentation or industry along the river and 2) document the nature and extent of sedimented industrial pollutants at these sites.

METHODS

The sampling plan for the Wenatchee area included collecting sediment samples at 11 stations within the Rock Island pool, as well as at 2 stations each above Rocky Reach Dam and below Rock Island Dam (Fig. 3). Even though there are two primary aluminum plants in the Columbia River Basin upstream from Wenatchee (one near Spokane, Washington, and one near Columbia Falls, Montana), by sampling above Rocky Reach Dam and above Rock Island Dam, we could separate the pollutant contribution of the Wenatchee plant. The samples

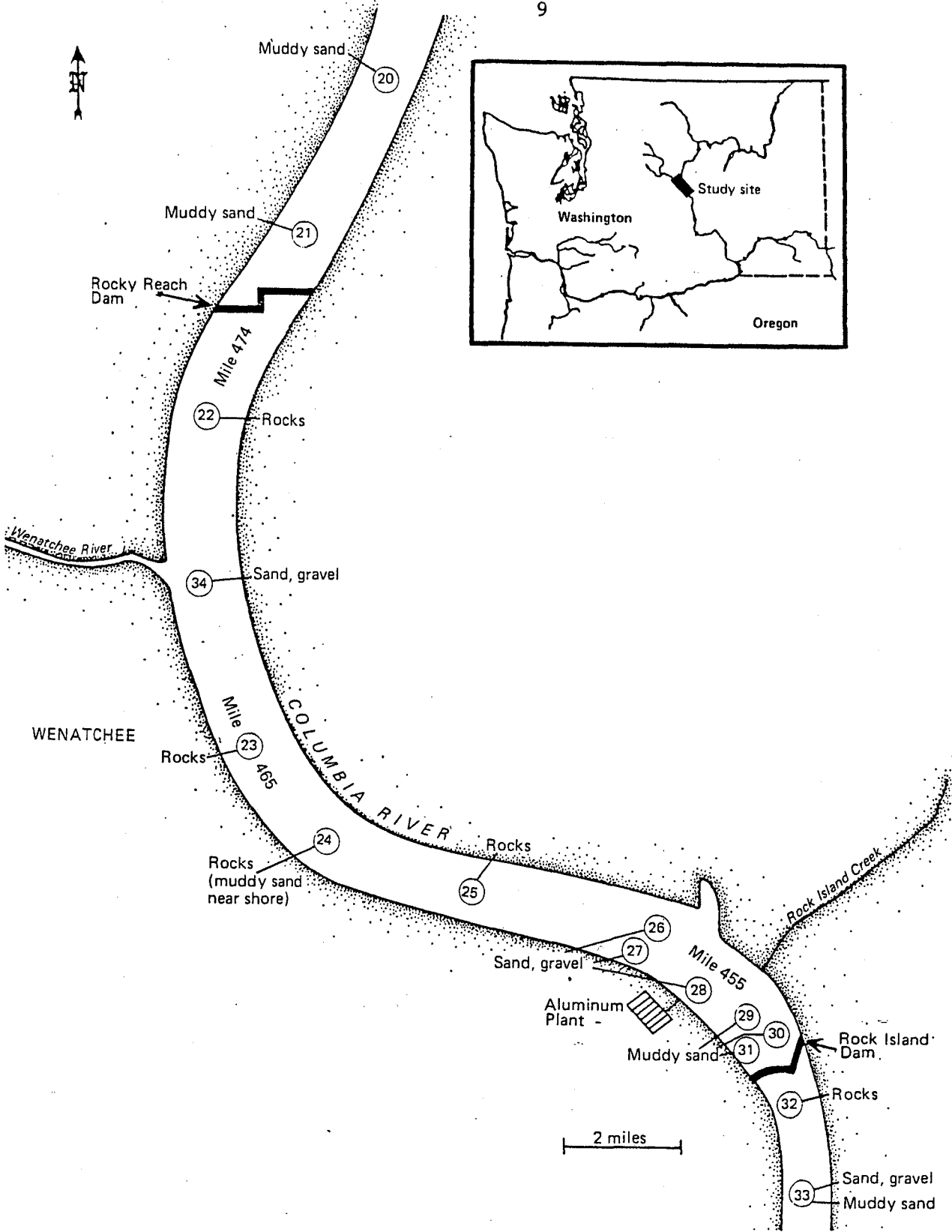


Figure 3.--study area for industrially-polluted sediments near Wenatchee, Washington; Columbia River. Circled numbers indicate sampling sites.

downstream from Rock Island Dam would give some indication of the distribution of these polluted sediments beyond the dam.

Hazardous currents, the generally rocky bottom found along this stretch the Columbia River, and the necessity of sampling from a small vessel precluded the use of gravity-corers or heavy grab samplers. Sediment samples for organic analyses were collected using a 6-1/2-inch OD by 6-inch long cast-iron pipe dredge with a clean cloth bag clamped over one end. This sampler was dragged along the bottom of the river until sufficiently filled with sediment. Sediment was scooped from the dredge using a stainless steel spoon and placed in pre-rinsed (CH_2Cl_2) sample bottles. Samples were immediately frozen with dry ice, transported with dry ice, and stored at -18°C until analyzed. All organic chemical analyses were done by the National Analytical Facility, Northwest and Alaska Fisheries Center. Analytical methods and instrumentation for organic analyses are discussed in MacLeod et al. (1985).

Basic physical characteristics were measured at each station where conditions allowed, using a Montedoro-Whitney Mark VA Water Quality Analyzer^{®.1/} This is a self-contained portable system for in situ measurements of depth and up to five factors as functions of depth [in this study: (1) temperature, (2) dissolved oxygen, (3) pH, and (4) conductivity]. Further information regarding specifications and capabilities of this instrument is in Damkaer (1983).

Water samples for fluoride and turbidity measurements were collected using Niskin[®] 1.2-liter closing water bottles constructed of teflon-lined PVC. Fluoride concentrations were determined with a HACH Company fluoride

1/ Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

meter with an ion-selective electrode. Turbidity measurements were made immediately after sample collection with an HF Instruments® portable turbidimeter (model DRT-15).

RESULTS AND CONCLUSIONS

Physical Characteristics

Dates, times, locations, depths of measurement, and corresponding physical characteristics of river water in the Wenatchee region for July 1986 are shown in Table 3. Because of the danger to the analytical probe posed by swift currents and the rocky bottom, environmental factors other than turbidity were not measured at some stations. Where measurements were made, however, only very small differences were detected vertically and horizontally in the well-mixed river water.

Fluoride

During a preliminary trip to the Wenatchee region in April, surface water samples were collected for fluoride analysis (Table 4). While the highest fluoride concentration was found near the aluminum plant outfall (Fig. 3, Station 28) the low, narrow range of concentrations measured throughout the study area did not suggest a particular problem with fluoride discharge to the river. Fluoride concentrations determined from July water samples were even lower and narrower in range (Table 5). In 1985, the Wenatchee aluminum plant converted air-emission control systems on three pot-rooms from wet to dry scrubbing; this eliminated a large water discharge from those systems. With this new equipment, the Wenatchee plant, while retaining a greater production capacity, is still able to comply with lower DOE discharge limitations than the aluminum plant near John Day Dam. Nevertheless, the fluoride

Table 3.--General physical characteristics of river water near Wenatchee,
Washington; Columbia River, July 23-24, 1986 (see Fig. 3 for station
locations).

Columbia River near
Wenatchee, Washington
July 23-24, 1986
General Physical Characteristics

Station	Date 1985	Time (PST)	Total depth (m)	Sample depth (m) "	Temperature °C	pH	Conductivity (mmhos)	Dissolved oxygen (ppm)	Turbidity (NTU)
20	23 Jul	0940	39.0	0	17.91	8.0	0.12	9.4	0.2
				5	17.71	7.9	0.12	9.3	
				10	17.70	7.9	0.12	9.5	0.2
				15	17.70	7.9	0.12	9.4	
				20	17.68	7.9	0.12	9.5	
				25	17.71	8.0	0.12	9.8	0.2
21	23 Jul	1130	30.0	0	17.95	7.9	0.12	9.4	0.2
				5	17.91	7.8	0.12	9.5	-
				10	17.88	7.8	0.12	9.8	0.2
				15	17.74	7.8	0.12	9.7	-
				20	17.73	7.8	0.12	9.8	-
				25	17.91	7.9	0.12	9.8	0.2
22*	24 Jul	0740	6.0	0			-	0.2	
23*	24 Jul	0820	15.0	0	-	-	-	0.2	
24*	24 Jul	0700	15.0	0			-	0.1	
25*	23 Jul	1805	8.0	0	-	-		-	0.3
26	23 Jul	1730	18.0	0	18.07	7.9	0.12	9.9	0.1
				5	18.10	8.0	0.12	9.8	-
				10	18.14	8.1	0.12	9.9	-
				15	18.27	8.1	0.12	9.9	0.1
27*	23 Jul	1700	18.0	0	-	-		-	0.1
				15	-	-		-	-
28	23 Jul	1515	12.0	0	18.06	8.0	0.12	9.8	0.15
				5	18.19	8.0	0.12	9.8	-
				10	18.38	8.0	0.12	10.0	0.15
29*	23 Jul	1630	22.0	0	-	-	-	-	0.2
				10			-	-	-
30*	23 Jul	1600	16.0	0	-	-	-	-	0.15
				14	-	-	-	-	-
31*	23 Jul	1550	9.5	0	-	-	-	-	0.2
				8	-	-	-	-	-
32*	24 Jul	1050	15.0	0	-			-	0.1
33	24 Jul	1100	15.0	10	18.01	7.9	0.12	9.6	0.3
				15	18.13	7.9	0.12	10.0	-
34	24 Jul	0800	3.0	0					0.2

* r...emely V., tea,.....-a /_.. --^--

Table 4.--Fluoride concentrations of river water near Wenatchee, Washington;
Columbia River, April 16, 1986 (see Fig. 3 for station locations).

Station	Surface (shore)
21	0.18
22	0.15
23	0.16
24	0.15
26	0.15
27	0.15
28	0.20
30	0.15
32	0.17
33	0.14
Columbia River upstream from confluence with Wenatchee River	0.18
Wenatchee River upstream from confluence with Columbia River	0.06

Table 5.--Fluoride concentrations of river water near Wenatchee, Washington;
Columbia River, July 23-24, 1986 (see Fig. 3 for station locations).

Columbia River near
Wenatchee, Washington
July 23-24, 1986
Fluoride (ppm)

Station	Bottom	Mid-depth	Surface
20	0.10	0.10	0.10
21	0.09	0.10	0.10
22		-	0.10
23			0.09
24			0.10
25			0.10
26	0.10	-	0.10
27	0.10	-	0.10
28	0.10	-	0.10
29	0.10	-	0.10
30	0.10	-	0.08
31	0.10	-	0.10
32	-	-	0.10
33			0.10
34			0.03

concentrations in the Columbia River near Wenatchee likely represent a measurable indication of the influence of industrial activity on river-water quality. For comparison, fluoride concentrations were considerably lower in the Wenatchee River in April (Table 4) and at the mouth of the Wenatchee River in July (Table 5, Station 34) than at the main Columbia River stations.

Organic Pollutants

Concentrations of aromatic and chlorinated compounds in the sediment samples collected in the Wenatchee area are shown in Tables 6 and 7. The sums of concentrations of aromatic analytes were noticeably elevated in sediments collected at Stations 29, 30, and 31 (just downriver from the aluminum-plant outfall; in the forebay of Rock Island Dam); and at Station 33 (below Rock Island Dam). Among the most concentrated compounds, fluoranthene, pyrene, benz[a]anthracene, chrysene, and benzo[e] and benzo[a]pyrene were lower in concentration here than in the highly polluted sediments collected near the aluminum-plant outfall above John Day Dam (Table 1, Station 10). However, phenanthrene and anthracene were found in comparable concentrations at the two study sites, and acenaphthene at Station 33 (Sediment #13) was considerably higher than at John Day Dam. As in the John Day Dam area, very few chlorinated hydrocarbons were present in measurable concentrations at the Wenatchee stations.

Despite the differences in concentrations of individual compounds at the two sites, the general similarity in the overall aromatic hydrocarbon profiles of the two areas implicates the aluminum plant at Wenatchee as an important source of these materials. The concentrations of aromatic hydrocarbons in sediments near Wenatchee appear to be somewhat lower than in sediments near the aluminum-plant at John Day Dam because of shallow water, strong currents,

Table 6.--Concentrations of aromatic compounds in sediment collected near Wenatchee, Washington; Columbia River, 23-24 July 1986 (see Figure 3 for station locations).

a, ,c

Concentrations of aromatic hydrocarbons in Columbia River sediment samples, ng/g (ppb) dry weight.

station # sediment # sample #	20 1 61-1	21 2 61-2	24 11 61-10	26 8 61-8	27 7 61-7	28 3 61-3	29 6 61-6
naphthalene	< 7	< 14	< 7	< 8	< 9	< 8	< 13
2-methylnaphthalene	< 8	< 15	< 8	< 8	< 9	< 9	< 14
1-methylnaphthalene	< 8	< 14	< 8	< 8	< 9	< 9	< 13
biphenyl	< 7	< 13	< 7	< 7	< 9	< 8	< 12
2,6-dimethylnaphthalene	< 7	< 13	< 7	< 7	< 9	9	13
acenaphthene	< 8	< 14	< 8	< 8	< 10	< 9	< 13
fluorene	< 7	< 13	< 7	< 7	< 9	< 8	34
phenanthrene	< 7	< 13	< 7	< 7	< 8	< 8	150
anthracene	< 7	< 12	< 7	< 7	< 8	< 7	160
1-methylphenanthrene	< 7	< 12	< 7	< 7	< 8	< 7	< 11
fluoranthene	< 7	74	94	< 7	< 8	< 7	280
pyrene	< 7	49	22	< 7	< 9	< 8	160
benz[a]anthracene	< 9	< 16	9	< 8	< 9	< 10	110
chrysene	< 10	< 17	10	< 9	< 10	< 11	160
benzo[e]pyrene	< 11	< 19	< 10	< 10	< 12	< 12	72
benzo[a]pyrene	< 11	< 19	< 10	< 10	< 12	< 12	30
perylene	< 11	< 20	< 11	< 11	< 12	< 12	25
dibenz[a,h]anthracene	< 11	< 20	< 10	< 10	< 12	< 12	< 15
Sum of the concentrations of the above analytes		120	140			9	1200
recovery of:							
naphthalene-d8							
acenaphthene-d10	85	83	89	83	68	84	78
perylene-d12	89	88	92	88	70	90	84
sample weight, g	73	76	89	89	75	75	93
% dry weight	10.06 81.3	10.07 40.2	10.01 73.1	10.04 75.6	10.06 79.3	10.09 65.0	10.07 54.1

a The concentrations of analytes from naphthalene through 1-methylnaphthalene were calculated using naphthalene-d8 as the internal standard; analytes from biphenyl through pyrene were calculated using acenaphthene-d10; analytes from benz[a]anthracene through dibenz[a,h]anthracene were calculated using perylene-d12.

b The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

c Concentrations and initial identifications were determined using flame ionization detection GC.

Table 6.--cont.

a,b,c

Concentrations of aromatic hydrocarbons in Columbia River sediment samples, ng/g (ppb) dry weight.

	station #	30	31	33(sand)	33(mud)	34
	sediment #	5	4	12	13	10
	sample #	61-5	61-4	61-11	61-12	61-9
naphthalene	<	8	<	8	<	11
2-methylnaphthalene	<	8	<	8	22	<
1-methylnaphthalene	<	8	<	8	<	11
biphenyl	<	8	<	8	15	<
2,6-dimethylnaphthalene	<	8	<	8	<	10
acenaphthene		38	<	8	120	<
fluorene	<	8	<	7	<	10
phenanthrene		58	100	<	7	14
anthracene		9	13	<	7	<
1-methylphenanthrene		10	<	7	<	10
fluoranthene		120	180	<	7	350
pyrene		72	150	<	7	41
benz[a]anthracene		27	120	<	9	80
chrysene		61	260	<	10	37
benzo[e]pyrene		36	110	<	11	<
benzo[a]pyrene		45	130	<	11	<
perylene		29	30	<	12	<
dibenz[a,h]anthracene	<	11	19	<	11	<
Sum of the concentrations of the above analytes		510	1100		680	180
recovery of:						
naphthalene-d8		96	81	84	82	57
acenaphthene-d10		95	86	90	90	67
perylene-d12		97	78	81	70	52
sample weight, g		10.03	10.05	10.08	10.02	10.05
dry weight		65.5	72.5	69.8	55.5	78.7

a The concentrations of analytes from naphthalene through 1-methylnaphthalene were calculated using naphthalene-d8 as the internal standard; analytes from biphenyl through pyrene were calculated using acenaphthene-d10; analytes from benz[a]anthracene through dibenz[a,h]anthracene were calculated using perylene-d12.

b The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

c Concentrations and initial identifications were determined using flame ionization detection GC.

Table 6.--c,---

Concentrations of aromatic hydrocarbons in blanks, ng/g (ppb) average dry weight, and percent recovery of analytes in spiked blank samples. ^{a,b,c}

	sediment # sample #	blank 61-14	spiked blank 61-13 ^d
naphthalene	<	9	100
2-methylnaphthalene	<	9	100
1-methylnaphthalene	<	9	100
biphenyl	<	8	99
2,6-dimethylnaphthalene	<	8	100
acenaphthene	<	9	99
fluorene	<	8	100
phenanthrene	<	8	100
anthracene	<	8	100
1-methylphenanthrene	<	8	110
fluoranthene	<	8	110
pyrene	<	8	110
benz[a]anthracene	<	11	120
chrysene	<	12	120
benzo[e]pyrene	<	14	110
benzo[a]pyrene	<	14	110
perylene	<	15	100
dibenz[a,h]anthracene	<	13	110
Sum of the concentrations of the above analytes			
^o % recovery of:			
naphthalene-d8		90	89
acenaphthene-d10		93	91
perylene-d12		76	82
sample weight, g			
% dry weight			

a The concentrations of analytes from naphthalene through 1-methylnaphthalene were calculated using naphthalene-d8 as the internal standard; analytes from biphenyl through pyrene were calculated using acenaphthene-d10; analytes from benz[a]anthracene through dibenz[a,h]anthracene were calculated using perylene-d12.

b The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

c Concentrations and initial identifications were determined using flame ionization detection GC.

d Percent recovery of analyte standards added to a blank sample which was then prepared and analyzed as a sample.

Table 7.--Concentrations of chlorinated compounds in sediment collected near Wenatchee, Washington; Columbia River, 23-24 July 1986 (see Figure 3 for station locations).

a,b,c,d

Concentrations of chlorinated analytes in Columbia River sediment samples, ng/g (ppb) dry weight.

station # sediment # sample #	29 6 61-6	30 5 61-5	31 4 61-4	33(mud) 13 61-12
hexachlorobenzene	< 1	< 1	< 1	< 1
lindane (gamma-BHC)	< 1	< 1	< 1	< 1
heptachlor	< 1	< 1	< 1	< 1
aldrin	< 1	< 1	< 1	< 1
heptachlorepoxyde	< 1	< 1	< 1	< 1
alpha-chlordane	< 1	< 1	< 1	< 1
trans-nonachlor	< 1	< 1	< 1	< 1
dieldrin	< 1	< 1	< 1	< 1
mirex	< 1	< 1	< 1	< 1
o,p'-DDE	< 1	< 1	< 1	< 1
p,p'-DDE	8	3	< 1	7
o,p'-DDD	4	< 1	< 1	2
p,p'-DDD	8	< 1	< 1	6
o,p'-DDT	< 1	< 1	< 1	< 1
p,p'-DDT	< 1	< 1	< 1	< 1
dichlorobiphenyls	< 1	< 1	< 1	< 1
trichlorobiphenyls	< 1	< 1	< 1	< 1
tetrachlorobiphenyls	< 1	< 1	< 1	< 1
pentachlorobiphenyls	< 1	< 1	< 1	< 1
hexachlorobiphenyls	< 1	< 1	< 1	< 1
heptachlorobiphenyls	< 1	< 1	< 1	< 1
octachlorobiphenyls	< 1	< 1	< 1	< 1
nonachlorobiphenyls	< 1	< 1	< 1	< 1
dichlorobutadienes	< 1	< 1	< 1	< 1
trichlorobutadienes	< 1	< 1	< 1	< 1
tetrachlorobutadienes	< 1	< 1	< 1	< 1
pentachlorobutadienes	< 1	< 1	< 1	< 1
hexachlorobutadienes	< 1	< 1	< 1	< 1
Sum of the concentrations of the above analytes	20	3		15
% recovery of: acenaphthene-dl O	84	95	86	90
sample weight, g	10.07	10.03	10.05	10.02
dry weight	54.1	65.5	72.5	55.5

a The concentrations of analytes were calculated using % recovery of acenaphthene-dl O.

b The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

c Concentrations and initial identifications were determined using electron capture detection GC.

d These four samples were selected to calculate concentrations of chlorinated analytes because they had the highest concentrations of analytes of the twelve samples analyzed for aromatic hydrocarbons.

Table 7.--co^{nt.}

a,b,c

Concentrations of chlorinated analytes in blank, ng/g (ppb) average dry weight.

sediment # sample #	blank 61-14
hexachlorobenzene	< 1
lindane (gamma-BHC)	
heptachlor	1
aldrin	1
heptachlorepoxyde	1
alpha-chlordane	1
trans-nonachlor	1
dieldrin	1
mirex	<
o,p'-DDE	
p,p'-DDE	
o,p'-DDD	1
p,p'-DDD	< 1
o,p'-DDT	1
p,p'-DDT	1
dichlorobiphenyls	< 1
trichlorobiphenyls	1
tetrachlorobiphenyls	< 1
pentachlorobiphenyls	< 1
hexachlorobiphenyls	< 1
heptachlorobiphenyls	1
octachlorobiphenyls	< 1
nonachlorobiphenyls	< 1
dichlorobutadienes	1
trichlorobutadienes	< 1
tetrachlorobutadienes	1
pentachlorobutadienes	1
hexachlorobutadienes	1

Sum of the concentrations
of the above analytes

% recovery of:

acenaphthene-dl 0

93

sample weight, g

% dry weight

a The concentrations of analytes were calculated using % recovery of acenaphthene-dl 0.

b The "less than" symbol (<) indicates that the analyte was not detected in concentrations above the stated value.

c Concentrations and initial identifications were determined using electron capture detection GC.

and little sedimentation in the Wenatchee area. In contrast, the large reservoir of relatively slow-moving water behind John Day Dam encourages sedimentation. At the aluminum plant near John Day Dam, sediment collected right at the outfall contained high concentrations of organic material since the slower movement of water dispersed these materials much less effectively downriver. Of course, even though the river currents near Wenatchee are, apparently, reasonably effective in flushing discharged contaminants downriver, it is quite possible these materials have accumulated in significant concentrations at nearby locations. Elevated concentrations of organic compounds were found downriver from the outfall at Rock Island Dam where limited sedimentation is possible. However, the most likely sites of accumulation would include areas just upriver from the major dams. It is now believed that the bulk of pollutants from the upriver aluminum plants are probably sedimented in McNary Dam reservoir with lesser amounts in Wanapum and Priest Rapids reservoirs. Because these areas will inevitably be dredged, it is important that possible toxic organic "hot spots" within them be located.

Although analytical results are not yet available, we have recently completed the collection of sediments from the McNary Dam reservoir (RM 292) and at several other downstream sites adjacent to aluminum plants, including: (1) John Day Dam reservoir; (2) The Dalles, Oregon (RM 186); (3) Troutdale, Oregon (RM 120); (4) Vancouver, Washington (RM 102); and (5) Longview, Washington (RM 62). Analyses of these samples will increase our understanding of the nature, origin, and extent of industrial pollution in the Columbia River.

The motivation for continued and expanded investigations of industrial pollutants in the Columbia River system is the protection of the valuable salmonid resource and related habitat. The information from these studies

could optimize the understanding of relationships between point-source pollution-discharge and dams, and contribute considerably to planned construction of new industrial/ hydroelectric complexes. State and federal Pacific Northwest fisheries and habitat management agencies would rapidly incorporate information from this research.

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FIGURES

Figure 1.--Study area for adult salmonid passage-delay program, John Day Dam region, Columbia River. Circled numbers indicate sampling sites (sampling sites on downstream side of The Dalles and Bonneville Dams not shown).

Figure 2.--Aluminum-production plants $I, \sim J$ on the Columbia River system.

Figure 3.--Study area for industrially-polluted sediments near Wenatchee, Washington; Columbia River. Circled numbers indicate sampling sites.

TABLES

Table 1.--Concentrations of aromatic compounds in sediment and water collected from the John Day Dam region, Columbia River.

Table 2.--The sums of concentrations of selected 1 through 5-ring aromatic compounds in sediment samples from the Columbia River (near John Day Dam) and Puget Sound (ng/g dry weight).

Table 3.--General physical characteristics of river water near Wenatchee, Washington; Columbia River, July 23-24, 1986 (see Fig. 3 for station locations).

Table 4.--Fluoride concentrations of river water near Wenatchee, Washington; Columbia River, April 16, 1986 (see Fig. 3 for station locations).

Table 5.--Fluoride concentrations of river water near Wenatchee, Washington; Columbia River, July 23-24, 1986 (see Fig. 3 for station locations).

Table 6.--Concentrations of aromatic compounds in sediment collected near Wenatchee, Washington; Columbia River, 23-24 July 1986 (see Figure 3 for station locations).

Table 7.--Concentrations of chlorinated compounds in sediment collected near Wenatchee, Washington; Columbia River, 23-24 July 1986 (see Figure 3 for station locations).