Smith

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Portland District
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An Annotated Bibliography
of

AQUATIC RESEARCH IN THE LOWER COLUMBIA RIVER

RIVER MILE (0 TO 106.5)

by

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INTRODUCTION

The Columbia River Navigation Channel from the mouth (MCR) to the Portland, Vancouver metropolitan area is presently 103.6 miles long, 600 feet wide and 40 feet deep. The Congress of the United States recently appropriated funds to determine the economic feasibility of deepening this navigation channel between the entrance at river mile (RM 3) and Portland, Oregon at (RM 106.5).

The following bibliography was prepared to provide a summary of biological, chemical and physical information on the aquatic ecosystem of the project area. The bibliography is divided into three main sections. The first section (Estuarine Research) was further divided by reach and river mile (Table 1) into four subsections; Lower Estuary (from the mouth to the Astoria-Meglar Bridge Rm 10), Mid-estuary (the bridge to Harrington Point at Rm 23.5), Upper estuary (Harrington Point to Jones Beach at Rm 46.6). The fourth sub-section contains studies which encompass two or more estuarine areas and is presented alphabetically by author.

The second section (Site Specific Research) covers riverine studies from Rm 53.5 to 106.3 and is presented by reach and river mile. The third section (System Wide Research) is presented alphabetically by author and covers research which encompasses at least two main sections. A supplemental reference list includes additional references.

No attempt was made to catalog Environmental Impact Statements or Fish and Wildlife Coordination Act Reports. These may serve as additional sources of summarized information. Due to its familiarity and accessibility, no attempt was made to review the data from the Columbia River Estuary Data Development Program.

Reach	River Mile	Reach	River Mile
Lower estuary			
1.1 Lower Desdemona:	4.4 to 6.4	4.1 Stella-Fisher :	55.6 to 59.4
1.2 Upper Desdemona:	6.4 to 10.0	4.2 Walker Island :	59.4 to 63.2
Mid-estuary		4.3 Slaughters :	63.2 to 67.1
1.3 Flavel :	10.0 to 13.6	4.4 L. Dobelbower :	67.1 to 69.9
1.4 Upper Sands :	13.6 to 17.5	4.5 U. Dobelbower :	69.9 to 72.8
1.5 Tongue Point :	17.5 to 21.4		
1.6 Miller Sands :	21.4 to 25.2	5.1 Kalama :	72.8 to 76.5
Upper estuary		5.2 Lower Martin :	76.5 to 80.3
1.7 Pillar Rock :	25.2 to 28.8	5.3 Upper Martin :	80.3 to 83.8
		5.4 St. Helens :	83.8 to 87.3
2.1 Brookfield :	28.8 to 32.6		
2.2 Skamokawa :	32.6 to 36.6	6.1 Warrior Rock :	87.3 to 90.4
2.3 Pudget Island :	36.6 to 40.8	6.2 Henrici Bar :	90.4 to 93.9
2.4 Wauna-Driscoll :	40.8 to 44.5	6.3 Willow Bar :	93.9 to 97.8
2.5 Westport :	44.5 to 48.2	6.4 Morgan :	97.8 to 101.3
Riverine			
3.1 Eureka :	48.2 to 51.9	7.1 L. Vancouver :	101.3 to 104.6
3.2 Gull Is. Bar :	51.9 to 55.6	7.2 Vancover Basin:	104.6 to 106.4

Table 1: Reaches of the Columbia River Navigation Channel used for reference by the U.S. Army Corps of Engineers along with Respective River Miles

LOWER ESTUARY (Rm 0 to 13.6)

Larson, K.W. And K. Patterson. 1989
Entrainment of Dungeness Crab by Hopper Dredge at the Mouth of the Columbia River OR, and WA, USA. In: XIIth. World Dredging Congress, 1989, Orlando FL. U.S.A. May 2-5 1989. Pp 268-285.

River Mile: -3 to 2 Reach: MCR
Study Emphases: Entrainment of Dungeness Crabs
Biological:* Dungeness Crabs
Frequency: Periodic Duration: April through Sept. 1985-88.
Comments: Realistic approach to entrainment study (crab).

Author's Abstract

Portland District U.S. Army Corps of Engineers conducted studies to determine the number and age of Dungeness crab entrained by hopper dredging at the mouth of the Columbia River (MCR). The study was done with a sampler developed for the Corps of Engineers hopper dredge Essayons. (Sampler is attached to the lander and samples the dredge material before it is discharged into the hopper). Samples were collected throughout the April to October dredging season at the MCR. Results indicated that juvenile crabs can be entrained in large numbers when they are abundant at the MCR. Subadult and adult crabs, however, were not entrained in large numbers during the study. No relationship between number of crabs entrained and any dredging or environmental parameter tested was apparent except direction of dredging and tidal stage in 1985. In 1985, the least number of juvenile crabs were entrained when dredging against the flood tide and the largest number were entrained while dredging against the ebb tide. This relationship was not apparent for the 1986, 1987, or 1988 data. Juvenile crab abundance, however, was considerable lower in these years than in 1985. It was uncertain what impact entraining has on the Columbia River estuary or coastal crab populations. Impacts to subadults and adult populations were uniformly low through out the study.

Larson, K.W. And C.E. Moehl. 1989
Entrainment of Anadromous Fish by Hopper Dredge at the Mouth of the Columbia River. U.S. Army Corps of Engineers, Portland District, Fish and Wildlife Branch P.O. Box 2946, Portland OR 97208-2946. 9 p.

River Mile: -3 to 2 Reach: MCR
Study Emphases: Entrainment of Fish
Biological:* Fish
Frequency: Periodic Duration: April through Sept. 1985-88.
Comments: In conjunction with above Crab study. Total number by species would have been useful.

Author's Abstract

Studies were conducted at the mouth of the Columbia River to determine the number and types of estuarine organisms entrained by hopper dredging. As part of the study, information was obtained on the number and types of fish species entrained. Fourteen species or species groups of fish were collected during the four year study. No juvenile or adult salmonids were collected. Numbers of individuals entrained were low for all species except Pacific sand lance (*Ammodytes hexapterus*), which were collected in moderate numbers throughout the study. None of the species collected showed any seasonality except Pacific sand lance, which were slightly more abundant in the late summer. These

results indicated that anadromous species were not entrained in any numbers by hopper dredging at the mouth of the Columbia River.

Emmett, R.L., and J.T. Durkin 1985.
The Columbia River Estuary: An important nursery for Dungeness crabs, *Cancer magister*. Mar. Fish. Rev. 47(3), 21-25 pp.

River Mile: Lower Estuary, Near off-shore. Reach: 0 1.2
Study Emphases: Frequency distribution.
Biological:* Dungeness crabs.
Frequency: 44 surveys Duration: between 1973-1982
Comments: Comparative size class distribution.

Author's Abstract

Carapace width frequency distribution data for Dungeness Crabs, *Cancer magister*, were collected during four bottom trawl surveys conducted between 1973 and 1982; two surveys were in the Columbia River estuary and two in coastal areas adjacent to the mouth of the Columbia River. The data indicated large differences in width frequency between coastal and estuarine crab populations: Coastal populations had few and estuarine populations had many 1+ (year) age crabs. Based on the indication that 1+ age crabs are found primarily in estuaries, it appears that estuaries play an important role in Dungeness crab life history.
Surveys: 1) Columbia River Estuarine Trawl Survey, 1973-74. Seventeen estuarine areas sampled monthly from July 1973 to June 1974. 2) Waterways Experiment Station Trawl Survey, 1974-76. Five nearshore coastal sites adjacent to the mouth of the Columbia River were sampled monthly from September 1974 to April 1976. 3) Columbia River Estuary Data Development Program (CREDDP), 1980-81. Twenty two estuarine sites were sampled monthly from February 1980 to August 1981. Black Sands Mining Survey, 1981-82. One nearshore site, located north of the North Jetty, was sampled bimonthly from May 1981 to May 1982.

McCabe, G.T. Jr., R.L. Emmett, T.C. Coley and R.J. McConnell. 1988.
Distribution, Density, and Size-Class Structure of Dungeness Crabs In the River-Dominated Columbia River Estuary. N.W.Science, 62:5. 254-262 pp.
Also 1986. Distribution, abundance, size class structure, and location and timing of movements across the bar of Dungeness crabs. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to U.S. Army Corps of Engineers Contract DACW57-84-F-0178). 21 pp.

River Mile: 0.7 to 19 Reach: 0 to 1.5.
Study Emphases: Distribution, density, size class.
Biological:* Dungeness crabs.
Frequency: Monthly Duration: 24 months; 1983-85.
Comments: Comprehensive data base.

Author's Abstract

Dungeness crabs, *Cancer magister* are important to the large west coast commercial fishing industry, and estuaries are important habitats for the crabs. To better understand the basic dynamics of crab populations, we studied the distribution, density, and size-class structure of Dungeness crabs in the Columbia River estuary (Oregon and Washington) monthly from November 1983 through October 1985.

Crabs were generally distributed from the bar (mouth of the estuary) to River Kilometer 28 (Rm-17.4). Overall, crab densities on the bar (mean=210 crabs/hectare) were significantly less than densities upstream from the bar (mean=395 crabs/hectare). Densities on the bar were greatest in spring and

summer when young-of-the-year (0 + age) crabs were relatively abundant. Densities of crabs on the bar were significantly greater during the second year of the study (mean=391 crabs/hectare) than during the first (mean=28 crabs/hectare). In areas upstream from the bar, densities were not significantly different between the two years; generally, there were no significant seasonal differences among upstream densities. Zero + age crabs were captured in the estuary beginning in May of both years; no 0 + age crabs were collected in intertidal areas of the estuary. Densities of 0 + age crabs on the bar increased during late spring and summer; however, there was no corresponding increase in densities upstream from the bar. Our data indicate that the Columbia River estuary provides valuable habitat for Dungeness crabs, particularly for crabs <130 mm in carapace width.

Low densities of Dungeness crabs in the spring and summer of 1984 were also reported from Grays Harbor estuary. This paper covers the first two years of a five year study to obtain a data base of Dungeness crabs in the Columbia River estuary.

McCabe, G.T.,Jr., R.1. Emmett and R.J. McConnell 1987a, 1987b.
McCabe, G.T.,Jr., and R.J. McConnell 1989

Abundance and size-class structure of Dungeness crabs in or near frequently-dredged areas in the Columbia River estuary. Nov 1985-Oct 1988. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Annual Repts. to U.S. Army Corps of Engineers Contract DACW57-86-F-0581) 31 pp.; Contract DACW57-86-F-0127) 29 pp.; and final rept. 1989, contract DACW57-86-F-0461) 22 pp.

Explanation

In October 1985 the NMFS completed a 2-year study of Dungeness crabs in the Columbia River estuary (McCabe et al. 1986; [previous bibliography]). The objective of the 2-year study was to determine distribution, abundance, size class structure, and location and timing of movements across the bar of Dungeness crabs. The 2-year study demonstrated that crab densities fluctuate annually i.e. densities on the bar in the spring and summer of 1984 were less than 115 crabs/hectare (ha), during the same period in 1985, densities exceeded 1,800 crabs/ha. Because of these wide fluctuations in crab densities, the Corps of Engineers (COE) and NMFS designed an additional 3-year study to expand the overall data base on Dungeness crabs in the estuary, specifically in areas subjected to frequent dredging. These studies also provided additional information for the COE crab entrainment studies. The following report is a summation and analysis of the 5-yrs. of data collected from Nov. 1983-Sept 1988

McCabe, G.T.,Jr., and R.J. McConnell 1989

Abundance and size-class structure of Dungeness crabs in or near frequently-dredged areas in the Columbia River estuary. November 1983 to October 1988. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Repts. to U.S. Army Corps of Engineers. 22 pp.

River Mile: 0.7 to 12.5 Reach: 0 to 1.5.
Study Emphases: Distribution, density, size class.
Biological:* Dungeness crabs.
Physical: Water temperature, salinity.
Frequency: Monthly/biweekly Duration: 5 years; 1983-88.
Comments: 5-year data base. Study continuing at a reduced basis.

Summary

This report is a summation and analysis of 5 years of data collected, from November 1983 through September 1988, at 9 sites in or near frequently dredged areas in the Columbia River estuary. Samples were taken monthly in Ilwaco Channel, Chinook Channel, and at Flavel Bar (Rm-12.5). Sampling frequency at the six bar stations was monthly during the first 2-years of the study;

thereafter biweekly from April through October. Normal maintenance dredging on the bar is typically done during this time period. A subsample of up to 100 crabs from each sampling effort were measured and weighted. Crabs were separated into four size-classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (> 129 mm).

Estimated mean monthly densities on the bar were generally relatively low. With the exception of June and July 1985 and September 1986, estimated mean monthly densities were <200 crabs/ha. During each of the 5 years of sampling, early instars or megalops larvae that metamorphosed to first instar juveniles, entered the estuary beginning in late April or May. Overall Size Class I crabs were the most common, while Size Class II was the least abundant size group on the bar. Crab densities at the three stations upstream from the bar varied within a specific year and between years. Crab densities in Ilwaco Channel were relatively high at times; in 10 of the 58 months sampled, densities exceeded 1,000 crabs/ha. Densities at this station tended to be lowest in April. The highest densities (>16,000 crabs/ha) during the 5 year study were in Chinook Channel in September and October 1985. Densities at this station tend to be lowest February to May. Size class II (50-99 mm) and III (100-129 mm) crabs were the dominant size classes in both Ilwaco and Chinook Channels. These shallow channels probably provide excellent feeding areas for crabs. Highest density (1,244 crabs/ha) at Flavel Bar was in June 1986 while lowest densities at this station occurred September through January. Size Class II was the most abundant size class at this station.

The five years of study clearly show that Dungeness crab densities fluctuate both temporally and spatially in the Columbia River estuary. High densities of crabs on the bar, during spring and summer, are extremely dependent on the immigration of early instar crabs or megalops larvae into the estuary. Although densities fluctuate annually, seasonal patterns have been identified. This information has and will continue to aid resource managers in making decisions about dredging schedules and methods to minimize impacts on Dungeness crabs.

Misitano, D.A. 1974.
Zooplankton, Water Temperature, and Salinities in the Columbia River Estuary, December 1971 Through December 1972. NMFS/NOAA Seattle, Wa. 98112 NMFS-DR-92, 31 pp.

River Mile: 2.8 to 23.5 Reach: 1 to 1.6
Study Emphases: Baseline data.
Biological:* Zooplankton species per cubic meter
Physical: Channel depth, Salinity, temperature.
Frequency: Monthly (17 surveys) Duration: 13 months; 1971-72.
Comments: Data base, no data analysis or site comparisons provided.

Author's Abstract:

Sampling was conducted at seven stations in the Columbia River estuary to provide baseline information on species diversity, relative abundance, and seasonal occurrence of zooplankton, as well as ambient water temperatures and salinities.

Brief summary: Plankton tows made monthly, from December 1971 through December 1972, at six navigation channel sites of varying salinities and at depths ranging from 12-26 meters. A shallower site in Youngs Bay was also regularly sampled. Additional sites in Youngs Bay and three sites on the Washington (north) side of the estuary were occasionally sampled. A 9-min oblique plankton tow was conducted at high tide with a Clarke-Bumpus plankton sampler with a digital recording flowmeter. Numbers of zooplankton per cubic meter is presented by station by survey. Related temperatures and salinities at the surface, mid-depth and bottom are also provided. December 1972, and

December 1971 were the two most productive months respectively. *Eurytemora hirundoides* appears to be the overall most common species. On the monthly neep tide cycle of October 18, 1972 salinities of 22.0 parts per thousand (ppt), and 6.6 ppt were recorded on the bottom, at Tongue Point (Rm 18.2) and at Harrington Point (Rm 23.5) respectively.

U.S. Army Engineer District, Portland. 1979.
Propeller Wash Agitation Dredging Chinook Channel, Washington. Navigation Division Research & Evaluation Report·NO. 2-79. Portland District, P.O. Box 2870, Portland, Or. 97208:
Part 1: Evaluation of Propeller Wash Dredging at Chinook Channel. 67 pp.
Part 2: Impact of Agitation Dredging at Chinook Channel. NMFS. 77 pp.

River Mile: Chinook channel Reach: 1.1
Study Emphases: Impact of agitation dredging.
Biological:* Demersal fish, epibenthic, and benthic
Chemical: DO.
Physical: Salinity, temperature, turbidity.
Frequency: Pre, during, post dredging Duration: 12 months; 1976-77.
Comments: Site specific, limited application.

Summary

A study was undertaken in 1976, at Chinook Channel, to evaluate the economic and environmental feasibility of propeller wash dredging using a large vessel with an adjustable deflector door. All dredging took place on ebb tide cycles. The study included the collection and analysis of hydrographic surveys, tide and current data, sediment samples, temperature and turbidity measurements, aerial photographs of plumes, biomass and species counts, and dredge records of operation and movements. Data collection included a pre-dredge, during, and post-dredge phases. Physical and biological monitoring was limited to the general vicinity of dredging and biological sampling was confined to aquatic, epibenthic and benthic macro-organisms of the area.

Summary conclusions: (NMFS) Impact on aquatic organisms. The wide range of salinities and temperature in evidence during the surveys indicates that aquatic organisms in Chinook channel are tolerant of physiological stress. There is little evidence that agitation dredging had a direct effect on fin fish, or on the dominant epibenthic macro-invertebrates. Agitation dredging did disrupt the dominant benthic community; some recover was in evidence after six months. Because of natural changes occurring in the area it was impossible to state to what degree the benthic community was impacted. Water quality remained in an acceptable biological range throughout the dredging period. However, on one occasion a high biological oxygen demand (BOD) did occur with dissolved oxygen decreasing from 11 parts per thousand (ppt) to 5.6 ppt.

McConnell, R.J. and D.A. Miller. 1990.
Currents Studied near Area-D; an in-water Dredged Material Disposal Site in the Columbia River Estuary. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final report to the U.S. Army Corps of Engineers, Contract-NO. E86880136). 17 pp. report in publication .

River Mile: 7, Reach: 1.
Study Emphases: Area-D current movement.
Frequency: 4 groups SBD; 6 sonic tracks: Duration: 2 months; 1988.
Comments: Short term, site specific.

Summary

Area-D is the authorized estuarine repository for material dredged from the lower Columbia River Navigation Channel. This 230-acre site in the North Channel, at Columbia River Mile (CRM 7), has an average mean-low-low-water (MLLW) depth of 38 feet. Since 1950 an estimated 24 million cubic yards of material has been deposited and dispersed from this site. Traditionally Area-D is used for disposal of clean sandy material from the navigation channel. Recent considerations to deposit fine-grained material from the upper reaches of Chinook Channel has focused renewed attention on the need to better understand sediment transport at this site.

The (NMFS) in cooperation with the (COE) conducted a study of net current movement and flow patterns from Area-D. To obtain information on net current movement, four groups of 25 seabed drifters (SBD) were released at the Area-D marker buoy during various tide stages. To gather data on flow patterns, SBDs were equipped with acoustic transmitters and their movement tracked. Of the 14 SBDs recovered 86% were found downstream of Area-D. Based on this information it is concluded that net current movement from Area-D was downstream. Median time to recovery was 12 days, ranging from 1 to 167 days. Although equal numbers of SBDs were released on outgoing (ebb) and incoming (flood) tides, 71% of the those recovered were released on a flood tide. Indicating SBDs released on ebb tides moved out of the estuary. This supposition was supported by SBD tracking information.

Varanasi, U., S-L. Chan, B.B. McCain, J.T. Landahl, M.H. Schiewe, R.C. Clark, D.W. Brown, M.S. Myers, M.M. Krahn, W.D. Gronlund, And W.D. Macleod, Jr. 1988. National Benthic Surveillance Project: Pacific Coast: Part I, Summary and overview of the results for Cycles I to III, (1984-86). NOAA Tech. Memo. NMFS F/NWC-156, 65 pp.
1989. National Benthic Surveillance Project: Pacific Coast: Part II, Technical Presentation of the Results for Cycles I to III, (1984-86). NOAA Tech. Memo. NMFS F/NWC-170: 158 p., plus Appendix, 45 pp.

River Mile:	7, Estuary Reach: 1.2
Study Emphases:	Document concentrations of chemical contaminants.
Biological:	Pathology of demersal target species (starry flounder).
Chemical:*	Aromatic & chlorinated hydrocarbons, trace metals in sediment and tissue.
Physical:	Sediment structure.
Frequency:	Annually Duration: 1984-86, continuing.
Comments:	Site specific. The highly uniform sampling protocol and state-of-the-art analytical methods are providing a useful and extensive database.

Summary

The National Benthic Surveillance Project (NBSP) was initiated in 1984 by NOAA as a component of the National Status and Trends Program. NBSP is designed to assess and document the status of and long-term changes in the environmental quality of the Nations coastal and estuarine waters. The specific objectives of the project are to measure concentrations of chemical contaminants, in sediment and in species of bottom-dwelling fish, to determine the prevalence of diseases in target fish species and to evaluate temporal trends of chemical contaminants. These contaminants include selected aromatic hydrocarbons, PCBs, organochlorine insecticides and metals in sediments and in liver tissue, bile, and stomach contents of selected bottom-fish. Also documented were the prevalence of a variety of presumptive pollution-related liver and kidney lesions in the same target fish species.

A total of 35 west coast embayments (from South San Diego Bay, California to Oliktok Point, Alaska) were sampled between 1984 and 1986. Site inclusion was based on the following characteristics: Availability of bottom-feeding

fish; Location in a subtidal, sedimentary-depositional zone; Location outside the zone of initial dilution of a point source or outside the zone of an authorized dumpsite; and Location not subject to dredging, scouring or slumping. Results of the first 3 years have demonstrated that concentrations of aromatic hydrocarbons and chlorinated hydrocarbons in sediments were generally correlated with levels of these compounds or their derivatives in fish. No positive correlation was found between metals in sediment and those in the liver of target fish species. The highest prevalence of pathological conditions were found in fish from sites with the highest levels of contaminations

The Columbia River sampling site is located at Columbia River mile 10, on Desdemona Sands. This site has been sampled during each of the three years (1984, 85, and 86). An exploratory site in Youngs Bay was sampled in 1986 for sediment metals and fish pathology. Target fish species for the Columbia River estuary is the Starry Flounder (*Platichthys stellatus*). Relatively low concentrations of chlorinated hydrocarbons and trace metals were found in sediments and fish from the two Columbia River sites. Moderate concentrations of aromatic hydrocarbons were found in sediments and the bile of starry flounder at the Young Bay site. In summary the sites in Alaska and Oregon were among the least polluted.

Durkin, J.T., S.J. Lipovsky, G.R. Snyder, And M.E. Tuttle. 1977
Environmental studies of Three Columbia River Estuarine Beaches. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to Columbia River Program Office, NOAA. 78 pp.

River Mile: 4, 9, 11 Reach: 1.1 to 1.3.
Study Emphases: Site comparison.
Biological:* Fish, benthos.
Physical: Water temperature, salinity.
Frequency: Monthly Duration: 5 months, May-September 1976.
Comments: Catch data can be misleading, comparisons made on total numbers and not on catch per units of effort

Modified Summary

Site specific information is essential if informed and supportable environmental decisions are to be made on potential development sites. Studies to obtain site specific information on aquatic life at three future development sites in the Columbia River estuary was initiated by NMFS in May 1976. One of the sites suggested for potential development (manufacturing or fabrication) is located on the west side at the mouth of Youngs Bay. The self-scouring area from the city of Hammond east to Tansy Point has been proposed, by the Port of Astoria, for future waterfront docking facilities. The third site is located on the Washington side of the estuary at upper Sand Island in Baker Bay. This site has been used and has the potential for continued use as a depository for sediments dredged from Chinook Channel.

Twenty three beach seine sets were made over the 5 month period, May through September 1976, to obtain information on fish assemblages at the three potential development sites. Two seine hauls each were made monthly at the Youngs Bay and Hammond sites, while at Sand Island only 3 beach seine sets were made 1 in May, and 2 in June. Salinity, temperature, and depths were recorded for each survey at each site. Stomachs were removed from a subsample of selected species for food utilization studies. In addition, benthic and epibenthic sampling was conducted at the Youngs Bay site.

Seven species represented 96.4% of the total catch of 31,846 finfish collected during the 23 beach seine efforts. Nearly half of all the fish (46.1%) were captured at the Youngs Bay site; however, when comparing catch per seine haul, the Sand Island site had the highest standing crop. Dominant species captured at Sand Island were Pacific herring, surf smelt and fall chinook salmon; at Hammond surf smelt, shiner perch and fall chinook salmon

were the most common species; while shiner perch, fall chinook salmon, and surf smelt dominated the Youngs Bay catches. The mysid, *Neomysis mercedis* was the most abundant epibenthic organism captured in Youngs Bay. Of the 22 species of benthic organisms captured during the 5 months effort in Youngs Bay the amphipod *C. salmonis* was clearly the dominate species, and represented at least 60% of the catch in each sample. The numbers of *C. salmonis* captured ranged from a low of 4,837/m² in July to a high of 11,457/m² in May. Development at any of the three sites would have an impact on the associated aquatic life. The greatest impact would occur at the shallow intertidal, subtidal areas at the Youngs Bay site.

Durkin, J.T., T.C. Coley, K. Verner, and R.L. Emmett. 1981. An aquatic species evaluation at four self scouring sites in the Columbia River Estuary. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to U.S. Army Corps of Engineers Contract DACW57-79-F-0145). 46 pp.

River Mile: 3, 10, 13, 18 Reach: 1.1-1.2-1.3-1.5.
Study Emphases: Scour site evaluation.
Biological:* Fish, benthos.
Chemical: volatile solids.
Physical: Water temperature, salinity sediment grain size.
Frequency: Two surveys Duration: October 1978 and May 1979.
Comments: Good comparative data of estuarine high energy areas.

Summary

Water velocities generated by the combined forces of fresh water inflow and tides tend to scour certain areas of the river bottom, especially areas adjacent to jetties, peninsulas, and bridge pilings. In 1978 the National Marine Fisheries Service in cooperation with the Portland District, Corps of Engineers conducted a biological inventory of four hydrologically dynamic sites within the estuary. The objectives of the study were to determine: if scour sites had low standing crops of aquatic life, if populations were stable, and if species tolerant of stress dominated the catch.

The 4 sites selected for study were within or adjacent to the navigation channel and all had mean low low water depths > 50 feet. The Jetty A test site at Columbia River mile (CRM 2.8) was in the navigation channel just west of Jetty A; Tansy Point (CRM 10.2) was in and adjacent to the Oregon side of the navigation channel; the Interstate Bridge site (CRM 13.5) was adjacent to the north side of the navigation channel; the Tongue Point site (CRM 18.2) was in and adjacent to the Oregon side of the navigation channel. Sampling was scheduled at a 6-month interval (Oct-Nov 1978) and (May 1979). Sampling included bottom trawling for demersal finfish and shell fish, and grab samples for benthic invertebrates and sediment samples. Pelagic finfish were not sampled at Jetty A but were sampled at the three upstream stations with a purse seine. Stomachs were removed from a subsample of fish captured during each sampling effort for food content examination.

A total of 31,870 finfish belonging to 46 species were collected at the four sites during the two sampling periods. The numbers of demersal finfish at Jetty A were relatively low during both surveys. At Tansy Point and Tongue Point pelagic fish dominated the catch during all surveys, while at the Interstate Bridge demersal fish dominated. In October, Pacific tomcod was the dominant demersal fish at Jetty A and during both sampling efforts at Tansy Point. In October, Longfin smelt was the dominant demersal species at Tongue Point and at the Interstate Bridge, and during the pelagic effort at the Interstate Bridge in May. Marine schooling fish dominated the pelagic catches at all sites in October. In October, 17,146 Pacific herring were taken in one purse seine set at Tongue Point, this accounted for 78% of all fish captured

during all efforts at this site. Juvenile anadromous finfish dominated the pelagic sampling efforts in May. Dungeness crabs were taken during all sampling efforts at Jetty A, Tansy Point, and the Interstate Bridge.

In October benthic invertebrate abundance ranged from a low of 138 per m^2 at Jetty A to 2,460 per m^2 at Tansy Point. In May higher densities were reported at all stations; ranging from a low of 2,178 per m^2 at Tansy Point to a high of 6,716 per m^2 at Tongue Point. Nematoda was the over all dominant species at Jetty A, while Copepods dominated at the other 3 sites. Medium grain sand (0.25-0.5 mm) was the single most common sediment size at all sites.

Data supporting the premise that high velocity estuarine scour sites have essentially low standing crops of fish and invertebrates was found only at Jetty A. Species were subjected to several stresses, the most obvious being the presence, absence, or level of salinity. Results indicate sediment deposition at the Tongue Point and Interstate Bridge site could potentially smother large numbers of important benthic food organisms. The Jetty A site should be evaluated as a permanent deposition site especially on ebb tides.

Fuhrer, G.F. 1984

Chemical analyses of elutriates, native water, and bottom material from the Chetco, Rogue, and Columbia Rivers in Western Oregon. U.S. Geological Survey Open-file Report 84-133, 57 p.

River Mile: 1.8 to 18.2 Reach: 1.1-1.5.
Study Emphases: Provide chemical data at selected dredging sites.
Chemical: Selected metals, insecticides, organic compounds.
Physical: Salinity, and sediment particle-size distribution.
Frequency: Reconnaissance Duration: April and August 1982.
Comments: Retrieval of chemical data can be made from either USGS's WATSTORE system or EPA's STORET system.

Modified Abstract

The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers participated in an elutriation study in April and August 1982. The purpose of the study was to collect reconnaissance data on elutriates, native water, and bottom material which could be used to evaluate short term impacts of dredging and disposal operations representative of selected dredging sites in Oregon. Reconnaissance data were collected from the Chetco and Rouge River estuaries in southwestern Oregon. Reconnaissance data were also collected from 11 sites in the Columbia River from the ocean to Tongue Point in Cathlamet Bay, 18.2 miles upstream.

In an elutriation test, bottom materials from a potential dredge site are mixed with native water - collected from either a dredge or disposal site - and the liquid portion of the mixture is removed, filtered, and chemically analyzed. Presented in this report are chemical and physical analyses of elutriates, native water, and bottom material for selected metals, ammonia, organic carbon, pesticides, particle size, and gas chromatographic/mass spectrometric semi-quantitative organic scans. Elutriate and bottom-material samples were screened specifically for phenolic compounds, particularly the chlorinated phenols; phenol was the only compound identified.

Comparisons of 1982 reconnaissance data from this study are made with the 1980 reconnaissance data, however the comparisons are total and not on a site to site basis. The 1982 maximum concentrations of DDT, methoxychlor, and perthane in bottom material samples exceed the maximum 1980 concentrations.

Fuhrer, G.F. 1986

Extractable Cadmium, Mercury, Copper, Lead, and Zinc in the Lower Columbia River estuary, Oregon and Washington. U.S. Geological Survey, Water Resources Investigations Report 86-4088. 61 p.

River Mile: 2.8, Ilwaco channel, Astoria ship pier Reach: 1.1, 1.3.
Study Emphases: Test selected metals in bottom material that could impact benthic deposit feeders.
Chemical: Cadmium, Mercury, Copper, Lead, and Zinc.
Physical: Sediment particle-size distribution.
Frequency: Survey Duration: July 1983
Comments: Provides a review of trace metals in bottom materials. Also a table of trace metal concentrations from previous surveys.

Modified Abstract

In July of 1983 the U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, collected and analyzed bottom-material samples from the Columbia River estuary in order to investigate trace metals associated with the bottom material that is expected to accumulate at the sediment/water interface of in-water disposal sites and thus impact benthic deposit feeders. The interaction between bottom material and water during dredging was simulated by volumetrically mixing bulk bottom materials with native water. The association of trace metals with bottom material at the disposal site was simulated by sieving the native water and bottom material slurry to less than 100 microns in diameter--those grain sizes frequently ingested by benthic deposit feeders--and chemically extracting with 1N HCL. The 1N-HCL extraction of bottom material finer than 100 microns is a non-specific extraction that has been shown in other studies to correlate well with concentrations of metals found in the tissues of many estuarine organisms. Concentrations of trace metals in estuarine organisms were not determined in this study.

Samples were collected from the main navigation channel west of Jetty A, five sites in the Ilwaco boat channel, and two sites between pier 1 and 2 at the Port of Astoria. Concentrations of copper, mercury, lead, and zinc in bottom materials processed under the simulated dredging/disposal procedure were not elevated. Studies have shown that the bioavailability of mercury is inversely related to total volatile solids, a measurement of organic carbon. Areas sampled in the Ilwaco boat channel contained large concentrations of total volatile solids. Thus bottom material from these areas are not likely to contain mercury in bioavailable forms.

Concentrations of cadmium from the high energy area of the navigation channel (Jetty A) were elevated when compared to concentrations found in lower energy areas of the Ilwaco channel and are similar to concentrations observed in other, anthropogenically contaminated estuaries. Bottom material at this site has small substrate-binding constituents like iron, manganese, and organic material. The bioavailability of cadmium to deposit feeders under these circumstances may be of concern.

Fuhrer, G.F., and A.J.Horowitz 1989
The Vertical Distribution of Selected Trace Metals and Organic Compounds in Bottom Materials of the Proposed Lower Columbia River Export Channel, Oregon 1984. U.S. Geological Survey, Water Resources Investigations Report 88-4099. 40 p.

River Mile: 7.5, Skipanon River, 12.8, Tongue Point Reach: 1.2, 1.5.
Study Emphases: Vertical distribution metals and organic compounds.
Chemical: Selected trace metals and organic compounds.
Physical: Sediment particle-size distribution_
Frequency: Single survey Duration: September, October 1984
Comments: Provides a table of EPA guidelines for various water uses; depth chemical distribution graphs.

Summary

A proposal to deepen the lower Columbia River navigational channel prompted a study of vertical distribution of selected trace metals and organic compounds in bottom material to evaluate the effects of dredging and disposal operations. Prior Columbia River reconnaissance studies found that sediments in some areas of the proposed channel may when mixed with native water, release dissolved Cd (cadmium), Cu (copper), Mn (manganese), and Ni (nickel) in concentrations exceeding U.S. Environmental Protection Agency (EPA) criteria for the protection of marine aquatic life. Also identified in previous studies of surficial bottom materials were organochlorine compounds, many of which are known to bioaccumulate. Based on these earlier studies, four sites were selected; Columbia River navigation channel (Rm-7.5 and 12.8), Skipanon River, and Tongue Point. Bottom-material core samples and native-mixing water samples were collected during September and October 1984. Bottom materials were cored to 6 meters (19.7 feet), to coincide with the proposed channel depths.

Sediment associated organochlorine compounds detected in the Skipanon River and Tongue Point core samples were as large as 0.1 µg/kg (micrograms per kilogram) for aldrin, 2.0 µg/kg for chlordane, 27 µg/kg for DDD (dichloro diphenyl dichloroethane), 5.0 µg/kg DDE (dichloro diphenyl dichloroethylene), 0.2 µg/kg for DDT (dichloro diphenyl trichloroethane), 0.2 µg/kg dieldrin, 37 µg/kg for PCB's (polychlorinated biphenyls), 0.1 µg/kg PCN's (polychlorinated naphthalenes), and 0.1 µg/kg for heptachlor epoxide. Mathematical normalization of the data to grain size shows that organochlorine compounds are preferentially sorbed to fine grained sediments rich in organic carbon. Small concentrations of phthalate esters (7 to 20 µg/kg) were detected in Skipanon River core samples and larger concentrations of polcyclic aromatics (8 to 278 µg/kg) were detected in Tongue Point core samples.

In the Columbia River core sample near Astoria, concentrations of cadmium as large as 3.6 µg/kg were found in a portion of the core. In the Skipanon River core sample, concentrations of lead and zinc were as large as 26 µg/kg and 210 µg/kg, respectively, throughout the core. In the Tongue Point core sample, concentrations of cadmium, chromium, copper, iron, and zinc associated with the less-than-100-micrometer size fraction are larger than those associated with the greater-than-100-micrometer fraction. Within upper core depths of the same core, large concentrations of cadmium, mercury, and zinc correspond to a time when naval vessels were being maintained in the Tongue Point area.

Jones, K.K.; M.A. Brzezinski; D.L. Higley; R.L. Holton. 1982. Vertical distribution of benthic infauna in the sediments of the Columbia River estuary, with notes on the selectivity of screen mesh size. School of Oceanography, Oreg. State. Univ., Corvallis, OR. 97331: 38 pp.

River Mile: 5, 10, 23 Reach: 1.1, 1.2, 1.6
Study Emphases: Benthic depth distribution and size relationships.
Biological:* Benthic
Physical: Sediment grain size.
Frequency: Single survey
Comments: Information valuable for study comparison.

Modified Author's Abstract

Three cores were collected from different intertidal environments in the Columbia River estuary, Baker Bay (RM-5), Desdemona Sands (RM-10), and Grays Bay (RM-23). The cores penetrated to a depth of 30 cm and were vertically sectioned at intervals of 1 cm, 2 cm and 5 cm. Each depth interval was sieved on a series of screens of mesh sizes 4.0, 1.0, 0.5, 0.25, 0.125, and 0.063 mm.

In general a concentration of amphipods, polychaetes, and small bivalves was found near the surface, a broad vertical distribution of nematodes and

oligochaetes, and the deeper location of large bivalves. The important amphipod *Corophium* was largely confined to the upper 15 cm. Size retention data generally supported the commonly used 0.5 mm separation between meiofauna and macrofauna. Some juvenile amphipods and bivalves passed through the 0.5 mm screens. Samples must be taken deep enough to collect the targeted animals and sieve sizes used, must retain the species and life stages under study.

Holton, Robert L., D.L. Higley and D.L. Brooker. 1984.
Salinity-Temperature Relations of the Amphipod Corophium salmonis in the Columbia River Estuary. Report to the U.S. Army Corps of Engineers, Portland District. by Dept of General Science, OSU, Corvallis, Oregon. 97331: 36 pp.

River Mile: 13 & Youngs Bay Reach: 1.2
Study Emphases: Salinity-temperature relations: Field, laboratory.
Biological:* Benthos
Physical: Salinity, temperature.
Frequency: 6 surveys Duration: 4 months; 1983.
Comments: Short term: need longer term study, at least 1 year.

Modified Executive Summary

The salinity-temperature relations of the amphipod *Corophium salmonis* in the Columbia River estuary were investigated through a combination of field and laboratory studies. *Corophium salmonis* has great trophic importance in the estuary because of its wide distribution, high densities, and strong contribution to the estuary's food chains, which involve several economically important fish species including juvenile salmonids.

Field studies were conducted in the summer and fall of 1983 on populations of *C. salmonis* existing along a seasonally temporary salinity gradient from upper Youngs Bay to outside the mouth of Youngs Bay (Desdemona Sands). Mid-summer tidal exchanges produced observed salinity extremes of 1 to 17 parts per thousand (ppt) in the outer bay, while lower maxima occurred at most up-bay stations. By October, a mostly uniform water mass occupied the bay, so that tidal depth was the major cause of salinity differences among stations. *C. salmonis* exhibited mid-summer peaks and late summer, early fall declines to near zero densities at all stations. Declines proceeded most slowly at the intertidal stations, suggesting that morality rates or migration patterns varied with salinity as influenced by tidal depth.

Laboratory studies found maximum survival rates near 10 ppt salinity. Death was rapid [<1 day] at salinities >30 ppt. Survival rate declined with increasing temperature (7, 14, & 21 degrees C.). The addition of silt to treatment vessels significantly increased survival rate. No pattern of salinity preference was exhibited by *C. salmonis* within the 0-20 ppt range.

This study combines with earlier studies to demonstrate that *C. salmonis* is adapted to moderate and low salinities, and that population dynamics and migration patterns may respond to local variations in salinity regime. Such responses could affect trophic relations within the Columbia River Estuary should channel depth be increased and allow greater intrusion of saline water.

Rathburn, R., S. Lipovsky, and C. Sherwood. 1983
Effects of Flow Lane Disposal in the Columbia River Estuary 1982-1983 Monitoring Studies. Rept. to Port Of Astoria, from Enviro Science, Inc. 741 S.W. Lincoln, Portland OR. 45 p, plus Appendix

River Mile: 13+ Reach: 1.2
Study Emphases: Impact of Flow Lane Disposal Port of Astoria
Biological:* Benthic
Physical: Sediment, salinity, temperature, turbidity.
Frequency: Pre, during, post dredging Duration: 4 months; 1982-83.

Comments: Site specific, conclusions made without supporting data being presented i.e. organics.

Summary

The purpose of the study was to collect data which could be used to assess the environmental effects of material dredged from between the piers at the Port of Astoria and deposited in the Columbia River Navigation channel. This study is a continuation of an annual monitoring program intended to fulfill dredge and disposal permit requirements.

Enviro Science designed and completed a monitoring program to evaluate pre-disposal, disposal and post-disposal conditions in an area within 600 meters of the disposal area. This investigation evaluated: 1) the effects of dredge disposal on benthic infauna and their associated sediment conditions; 2) the distribution of suspended sediments in the water column; and 3) the probable fate of dredge spoil on the localized bathymetric conditions.

The biological communities consisted of abundant species which compiled 97% of the total species count. These were the clam *Macoma balthica*, the polychaete *Neanthes limnicola*, Nemertea flatworms, oligochaete, and the amphipod *Eogammarious confervicolus*. The effect of dredging on the biological communities varied indirectly with increasing distance from the outfall. The high impact area near the outfall had a 77% reduction in species, the intermediate impact area was reduced by 55%, while the farthest area 550 meters downstream was apparently unaffected. No recovery of species numbers to pre-dredge conditions was observed.

The movement of sediment spoil within the Columbia River channel appeared to vary with the timing of the ebb tide. Coarser sand sediments settled quickly and became a part of the bedload. Finer silt/clay sediments moved from the surface waters to intermediate depths, and then moved with the currents. Sediments at all stations became finer during the dredging operation. After dredging was terminated the principal sediment types returned to pre-discharge conditions.

Wilson, Stephanie Lynn. 1983.
The Life History of *Corophium salmonis* in the Columbia River Estuary
School of Oceanography, Oreg. State. Univ., Corvallis, OR.: Thesis. 66 pp.

River Mile: 10, 23. Reach: 1.2, 1.6.
Study Emphases: Life history Corophium salmonis.
Biological:* Benthos.
Physical: Water temp., salinity, sediment grain size.
Frequency: Monthly to April 81, then twice a month to Sept 81.
Duration: 13 months; 1980-81.
Comments: Informative thesis.

Summary

The life history of *Corophium salmonis* was studied (August 1980-September 1981) in two different habitats in the Columbia River estuary. Grays Bay, a large protected embayment on the North side of the estuary is located between the mixing and fresh water zone. Desdemona Sands is a midriver sand shoal in the mixing salinity zone which differs from Grays Bay in both tidal energy and salinity. C. salmonis from both sites exhibited a two generation per year life cycle; a spring generation in May and a fall generation in July or August. The population of C. salmonis disappeared from Desdemona Sands in September 1980 and reappeared in April 1981. Observed salinity fluctuations at Desdemona Sands suggests salinity controlled migrations into and out of the site.

Haertel, D.L. and C.L. Osterberg. 1967.
Ecology of Zooplankton, Benthos, and Fishes in the Columbia River Estuary.
Ecology 48(3): 459-472 pp.

River Mile: 2, 8, 15, & 23 Reach: 1.1, 1.4, 1.6
Study Emphases: Estuarine ecology.
Biological:* Zooplankton, demersal fish.
Chemical: DO.
Physical: Salinity, temperature.
Frequency: monthly (varies by sta.) Duration: 22 months.
Comments: Limited benthic; Species list provided.

Author's Abstract

Fauna of the Columbia River estuary were sampled regularly for 21 months. Analyses of plankton samples indicated that three distinct populations existed in the estuary: a freshwater group, a marine group, and an indigenous group. The latter consisted principally of a large population of *Eurytemora hirundoides*. Changes in the salinity of the estuary were reflected in the composition of the plankton.

The majority of the fish and benthic invertebrates found in the estuary are euryhaline. The largest numbers of fish species, as well as the largest numbers of individuals occupy the slightly brackish waters of the central portion of the estuary. The major plankton blooms also occur in this area. Starry flounder (*Platichthys stellatus*) and sand shrimp (*Crangon franciscorum*) use the upper estuary as a nursery ground. Extensive analyses of fish stomach contents confirm that food habits of fishes generally reflect the availability of prey.

The paper deals with certain physical parameters in the estuary, a census of organisms present, food habits of the common fishes, and a few of the more obvious relationships. Sampling was limited to those animals that could be collected with otter trawls (bottom), mid-water trawls, and plankton nets.

Durkin, J.T. and R.L. Emmett. 1980.
Benthic Invertebrates, Water Quality, and Substrate Texture in Baker Bay, Youngs Bay, and Adjacent Areas of the Columbia River Estuary. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to U.S. Fish Wilfl. Serv. 44 pp.

River Mile: Baker Bay, Youngs Bay, to Tongue Point Reach: 1.1 to 1.5.
Study Emphases: Base line classification data.
Biological:* Benthos.
Chemical: DO, pH, volatile solids.
Physical: Salinity, temperature, sediment texture.
Frequency: Quarterly Duration: 12 months; 1977-78.
Comments: Useful base-line data. See following bibliography.

Summary

Information on abundance, diversity, seasonality, and biomass of estuarine benthic invertebrates is useful in determining the biological importance of an aquatic habitat. Benthic invertebrates are prey for other invertebrates, fish, birds, and man. Also, invertebrates are important in recycling nutrients within the estuarine ecosystem. To comprehend why certain invertebrates occur in an area, physical characteristics of the habitat, such as substrate composition, salinity, and water temperature need to be known. Since physical factors may determine abundance and/or distribution of species, they should be measured during the collection of biological data.

To provide resource management agencies with much needed baseline classification information, the National Marine Fisheries Service (NMFS) in cooperation with the U.S. Fish & Wildlife Service established 45 subtidal and intertidal benthic invertebrate sampling sites in the Columbia River estuary. These sites were located in Baker Bay, a shallow marine-oriented habitat; Youngs Bay, a shallow oligohaline embayment; and along the southern estuarine shore line from Hammond Or. (Rm-9) through Tongue Point Or. (Rm-19).

Information dealing specifically with benthic invertebrate numbers and weights; associated sediment texture, volatile solids, and water quality data were collected during 4 surveys; June, September, and December 1977 and March 1978.

Embayments on the Oregon side of the estuary had greater numbers of benthic organisms whereas weights averaged more on the Washington side. Seasonal shifts in weights and numbers were noted, but changes were not consistent between areas. Principal benthic component of the Baker Bay community was the bivalve, *Macoma balthica*. The Youngs Bay benthic assemblage had large populations of Oligochaeta and amphipoda, while the major component at the four Tongue Point stations was Copepoda. Sediment texture was usually silt to fine sand in the Oregon embayments, but was fine sand to medium sand in Baker Bay and near the navigation channel. Over 20% of the sediment samples exceed EPA volatile solid levels, but other water quality measurements such as oxygen, pH, and temperature were in the acceptable range for aquatic life.

MIDDLE ESTUARY (Rm 13.6 to 23.5)

Durkin, J.T., R.L. Emmett, K. Verner, T.C. Coley, W.D. Muir, G.T. McCabe, and R.J. McConnell. 1987.
Benthic Macroinvertebrates, and Substrate in Cathlamet Bay, Oregon, Columbia River Estuary. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to U.S. Fish Wilfl. Serv. 36 p.

River Mile: Tongue Point, Cathlamet Bay Reach: 1.4 to 2.1.
Study Emphases: Base line data.
Biological:* Benthos.
Chemical: DO, pH, volatile solids.
Physical: Salinity, temperature, sediment texture.
Frequency: Quarterly Duration: 12 months. 1978-79
Comments: Good base line data. Continuation of Durkin, J.T. & Emmett R.L. 1980.

Summary

In 1978 the National Marine Fisheries Service (NMFS) in cooperation with the U.S. Fish & Wildlife Service established 24 subtidal benthic invertebrate sampling sites in Cathlamet Bay. To assure continuity and comparability, seven sites in the Tongue Point area were the same as those used in a previous study by Durkin & Emmett (1980). The 24 sampling sites were located throughout Cathlament Bay, from Tongue Point, into the John Day River and east to Aldrich Point at the upstream end of Prairie Channel. These sites were usually associated with structures (buoys or dolphins) or fixed shoreline features to assure consistent repetitive sampling. Criteria for selecting a station included reasonable spacing between sites and location in different types of habitats. Benthic invertebrate and substrate samples, along with related water quality data, were taken quarterly at each site September and December 1978 and March and June 1979.

Cathlament Bay is the largest of the four bays within the Columbia River estuary. Salinity differences account for much of the variation in benthic macroinvertebrate diversities between the three bays, unlike Baker and Youngs Bay, Cathlament Bay is essentially a freshwater embayment. Baker and Youngs Bays have higher benthic macroinvertebrate diversities, with many mesohaline species, Cathlament Bay, however has only a few euryhaline and freshwater species. Average annual density of all benthic macroinvertebrate at 24 sites in Cathlamet Bay (8,644/m^2) was greater than the average of 12 sites in Baker Bay, but less than the 12 sites in Youngs Bay which had large numbers of many different species, in Cathlamet Bay overall density was determined primarily by

one species, Corophium salmonis. Densities of C salmonis (up to 61,500/m²) found in this study are the highest reported in the Columbia River estuary. Seasonal changes of invertebrate densities in Cathlamet Bay did not coincide with seasonal changes in Youngs and Baker Bays. The highest measured macroinvertebrate abundance in Cathlamet Bay was in December, in Youngs and Baker Bays highest abundance occurred in June and September, respectively.

Highest total invertebrate density (68,340/m²) occurred in the North channel of Cathlament Bay in December 1978. The lowest density (80/m²) was at Seal Island and Knappa Slough in March 1979. Average total invertebrate density in Cathlamat Bay was highest in December (11,202/m²) followed by March (10,085/m²), June (7,654/m²)and September (5,636/m²). Water temperatures in Cathlament Bay were greatly influenced by seasonal freshwater inflow; there was little evidence of stratification. Highest salinities measured (4.6 ppt) was at the mouth of the John Day River with salinities ≥ 1 ppt occurring in the John Day River at the highway 30 bridge. At most sites, fine sand (0.125-0.25 mm) was the major sediment size. The average percent organic content of sediment samples increased with each survey September to June, highest levels (6%) were found at the mouth of Big Creek and in Blind Slough. There was no significant correlation between benthic macroinvertebrate abundance and sediment grain size, although some trends did appear. For example, most sites with low organics and a high percentage of fine sand also had large numbers of C salmonis. Oligochaetes were associated with moderate amounts of very fine sand and high levels of organics.

The high densities of C salmonis found in this study and the importance of C salmonis as prey for Columbia River fishes indicate the importance of Cathlament Bay as an important source of fish forage.

Olhausen, Steven K 1980.
Fish Sampling Operations at Tongue Point, Oregon. U.S. Department of Interior, U.S. Fish and Wildlife Service, Fisheries Assistance Office, Vancouver, Wa. 9 p.

Smith, James. G. 1981
Addendum Report fish sampling operations at Tongue Point, Oregon. U.S. Department of Interior, U.S. Fish and Wildlife Service, Fisheries Assistance Office, Vancouver, Wa. 7 p.

River Mile: Tongue Point Reach: 1.5
Study Emphases: Determine fish utilization.
Biological:* Fish, Food consumption.
Frequency: Weekly Duration: May through September 1979
Comments: Provides useful information.

SUMMARY

Two reports describing results of fish sampling (May through Sept.1979) at Tongue Point OR, in the Columbia River estuary. Purpose of the study was to document the use of Tongue Point by salmonid fishes. Initially gillnets, fyke nets, and beach seines were used to determine the most practical and efficient method to capture fish in this area. A beach seine proved to be the most practical and best suited. Five sampling sites were selected on the bases of beach slope and resultant habitat created by prevailing tidal conditions. The 1981 addendum report by Smith provides additional information on a sixth site; as well as a comparison of salmonid catches between Tongue Point (Rm-18.2) and Jones Beach (Rm-46.6).

Eighteen species of fish were captured in the Tongue Point area, however, three species accounted for 77% of the total catch; Threespine stickleback, chinook salmon, and starry flounder. Juvenile salmonids were present throughout the sampling period with juvenile chinook being the most common followed by coho and chum salmon respectively. Occurrence of juvenile fall

chinook in the Tongue Point area appears to correspond to the major outmigration of fish from upriver sites and from Big Creek hatchery releases. Stomach analysis reveled that salmonids were feeding in the Tongue Point area and that the Amphipod *Corophium salmonis* made up 80% of the diet.

Cates, Brian C. 1983.
Fish Sampling Operations at Tongue Point, Oregon. U.S. Department of Interior, U.S. Fish and Wildlife Service, Fisheries Assistance Office, Vancouver, Wa.22 p.

River Mile: Tongue Point Reach: 1.5
Study Emphases: Provide addional data to fish utilization of Tongue Point.
Biological:* Fish,
Frequency: Weekly Duration: March through August 1981
Comments: Adds useful information to the 1979 study.

Author's Conclusions

The six sampling sites utilized in 1979 were used again in 1981. A seventh site was added on Mott Island. Six sites were within the shelter of the islands the other was located on the Columbia River side of Lois Island.

Two years of sampling effort have shown that the Tongue Point area is utilized by migrating anadromous salmonids. Some are present for a short time while others feed and grow in the sheltered waters outside of the main Columbia River channel. Tongue Point is utilized by salmon from at least March to September. The importance of this type of habitat to hatchery salmon may be significant; not only to upriver stocks but also to stocks occurring in the general area, and even those originating downstream. Tongue Point may prove to be a last stop for many migrating salmon before ocean entry. Those fish not physiologically ready for ocean entry may require areas such as Tongue Point to gain the necessary growth and go through physiological changes that will increase their chances of ocean survival. The Tongue Point area maybe especially important to all nearby anadromous stocks like those of Big Creek which appeared to represent a large percentage of the catch. It may also be a major area for chum salmon.

Careful consideration must be given to the impact development projects, in this area, may have on the aquatic habitat, not only from the aspect of harming anadromous fish production but also decreasing the juvenile rearing capabilities of other commercially important non-salmonids that utilize the area. Even those species that have no direct commercial value can be an important component of the ecological balance of the Columbia system.

McCabe, G.T. Jr., R.L. Emmett, T.C. Coley, W.D. Muir, and R.J. McConnell. 1984.
Fish Sampling in Cathlament Bay Oregon 1984.
Emmett, R.L.,J.T. McCabe Jr., T.C. Coley, R.J. McConnell and W.D. Muir 1985.
Benthic Sampling in Cathlament Bay Oregon 1984. U.S. Nat. Mar. Fish. Serv. NOAA, NMFS Point Adams Station P.O. 155 Hammond Oregon 97121 two data reports to U.S. Army Corps of Engineers. Contract (DACW57-84-F-0348). Fish 49 pp. & Benthic 70 pp

River Mile: Cathlament Bay Reach: 1.5
Study Emphases: Obtain biological information.
Biological:* Fish, Benthos,
Chemical: Volatile solids.
Physical: Water temperature, Salinity, and Sediment grain size.
Frequency: Biweekly Duration: 7 months March through Sept. 1984.
Comments: Data base. No analysis between sites or over time. data is on computer tape and available upon request.

Summary

Cathlament Bay is mainly a freshwater system, however when flows are reduced saline water does enter the bay through its interconnecting channel systems. In 1984 a renewed interest in deepening the navigation channel from the mouth of the Columbia River to either Astoria or Tongue Point, Oregon caused concern over the possibility of increased salinity levels in Cathlament Bay. This embayment supports large populations of invertebrates, an important food source for many fish species in the estuary. It is also heavily utilized by juvenile salmonids as a feeding area during their migrations to the Pacific ocean. Alterations of salinity regimes in Cathlament Bay could reduce the invertebrate populations and subsequently adversely impact the use of the bay as a feeding and nursery area.

In 1984 the Portland District, Army Corps of Engineers and the National Marine Fisheries service (NMFS) entered into a cooperative agreement to obtain salinity and biological information from the interconnecting channels in Cathlament Bay. Three recording salinity meters were installed, by the Corps, in channel areas of the bay, however adequate salinity information was never obtained because one meter was stolen or lost, and another malfunctioned.

NMFS gathered biological information on the benthic invertebrate and fish communities at South Tongue Point, North channel, Woody Is. channel, and Prairie channel. All sites had previously been sampled during the (1978-79 Cathlamet Bay benthic study and/or CREDDP). Seven surveys were made from March to September 1984 in the four channel areas using a semi-balloon shrimp trawl to sample channel bottoms. In addition a purse seine was used in the North Channel and Woody Is. channel to obtain pelagic fish. A total of 5,924 fish representing 19 species were collected. Juvenile salmonids were taken by purse seine April through August. Juvenile salmonid species captured were spring and fall chinook, coho, and sockeye salmon; steelhead, and cutthroat trout were also present. Fall chinook peaked around the first of August. The Tongue Point demersal catch exceeded the combined catch at the other 3 sites. Prickly sculpin, Longfin smelt, and Starry flounder dominated the catch at this location. White sturgeon were taken in all trawl sets in North Channel and at all sites. The fish data report contains a list of the fish species captured during the survey. Physical and biological data are presented for each station by month. Mean lengths and weights with standard deviations have been calculated for each species at each station by month.

Thirteen benthic sampling surveys were conducted at the 4 Cathlament Bay channel stations at approximately two-week intervals from March to September 1984. Samples were collected by SCUBA divers using a 3.85-cm (inside diameter) coring device which takes a consistent 15 cm deep core. Initially 15 invertebrate cores and 1 sediment core were taken from within the confines of a square meter aluminum frame. Subsequent statistical analysis revealed 10 invertebrate cores sufficiently described the benthic community, therefore after the 4th survey (1 Aug 84) 10 benthic cores per station were collected. Samples were washed through a 0.25 mm mesh screen and identified to the lowest practical taxa and counted. Thirty five benthic invertebrate taxa were found in Cathlament Bay, March through September 1984. Numbers ranged from a low of 11,248/ m^2 at the Prairie channel site (17 July) to a high of 267,540/ m^2 at Tongue Point (29 Aug). The Tongue Point site was the richest in regards to total number per m^2, followed by North channel, Prairie channel, and Woody Is. channel sites. The Harpacticoid Copepod Scottolana canadensis was the dominated organism at Tongue Point and at the North channel site, Nematoda and Corophium salmonis were the two most common organisms at the Prairie channel, and Woody Island sites. Physical and biological data are presented for each station for each sampling period. Physical data presented includes, depth, bottom salinity and temperature. Biological information provided in the report includes sample size, total numbers, frequency of occurrence, and mean number per meter squared. Also calculated are the Shannon-Weaver diversity function

H', Simpson diversity value SD, species richness SR, and species evenness value J. A list of the benthic invertebrate taxa captured and sediment analysis data are also included in the benthic data report.

Although the purpose of this study was to obtain base line information prior to modification of the ship navigational channel, caution must be used in interpreting the data. If used for comparison to other studies it must be remembered samples were collected by divers using a constant penetrating coring device which is much more effective than grab samplers, also organisms where screened through a 0.025 mesh screen. The study was short term and therefore does not take into account year to year variations. The March 19, 1984 Mobiloil, oil spill may have affected the local benthic invertebrate biota. Oil was noted in the benthic samples starting on the third survey (18 April) and was present through the end of the study on 14 September 1984. Although some stations had more oil than others, effects on the invertebrate populations were not obvious, .

McConnell, R.J., G.R. Snyder, J.T. Durkin and T.H. Blahm. 1980.
Concentration, extent, and Duration of Salinity Intrusion into the Columbia River Estuary. September-October 1977-1978. Proceedings of the National Symposium on Freshwater Inflow to Estuaries: Fish & Wildlife Service Office of Biological Services Report FWS/OBS-81/04-vol-II 41-53 pp: Also December 1979. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Report to the U.S. Army Corps of Engineers. Contract NO. DACW57-79-F-0778). 37 pp.

River Mile: 18.2-26.5 Reach: 1.5-1.7
Study Emphases: Salinity intrusion.
Physical:* Salinity, conductivity, temperature.
Frequency: Eight, 24hr surveys Duration: 1977-1978.
Comments: Low flow period of year; highest concentrations and furthest upstream intrusion recorded for Columbia River estuary. Need for continuous monitoring stations.

Author's Abstract

Eight 24 hour surveys were conducted during monthly neep and spring tide cycles to record salinity intrusion into the middle Columbia River estuary (September and October 1977 and 1978). Initial objective was to determine salinity intrusion, during the near record low flow conditions that existed in the fall of 1977. The study was extended to obtain comparative data during the more normal flow year of 1978. Salinity, conductivity, and temperature were measured, at least hourly at each meter of depth, at Tongue Point, Harrington Point, Grays Point, and in the north channel of Cathlamet Bay.

Monthly neap tides produced the highest concentrations with the longest durations and farthest upstream intrusions of saline waters. Salinities reached 30 parts per thousand (°/oo) at Tongue Point (RM 18.2) and 17°/oo at Harrington Point (RM 23.4). Concentrations exceeding 11°/oo salinity were measured continually throughout one 24 hour survey at Tongue and Grays Points. The farthest upstream intrusion of salt water ≥ 2.0°/oo was recorded between buoy 14 and 14A at RM 26.5.

McConnell, R.J., S.J. Lipovsky, D.A. Misitano, D.R. Craddock, and J.R. Hughes. 1978.
Habitat Development Field Investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, OR. Appendix B: Inventory and Assessment of Predisposal and Postdisposal Aquatic Habitats. 4 microfiche. Tech. Rep. D-77-38, U.S. Army Engineer Waterways Experiment Station Vicksburg, MS.

River Mile: 24 (Miller Sands). Reach: 1.6.
Study Emphases: Habitat Development.
Biological:* Fish, Benthos, Food consumption.
Chemical: DO_2, pH, Ammonia, total alkalinity, volatile solids.
Physical: Salinity, temperature, turbidity sediment texture.
Frequency: Bimonthly Duration: 15 surveys. 1975-1977.
Comments: Site specific. intensive survey.

Modified Abstract.

Miller Sands, an island-lagoon complex located in the Columbia River estuary at River Mile 24 was one of five research projects of the Waterways Experiment Stations, Dredged Materials Research Program, where the feasibility of using dredged material for beneficial habitat development was studied. The study was conducted in three phases, pre-disposal, disposal and post-disposal from March 1975 to July 1977. The National Marine Fisheries Service (NMFS) was one of a five agency team charged with the investigation of various parameters during the marsh development program. NMFS research findings presented, describe changes in sediments, macroinvertebrates, various water quality parameters, nekton, nekton food utilized, and zooplankton.

Twenty species of finfish totaling 13,755 individuals were captured with beach seines and fyke nets at 13 different sites during the three year study. From July 1976-July 1977 all sites were sampled both during the day and at night. At the 95% confidence interval there was no statistical reason to conclude catches were different day to night; however, there was monthly variations. Four species dominated the catch during the 15 bimonthly surveys and accounted for 93% of the total catch i.e. juvenile chinook salmon, peamouth, starry flounder and threespine stickleback. Statistical analysis of age, weight, length, or number captured failed to reveal any significant changes as a result of disposal or as a benefit of habitat development at Miller Sands.

Over 54,000 prey organisms representing 36 taxa were consumed by the fish examined during food utilization studies. Four species made up 95% of the total number of prey items consumed. These were Daphnia, Eurytemora, Corophium, and Chironomid (larvae and pupae). With few exceptions the fish contained food during the entire study. Zooplankton was dominated by two Cladocerans, Daphina and Bosmina, and the Copepod, Cyclops. Zooplankton were excluded after the first year because it was felt qualitative analysis, based on bimonthly sampling was not feasible. Overall comparisons of benthic organisms between years was difficult because stations were added, changed, and material was added to the site. However, the average number of benthic invertebrates per square meter was much higher during the first year, also the number of species declined. Oligochaetes, Corophium, and Chironomids made up 92-94% of the 209,000 benthic organisms captured at Miller Sands.

Results of sediment analysis showed medium to fine sand (0.074-0.41 mm) comprised about 90-95% of the sample at all stations. Organic matter was between 3 and 8% with no significant seasonal changes. Water quality parameters monitored were water temperature, pH, salinity, dissolved O_2, and N_2, turbidity, ammonia, and total alkalinity. Water quality remained within safe biological limits. Water flows in the Columbia River were high in 1975, average in 1976, and exceedingly low during the winter of 1976 and the spring-summer of 1977. Biological and water quality parameters manifested as a result of the extreme flow conditions probably overpowered minor changes that could have developed as a result of the habitat improvement project at Miller Sands.

Durkin, Joseph T. S.J. Lipovsky and R.J. McConnell. 1979
Biological Impact of a Flowlane Disposal Project Near Pillar Rock in The Columbia River Estuary. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Report to the U.S. Army Corps of Engineers. (Contract NO. DACW57-77-F-0621), Jan. 1979, 91 pp

River Mile: 28, Reach: 1.7 .
Study Emphases: Flow-lane disposal; channel widening project.
Biological:* Pelagic & demersal fish, benthic, diet.
Chemical: Basic water quality, volatile solids.
Physical: Sediment grain size, depth profiles, turbidity
Frequency: Five surveys. Duration: 5 months; 1977-78.
Comments: Well done, site specific; author states qualifications.

Summary

A hydrobiological study to assess impacts of channel widening near Jim Crow Point and Pillar Rock in the upper Columbia River estuary. Pre-dredge and post-dredge finfish catches and benthic invertebrate counts served as a comparative base. Six surveys over a 5-month period (two each: before, during, and after dredging) included: demersal trawl tows, purse seine sets, beach seine sets, benthic grabs, epibenthic sled tows, sediment samples, and water quality measurements. A sub-sample of all finfish species were examined for stomach contents. Test results indicate short-term changes in the secondary and tertiary trophic levels at the dredge and disposal site.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankis, G.E. Monan, and F.J. Ossiander. 1986.
Migrational characteristics, biological observations, and related survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Report to BPA, Contract DE-A179-84BP39652, Available from Northwest Fisheries Center, 2725 Montlake Blvd. E. Seattle, WA 98112. 256 p., with Appendix.

River Mile: 46.6 (estuarine wide) Reach: 2.5
Study Emphases: Juvenile salmonid migration.
Biological:* Fish; food consumption.
Physical: Water temperature, salinity.
Frequency: Intense, during outmigration Duration:1966-72; 1977-83.
Comments: An informative 14 year data base on migration of juvenile salmonids into and through the estuary.

Summary

Hatchery procedures and facilities are continually being modified to improve both the efficiency of production and the quality of juveniles produced. Initial efforts to evaluate changes in hatchery procedures were dependent upon adult contributions to the fisheries and returns to the hatchery. Since salmonid survival depends on river, estuarine, and ocean habitats, the variations in adult return data are difficult to evaluate and unknown factors may overshadow the impacts of changes in hatchery culture techniques.

From 1966-1972, the National Marine Fisheries Service (NMFS), developed and refined procedures for sampling juvenile salmon and steelhead entering the Columbia River estuary and ocean plume. During the initial phase different fishing methods (fyke, trawl, gill, purse seine and beach seine nets) were evaluated at various sites throughout the estuary. Beach and purse seines were found to be the most efficient, least destructive sampling procedure. Thirty-

three beach seine sites were fished throughout the estuary with effort varying as to site and intensity each year. Purse seines were used to sample deep-water channels and the near off shore ocean plume. After evaluating a number of factors, a primary sampling site was established at the upper extent of the estuary (Jones Beach Rm-46.6), were the river is approximately a mile wide. Specific research objectives during the 1966-1972 studies were to provide information on movement rates and survival of juvenile salmonids during migration to the estuary and to examine migration timing, movement patterns, and residence time in the estuary.

From 1973 through 1976 The estuarine sampling program was not funded. From 1977 through 1983, The Northwest Regional Council and the Bonneville Power Administration funded estuarine sampling to provide assessment of salmonid outmigration from wild stocks and from mitigation hatcheries experimenting with enhanced cultural procedures. The extensive fish marking programs by state and federal fishery agencies provided the needed tool to assess migrational behavior and relative survival of identifiable hatchery and wild stocks General Conclusions: based on 14 years of the estuarine sampling program. Subyearling chinook salmon concentrate in the shallow near-shore areas of the estuary or within the top 10 feet of the surface. Larger (yearling) salmonids and steelhead concentrate in mid-river. Most movement of juvenile salmonids through the estuary occurs during daylight hours. Movement rates through the estuary and into the ocean are similar to the rate of movement from release site to Jones Beach; indicating limited use of the estuary by juvenile salmonids originating upstream from Jones Beach. Timing of juvenile salmonids to the estuary is dependent on time of release and river flow. Food consumption of migrants, examined at Jones Beach, appears to be substantially less than in other reaches of the river and in other river systems. Cultural practices, poor health, and release timing affects food consumption of migrants. Resident populations of squawfish have increased dramatically (0 in 1966 to 1,754 in 1981) at Jones Beach during the period of sampling. This increase was accelerated in 1980 beginning with the heavy turbidity created by the eruption of Mount St. Helens. However, examination of squawfish stomach contents does not indicate predation on salmonids.

Dawley, E.M., R.D. Ledgerwood, and A.L. Jensen. 1985
Beach and purse seine sampling of juvenile salmonids in the Columbia River estuary and ocean plume, 1977-1983. Volume I: Procedures, sampling effort, and catch data. U.S. Dept. of Commer., NOAA Tech. Meno. NMFS N/NWC-74:1-260.

River Mile: 4.3, 5.5, 10 Reach: 1.1 to 1.2 and 2.5.
Study Emphases: Beach & purse seine sampling for juvenile salmonids.
Biological:* Fish.
Physical: Water temperature, river flow, salinity.
Frequency: Extensive Duration: 1977-1983.
Comments: Catch data presented in tables.

Author's Abstract

Procedures for beach and purse seine sampling of juvenile salmon, Oncorhynchus spp., and steelhead, Salmo gairdneri, in the Columbia River estuary and ocean plume are described. Sampling effort and catch data from 1977 through 1983 are listed and summarized. Included are data summarizing fork lengths of each salmonid species, catches of species incidental to the program, water temperatures, and river flow.
Summary: The primary sampling site was Jones Beach (Rm-46.6), secondary sites were near the downstream extent of the estuary at McGowan (Rm-10), Clatsop Spit (Rm-5.5), and Sand Island (Rm-4.3), were salt water intrusion occurs. Incidental sites, sampled intermittently, were scattered throughout the estuary and ocean plume.

Fox, D.S., and P. Benoit 1985
The Physical and Biological Characteristics of the Columbia River Estuary--Summarized by Sub-Region. Columbia River Estuary Study Taskforce (CREST) P.O. box 175, Astoria, Or. 97103 Draft, 247 p., plus appendixes

River Mile: 0 to 46 Reach:
Study Emphases: Estuarine biological & physical characteristics.
Biological: Principal plants to terrestrial mammals.
Physical: Habitat & shoreline types, water circulation, tides, and salinity
Comments: Provides a useful reference, & access to source documents

Summary

Report briefly describes the physical and biological characteristics of the Columbia River estuary, drawing primarily on new information from the Columbia River Estuary Data Development Plan (CREDDP). Other technical sources provide information in areas where CREDDP data lack adequate coverage. The primary purpose of the report was to provide materials needed to update the estuarine element of the Oregon Department of Environmental Quality "Oil Spill Protection Plan for the Natural Resources of the Lower Columbia and Willamette Rivers". A secondary purpose is to summarize CREDDP and other pertinent information by region and, through extensive referencing, to facilitate access to the source documents.

The discussion of physical and biological characteristics appears as brief descriptions of 19 regions, subareas, of the estuary. Each subarea is a geographic unit possessing relatively uniform biological and physical characteristics. Each subarea narrative follows the same organizational format, consisting of a physical, biological, and findings section. Physical section includes descriptions of types of habitats, shoreline types, sediment types, water circulation and tides, and salinity. The biological section describes the principal plant, invertebrate, fish, bird, marine mammal and aquatic terrestrial mammal resources. Also provided is a map of each subarea showing the habitat types, shoreline types, and selected biological resources.

Gaumer, et al. 1973
1971 Columbia River Estuary Resource Use Study. Fish Commission of Oregon.

River Mile: Estuary, Reach:
Study Emphases: Informational report.

Summary

Findings of a comprehensive study of recreational use of marine food fish, shellfish, and other miscellaneous invertebrates in the Columbia River Estuary. Information on boat, shore, tideflat, and commercial fisheries. Food production areas, fish feeding areas, fish migration routes, and known herring spawning areas.

Harman, G.M., J.T. Durkin, and R.L. Holton. 1981
Utilization of the Columbia River Estuary by American Shad, *Alosa sapidissina*. School of Oceanography, OSU, Corvallis, Oregon. 97331: Thesis 25 pp

River Mile: Estuary. Reach:
Study Emphases: Utilization by shad.
Biological:* Fish, Benthos, Diet.

Physical: Salinity zones.
Frequency: Monthly Duration: 12 months 1980-1981.
Comments: Masters thesis. from CREDDP data.

Author's Abstract

The migrations, distributions, and feeding of American shad *Alosa sapidissima*, was studied from February 1980 through January 1981 in the Columbia River estuary, an important rearing zone for young-of-the-year shad. Sampling was performed with purse seine, beach seine, and otter trawl.

Adult shad and large numbers of juveniles from the 1979 spawning (age group I) entered the estuary from the ocean in May 1980. Adults continued on their upstream migration while age group I juveniles appeared to congregate in the estuary, joining those that had over wintered there. Many young-of-the-year shad (age group 0) reached the estuary on their seaward migration in September, 1980, during which time most of the age group I juveniles migrated back to sea. By January 1981, large numbers of young-of-the-year shad migrated to sea, although a few remained in the estuary.

The stomachs of 26 adult shad and 503 juveniles were analyzed. Adults did not appear to feed during their upstream migration, but juvenile shad fed extensively. Difference in diet were found among shad caught in different seasons, gear types, and salinity zones. Calanoid copepods were important throughout the year, while *Corophium salmonis* and *Neomysis mercedis* were important during fall, winter, and spring. Freshwater prey were consumed during summer and fall, the most important of which was *Daphnia spp*, chrionomidae larvae and pupae, and Trichoptera adults for shad feeding in shallow water near beaches.

Higley, D.L., S.L. Wilson, K.K. Jones; K.K.; R.L. Holton. 1983. Distribution and Community Structure of Benthic Infauna in Channel and Protected Flat Habitats of the Columbia River Estuary. Report to the U.S. Army Corps of Engineers. School of Oceanography, Oreg. State. Univ., Corvallis, OR. 97331: 81 pp.

River Mile: 0 to 46 Reach: 0 to 2
Study Emphases: Benthic community structure.
Biological:* Benthic
Chemical: Salinity zones
Physical: Sediment grain size.
Frequency: Single survey 16 sites: Sept 1981.
Comments: One time: comparative community structure data:

Summary

A single stratified random sample survey of the benthic infauna of the Columbia River estuary was conducted between 8-11 September 1981. The estuary was divided into 16 habitats according to salinity zone (Marine, Mixing, and Freshwater) and substrate. To describes the patterns of distribution and abundance of benthic infauna 102 grab samples were collected at eight channel and protected flat habitats between (CRM-0 and CRM-46).

The shallower stations (protected flat habitats) had the highest average animal densities, the highest (21,000 per m^2) occurred in Baker Bay. The lowest average density was 650 per m^2 in the center of the channel of the Marine Zone. Dominant taxa in the lower estuary were Rhynchocoela, Oligochaeta, *Macoma balthica*; in the upper estuary *Corophium salmonis*, Oligochaeta, Chironomidae, and *Corbicula manilensis*.

The authors emphasize that this single survey does not provide a definitive statement about habitats and infauna communities of the estuary. However, the strong relationship between infauna community structure and salinity-substrate properties found in this study emphasizes the potential for major shifts in community structure should major physical alterations occur.

Monaco, M.E, D.M. Nelson, R.L. Emmett, and S.A. Hinton. 1990.
Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries Volume I: Data Summaries. Strategic Assessment Branch, NOS/NOAA. Rockville, MD. 240 pp.

River Mile: Estuary Reach:
Study Emphases: Biological database.
Biological:* Spatial and temporal distributions, and abundance for 30 species of fish and invertebrates.
Chemical: Salinity zones.
Comments: Reliable, useful database.

Summary

This report is the first of two volumes that present information on the spatial and temporal distribution, relative abundance, and life history characteristics of 47 fish and invertebrate species in 32 estuaries along the contiguous West Coast of the U.S. Its purpose is to disseminate data developed in NOAA's "Estuarine Living Marine Resources (ELMR) project". The objective of ELMR is to develop a consistent data base on the distribution and abundance of selected fishes and invertebrates in the Nation's estuaries.

Salinity zones provide the spatial framework for organizing information on species distribution and abundance within each estuary. The primary data developed for each species for each salinity zone include spatial and temporal distributions and relative abundance by life history stage. A detailed estuarine life history profile for each species will be available in Volume II later in 1990.

The four criteria used for species selection were: 1) commercial value, 2) recreational value, 3) indicator species of environmental stress and 4) ecological value. Of the 47 species selected, by a peer review panel, at least one of the life history stage of 30 species utilize the Columbia River estuary. A deliberate effort was made to assess and present the overall reliability of the database so that the information can be used appropriately.

Simenstad, Charles A. 1983
The Ecology of Estuarine Channels of the Pacific Northwest Coast: A Community Profile. Rept. by Fisheries Research Institute, Univ. of Washington, Seattle, Wa. 98195; to USFWS, U.S. Dept. of Interior, Washington D.C. 20240. FWS/085-83/05; 181 p.

River Mile: Estuary
Study Emphases: Estuarine Community profile.
Comments: Useful habitat information base.

Author's Abstract

This report on the estuarine channel habitats of the Pacific Northwest is one of a series of community profiles that synthesize useful information about specific natural coastal habitats. This profile will assist environmental scientists and biologists and coastal planners and managers who are interested in the open-water channels of coastal estuaries from the Straits of Juan de Fuca in Washington, south to Cape Mendocino, California.

The profile describes the geomorphological, hydrological, chemical, and biological components and natural processes of the channels, their energy interchange, and interactions among adjacent habitats. In combination these habitat components and their interactions dictate the ecological structures and functions of the channels, The subject materials of the various chapters are integrated and summarized in the last chapter, and considerations for habitat management are identified.

Wilson Stephanie L., D.L. Higley and R.L. Holton. 1983.
Seasonal Changes in Community Structure of Benthic Infauna at Six Stations in the Columbia River Estuary. Report to the U.S. Army Corps of Engineers, Portland District. by School of Oceanography, OSU, Corvallis, Oregon. 9.331: 95 pp.

River Mile: 3, 5, 10, 15, 23, 30 Reach:0 to 2.1
Study Emphases: Benthic community structure.
Biological:* Benthos.
Frequency: monthly/quarterly Duration: 1 year; 1980-81.
Comments: Community structure over time.

Modified Author's Abstract

Field studies were conducted, from August 1980 through September 1981, to characterize seasonal changes in benthic communities at six locations in the Columbia River estuary. Intertidal stations sampled were in Baker Bay (Rm-5), Desdemona Sands (Rm-10), Grays Bay (Rm-23) and Quinns Island (Rm-30); subtidal stations were in the North Channel (near Sand Island) (Rm-3) and the navigation channel (near Astoria) (Rm-15). River miles are approximate.
All stations were dominated numerically by one or two taxa which dictated the patterns of total seasonal density at the stations. *Corophium salmonis* was dominant at Grays Bay, Desdemona Sands and at Quinns Island. While Baker Bay and the North Channel station were characterized by communities composed of polychaetes and bivalves.

Study demonstrates that seasonal changes in density can be important in communities and influence sampling frequency and the impact of events (dredging for example) at a site. It also demonstrates that colonization by adults of some taxa is possible and is observed in *Corophium salmonis*.

SITE SPECIFIC STUDIES

CRM 53.5

Lee, Patrick. 1974.
Water Quality Report-The Columbia River below Longview, Washington, Dec. 1971-Nov. 1972. Technical Rept. No. 74-7, Feb. 1974, State of Washington Dept. of Ecology, Olympia, Wa.

River Mile: 53.5, 72 Reach: 3.2, 4.5.
Study Emphases: Comparative water quality above and below industrial area.
Frequency: Continuous. Duration: 12 months; 1971-1972.
Comments: Good comparative water quality information. Should be updated with similar data.

Summary

Water quality data was collected, at Port Westward (CRM 53.5), by a continuously operating automatic water quality data acquisition system. Backup data was obtained from routine monitoring. Maximum allowable coliform standards were exceeded during most of the year. Sporadically, during late summer and early fall, the river did not meet water quality standards for temperature and dissolved oxygen.

Data from Port Westward (Rm-53.5) was compared to water quality data collected by the National Marine Fisheries near Prescott, Or. (Rm-72). No apparent water quality violations were observed at Prescott, which is located approximately six miles upstream from the industrial complex at Longview, WA.

It was concluded that the industrial and municipal discharges from the Longview-Kelso area significantly contribute to the water quality violations at Port Westward. This conclusion supports EPA findings on water quality conditions in the Lower Columbia River 1970-1971.

CRM 68

McCabe, George T. Jr., S.A. Hinton, and R.J. McConnell. 1990
Benthic Invertebrates, Sediment Characteristics, and Demersal Fishes off Cottonwood Island, Columbia River, Before and After Rock-Groin Construction, 1987-1988. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Report to the U.S. Army Corps of Engineers. (Contract NO. DACW57-87-F-0641). 16 pp.

River Mile: 68, Reach: 4.4-4.5
Study Emphases: Impact of structure modification, installation.
Biological:* Demersal fish, Benthic
Chemical: Sediment volatile solids.
Physical: Sediment grain size
Frequency: 2 surveys before, 2 after. Duration: 12 months; 1987-88.
Comments: Site specific, short term.

Authors Summary

In 1988 seven submerged rock groins were constructed by placing rock around existing pile dikes on Cottonwood Island at Columbia River Mile (68.4-70.6). The National Marine Fisheries Service conducted four surveys, two prior to construction and two after, to assess changes in benthos and demersal fish communities. Five benthic invertebrate samples and one sediment sample were collected at six sites during each survey. Three trawl tows, of 5 minute duration, were made during each survey to obtain information on demersal fishes. Benthic invertebrate densities were higher post-construction. The amphipod *Corophium salmonis* was the dominant benthic invertebrate at Cottonwood Is., mean densities ranged from 27 to 3,912/m^2. Few demersal fish were captured at Cottonwood Island (6.9 fish/effort). It appears that the installation of rock groins did not adversely affect the benthic and demersal fish communities during this short-term study.

CRM 70 to 77

McConnell, R.J. And G.R. Snyder 1970.
Occurrence of Fish in the Vicinity of Proposed sites of two Nuclear Electric Plants on the Lower Columbia River. U.S. Nat. Mar. Fish. Serv. NOOA 2725 Montlake Blvd.E., Seattle, WA 98112. Vol. 1, Columbia River Thermal Effects Study.

River Mile: 70, 77 Reach: 4.5, 5.2
Study Emphases: Fish occurrence.
Biological:* Fish; (beach & purse seine)
Frequency: Weekly Duration: 25 months. 1968-1970.
Comments: Very basic fish occurrence data; combined with the following report it provides a fair data base.

Author's Summary

Before a resource can be protected biologists must know what species are present in the area under consideration. The occurrence of fish, in the area of two proposed thermal (nuclear) electric plants, was studied from January 1968 through February 1970. The area of study was the section of the Columbia River between river miles (Rm) 70 and 78. The two proposed plants were Portland General Electric's "Trojan" plant at Rm-73 and Clark and Cowlitz County Public Utility District's "Kalama" plant at Rm-78. Four beach seine sampling sites were established at sloping sandy beaches on both sides of the Columbia River; two at Rm-70, downstrean from the proposed Trojan plant, and two at Rm-77 downstream of the proposed Kalama site. In addition a three station cross-section of the river, at the Trojan sit (Rm73), was sampled with a purse seine.

A total of 55,509 fish representing 27 species were captured during the two year study. Four species accounted for 91% of the total catch; juvenile chinook salmon 48%, threespine stickleback 29%, juvenile coho salmon 8%, and American shad 6%. Juvenile chinook salmon were present in the study area during all months, with peak catch occurring in May 1968 and June 1969. Study emphases was on juvenile salmonids.

CRM 77 & 79)

McConnell, R.J., And T.H. Blahm 1974.
Occurrence of Fish Near the Kalama Nuclear Power Plant Site Columbia River. October 1970-October 1973 U.S. Nat. Mar. Fish. Serv. NOAA 2725 Montlake Blvd.E., Seattle, WA 98112. Rept. to Clark and Cowlitz Counties Public Utilities Districts. 27 p.

River Mile: 77, 79 Reach: 5.2
Study Emphases: Fish occurrence.
Biological:* Fish (beach seine)
Chemical: Water quality, temp., dissolved O_2 & N_2.
Physical: Depth visibility (Secchi Disk)
Frequency: Semiweekly Duration: 36 months. 1970-1973.
Comments: Fair data base on occurrence of fish (Rm 71-79).

Author's Summary

This study was in accordance with Washington State's requirements for power plant siting i.e. "to provide acceptable research or study plans for determining the abundance of, distribution of, and project effects on wildlife, fish, and other aquatic life, in the proposed project influence area."

Four beach seine sampling sites were established at sloping sandy beaches on both sides of the Columbia River--two upstream and two downstrean from the proposed plant. Sampling sites 1 and 2 (Rm-77) were established, during 1968 and 1969, coincidental to a fish occurrence study relating to the Trojan Plant. Site 3 and 4 (Rm-79) were added in 1970 to bracket the proposed Kalama

Plant site (Rm-77). Seining was scheduled twice weekly through out the year; all beaches to be fished on the same day. However, due to adverse weather conditions, and river flows the schedule was altered on several occasions. Fishing frequency was increased during periods when concentrations of hatchery released juvenile salmonids were moving through the lower Columbia River.

During the thirty-six month study 522 net sets were made on each side of the river. Twenty six species (115,074 individual fish) were captured during this time frame. Juvenile chinook, threespine stickleback, and American shad made up 85% of the total catch. Juvenile chinook were captured during each month of the study. Sixth-three percent of the combined total catch occurred on the Oregon side of the river.

Presented in tabular form is the low, high, and average monthly temperature and depth visibility for each site. From March 1971 through July 26, 1973 the percent oxygen, and nitrogen gas saturations plus related water temperatures are also included for both the Washington and Oregon side of the river at (Rm-72).

CRM 71

Blahm, Theodore H., and Robert J. McConnell. 1979.
Impact of Flow-lane Disposal at Dobelbower Bar. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Rept. to U.S. Army Corps of Engineers. Contract NO. DACW57-76-F-0918), May 1979, 25 pp

River Mile: 71, Reach: 4.5 .
Study Emphases: Flow-lane disposal
Biological:* Zooplankton, Benthos
Chemical: Basic water quality, temp., O_2, conductivity, pH.
Physical: Turbidity
Frequency: Monthly-Zoo, weekly-WQ: Duration: 15 months. 1976-1977.
Comments: Monitoring continued [unpublished] through Aug. 1982.

Authors summary:

Before, during, and after pilot study of flow lane disposal. A Pipe-line Dredge deposited material at depths > 20 feet. Monitored: extent and concentration of turbidity, water quality, retention time of material, zooplankton, and benthos. Increased turbidity near the discharge pipe were recorded; turbidity levels did not exceed 30 JTU's; (natural occurring turbidities exceeding 70 JTUs were recorded in the Columbia River in 1976). Ther were no long-term effects on water quality parameters measured, also no noticeable impact on zooplankton was observed, seasonal variations, on benthic numbers, was greater than test variation before, during and after disposal. Material dispersed within the year. Study led to acceptance of flow lane disposal, at depths > 20 feet, as an alternative method for disposal of clean dredged material.

CRM 72

Snyder, G.R. and R.J. McConnell. 1970.
Subsurface Water Temperatures of the Columbia River at Prescott, Oregon (River Mile 72), 1968-1969 U.S. Nat. Mar. Fish. Serv. NOOA 2725 Montlake Blvd.E., Seattle, WA 98112. Report to the Columbia River Thermal Effects Study. 8 p.

River Mile: 72 Reach: 4.5.
Study Emphases: Monitoring water temperature
Physical:* Water temperature
Frequency: Continuous Duration: 2 years; 1968-69.
Comments: Historical background, outdated.

Summary

Two thermal nuclear electric plants (Trojan & Kalama) were proposed for installation on the lower Columbia River during the 1970. Preplant water temperatures were needed to establish and predict any changes in water temperatures as a result of plant operation and what effect temperatures could have on the aquatic ecology of the river.

Water temperatures were continuously recorded at the NMFS Prescott Environmental Field Facility at Prescott, Or. Daily maximum, mean, and minimum water temperatures are presented in tabular form for 1968-1969. Periodic temperature-depth profiles indicated little variation (<0.2° C.) in water temperatures from surface to bottom (20 feet).

CRM 72

Snyder, G.R., and R.J. McConnell. 1973.
Frequency and Duration of Flow Reversal in the Lower Columbia River, April 1968-March 1970. Fishery Bulletin: Vol. 71-1, 1973. 312-315 pp.

River Mile: 72 Reach: 4.5.
Study Emphases: Flow reversal
Physical:* Tide height, flow volume and velocity.
Frequency: Continuous Duration: 2 years; 1968-70.
Comments: Usefull data base.

Author,s Summary

It has been determined that flow reversals can increase the accumulation of discharge effluents per given volume of river water by as much as 3.5 times over the accumulation at mean flow rates. To help understand the importance of flow reversal; water velocity and current direction were recorded for a 2-year period at Prescott, Or., river mile 72. Duration of flow reversal was defined as the the time interval between positive downstream flows wherein flow stops, moves upstream, stops, and then moves downstream again. Only those flow reversals of 60-min duration or longer were considered to constitute true reversals.

During the two year study 646 flow reversals ≥ 60-minutes duration were observed. Columbia River flows averaged 239,000 cubic feet per second (cfs.) and ranged from 78,000 to 510,000 cfs. over the study period. High tides at Astoria ranged from 4.9 to 10.1 feet. The lowest high tide at which a reversal was recorded (90 Min) was 4.9 ft. at 139,000 cfs. The longest period of reversal was 5 hrs. and 45 min. at a tide height of 8.9 ft. and 196,000 cfs. Flow reversal was not significant at Rm 72, at flows greater than 300,000 cfs.

CRM 72

Craddock, D.R., T.H. Blahm and W.D. Parente. 1976.
Occurrence and utilization of zooplankton by juvenile Chinook salmon in the lower Columbia River. Transaction of Amer. Fish. Soc. Vol. 105, No 1, January 1976. 72-76 pp.

River Mile: 72-80 Reach: 4.5-5.2
Study Emphases: Utilization of Zooplankton by Juv. Chinook.
Biological:* Zooplankton, Fish.
Physical: Temperature
Frequency: Weekly Duration: 1 year; 1968-69.
Comments: Good zooplankton data for this reach.

Author's Abstract

The stomachs of juvenile chinook salmon *Oncorhynchus tshawytscha*, taken in the Prescott-Kalama area of the Columbia River during July-November 1968 and March-December 1969 were examined to obtain information on their contents.

Zooplankton, especially *Daphnia*, were the major item in the diet of the young salmon from July through October, whereas insects were the most important constituents of the diet during spring and fall.

The zooplankton in the area was sampled from January 1968 to November 1969 and examined in relation to the relative abundance of juvenile chinook salmon and their stomach contents. *Daphnia*, *Bosmina*, and cyclopoid copepods were major zooplankters in the area, and their periods of highest abundance were associated with high water temperatures of summer. Samples taken during daylight hours indicated *Bosmina*, were most numerous at the surface, *Daphnia* were most numerous below 5 m, and cyclopoid copepods were relatively uniform in their vertical distribution. The zooplankton populations were generally increasing during the season of juvenile chinook abundance (April-July). Juvenile chinook were selective in their feeding habits and consistently consumed *Daphnia* in a much higher percentage than it was found in the zooplankton samples.

CRM 72

National Marine Fisheries Service unpublished

Water Quality and zooplankton data collected from the Columbia River at Prescott OR. (CRM 72) 1975-1982. U.S. Nat. Mar. Fish. Serv. NOAA, Coastal Zone and Estuarine Studies Div., 2725 Montlake Blvd.E., Seattle, WA 98112.

Explanation

In conjunction with other ongoing studies (dissolved gas monitoring, bioassay tests, and the Dobelbower Bar evaluation) water quality data were routinely collected at the Prescott Environmental Facility. Weekly Columbia River water quality data was collected at three cross-sectional stations (Oregon side, mid-channel, and Washington side); more frequently on the Oregon side at the Prescott facility. Water quality data collected between 1975-1982 includes; temperature, conductivity, pH, CO_2, total alkalinity, turbidity, settleable matter, Non-Filterable residue, dissolved oxygen and % saturation, dissolved nitrogen and % saturation. This data is computerized but has not been verified as to entry errors. Zooplankton populations were monitored during the 1975-77 Dobelbower Bar inwater disposal site evaluation. Because of the weekly cross section water quality surveys, tows for zooplankton at the mid channel station also became part of the routine collection procedure. The zooplankton data (1975-1982) are still on rough field data sheets.

CRM 72 to 73.7

Portland General Electric Company. 1978

Operational Ecological Monitoring Program for the Trojan Nuclear Plant. Annual Report (PGE-1009-77). Prepared by Beak Consultants Inc. for Portland General Electric Company, 121 S.W. Salmon St. Portland, Or. 97204

River Mile: 72, 72.4, 73.7 Reach: 4.5, 5.1
Study Emphases: Ecological Monitoring
Biological: Fish, Ichthyoplankton, Zooplankton, Phytoplankton.
Chemical: Water quality parameters, and selected metals.
Physical: Depth visibility (Secchi Disk)
Frequency: Monthly Duration: 12 months. 1977
Comments: Good data base; ecological monitoring was conducted 1974-1977; Reports & data available from PGE.

Summary

The Environmental Technical Specification for the Trojan Nuclear Plant contains monitoring requirements necessary for plant operation. This Environmental Surveillance Program was divided into the areas of ecological and

radiological surveillance. The ecological surveillance phase contains monitoring for the Columbia River Aquatic Program. This annual report summarizes aquatic data collected during the fourth year of the study (January through December 1977).

Relative fish abundance, in the area of the diffuser, was monitored using an echo sounding technique with concurrent gill net sets for species determination. Day and night transects above, near, and below the diffuser were made bi-monthly. Only nine species were collected with peamouth and steelhead making up 75.0% and 8.4% of the total gillnet catch. A box-trap in front of the plants water intake sampled fish continuously throughout the year. Fifteen species plus crayfish were collected in the intake box-trap, Prickly sculpin, Black crappie, and Yellow perch accounted for 77.0% of the catch. Juvenile salmonids made up an additional 8.5% of the 528 fish captured.

Ichthyoplankton, collected from the river and in Trojan make up water, were identified and enumerated to describe differences in density between water pumped into the plant and river water. Six species of larvae or eggs were collected with peak catches occurring in April and May with no substantial concentration of eggs or larvae after August. The eulachon *Thaleichthys pacificus* was the most abundant species captured. They occurred in significant numbers from March 17 through July 12. *Cottus sp.* were the second most abundant larval species collected.

Monthly zooplankton surveys were conducted at four sampling stations along each of three transects at river miles (Rm) 72.0, 72.4, and 73.7 from January through December 1977. Seasonal patterns of total zooplankton densities among stations and transects were very similar. Densities were low in January and February, increased to a peak in May (82,875-125,817/m^3), then generally declined through December. The zooplankton community consisted of three taxonomic groups (Rotifera, Copepoda, and Cladocera) in 1977 as in previous years.

Phytoplankton samples for algal and chlorophyll a, b, and c analyses were also collected monthly at the same sampling stations. Total unit densities during 1977 showed a sharp increase from February through May with a subsequent continous decline through December. The increases in phytoplankton and chlorophyll a in April and May were associated with increaseing solar radiation and water temperature.

The 1977 physical-chemical monitoring program was a continuation of the program initiated in 1974. The objective was to document the physical and chemical character of the Columbia River near Prescott, Oregon, during preoperational and operational periods of the Trojan plant. In addition to the above mentioned sampling locations samples were also collected in the Kalama River and at (Rm-72.7). Columbia River water was sampled monthly and analyzed for dissolved oxygen and nitrogen, residual chlorine, total sulfates and phosphates, conductivity, turbidity, and temperature. In addition, pH, total alkalinity, and Secchi disc transparency were measured. Concentrations of magnesium, zinc, hexavalent chromium, boron, sodium, and calcium were monitored quarterly. Comparison of 1977 data with that for 1974, 1975, and 1976 indicates although all four years were generally similar, differences in seasonal trends as well as among stations did exist. It appears the chemistry of the Columbia River at Trojan in 1977 was significantely affected by the drought.

CRM 98 to 102

U.S. Army Corps of Engineers. 1979
Portland Harbor Dredging and Columbia River In-Water Disposal Water Quality Investigations. Navigation Division Research & Evaluation Report # 1-79, Portland District, Portland, OR: October 1979, 61 p.

River Mile: 99.0-102.0 Reach: 6.4, 7.1
Study Emphases: Water quality investigations
Biological: Fish, benthic.
Chemical: River waters for elutriation tests, sediments.
Physical: Temperature, turbidity, sediment grain size.
Frequency: Series of various surveys Duration: 1977, 1978.
Comments: Short term, area specific, reliable data.

Summary

Based upon suspended sediment concentrations, it is estimated that five million cubic yards of Willamette River material moves into the Columbia River during a normal flow year.

In 1977 representatives of the Corps of Engineers (CofE), National Marine Fisheries Service (NMFS) and the U.S. Geological Survey (USGS) met to discuss a monitoring program which would provide needed information as to the feasibility of depositing dredge material from the Willamette River's Portland Harbor directly into the Columbia River. Because this is one of the most extensive series of dredging studies ever accomplished in a freshwater environment, the findings were summarized in the above report. The following reports, covering various phases of the study, can be obtained from the respective agencies or from the Portland District, U.S. Army Corps of Engineers.

McKenzie, S.W., 1977, Analysis of Bottom Material from the Willamette River, Portland Harbor, Oregon, U.S. Geol. Survey Open-File Rept 77-740 8 p.
In February 1977, the USGS collected Portland Harbor bottom samples from the navigation channel at Willamette River mile (WRM) 9.2. Samples were analyzed for oxygen demand; particle size; percent moisture and residue, loss on ignition; and other chemical constituents that could adversely affect Columbia River aquatic life. Samples were also sent to the NMFS Northwest Fisheries Center Laboratory in Seattle for hydrocarbon analysis.

Rinella, J.F., and S.W. McKenzie, 1977, Elutriation study of Willamette River bottom material and Willamette-Columbia River water: U.S. Geol. Survey Open-File Rept 78-28, 8 p.
After reviewing results of the analysis, the Environmental Protection Agency (EPA) suggested that an elutriate study be made. Bottom material from the Willamette River was collected on May 17, 1977 and mixed with Willamette and Columbia River waters. Bottom samples as well as the elutriate (mixing water), were analyzed for selected nutrients, metals, and pesticides. Results show that the average dissolved ammonia, manganese, and zinc concentrations would require dilution by receiving water to achieve aquatic-life criteria levels.

McConnell, R.J., T. H. Blahm, and M.C. Laird, 1979, Portland Harbor Pilot Dredging Study and Sediment Bioassay Tests. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Rept. to Portland Dist., U.S. Army Corp of Engineers.,. (Contract NO. DACW57-77-F-0686).
Preliminary USGS elutriation data was reviewed at a June 1977 meeting of management agencies. After this preliminary review it was decided that bioassay tests be conducted. In September 1977, the NMFS Prescott Field Facility commenced static and flow-through bioassay tests. Juvenile chinook salmon and adult threespine stickleback were tested at various concentrations of Portland Harbor bottom sediments from WRM-9.2 and Columbia River Water from CRM-72. A series of static tests established that a 1:32 sediment to water concentration was 100% lethal to juvenile chinook salmon in 403 minutes (oxygen limiting). Replicate 96-hour flow-through bioassay tests using 100, 75, 50, 25, and 0 percent concentrations of the 1:32 base mixture were conducted at 10, 15 and 20°C. There were no mortalities at 10 or 15°C. however, 70% and 100% mortality did occur at the 100% (1:32) base concentration in both 20°C. test series of juvenile fall chinook, mortality did not occur at the lower

concentrations. It was concluded the cause of the mortality was the result of stress brought on by the synergistic effects of temperature (20°C), low oxygen (3.5 mg/l), high turbidity (1013 NTU), and exposure to various toxicity levels of dissolved constituents.

Rinella, J.F., and S.W. McKenzie, 1978, Monitoring Water Quality During Pilot Dredging in the Willamette and Columbia Rivers, Oregon. U.S. Geol. Survey Open-File Rept 78-554, 16 p.

Static bioassay tests showed that a 1:32 sediment to water mixture would expose juvenile fall chinook salmon to lethal conditions. It was therefore necessary to verify that the 1:32 concentration exceeded those found during actual dredging operations. Approvals were granted to perform a closely monitored dredging and disposal hopper dredge pilot study. On December 16, 1977 the USGS, NMFS, and CofE monitored the Hopper Dredge Biddle as it dredged three loads of Portland Harbor bottom material from WRM-9.2 and deposited the material at CRM-100.5. These tests proved conclusively that the 1:32 bioassay mixture exceeded the concentrations of actual hopper dredgeing and disposal. With high river flows and low temperatures, dissolved oxygen conditions were not significantly altered, and other water quality parameters generally remained within the prescribed standards.

Blahm, T.H., J.T. Durkin, R.J. McConnell, L.G. Davis, and T.C. Coley 1979 Portland Harbor predredge and disposal study, U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Rept. to Portland Dist., U.S. Army Corp of Engineers.,. (Contract NO. DACW57-78-F-0575).

In the spring of 1978, it was determined that about 40,000 cubic yards of material had to be dredged from the Willamette River at WRM-11.5. In March 1978, at the CofE's annual resource agency meeting it was proposed that the 40,000 cubic yards of material from WRM-11.5 be dredged with a clamshell and the material be deposited at the Columbia River test site (CRM 100.5). No opposition was indicated providing the test was closely monitored and halted if water quality conditions deteriorated beyond prescribed limits.

During May and June 1978, NMFS conducted a predredge biological assessment of the Columbia River between CRM 98 and 102. On May 16 & 17th. 24 bottom trawl tows were made to determine demersal finfish abundance in the area of the proposed disposal site. Only 43 fish representing 10 species were captured during the two day trawling effort; pacific lamprey and white sturgeon were the two most abundant species. On June 5, six purse seine sets were made to determine pelagic fish abundance in the area. Juvenile fall chinook and coho salmon accounted for 65% of the 457 pelagic finfish captured in the June purse seine effort. A subsample of fish stomachs were taken to provide background diet information. White sturgeon were found to be feeding on the amphipods: Corophium spinicorne and Anisogammarus ssp., chironomid (diptera) larvae. Juvenile fall chinook salmon were consuming primarily insects and amphipods, along with some cladoceran and copepods.

Twenty benthic invertebrate samples were collected between CRM 99 and 102 in May 1978. A total of 10 groups of organisms were found with a total density of 329.7 per m^2, numerically important groups were bivalves, diptera, amphipods, copepodes, and oligochaetes.

Due to agency objections the Columbia River dredge disposal tests were never undertaken. The May and June 1978 Columbia River biological data base proved to be extremely valuable baseline information for evaluating the June 27, 1978 Toyota Maru oil spill at CRM 102.5.

SYSTEM WIDE STUDIES

Blahm, T.H., J.T. Durkin, G.R. Snyder, T.C. Coley, and R.L. Emmett. 1980. Columbia River Oil Spill Study June-July 1978. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Contract report to the Environmental Protection Agency (EPA-78-D-X-0390), December 1980. 41 p.

River Mile: 4.5 to 105 Reach: 1.1-1.5, 1.7, 2.1, 2.5, 5.2, 6.4-7.2.
Study Emphases: Biological Impact of oil spill.
Biological: Fish, benthic, stomach content.
Chemical: Petroleum hydrocarbon analysis, volatile solids.
Physical: Sediment particle size analysis.
Frequency: 2 surveys, 28 sites. Duration: June-July 1978.
Comments: Short term, provides data before and after oil spill

Summary

On 27, June 1978, the Toyota Maru #10 ruptured a fuel tank and released between 30 and 58 thousand gallons of Bunker C (#6) fuel oil into the Columbia River at river mile (Rm-102.5). A major concern was the potential impact of the oil on approximately 80 million juvenile chinook salmon that were at the peak of their downstream migration. The National Marine Fisheries Service (NMFS) in cooperation with the Environmental Protection Agency undertook an evaluation of the downstream extent of the oil spill. In May 1978, the NMFS had completed a dredge related biological survey between Rm 98-102, in addition there was an ongoing site evaluation study at Pillar Rock Rm-28. These studies provided a background data base of species composition and abundance prior to the oil spill.

Assessment of the biological effect of the oil spill was based on the results of petroleum hydrocarbon incidence in finfish, sediment, and benthos taken at 28 sites in the Columbia River between Rm-105 and Rm-4. Summary observations: 1) Bunker C oil components were identified at Tongue Point, 2) Bunker C oil fractions were identified in 26 of 28 sediment samples taken between Rm 4.5 & 105, 3) Three of 18 fish flesh samples contained significant Bunker C oil components, 4) Finfish (demersal and pelagic) captured showed a decrease in diversity and abundance. Dead fish were not found. Indications from the data collected, and from observations, in relation to finfish, benthic invertebrates, and sediments are that changes occurred which demonstrates an impact on the biota of the Columbia River and its estuary. However, even with extensive riverine fishery baseline data in the area of an oilspill it is unlikely, using the present assessment approach, that conclusions could be made regarding the extent of damage to finfish resources from a Bunker C spill of the magnitude of Toyota Maru #10.

Clark, Shirley M., and George R. Snyder. 1970. Limnological Study of the Lower Columbia River, 1967-68. U.S. Fish Wildl. Serv., BCF., Spec. Sci. Rep. Fish. 610. 14 p.

River Mile: 34 to 104, Reach: 2.2, 2.5, 4.3, 5.1, 5.4, 7.1 .
Study Emphases: Limnological data
Biological: chlorophyll a, zooplankton
Chemical: pH, DO_2, phosphate, silicate, calcium, magnesium, sodium
Physical: temperature, turbidity, conductivity, salinity
Frequency: monthly. Duration: 18 months; 1967-1968.
Comments: Well done.

Modified Author's Abstract.

Limnological data were collected, July 1967 through December 1968, at seven sampling stations from above the mouth of the Willamette River to below Puget Island. Items studied were: physical (water temperature, turbidity,

conductivity, and salinity), chemical (pH, dissolved oxygen, phosphate, silicate, calcium, magnesium, and sodium], biological (chlorophyll a and zooplankton).

Greatest difference between adjoining stations were between stations 1 and 2 (Rm-104 & 87); respectively located above and below the confluence of the Willamette River. Water temperatures ranged from 23.2 to 4.8°C., turbidity 1.1 to 30+ JTUs, dissolved oxygen ranged from 12.6 to 6.5 mg/l., while pH ranged from a high of 8.7 to a low of 7.0. The numbers of zooplankton tended to increase progressively downriver from Rm 104 to Rm 34. The largest numbers of zooplankton organisms collected was in September. Cyclopoids and Bosmina were the two most abundant zooplankters. Limnological data are compared with data from Sylvester (1958). Dissolved oxygen was lower in 1967-68 and was not a factor of temperature. There was not a significant difference in pH, turbidity, or calcium and sodium concentrations.

Fies, Ted T. 1971

Surveys of Some Sloughs of the Lower Columbia River. Oregon State Game Commission, Fisheries Div. January 1971. 58 p.

River Mile: 18 to 140
Study Emphases: Biological survey of slough areas.
Biological:* Fish.
Chemical: Temperature, Dissolved Oxygen, pH, & Turbidity.
Physical: Depth, area discription.
Frequency: one or two surveys Duration: May through September 1970.
Comments: Short term, data is old; however, the only known biological survey of these important slough areas.

Summary

The lower Columbia River from Tongue Point to Bonneville Dam has within its drainage many sloughs which have been generally neglected by both anglers and fisheries scientists. In the spring of 1970 the Oregon State Game Commission initiated a survey program to gather basic, physical, biological, and chemical, data from 22 of these major slough areas.

The primary purpose of the survey was to determine the angling potential. Determination of angling potential was accomplished by analysis of biological, chemical and physical data from each slough sampled. Gill nets were used to sample fish populations in the spring of 1970, several selected sloughs were sampled again in September. Biological data includes; species, number taken, length, percent of total catch, and minimum acceptable size. Chemical data includes; water temperature, dissolved oxygen, pH, and turbidity. Physical data includes; depth, an area description, accessibility, and maps.

The study was dived into three areas: area 1, Blind (Rm-26) to Mayger slough (Rm-57.5), contains the largest amount of slough area on the lower Columbia. Surveys in this area revealed an abundance of angling potential, with Westport, Blind and Beaver sloughs as prime areas for warm-water game fish production. Shallow water and an abundance of rough fish species limit productivity in Area 2, Lower Lord Island slough (Rm-62) to Willow Bar slough (Rm-96). Area 3 from Government Island slough (Rm-112) to Rooster Rock slough (Rm-140) is characterized by having a small amount of slough areas. Only two sloughs were surveyed and both contained fishable populations of game fish.

Fuhrer, G.F., and F.A., Rinella, 1983

Analyses of elutriates, native water, and bottom material in selected rivers and estuaries in Western Oregon and Washington. U.S. Geological Survey Open-file Report 82-922, 147 p.

River Mile: 1 to 87 · Reach: (1.1-1.3),1.5,2.2,(4.2-4.6),6.1.
Study Emphases: Determine water quality conditions
Chemical: Selected metals, insecticides, organic compounds.
Physical: Salinity, and sediment particle-size distribution.
Frequency: Reconnaissance Duration: May through Dec. 1980.
Comments: Ongoing chemical data base. Emphasis on dredge sites
Retrieval of data can be made from either USGS's
WATSORE or EPA's STORET systems.

Author's Abstract

The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, collected native water and bottom-material samples and processed elutriate samples between May and December 1980. The Primary purpose of the study was to provide reconnaissance data to determine short-term water-quality conditions associated with dredging operations in rivers and estuaries. The data were collected from selected rivers and estuaries as far south as the Coos River in western Oregon, as far north as Baker Bay in southwest Washington, and as far inland as Bonneville Dam on the Columbia River.

In an elutriation test, bottom material from a dredging site is mixed with native water and the filtrate is analyzed. Results of chemical analyses of elutriates, native water, and bottom material for selected metals, nutrients, and organic compounds are presented. Elutriate-test results showed variability in concentrations of dissolved chemicals as follows: in micrograms per liter (µg/L), manganese ranged from 0 to 10,000, iron from 10 to 4,300, zinc from 1 to 90, and phenols from 0 to 420; in milligrams per liter (mg/L), ammonia as nitrogen ranged from 0.03 to 46 and organic carbon from 0.5 to 46.

Inclusion: Sampling sites in the Columbia River estuary were located in Baker Bay, Area D, Hammond to Tansy Point, the Skipanon, Youngs Bay, Port of Astoria Piers, and Astoria water front to Tongue Point. Columbia River stations were located at Skamokawa (Rm 33-34), and in the Longview area (Rm 59.4-72). Also included are elutriation data for the Columbia and Cowlitz Rivers prior to and after the May 18, 1980, eruption of Mount St. Helens.

Johnson Art, and Dale Norton 1988
Screening Survey Chemical Contaminants and Toxicity in Sediments at Five Lower Columbia River Ports September 22-24 1987. Wash., State Dept., of Ecology, Olympia, Wa. 98504. 20 pp.

River Mile: 3, 56-67, 102-105, 118, 124. Reach: CRM, (4.1-4.3), 7.1.
Study Emphases: Sediment Contaminants.
Biological: Bioassay
Chemical:* Metals, Polyaromatic hydrocarbons, volatiles.
Physical: Sediment particle-size distribution.
Frequency: One survey, Duration: Sept. 22-24, 1987
Comments: short term; pooled, homogenized samples.

Author's 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 bioasssay with two crustacean species *Hyalella azteca* (amphipod) and *Daphina pulex* (cladoceran). Ports included in the survey were Camas, Vancouver, Kalma, 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.
Author's conclusions: Results of this 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.

Krahm, M.M., L.J. Kittle Jr., W.D. MacLeod Jr. 1986.
Evidence for exposure of Fish to Oil Spilled into the Columbia River
Marine Environmeental Research 20(1986) 291-298 pp.

River Mile: 30, 87, 100, 125 Reach: 2.1, 6.1, 6.4, 8
Study Emphases: Detection of spilled oil in fish.
Biological: White sturgeon
Chemical:* Oil (aromatic compounds).
Frequency: March 19, 1984 Mobiloil oil spill.
Comments: Rapid and relatively inexpensive way of evaluating impact of spilled oil on fish. May be applied to other point source discharges

Author's Abstract:

On March 19, 1984, more than 170,000 gallons of oil were spilled into the Columbia River. We had recently developed analytical methods for estimating the exposure of fish to aromatic compounds by measuring the concentrations of metabolites of these contaminants in fish bile. The oil spill provided an opportunity to field test our methods in assessing the exposure of fish to petroleum aromatic compounds from the spilled oil. Our findings indicated that, within 5 days after the spill, mean concentration of metabolites of aromatic compounds in the bile of white sturgeon (*Acipenser transmontanus*) captured 57 miles downstream from the spill were significantly higher than those of sturgeon caught upriver.

McCabe, G.T.,Jr., S.A. Hinton, and R.J. McConnell. 1989.
Report D. Pages 167-207 in A.A. Nigro, (editor). Status and Habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Annual Progress Report to Bonneville Power Administration (Project 86-50). Portland, OR.

River Mile: 28-145, Reach: 1.7, 5.1, 5.2, 6.1, 6.3
Study Emphases: Juvenile white sturgeon; habitat.
Biological:* Sturgeon, demersal fish, benthos.
Chemical: Basic water quality, volatile solids.
Physical: Sediment grain size, flow velocity
Frequency: Semimonthly. Duration: 8 months annually, 5 yr study.
Comments: Ongoing long term study. Should provide good data base.

Summary

This report covers the third year of an ongoing five year, multi agency, cooperative study of white sturgeon in the Columbia River between the estuary and McNary Dam. Two agencies, Washington Department of Fisheries (WDF), and the National Marine Fisheries Service (NMFS) are responsible for the study area downstream of Bonneville Dam. Agency objectives are:

WDF:

(Report B) Describe life history and population dynamics of subadults and adults; describe reproductive and early life history characteristics. WDF has been involved in state funded mark and release study in the lower Columbia River since 1983. From mark-recapture ratios, abundance of 3-6 foot white

sturgeon (1986-88) was estimated to range from 121,000 to 216,000. Estimated harvest, for the same period, ranged from 50,000 to 72,000 white sturgeon.

NMFS:

(Report D) Describe reproduction and early life history characteristics, define habitat requirements for spawning and rearing: quantify extent of available habitat downstream from Bonneville Dam. White sturgeon egg and larval sampling took place at various sites from CRM 107-145 (Bonneville Dam). It was estimated that in 1988 white sturgeon spawned immediately downstream of Bonneville Dam from April 19 to June 20. In 1987 five index sites were selected to establish habitat preferences or requirements of white sturgeon juveniles. These sites are located at CRM's 28, 75-79, 88-95, 114, and 127-131. Parallel transacts using an 8 meter semiballon shrimp trawl were made at each index site semimonthly from March through October. Ninty one percent of tagged fish were recovered where released, indicating that juvenile sturgeon did not move over time. Juvenile sturgeon densities were highest at sites with maximum depths greater than 60 feet. Two surveys of benthic invertebrates and sediment substrate were made at each index site in 1988. A poor relationship between juvenile sturgeon densities and benthic invertebrate densities or substrate sediment structure was indicated. Stomach content analyses showed *Corophium salmonis*, had the highest index of relative importance of all juvenile sturgeon food items.

Muir, W.D., R.L. Emmett, and R.J. McConnell 1988
Diet of Juvenile and Subadult White Sturgeon in the Lower Columbia River and its Estuary. Calif. Fish and Game 74(1): 49-54 1988.

River Mile: 2 to 100 Reach: 1 to 7.
Study Emphases: Diet study.
Biological:* Fish, food organisms
Frequency: Two periods Duration: 18 months 1980-81, 3 months 1983.
Comments: Basic diet study, Data covers all months.

Author's Abstract

This note describes the diet of white sturgeon, *Acipenser transmontanus*, from the lower Columbia River and its estuary (Washington and Oregon). Samples were collected from 1980 to 1983. White sturgeon were captured by bottom trawl, purse seine, and hook and line and ranged from 5 to 129 cm in total length. The amphipod *Corophium salmonis* was primary prey for white sturgeon <80 cm long but not white sturgeon ≥ 80 cm. Larger white sturgeon consumed fish and large invertebrates. In general diet diversity increased with length.

Sanborn, Herbert R. 1975.
Benthic infauna observed at five sites in the Columbia River from August 1973 to July 1975. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Report to the U.S. Army Corps of Engineers and Columbia River Programs Office. Mar. 1975, 20 pp.

River Mile: 18 to 104, Reach: 1.5, 5.1, 6.3, 7.1:
Study Emphases: Benthic density; site, time, and depth comparison.
Biological:* Benthos
Physical: Sediment
Frequency: monthly. Duration: 18 months; 1973-1974.
Comments: Study and sampling methods outdated. General information.

Summary

Study of the seasonal patterns of benthic infauna in the Columbia River. Four Areas studied between Columbia river mile (CRM) 104 (Portland) and CRM 18 near Tongue Point. Benthic infauna and sediment samples were collected: Shallow

water stations had the greatest number of individuals and species. Deep-water stations had less numbers of species and a low number of individuals over all sample periods. A large decrease in the numbers of individuals was observed between 1973 (a low flow year) and 1974 (a high flow year). Two species were dominant; the Amphipod *Corophium salmonis* and the clam *Corbicula fluminea*.

Snyder, G.R., R.J. McConnell, J.T. Durkin, D.A. Misitano, H.R. Sanborn. 1973. Checklist of Aquatic Organisms in the Lower Columbia and Willamette Rivers. Nov. 1973, U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Report to the U.S. Army Corps of Engineers Portland OR, 44 p.

River Mile: CR, 18-105, Willamette, 11 Reach: 1.5, 4.5, 6.3, 7.5.
Study Emphases: Species checklist.
Biological:* Finfish, Shellfish, Benthic, Epibenthic, zooplankton.
Frequency: Four surveys. Duration: Monthly, July to November 1973.
Comments: Basic inventory, old, incomplete.

Summary

An assessment of aquatic organisms of the lower Columbia and Willamette Rivers was conducted using reviews of past findings and surveys in designated areas. The resulting inventory of species represents the uppermost layers of the food chain in the project region. the assessment consisted of four separate substudies. "A list of Fishes of the Lower Columbia and Willamette Rivers" identified approximately 70 fish species. "A list of Crustacean Shellfish of the Lower Columbia River between the Mouth and River Mile 108, July to October 1973" identified four species of shellfish. "A List of Benthic animals in the Lower Columbia and Willamette Rivers, August to October 1973" identified 26 species of benthic and epibenthic organisms. "A List of Zooplankton in the Lower Columbia and Willamette Rivers, July to October 1973" listed over 50 taxa excluding larval fish. Each of the separately authored substudies contained techniques, data, and literature cited.

Sutherland, G. Bruce 1979
Oil Spill Protection Plan for the Natural Resources of the Lower Columbia and Willamette Rivers. Oregon Dept. of Environmental Quality, Prepared for Oregon Dept. of Land Conservation and Development. July 1979. 86 p.

Summary

The chain of events which immediately followed the 27 June 1978 Toyota Maru #10 oil spill suddenly focused attention on the serious and potentially disastrous environmental and economic threat a large oil spill poses to the Columbia River system. It also demonstrates that a better knowledge of the river system, its natural resources, and its physical processes is absolutely necessary in order to have an adequate protection response.

Although the oil spill protection plan does not fit into the research format, it does contain valuable resource information not readile available from other sources i.e. locations of commercial fishing drifts, and popular sport fishing holes. Resource maps provided general information and locations of; habitat types, important aquatic and wildlife concentration areas, etc.

The Oregon "Oil Spill Protection Plan" has been or is in the process of being updated.

Toombs, G.L., S.L. Martin, P.B. Culter, and M.G. Dibblee. 1984. Environmental Radiological Surveillance Report on Oregon Surface Waters Volume I, 1961-1983. Oregon State Health Div., Radiation Control Sec. Post Office Box 231, Portland, Or. 97207. 40 pp., plus appendixes.

River Mile: Columbia River
Study Emphases: Radiological surveillance
Biological: Aquatic plants and animals
Chemical:* Radionuclides
Physical: Sediments.
Frequency: Monthly-quarterly, 6 sites. Duration: 22 years; 1961-83.
Comments: Outstanding 22 year data base.

Summary

Concern over atmospheric testing of nuclear weapons in the late 1950's and early 1960's led to the establishment of world wide radiation surveillance networks. Oregon's state wide surface-water sampling program was established in 1961 to determine the occurrence and distribution of radioactive material in the aquatic environment. These radionuclides included those from natural sources, fallout from above-ground nuclear weapons testing and disposal of radioactive waste. Stream-bottom sediments, aquatic plants, and small aquatic animals, all of which tend to concentrate radioactivity were studied.

When the program started in 1961 the Columbia was the most radioactive river in the state. The radioactivity in the Columbia has dropped correspondingly to the one by one shutdown of Hanford's eight plutonium production reactors and is now about the same or lower than the levels in the other bodies of water in the state. It is important to note that radioactivity never exceeded the limits established by national regulatory agencies. The author (personal communication) does not believe there is any foreseeable problem with retention of radioactive material in lower Columbia River sediments.

SUPPLEMENTAL REFERENCE LIST

Clairain, E.J.; R.A. Cole; R.J. Diaz; A.W. Ford; R.T. Huffman; L.J. Hunt; B.R. Wells. 1978 *Habitat development field investigations, Miller Sands marsh and upland habitat development site, Columbia River, Oregon.* Vickburg, MS: U.S. Army Engineer Waterways Experiment Station, Technical report, D-77-38;

Clark, S.M., and G.R. Snyder 1969. "*Timing and Extent of a Flow Reversal in the Lower Columbia River,*" Limnological and Oceanography, Vol. 14, No. 6 Nov

Cushing, C.E., and D.G. Watson, 1966. "*Accumulation and Transport of Radionuclides by Columbia River Biota,*" Proceedings of a Symposium on Disposal
of Radioactive Wastes into Seas, Oceans, and Surface Waters, Vienna, International Atomic Energy Agency

Durkin J.T. 1975. *An investigation of fish and decapod shellfish found at four dredge disposal sites adjacent to the mouth of the Columbia River.* Rept. to Portland District Corps of Engineers and NMFS Prog. Off. 29 p.

Ellinger, E., and G.R. Snyder. 1975. *An Annotated Bibliography of The Effects of Dredging and Dredge Disposal on the Aquatic Organisms in the Pacific Northwest.* U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. Final Rept. to U.S. Army Corps of Engineers Contract (WESRF 75-88) 51 p.

Environmental Protection Agency 1971. *Columbia River Thermal Effects study. Vol.1) Biological Effects Studies. 79 pp.: Vol 2) Temperature Prediction.* 64 pp. by EPA, AEC, & NMFS Jan. 1971

Fox, D.S., W. Nehlsen, S. Bell, and J. Damron. 1984. *The Columbia River estuary atlas of physical and biological characteristics.* Columbia River Estuary Data Development Program, Astoria Oregon.

Griffin, W.C., F.A. Watkins, JR., and H.A. Swenson 1956. *Water resources of the Portland, Oregon, and Vancouver, Washington, area.* U.S. Dep. Int. Geol. Surv. Circ. 372, 45pp.

Haertil L.J.S. 1970. *Plankton and nutrient ecology of the Columbia River Estuary* PhD Thesis, Oreg. State. Univ., Corvallis, 78 p.

Henny, C.J. 1981. *PCB's and Organochlorine Pesticides in Wild Mink and River Otters from Oregon.* ?

Higley, D.L.; R.1. Holton, 1978. *A grab-sample study of the benthic invertebrates of the Columbia River estuary.* Corvallis, OR.: Oreg. State. Univ., 27 p.

Higley, D.L.; K.K. Jones; S.L. Wilson; R.L. Holton, 1982. *Impact of flowlane disposal of Port of Astoria slip sediments, Columbia River estuary.* Corvallis, OR.: Oreg. State. Univ., 212 p.

Johnsen, R.C. and C.W. Sims 1973. *Purse seining for juvenile salmon and trout in the Columbia River estuary.* Trans. Am. Fish. Soc. 102:341-345.

Gailbreath, J.L. 1983. *Status, Life History, and management of Columbia River white sturgeon* Acipenser transmontanus. Symposium on Biology and Management of sturgeon (at) 113. Annual Meeting of the American Fisheries Soc. Milwaukee, WI. 16-20 Aug. 1983

Kirn, R.A., R.D. Ledgerwood, & A.L. Jensen 1986. *Diet of subyearling chinook salmon (Oncorhynchus tshawytscha) in the Columbia River estuary and changes effected by the 1980 eruption of Mount ST. Helens.* North.W. Sci. 60(3): 191-196.

Lehmann, E.J. 1975. *Environmental and Ecological Effects of Dredging (A Bibliography with Abstracts).* NTIS/PS-75/050/5GA, Jan 1975, National Technical Information Service, Springfield, Va.

McCabe, G.T.,Jr., W.D. Muir, R.L. Emmett and J.T. Durkin. 1983. *Interrelationships between juvenile salmonids and nonsalmonid fish in the Columbia River estuary.* Fish. Bull., U.S. 81(4):815-826.

McConnell, R.J., T.H. Blahm and M.C. Laird 1977. *Depth Distribution of Fish in the Columbia River as Determined by Sonic Detection.* Processed Rept. U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. 8 pp.

Misitano, David A. 1977. *Species composition and relative abundance of larval and post-larval fishes in the Columbia River estuary, 1973.* Fish. Bull. 75:218-222.

Ogden Beeman & Associates, Inc. 1985. *Studies to control shoaling of the navigation channel lower Columbia River.* Final Rept. to U.S. Army Corps of Engineers, Contract #(DACW57-C-0067) 176 pp.

Ortolando, L. and W.W. Hill. 1972. *An Analysis of Environmental Statements for Corps of Engineers Water Projects.* Jun 1972, Stanford University for the U.S. Army Corps of Engineers, contract No. DACW31-71-C-0127.

Pruter, A.T., and D.L. Alverson, (eds). 1971 *The Columbia River estuary and adjacent ocean waters, bioenvirnmental studies.* University of Washington Press, Seattle

Sanborn, H.R. 1975. *An investigation of the benthic in fauna at two dredge and four dredge disposal sites adjacent to the mouth of the Columbia River.* U.S. Nat. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd.E., Seattle, WA 98112. 19 pp.

Smith, W.E., and R.W. Saalfeld. 1955. *Studies on Columbia River Smelt* Thaleichthys pacificus . Washington Dept. of Fisheries. Fisheries Research Papers 1(3):3-26.

Sylvester, R.O. 1958. *Water quality studies in the Columbia River Basin.* U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 239, 134 pp.

Sylvester, R.O. and D.A. Carlson. 1961. *A report on lower Columbia River basic water quality data analysis for the year 1960.* [Prepared for the] Oregon State Sanitary Authority, Northwest Pulp Pap. Ass. and Wash. State Polut. Contr. Comm., Univ. Wash. State Seattle, 52 pp.

U.S. Geological Survey
1959a. *Quality of surface waters of the United States 1954.* Parts 9-14. Colorado River Basin to Pacific slope Basin in Oregon and Lower Columbia River Basin. Its Water-Supply Paper 1353. 426 pp.

1959b. *Quality of surface waters of the United States 1955.* Parts 9-14. Colorado River Basin to Pacific slope Basin in Oregon and Lower Columbia River Basin. Its Water-Supply Paper 1403. 437 pp.

1964. *Quality of surface waters of the United States 1962.* Parts 9-14. Colorado River Basin to Pacific slope Basin in Oregon and Lower Columbia River Basin. Its Water-Supply Paper 1945. 691 pp.

Water Resources Information System. 1973. *A Selected Annotated Bibliography on Columbia and Snake Rivers.* State of Washington Department Of Ecology, Olympia, Washington.

Weston, D.P. and B.J. Morson, 1985. *The Columbia River Mobiloil spill: A study of fates and effects.* Final report from the Washington Department of Ecology. June 1985.

Williams, G.T. 1983. *Distribution and relative abundance of major epibenthic crustacea in the Columbia River estuary.* M.S. Thesis. Univ. Wash., Seattle. 98 pp.