United States
Environmental Protection
Agency

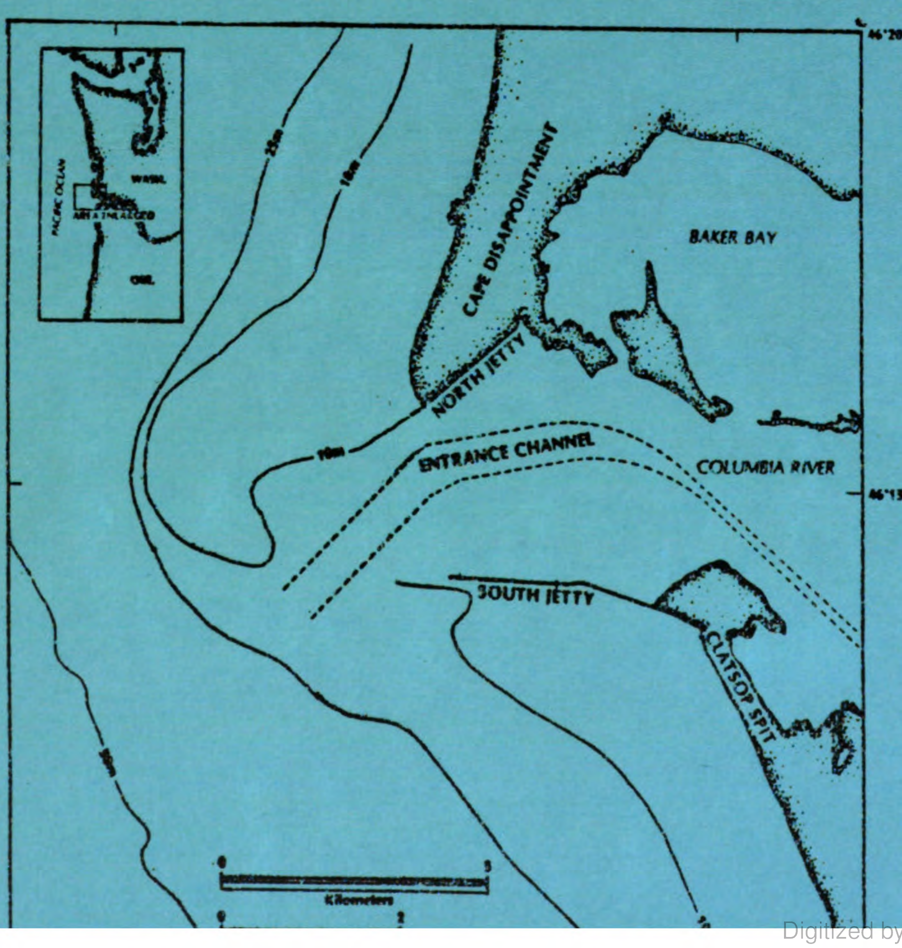
Office of Water
Criteria and Standards Division
Washington, DC 20460

September 1982

Water

Environmental Impact Statement (EIS) for the Mouth of Columbia River Dredged Material Disposal Site Designation

Draft



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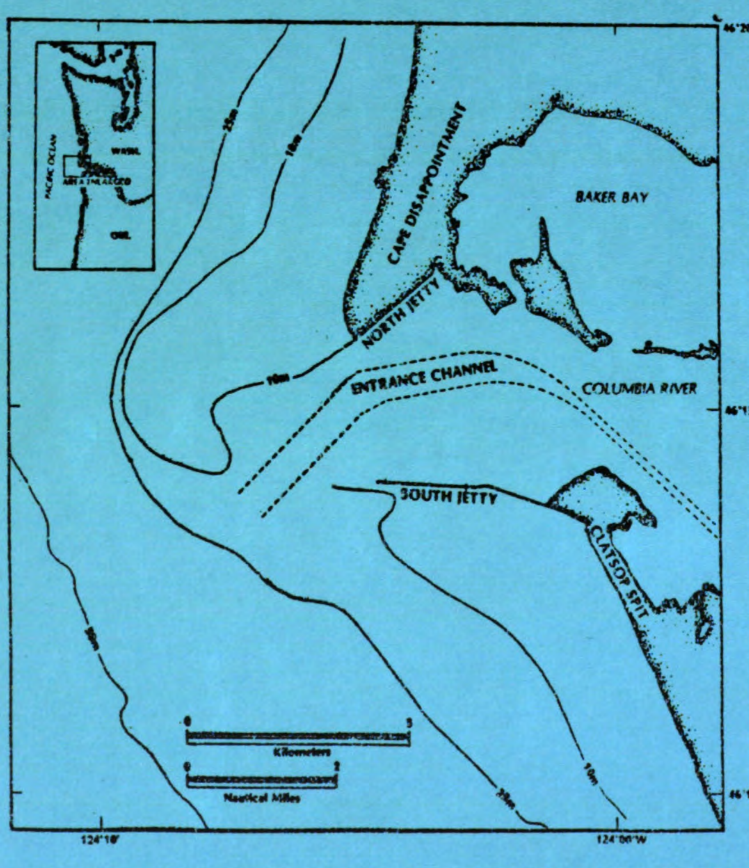

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measure

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	30.	centimeters	cm
yd	yards	0.9	meters	m
fm	fathoms	1.8	meters	m
mi	statute miles	1.6	kilometers	km
nmi	nautical miles*	1.9	kilometers	km

*1 nautical mile = 6.076 feet = 1.15 statute miles

Symbol	When You Know	Multiply by	To Find	Symbol
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
nmi^2	square nautical miles	3.4	square kilometers	km^2
		MASS (weight)		
oz	ounces	28.	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lbs)	0.9	tonnes†	t

†1 tonne = 1,000 kg = 1 metric ton

Symbol	When You Know	Multiply by	To Find	Symbol
		VOLUME		
fl oz	fluid ounces	30.	milliliters	ml
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	0.55(°F) - 32	Celsius temperature	°C
		VELOCITY		
in/sec	inches per second	2.5	centimeters per second	cm/sec
ft/sec	feet per second	30.	centimeters per second	cm/sec
ft/min	feet per minute	0.5	centimeters per second	cm/sec
mph	miles per hour	1.6	kilometers per hour	kph
kn	knots**	51.	centimeters per second	cm/sec
kn	knots (nautical miles per hour)	1.9	kilometers per hour	kph

**1 knot = 1.15 mph

Approximate Conversions from Metric Measure

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
m	meters	0.6	fathoms	fm
km	kilometers	0.6	statute miles	mi
km	kilometers	0.5	nautical miles*	nmi

*1 nautical mile = 6.076 feet = 1.15 statute miles

Symbol	When You Know	Multiply by	To Find	Symbol
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	11.	square feet	ft^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
km^2	square kilometers	0.3	square nautical miles	nmi^2
		MASS (weight)		
g	grams	0.4	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes†	1.1	short tons (2,000 lb)	

†1 tonne = 1,000 kg = 1 metric ton

Symbol	When You Know	Multiply by	To Find	Symbol
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.1	quarts	qt
l	liters	0.3	gallons	gal
m^3	cubic meters	35.	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8(°C) +32	Fahrenheit temperature	°F
		VELOCITY		
cm/sec	centimeters per second	0.4	inches per second	in/sec
cm/sec	centimeters per second	0.03	feet per second	ft/sec
cm/sec	centimeters per second	2.0	feet per minute	ft/min
cm/sec	centimeters per second	0.02	knots (nautical miles per hr)**	kn
kph	kilometers per hour	0.6	miles per hour	mph
kph	kilometers per hour	0.5	knots	kn

**1 knot = 1.15 mph

DRAFT

ENVIRONMENTAL IMPACT STATEMENT (EIS)
for
MOUTH OF THE COLUMBIA RIVER DREDGED MATERIAL DISPOSAL SITES DESIGNATION

AUGUST 1982

U.S. ENVIRONMENTAL PROTECTION AGENCY
Criteria and Standards Division
Washington, D.C. 20460

SUMMARY SHEET

ENVIRONMENTAL IMPACT STATEMENT
FOR
MOUTH OF THE COLUMBIA RIVER
DREDGED MATERIAL DISPOSAL SITES

(X) Draft

( ) Final

( ) Supplement to Draft

ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF WATER REGULATIONS AND STANDARDS

CRITERIA AND STANDARDS DIVISION

1. Type of Action

(X) Administrative/Regulatory action

( ) Legislative action

2. Brief background description of action and purpose.

The proposed action is the designation of the Mouth of the Columbia River Dredged Material Disposal Sites. The sites are off of the Mouth of the Columbia River, Oregon-Washington, and used for disposal of materials dredged from the entrance channel to the Columbia River and other small harbors bordering the lower river. The purpose of the action is to provide environmentally acceptable areas for disposal of dredged materials, in compliance with EPA Ocean Dumping Regulations.

3. Summary of major beneficial and adverse environmental and other impacts.

An important beneficial effect of this action is to provide suitable locations for the disposal of dredged materials. Disposal at Site E may provide beneficial beach nourishment material to adjacent coastal beaches. Previous disposal of dredged material at the Mouth of the

Columbia River disposal sites has caused only minor and reversible effects: temporary mounding, changes in sediment texture, smothering of some benthic organisms and temporary disturbances of demersal fish asssemblages.

4. Major alternatives considered.

The alternatives considered in this EIS are (1) no action, which would allow the interim designation of the existing sites to expire without permanent designation of an ocean site(s), (2) permanent designation of the interim designated sites, and (3) designation of an alternative ocean site for disposal of dredged materials (e.g., Astoria Canyon, 16.5 nmi offshore).

5. Comments have been requested from the following:

<u>Federal Agencies and Offices</u>

Council on Environmental Quality
Department of Commerce
  National Oceanic and Atmospheri Administration (NOAA)
  Maritime Administration
Department of Defense
  Army Corps of Engineers
Department of Health, Education, and Welfare
Department of the Interior
  Fish and Wildlife Service
  Bureau of Outdoor Recreation
  Bureau of Land Management
  Geological Survey
Department of Transportation
  Coast Guard
Water Resources Council
National Science Foundation

States and Municipalities

Oregon Division of State Lands
Washington Department of Fisheries
Oregon Department of Fish and Wildlife
Oregon Department of Land Conservation and Development

Private Organizations

American Littoral Society
Audubon Society
Center for Law and Social Policy
Environmental Defense Fund, Inc.
National Academy of Sciences
National Wildlife Federation
Sierra Club
Water Pollution Control Federation

Academic/Research Institutions

Pacific Northwest River Basins Commission
Columbia River Estuary Study Taskforce
Oregon State University
University of Washington

6. The draft statement was officially filed with the Director, Office of Environmental Review, EPA.

7. Comments on the Draft EIS are due 45 days from the date of EPA's publication of Notice of Availability in the Federal Register which is expected to be OCT 15 1982

Comments should be addressed to:

William C. Shilling
Criteria and Standards Division (WH-585)
Office of Water Regulations and Standards
Environmental Protection Agency
Washington, D.C. 20460

Copies of the Draft EIS may be obtained from:

Criteria and Standards Diivsion (WH-585)
Office of Water Regulations and Standards
Environmental Protection Agency
Washington, D.C. 20460

The draft statement may be reviewed at the following locations:

Environmental Protection Agency
Public Information Reference Unit, Room 2404 (Rear)
401 M Street, SW
Washington, D.C. 20024

Environmental Protection Agency
Region X
1200 6th Ave
Seattle, Washington 98101

U.S. Army Corps of Engineers
319 S.W. Pine Street
Portland, Oregon 97208

SUMMARY

INTRODUCTION

This Environmental Impact Statement (EIS) considers final designation of four dredged material disposal sites, offshore of the Mouth of the Columbia River (MCR), Oregon-Washington, for continued use. The sites are identified as MCR Interim Sites A, B, E, and F* (Figure S-1), and are used for disposal of materials dredged from the entrance channel to the Columbia River and other small harbors bordering the lower river. An alternative ocean disposal site for dredged materials is in Astoria Canyon, 16.5 nmi offshore.

This EIS is an integral part of the Environmental Protection Agency (EPA) procedure for designating the use of ocean sites for disposal of dredged materials. Evaluations of the suitability of the MCR and Astoria Canyon Sites are based on environmental data presented in the main body of this report.

This summary describes the major conclusions and recommendations presented in the EIS.

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* The boundary coordinates are:

Site A,	46°13'03"N, 124°06'17"W	Site E,	46°15'43"N, 124°05'21"W
	46°12'50"N, 124°05'55"W		46°15'36"N, 124°05'11"W
	46°12'13"N, 124°06'43"W		46°15'11"N, 124°05'53"W
	46°12'26"N, 124°07'05"W		46°15'18"N, 124°06'03"W
Site B,	46°14'37"N, 124°10'34"W	Site F,	46°12'12"N, 124°09'00"W
	46°13'53"N 124°10'01"W		46°12'00"N, 124°08'42"W
	46°13'43"N, 124°10'26"W		46°11'48"N, 124°09'00"W
	46°14'28"N, 124°10'59"W		46°12'00"N, 124°09'18"W

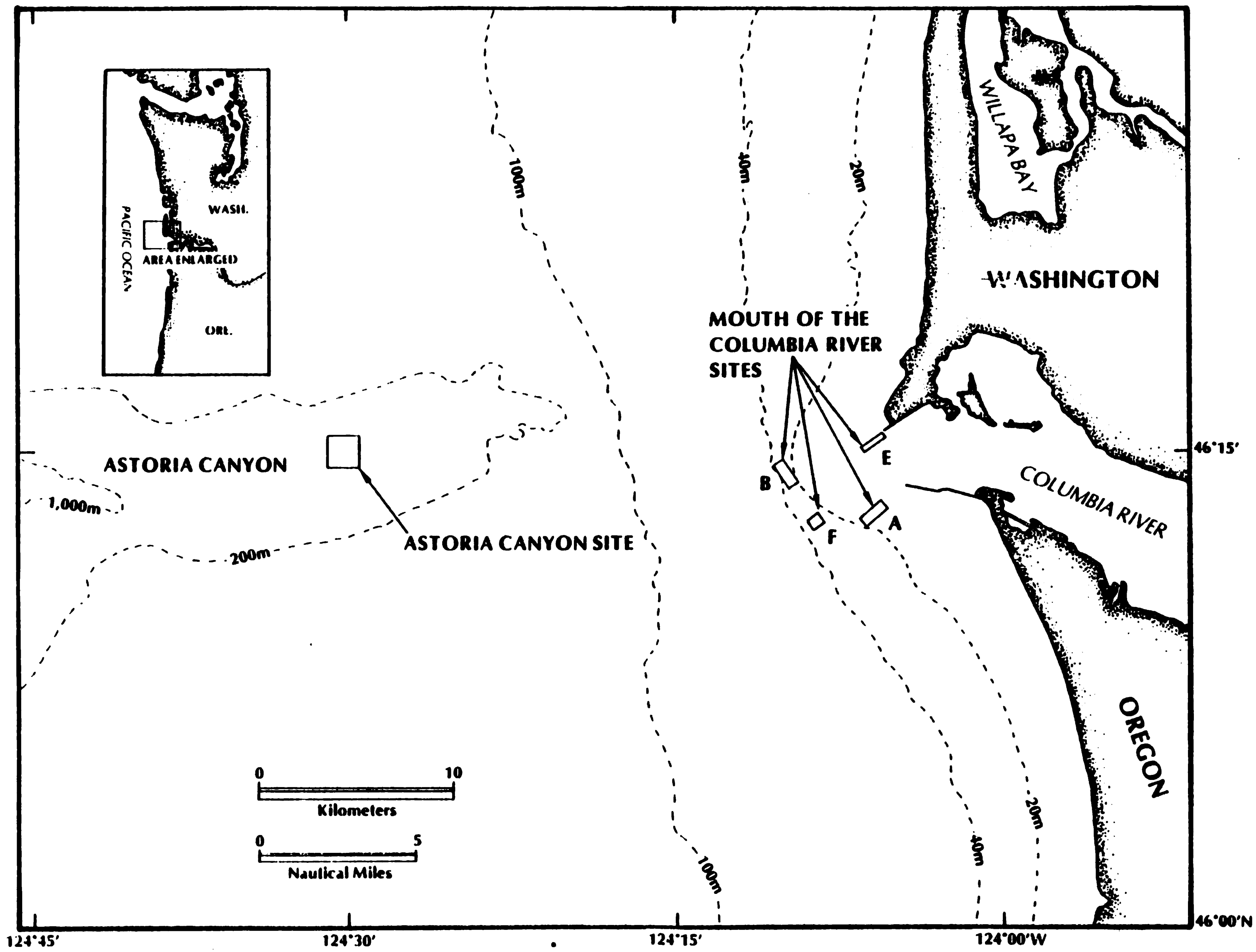

Figure S-1. Locations of the MCR and Astoria Canyon Sites

BACKGROUND

Columbia River is the largest river on the West Coast of North America. The river has approximately 270 nmi of navigable waterway and provides access to the ports of Astoria and Portland, Oregon, and Vancouver, Washington; collectively, the tenth-largest shipping port in the United States. Maintaining a permanently navigable shipping channel through the lower river is necessary for the continued viability of the large shipping industry (approximately 44 million tons per year).

The bathymetry of the Mouth of the Columbia River is continually being altered due to large and seasonally variable river flows, large and variable diurnal tides, littoral currents, and storm waves. Since 1882 efforts to stabilize sediment accretion by constructing jetties and occasional dredging have been largely ineffectual. Currently, annual dredging of approximately 6 million yds^3 is necessary to maintain the 15m (48 ft) channel depths.

The frequency of winter storms, lasting from 3 to 7 days, and producing wind velocities to 60 kn with 6 to 12m waves, restricts dredging in the entrance channel to a 6-month period (mid-April to mid-October). Currently, material dredged from the entrance channel is dumped at four ocean and one estuarine disposal sites. This EIS is concerned with ocean dumping of dredged material and therefore does not consider final designation of the estuarine site.

SELECTION OF ALTERNATIVE SITES

The EPA and Army Corps of Engineers (CE) evaluate the need for and alternatives to ocean dumping according to Ocean Dumping Regulations (40 CFR Part 227 Subpart C). When the need for ocean dumping has been established, potential sites are evaluated for the disposal of dredged materials. Criteria used for site selection are based on considerations of potential interferences by disposal operations with other marine activities and resources, potential perturbations of water quality, impacts on beaches or other amenity areas, previous uses for dredged material disposal, and geographic location.

Four MCR Interim Sites, A, B, E, and F, and one Alternative Site in Astoria Canyon, are considered in this EIS for ocean disposal of dredged materials. MCR Sites A, B, and F have been used since 1957, and site E since 1973, as primary disposal sites for sediments dredged from the entrance channel of the Columbia River. Detectable effects of dredged material disposal are limited to temporary mounding, changes in sediment texture, smothering of some benthic organisms, and temporary disturbances of demersal fish assemblages. Uncontaminated dredged sediments dumped at Site E are potentially beneficial as sand nourishment for adjacent beaches. Continued use of MCR Interim Sites A, B, E, and F would permit optimal utilization of a restricted dredging season and increased flexibility in disposal site selection, depending on weather conditions, fishing vessel traffic, sediment accumulation, and the number of hopper dredges dredging the Mouth of the Columbia River.

One other nearshore site, Interim Site G, has been used previously by the CE for dredged material disposal. Final designation of Site G for continued use, in addition to Sites A, B, E, and F, is not recommended because there is no demonstrable need for an additional site based on the present annual dredged material volumes. Furthermore, final designation of Site G in lieu of Sites A, B, E, and F is not recommended because there would be no significant change in the impact on the ecosystem, and less potential for beach nourishment.

The Portland District of the Corps of Engineers, in cooperation with the Washington State Soil Conservation Service, is currently assessing the feasibility of beach nourishment/sand stabilization sites for the future disposal of MCR dredged materials. However, until the site location and disposal volumes can be identified by the CE and the Soil Conservation

Service, the environmental and economic consequences of designating beach nourishment sites cannot be adequately assessed. Therefore, further evaluation of beach nourishment sites awaits completion of the preliminary assessment by the CE.

Alternative Sites in the mid-Shelf and Astoria Canyon have not been previously used for dredged material disposal, and the potential effects of dredged sediments on indigenous organisms and resources are presently unknown. Uses of offshore sites, either in the mid-Shelf or Shelf-break, would present additional serious problems because of the limited dredging season. The duration of the dredging season is restricted by weather conditions, thus the increased transit distance required by offshore disposal would decrease the effective dredging time and increase costs. Unless the dredging efforts were substantially increased by the CE, further restrictions on dredging time could reduce the effectiveness of annual dredging to an extent where the authorized 15m channel depths could not be maintained.

The No-Action Alternative is not considered acceptable. The interim designation of the Columbia River ODMDS's will expire in February 1983, without permanent designation of those sites or an alternate ocean disposal sites(s) for continuing use.

PROPOSED ACTION

After reviewing the alternatives, the EPA proposes that Sites A, B, E, and F be permanently designated. The locations of the four MCR Interim Sites are shown in Figure S-1. Each of the MCR Interim Sites is within 5 nmi from shore and in water depths ranging from 18 to 40 m.

The MCR Interim Sites have been used for more than 20 years and no significant adverse effects due to dredged material disposal are evident. Records of dredged material disposal before 1973 are incomplete; however, since 1973 the majority of the dredged material was released at Site B or Site E. Sites A and F have been used infrequently.

The impacts of dumping on the MCR environment have been investigated by the CE Dredged Material Research Program; the results of these studies are summarized by Boone et al. (1978) and discussed in Chapters 3 and 4. In general, dredged material disposal caused no significant changes in water or sediment quality. Temporary mounding, changes in sediment texture, and smothering of benthic organisms, and reductions in fish abundances are restricted within the site boundaries. Furthermore, dredged sediments dumped at Site E may provide clean sands to adjacent beaches.

Use of the Astoria Canyon Site is not recommended. This site has not been previously used for dredged material disposal. The Astoria Canyon Site is 16.5 nmi offshore, over the axis of the Canyon and seaward of the 500 m depth contour. The increased distance from shore increases disposal time, reduces effective dredging time, increases the difficulties of site monitoring, and increases the possibilities of emergency dumping in relative sensitive mid-shelf areas. In addition, the possible effects of dumping on the organisms at the site are unknown since no baseline data exist for the Astoria Canyon Site. For comparsion of alternatives, see Table S-1.

AFFECTED ENVIRONMENT

MOUTH OF THE COLUMBIA RIVER

Interactions of temporally variable river, tidal, and wind-generated currents with the effects of nearshore wave activity create a complex and dynamic environment at the Mouth of the Columbia River. Mixing seawater with fresh water discharges from the river has a profound effect on the biological, chemical, and geological characteristics of the MCR environment.

Sediments in the Columbia River entrance channel are generally coarser than nearshore Shelf sediments. Due to natural sedimentation and transport processes, sediments south of the entrance channel are composed of fine to very fine sands, whereas north of the entrance channel sediments are composed of fine sand and silt. Fine and medium-grained sands, comprising previously released dredged material, are generally stable, but may move slowly northward as bedload under the influence of strong, storm-generated bottom currents.

TABLE S-1
SUMMARY COMPARISON

Criteria as Listed at 40 CFR 228.6	Interim Sites Near the Mouth of the Columbia River	Alternative Site at Astoria Canyon
(1) Geographical position	Four Interim Sites (A, B, E, and F) - nearshore (<5 nmi), shallow (18 to 40m), medium to fine-grained sand sediments	Located offshore (16.5 nmi), deep (>500 m); varying sediment types (predominantly silts and clays)
(2) Distance from important resource areas	Some activity (breeding, feeding, passage) over entire area where sites are located; area is heavily fished, crabs fished during winter when no dredging occurs	Potential fisheries resources; extent of other biological activity unknown
(3) Distance from beaches	Close to beaches; beach nourishment potential	Offshore of beaches; material transported seaward, no potential for beach nourishment
(4) Types and quantities of material	Uncontaminated sand from high-energy environment; volume 6 million yd^3 per year	Same as Interim Sites
(5) Surveillance and monitoring	Surveillance requirements low because disposal sites are close to dredging areas Monitoring simplified because: - Sites are nearshore and shallow - Historical data are available	Surveillance requirements high because disposal site would be far offshore; probability of emergency or short dumping is higher Monitoring is difficult because: - Site is far offshore and deep - Site-specific data are not available, predisposal survey necessary
(6) Dispersal, horizontal and vertical mixing	Rapid settling; no persistent turbidity plume, negligible addition due to high suspended sediment load. Net transport of sediment northwards at Sites A, B, and F; bedload transport slow, 0.25 nmi per year. Rapid sediment dispersion at Site E; potential for beach nourishment.	Rapid settling; no persistent turbidity Transport down-Canyon away from Shelf
(7) Effects of previous dumping in the ocean	All effects are minor and restricted to the site; significant adverse effects have not been noted outside boundary of site Minor effects detected: - Temporary mounding - Slight change in sediment texture - Reduction in fish abundances - Changes in benthic community structure	No sediments have been previously dumped in this area
(8) Interference with other uses of the ocean	Mineral extraction, desalination, fish and shellfish culture do not occur Disposal does not interfere with commercial or recreational shipping traffic Extensive fishing activities throughout MCR; minor interference from dredged material disposal	Same as Interim Sites Same as Interim Sites No current fisheries activities or interferences with shipping traffic in the area
(9) Existing water quality and ecology	Disposal of uncontaminated wastes does not adversely affect water quality Temporary disturbance of demersal fish abundances and benthic community structure within the site boundaries Important Dungeness crab fishery occurs in winter when no dredged material disposal occurs	Same as Interim Sites No ecological data available; potential impact unknown, although expected to be insignificant
(10) Potential for nuisance species	Uncontaminated sand does not contain material which would attract nuisance species	Same as Interim Sites
(11) Existence of significant natural or cultured features	Numerous shipwrecks	No known features

Distributions and concentrations of various chemical species in nearshore waters vary with seasonal, tidal, and diurnal cycles. In summer river water contributes large quantities of dissolved silicate, and some nitrate and phosphate, to nearshore ocean waters. Upwelling contributes moderate amounts of silicate and phosphate, and virtually all nitrate present in surface waters. Concentrations of trace metals and organic carbon in sediments are apparently related to the amounts of silt. In the high-energy river channel medium-grained sands contain low concentrations of trace metals and organic carbon. Further offshore (Site B for example) where river transported silts settle out, concentrations of trace metals and organics are typically higher (Boone et al., 1978).

Relative to other areas along the Oregon-Washington coast, the nearshore region adjacent to the river mouth sustains a large and diverse benthic fauna due to high productivity and the addition of organic-rich, river-borne sediments. Seasonal variations in abundance and diversity of the nearshore communities are affected by river discharges. Several pelagic and demersel finfish species occur throughout the lower river and adjacent nearshore areas, and support large commercial and sport fisheries.

ASTORIA CANYON

Limited observations within and adjacent to Astoria Canyon demonstrate the existence of currents flowing parallel to the bottom contours near the head of the Canyon, and along the Canyon axis, predominantly in a downslope direction inside the Canyon. Five sediment types have been identified from cores taken inside Astoria Canyon: silty-clay, laminated clays, bedded silt and sand, gravel beds, and mottled sediments containing irregular sand and clay deposits. Active sediment transport within the Canyon, due to turbidity currents and slumping, has been postulated (Carlson and Nelson, 1969). No data are available for the chemical constituents of water and sediments within Astoria Canyon. Little information is available on benthic and nektonic communities inhabiting Astoria Canyon. Investigations of the biota from adjacent Shelf areas have demonstrated the occurrences of several potentially important finfish and shellfish species of commercial value.

ENVIRONMENTAL CONSEQUENCES

MOUTH OF THE COLUMBIA RIVER

After 20 years of dredged material disposal at the MCR Interim Sites, no irreversible or significant adverse environmental impacts have been detected. Potential environmental consequences of dredged material disposal at MCR, elucidated by the DMRP, are summarized below. Previous dumping of dredged material at the MCR Interim Sites has caused minor, reversible effects on benthic communities. Direct burial by dredged material produces a temporary change in the benthic community structure, primarily by smothering nonmotile polychaetes and amphipods. Temporary decreases in the biomass of benthic organisms produce a shift in fish food availability, which cause temporary decreases in finfish abundance, species diversity, and size frequency.

Dredged material disposal has caused no detectable changes in water quality at the MCR Interim Sites; concentrations of trace metals and trace organics in the sediments and water after dumping are not significantly different from those occurring before dumping. Dumping dredged material at the MCR Interim Sites does, however, cause a slight change in sediment texture, because dredged .sediments are generally slightly coarser than those originally found at the disposal sites.

Most commercial bottom fishing occurs from 3 to 40 nmi from shore, both north and south of the river mouth. All MCR Interim Sites are within 5 nmi of the river mouth, thus, minor interferences from dredged material disposal operations are expected. Previous dumping operations have produced no detectable adverse effects on commercial, demersal, finfish species (Durkin and Lipovsky, 1977). Dredged material disposal is not expected to interfere with crab fishing because fishing and dredging seasons occur at different times of the year. Sport and commercial troll fisheries are active in the vicinity of the MCR Interim Sites, especially during salmon runs (from mid-June to late autumn). Dredged material disposal activities may, therefore, interfere with some sport and commercial fishing activity.

The MCR Interim Sites are near shipping corridors, thus minor interferences with shipping and navigation are expected during dredged material disposal operations. Navigational hazards created by mounding of dredged material at the dump sites have not occurred.

Previous dumping of dredged material at the MCR Interim Sites has not caused any adverse aesthetic effects. The dredged material is predominantly sand, therefore it does not create a persistant turbidity plume during dumping. Dredged material disposal at Site E may provide beach nourishment for adjacent beaches.

At present disposal rates no mitigating action is necessary for dredged material disposal at the MCR Interim Sites.

ASTORIA CANYON

No fishing operations currently exist in the Astoria Canyon Site, therefore no potential interference of dredged material disposal operations is expected. No potential interference of dredged material disposal with navigation exists at the Astoria Canyon Site.

The environmental consequences of dumping at Astoria Canyon would probably not be significantly different than at the MCR Interim Sites. No changes in water or sediment quality would be expected. Smothering of some benthic organisms is predicted, although endemic organisms are probably adapted to frequent substrate agitation. Adverse impacts associated with dumping in the Canyon are primarily related to necessitated increases in dredging effort, and a concommitant economic burden, increased difficulty in site monitoring and predisposal, the need to conduct baseline surveys, and technical problems implicated in transporting materials offshore during periods of rough weather.

ORGANIZATION OF THE ENVIRONMENTAL IMPACT STATEMENT

This EIS is organized as follows:

- Chapter 1 specifies the purpose and need for the proposed action, presents initial background information relevant to the dredging and disposal sites, and discusses legal framework guiding EPA's selection and designation of disposal sites, and the CE's responsibilities in ocean disposal of dredged material.

- Chapter 2 presents alternatives, including the proposed action, the specific criteria used in evaluating alternatives, and applies the 11 site selection criteria to the proposed and alternative actions.

- Chapter 3 describes the affected environment of the alternative sites and the history of dredged material disposal at the Mouth of the Columbia River.

- Chapter 4 analyzes the environmental consequences of dredged material disposal at the Interim and Alternative Sites.

Chapters 5 and 6 provide supplementary information. Chapter 5 lists the authors of the EIS. Chapter 6 contains a glossary and lists abbreviations and references cited in the text.

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Chapter 1

PURPOSE OF AND NEED FOR ACTION

The Columbia River provides access for foreign and domestic vessels to inland harbors. As a result of natural shoaling processes, the entrance channel to the Columbia River must be dredged annually to provide safe ship passage through the lower river. Ocean dumping is a feasible means for the disposal of the dredged material. The action proposed in this Environmental Impact Statement is the final designation of the Mouth of the Columbia River Dredged Material Disposal Sites.

The proposed action in this Environmental Impact Statement (EIS) is the final designation Mouth of the Columbia River (MCR) Dredged Material Disposal Sites (DMDS). The purpose of the proposed action is to provide the most environmentally acceptable ocean location for the disposal of materials dredged from the entrance channel of the Columbia River. The EIS presents the information needed to evaluate the suitability of ocean disposal areas for final designation for continuing use and is based on one of a series of disposal site environmental studies. The environmental studies and final designation process are being conducted in accordance with the requirements of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) (86 Stat. 1052), as amended (33 U.S.C.A. §1401, et. seq.); the Environmental Protection Agency's (EPA) Ocean Dumping Regulations and Criteria (40 CFR 220 - 229); and applicable Federal environmental legislation.

Based on an evaluation of all reasonable alternatives, the proposed action in this EIS is to permanently designate the existing interim designated Mouth of the Columbia River Ocean Dredged Material Disposal Sites A, B, E, and F. The sites are all within 5 nmi of the entrance channel and have a total area of approximately 1 nmi^2. The boundary coordinates of the disposal sites (shown in Figure 1-1) are:

- Site A, 46°13'03"N, 124°06'17"W; 46°12'50"N, 124°05'55"W; 46°12'13"N, 124°06'43"W; 46°12'26"N, 124°07'05"W

- Site B, 46°14'37"N, 124°10'34"W; 46°13'53"N, 124°10'01"W; 46°13'43"N, 124°10'26"W; 46°14'28"N, 124°10'59"W

- Site E, 46°15'43"N, 124°05'21"W; 46°15'36"N, 124°05'11"W; 46°15'11"N, 124°05'53"W; 46°15'18"N, 124°06'03"W

- Site F, 46°12'12"N, 124°09'00"W; 46°12'00"N, 124°08'42"W; 46°11'48"N, 124°09'00"W; 46°12'00"N, 124°09'18"W

The Mouth of the Columbia River Ocean Dredged Material Disposal Sites (ODMDS), as delineated above, would be designated for the disposal of dredged material. The sites may be used for disposal of the dredged material only after evaluation of each Federal project or permit application has established that the disposal is within site capacity and in compliance with the criteria and requirements of EPA and the U.S. Army Corps of Engineers (CE) regulations.

PURPOSE AND NEED

Marine Protection, Research, and Sanctuaries Act

The MPRSA was enacted in October 1972. Congressional intent for this legislation as expressed in the Act is:

> **Sec.2(b). The Congress declares that it is the policy of the United States to regulate the dumping of all types of materials into ocean waters and to prevent or strictly limit the dumping into ocean waters of any material which would adversely affect human health, welfare, amenities, or the marine environment, ecological systems, or economic potentialities.**
>
> **(c). It is the purpose of this Act to regulate (1) the transportation by any person of material from the United States and, in the case of United States vessels, aircraft, or agencies, the transportation of material from a location outside the United States, when in either case the transportation is for the purpose of dumping the material into ocean waters, and (2) the dumping of material transported by any person from a location outside the United States if the dumping occurs in the territorial sea or the contiguous zone of the United States.**

Title I of the MPRSA, which is the Act's primary regulatory section, authorizes the Administrator of EPA (Section 102) and the Secretary of the Army acting through the CE (Section 103) to establish ocean disposal permit programs for nondredged and dredged materials, respectively. Title I also requires EPA

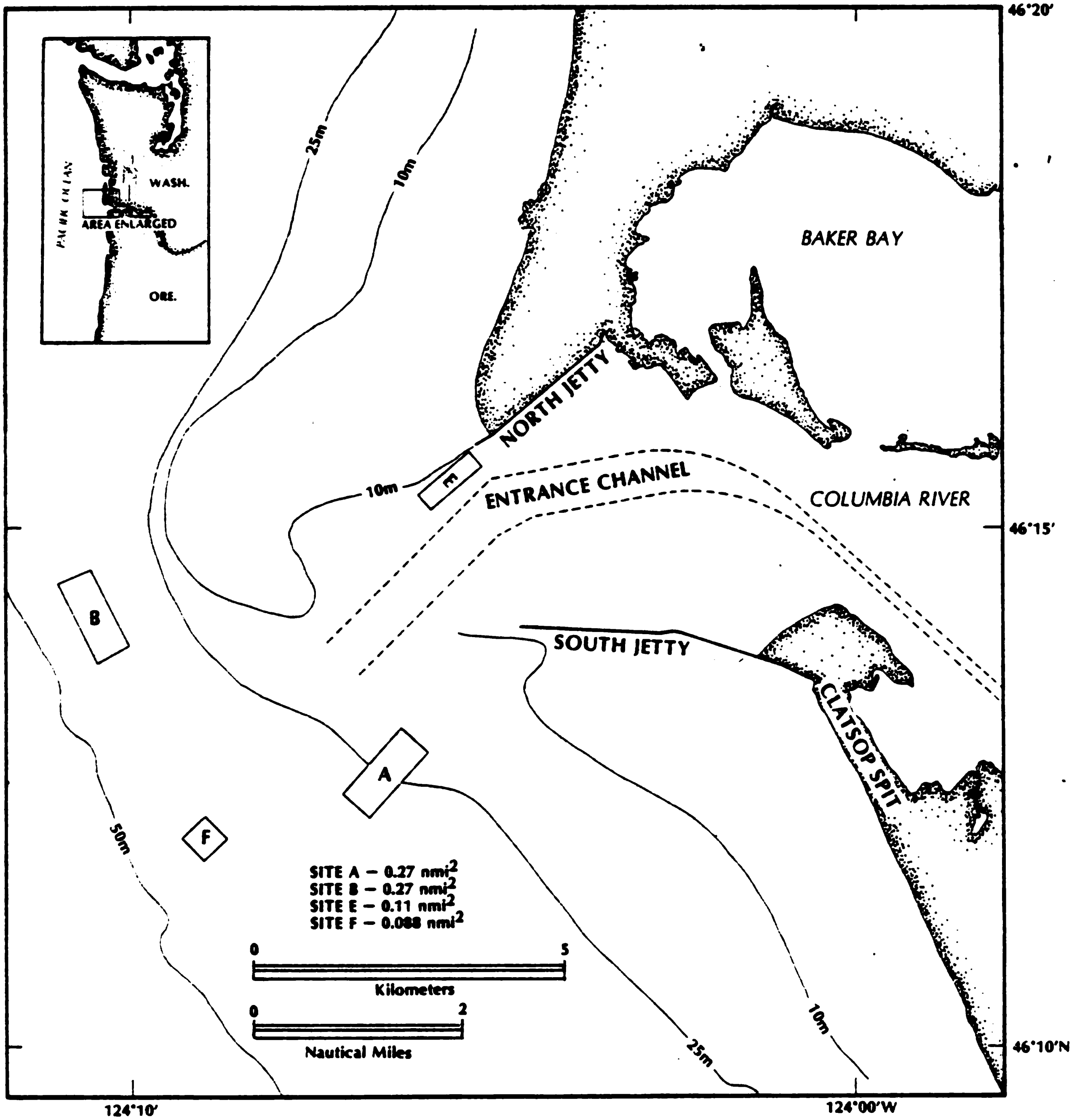

Figure 1-1. Locations of MCR Interim Sites

Title I of the MPRSA, which is the Act's primary regulatory section, authorizes the Administrator of EPA (Section 102) and the Secretary of the Army acting through the CE (Section 103) to establish ocean disposal permit programs for nondredged and dredged materials, respectively. Title I also requires EPA to establish criteria, based on those factors listed in Section 102(a), for the review and evaluation of permits under the EPA and CE permit program. In addition, Section 102(c) of Title I authorizes EPA, considering criteria established pursuant to Section 102(a), to designate recommended ocean disposal sites or times for dumping of nondredged and dredged material.

Corps of Engineers National Purpose and Need

Section 103 of Title I requires the CE to consider in its evaluation of Federal projects and 103 permit applications the effects of ocean disposal of dredged material on human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. As part of this evaluation, consideration must be given to utilizing, to the extent feasible, ocean disposal sites designated by the EPA pursuant to Section 102(c). Since 1977, the CE has used those ocean disposal sites designated by EPA on an interim basis. Use of these interim designated sites for ocean disposal has been an essential element in the CE's compliance with the requirements of the MPRSA and its ability to carry out its statutory responsibility for maintaining the nation's navigable waterways. To continue to maintain the nation's waterways, the CE considers it essential that environmentally acceptable ocean disposal sites be identified, evaluated, and permanently designated for continued use pursuant to Section 102(c). These sites will be used after review of each project has established that the proposed ocean disposal of dredged material is in compliance with the criteria and requirements of EPA and CE regulations.

CORPS OF ENGINEERS LOCAL NEED

The Columbia River is the largest river on the west coast of North America and the tenth-largest shipping port in the United States. The river system provides approximately 270 nmi of navigable waters for commercial vessels, supports large shipping commerce (approximately 44 million tons per year) (PNRBC, 1979), and provides access to one of the major commercial and sport fisheries in the United States (valued at approximately $27 million per year) (State of Washington, 1980; Rompa et al., 1979). Consequently, substantial portions of Oregon and Washington are economically dependent on maintaining a safe shipping channel through the Mouth of the Columbia River.

Each year the Columbia River entrance channel must be dredged because natural processes cause it to shoal. Due to the severity of winter storms, dredging in MCR is attempted only from mid-April to mid-October. Approximately 6 million yd^3 of material are dredged annually from the Columbia River entrance channel, and no reasonable land locations are available to receive this quantity of material. State and Federal resource agencies have requested the Corps of Engineers (CE) use ocean sites for the disposal of materials dredged from the Mouth of the Columbia River for purposes of beach nourishment and protection of estuarine wetlands.

EPA'S PURPOSE AND NEED

As previously stated, the CE has indicated a need for locating and designating environmentally acceptable ODMDS's to carry out its responsibilities under the MPRSA and other Federal statutes. Therefore, in response to the CE's stated need, EPA, in cooperation with the CE, has initiated the necessary studies pursuant to the requirements of 40 CFR 228.4(e) to select, evaluate, and possibly designate the most suitable sites for the ocean disposal of dredged material. This document has been prepared to provide the public and decisionmakers with relevant information to assess the impacts associated with the final designation for one of the sites proposed for final designation, the Columbia River ODMDS. It is not anticipated that the CE will conduct any further environmental studies with respect to the selection of this site.

INTERIM DUMPING SITES

On 11 January 1977, EPA promulgated final Ocean Dumping Regulations and Criteria to implement MPRSA. The Regulations set forth criteria and procedures for the selection and designation of ocean diposal sites. In addition, the regulations designated 129 ocean sites for the disposal of dredged material to allow the CE to fully comply with the purpose and procedural provisions of the MPRSA. These site could be used for an interim period by the CE, pending completion of site designation studies as required by the Regulations. Use of the interim-designated sites by the CE would be dependent on compliance with the requirements and criteria contained in EPA's Ocean Dumping Regulations and Criteria.

Those sites given interim designation were selected by EPA in consultation with the CE, with the size location of each site based on historic use. The interim designation would remain in force for a period not to exceed

3 years from the date of the final promulgation of the Regulations. However, due to the length of time required to complete the necessary environmental studies and operating restraints of both a technical and budgetary nature, environmental studies were not completed within the approved 3-year period. As a result, the Regulations were amended in January 1980 to extend the interim designation for those sites currently under study for a period not to exceed 3 years, while the remaining sites' interim status was extended indefinitely pending completion of studies and determination of the need for continuing use.

SITE STUDIES

In mid-1977, EPA by contract initiated environmental studies on selected nondredged material disposal sites. The studies were designed to characterize the sites' chemical, physical, and biological features and to provide the data needed to evaluate the suitability of each site for continuing use. All studies are being conducted in accordance with the appropriate requirements of Part 228 of the EPA Ocean Dumping Regulations and Criteria. Results of these studies are being used in the preparation of an EIS for each site where such a statement is required by EPA policy. The CE, to assist EPA in its national program for locating and designating suitable sites for the ocean disposal of dredged materials, agreed in 1979 to join the contract effort by providing funds for field surveys to collect and analyze baseline data. Data from each field survey and other relevant information are being used by EPA in the disposal site evaluation study and EIS to ascertain the acceptability of an interim site and/or other site(s) for final designation. In addition to providing funds, the CE agreed to further assist EPA by providing technical review and consultation.

The EPA, in consultation with the CE, selected 25 areas containing 59 interim designated ODMDS's for study under the EPA contract. Regional priorities and possible application of the data to similar areas were considered in this selection process. For some selected areas, an adequate data base was found to exist; consequently, field studies for these areas were considered unnecessary for disposal site evaluation studies. For the remaining selected areas, it was determined that surveys would be required for an adequate data base to characterize the areas' physical, chemical, and biological features and to determine the suitability of a site(s) in these areas for permanent designation. Field surveys were initiated in early 1979 and were completed in mid-1981.

The studies are directed to the evaluation of ocean disposal sites for the disposal of dredged material in an area. Based on the data from the disposal site evaluation study and other relevant information, an EIS will be prepared for each of the 25 selected areas. These EIS's only address those issues germane to the selection, evaluation, and final designation of environmentally acceptable ODMDS's. As a result, the data and conclusions contained in Chapters 2, 3, and 4 are limited to those significant issues relevant to site designation; e.g., analyses of impacts on site and adjacent area from the disposal of dredged material. Non-ocean disposal alternatives (e.g., upland, beach nourishment) are not addressed in the EIS's since site designation is independent of individual project disposal requirements. However, in the event that non-ocean disposal alternatives have been previously addressed, a summary of the results and conclusion is included in Chapter 2.

Site Designation

In accordance with the EPA's Ocean Dumping Regulations and Criteria, site designation will be by promulgation through formal rulemaking. The decision by EPA to designate one or more sites for continuing use will be based on appropriate Federal statutes, disposal site evaluation study, EIS, supporting documentation and public comments on the Draft EIS, Final EIS, and the public notice issued as part of the proposed rulemaking.

In the event that one or more selected areas are deemed suitable for final designation, it is EPA's position that the site designation process, including the disposal site(s) evaluation study and the development of the EIS, fulfill all statutory requirements for the selection, evaluation, and designation of an ODMDS.

The EIS and supporting documents provide the necessary information to determine whether the proposed site(s) is suitable for final designation. In the event that an interim designated site is deemed unacceptable for continuing use, the site's interim designation will be terminated and either the no action alternative will be selected (no site will be designated) or an alternative site(s) will be selected/designated. Furthermore, final site designation infers only EPA's determinations that the proposed site is suitable for the disposal of dredged material. Approval for use of the site will be determined only after review of each project to ensure that the proposed ocean disposal of dredged material is in compliance with the criteria and requirements of EPA and CE regulations.

LEGISLATION AND REGULATION BACKGROUND

Federal Legislation

Despite legislation dating back almost 100 years for the control of disposal into rivers, harbors, and coastal waters, ocean disposal of dredged material was not specifically regulated in the United States until passage of the MPRSA in October 1972. The first limited regulation was provided by the Supervisor of New York Harbor Act of 1888, which empowered the Supervisor (a U.S. Navy line officer) to prevent the illegal deposit of obstructive and injurious materials in New York Harbor, its adjacent and tributary waters, and Long Island Sound. In 1952, an amendment provided that the Secretary of the Army appoint a Corps of Engineers officer as Supervisor and, since that date, each New York District Engineer has automatically become the Supervisor of the Harbor. In 1958, an amendment extended the act to apply to the harbors of Hampton Roads, Virginia, and Baltimore, Maryland. Under the 1888 Act, the Supervisor of the Harbor established sites in the Hudson River, Long Island Sound, and Atlantic Ocean for dumping certain types of materials. Further limited regulation was provided by the River and Harbor Act of 1899, which prohibited the unauthorized disposal of refuse into navigable waters (Section 13) and prohibited the unauthorized obstruction or alteration of any navigable water (Section 10).

The Fish and Wildlife Coordination Act was passed in 1958. Its purpose was "...to provide that wildlife conservation shall receive equal

consideration and be coordinated with other features of water-resource development programs..." The law directed that water-resource projects, including channel deepening, be performed **"with a view to the conservation of wildlife resources by preventing loss of and damage to such resources..."** This was a first step towards concern for ocean areas. After the passage of this law, the CE (backed by judicial decisions) could refuse permits if the dredging or filling of a bay or estuary would result in significant unavoidable damage to the marine ecosystem.

Passage of the National Environmental Policy Act (NEPA) of 1969 (PL 91-190, 42 USC Parts 4321-4347, 1 January 1970) reflected public concern over the environmental effects of man's activities. Subsequently, particular attention was drawn to the effects of dredged materials by the River and Harbor Act of 1970 (PL 91-611). This act initiated a comprehensive nationwide study of dredged material disposal problems. Consequently, the CE established the Dredged Material Research Program (DMRP) in 1973, a 5-year, $30-million research effort. Objectives were (1) to understand why and under what conditions dredged material disposal might result in adverse environmental impacts, and (2) to develop procedures and disposal options to minimize adverse impacts (CE, 1977).

Two important acts were passed in 1972 that specifically addressed the control of waste disposal in aquatic and marine environments: (1) the Federal Water Pollution Control Act Amendments (FWPCA), later amended by the Clean Water Act of 1977, and (2) the MPRSA. Section 404 of the FWPCA established a permit program, administered by the Secretary of the Army acting through the Chief of Engineers, to regulate the discharge of dredged material into the waters of the United States (as defined at 33 CFR §323.2[a]). Permit applications are evaluated using guidelines jointly developed by EPA and the CE. Section 404(c) gives the EPA Administrator authority to restrict or prohibit dredged material disposal if the operation will have unacceptable adverse effects on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding grounds), wildlife, or recreational areas. Procedures to be used by EPA in making such a determination are found at 40 CFR Part 231.

MPRSA regulates the transportation and ultimate dumping of materials in ocean waters. The Act is divided into three parts: Title I--Ocean Dumping, Title II--Comprehensive Research on Ocean Dumping, and Title III--Marine Sanctuaries. This EIS is concerned only with Title I of the Act.

Title I, the primary regulatory section of MPRSA, establishes the permit program for the disposal of dredged and nondredged materials, mandates determination of impacts and alternative disposal methods, and provides for enforcement of permit conditions. The purpose of Title I is to prevent or strictly limit the dumping of materials that would unreasonably affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. Title I of the Act provides procedures for regulating the transportation and disposal of materials into ocean waters under the jurisdiction or control of the United States. Any person of any nationality wishing to transport waste material from a U.S. port, or from any port under a U.S. flag, to be dumped anywhere in the oceans of the world, is required to obtain a permit.

Title I prohibits the dumping into ocean waters of certain wastes, including radiological, biological, or chemical warfare agents, and all high-level radioactive wastes. In March 1974, Title I was amended (PL 93-253) to bring the Act into full compliance with the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, discussed below under "International Considerations." The provisions of Title I include a maximum criminal fine of $50,000 and jail sentence of up to one year for every unauthorized dump or violation of permit requirements, or a maximum civil fine of $50,000. Any individual may seek an injunction against an unauthorized dumper with possible recovery of all costs of litigation.

FEDERAL CONTROL PROGRAMS

Several Federal departments and agencies participate in the implementation of MPRSA requirements, with the lead responsibility given to EPA (Table 1-1). In October 1973, EPA implemented its responsibility for regulating ocean dumping under MPRSA by issuing the Final Ocean Dumping Regulations and Criteria, which were revised in January 1977 (40 CFR Parts 220-229). The Ocean Dumping Regulations established the procedures and criteria to apply for dredged material permits (Part 225), enforce permit conditions (Part 226), evaluate permit applications for environmental impact (Part 227), and designate and manage ocean disposal sites (Part 228).

Ocean Dumping Evaluation Procedures

The Ocean Dumping Regulations specify the procedures for evaluating the effects of dredged material disposal. The EPA and CE evaluate Federal projects and permit applications for non-Federal projects to determine (1) whether there is a demonstrated need for ocean disposal and that other environmentally sound and economically reasonable alternatives do not exist (40 CFR Part 227 Subpart C), and (2) compliance with the environmental impact criteria (40 CFR Part 227 Subparts B, D, and E). Figure 1-3 outlines the cycle used to evaluate the acceptability of dredged material for ocean disposal.

Under Section 103 of MPRSA, the Secretary of the Army is given the authority, with certain restrictions, to issue permits for the transportation of material dredged from non-CE projects for ocean disposal. For Federal projects involving dredged material disposal, Section 103(e) of MPRSA provides that **"the Secretary [of the Army] may, in lieu of the permit procedure, issue regulations which will require the application to such projects of the same criteria, other factors to be evaluated, the same**

TABLE 1-1
RESPONSIBILITIES OF FEDERAL DEPARTMENTS AND AGENCIES
FOR REGULATING OCEAN DISPOSAL UNDER MPRSA

Department/Agency	Responsibility
U.S. Environmental Protection Agency	Issuance of waste disposal permits, other than for dredged material Establishment of criteria for regulating waste disposal Enforcement actions Site designation and management Overall ocean disposal program management Research on alternative ocean disposal techniques
U.S. Department of the Army Corps of Engineers	Issuance of permits for transportation of dredged material for disposal Recommendation of disposal site locations
U.S. Department of Transportation Coast Guard	Surveillance Enforcement support Issuance of regulations for disposal vessels Review of permit applications
U.S. Department of Commerce National Oceanic and Atmospheric Administration	Long-term monitoring and research Comprehensive ocean dumping impact and short-term effect studies Marine sanctuary designation
U.S. Department of Justice	Court actions
U.S. Department of State	International agreements

procedures, and the same requirements which apply to the issuance of permits..." for non-Federal dredging projects involving disposal of dredged material. Consequently, both Federal and non-Federal dumping requests undergo identical regulatory reviews. The only difference is that, after the review and approval of the dumping request, non-Federal projects are issued an actual permit. The CE is responsible for evaluating disposal applications and granting permits to dumpers of dredged materials; however, dredged material disposal sites are designated and managed by the EPA Administrator or his designee. Consequently, dredged material generated by Federal and non-Federal projects must satisfy the requirements of the MPRSA (as detailed in the Ocean Dumping Regulations) to be acceptable for ocean disposal.

Environmental Impact Criteria

Section 103(a) of the MPRSA states that dredged material may be dumped into ocean waters after determination that **"the dumping will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, or ecological systems, economic potentialities."** This applies to the ocean disposal of dredged materials from both Federal and non-Federal projects. To ensure that ocean dumping will not unreasonably degrade or endanger public health and the marine environment, the Ocean Dumping Regulations restrict the transportation of all materials for dumping, specifically:

- Prohibited materials: High-level radioactive wastes; materials produced or used for radiological, chemical, or biological warfare; materials insufficiently described to apply the Criteria (40 CFR Part 227); and persistent inert synthetic or natural materials which float or remain suspended and interfere with fishing, navigation, or other uses of the ocean.

- Constituents prohibited as other than trace contaminants: Organohalogens; mercury and mercury compounds; cadmium and cadmium

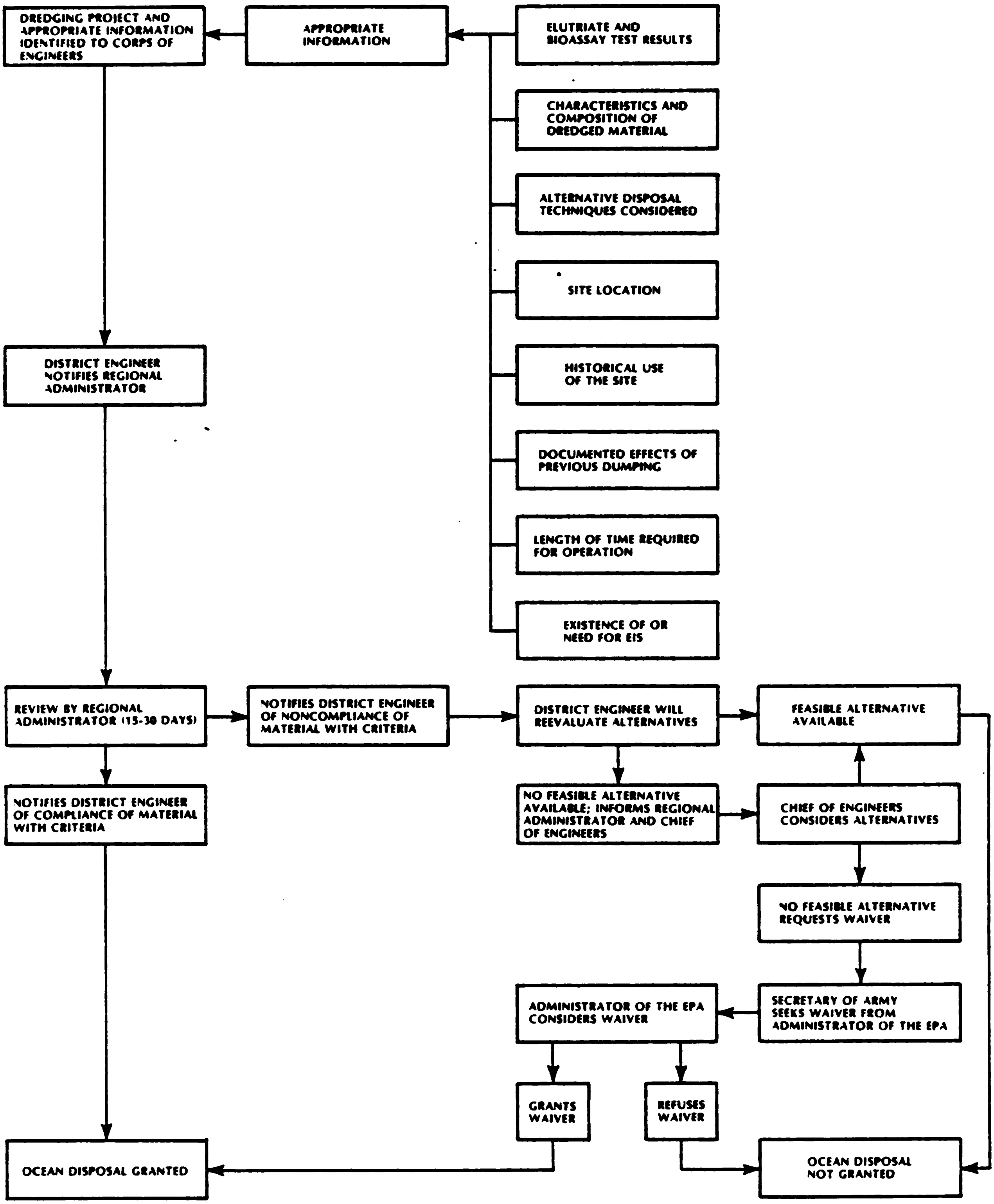

Figure 1-2. Dredged Material Evaluation Cycle

compounds; oil; and known or suspected carcinogens, mutagens, or teratogens.

- Strictly regulated materials: Liquid waste constituents immiscible with or slightly soluble in seawater (e.g., benzene), radioactive materials, wastes containing living organisms, highly acidic or alkaline wastes, and wastes exerting an oxygen demand.

Dredged material is environmentally acceptable for ocean disposal without further testing if it satisfies any one of the following criteria:

- **Dredged material is composed predominantly of sand, gravel, rock, or any other naturally occurring bottom material with particle sizes larger than silt, and the material is found in areas of high current or wave energy...**

- **Dredged material is for beach nourishment or restoration and is composed predominantly of sand, gravel, or shell...**

- **When: (i) the material proposed for dumping is substantially the same as the substrate at the proposed disposal site; and (ii) the [proposed dredging] site...is far removed from known existing and historical sources of pollution so as to provide reasonable assurance that such material has not been contaminated by such pollution. (40 CFR §227.13[b])**

If dredged material does not meet the above criteria, then further testing of the liquid, suspended particulate, and solid phases is required. The Ocean Dumping Regulations require that the liquid phase **"not contain...constituents in concentrations which will exceed applicable marine water quality criteria after allowance for initial mixing"** (40 CFR §227.6), and that **"bioassays on the liquid phase of the dredged material show that it can be discharged so as not to exceed the limiting permissible concentration..." (40 CFR §227.13).**

The suspended particulate and solid phases must be tested using bioassays which can demonstrate that dredged materials will not cause the **"occurrence of significant mortality or significant adverse sublethal effects including bioaccumulation due to the dumping..."** (40 CFR §227.6) and that the dredged material **"can be discharged so as not to exceed the limiting permissible concentration..."** (40 CFR §227.13) The bioassays ensure that **"no significant undesirable effects will occur due either to chronic toxicity or to bioaccumulation."** (40 CFR §227.6) The required testing ensures that dredged material contains only constituents which are:

> (1) **present in the material only as chemical compounds or forms (e.g., inert insoluble solid materials) non-toxic to marine life and non-bioaccumulative in the marine environment upon disposal and thereafter, or (2) present in the material only as chemical compounds or forms which, at the time of dumping and thereafter, will be rapidly rendered non-toxic to marine life and non-bioaccumulative in the marine environment by chemical or biological degradation in the sea; provided they will not make edible marine organisms unpalatable; or will not endanger human health or that of domestic animals, fish, shellfish, or wildlife.** (40 CFR §227.6)

Permit Enforcement

Under MPRSA, the Commandant of the U.S. Coast Guard (USCG) is assigned responsibility by the Secretary of Transportation to conduct surveillance of disposal operations to ensure compliance with the permit conditions and to discourage unauthorized disposal. Alleged violations are referred to EPA for appropriate enforcement. Civil penalties include a maximum fine of $50,000; criminal penalties involve a maximum fine of $50,000 and/or a 1-year jail term. Where administrative enforcement action is not appropriate, EPA may request the Department of Justice to initiate relief actions in court for violations of the terms of MPRSA. Surveillance is accomplished by means of spot checks of disposal vessels for valid permits, interception or escorting of dump vessels, use of shipriders, and aircraft overflights during dumping.

The Commandant of the Coast Guard has published guidelines for ocean dumping surveillance and enforcement in Commandant Instruction 16470.2B, dated 29 September 1976. An enclosure to the instruction is an Interagency Agreement between the CE and the USCG regarding surveillance and enforcement responsibilities over federally contracted ocean dumping activities associated with Federal Navigation Projects. Under the agreement, the CE **"recognizes that it has the primary surveillance and enforcement responsibility over these activities."** The CE directs and conducts the surveillance effort over CE contract dumpers engaged in ocean disposal activities, except in New York and San Francisco; the USCG retains primary responsibility for surveillance in these two areas. In all other areas, the USCG will respond to specific requests from the CE for surveillance missions. The USCG retains responsibility for surveillance of all dredged material ocean dumping activities which are not associated with Federal Navigation Projects.

Ocean Disposal Site Designation

EPA is conducting studies of various disposal sites in order to determine their acceptability. The Agency has designated a number of existing disposal sites for use on an interim basis until studies are completed and formal designation or termination of each site is decided (40 CFR §228.12, as amended 16 January 1980, 45 FR 3053).

Under Section 102(c) of MPRSA, EPA is authorized to designate sites and times for ocean disposal of acceptable materials. Therefore, EPA established criteria for site designation in the Regulations. These include general and specific criteria for site selection and procedures for designating the sites for disposal. If it appears that a proposed site can satisfy the general criteria, then the specific criteria for site selection will be considered. Once designated, the site may be monitored for adverse disposal impacts. The criteria site selection and monitoring are detailed in Chapter 2.

INTERNATIONAL CONSIDERATIONS

The principal international agreement governing ocean dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention), which became effective in August 1975, upon ratification by 15 contracting countries including the United States (26 UST 2403: TIAS 8165). There are now 44 contracting parties. Designed to control dumping of wastes in the ocean, the Convention specifies that contracting nations will regulate disposal in the marine environment with their jurisdiction and prohibit disposal without permits. Certain hazardous materials are prohibited (e.g., radiological, biological, and chemical warfare agents, and high-level radioactive matter). Certain other materials (e.g., cadmium, mercury, organohalogens and their compounds; oil; and persistent, synthetic or natural materials which float or remain in suspension) are also prohibited as other than trace contaminants. Other materials (e.g., arsenic, lead, copper, zinc, cyanides, fluorides, organosilicon, and pesticides) are not prohibited from ocean disposal, but require special care. Permits are required for ocean disposal of materials not specifically prohibited. The nature and quantities of all ocean-dumped material, and the circumstances of disposal, must be periodically reported to the Inter-Governmental Maritime Consultative Organization (IMCO) which is responsible for administration of the Convention.

U.S. ocean dumping criteria are based on the provisions of the London Dumping Convention (LDC) and include all the considerations listed in Annexes I, II, and III of the LDC . Agreements reached under the LDC also allow exclusions from biological testing for dredged material from certain locations. These agreements are also reflected in the U.S. ocean dumping criteria. Thus, when a material is found to be acceptable for ocean dumping under the U.S. ocean dumping criteria, it is also acceptable under the LDC.

By taking no action the present ocean sites would not receive final designations, nor would an alternative ocean disposal site be designated. Consequently, the CE would not have an EPA-recommended ocean disposal site available in the area, thus precluding ocean dumping as a disposal method for dredged material. The CE would be required to (1) justify an acceptable alternative disposal method (e.g., land-based or estuarine disposal), (2) develop information sufficient to select an acceptable ocean site for disposal, or (3) modify or cancel a proposed dredging project that depends on disposal in the ocean as the only feasible method for the disposal of dredged material. The no-action alternative is not considered to be acceptable.

NON-OCEAN DISPOSAL

Both land disposal and in-water, estuarine disposal methods are presently used for materials dredged from the Columbia River Estuary (CE, 1975). However, while evaluating the need to dump MCR dredged materials in ocean disposal sites, the CE assessed and rejected the land disposal alternative for economical and technical reasons (Heineman, 1980)*. The Columbia River Estuary Regional sl2agement Plan (McColgin, 1979) also recognized the limited capacity and greater economic costs associated with upland disposal of MCR dredged materials, and recommended ocean disposal in lieu of land disposal. During the development of the Dredged Material Management Plan (DMMP), "...shoreland sites were identified, and it was soon apparent that sites that would meet environmental and economic standards are not of sufficient capacity to provide for disposal needs over the next 20 years" (p. v-2). The DMMP concluded that "[t]he materials at the MCR are clean sands and do not require pumping ashore to avoid pollution. Unless an economic demand for material offsets the additional costs realized by pumping ashore, pumping will probably not be used during the 20-year study time" (55.11, p. v-14). Consequently, land disposal is not considered a viable alternative at this time.

*A.J. Heineman; U.S. Army Corps of Engineers, Portland District (personal communication)

Chapter 2

ALTERNATIVES INCLUDING THE PROPOSED ACTION

Alternative choices of suitable sites for ocean disposal of dredged material from the entrance channel of the Columbia River are discussed herein. The 11 site criteria listed at 40 CFR §228.6 are the bases for comparing the environmental impacts associated with disposal at each site. Minor environmental impacts resulting from disposal of dredged material at the Mouth of the Columbia River Dredged Material Disposal Sites consist of temporary mounding, disturbance of benthic organisms, reductions in fish abundances, and slight changes in sediment texture. Since little is currently known about the biota at the Astoria Canyon Alternative Site, predictions about the potential environmental impacts of dredged material disposal are not possible. On the basis of previous use and the absence of significant adverse impacts, EPA proposes final designation of Interim Sites A, B, E, and F.

The proposed action (described in Chapter 1) is the final designation of four MCR Interim Sites. Alternatives to the proposed action include no action and use of alternative ocean disposal sites. Alternative sites in nearshore, mid-Shelf, and Shelf-break regions are considered. Evaluations and comparisons of specific alternative disposal sites are based on the 11 specific site criteria listed at 40 CFR §228.6 (Ocean Dumping Regulations). Additional recommendations for use and monitoring of the dredged material disposal sites are discussed in this chapter.

NO-ACTION ALTERNATIVE

The no-action alternative to the proposed action would be to refrain from designating an ocean site for the disposal of dredged material from the Mouth of the Columbia River. Existing sites are currently designated on interim bases. The interim designations are scheduled to expire in February 1983 unless formal rulemaking is completed earlier which either (1) designates the interim sites for continuing use, or (2) selects and designates an alternative site.

State and Federal resource agencies have requested the CE use ocean disposal sites, in lieu of in-water, estuarine sites, for purposes of beach nourishment and protection of estuarine wetlands (Heineman, 1980; personal communication). Futhermore, the DMMP suggested "[l]ong-term use of disposal sites within the estuary should be permitted only when no alternative exists and the bio-physical impacts are minimal" (51.24, p. v-4). An estuarine disposal site is used for MCR dredged materials only when weather and wave conditions preclude use of the ocean disposal sites; the effects of using the estuarine site are presently unknown. Estuarine disposal of all MCR dredged materials is not considered a viable alternative.

The subject of land-based dispoal or any other feasible alternatives mentioned in the Ocean Dumping Regulations and Criteria (40 CFR §227.15) are not being permanently set aside in favor of ocean disposal. The need for ocean dumping must be demonstrated each time an application for ocean disposal is made. At that time the availability of other feasible alternatives must be assessed.

OCEAN DISPOSAL

Ocean Disposal of materials dredged from MCR is considered the most feasible alternative. In fact, the DMMP (McColgin, 1979; p. v-2) concluded "[o]ver the twenty-year horizon of this plan, increasing reliance will be placed on ocean disposal of [Columbia River Estuary] dredged materials."

Selection of an appropriate ocean disposal site(s) requires identification and evaluation of suitable areas for receiving the dredged sediments. Identification of these areas relies on available information obtained from previous site-specific and synoptic oceanographic research. Specific alternative (or candidate) sites may be identified within these areas based on historic and current use of the area, presence of previously used disposal sites, and recommendations from state and Federal resource agencies and the district and division offices of the CE.

SELECTION OF ALTERNATIVE SITES

General criteria used to select a dredged material disposal site are:

- "The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation."

- "Locations and boundaries of disposal sites will be so chosen that temporary perturbations in water quality...can be...reduced to normal ambient seawater levels or to undetectable contaminant concentrations or effects before reaching any beach, shoreline, marine sanctuary, or known geographically limited fishery or shellfishery."

- "The sizes of ocean disposal sites will be limited in order to localize any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long range impact."

- "...whereever feasible, designate ocean dumping sites beyond the edge of the Continental Shelf and other such sites that have been historically used." (40 CFR 228.5).

Three general ocean areas (nearshore, mid-shelf, and shelf-break) were selected as representative areas in which an ODMDS could be located. These areas were selected because of their range in depths and distances from shore. The suitability of these areas for the disposal of dredged material was subjected to general evaluations. The results of these evaluations are presented below.

NEARSHORE SITES

The nearshore zone within 5 nmi from shore and with depths shallower than 40m is a highly dynamic area influenced by tides, longshore currents, waves, and

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river discharges. Nearshore sediments consist of medium- to fine-grained beach sands and Columbia River bedload materials, with some river-derived silts. Concentrations of nutrients and trace elements are affected by tides, river discharges, upwelling, and biological activity. Biological communities are also affected locally by river discharge; benthic assemblages near the river mouth have relatively higher densities and diversity than other nearshore areas along the Oregon-Washington coast (Boone et al., 1978).

Commercial fishing activities are prevalent in the nearshore zone for a number of seasonal and anadromous species, including salmonids, smelt, shad, and dungeness crabs (CE, 1975). Several other finfish and shellfish species are taken year-round by recreational fisherman (Squire and Smith, 1977). Commercial shipping and recreational boating activities also occur throughout the river mouth and adjacent nearshore areas.

The MCR Interim Sites A, B, and F have been used since 1957, and Site E since 1973. In 1974 the CE Dredged Material Research Program (DMRP) investigated the effects of dumping dredged materials at the MCR Interim Sites. Result of the DMRP are discussed in Chapters 3 and 4. Since the MCR Interim Sites have been used previously, and impacts on dumping on the nearshore environment have been elucidated by the DMRP, the advantages and disadvantages of using the sites are relatively well known.

One other nearshore site, Interim Site G, was used once by the CE in 1976 on an experimental basis. Since site G has not been used since 1976, there is no demonstrable need for its continued use at this time. There are no indications that significant changes in the impact on the nearshore ecosystem would occur if nearshore sites other than MCR Interim Site A, B, E, and F were used for dredged material disposal. The advantages and disadvantages associated with use of Sties A, B, E, and F (discussed below) are considered representative of the effects that would result from use of other areas in the nearshore region.

Advantages of dumping at the MCR Interim Sites include:

- The sites have been used previously and the effects of dumping are predictable

- Clean sands dumped at Site E may be available for nourishment of adjacent coastal beaches

- Physical and chemical similarities between the dredged and extant sediments minimize adverse impacts of biota

- Surveillance and monitoring are facilatated because the sites are close to shore and in relatively shallow water

- Use of the MCR Interim Sites is significantly more cost effective

Impacts associated with use of the MCR Interim Sites are:

- Temporary mounding

- Smothering of some benthic organisms

- Temporary decrease in abundance and diversity of finfish

- Potential return of some dredged materials into the estuary

- Minor interferences with demersal fisheries and commercial and recreational navigation

Impacts associated with use of a mid-Shelf site are:

- No dumping has previously occurred in the mid-Shelf
- Dredged materials are coarser than existing sediments
- Smothering of some benthic organisms would occur
- Interferences with demersal finfish and shellfish fisheries are probable
- Transit times and distances are greater, thus dredging costs are appreciably higher
- Beach nourishment is precluded
- Monitoring and surveillance are more difficult due to increased depths and distance from shore

SHELF-BREAK SITE

The Shelf-break occurs at a depth of 165m, from 10 to 30 nmi from shore. Astoria Canyon provides an accessible Shelf-break disposal site within 16.5 nmi of the mouth of the Columbia River, and with water depths greater than 500m. The Astoria Canyon environment is probably more dynamic than either the adjacent Shelf or Slope. Although few data are available, appreciable water and sediment movement within the Canyon may be due to internal waves and turbidity currents (Carlson and Nelson, 1969). Bottom sediments consist mainly of fine sands with silts and clay (ibid.). Chemical and biological features of Astoria Canyon have not been previously described.

Astoria Canyon does not support existing bottom fisheries, or commercial and recreational navigation. Several potentially important commercial finfish and shellfish species have been captured at similar depths in adjacent Slope regions, however, and may also occur within the Canyon.

Multiple sites are needed to facilitate disposal activities when more than one hopper dredge is available, and to accommodate larger volumes of dredged materials (Heineman, 1980; personal communication). Future navigational safety, or the effects of catastrophic events (e.g., the eruption of Mount St. Helens), may necessitate expanded dredging efforts. Continued use of the MCR Sites would permit optimal utilization of a restricted dredging season and increased flexibility in disposal site selection, depending on weather conditions, fishing vessel traffic, sediment accumulation, and the number of hopper dredges working in the entrance channel.

MID-SHELF SITES

Off the Oregon and Washington coasts the mid-Shelf zone extends from approximately 5 nmi to 20 nmi offshore. The mid-Shelf environment is characteristically more stable than the nearshore regime, but is influenced by storm waves, seasonal upwelling, and circulation patterns, and, to a lesser extent, by discharge from the Columbia River. Sediments are typically fine-grained sands mixed with organically rich muds (Kulm et al., 1975). Chemical processes are influenced by upwelling, biological activity, river discharge, and surface wind and wave mixing (Stefannson and Richards, 1964). The benthic biomass in the mid-Shelf is generally higher than in nearshore or outer-Shelf regions. The density of the mid-Shelf benthos is also relatively greater than in nearshore areas because both the organic content and stability of sediments are higher (Carey, 1972).

The Shelf region supports valuable commercial bottom and shrimp fisheries, which extend from approximately 3 to 40 nmi and 10 to 25 nmi offshore, respectively (Rompa et al., 1979; Pruter, 1972). Recreational fishing and boating, commercial navigation, and other activities are not as prevalent in the mid-Shelf as the nearshore region.

The advantage of using a mid-Shelf disposal site is:

- Dredged materials are more permanently removed from the nearshore regime, and therefore less available for transport back into the river.

Advantages of using the Astoria Canyon Site are:

- Dredged materials are permanently removed from the nearshore regime
- Nearshore and Shelf fisheries would be less affected by dredged material disposal.
- Interferences with navigation are minimal

Disadvantages of using Astoria Canyon are:

- Increased transit times significantly increase dredging costs
- Little is known about the Canyon ecology or the potential impacts of dumping
- No dumping has occurred previously
- Dredged sands are unavailable for beach nourishment
- Surveillance and monitoring are difficult because of extended distance from shore and greater water depths

SITES DROPPED FROM FURTHER CONSIDERATION

Based on the foregoing evaluations, the following areas were eliminated from further consideration for the designation of an ODMDS at this time.

- Nearshore areas other than the four MCR Interim DMDS
- Mid-Shelf region
- Shelf-break areas other than Astoria Canyon

Use of nearshore areas other than Sites A, B, E, and F, including Interim Site G which has been historically used, would not significantly ameliorate the present impact of dumping on the nearshore environment. The Portland District of the CE, in cooperation with the Washington Soil Conservation Service, is currently assessing the feasibility of beach nourishment/sand stabilization sites for the future disposal of MCR dredged materials. However, until the specific site locations and disposal volumes are identified by the CE and Soil Conservation Service, the environmental and economic consequences of using nourishment sites cannot be adequately assessed. Therefore, use of nearshore sites other than MCR Interim Sites A, B, E, and F is not recommended.

Dredged material disposal has not occurred previously within the mid-shelf region. Relative to use of the MCR Interim Sites, no significant reduction in potential interferences with commercial fisheries or disturbances of benthic communities would occur. Dredged materials would be unavailable for beach nourishment, and the necessitated increases in dredging costs would be significant. The disadvantages of using the mid-Shelf site appreciably outweigh the advantages. For these reasons, dredged material disposal in the mid-Shelf region is not recommended.

Dredged material disposal in Shelf areas shallower than 500m may interfere with fisheries resources (Pequegnat, 1978). Astoria Canyon is a Shelf-break environment, relatively close to MCR, providing bottom depths greater than 500m, and therefore potentially suitable as a site for dredged material disposal. Other areas beyond the Shelf are not recommended as ocean dumping sites because, relative to Astoria Canyon, no significant environmental benefits are accrued, and greater transit distances, time, and expense are required.

SITES CONSIDERED IN DETAIL

Alternative disposal sites considered in greater detail (evaluated with the 11 criteria) are as follows:

- Interim Sites - MCR Dredged Material Disposal Sites A, B, E, and F; within 5 nmi of the entrance channel, with a total area of approximately 1 nmi^2

- Astoria Canyon Site - 16.5 nmi from the entrance channel, and immediately seaward of the 500m isobath. A 1 nmi^2 area would be suitable for present dredged material disposal volumes.

Final site(s) selection was based on comparisons between the Interim (Mouth of the Columbia River DMDS) and the Alternative (Astoria Canyon) Sites, using the 11 criteria listed at §228.6 of the Ocean Dumping Regulations. The 11 criteria constitute **"an environmental assessment of the impact of the use of the sites for disposal."** Information contained in Chapters 3 and 4 is utilized in the following discussions for comparisons of the sites under each criteria.

GEOGRAPHICAL POSITION, DEPTH OF WATER, BOTTOM TOPOGRAPHY, AND DISTANCE FROM COAST (40 CFR §228.6[1])

MCR INTERIM SITES

The boundary coordinates of the MCR Interim Sites are identified in Chapter 1. The MCR Interim Sites are all within 5 nmi of the entrance channel of the Columbia River (Figure 2-1). Site specific information is described in greater detail in Chapter 3. Water depths of the three sites range from 18 to 40m. The bottom topography of the nearshore MCR region is characterized by a northward trending tidal delta and a mound within Site B composed of previously disposed dredged materials (Boone et al., 1978).

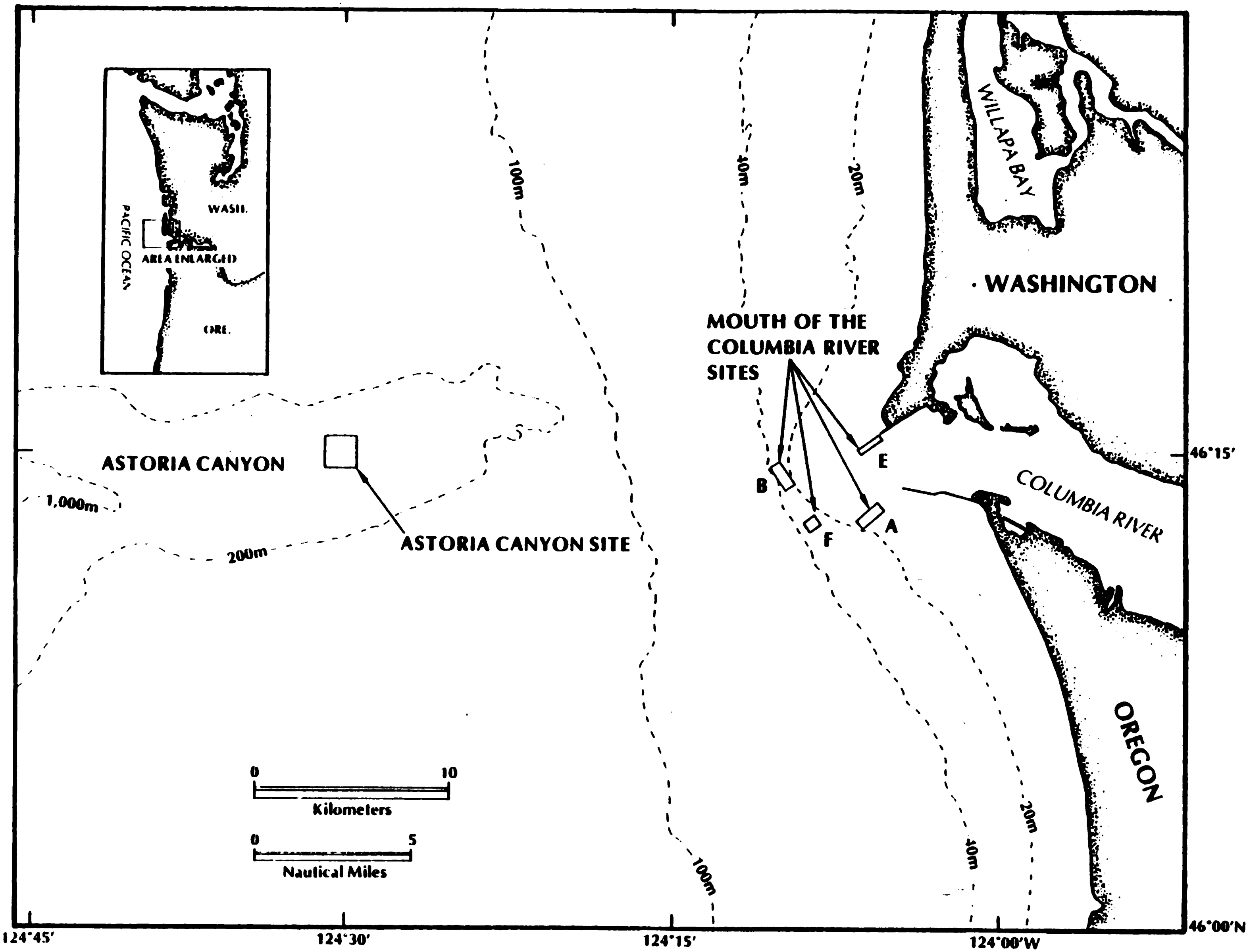

Figure 2-1. Locations of Alternative Dredged Material Disposal Sites

ASTORIA CANYON SITE

The generalized Astoria Canyon Site (Figure 2-1) is 16.5 nmi from the entrance channel, in water depths ranging from approximately 500 to 550m. The site overlies the axis of the Canyon, which is oriented in a west-southwest direction; the upper Canyon has a U-shaped profile (Nelson et al., 1970).

LOCATION IN RELATION TO BREEDING, SPAWNING, NURSERY, FEDDING, OR PASSAGE AREAS OF LIVING RESOURCES IN ADULT AND JUVENILE PHASES (40 CFR §228.6[2])

MCR INTERIM SITES

Breeding, spawning, nursery, and passage activities of commercially important finfish and shellfish species all occur on a seasonal basis close to MCR. The spawning season of the dungeness crab (*Cancer magister*) is from December to April (Morris et al., 1980), and during the DMRP few crab larvae were evident in the plankton after March (Holton and Small, 1978). Therefore, the probability that dredged material disposal at MCR will interfere with *C. magister* larval survival is small. Due to the mobility of finfish, it is unlikely that disposal operations will interfere with the migrations of commercially important anadromous species (e.g., salmonids) (CE, 1975).

Twenty years of dumping at the MCR has not caused significant or irresistable impacts on living resources. The effects of disposal at MCR on demersal fish are apparent temporary decreases in abundance, numbers of species, mean size, and a change in food preference; "...deposition at Sites B [DMDS] and C [DMDS F] in prior years revealed no apparent lasting effect on the diversity and number of finfish" (Durkin and Lipovsky, 1977; p. 14). The feeding, breeding, and migratory activities of marine mammals are not significantly affected by dredged material disposal in the MCR area.

ASTORIA CANYON SITE

No site-specific biological information exists for the Astoria Canyon Site, and no commercial or recreational fishing occurs within the area. Some submarine canyons are known to be spawning grounds for certain fish and squid species (Pequegnat, 1978). Whether Astoria Canyon is used as a spawning and nursing ground is not presently known. The Canyon may provide a habitat for sablefish, Pacific hake, dover sole, Pacific ocean perch, and other potentially important commercial fish species (Pequegnat, 1978). Effects of dredged material disposal on the biota are not known.

<u>LOCATION IN RELATION TO BEACHES AND OTHER AMENITY AREAS</u> (40 CFR §228.6[3])

MCR INTERIM SITES

All of the Interim Sites are close to shore, but only sediment dumped at Site E is likely to reach adjacent beaches. Sediments with median diameters 0.18 mm (e.g., dredged sediments from the entrance channel) may be transported as bedload during winter storms (Borgeld et al., 1978). However, net sediment transport from Sites A, B, and F is northward and generally parallel to the isobaths, at rates of 0.25 nmi/yr (Sternberg et al., 1977; Borgeld et al., 1978). Therefore, sediments dumped at Sites A, B, or F are not likely to be transported onto adjacent beaches. The fate of dredged sediments released at Site E is unknown; however, northeastward transport onto Peacock Spit and adjacent beaches has been postulated (Borgeld et al., 1978; CE, unpublished data, 1980). The material is predominantly clean sand which is suitable for beach nourishment; consequently, transport of dredged materials from Site E should have beneficial effects on local beaches. Furthermore, Washington State Parks Department has requested preferential use of Site E to retard erosion of the coastal beaches (McColgin, 1979).

ASTORIA CANYON

Because Astoria Canyon is 16.5 nmi from shore, and the westward sloping bottom topography and currents would favor westward transport of sediments, dredged materials dumped at the Astoria Canyon Site would not reach coastal beaches or other amenity areas. Dredged materials would, consequently, be unavailable for beach nourishment.

TYPES AND QUANTITIES OF WASTE PROPOSED TO BE DISPOSED OF AND PROPOSED METHODS OF RELEASE, INCLUDING METHODS OF PACKAGING, IF ANY (40 CFR §228.6[4])

Dredged sediments from the main entrance channel and from entrance channels to other small harbors west of Astoria Bridge are the only materials presently dumped at the designated sites (CE, 1978). Dredged materials are 95% to 98% sand and comply with the requirements of §227.13(b). Sediments are transported by a hopper dredge equipped with a subsurface release mechanism, and are not packaged in any manner. Annual disposal volumes average 6 million yd^3.

Future dredged material volumes may exceed present volumes if the navigational safety of the entrance channel necessitates expanded dredging efforts; or if other dredged material is disposed at the site. Any, materials disposed at the sites must be within the capacity of the sites and must comply with EPA dredged material criteria in §227.13 subpart B of the Ocean Dumping Regulations (40 CFR 220 to 229).

It is anticipated that the dredged material will continue to be transported by hopper dredges equipped with a subsurface release mechanism. However, other means of transportation and release, consistent with the environmental requirements of the sites, may be utilized. None of the dredged material will be packaged in any manner.

The MCR Interim Sites are closer to the dredging sites. Their use would minimize transport time and facilitate a coordinated controlled dumping schedule. Use of the Astoria Canyon site would require additional transport time, possibly leading to the need for different equipment and disposal methods.

FEASIBILITY OF SURVEILLANCE AND MONITORING (40 CFR §228.6[5])

MCR INTERIM SITES

The U.S. Coast Guard is not currently carrying out surveillance at the MCR Interim Sites. However, due to the proximity of the MCR Interim Sites to shore, surveillance would not be difficult. Monitoring is not a problem because the sites are close to shore and in shallow water. Prior to and during annual dredging the CE surveys the entrance channel and bottom topography within the site boundaries and identifies shoaling or mounding areas.

ASTORIA CANYON

The Astoria Canyon Site would be more difficult to monitor due to the greater depth and distance, which would be critical during adverse weather conditions. If the Astoria Canyon Site is used, a predisposal survey is needed to provide baseline data.

DISPERSAL, HORIZONTAL TRANSPORT, AND VERTICAL MIXING CHARACTERISTICS OF THE AREA, INCLUDING PREVAILING CURRENT DIRECTION AND VELOCITY (40 CFR §228.6[6])

MCR INTERIM SITES

Dredged material is primarily medium- to fine-grained sand, thus rapid settling of the released sediments occurs with slight horizontal mixing or vertical stratification. Rapid settling precludes persistant changes in postdisposal suspended sediment concentration (Boone et al., 1978). Large waves and tidal currents at Site E may result in a significantly greater horizontal dispersion of released sediments relative to Sites A, B, and F.

Previous studies (Sternberg et al., 1977; Borgeld et al., 1978) have demonstrated the relative immobility of dredged sediments dumped at Sites A, B, and F. Large percentages of the dredged sediments released at these sites will remain within the boundaries of the sites; smaller proportions of dredged material move slowly (0.25 nmi/yr) northwards. Dredged materials dumped at Site E during summer are eroded during the following winter. Previous studies have indicated a probable northeasterly transport of sediments onto Peacock Spit and adjacent beaches (Borgeld et al., 1978; CE, unpublished data, 1980), althought portions of the material dumped at Site E may move eastward into the estuary (Walter et al., 1979).

ASTORIA CANYON

The great depths of Astoria Canyon would permit a greater dispersion of dredged material; however, sluggish currents would tend to minimize horizontal transport and vertical mixing. Bottom current velocities have not been determined, but may be similar to the observed 7.6 cm/s current velocities in Carmel Canyon (Shepard et al., 1974a). Down-canyon transport of bottom sediment in Astoria Canyon, due to turbidity currents, has been postulated by Carlson and Nelson (1969).

EXISTENCE AND EFFECTS OF CURRENT AND PREVIOUS DISCHARGES AND DUMPING IN THE AREA (INCLUDING CUMULATIVE EFFECTS) (40 CFR §228.6[7])

MCR INTERIM SITES

Results of the DMRP indicate that disposal of dredged material at the MCR Interim Sites causes only minor impacts: temporary localized mounding, slight changes in sediment texture, and temporary disturbance of benthic infauna and demersal finfish assemblages (Boone et al., 1978). Clean sands dredged from the high-energy entrance channel have not produced any changes in water or sediment quality at the disposal sites (Holton et al., 1978).

Sediment has accumulated within Site B at a shoaling rate of approximately 3m in 20 years. Present water depths range from 22 to 36m (Sternberg et al., 1977); therefore, shoaling does not currently present a problem to navigation. Mounds of accumulated dredged sediments tend to spread laterally and flatten under the influence of bottom currents and wave-induced turbulence (Sternberg et al., 1979).

Disturbances to infauna are caused by direct burial of sessile or slow-moving organisms. Substrate disturbances cause temporary (1 to 2 months) changes in infaunal biomass and diversity (Boone et al., 1978). Other benthic species are motile or able to withstand temporary burial (Richardson et al., 1977). Localized and temporary changes in finfish abundances may result from changes in fish food abundances (Durkin and Lipovsky, 1977). Effects on the biota are neither cumulative nor irreversible.

ASTORIA CANYON

Previous dredged material disposal has not occurred in Astoria Canyon.

<u>INTERFERENCE WITH SHIPPING, FISHING, RECREATION, MINERAL EXTRACTION, DESALINATION, FISH AND SHELLFISH CULTURE, AREAS OF SPECIAL SCIENTIFIC IMPORTANCE, AND OTHER LEGITIMATE USES OF THE OCEAN</u> (40 CRF §228.6[8])

MCR INTERIM SITES

Extensive shipping, fishing, and recreational activities, in addition to scientific investigations, take place in the vicinity of the MCR Interim Sites. Minor interferences with these activities may occur; however, dredging personnel can shift disposal operations to another site, or temporarily suspend dredging, during periods of conflict (CE, 1977b). Mineral extraction, desalination, and aquaculture activities do not presently occur in the vicinity of MCR. However, a black sand mining operation is planned for a nearshore area 4 nmi north of the North Jetty. Dredged material disposal at Site E could increase the sand overburden at the mining site, thus increasing mining costs (Vining, 1981)*.

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* R.L. Vining, Washington State Department of Natural Resources (personal communication)

ASTORIA CANYON SITE

Dredged material disposal at the Astoria Canyon Site would not interfere with shipping or fishing. Fish culture, desalination, recreation, and mineral extraction activities do not occur at Astoria Canyon.

THE EXISTING WATER QUALITY AND ECOLOGY OF THE SITE, AS DETERMINED BY AVAILABLE DATA OR BY TREND ASSESSMENT ON BASELINE SURVEYS (40 CFR §228.6[9])

MCR INTERIM SITES

The mouth of the Columbia River is a dynamic, high-energy environment. Water quality and ecology are influenced by river discharge, tides, and storm effects. Data from the DMRP suggest that the disposal of clean sands, dredged from the entrance channel, will have minimal adverse impacts on the water quality or ecology at the MCR Interim Sites (Boone et al., 1978).

Water quality parameters (concentrations of dissolved nutrients, trace metals, dissolved oxygen, pH, or turbidity) are influenced by river discharge volumes, tidal cycles, and biological activity. Holten et al, (1978, p. 2) stated "...nutrient and metal levels in the water column were well below what would be considered contaminated." Dissolved oxygen levels are typically high in surface waters (>6 mg/l), but lower in bottom waters (1 to 6 mg/l). Mixing of nearshore water masses precludes anoxic conditions at MCR. Surface water turbidity increases during ebb tides and periods of high river discharge; bottom waters are typically less turbid than surface waters, although temporary increases in turbidity may result from sediment resuspension (Boone et al., 1978).

The distribution of nearshore planktonic communities is both temporarily and spatially variable. Phytoplankton communities consist of a diverse assemblage of diatoms and dinoflagellates, with seasonally variable productivities and standing crop. Zooplankton are dominated by calanoid copepods, gammarid amphipods, cumaceans, and mysids. Smelt, anchovy, right eye flounder, and codfish, which are part of the icthyoplankton community at certain stages of their life cycle are dominant.

and ichthyoplankton are characteristically high in winter and spring, and relatively low in summer (Boone et al., 1978).

Diverse benthic assemblages at MCR are regulated by sediment type and depth. The relatively large abundances of benthic organisms at MCR are related to the high primary productivity and high organic content of the substrate. Seasonal changes in the composition of benthic assemblages are probably due to variations in river discharge volumes and substrate disturbances caused by winter storms (Richardson et al., 1977). Polychaetes, crustaceans, and molluscs are the dominant benthic organisms (Boone et al., 1978).

Several pelagic, anadromous, and demersal finfish species occur throughout the lower river and adjacent nearshore area. Dominant demersal fish species include anchovy, smelt, sanddab, and tomcod. Several anadromous salmonid species occur seasonally at the mouth of the river, supporting a valuable commercial fishery. Several marine mammal species, including whales, sea lions, seals, and porpoise, occur seasonally in the lower river and along adjacent coasts (Boone et al., 1978).

ASTORIA CANYON

No data were available to characterize the water quality or ecology at Astoria Canyon. Water quality is probably influenced by horizontal and vertical current mixing, sediment resuspension, and biological activity. Benthic organisms are probably adapted to frequent substrate agitation from natural sediment movement through the Canyon.

POTENTIALITY FOR THE DEVELOPMENT OR RECRUITMENT OF NUISANCE SPECIES IN THE DISPOSAL SITE (40 CFR §228.6[10])

MCR INTERIM SITES

Previous surveys at the MCR Interim Sites (Boone et al., 1978) did not detect the development or recruitment of nuisance species.

ASTORIA CANYON

There are no components in dredged material or consequences of its disposal which would attract nuisance fauna to the Astoria Canyon Site.

EXISTENCE AT OR IN CLOSE PROXIMITY TO THE SITE OF ANY SIGNIFICANT NATURAL OR CULTURAL FEATURES OF HISTORICAL IMPORTANT (40 CFR §228.6[11])

MCR INTERIM SITES

The Washington State Department of Archeology is currently compiling an inventory of cultural and historic resources for the Mouth of the Columbia River. Although the density of known shipwrecks is high, informaiton about the exact location, historical value, and accessibility of individual wrecks will not be available until 1982. Previous dredged material disposal has reduced the potential for locating or recovering cultural features of historical importance at the Interim Sites (Smith, 1980)*.

ASTORIA CANYON SITE

No significant historical features are known to exist in the Astoria Canyon Site; however, a predisposal survey is needed to verify the presence or absence of significant natural and cultural features.

DISPOSAL COSTS

The CE combines the costs of dredging and disposal to obtain a unit cost per cubic yard of dredged material. The unit cost of dredging during 1977, using the MCR Interim Sites, averaged $0.64 per yd^3 (CE 1977b). Travel time is a component of the unit cost. Thus, an increase in the distance from the dredging location to the disposal site increases total costs. The MCR Interim Sites are closer to the dredging site, therefore, their use would minimize transport costs. Use of the Astoria Canyon Site would increase the transit distance an average 31 nmi and transit time by 5 hours, resulting in a 330% increase in dredging costs (Heineman, 1980; personal communication). The additional time and expenses accrued in transporting dredged material to Astoria Canyon are substantial, and present serious disadvantages.

CONCLUSIONS

The considerations for final site designation, based on EPA Ocean Dumping Regulations 11 Site Selection Criteria, are summarized in Table 2-1. Final

*Dr. Bill Smith, Washington State Department of Archelogy (personal communication)

TABLE 2-1
SUMMARY COMPARISON

Criteria as Listed at 40 CFR §228.6	Interim Sites Near the Mouth of the Columbia River	Alternative Site at Astoria Canyon
(1) Geographical position	Four Interim Sites (A, B, E, and F) - nearshore (<5 nmi), shallow (18 to 40m), medium to fine-grained sand sediments	Located offshore (16.5 nmi), deep (>500m); varying sediment types (predominantly silts and clays)
(2) Distance from important resource areas	Some activity (breeding, feeding, passage) over entire area where sites are located; area is heavily fished, crabs fished during winter when no dredging occurs	Potential fisheries resources; extent of other biological activity unknown
(3) Distance from beaches	Close to beaches; beach nourishment potential	Offshore of beaches; material transported seaward, no potential for beach nourishment
(4) Types and quantities of material	Uncontaminated sand from high-energy environment; volume 6 million yd^3 per year	Same as Interim Sites
(5) Surveillance and monitoring	Surveillance requirements low because disposal sites are close to dredging areas Monitoring simplified because: - Sites are nearshore and shallow - Historical data are available	Surveillance requirements high because disposal site would be far offshore; probability of emergency or short dumping is higher Monitoring is difficult because: - Site is far offshore and deep - Site-specific data are not available, predisposal survey necessary
(6) Dispersals horizontal and vertical mixing	Rapid settling; no persistent turbidity plume, negligible addition due to high suspended sediment load. Bedload transport slow, 0.25 nmi/yr; net transport of sediment northwards at Sites A, B, and F, rapid sediment dispersion at Site E; potential for beach nourishment.	Rapid settling; no persistent turbidity Transport down-Canyon away from Shelf
(7) Effects of previous dumping in the ocean	All effects are minor and restricted to the site; significant adverse effects have not been noted outside boundary of site Minor effects detected: - Temporary mounding - Slight change in sediment texture - Reduction in fish abundances - Changes in benthic community structure	No sediments have been previously dumped in this area
(8) Interference with other uses of the ocean	Mineral extraction, desalination, fish and shellfish culture do not occur Disposal does not interfere with commercial or recreational shipping traffic Extensive fishing activities throughout MCR; minor interference from dredged material disposal	Same as Interim Sites Same as Interim Sites No fisheries activities or interferences with shipping traffic in the area
(9) Existing water quality and ecology	Disposal of uncontaminated wastes does not adversely affect water quality Temporary disturbance of demersal fish abundances and benthic community structure within the site boundaries	Same as Interim Sites No ecological data available; potential impact unknown, although expected to be insignificant
(10) Potential for nuisance species	Uncontaminated sand does not contain material which would attract nuisance species	Same as Interim Sites
(11) Existence of significant natural or cultured features	Numerous shipwrecks	No known features

site designations of MCR Interim Sites A, B, E, and F are recommended for the following reasons:

- After 20 years of dredged material disposal at the MCR Interim Sites, no significant adverse effects have been observed. Site-specific investigations (Boone et al., 1978) have detected only minor, temporary changes in the benthic infaunal density and diversity following dredged material disposal, concomitant changes in fish abundance and diversity, and slight changes in sediment texture.

- Surveillance and monitoring are significantly easier because the Interim Sites are close to shore and within shallow-water depths

- Disposal at Interim Site E may provide beneficial beach nourishment

- Dredged material disposal at the MCR Interim Sites is significantly more cost effective

A disposal site in Astoria Canyon is not recommended for the following reasons:

- No dumping has previously occurred within the Canyon

- The existing water quality, ecology, and resources of the Canyon are unknown. A predisposal survey would be necessary to identify potential resources sensitive to dumping.

- The additional costs and increase dredging efforts necessitated by use of the Alternative Site are substantial.

- Monitoring and surveillance are more difficult due to greater depths and distance offshore.

- The probabilty of emergency dumping onto the mid-Shelf region is higher.

- Pequegnat (1978, p. 137) noted..."at the present time at least the Columbia River does not appear to be in need of ocean disposal in deep water..."

Therefore, on the basis of historical use, the absence of significant adverse impacts, cost effectiveness, and the relative case of site monitoring, EPA proposes, in accordance with the Regulations, that the Mouth of the Columbia River Dredged Material Disposal Sites A, B, E, and F receive final designations.

USE OF THE SITES

All future uses of the MCR Interim Sites for Ocean Dumping must comply with the EPA Ocean Dumping Regulations and Criteria. Only dredged material from the entrance channel to the Columbia River and other materials meeting the requirements of 40 CFR §227.13 will be dumped at ODMDS A, B, E, and F. The sites may be used for such disposal only after evaluation of each Federal project or permit application has established that the disposal is within site capacity and in compliance with the criteria and requirements of EPA and CE regulations.

PERMISSIBLE MATERIAL LOADINGS

More than 20 years of dredged material disposal at the MCR Interim Sites, with volumes ranging from 1 to 9 million yd^3 per year, has caused only localized mounding, slight changes in sediment texture, and minor effects to the benthic fauna (described in previous sections). Therefore, it is difficult to assign an upper loading limit beyond which significant adverse effects might occur. Since bottom sediment transport is slow, increasing dredged material volumes or concentrating dumping at one disposal site may aggravate sediment accumulation. Continuation of historic annual dredging volumes of approximately 6 million yd^3 will have few if any significant adverse impacts. If dredged material volumes are significantly increased the CE monitoring effort should be intensified to identify and mitigate potential adverse effects.

DISPOSAL METHODS

Present disposal methods practiced by the CE at the MCR Interim Sites are acceptable for future dumping. Material is dredged, transported by hopper dredge, and discharged from underwater ports while the hopper dredge is underway and within the boundaries of the disposal sites.

DISPOSAL SCHEDULE

Schedules of dredge and disposal operations are dependent on weather conditions and availability of the hopper dredge. Historically, the operational schedule has been conducted from mid-April to mid-October, weather permitting. This schedule will be continued, as it has been proven to be practical. Use of Site E should be restricted to periods of ebb or slack tides to minimize transport of dredged materials back into the estuary.

MONITORING THE DISPOSAL SITES

Section 228.9 of the Ocean Dumping Regulations established that the impacts of dumping on a disposal site and surrounding marine environment will be evaluated periodically. The information used in making the disposal impact evaluation may include data from monitoring surveys. Thus, "if deemed necessary" the CE District Engineer (DE) and the EPA Regional Administrator (RA) may establish a monitoring program to supplement the historical site data (40 CFR §228.9). The DE and RA develop the monitoring plan by determining the appropriate monitoring parameters, the frequency of sampling, and the areal extent of the survey. The factors considered in making determinations include the frequency and volumes of disposal, the physical and chemical nature of the dredged material, the dynamics of the sites' physical processes, and the life histories of the species monitored.

The primary purpose of the monitoring program is to determine whether disposal at the sites is significantly affecting areas outside the sites, and to detect long-term adverse effects. Consequently, the monitoring study must survey the sites and surrounding areas, including control sites and areas likely to be affected, as indicated by environmental factors (e.g., prevailing currents and sediment transport). The results of an adequate survey will provide early indication of potential adverse effects radiating from the sites. Knowledge of density and concentration gradients facilitates prediction of future impacts on areas surrounding the disposal sites, and provides direction for management of future disposal activities.

GUIDELINES FOR THE MONITORING PLAN

Historically, no significant adverse effects from previous disposal activities have been observed. Monitoring requirements for the sites are minimized by the nature of the dredged material (sand) and its similarity to sediments at the disposal sites and surrounding areas. Many physical parameters will not be significantly affected by disposal (e.g., temperature, and salinity). Physical parameters showing variation during disposal (e.g., turbidity) quickly return to ambient levels due to the high-energy environment in the sites and the nature of the dredged material. The DE and RA may, however, choose to monitor selected parameters occasionally experiencing a wide natural variability (e.g., sediment characteristics during exceptionally high runoff) in order to separate natural environmental fluctuations from those caused by dredged material disposal.

The requirements for the MCR Interim Sites monitoring plan can be determined by applying the following six considerations. Changes in the monitoring plan may be warranted, based on assessment of the results of the initial monitoring by the DE.

(1) MOVEMENT OF MATERIALS INTO ESTUARIES OR MARINE SANCTUARIES, OR ONTO OCEANFRONT BEACHES OR SHORELINES

The nearest established marine sanctuary is Willapa Bay, approximately 28 nmi from the MCR Interim Sites. Transport of released dredged materials for distances of 28 nmi is unlikely. Net transport of sediments from Sites A, B, and F occurs in a northerly direction, at rates of 0.25 nmi/yr, therefore, movement of materials onto local beaches is not likely. However, sediment transport at Site E may cause movement of dredged sands onto the southwestern edge of Peacock Spit (shallow submerged area directly northwest of the North Jetty) and subsequently to the adjacent beach, or to a lesser extent, eastward into the Columbia River estuary (lower Columber River). The dredged material is clean sand and movement of sands onto oceanfront beaches provides desirable beach nourishment. Monitoring dredged sediment movement is not warranted.

The monitoring plan should include periodic bathymetric surveys of the MCR Interim Sites and adjacent areas. Surveys conducted infrequently (e.g., 5-year intervals) will detect any accumulation of dredged material.

(2) MOVEMENT OF MATERIALS TOWARDS PRODUCTIVE FISHERY OR SHELLFISHERY AREAS

Organisms taken from human consumption from the disposal sites and adjacent areas are typically mobile and adapted to the natural bedload. The disposal material is clean sand, and similar to sediments at the disposal sites and surroundings; thus, the dumped material enters the natural transport cycle and presents minimal stresses to the fisheries species. Consequently, monitoring dredged sediment movement towards fisheries areas is not necessary.

(3) ABSENCE FROM THE DISPOSAL SITES OF POLLUTION-SENSITIVE BIOTA CHARACTERISTIC OF THE GENERAL AREA

As mentioned previously, the dredged material is primarily clean sand taken from a high-energy environment and is excluded form further testing in accordance with §227.13(b)(1). Such material is considered acceptable for disposal because potentially harmful levels of pollutants are highly unlikely. As long as the dredged material remains the same, the pollution-sensitive biota in the MCR area will not be significantly affected by dredged material disposal and need not be monitored. However, if other material is disposed at the site, the effects of the change in dredged materials should be periodically checked by monitoring the pollution-sensitive biota.

(4) PROGRESSIVE, NONSEASONAL CHANGES IN WATER QUALITY OR IN SEDIMENT COMPOSITION AT THE DISPOSAL SITES ATTRIBUTABLE TO DREDGED MATERIAL

The similarity between the high-energy dredging site and MCR Interim Sites preclude the need to monitor the water quality or sediment composition. If other dredged materials (e.g., silts) which meet the criteria listed at 40 CFR §227.13 are released at the MCR Interim Sites, the monitoring plan will reflect this change in dredged sediment characteristics.

(5) PROGRESSIVE, NONSEASONAL CHANGES IN COMPOSITION OR NUMBERS OF DEMERSAL, OR BENTHIC BIOTA AT OR NEAR THE DISPOSAL SITES ATTRIBUTABLE TO DREDGED MATERIAL

Pelagic and demersal organisms in the disposal sites and surrounding areas are mobile and are not significantly affected by disposal. Therefore, monitoring pelagic and demersal species would not be informative. The benthic infauna provide a more effective index for determining dredged material impacts, particularly tube-dwelling polychaete and amphipod species which are least resistant to dredged material effects (e.g., Nepthys caecoides, Eohaustorius sencillus, Paraphoxus vigitegus). The DE and RA may select appropriate species to monitor and establish survey transects extending through the disposal sites, as well as upcurrent and downcurrent areas. Additional control stations could be located to the north or south of the entrance channel. The survey design will facilitate detection of biotic changes extending past site boundaries.

(6) ACCUMULATION OF MATERIAL CONSTITUENTS (INCLUDING HUMAN PATHOGENS) IN MARINE BIOTA AT OR NEAR THE SITES

Clean sands currently dredged from the entrance channel do not require bioaccumulation tests (40 CFR §228.13[b]). However, if the DE and RA have reason to believe that future dredged materials contain trace constituents which may be bioaccumulated, these parameters may be subject to monitoring in selected marine species, including infaunal species and species which feed at higher trophic levels (e.g., fish).

Chapter 3

AFFECTED ENVIRONMENTS

Chapter 3 describes the environments of the Interim and Alternative sites. Physical mixing processes at the MCR are influenced by river, tidal, and oceanic currents; water and sediment movement within Astoria Canyon is influenced by predominantly down-canyon currents. Sediments at the MCR are composed of fine- to medium-grain sands; sediments in Astoria Canyon generally contain relatively high percentages of silts and clays. The MCR supports a large and diverse biological community, including several commercially important species. Relatively little is known about the indigenous biological community of Astoria Canyon, but the occurrence of several potentially important commercial species has been surmised.

The environmental characteristics which will either affect or be affected by the proposed dredged material disposal operations are described in Chapter 3. Characteristics which are susceptible to significant adverse impacts are generally categorized as either geological, chemical, or biological. Regional and site-specific environmental characteristics are discussed separately. Ancillary meteorologic and oceanographic information is also presented in this chapter because natural physical processes influence the fate of the released dredged material and the impacts of dumping. The history of dredging activities, and commercial and recreational resources which may be affected by dredged material disposal are also discussed.

Considerable environmental information for the Mouth of the Columbia River and adjacent nearshore waters have been obtained since 1970, especially by the CE Dredged Material Research Program (DMRP) (see Boone et al., 1978). Further studies include those performed under the auspices of the U.S. Atomic Energy Commission (Pruter and Alverson, eds., 1972); geological investigations by Sternberg et al. (1979), Walter et al. (1979), and Borgeld et al. (1978); and biological studies by Durkin (1975) and Durkin and Lipovsky (1975). Comparable data for Astoria Canyon are unavailable, although some geological information is presented in Nelson et al. (1970) and Carlson and Nelson (1969).

ENVIRONMENTAL CHARACTERISTICS

REGIONAL OVERVIEW

The 2,000-km-long Columbia River originates at Columbia Lake in British Columbia and empties into the Pacific Ocean between Oregon and Washington. The drainage basin of the Columbia River and its main tributaries, the Spokane, Okanogan, Wenatchee, Yakima, Snake, Cowlitz, Lewis, Umatilla, John Day, Deschutes, and Willamette Rivers, is about 670,800 km^2, encompassing parts of seven western states and western Canada (Neal, 1972).

The coastline north and south of the river mouth is generally characterized by prograding sandy beaches. Sand dunes and beach ridges run parallel to the coast, extending inland an average distance of 3.2 km, at heights of 3 to 6m (Ballard, 1964).

The northern Oregon and southern Washington Continental Margin is characterized by broad sandy beaches which slope onto a narrow Continental Shelf, with an average gradient of 3 to 4 m/km (Figure 3-1). The Continental Shelf is 10 to 30 km wide, and the Shelf break occurs at a depth of 165m (McManus, 1972). Offshore isobaths are concentric to shore and the Columbia River tidal bar.

METEOROLOGY

Seasonal weather patterns have profound effects on dredging operations in MCR. For example, the severity of winter storms restricts dredging operations to summer months (mid-April to mid-October). In addition, seasonal variations in precipitation and wind direction and velocity affect river discharge volumes, and the direction and velocity of nearshore bottom currents respectively.

The north-south trending Cascade Mountain Range in western Oregon and Washington effectively divides the Columbia River Drainage Basin into two climatic zones, coastal and continental. Climatic conditions in the coastal zone west of the Cascades are influenced by moist air moving inland from over

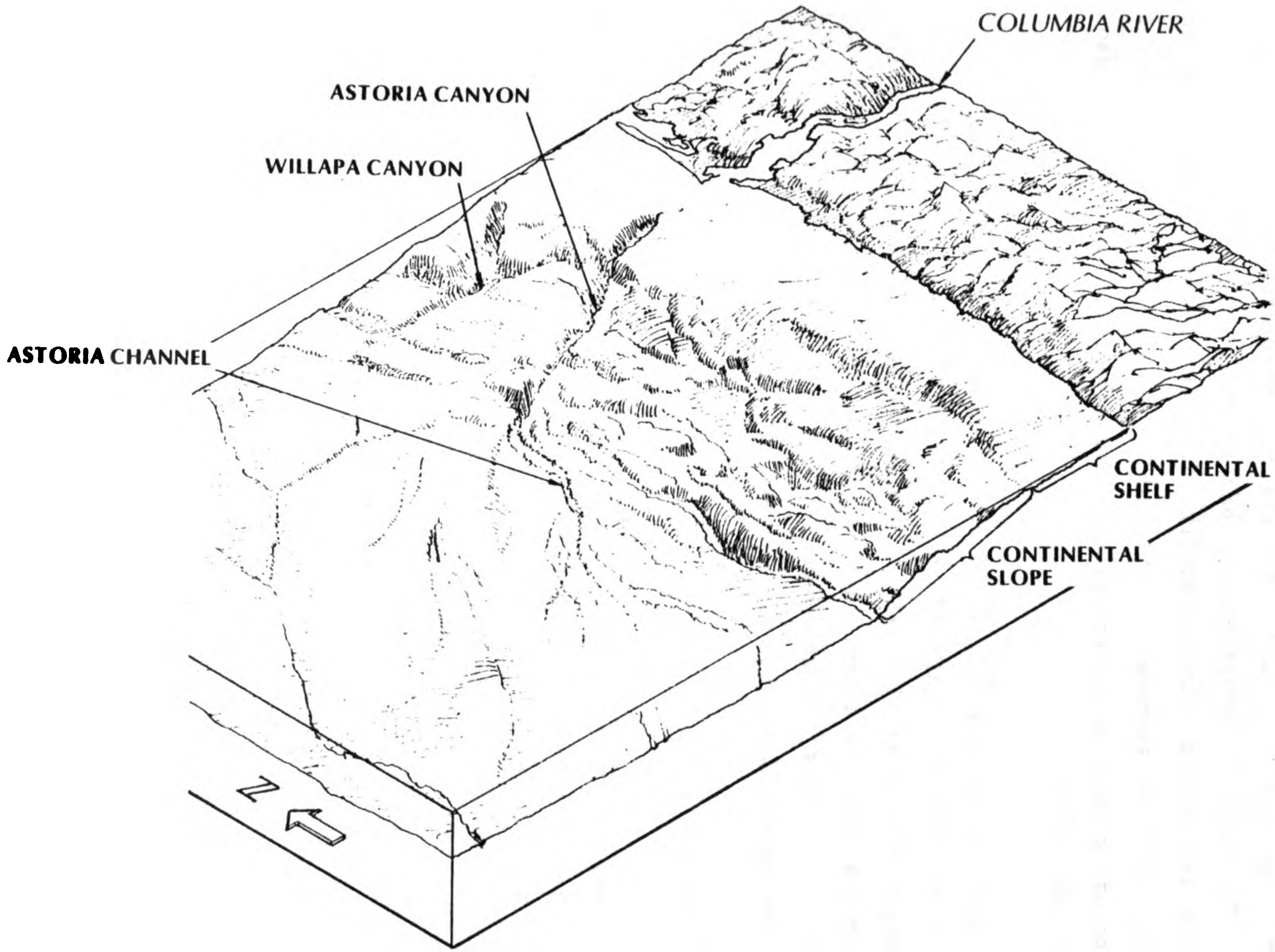

Figure 3-1. Topography of the Continental Margin Adjacent to the MCR
Source: Nelson et al. (1970)

the Pacific Ocean. The maritime climate is characterized by wet winters and dry summers, with moderate winter and summer temperatures. Average summer temperatures range from 7° to 27°C, and the average winter temperature range is -4° to +7°C. Summer (May-September) coastal winds are northerly at 10 to 13 kn; winter and spring (October-April) winds are generally southerly to southwesterly, with an average velocity of 14 to 18 kn. Extra-tropical storms, which are common in winter, produce the strongest winds of the season (over 59 kn) (CE, 1975).

Annual precipitation ranges from 165 to 229 cm/yr in coastal areas and is controlled by seasonal movements of the North Pacific High and Aleutian Low pressure systems (Barnes et al., 1972). Precipitation varies along the coast, increasing inland with elevation, then decreasing east of the Cascades. Fog along the coast accounts for an average 1-day per month delay in dredging activities from mid-April through mid-October (CE, 1977b).

PHYSICAL OCEANOGRAPHY

In summer and autumn the California Current flows southward under the influence of the predominantly northerly winds at an average velocity of 0.1 to 0.2 kn. The 300-nmi-wide surface current flows in a transition zone between coastal waters and the Eastern North Pacific Water Mass (Gross, 1972a). During late autumn, when the northerly winds decrease in strength, the Davidson Current develops and flows northward along the coast, under the influence of southerly winds, at velocities of 0.2 to 0.4 kn (Barnes et al., 1972). In late spring the predominant winds swing around to the north and the California Current reappears, flowing to the south. Ekman transport (net transport of a water mass in a direction perpendicular to the surface stress, i.e., wind) is responsible for driving surface waters offshore in the summer months, and causes upwelling of cold, nutrient-rich waters in nearshore areas. In winter, Ekman transport is onshore, resulting in coastal downwelling. Bottom currents over the Shelf flow northwards throughout the year (Gross et al., 1969).

Fresh water discharge from the Columbia River creates a plume of dilute seawater which is customarily dilineated by the $32.5^{o}/oo$ isohaline. The size of the plume, which extends 400 nmi southward in the summer, 300 nmi northward in winter, and 300 nmi from shore, is controlled by seasonal wind and current patterns (Duxbury et al., 1966). Dilution of seawater with fresh water from the Columbia River decreases the density of the surface water and consequently increases the stability of the nearshore water column (Hobson, 1966).

GEOLOGY

Continental Shelf sediments adjacent to MCR can be separated on the basis of texture into three regimes occurring in bands, generally parallel to the coast. The nearshore regime has fine sands (0.149 to 0.125 mm particle diameters) and extends from the shore to depths of approximately 50 to 60m; a mid-Shelf silty sand regime extends seaward from the fine-sand regime to depths of 150m; a relict band consisting of fine sand extends offshore to the outer Shelf (Borgeld et al., 1978) (Figure 3-2).

CHEMISTRY

Nutrients and trace elements are supplied to surface waters off the Oregon-Washington coast by river discharge and upwelling of deeper waters. Concentrations are dependent on mixing ratios and biological and physical processes that remove specific elements from solution (Stefannson and Richard, 1963). The chemical composition of Shelf sediments is related to the source of the sediment and the abundance of organically rich, fine-grained materials (White, 1970; Gross, 1967).

BIOLOGY

Phytoplankton species present in Shelf Waters off the Oregon-Washington coast have been grouped into three assemblages corresponding to inshore, transition, and offshore areas (Hobson, 1966). The standing stock of phytoplankton is typically higher within the Columbia River plume, due to the greater stability of the surface mixed layer (Anderson, 1972). Annual primary productivity varies between 125 g C/m^2 in the plume and adjacent oceanic areas, to 300 g C/m^2 in localized upwelling areas (Anderson, 1972).

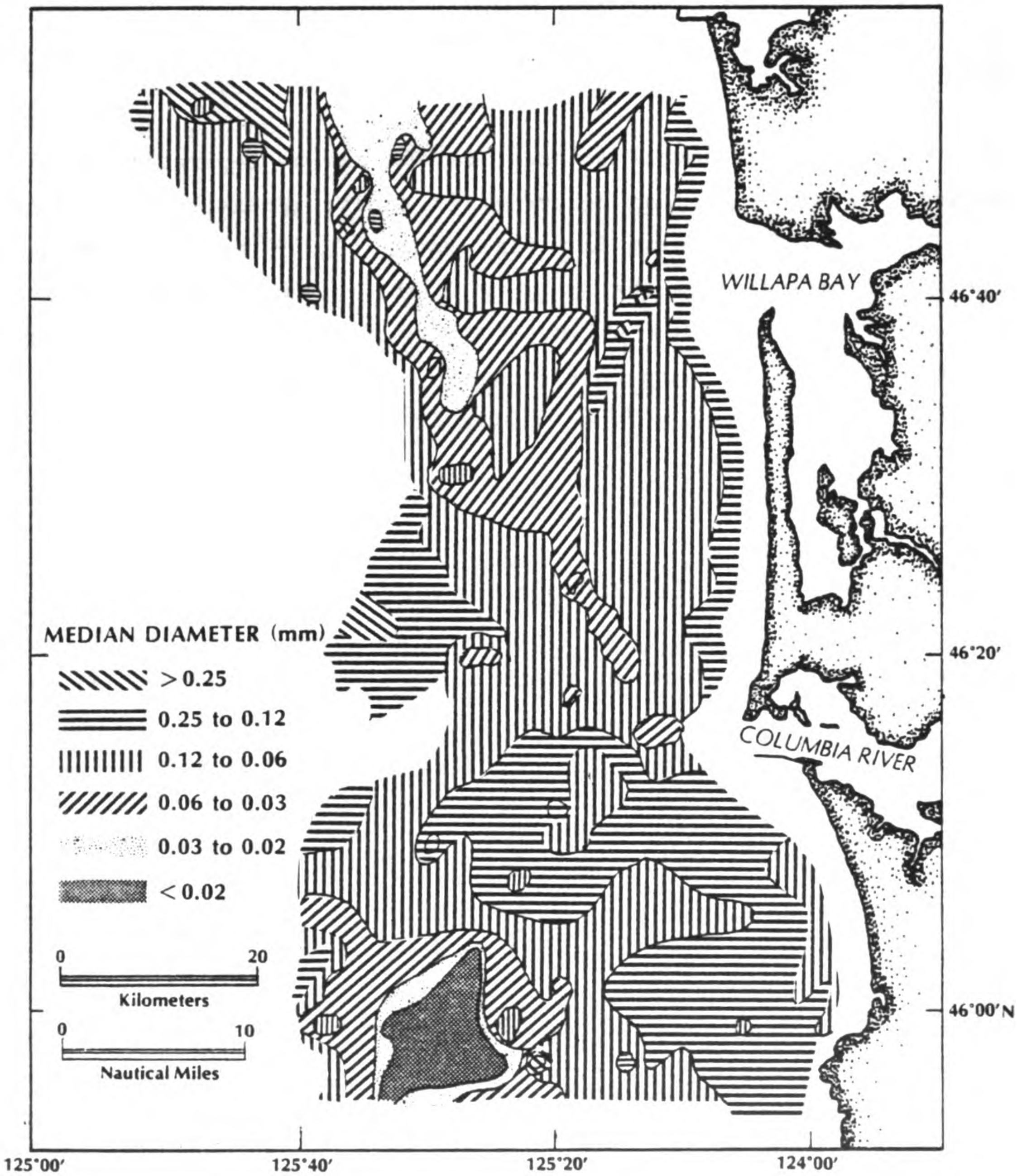

Figure 3-2. Distributions of Sediments on the Nearshore Continental Shelf Adjacent to MCR
Source: McManus (1972)

The abundances of nearshore zooplankton varies seasonally in response to upwelling, water transport, and predation (Peterson, 1972). In general, calanoid copepods are numerically dominant, although mysids, decapod crustacean larvae, euphausiids, sergestid shrimp, and chaetognaths may also be present in large numbers during winter and spring. Vertical migration patterns of several zooplankton species may account for diel changes in zooplankton abundances (Boone et al.; Percy, 1972).

The distribution and abundances of benthic organisms along the Washington-Oregon Continental Shelf are related to sediment texture and depth (Carey, 1972). Three benthic assemblages occur in parallel bands along the coast; an inshore shallow-water sand community (0 to 90m depth), an intermediate silty sand community (50 to 164m), and a deepwater mud assemblage (80m to the Continental Slope) (Richardson et al., 1977). In general, echinoderms, arthropods, and molluscs are the three major groups of epibenthic invertebrates present off the coast adjacent to MCR; echinoderms are dominant within the depth range of 183 to 457m, while arthropods are dominant from 503 to 1,189m (Pereyra and Alton, 1972). The benthic infauna is dominated nearshore by a filter-feeding arthropod assemblage, and offshore by burrowing polychaetes. Molluscs typically comprise 25% of the infauna in the sublittoral zones (Carey, 1972).

The density and biomass of benthic invertebrates increase with distance offshore, reaching a maximum at the outer edge of the Continental Shelf, in relation to increases in the organic content of the substrate (Carey, 1972). Diversity (generally, a numerical relationship between the number of species and the number of individuals per species) and species richness (numbers of species) increase offshore in relation to increases in sediment stability. Conversely, the lowest diversity occurs close to shore, where sediments are seasonally less stable.

Alton (1972) described four demersal fish assemblages occurring off the northern Oregon coast: (1) a Shelf association, including three species of flounder which feed on benthic organisms such as polychaetes, crustaceans, and molluscs; (2) a rockfish association occurring on the upper Slope (183 to

411m), composed of species which feed on nektonic organisms; (3) a codfish association which occurs in deep water (1,097 to 2,121m); and (4) a bathyal association, composed of sharks, snailfish, rockfish, sablefish, and eelpouts.

The diversity and biomass of demersal fish are greatest on the outer Continental Shelf (91 to 320m), and decrease with increasing depths. The geographic and depth ranges of demersal finfish and shellfish species occurring on the outer Shelf are listed in Table 3-1. Between the depths of 500 and 1,200m tanner crabs are the dominant epibenthic invertebrate species, with standing stocks in the 457 to 869m depth range of 10 million lb (4.5 million kg) (Pereyra, 1972). Standing stock estimates of demersal fish in the 183 to 547m depth range along the Oregon-Washington Shelf are 350 million lb (160 million kg) (Alverson et al., 1964). The commercial catch of demersal fish is characterized by seasonal differences in abundance; maximum seasonal abundances occur in the summer, and are due to bathymetric and latitudinal migrations of several fish species from the Continental Slope to Shelf depths. During summer average trawl catches range from 3,000 lb/hr (1,400 kg/hr), in water depths of 91 to 411m, to 200 lb/hr (90 kg/hr) in water depths of 1,097 to 2,103m. Six species of fish, Pacific hake (Merluccius productus), sablefish (Anoplopoma fimbria), dover sole (Microstomas pacificus), rex sole (Glyptocephalus zachirus), turbot (Atheresthes stomias), and Pacific ocean perch (Sebastes alutus), dominate the commercial trawl catch on the Continental Shelf (Alton, 1972).

MOUTH OF THE COLUMBIA RIVER

OCEANOGRAPHY

Physical oceanographic parameters determine the nature and extent of mixing zones, which influence sediment transport and the chemical environment at a DMDS. Strong temperature or salinity gradients inhibit or prevent mixing of surface and bottom waters, whereas waves aid such mixing, resuspend bottom sediments, and affect water turbidity. Currents, especially bottom currents, determine the direction, and influence the extent of sediment transport into and out of the DMDS. Tidal currents, which may contribute to the transport of dumped materials, do not usually add net directional effects.

TABLE 3-1
COMMERCIALLY IMPORTANT DEMERSAL FINFISH AND SHELLFISH
FROM THE NORTHEAST PACIFIC OUTER CONTINENTAL SHELF AND UPPER SLOPE

Species	Occurrence	Common Depth Range (m)
Pacific ocean perch (Sebastes alutus)	Entire west coast to Gulf of Alaska and into Bering Sea	150 to 450
Pacific hake (Merluccius productus)	Gulf of California to Gulf of Alaska	50 to 550
Sablefish (black cod) (Anoplopoma fimbria)	Northern Baja to Gulf of Alaska into Bering Sea	50 to 1,000
Pacific cod (Gadus macrocephalus)	West coast to Gulf of Alaska and into Bering Sea	50 to 450
Arrowtooth flounder (Atheresthes stomias)	West coast to Gulf of Alaska and into Bering Sea	50 to 650
Dover sole (Microstomus pacificus)	Baja California to Bering Sea	80 to 820
Tanner crab (Chionoecetes tanneri)	West coast to Gulf of Alaska into Bering Sea; most abundant at 500 to 730m off Washington, but moves to shallower water of less than 200m in Gulf of Alaska and further north	200. to 1,500
Deepwater prawns (Pandalopsis dispar P. borealis)	West coast to Gulf of Alaska and into Bering Sea	50 to 200

Source: Pequegnat (1978)

Physical processes which mix nearshore waters are complex due to seasonal flucuations and interactions of oceanic, river, and tidal currents. Mixing is rapid in the upper 15m, where salinities vary with the strength of the river discharge, from 10 to $30^{o}/oo$. Below 15m the salinity does not change substantially from $34^{o}/oo$. Surface water temperatures range from 5°C in winter to 20°C in the summer (Boone et al., 1978).

Currents

Nearshore surface and bottom currents respond to seasonally variable wind and wave conditions and, locally, to tidal flow and fresh water discharge near the mouth of the river. Each component has variable speed and direction characteristics, which are discussed below. Net bottom currents resulting from interactions of several velocity components may be sufficient to cause localized sediment movement (Sternberg et al., 1977).

Near the river mouth tidal currents are the primary velocity contribution upon which other components are superimposed (Sternberg et al., 1977). Mixed semidiurnal tides have an average range of 2m and a maximum range of about 4.5m. Maximum surface ebb currents of 6.4 kn occur along the southern channel boundary, while maximum flood currents of 3.6 kn occur along the northern channel boundary (Borgeld et al., 1978). The tidal component of bottom current velocities ranges from 0.3 to 0.4 kn in areas adjacent to the river mouth, flowing north and south, parallel to the isobaths, in response to flood and ebb tides, respectively (Sternberg et al., 1977).

The river flow velocity component varies seasonally in response to changes in river discharge. Seasonal discharge volumes are minimal (6 million m^3/day) in late summer, and reach a maximum (2.9 billion m^3/day) during spring (Borgeld et al., 1978). Net bottom flow is easterly, into the river, in the vicinity of the south jetty; net bottom currents flow westerly near the north jetty and northerly to northwesterly in adjacent nearshore areas (Sternberg et al., 1977).

Sternberg et al. (1977) noted a correlation between surface winds and nontidal bottom current flow. For example, strong, southerly winds associated with winter storms produce high current velocities and net northward flow parallel to the isobaths in the nearshore Shelf area. In April and May bottom current measurements in the vicinity of Site B recorded velocities typically less than 0.4 kn, with strong tidal variation. However, in December and January bottom current velocities averaged 0.6 kn, and speeds of 1.6 kn were recorded during the passage of storms. "The stronger wind-generated bottom flows exhibited a northerly set that persisted even when superimposed upon the tidal currents and the hydraulic regime seaward of the river mouth" (Sternberg et al., 1977; p. 263).

Nontidal bottom currents exceeding 0.2 kn, in conjunction with nearshore tidal flows, are sufficient to erode bottom sediment. The annual frequency of wind speeds required to produce bottom currents of 0.2 kn (20 kn) is shown in Figure 3-3. The higher frequency of southerly winds with velocities greater than 20 kn suggest an annual net northerly transport of water and sediment (Sternberg et al., 1979).

<u>Waves</u>

Wind waves and swells approach the coast from a northwesterly direction in summer and a southwesterly direction in winter. Large waves (3m or greater in height) occur during an average 48 days per year, and are frequent during the winter months and infrequent during the summer. Storm waves with significant wave heights of 6 to 12m approach the coast from the southwest (Lockett, 1967). Net longshore transport is northwards due to the greater energy of winter waves (Ballard, 1964). Nearshore wave activity may resuspend finer sediments within the disposal sites and initiate sediment movement. Wave surge, however, does not effect net bottom current velocities (Sternberg et al., 1979).

GEOLOGY

Geological information relevant to a DMDS includes bathymetry, sediment characteristics, and dredged material characteristics. Bathymetric data provide information on bottom stability, persistence of sediment mounds, and shoaling. The type of bottom sediments strongly influences the composition of resident benthic biota. Differences in sediment types between natural DMDS sediments and dumped material may be used as tracers to determine areas of bottom influence due to dumping of dredged material. Changes in DMDS sediment type by dumping may produce significant changes in physical and chemical characteristics, and thus change the composition of benthic biota.

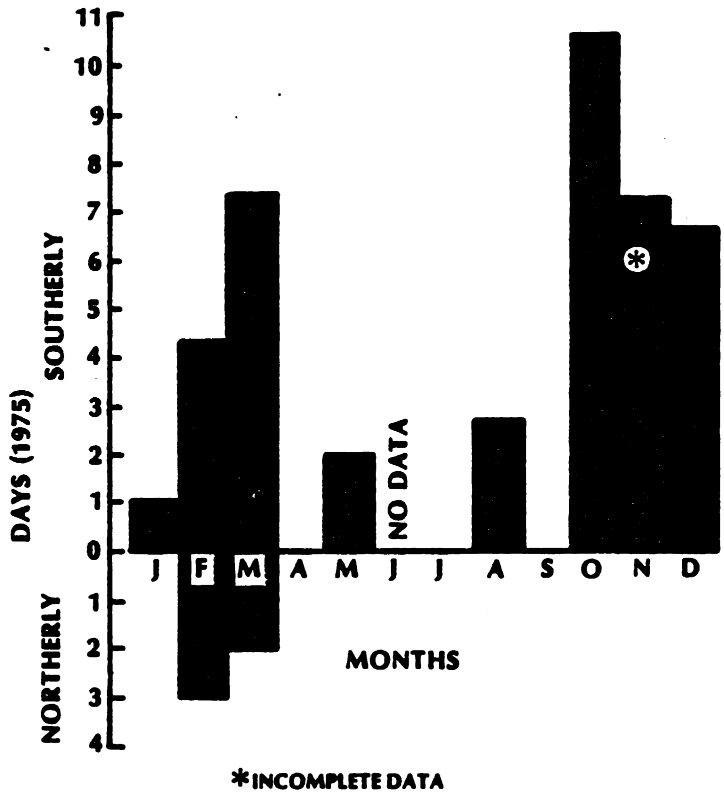

Figure 3-3. Frequency of Time in Days During Each Month of 1975 That Mean Wind Speeds Exceeded 20 kn Blowing from the North or the South. Winds were Measured at the Columbia River Lightship and all Data were Averaged for 25-hr Periods Prior to Analysis. Source: Sternberg et al. (1977)

Bathymetry

The bathymetry of the nearshore area adjacent to the river mouth is characterized by an outer tidal delta, skewed to the north, extending seaward to the 30m isobath (Figure 3-4). Steep north and west edges of the delta are areas of maximum sediment accretion. A "secondary bathymetric feature" occurs in the vicinity of Site B, consisting of previously dumped dredged material (Boone et al., 1978).

Sediments

Both marine and river-derived sediments occur in the MCR. River-derived sediments are mineralogically dissimilar, therefore, they are distinguishable from marine sediments. Consequently, it is possible to trace the source of

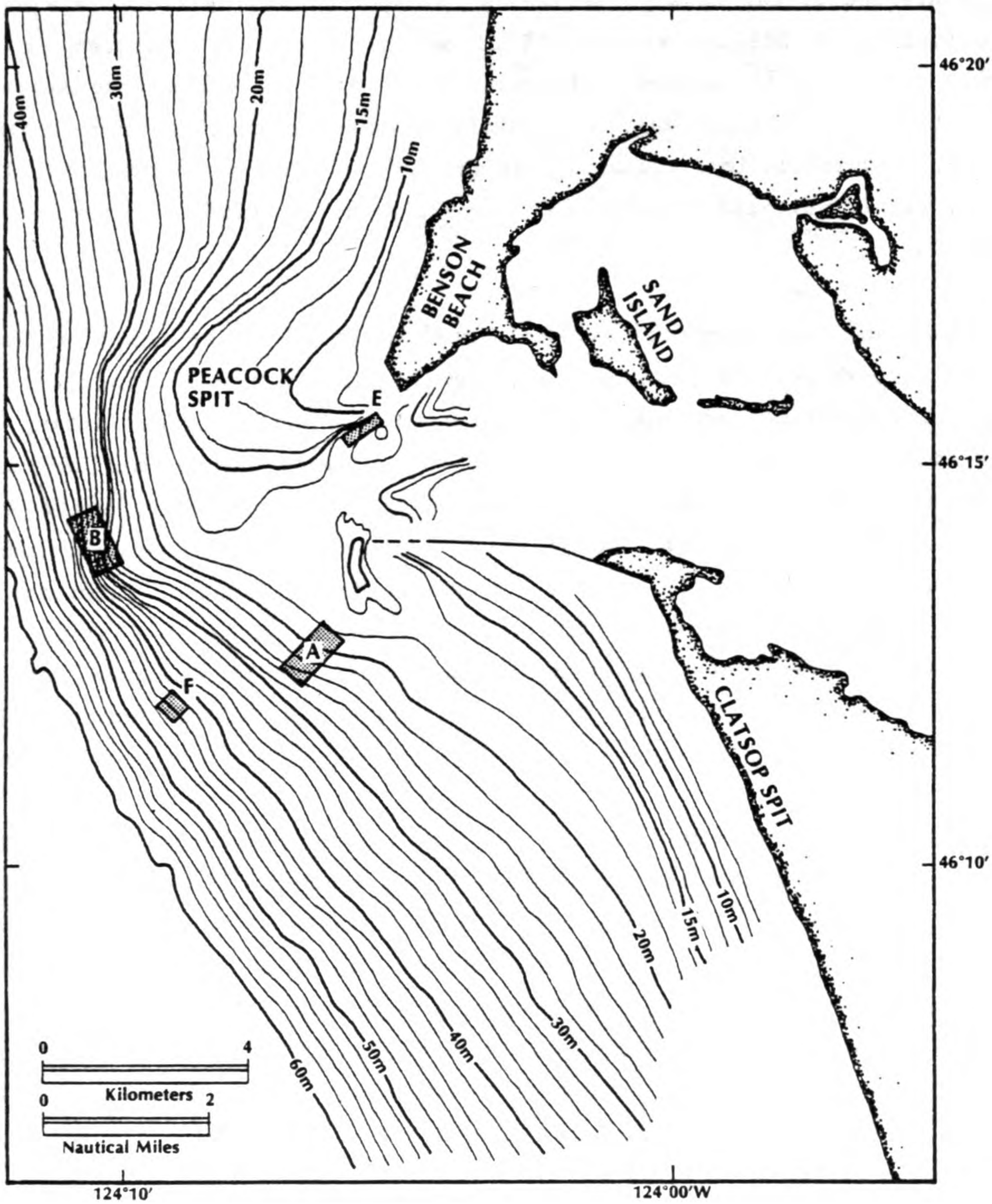

Figure 3-4. Bathymetry of Nearshore MCR Region
Source: Borgeld et al. (1978)

nearshore and Shelf sediments and, together with bottom current measurements, determine rates and direction of sediment (including dredged material) movement.

The average annual mass of sediments transported by the Columbia River is approximately 10 billion kg/yr, 10% of which is bedload (Whetten et al., 1969). According to Conomos and Gross (1972), 85% to 95% of the suspended particulates are lithogenous, with median diameters ranging from 0.004 to 0.64 mm. Fluvial bedload sediments are primarily lithic fragments (56% of the total), mainly volcanic, quartz (13%), and plagioclase (20%) (Whetten et al., 1969).

Bedload and some suspended sediments are deposited in the entrance channel and crescent-shaped tidal delta, respectively, directly seaward of the river mouth. The greatest sediment deposition occurs in April and May during high river discharge (Ballard, 1964). Within the entrance channel medium-grained sediments (0.18 mm diameter) occur in deeper, scoured areas, while finer sediments (<0.15 mm diameter) occur along the borders and seaward portions of the channel (Borgeld et al., 1978). In winter bottom currents resuspend the lighter plagioclase fractions and transport them across the Shelf in a northwesterly direction. Magnetite-rich sediments remain nearshore, and are reworked by shoaling waves and longshore currents (Smith and Hopkins, 1972; Boone et al., 1978).

Nearshore Shelf sediments consist of either Columbia River bedload material or modern beach sands containing high percentages of opaque, magnetic material. In general, bottom sediments in areas south of the entrance channel are fine to very fine sands (0.15 to 0.105 mm), and little seasonal change in sediment texture is evident. In contrast, sediments occurring north of the entrance channel are fine sands and silt (0.105 to 0.0024 mm). Seasonal changes in sediment texture have been reported at Site B (Sternberg et al., 1977). The distributions of major sediment types in the nearshore MCR region are shown in Figure 3-5.

Sediment Transport

In 1974 the CE initiated a Dredged Material Research Program (DMRP) to investigate hydraulic and geologic conditions at the Mouth of the Columbia River, and assess the fate of dredged materials at the disposal sites. Sediment movement following an experimental dump of approximately 600,000 yd^3

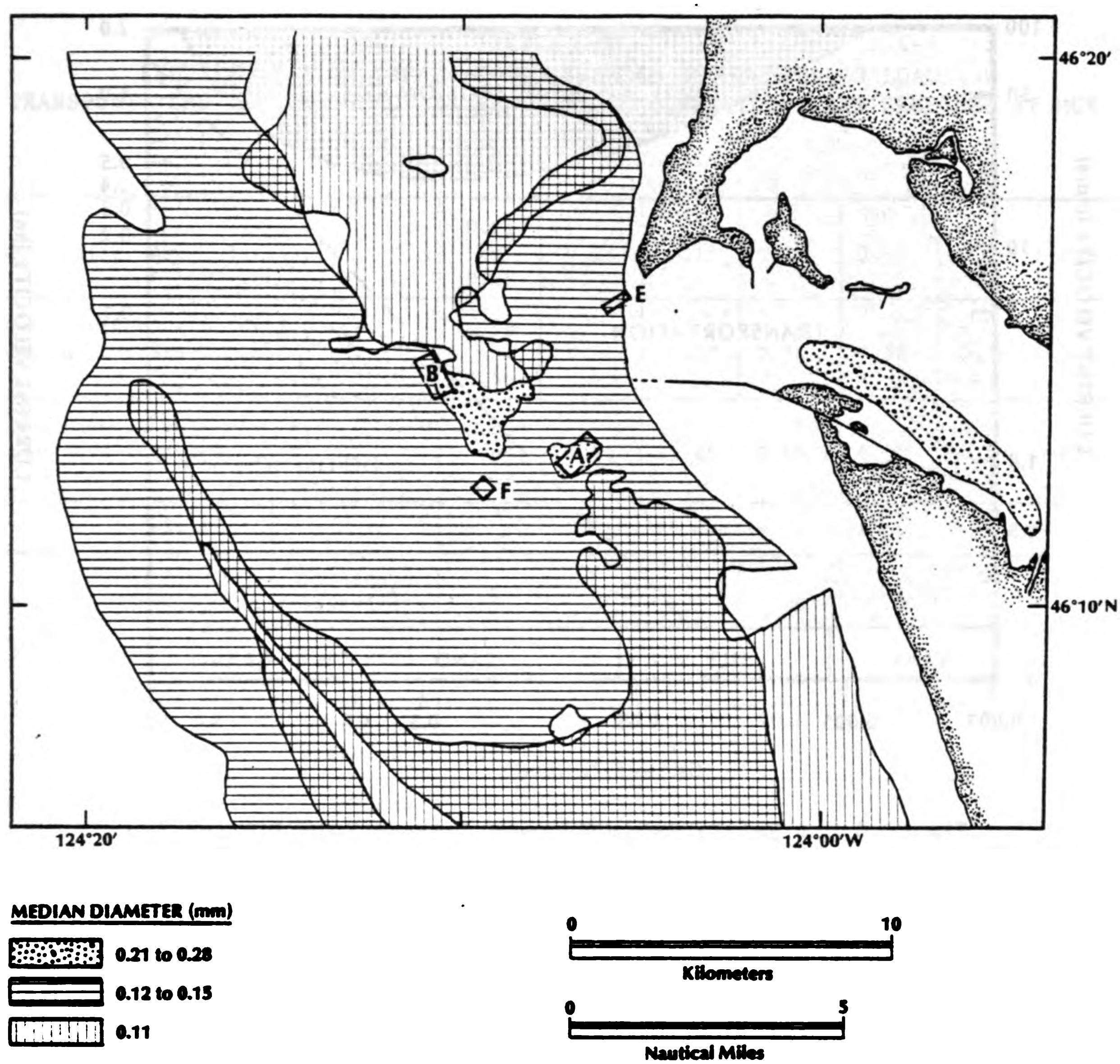

Figure 3-5. Areal Distribution of Nearshore Sediment Types
Source: Sternberg et al. (1977)

of dredged material at Site G was monitored. The results of these investigations are discussed by Boone et al. (1978) and Sternberg et al. (1979), and are summarized below.

Bottom sediments within the MCR DMDS may be resuspended or transported once the threshold current velocities have been exceeded. The relationship between current velocity and sediment transport is shown for various grain size classes in Figure 3-6. Sediments may be transported in either a bedload or suspended mode. Bottom current velocities required to transport sediments in either a bedload or suspended mode are listed in Table 3-2. Sediments with

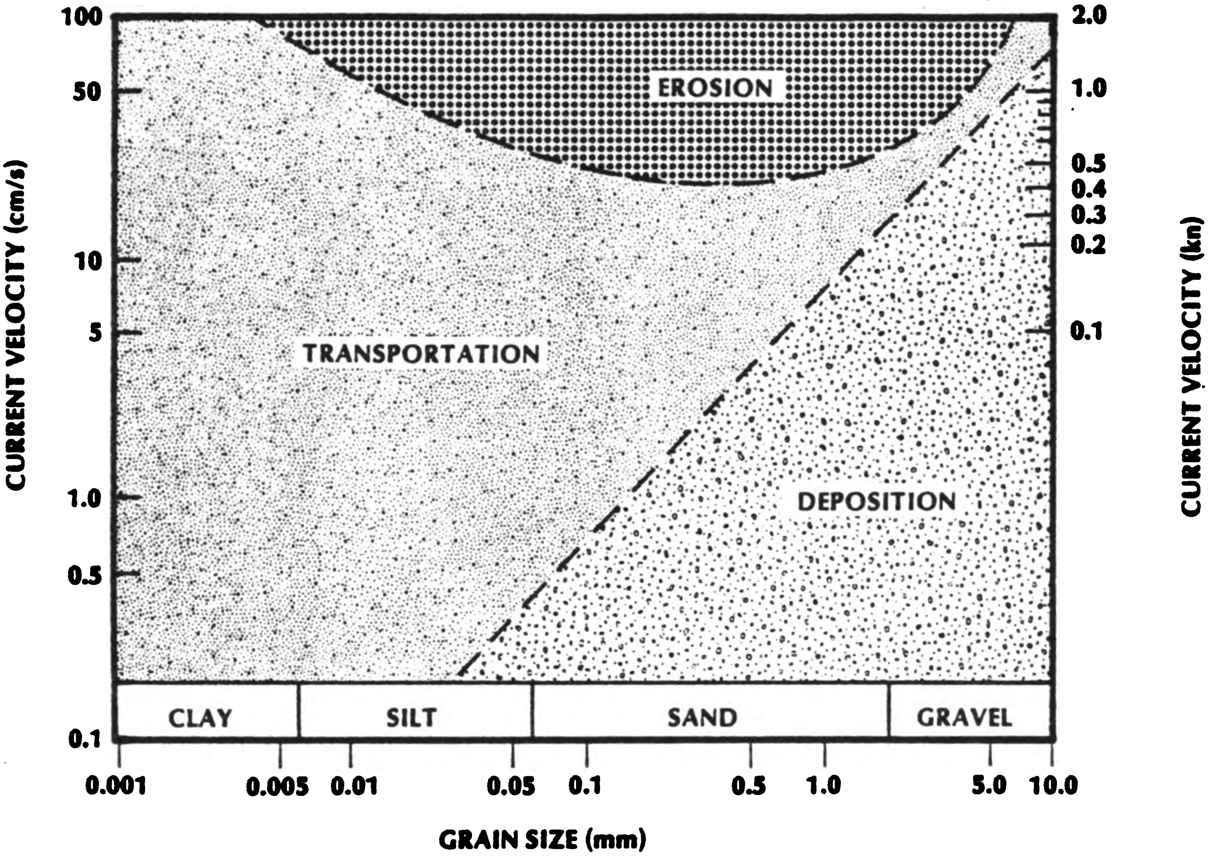

Figure 3-6. Relationship Between Current Velocity and its Potential to Deposit, Transport, or Erode Sediments of Various Grain Sizes
Source: Adapted from Moherek (1978).

particle diameters less than 0.15 mm may be resuspended by 0.5 kn bottom currents; sediments coarser than 0.18 mm are not resuspended, but transported only as bedload. Frequencies of current-induced grain movement at MCR are shown in Table 3-2. Sediment movement at Site B, for example, occurs infrequently in summer, but may occur up to 66% of the time during December and January; grain movement in spring and autumn is variable, depending on the frequency of storm conditions (Sternberg et al., 1979).

Mass transport of bottom sediments from the DMDS is seasonal, and dependent on the frequency, duration, and severity of storm activity (Sternberg et al., 1979). Calculations of sediment transport from Site G, due to storm activity in 1975, are presented in Table 3-3. Sepérate storms may transport 0.33 yd^3 of 0.25 to 0.21-mm-diameter sediments, and 330 yd^3 of 0.18-mm-diameter sediments, distances of 2m and 100m respectively (ibid.). Calculations of

TABLE 3-2
REQUIRED BOTTOM CURRENTS FOR BEDLOAD AND SUSPENDED LOAD TRANSPORT, AND THE FREQUENCY IN WHICH THESE CONDITIONS WERE EXCEEDED AT MCR

Grain size (mm)			0.25 to 0.21	0.18	0.15	0.11	0.071	0.044	0.016
Mean current velocity for bedload transport (kn)			0.58 to 0.56	0.56	0.56	0.56	0.56	0.56	0.56
Mean current velocity for suspended load transport (kn)			3.03 to 2.29	1.75	1.26	0.66	0.56	0.59	0.56
Date	Station	Mode	Frequency (% Time)						
4/12/75 to 5/6/75	Site B	Threshold Exceeded	8	8	8	8	8	8	8
		Suspended Load	0	0	0.2	5	8	8	8
4/12/75 to 5/6/75	Site B Control	Threshold Exceeded	11	11	11	11	11	11	11
		Suspended Load	0	0	0.1	6	11	11	11
6/15/75 to 7/8/75	Site A	Threshold Exceeded	0	0	0	0	0	0	0
		Suspended Load	0	0	0	0	0	0	0
8/19/75 to 9/12/75	Site G	Threshold Exceeded	3	3	3	3	3	3	3
		Suspended Load	0	0	0	2	3	3	3
8/19/75 to 9/12/75	Site G Control	Threshold Exceeded	3	3	3	3	3	3	3
		Suspended Load	0	0	0	2	3	3	3
12/12/75 to 1/6/76	Site B	Threshold Exceeded	66	66	66	66	66	66	66
		Suspended Load	0	0	4	43	66	66	66

Source: Sternberg et al. (1977)

TABLE 3-3
CALCULATIONS OF MASS TRANSPORT AND DISPLACEMENT OF SEDIMENTS DUE TO STORM ACTIVITY IN 1975

Month	Events With Wind Velocities Greater than 25 kn	Estimated Nontidal Current Velocity (kn)	Estimated Bedload Transport (yd^3/deposit/storm)	Estimated Sediment Displacement (m/storm)
Jan	0.0			
Feb	38.8	1.2	210	100
Mar	29.7	0.68	1	4
	31.8	0.80	3	8
	(33.6)*	(0.87)	(7)	(13)
Apr	0.0			
May	31.8	0.80	3	8
Jun	No Data			
Jul, Aug, Sep	0.0			
Oct	31.8	0.80	3	8
	38.0	1.1	150	75
	38.8	1.2	210	100
Nov	25.2	0.50	<1	1
	29.1	0.66	1	2
	36.1	1.0	40	33
Dec	33.0	0.85	6	11
	28.7	0.64	1	3
	38.8	1.2	210	100
	26.0	0.50	<1	1
Total			847 yd^3 across Site G	467 = 0.24 nmi north of Site G

* Winds from the north; calculated values have been subtracted from the total

Source: Sternberg et al. (1977)

mass sediment transport from Site G predict movements of 850 yd^3 of dredged sediments per year 0.25 nmi northwards from the disposal site. These estimates suggest that only 0.2% of the total volume of dredged materials will be transported, and movement occurs slowly in a northerly direction. Disposal mounds, however, will tend to spread laterally and flatten due to local shear stresses caused by bottom currents and turbulence from wave action (ibid.).

As mentioned previously, natural sediments occurring south of the entrance channel and within Site G were primarily fine sands (0.11 to 0.15 mm diameter). Postdisposal surveys at Site G identified coarser sands (0.25 to 0.21 mm) deposited in a curved band, which corresponded to the path of the hopper dredge. The areal extent of the coarse-grained sediments steadily diminished with time following the cessation of dumping, as fine-grained sands, resuspended and transported from surrounding areas, eventually covered the dredged materials (Sternberg et al., 1979).

Sediment transport from Sites A, B, and F is probably similar to that at Site G (Borgeld et al., 1978). Natural sediments at Sites A, B, and F are predominantly fine-grained sands (0.15 to 0.11 mm diameter). Fine-grained sands dredged from the outer entrance channel and dumped in these sites will be texturally similar to extant sediments and subject to dispersion and transport by storm-related bottom currents. Coarser materials (>0.15 mm) dredged from the inner entrance channel and dumped at these sites may disperse laterally, but will remain within or in close proximity to the site (Borgeld et al., 1978).

Relative to Sites A, B, or F, the environment at disposal Site E is more dynamic due to tidal current and river scour, and the effects of shoaling waves. Although measurements have not been made at Site E, bottom currents sufficient to erode dredged materials must be present during a portion of the year. Borgeld et al. (1978) monitored the bathymetry of Site E during and subsequent to dredged material disposal. Their results indicate that emplaced sediments remained within the site in early summer, although the disposal mound was slightly modified by bottom currents. Dredged materials dumped in late summer through early autumn were dispersed and no sediment accumulation was detected. Borgeld et al. (1970) concluded that dredged sediments were transported either in a northeastward direction and eventually deposited along the southwest edge of Peacock Spit, or transported northwards from the site, parallel to the beach. Subsequent investigations by Walter et al. (1979) presented evidence that a portion of the materials dumped at Site E may be transported eastward in the estuary.

In summary, the susceptibility of dredged material to transport from the disposal site is related to sediment grain size and bottom current velocity. Sternberg et al. (1979; p. 47) concluded that at Site G "dredged materials will remain more or less in place with a slight tendency to migrate northward parallel to the isobaths. The deposit will spread laterally as a result of waves and currents, hence its bathymetric expression will be reduced. The sediment texture and composition will continue to be a recognizable feature although finer grained sediments (<0.15 mm) will move seasonally across the area depending on river input and hydraulic conditions." Sediments dumped at Site E, the primary disposal site, are eroded from late summer through winter. The fate of these sediments are not known, but a predominant north-northeasterly transport is postulated (Borgeld et al., 1978). Movement of Columbia River bedload materials onto southern Washington beaches, via a similar pathway adjacent to Peacock Spit, has also been documented by Ballard (1964) and Gross et al. (1969). The results of bottom drifter studies (Figure 3-7) suggest that "coastal sands would be transported slowly in a onshore direction except during storms sufficiently severe to put the material in suspension. For the coarser sands this occurrence would be unlikely, but the finer sands may well be moved seaward by this mechanism. In this way the coarser material is trapped next to the coast and continually reworked" (Smith and Hopkins, 1972; pp 163-164). Consequently, physical processes may eventually transport dredged sediments dumped at Site E onto adjacent beaches, providing beneficial beach nourishment.

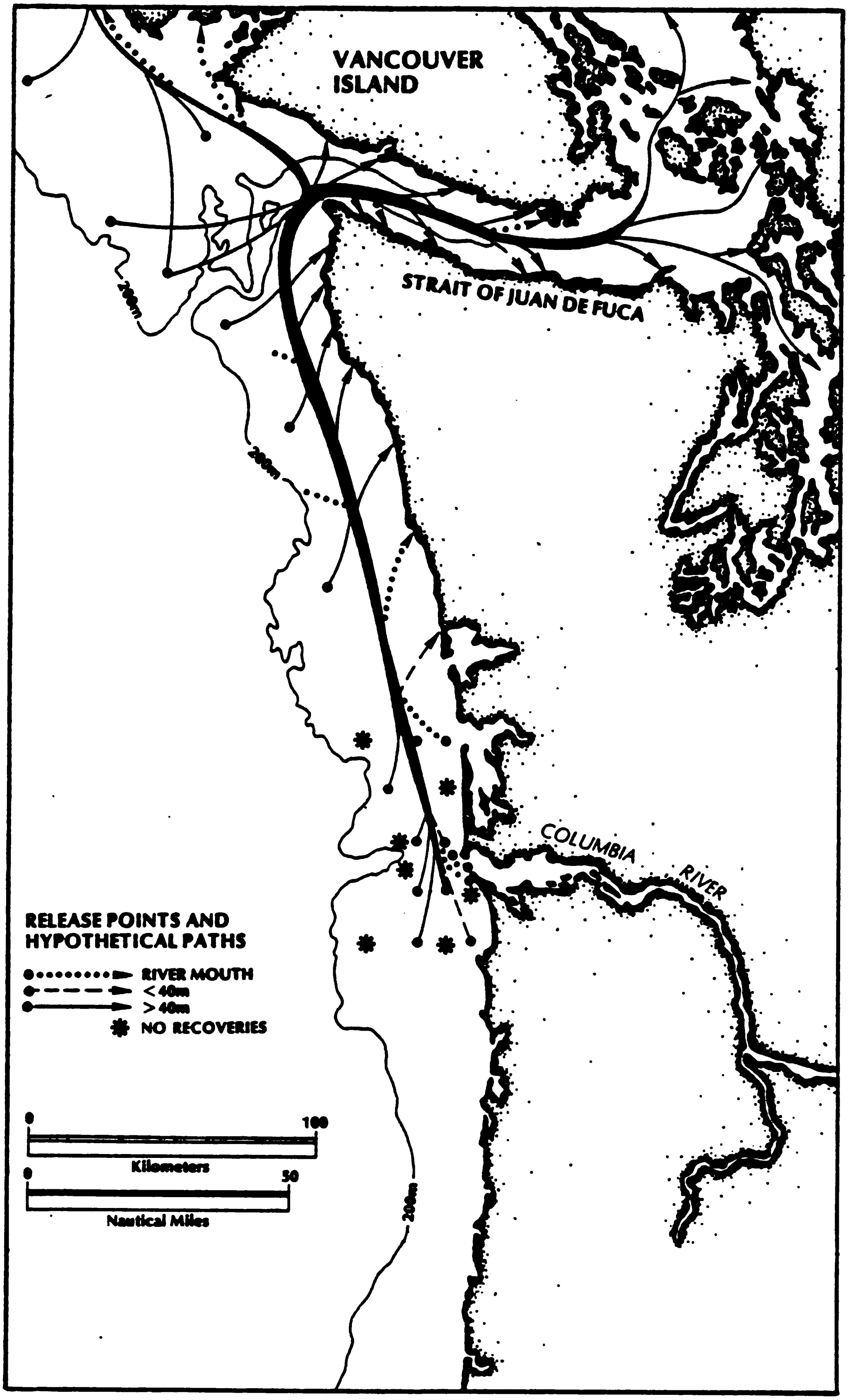

Figure 3-7. Paths of Seabed Drifters Released Along the Washington Continental Shelf
Source: Barnes et al. (1972)

CHEMISTRY

Water Column Chemistry

The chemical parameters pertinent to evaluation of a DMDS include suspended solids, nutrients important to phytoplankton growth (e.g., nitrate and phosphate), dissolved and particulate trace elements (e.g., Cd, Hg, and Pb), and hydrocarbons (e.g., PCB, DDT, and phenol).

Potential impacts depend on the concentrations of constituents released from dredged material and physical factors such as mixing and dilution rates. However, because of the transient nature of water masses, adverse effects are expected to be minor in most cases.

High levels of suspended solids may reduce light penetration through the water column and thereby inhibit phytoplankton productivity, or clog respiratory structures of fishes and other organisms.

Nutrients are essential for growth and reproduction of phytoplankton. However, under certain conditions, and at elevated levels, nutrients may promote eutrophication with subsequent depletion of dissolved oxygen, or in the case of ammonia, may be toxic to organisms in the water column.

Several trace elements are necessary micronutrients in the life processes of organisms. Many elements, such as mercury and cadmium, can be toxic if present in relatively high levels in water, or in food sources such as suspended particulates. Many chlorinated or petroleum hydrocarbons are toxic, and may be bioaccumulated by marine organisms if ingested in sufficient quantities.

Dissolved Nutrients

Concentrations of several dissolved and particulate chemical species within the nearshore waters are controlled by physical mixing and biological processes. Therefore, chemical concentrations vary with seasonal, tidal, and diurnal cycles. For example, dissolved silicate concentrations in waters adjacent to MCR are influenced by the concentrations and mixing ratios of three water bodies: river water, which contains high concentrations of silicate (80 to 230 µg-at/l); surface seawater, containing relatively low concentrations (2 to 10 µg-at/l); and subsurface seawater, with silicate concentrations which are intermediate between river and surface seawater (approximately 90 µg-at/l) (Duxbury and McGary, 1968). The relative contributions of each of the three water bodies to observed nearshore nitrate and phosphate concentrations are also variable and dependent on the rate of biological utilization before mixing. However, in summer river water generally contributes large amounts of silicate, moderate amounts of phosphate, and essentially no nitrate to the estuarine area. Upwelling provides a major source of both nitrate and phosphate (Conomos et al., 1972). Average summer concentrations of dissolved nutrients in nearshore waters are presented in Figure 3-8. Larger concentrations of dissolved nutrients would be expected during the winter season in waters adjacent to MCR, due to increased nutrient inputs from river water, vertical mixing and entrainment of nearshore waters, and decreased biological uptake. Tidal oscillations also affect nearshore vertical nutrient gradients by transporting oceanic waters, with steep nutrient gradients, onshore during flood tides and entraining deeper nutrient-rich ocean waters during ebb tides (Boone et al., 1978).

<u>Trace Metals</u>

The concentrations of trace metals in nearshore waters are influenced by inputs from river water, upwelling and surface advection. Processes removing trace metals from nearshore waters include advection, biological activity, sorption, flocculation, ion exchange, precipitation and coprecipitation (Boone et al., 1978). Observed dissolved and particulate trace metal concentrations in water adjacent to MCR are generally low or below detection limits (e.g., nickel - 0.5 µg/l; copper - 0.5 µg/l; zinc - 2.5 µg/l; lead - 0.22 µg/l). Systematic changes in trace metal concentrations, due to inputs from the Columbia River, are apparent (Holton et al., 1978).

No data are available for the concentrations of trace metals in the tissues of MCR organisms.

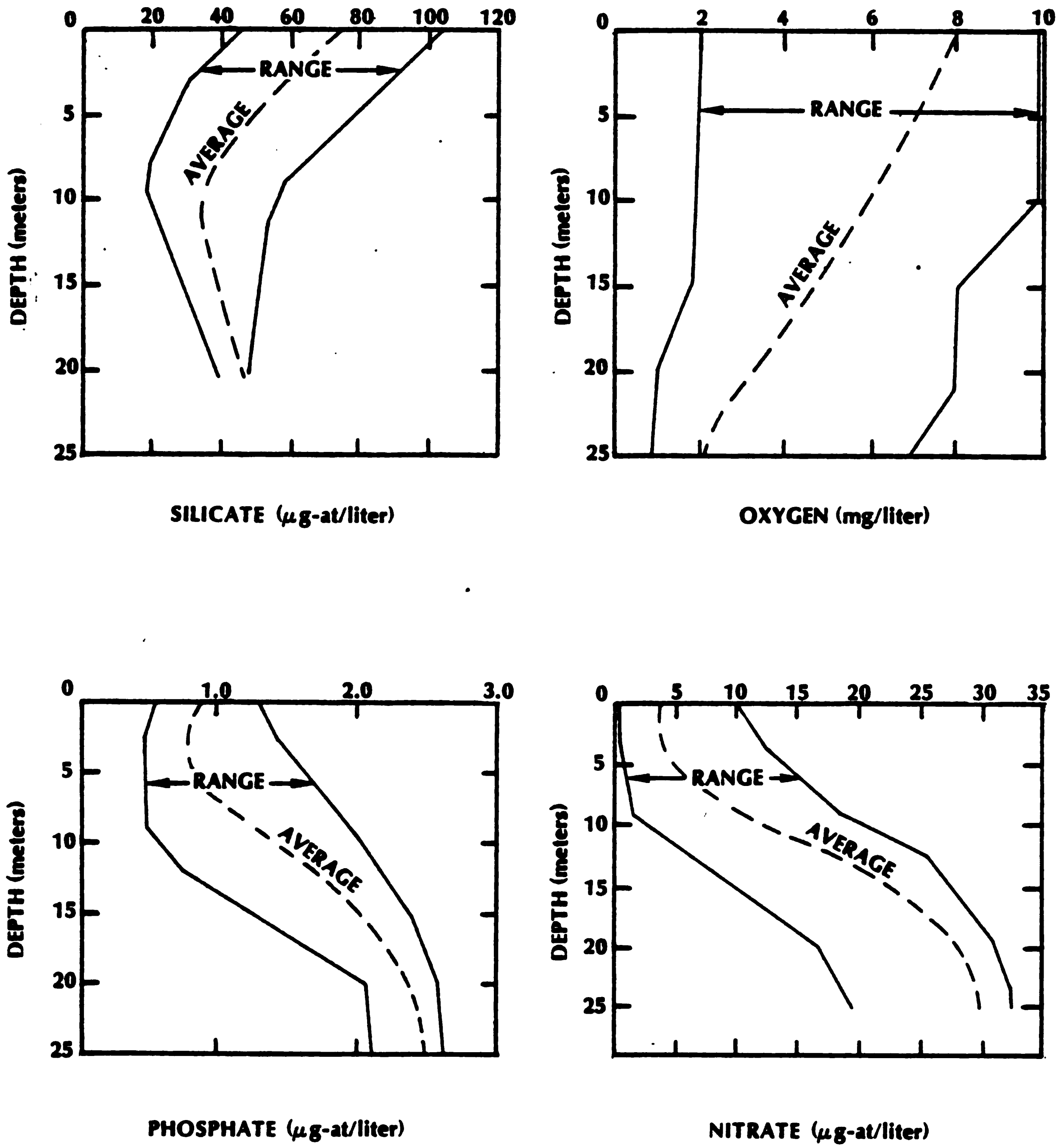

Figure 3-8. Average Summer Concentrations of Dissolved Oxygen and Nutrients in Nearshore Waters
Source: Duxbury and McGary (1968), Holton et al. (1978)

Dissolved Oxygen

Dissolved oxygen concentrations in waters adjacent to MCR vary from 1.0 to 10 mg/l, and are influenced by atmospheric exchange, physical mixing, and biological processes (Holton et al., 1978). High photosynthetic rates by estuarine phytoplankton are responsible for the supersaturation of nearshore surface waters in spring and early summer, while biochemical oxidation is responsible for a decline in the percent oxygen saturation in the fall and winter (Park et al., 1972). Concentration ranges of dissolved oxygen in nearshore waters during summer are presented in Figure 3-8.

Sediment Chemistry

A variety of trace contaminants, such as trace metals, petroleum, and chlorinated hydrocarbons, and other organic materials, commonly expressed as total organic carbon (TOC), may accumulate in sediments. Elevated levels of marine sediment contaminants are generally caused by anthropogenic inputs such as municipal and industrial waste, urban and agricultural runoff, atmospheric fallout from urban centers, and accidental spillage.

Silty and clayey sediments exhibit greater absorptive capacities for trace contaminants, and have typically higher TOC levels than coarser materials, because of the large surface area to volume ratios and charge densities. Accumulation of trace elements and chlorinated or petroleum hydrocarbons in sediments may produce short- or long-term negative effects on marine organisms. Many benthic organisms are nonselective deposit feeders that ingest substantial quantities of suspended and bottom sediments. Thus, potential bioaccumulation of trace contaminants (e.g., mercury, cadmium, and lead, and some chlorinated hydrocarbons) by these organisms is an important environmental concern.

High concentrations of organic materials in sediments could lead to anoxic conditions and produce hydrogen sulfide or metal sulfides. Oxidation of these sulfides is responsible for much of the initial consumption of oxygen immediately following dredged material disposal. Significantly lowered oxygen levels in sediments or near-bottom waters may adversely affect marine organisms.

The concentrations of particulate carbon and nitrogen, as well as particulate trace metals, in sediments offshore of MCR are expected to vary in direct proportion to the percentages of silt (Chen et al., 1976). A resume of the concentrations of trace metals measured in the sediments of the area during the DRRP is presented in Table 3-4. Elevated but variable concentrations of particulate carbon, nitrogen, nickel, iron, manganese, copper, zinc, cadmium, mercury, and lead were measured in the sediments at Site B. Elevated trace metal and organic concentrations are associated with the abundance of fine grain sediments which are derived from both natural deposition and dredged material disposal. Boone et al. (1978) concluded that elevated concentrations of trace metals in Site B sediments are within the ranges expected for clean sands, and therefore not indicative of polluted materials. Small quantities of magnetite or black sands account for the observed high concentrations of iron and manganese in the area sediments.

Oil and Grease, pH

Sediments at Site G contain low concentrations of oil and grease (<100 mg/kg) and pH values ranging from 7.5 to 7.8. Although analyses have not been performed on predisposal sediments from Sites A, E, or F, concentrations of oil and grease and pH values are not expected to be significantly different from the corresponding values for Site G sediments. Oil and grease concentrations exceeding 700 mg/kg have been measured in sediments from the vicinity of Site B, in association with fine-grain sediments (Boone et al., 1978).

BIOLOGY

Biota in the water column and in benthic environments of the DMDS are described in this section. Water column biota include phytoplankton, zooplankton, and nekton; benthic biota include infaunal and epifaunal

TABLE 3-4

CONCENTRATIONS OF TRACE METALS FROM MCR DISPOSAL AREA SEDIMENTS

Element	Concentration (mg/kg)			
	Mean	Mean Range		
Cadmium	0.12	0.02	to	0.36
Copper	2.7	0.68	to	4.5
Iron	4344	3560	to	5156
Manganese	77.4	39.7	to	292
Nickel	6.5	3.5	to	44
Zinc	16.4	8.	to	33.3
Lead	4.22	2.1	to	15.2
Mercury	0.385	0.0078	to	1.51

Adapted from Boone et al (1978)

organisms and demersal fish. Benthic biota, especially the infauna, can be generally sedentary or sessile, and cannot readily emigrate from areas of disturbance. Infauna, therefore, are used as important indicators of environmental conditions. Dredged material disposal causes only short-term effects on planktonic communities because of the natural patchiness of the species and the transient nature of the water masses they inhabit. Nekton are highly mobile and normally are not affected by disposal of dredged material.

Significant adverse impacts due to the disposal of dredged material may be manifested by changes in the existing biological community. However, variability in natural populations often obscure changes caused by disposal operations. Therefore, extensive background data are usually required in order to detect significant perturbations. Conclusions based on previous studies of the biological communities occurring at MCR and summarized in this section, are limited by insufficient seasonal and predisposal data.

Plankton

Phytoplankton communities consist of a diverse assemblage of diatoms and dinoflagellates having seasonally variable standing stocks and productivities. Common winter diatom species include *Asterionella formosa*, *Melosira islandica*, and *Thallassionema nitzschoides*; spring and summer assemblages are represented by *Chaetoceros compressus*, *Asterionella japonica*, and *Rhizoselenia alata*. Annual primary productivities range from approximately 200 mgC/m^3/hr in spring to less than 5 mgC/m^3/hr in winter (Anderson, 1972).

Zooplankton and ichthyoplankton populations in the areas of the MCR Interim Sites were investigated by Holton and Small (1978). Logistic problems and inadequate sampling limited the extent of their conclusions; however, the following trends were apparent: ichthyoplankton populations were comprised mainly of smelt (Osmeridae, 60% of the total catch), anchovy (Engraulidae, 12% of the total), righteye flounder (Pleuronectidae, 8.9% of the total), and codfish (Gadidae, 8.0% of the total). Ichthyoplankton abundances vary seasonally, reach their peak in March, and nadir in August.

In general, the zooplankton are dominated by calanoid copepods, gammarid amphipods, cumaceans, and mysids. *Cancer magister* zoea were abundant from January to March but with the exception of the small numbers of megalopae present in June, larvae were essentially absent from the plankton during the rest of the year. The abundances of other shrimp and crab larvae were highest during the winter (approximate densities of 75 animals per 1,000 m^3) and lowest (densities less than 10 animals per 1,000 m^3) in the summer (Boone et al., 1978). Diel changes in zooplankton abundance were noted; most species were collected near the bottom during the day, and higher in the water column during the night.

Benthos

Factors influencing the structure of benthic communities along the Oregon-Washington Shelf (e.g., organic content, stability, and composition of the substrate) also influence the benthos in areas adjacent to MCR (Richardson et al., 1977). For example, the deposition of organically rich silt from the Columbia River at Site B is ostensibly responsible for low diversity, and high biomass and density of organisms at the site. Seasonal changes in community structure at Site B are influenced by relatively frequent sediment agitation and seasonal changes in sediment texture. In contrast, sediments in the vicinity of Site G are typically well-sorted, fine- grained sands that do not vary seasonally in texture, and consequently the indigenous biological community has a higher diversity and lower biomass. The benthic community at Site E is influenced more than other MCR disposal sites by the Columbia River currents, and has a consistently lower density and diversity (Richardson et al., 1977).

Richardson et al. (1977) sampled benthic infauna from October 1974 through June 1976 and identified five benthic assemblages in the nearshore region adjacent to MCR. Four of the five assemblages exhibited a higher density, diversity, and biomass than assemblages from comparable depths in other areas along the coasts of Washington and Oregon. Recognizable differences in composition, diversity, and abundance are apparently related to increased primary productivity and the influence of sediment input from the Columbia River.

Finfish and Shellfish

Durkin and Lipovsky (1977) sampled demersal finfish and shellfish from October 1974 to April 1976 and noted spatial differences in the abundances of the dominant finfish species of the MCR area. Pricklebreast poacher (*Stellerina xyosterna*) and showy snailfish (*Liparis pulchellus*) were numerically dominant in areas north of the entrance channel, whereas butter sole (*Isopsetta isolepsis*) and Pacific sanddab (*Citharichthys sordidus*) were dominant in areas south of the channel. Whitebait smelt (*Allosmerus elongatus*), English sole (*Parophrys vetulus*) and Pacific tomcod (*Microgadus proximus*) were abundant at all sampled sites adjacent to MCR, while anchovy (*Engraulis mordax*) and longfin smelt (*Spirinchus thaleichthys*) were abundant at all stations except Site G. Site-specific differences in finfish abundances are posssibly due to specific food preferences and selective feeding patterns. Limited data restrict conclusions about the seasonal abundance patterns of individual finfish species in the nearshore MCR area. However, significant differences in seasonal abundances of 9 of the 11 dominant finfish and shellfish species were detected. During 1975, abundances of two of the dominant and commercially important species, Pacific sandab and English sole, were apparently higher in summer (Durkin and Lipovsky, 1977).

The dominant shellfish in the MCR are shrimp (Crangon spp.) and Dungeness crab (Cancer magister). More Crangon franciscorum and large numbers of C. magister were collected at sites north of the entrance channel, than at sites south of the entrance channel. Cancer magister occur throughout the year in the MCR area, although few crabs were captured from April to July of 1975. The ratio of male to female crabs is higher from November through January (Durkin and Lipovsky, 1977).

Marine Mammals

A list of the marine mammals occurring in the area adjacent to MCR is presented in Table 3-5. The majority of cetaceans (Mysticeti and Odontoceti) are usually found offshore. The four cetacean species occurring nearshore and within the lower Columbia River are Orcinus orca, Phocoeana phocoena, Phoconoides dalli, and Eschrichtius robustus. The population status of these four species in the MCR area is not well known (Everitt et al., 1980).

Phocoeana phocoena is found in the area throughout the year, but Phocoenoides dalli occurs only in the spring and summer. Gray whales (Eschrichtius robustus) are present during southerly and northerly migrations (late autumn and late winter to early spring, respectively). Harbor seals (Phoca vitulina) are common in the Columbia River and along the adjacent coast in fall and winter months. Northern sea lions (Eumatopius jubatus) and California sea lions (Zalophus californianus) also occur within the River and along the adjacent coast from autumn until early spring (Everitt et al., 1980).

TABLE 3-5
MARINE MAMMALS OF THE OUTER COAST OF WASHINGTON AND OREGON

Species Common Name	Scientific Name
Mustelidae	
Sea otter	*Enhydra lutris* *
Pinnipedia	
California sea lion	*Zalophus californianus*
Northern (Steller's) sea lion	*Eumatopias jubatus*
Northern fur seal	*Callorhinus ursinus*
Harbor seal	*Phoca vitulina richardsi*
Northern elephant seal	*Mirounga anguestirostris*
Mysticeti	
Gray whale	*Eschrichtius robustus* †
Minke whale	*Balaenoptera acutorostrata*
Sei whale	*Balaenoptera borealis* †
Fin whale	*Balaenoptera physalus* †
Blue whale	*Balaenoptera musculus* †
Humpback whale	*Megaptera novaeangliae* †
Right whale	*Balaena glacialis* †
Odontoceti	
Right whale dolphin	*Lissodelphis borealis*
Whitehead grampus	*Grampus griseus*
Striped dolphin	*Stenella coeruleoalba*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*
Saddleback dolphin	*Delphinus delphis*
False killer whale	*Pseudorca crassidens*
Shortfin pilot whale	*Globicephala macrorhynchus*
Killer whale	*Orcinus orca*
Harbor porpoise	*Phocoeana phocoena*
Dall porpoise	*Phocoenoides dalli*
Pygmy sperm whale	*Kogia breviceps*
Goosebeak whale	*Ziphius cavirostris*
North Pacific giant bottlenose whale	*Berardius bairdi*
Arch-beaked whale	*Mesoplodon carlhubbsi*
Bering Sea beaked whale	*Mesoplodon stejnegeri*
Sperm whale	*Physeter catodon* †

* Threatened species
† Endangered species

Source: Everitt et al., 1980

ASTORIA CANYON

OCEANOGRAPHY

Currents at the head of Astoria Canyon have been measured by Hickey and Smith (1978). Preliminary data indicate that current flows near the head are perpendicular to the Canyon axis (oriented northeast to southwest), whereas flows inside the Canyon are parallel to the axis, predominantly in a southwesterly, down-slope direction. Previous investigations of other Pacific Coast submarine canyons have shown that internal waves influence up-canyon and down-canyon currents; a similar mechanism may affect currents in Astoria Canyon (Shepard et al., 1974a,b).

GEOLOGY

Astoria Canyon is the largest submarine valley near the MCR. The canyon head starts at 100m, beyond the zone of longshore drift (Nelson et al., 1970). Five bottom sediment types identified in cores are: (1) silty clay, (2) laminated clay, (3) sand and silt beds, (4) graded beds, and (5) mottled sediment (Carlson and Nelson, 1969). The texture and composition of the graded bedding suggest the occurrence of turbidity currents (ibid.) In addition, the presence of plant and wood fragments, sediment-associated radionuclides, and sediment trace metal concentrations similar to those found in Columbia River sediments, suggest that some sediments in Astoria Canyon are derived from the Columbia River (ibid.) The sedimentation rate in the upper portion of the Canyon is approximately 75 cm per thousand years (ibid.)

CHEMISTRY

Water and sediment chemistry data are unavailable for the Astoria Canyon. The biological and physical processes which influence the concentrations of dissolved and particulate chemical species in the MCR area, river discharge, tidal currents, and photosynthesis for example, are not as prevalent in Astoria Canyon. Therefore, concentrations of chemical species in the Canyon water and sediments are not anticipated to be as variable as those at MCR.

The major chemical input sources to Astoria Canyon are terrigenous materials from the Columbia River, sinking particulate material and entrained Shelf sediments (Carlson and Nelson, 1969).

BIOLOGY

Site-specific biological data for Astoria Canyon are unavailable. However, benthic trawl data from areas immediately south of Astoria Canyon, and within 10 nmi of the Alternative Site, have demonstrated the occurrence of several potentially important commercial finfish and shellfish species, including sablefish (*Anoplopoma fimbria*), Pacific ocean perch (*Sebastes alutus*), dover sole (*Microstomus pacificus*), and tanner crab (*Chionoecetes tanneri*) (Alton, 1972; Pereyra, 1972).

THREATENED AND ENDANGERED SPECIES

Threatened and endangered mammal species occurring within the vicinity of either the Columbia River or Astoria Canyon are listed in Table 3-5. The endangered mammal species, with the exception of gray whales, and bald eagles (*Haliaeetus leucocephalus*) are rarely encountered at the MCR Interim Sites. Gray whales migrate past MCR, to the south in November and December, and northerly from February to April, generally within 1 to 3 nmi from shore.

HISTORY OF DREDGING ACTIVITIES

The forces of river, tidal, and ocean currents continually alter the depths and location of the entrance channel to the Columbia River. Efforts to regulate the physical forces and stabilize channel depths are necessary to prevent shoaling and to maintain navigable water depths. Before 1882 attempts to maintain the entrance channel consisted of occasional dredging and construction of temporary training structures which were not effective in controlling shoaling processes. In 1882 Congress authorized the construction of a 7.2 km jetty, due west from Clatsop Spit. Subsequent to completion of the South Jetty, a single channel with a depth of 9.1m, extended from the river mouth across the outer tidal delta. By 1898 the entrance channel had migrated northward, reducing channel depths to 6.7m. A plan to improve navigational safety in the entrance channel by construction of a North Jetty, extending the existing South Jetty, and additional dredging was authorized by Congress in 1905. Completion of the project in 1917 subsequently resulted in a 1.6-km-wide channel with a depth of 14m.

Shoaling eventually occurred north and west of Clatsop Spit along the South Jetty, reducing channel depths to 13m in 1931. In addition to limited channel dredging, annual dredging of the northwest section of Clatsop Spit was initiated in 1939. Congress modified the entrance project in 1954 to accommodate the needs of modern ocean navigation and established a minimum channel depth of 15m, throughout the 0.8 km wide channel, maintained by annual dredging. The authorized entrance channel extends upriver 3 nmi.

Initially, the majority (75%) of dredged material was dumped at MCR Interim Site A; the remainder was dumped at Site B and at other disposal sites within the estuary (Lockett, 1963). Descriptions of the sites used for dredged material disposal before 1973 are unavailable. Annual volumes of dredged material released at the MCR Interim Sites subsequent to 1973 are presented (by disposal site) in Table 3-6.

Locations of each of the disposal sites are shown in Figure 3-9. In 1952 bottom current measurements in areas adjacent to MCR suggested that dredged material released at Site A would return to the entrance channel (Lockett, 1963). Consequently, use of Site A was discontinued until 1971, and it has been used only occasionally since then. The majority of the material dredged from the entrance channel is now dumped in Sites B and E, although approximately 29% of the total dredged material volume was released at Site A in 1977.

Site G, an experimental disposal site maintained by the Corps of Engineers, received approximately 600,000 yd^3 of dredged material in 1976, and has not been used since then for disposal. Site F received small amounts of material annually until 1976, and has not been used since that time.

TABLE 3-6
DISPOSAL OF DREDGED MATERIAL AT THE MCR (1973-1979)

Year	Sites (Amounts of dredged material released in yd^3)						
	A	B	D	E	F	G	Total
1973		3,051,780	409,656	291,450	3,060		3,755,946
1974		994,098	506,730	2,168,627	29,124		3,698,579
1975		33,462	895,594	4,886,792	27,540		6,143,388
1976	2,574	1,017,100	758,743	4,257,150	53,250	581,616	6,670,433
1977	2,867,393	1,868,579	710,373	3,678,429			9,124,774
1978	3,060	187,704	312,635	3,925,986			4,429,385
1979		116,502	158,466	4,930,840			5,205,808

Source: A.J. Heineman, CE Portland District (personal communication)

Dredged material disposal at the estuarine disposal Site D (Figure 3-9) occurs when weather conditions preclude the use of ocean disposal sites, or during crew changes on the hopper dredge. Annual volumes dumped at Site D vary considerably and, since 1957, have ranged from approximately 2,000 yd^3 to 2 million yd^3. Disposal Site C, also located within the estuary, immediately southeast of the North Jetty, was used intermittently until 1971 for volumes ranging from 800 yd^3 to 1.11 million yd^3 annually.

CHARACTERISTICS OF DREDGED MATERIAL

PHYSICAL CHARACTERISTICS

Dredged sediments consist primarily (95% to 98%) of medium to fine, clean sands (median diameters 0.25 to 0.15 mm). Coarser sands are dredged from the deeper, central areas of the channel, while the finer sands are dredged from the borders and seaward end of the entrance channel (Borgeld et al., 1978).

CHEMICAL CHARACTERISTICS

Dredged sediments are presently predominantly sand, therefore they are environmentally acceptable for ocean dumping without further testing (40 CFR §227.13b). Extensive chemical measurements for these sediments are unavailable; however, a partial chemical characterization of sediment samples dredged from the entrance channel is presented, together with a characterization of area

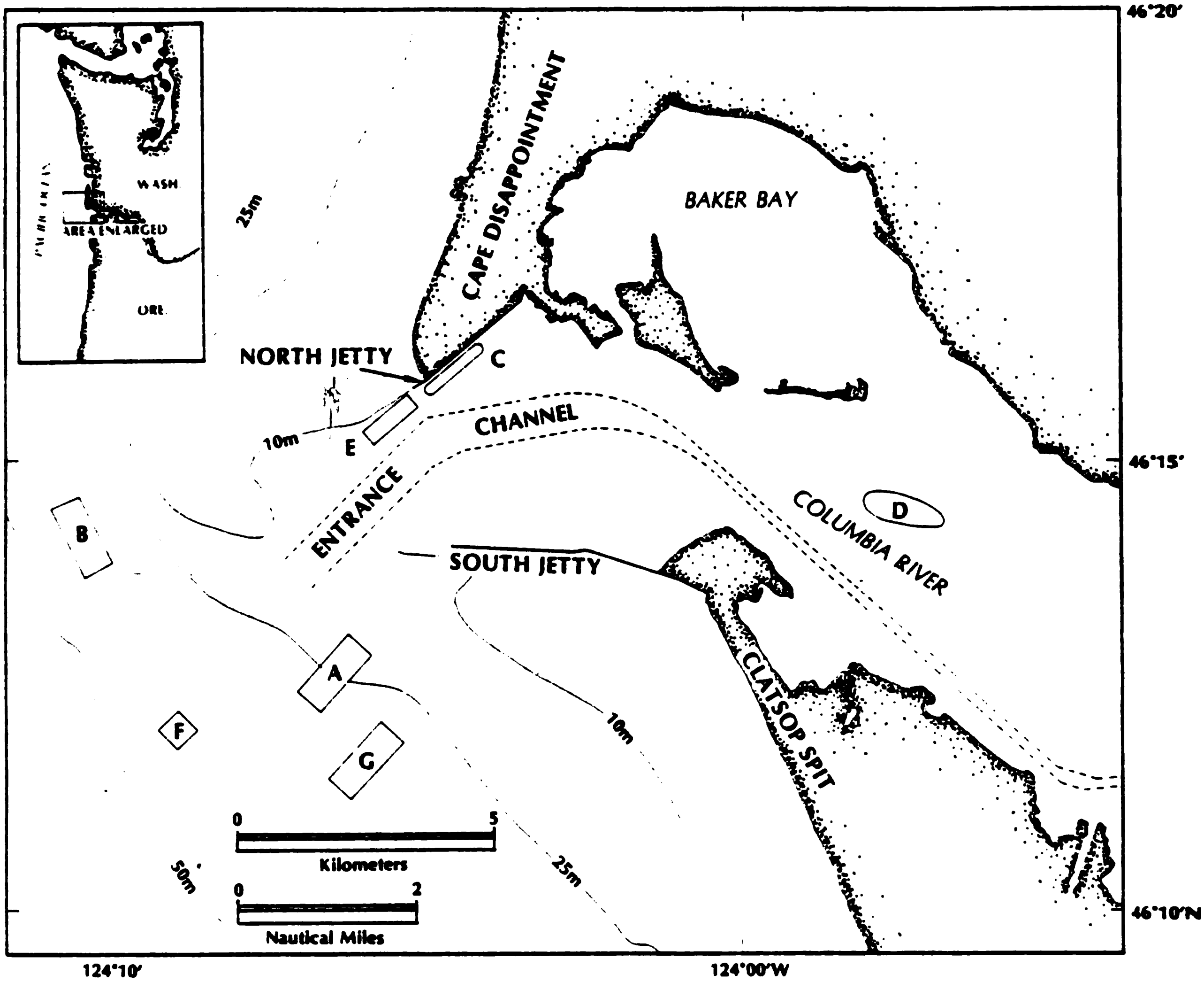

Figure 3-9. Locations of Estuarine and Ocean Disposal Sites Previously Used for the MCR Dredging Project

sediments in Table 3-7. Dredged material from other areas would need to be evaluated prior to its disposal.

OTHER ACTIVITIES

FISHERIES

Mouth of the Columbia River

The MCR is one of the most heavily fished areas in the Pacific Northwest (Squire and Smith, 1977). Commercial and sport fishing operations based in

TABLE 3-7

CHEMICAL CHARACTERISTICS OF DREDGED SEDIMENTS

Element	Dredged Sediments (mg/kg)		Area Sediments (mg/kg)	
	Mean	Range	Mean	Range
Cadmium	0.1	BD* to 0.1	0.12	0.02 to 0.36
Copper	0.78	0.1 to 1.5	2.74	0.68 to 4.5
Iron	3560	3400 to 4000	4344	3560 to 5156
Zinc	47	24 to 63	77.4	39.7 to 292
Manganese	9.08	5.1 to 11.4	16.4	8. to 33.3
Nickel	4.7	2.8 to 6.0	6.5	3.5 to 44
Lead	2.0	1.6 to 2.5	4.22	2.1 to 15.2
Mercury	0.0078	0.0063 to 0.011	0.385	0.0078 to 1.51
Sulfide	BD			
Oil & grease	BD			

* BD denotes below detection

Adapted from Boone et al., 1978

the Columbia River system are valued at $27 million per year and are dependent on catches of both marine and anadromous species (State of Washington, 1980; Rompa et al., 1979).

Salmonids constitute the most valuable fisheries resource in the Columbia River and adjacent nearshore waters. The commercial catch consists primarily of chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*) and, to a lesser extent, chum (*O. keta*), pink (*O. gorbuscha*), and sockeye salmon (*O. nerka*). The combined ocean and river catch of salmonids was worth approximately $24 million in 1978 (State of Washington, 1980) (Table 3-8).

Salmon are taken in the lower river below Bonneville Dam with gillnets. At present there are 1,200 licensed commercial gillnet fisherman operating in the lower Columbia River (Everett et al., 1980). The size and duration of the spring, summer, and fall runs of salmonids are presented in Table 3-9. Primary migration routes of salmonids, as well as other anadromous species, are shown in Figure 3-10.

TABLE 3-8
COMMERCIAL FISH LANDINGS AT MCR

Species	River*			Ocean†		
	Landings (Number of fish)	Weight (lb)	Value ($)	Landings (Number of fish)	Weight (lb)	Value ($)
Spring Chinook	13,500		596,250			
Summer Chinook						
Fall Chinook		3,700,000 (annual total)		529,800 (annual total)	6,358,000 (annual total)	11,126,500 (annual total)
Early Fall	39,700		1,307,890			
Late Fall	71,600		1,854,150			
Coho	132,600	1,100,000	1,713,510	1,036,500	8,618,668	9,308,200
Chum	1,500	20,300	20,300			
White Sturgeon	9,900		172,740			
Green Sturgeon	1,800		4,930			
Shad	111,700		31,290			
Smelt			216,288			
Flounder		525,800	12,750			
Steelhead	24,890	237,700	202,100			
Total	407,190	5,583,800	$6,132,198	1,566,300	15,000,000	$20,434,700

*1978
†Annual Average, 1976 to 78

Sources: Everitt et al. (1980), Rompa et al. (1979), State of Washington (1980)

TABLE 3-9
SIZE AND DURATION OF SALMONID RUNS INTO THE COLUMBIA RIVER

Species	Estimates of Runs Into Columbia River (1978)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring Chinook	120,100	......	......	------	------								
Summer Chinook	43,400					......	------	......					
Fall Chinook	240,100							......	......	......	......	......	......
Pink Salmon	No data								......	......	......		
Chum Salmon	No data										......	......	
Sockeye Salmon	18,400						......	......					
Coho Salmon	374,400								......	------	------	......	......
Summer Steelhead	105,000				......	......	......	------	------	......	......		
Winter Steelhead	44,700	------	------	......							......	------	------

Dashed lines (--------) indicate periods of intensive sport harvest

Dotted lines (........) indicate presence in river

Sources: Pacific Fishery Management Council (1980); Oregon Department of Fish and Wildlife, Washington Department of Fisheries (1979)

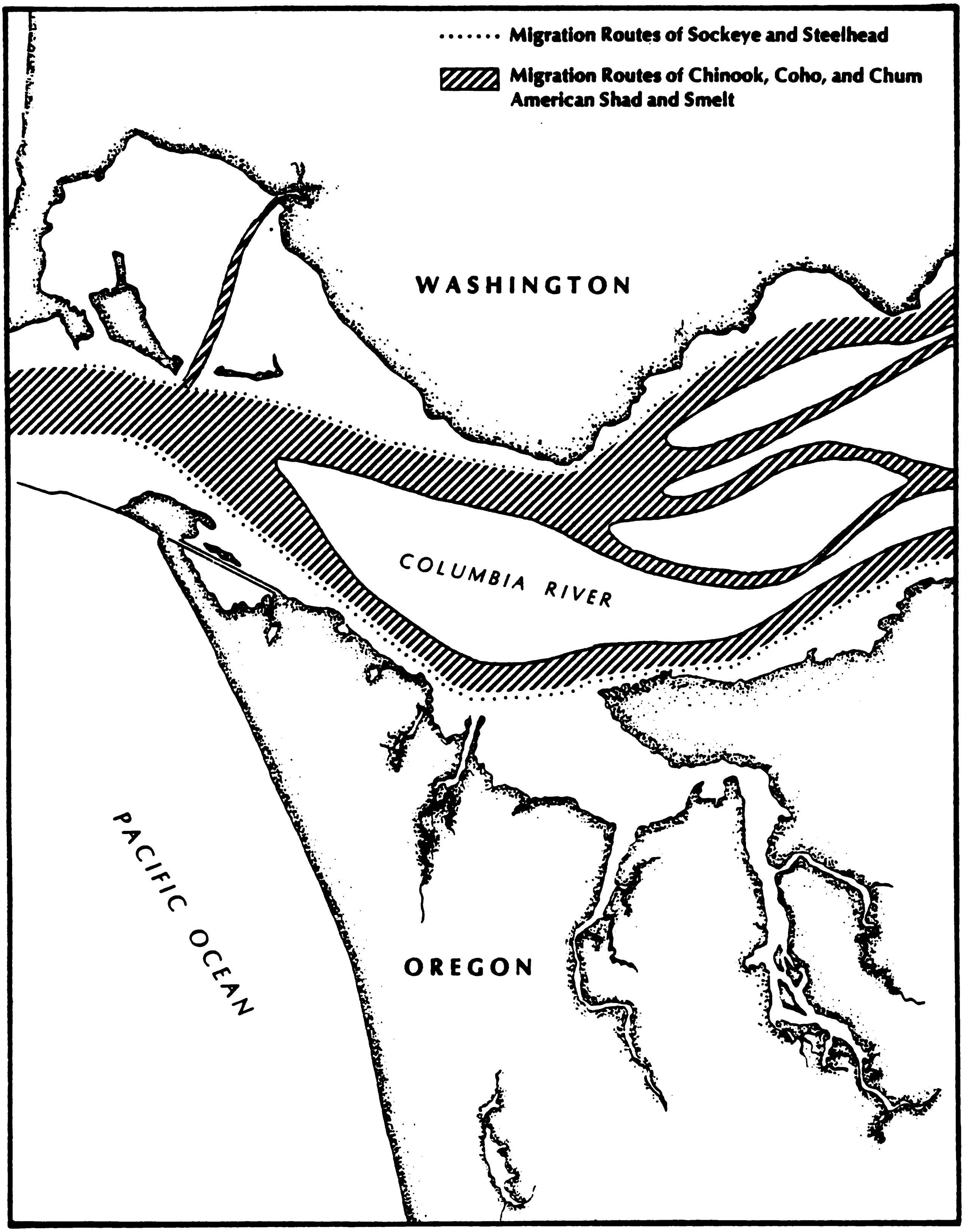

Figure 3-10. Primary Migration Routes of Anadromous Finfish
Source: CREST (1977)

Approximately half of the total salmonid catch is taken by commercial trollers near the river mouth and adjacent ocean waters. Coho and chinook are generally caught offshore in the early summer and further inshore later in the season (Squire and Smith, 1977). The largest ocean catches of chinook and coho are from May through August and June through October respectively (INPFC, 1979).

Sport fishermen take approximately one-third of the total annual salmon catch (Oregon Department of Fish and Wildlife, Washington Department of Fisheries, 1979). An estimated 163,000 fishing trips for salmonids were made on the lower Columbia River by sport fishermen in 1978. Salmonids are also taken by anglers at the South Jetty, where chinook are caught from June to July, and coho from June to September (Squire and Smith, 1977). Large steelhead trout (Salmo gairdneri) runs in the lower river provide recreational fisheries from November to March.

In addition to salmonids, smelt (Thaleichthys pacificus), shad (Alosa sapidissima), green sturgeon (Acipenser medirostris), white sturgeon (A. transmontanus), and starry flounder (Platichthys stellatus) are caught within the estuary; redtail surfperch (Amphistichus rhodoterus), Pacific tomcod (Microgadus proximus), and starry flounder (Platichthys stellatus) are taken at the South Jetty by sport fishermen (Everitt et al., 1980). The distributions of these species within the estuary and adjacent coastal areas are shown in Figure 3-11.

The tuna catch by Columbia River-based commercial fishermen consists of yellowfin (Thunnus albacares), skipjack (Euthynnus pelamis), and albacore (T. alalunga). However, only albacore are caught locally, from 30 to 200 nmi offshore, during the summer months when the water temperature reaches 14°C (Rompa et al., 1979).

The commercial catch of demersal species comprises Pacific cod (Gadus microcephalus), ocean perch, rockfish, turbot, flounder, red snapper (Sebastes miniatus), ling cod (Ophiodon elongatus), and several species of sole: petrale (Eopsetta jordani), sand (Psettichthys melanostictus), rex

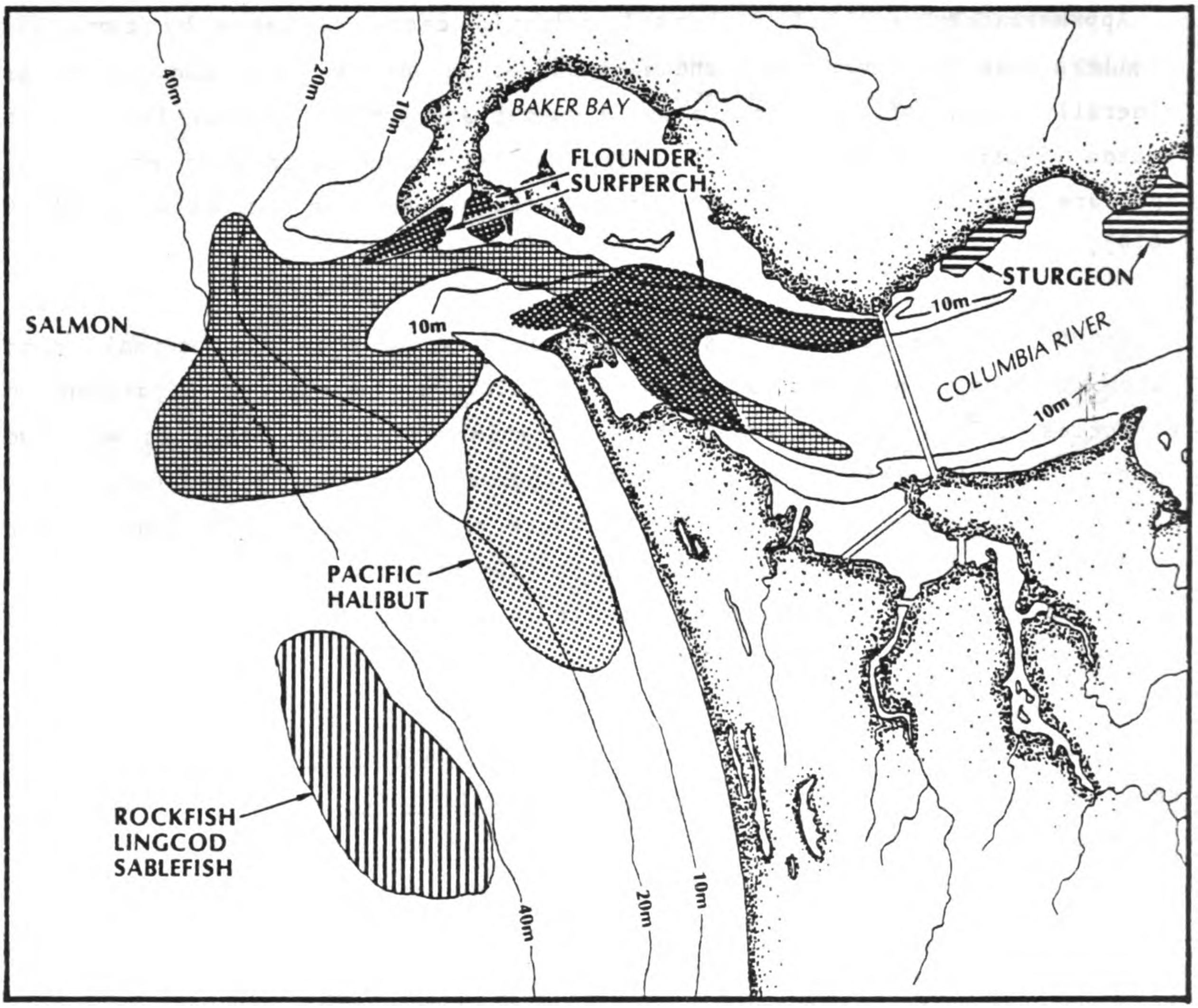

Figure 3-11. Distributions of Commercial and Sport Fisheries in the Lower Columbia River and Adjacent Nearshore Waters Source: Squire and Smith (1977)

(Glyptocephalus zachirus), English (Parophys vetulus), and dover (Microstomas pacificus). The demersal fishery extends from 3 to 40 nmi from the coast; however, the distributions of individual species are typically related to substrate type and depth (Rompa et al., 1979; Demory et al., 1976; Barss et al., 1977). Annual commercial catch volumes consistently average 23,000 kg per year (Rompa et al., 1979).

The existing crab fishery in areas adjacent to MCR is dominated by one species, Cancer magister. Crabs are caught commercially with pots on sandy bottoms and in water depths ranging from 3.5 to 46m (Pruter, 1972). The fishing season lasts from December to April, and the harvest consists of sexually mature males (Rompa et al., 1979).

Additional nearshore commercial and sport fisheries exist for two species of shrimp (*Pandalus jordani* and *P. borealis*), oysters, and several species of clams (Pruter, 1972). Shrimp are caught by trawlers in water depths of 73 to 183m. Clamming areas are located along the sandy beaches south of the Columbia River. The numbers and values of commercial and sport fish are presented in Table 3-8.

Astoria Canyon

Fisheries resources in Astoria Canyon are not well known. A list of commercially important demersal finfish previously found on the outer Continental Shelf of the Northeast Pacific is presented in Table 3-1. Sablefish, in particular, are underutilized inhabitants of submarine canyon along the west coast of North America, and represent a "substantial latent resource off Washington and Oregon" (Pruter, 1972; p. 105). Male tanner crabs (*Chionoecetes tanneri*) have been found in large numbers in areas immediately south of Astoria Canyon, within the depth range of 450 to 550m (Pereyra, 1972).

SAND AND GRAVEL

Sand is an important resource at the MCR area. The direct economic value is limited, but sand supply for beach replenishment has an important bearing on the local tourist industry.

Several black sand deposits exist along the lower river and adjacent coastal beaches. Previous attempts to extract the important minerals (e.g., titaniferous magnetite, chromite, and gold) in the deposits did not prove to be economically feasible. However, commercial mining of nearshore black sand deposits 4 nmi north of the North Jetty has been proposed (Vining, 1981; personal communication).

During the late 1940's and 1950's, the U.S. Bureau of Mines sampled dredged sediments from the entrance channel of the Columbia River to test for the presence of black sands. Although dredged materials contained an average 0.74% iron, 0.20% titanium oxide, and 0.006% chromite, the Bureau personnel determined that black sands were not concentrated in submerged bars in the entrance channel, therefore, black sand mining would not be economically feasible (Norberg, 1980).

An estimated 10.5 billion yd^3 of gravel exist on the Oregon-Washington Continental Shelf, but only a small fraction of the deposits occur in water depths shallower than 20m (Figure 3-12). As onshore deposits are depleted, exploitation of the offshore gravel deposits will become more attractive. However, Moore and Luken (1979) suggest that environmental and economic factors (e.g., potential interferences with fisheries resources) will determine whether commercial gravel dredging is feasible. The authors claim (p. 150) "...present evidence suggests that dredging [sand or gravel] will have little harmful effect on the fish, crab, and shrimp species now being taken from the outer Continental Shelf and will not physically interfere with fish trawling."

OIL AND NATURAL GAS

Braislen et al. (1971) suggested that the late Tertiary basins along the Continental Margin of the Oregon-Washington coast represent the greatest oil and gas potential in the Pacific Northwest. The lack of commercial production is due to the fact that source rocks, reservoir rocks, and petroleum traps have not been found together in areas where previous drilling has taken place.

The Outer Continental Shelf Office of the Bureau of Land Management (BLM) is responsible for the management of natural gas and petroleum reserves in Federal waters. According to BLM projections, no oil or gas explorations will occur on the Continental Shelf adjacent to Washington and Oregon within the current 5-year (June 1980 to 1985) projection period (Fields, 1980)*.

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* John Fields; Bureau of Land Management, Los Angeles (personal communication)

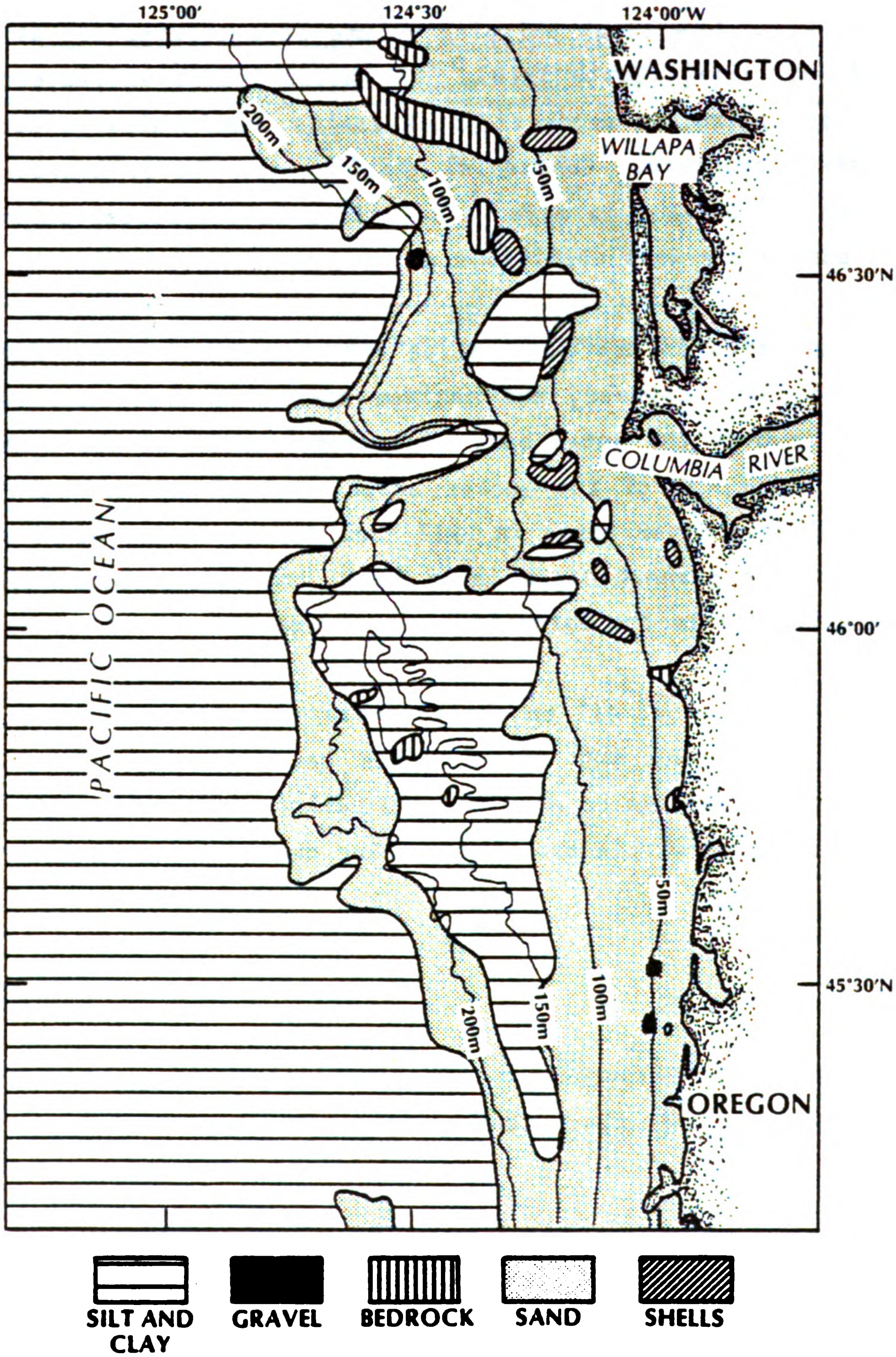

Figure 3-12. Sand and Gravel Resources on the Oregon-Washington Continental Shelf
Source: Moore and Luken (1979)

SHIPPING

The Mouth of the Columbia River is the tenth-busiest port system in the United States, with a total shipping volume of approximately 44 million tons in 1975 (PNRBC, 1979) (Table 3-10). The major import and export commodities are forest and petroleum products, bulk grains, wood chips, mineral ores, and iron and steel products. Commercial shipping traffic is heaviest during the summer, when the weather is mild, and traffic is restricted during the winter by storms and severe wave conditions at the river mouth.

The average size of dry cargo ships entering the Columbia River increased from 1973 to 1977; however, the maximum operating draft may be limited by channel depths over the outer bar. For example, 26% of the combination bulk per vehicle ships, 3% of the tanker ships, and 3% of the bulk ships which called at Columbia River ports in 1977, had design drafts of 40 or more feet. Since the present channel depth is 48 feet, the ships might carry a reduced load when sailing into the Columbia River (Ogden Beeman and Assoc., 1980).

The transportation of oil on the Columbia River amounts to 6 million tons per year, constituting 600 tanker trips per year with an average 30,000 deadweight tons. The loss of over 189,000 gallons of oil, in approximately 890 oil spills, occurred within the river during the period 1973 to 1977 (Johansen and Parrish, 1979).

RECREATION

The MCR provides resources for recreational fishing, swimming, boating, nature observation, and other water-related activities.

TABLE 3-10
WATERBORNE COMMERCE ON THE COLUMBIA RIVER (1975)
(1,000 tons)

	Total	Foreign Inbound	Coastwise Receipts	Total Inbound	Foreign Exports	Coastwise Shipments	Total Outbound	Internal Movement
Portland	19,600	2,030	3,266	5,296	6,560	340	6,900	7,404
Longview	7,380	487	436	923	3,367	36	3,403	3,054
Vancouver	3,467	907	27	934	928	-	928	1,605
Astoria	3,234	42	5	47	1,343	93	1,436	1,751
Kalama	1,549	34	11	45	837	-	837	667
Other Ports	8,546	-	15	15	33	143	176	8,355
Totals	43,776	3,500	3,760	7,260	13,068	612	13,680	22,836

Source: PNRBC (1979)

Chapter 4
ENVIRONMENTAL CONSEQUENCES

The predominantly sand composition of the dredged material from the Columbia River entrance channel minimizes adverse effects on fisheries resources, navigational safety, and aesthetics, and eliminates the need for mitigating measures. Previous use of the MCR Interim Sites for dredged material disposal caused only localized mounding, minor temporary adverse effects on the benthic fauna, and decreases in fish abundances. Baseline data are unavailable for Astoria Canyon; therefore, the potential effects of dredged material on the ecosystem are problematic.

Effects of dredged material disposal, described in this chapter, are classified under two broad categories: ecosystem and public health and safety. The ecosystem section describes the environmental effects of dredged material disposal and emergency dumping on water and sediment chemistry and the biota. The public health and safety section includes effects on commercial and recreational fishing, navigation, and aesthetics. Additional information describes unavoidable, adverse, environmental effects and mitigating measures, short-term use versus long-term productivity, and irreversible and irretrievable commitments of resources. This chapter provides the scientific and analytical bases for evaluation and comparisons of the alternatives described in Chapter 2.

EFFECTS ON THE ECOSYSTEM

The effects of dredged material disposal on water and sediment quality, biota, and endangered species are discussed in the following sections. Potential impacts on the ecosystem from emergency dumping are also considered.

The CE's Dredged Material Research Program (DMRP) for the Mouth of the Columbia River investigated the effects of dredged materials on the ecosystem at experimental Site G. The ecological consequences of dredged material disposal, elucidated by the DMRP, are discussed in the following section.

Few data exist on the Astoria Canyon area, therefore an assessment of the potential impact of dredged material disposal on the ecosystem is not possible.

MOUTH OF THE COLUMBIA RIVER

WATER QUALITY

Changes in dissolved nutrient concentrations caused by dredged material disposal have not been detected in nearshore waters adjacent to the MCR Interim Sites. Observed variations in the nearshore concentrations of nitrate, phosphate, and silicate, as well as dissolved oxygen and pH, are correlated with tidal periodicity (Holton et al., 1978). Concentration changes resulting from the disposal of dredged materials are smaller than and obscured by natural variation.

Increased concentrations of trace metals, lead, cadmium, zinc, manganese, iron, nickel, and copper, were not detected in waters at Site G subsequent to dredged material disposal. Natural variability in trace metal concentrations result from dissolved and particulate trace metal inputs from the Columbia River (Holton et al., 1978). Additional variability noted by the DMRP resulted from poor analytical precision when trace metal concentrations approached analytical detection limits. Boone et al. (1978) concluded that dredged material disposal at the MCR Interim Sites had no detectable effect on observed dissolved trace metal concentrations. Dredged sediments are clean, fine to medium-grained sands which are relatively resistant to resuspension within the disposal site (Sternberg et al., 1977). Therefore, resuspension and subsequent release of adsorbed nutrients or toxic materials is not likely (Snyder, 1976).

SEDIMENT QUALITY

Boone et al. (1978; p. 93) concluded that dredged materials "were chemically similar to the ambient Shelf sediments." Furthermore, DMRP analyses of Site G sediments before and after dumping demonstrated no significant changes in sediment nutrient or trace metal concentrations (Holton et al., 1978). However, levels of trace metals and nutrients were higher in sediments from the vicinity of Site B than in sediments from adjacent areas. The elevated trace metal and nutrient concentrations are apparently related to the presence of a greater percentage of silt-sized sediments, which are transported to the site by natural processes (Holton et al., 1978). The release of dredged material may slightly alter the sediment texture at Sites A, B, and F because channel sediments tend to be slightly coarser than Shelf sediments (Boone et al., 1978).

BIOTA

In general, dredged material disposal presents four potential problems to aquatic organisms: (1) direct burial, (2) temporary increases in turbidity, (3) changes in physical and chemical characteristics of sediments, and (4) the possible introduction of pollutants. It is difficult to distinguish significant adverse effects caused by sediment disposal from changes due to natural variability in species abundances. The conclusions of the DMRP concerning the impact of dredged sediments on MCR biota are discussed below.

Plankton

Effects of dredged material disposal on phytoplankton, zooplankton, and ichthyoplankton are difficult to assess because of high natural variability. In addition, the influence of tidal and river discharges, as well as diel changes in zooplankton and ichthyoplankton abundances, increase the difficulty of measuring disposal effects. Sullivan and Hancock (1977) concluded that for most oceanic areas, natural plankton population fluctuations are so large that field surveys would not be useful for detecting the impacts of dredged material disposal.

Releases of dredged material do not produce a persistent turbidity plume (Boone et al., 1978), thus decreased light transmission with a concomitant decrease in phytoplankton primary productivity is not expected to occur. In addition, no detectable changes in dissolved nutrient or trace metal concentrations accompany disposal; therefore, no significant adverse impacts on phytoplankton productivity are expected.

The effects of dredged material disposal on primary productivity and zooplankton and ichthyoplankton viability were not determined by the DMRP. Nevertheless, Boone et al. (1978, p. 82) noted "[l]arval fish members varied throughout the studies, with no obvious disposal effects." The impacts of dumping on larvae crabs are unknown; larval mortality due either to entrainment in a disposal plume or gill clogging has not been investigated. However, dredged material disposal is limited to a period when Cancer magister larvae are not abundant in the MCR area (Holton and Small, 1978).

Benthos

Benthic organisms at the MCR Interim Sites are subjected to burial and slight changes in sediment texture. Adverse impacts due to disposal-related turbidity are improbable because postdisposal, suspended particulate concentrations are not significantly different from predisposal concentrations (Sternberg et al., 1977). Similarly, because no detectable amounts of trace contaminants are released from the dredged sediments subsequent to dumping, significant impacts on the benthos due to the introduction of pollutants are not expected (Richardson et al., 1977).

Effects of Burial - Dredged material disposal at Site G caused a significant reduction in abundances of 11 of the 31 numerically dominant species. The 11 affected species included 5 amphipod, 5 polychaete, and 1 ophiuroid species. The abundances of 13 other species, including 4 cumacean, 2 gastropod, 3 polychaete, and 1 each mysid, amphipod, bivalve and nemertean species, did not change after disposal. All of the unaffected species are active and capable of burrowing, rapid horizontal movement, or rapid recolonization (Richardson et al., 1977). It is apparent that dredged material disposal has an adverse impact on the less mobile benthic species, whereas active species are able to escape burial.

The observed increase in benthic diversity and decrease in density at Site G, following dredged material disposal, was due primarily to the disproportionate reduction in the abundance of the polychaete Spiophanes bombyx, the numerically dominant benthic species. Observed changes in diversity persisted for 2 months, but changes in density persisted for 10 months (the duration of the postdisposal study) (Boone et al., 1978).

The dredged material disposal sites are repopulated by benthic organisms which either burrow up through the substrate or migrate into the site from the adjacent Shelf. A recolonization process involving the introduction of new species was not evident at Site G (Boone et al., 1978).

Boone et al. (1978, p. 95) concluded "[o]rganism impacts were limited to those physical effects associated with disposal of large amounts of dredged material." Benthic species which are affected by dredged material disposal generally have limited mobility and are restricted in distribution to areas of nearshore sandy sediments, south of the entrance channel. Species which are not affected by the disposal operation are active, capable of burrowing or migrating, and generally ubiquitous in the MCR area. These organisms are adapted to frequent substrate disturbance, caused by wave- and bottom current-induced turbulence, and are probably tolerant of sediment movement and temporary burial (Richardson et al., 1977). The effects of sediment disposal do not extend beyond the boundaries of the disposal site.

Effects of Changes in Sediment Texture - At Site G recolonization patterns, biomass levels, and species diversity were not affected by the slight change in sediment texture caused by dredged material disposal (Richardson et al., 1977). It is possible that persistent or cumulative alterations in sediment texture would eventually produce permanent changes in the benthic ecosystem; however, Site B has been used for dumping dredged material for the past 20 years without incurring any obvious cumulative impact on the benthos.

Demersal Fish and Shellfish

The effects of disposal on demersal fish and shellfish were evaluated by Durkin and Lipovsky (1977). Conclusions drawn from this study were limited by insufficient predisposal data and by seasonal variabilities in the abundances of natural populations in the MCR area. Nevertheless, the authors suggest that dumping results in a 3- to 6-month decrease in the numbers of finfish species and individuals at Site G. In addition, individual fish captured at Site G following dumping tended to be smaller than individuals of the same species from control sites.

Apparent changes in finfish size frequency distributions may result from changes in food consumption. For example, immediately following disposal, changes in food preferences included decreased utilization of cumaceans, copepods, mysids, and amphipods, and increased consumption of shrimp and small fish. The apparent effects are temporary; food consumption patterns and finfish abundances at the disposal sites were similar to those at control sites within a period of 1 to 6 months. Total numbers of finfish and shellfish were generally higher north of the entrance channel relative to areas south of the entrance channel (Durkin and Lipovsky, 1977); thus, disposal activities at Site B may impact a greater number of organisms than if sediment disposal were concentrated at Sites A or F.

Demersal finfish within the MCR Interim Sites are not subjected to increased turbidity, toxic materials, or burial by released dredged materials. Dredged sediments sink rapidly without significantly increasing suspended particulate concentrations, and therefore suffocation of finfish by gill-clogging is not expected. Similarly, dredged sediments do not release significant amounts of trace pollutants, therefore disposal will not increase the bioavailability of toxic substances. Because of their mobility, demersal finfish can prevent burial by escaping from released dredged materials. Durkin and Lipovsky (1977, p. 141) state "sediment removal from the navigation channel annually exceeds 4,000,000 m^3, but deposition at Sites B [DMDS B] and C [DMDS F] in prior years revealed no apparent lasting effect on the diversity and number of finfish."

Effects of disposal on shellfish, particularly Dungeness crabs, are unclear (Durkin and Lipovsky, 1977), although no significant impact was evident at Site G. Natural seasonal variations in shellfish abundance are greater than predisposal or post disposal changes. Chang and Levings (1978), who evaluated the effects of burial on <u>Cancer magister</u> viability in the laboratory, claim (p. 412) that "exposed crabs are able to avoid burial except during extremely rapid deposition" and can escape from up to 10 cm of sediments. Crabs directly beneath the path of the hopper dredge, where sediment deposition exceeds 10 cm, may suffocate. Dredged material is predominantly clean sand and resistant to transport; therefore, the impacts of dredged sediments on shellfish will be restricted to areas within the site.

Marine Mammals

Dredged material disposal involves negligible risk to marine mammals. Marine mammals tend to avoid man's activities, therefore the probability of an animal colliding with a hopper dredge or released dredged sediments is small. In addition, dumping will not likely cause injury. Pinnipeds (seals and sea lions) and cetaceans (whales, dolphins, and porpoises) are strong swimmers and can escape the sediment release zone.

Sea lions and fur seals breed, feed, and migrate in the vicinity of the MCR (Everitt et al., 1980). Disposal at the MCR Interim Sites will neither significantly alter the breeding and haulout areas nor disturb the food supply of the harbor seals, California sea lions, or sea otters (CE, 1975). Grey whales do not generally migrate through the MCR area during the dredging season; humpback and finback whales occur within 100 miles of the coast during summer, but their appearance nearshore is rare. Dredged materials do not contain significant quantities of toxic substances that could possibly bioaccumulate in the food sources of migratory cetaceans.

ENDANGERED SPECIES

Several species of baleen whales (listed in Table 3-5) and sperm whales (<u>Physeter catadon</u>) migrate offshore of the Oregon-Washington coast. Only gray whales (<u>Eschrichtius robustus</u>) occur consistently within the vicinity of the MCR Interim Sites. However, gray whales migrate past MCR from November to December and from February to April, whereas dredging operations occur from mid-April to mid-October. Therefore, infrequent and localized ocean disposal of dredged material will have no significant effect on the food source or migratory routes of these endangered species.

The bald eagle (Haliaeetus leucocephalus) occurs infrequently in the lower Columbia River area.

EMERGENCY DUMPING

Distances between the dredging and MCR Interim Sites vary from 0.5 to 5 nmi. Due to the proximity of the MCR Interim Sites to shore, emergency dumping is not considered a significant problem. In addition, short dumping in the MCR area would not cause any significant change in sediment texture.

ASTORIA CANYON

WATER QUALITY

Sediment resuspension due to slumping or turbidity currents, internal waves, and biochemical processes are probably major factors affecting concentrations of dissolved nutrients and trace metals in the Canyon. Specific amounts of nutrients and trace metals which would be released at Astoria Canyon are unknown, but conclusions of the DMRP suggest that chemical releases from dredged sediments would be negligible.

SEDIMENT QUALITY

Clean marine sands dredged from the Columbia River entrance channel and released at the Astoria Canyon Site should have no significant adverse impact on the ambient sediment chemistry. However, Astoria Canyon sediments are composed of sands with large percentages of silts and clays; therefore, the release of the texturally dissimilar MCR sediments would slightly alter the existing sediment composition. A change in sediment texture would be temporary because periodic turbidity currents transport sediments down the Canyon.

BIOTA

Sediment transport within the Canyon is common (Carlson and Nelson, 1969); therefore, benthic organisms are probably adapted to frequent substrate disturbances. Disposal in Astoria Canyon may have a minimal effect on organisms which are tolerant of periodic sediment inundation.

Dumping would cause a temporary change in sediment texture because medium-grained sands from the entrance channel are coarser than Canyon sediments. Effects of changes in sediment texture are unknown because few data are available about the tolerances of deep-sea organisms to dredged material disposal (Pequegnat, 1978).

Significant amounts of trace contaminants are not released from the dredged materials; thus, the Astoria Canyon fauna would not be subjected to toxic chemicals.

ENDANGERED SPECIES

It is not likely that dredged material disposal at Astoria Canyon would interfere with food source or habitat of any of the endangered species found in the vicinity of the site.

EMERGENCY DUMPING

If the Astoria Canyon Site is used, the possibility of emergency dumping increases, particularly during marginal and deteriorating weather conditions. Potential adverse effects are more likely offshore because existing sediments are texturally finer grained than the dredged material, and benthic organisms in mid-Shelf regions are generally not as tolerant of periodic burial (Oliver et al., 1977).

SUMMARY OF ENVIRONMENTAL EFFECTS

The DMRP detected no significant impacts on water or sediment quality, and temporary effects on benthic and demersal finfish assemblages; the effects of dumping are limited to the disposal sites. In contrast, the potential impacts of dredged material disposal on the Astoria Canyon ecosystem are speculative. Dumping clean sands in the Canyon would not seriously affect water or sediment quality. Adverse impacts on the benthos are problematic because the fauna of Astoria Canyon have not been previously investigated, and the tolerances of deepwater organisms are not well known (Pequegnat, 1978).

Probabilities of emergency or short dumping would be significantly greater with use of the Astoria Canyon Site. Inadvertent dumping on mid-Shelf areas could appreciably impact the benthos and demersal fish.

PUBLIC HEALTH AND SAFETY

The impacts of dredged material disposal on human health and economics of the local area are another primary concern. Potential impacts of dumping on fisheries, navigation, and aesthetics at the MCR Interim Sites and Astoria Canyon Site are considered in the following sections.

MOUTH OF THE COLUMBIA RIVER

FISHERIES

A number of commercially and recreationally important species are caught within the MCR area. Commercial trolling and sport fishing activities, for example, occur both within the entrance channel and in the areas of the MCR Interim Sites. During winter, crab fishing activities are intense throughout the areas immediately offshore from MCR. With the exception of crab fisheries, most commercial and sport fishing occurs during summer, concurrent with dredging operations.

Dredged material disposal at the MCR Interim Sites causes minimal impacts on commercial species. The dredged sediments are clean sands which, after release, settle rapidly to the bottom without producing a persistant detectable turbidity plume, or significantly altering water chemistry (Boone et al., 1978). Dredged material disposal will not result either in suffocation from gill clogging or exposure to toxic substances. Finfish are mobile; thus, direct burial of demersal fish, or interference with anadromous and pelagic species by dredged material, is not expected.

The Dungeness crab (Cancer magister) is the most valuable commercial shellfish in the MCR area. The dredging season (mid-April to mid-October) does not overlap with either the crab fishing season (December to April) or the crab spawning season (December to April; Morris et al., 1980). Adult crabs are present in the MCR area throughout the year, however, the extent of crab mortality due to direct burial by dredged material disposal is unknown. An abundance of crab traps located within the MCR Interim Sites (Durkin and Lipovsky, 1977) suggest that previous dredged material disposal has not significantly altered the Dungeness crab habitat. Crab abundances are typically greater north of the entrance channel, relative to areas south of the entrance channel (ibid.). Therefore, dredged material disposal at Site B would affect a greater number of crabs than if disposal were concentrated at Sites A and F. Less than 5% of the total crab fishing area is contained within the MCR Interim Sites, therefore, the impact of dredged material disposal on the crab fisheries is minimal.

NAVIGATION

The disposal of dredged sediments could present two potential problems to navigation: (1) mounding of sediments within the disposal site and (2) interference of the hopper dredge with commercial shipping traffic during transit to and from the disposal site.

Mounding

Approximately 33% of the dredged material released at Site B has remained within the site boundaries, causing shoaling from the 1957 depth range of

25 to 40m, to the present range of 22 to 36m (Sternberg et al., 1977). Although portions of the dredged sediments remain within the boundaries of Sites A, B, and F, strong bottom currents generated by winter storms tend to spread the released sediments laterally so that localized mounding is not a significant problem.

Dredged materials released at Site E are eroded during late summer and winter (Borgeld et al., 1978); therefore, sediments are not likely to create mounding problems. However, a small percentage of sediments released at Site E may be transported back into the estuary (Walter et al., 1979), and increase the shoaling rate within the entrance channel.

Interference With Shipping Traffic

The hopper dredges used in the MCR dredging operations are not as hazardous to navigation as pipeline or bucket dredges, because there is no need for anchor lines, pipelines, or barges. Hopper dredge traffic from the dredging site to the disposal site will not significantly interfere with commercial shipping traffic, although a collision between a hopper dredge and a commercial vessel occurred in 1977 during transit to a disposal site (CE, 1977b). Sites B and E are adjacent to shipping lanes, thus some interference with shipping traffic during dredged sediment discharge is unavoidable. The dredging personnel are responsive to sport fishing traffic, and either shift disposal operations to another site or temporarily suspend dredging operations during periods of conflict (CE, 1977b).

AESTHETICS

Disposal of dredged materials from the MCR does not significantly degrade the quality of the receiving waters. The dredged material is predominantly sand which settles rapidly after release with little horizontal transport. A surface turbidity plume is dispersed within minutes after dumping (Holton et al., 1978); however, strong surface ebb currents may cause slightly greater horizontal dispersion of sediments at Site E. Excessive noise or odors resulting from disposal are unlikely at the MCR Interim Sites.

ASTORIA CANYON

FISHERIES

There are no present fisheries activities at Astoria Canyon. Fisheries resources at the Alternative Site are unknown, although potential commercially important demersal finfish and shellfish have been previously found along the adjacent outer Continental Shelf and Slope.

NAVIGATION

Mounding

Due to the greater water depths localized mounding in Astoria Canyon is not a potential problem. However, the duration of the dredging season is restricted by weather conditions and present dredging operations are capable of maintaining only the minimum 15m channel depths. Therefore, use of the Astoria Canyon Site would require increased transit times and reduce effective dredging time to such an extent that the minimum channel depth could not be maintained. Unless the current dredging effort is expanded natural shoaling within the channel would produce a navigational hazard.

Interference With Shipping Traffic

Neither the transit nor the discharge phases of dredged material disposal at Astoria Canyon would affect navigation. However, use of the Astoria Canyon Site would be restricted to periods of calm weather and sea conditions because the hopper dredge cannot function in rough weather.

AESTHETICS

Dumping dredged materials in Astoria Canyon would not cause any offensive turbidity plumes, odors, or noise.

SUMMARY OF EFFECTS ON PUBLIC HEALTH AND SAFETY

The impacts of dredged material disposal at the MCR Interim Sites on public health and safety are minimal. Interferences with uses of marine resources, such as fisheries or mineral extraction, are difficult to quantify, but the similarity between dredged materials and extant sediments suggest that adverse impacts will be minor. Corps of Engineers (1975; p. 4-7) speculated that "no direct effect on commercial species such as crabs or shrimp is expected [from dredged material disposal] due to the scheduling of disposal to avoid seasonal migrations and the ability of these organisms to tolerate high turbidity levels." In addition, the impact of continual use of the MCR Interim Sites on navigation, aesthetics, and public health are negligible. Furthermore, the current use of Site E may provide beneficial beach nourishment material to oceanfront beaches.

The direct impact of dredged material disposal at the Alternative Site is also small; adverse effects on public health and aesthetics would be negligible. Current fishing activity in the vicinity of the Canyon is not extensive, and dumping would not interfere with utilization of future commercially important species. However, use of the Canyon Site would require an increased dredging effort to compensate for the greater transit distances, thus incurring a greater financial burden.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS AND MITIGATING MEASURES

The environmental effects of dredged material disposal at the MCR Interim Sites have not caused an observable degradation of the marine environment outside the sites. Adverse effects outside the MCR Interim Sites boundaries have not been detected, therefore mitigating measures to protect the environment are not needed.

Minor adverse effects have occurred within the sites boundaries. Unavoidable effects include slight changes in bathymetry, sediment texture, temporary changes in demersal fish distribution and benthic community composition. Mounding is not a serious problem at the MCR Interim Sites.

Annual erosional processes disperse dredged sediments which are released at Site E (Borgeld et al., 1978). Persistent mounding at Site B is precluded by sediment dispersion during winter storms. Significant mounding at Sites A and F has not been detected. Effects on the benthic and demersal fish communities are neither cumulative nor irreversible.

Commercial and recreational fishing occurs throughout the year at MCR. Altering the dredging season will not significantly ameliorate the impact on fisheries. Furthermore, dredging is not technically feasible during the turbulent winter months.

RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

Disposal operations do not interfere with the long-term uses of any resources of the MCR area. Commercial and sport fisheries, and indigenous finfish and shellfish species are not significantly affected by present dredged material disposal operations. Other natural, marine resources are not jeopardized by dumping at the MCR Interim Sites.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Irreversible or irretrievable resources committed to the dredged material disposal operation at MCR are:

- Loss of energy (i.e., fuel used by hopper dredge). Transport to distant sites requires more fuel.

- Loss of economic resources due to costs of the disposal operation.

The losses are insignificant in comparison with the advantage of disposing of dredged material from the entrance channel at the MCR Interim Sites (see Chapter 2).

Chapter 5

COORDINATION

PREPARERS OF THE DRAFT EIS

This Draft EIS was issued by the Environmental Protection Agency's Ocean Dumping EIS Task Force. This document was based on a Preliminary Draft prepared by Interstate Electronics Corporation. Reviews and revisions were made by William C. Shilling. Additional reviews and support were provided by members of the EIS Task Force:

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The preparers and the sections of the Preliminary Draft EIS for which they were responsible are presented in Table 5-1.

TABLE 5-1
LIST OF PREPARERS

Author	Summary	Chapter			
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REVIEWERS OF THE PRELIMINARY DRAFT EIS

The entire Preliminary Draft EIS was edited and reviewed by Dr. Richard Terry, Andrew Lissner, Robert Tait, Messrs. William Steinhauer, Marshall Holstrom, and Ms. Roxanne Mills of IEC. The Preliminary Draft EIS was reviewed by IEC's Scientific Advisory Panel members: Drs. Dayton E. Carritt, William M. Dunstan, M. Grant Gross, Willis E. Pequenat, and K. Tenore. The review does not mean that they agree with the analyses or conclusions in the Preliminary Draft EIS.

Chapter 6

GLOSSARY AND REFERENCES

GLOSSARY

ABUNDANCE The number of individuals of a species inhabiting a given area. Normally, a community of several component species will inhabit an area. Measuring the abundance of each species is one way of estimating the comparative importance of each component species.

ADSORB To adhere in an extremely thin layer of molecules to the surface of a solid or liquid.

AMBIENT Pertaining to the undisturbed or unaffected conditions of an environment.

AMPHIPODA An order of crustaceans (primarily marine) with laterally compressed bodies, which generally appear similar to shrimp. The order consists primarily of three groups: hyperiideans, which inhabit open ocean areas; gammarideans, which are primarily bottom dwellers; and caprellideans, common fouling organisms.

ANTHROPOGENIC Relating to the effects or impacts of man on nature. Construction wastes, garbage, and sewage sludge are examples of anthropogenic materials.

ASSEMBLAGE A group of organisms sharing a common habitat.

BACKGROUND The naturally occurring concentration of a substance level within an environment which has not been affected by unnatural additions of that substance.

BASELINE SURVEYS AND BASELINE DATA Surveys and the data collected prior to the initiation of actions which may alter an existing environment.

BATHYAL Pertaining to ocean depths between 180 and 3,700m.

BEDLOAD Sediments rolled along the bottom of a river by moving water.

BENTHOS All marine organisms (plant or animal) living on or in the bottom of the sea.

BIOACCUMULATION The uptake and assimilation of materials (e.g., heavy metals) leading to elevated concentrations of the substances within organic tissue, blood, or body fluid.

BIOMASS	The quantity (wet weight) of living organisms inhabiting a given area or volume at any time; often used as a means of measuring the productivity of an ecosystem.
BIOTA	Animals and plants inhabiting a given region.
BLACK SANDS	Local deposits of heavy minerals, including magnetite, ilmenite, and hematite, concentrated by wave and current action.
CARCINOGEN	A substance or agent producing a cancer or other type of malignancy.
CEPHALOPODS	Exclusively marine animals constituting the most highly evolved class of the phylum Mollusca (e.g., squid, octopus, and Nautilus).
COELENTERATA	A large diverse phylum of primarily marine animals, members possessing two cell layers and an incomplete digestive system, the opening of which is usually surrounded by tentacles. This group includes hydroids, jellyfish, corals and anemones.
CONTINENTAL MARGIN	A zone separating the emergent continents from the deep-sea bottom; generally consists of the Continental Slope, Continental Shelf and Continental Rise.
CONTINENTAL SHELF	That part of the Continental Margin adjacent to a continent extending from the low water line to a depth, generally 200 meters, where the Continental Shelf and the Continental Slope join.
CONTINENTAL SLOPE	That part of the Continental Margin consisting of the declivity from the edge of the Continental Shelf down to the Continental Rise.
CONTOUR LINE	A line on a chart connecting points of equal elevation above or below a reference plane, usually mean sea level.
CONTROLLING DEPTH	The least depth in the approach or channel to an area, such as a port, governing the maximal draft of vessels which can enter.
COPEPODS	A large diverse group of small planktonic crustaceans representing an important link in oceanic food chains.
CRUSTACEA	A class of arthropods consisting of animals with jointed appendages and segmented exoskeletons composed of chitin. This class includes barnacles, crabs, shrimps, and lobsters.

CUMACEANS	Small motile crustaceans which usually inhabit the surface layers of sediment, although some species exhibit diurnal vertical migrations in the water column; their presence is often indicative of unstable sediment conditions.
DECAPODA	The largest order of crustaceans; members have five sets of locomotor appendages, each joined to a segment of the thorax; includes crabs, lobsters, and shrimps.
DEMERSAL	Living at or near the bottom of the sea.
DENSITY	The mass per unit volume of a substance, usually expressed in grams per cubic centimeter (1 gallon water in reference to a volume of 1 cc at 4°C).
DIATOMS	Microscopic phytoplankton characterized by a cell wall of overlapping silica plates. Sediment and water column populations vary widely in response to changes in environmental conditions.
DISCHARGE PLUME	The region of water affected by a discharge of waste which can be distinguished from the surrounding water.
DISPERSION	The dissemination of discharged matter over large areas by natural processes (e.g., currents).
DISSOLVED OXYGEN	The quantity of oxygen (expressed in milligrams per liter, milliliters per liter or parts per million) dissolved in a unit volume of water. Dissolved oxygen (DO) is a key parameter in the assessment of water quality.
DIVERSITY (Species)	A statistical concept which generally combines the measure of the total number of species in a given environment and the number of individuals of each species.
DOMINANT SPECIES	A species or group of species which, because of their abundance, size, or control of the energy flow, strongly affect a community.
DRY WEIGHT	The weight of a sample of material or organisms after all water has been removed; a measure of biomass, when applied to organisms.
DUNGENESS CRAB	A brachyuran crab; one of the most common edible species (the "market crab").
EBB CURRENT, TIDE	Tidal current moving away from land or down a tidal ebb stream.

ECHINODERMS	Exclusively marine animals which are distinguished by radial symmetry, internal skeletons of calcareous plates, and water-vascular systems which serve the needs of locomotion, respiration, nutrition, or perception; includes starfishes, sea urchins, sea cucumbers and sand dollars.
ECOSYSTEM	The organisms in a community together with their physical and chemical environments.
EDDY	A circular mass of water within a larger water mass which is usually formed where currents pass obstructions, either between two adjacent currents flowing counter to each other, or along the edge of a permanent current. An eddy has a certain integrity and life history, circulating and drawing energy from a flow of larger scale.
EFFLUENT	Liquid waste of sewage or industrial processing.
EH	Redox potential or oxidation-reduction potential; measurement of the state of oxidation of a system by a voltage difference at an inert electrode immersed in a reversible oxidation-reduction system. Positive values reflect an oxidizing environment and a surplus of oxygen, whereas negative values represent a reducing environment; often indicated by the presence of hydrogen sulfide.
ENDEMIC	Restricted or peculiar to a locality or region.
ENTRAIN	To draw in and transport by the flow of a fluid.
EPIFAUNA	Animals which live on or near the bottom of the sea.
ESTUARY	A semienclosed coastal body of water which has a free connection to the sea, commonly the lower end of a river, and within which the mixing of saline and fresh water occurs.
FAUNA	The animal life of any location, region, or period.
FELDSPAR	A general name for a group of abundant rock-forming minerals (e.g., orthoclase, plagioclase, microcline).
FINFISH	Term used to distinguish "normal" fish (e.g., with fins and capable of swimming) from shellfish. Usually in reference to the commercially important species.
FLOOD TIDE, FLOOD CURRENT	Tidal current moving toward land, or up a tidal stream.
FLUVIAL	Produced by river action.

GASTROPODS	Mollusks which possess a distinct head (generally with eyes and tentacles), a broad, flat foot, and usually a spiral shell (e.g., snails).
GEOSTROPHIC CURRENT	A current resulting from the balance between gravitational forces and the Coriolis force.
HERBIVORES	Animals which feed chiefly on plants.
HOPPER DREDGE	A self-propelled vessel with capabilities to dredge, store, transport, and dispose of dredged materials.
ICHTHYOPLANKTON	That portion of the planktonic mass composed of fish eggs and weakly motile fish larvae.
INDICATOR SPECIES	An organism so strictly associated with particular environmental conditions that its presence is indicative of the existence of such conditions.
INDIGENOUS	Having originated in, being produced, growing, or living naturally in a particular region or environment; native.
INFAUNA	Aquatic animals which live in the bottom sediment.
INITIAL MIXING	Dispersion or diffusion of liquid, suspended particulate, and solid phases of a waste material which occurs within 4 hours after dumping.
INTERIM DISPOSAL SITES	Ocean disposal sites tentatively approved for use by the EPA.
INVERTEBRATES	Animals lacking a backbone or internal skeleton.
ISOBATH	A line on a chart connecting points of equal depth below mean sea level.
ISOPODS	Small crustaceans with flattened bodies, and reduced heads and abdomens. They are an important intermediate link in marine food chains.
ISOTHERMAL	Approximate equality of temperature throughout a geographical area.
LARVA	A young and immature form of an organism which must usually undergo one or more form and size changes before assuming characteristic features of the adult.
LITHIC	Refers to sediments or rocks in which rock fragments are more inportant than feldspar grains.
LITTORAL	Of or pertaining to the seashore, especially the regions between tide lines.

LONGSHORE CURRENT	A current which flows in a direction parallel to a coastline.
MICROGRAM-ATOM (μg-at)	Mass of an element numerically equal to its atomic weight in grams divided by 10^6.
MICRONUTRIENTS	Microelements, trace elements, or substances required in minute amounts; essential for normal growth and development of an organism.
MIXED LAYER	The upper layer of the ocean which is well mixed by wind and wave activity.
MOLLUSCA	A phylum of unsegmented animals most of which possess a calcareous shell; includes snails, mussels, clams, and oysters.
MONITORING	As used herein, observation of environmental effects of disposal operations through biological and chemical data collection and analyses.
MUTAGEN	A substance which increases the frequency or extent of mutations (changes in hereditary material).
NEKTON	Free swimming aquatic animals which move independently of water currents.
NUISANCE SPECIES	Organisms of no commercial value, which, because of predation or competition, may be harmful to commercially important organisms.
OMNIVOROUS	Pertaining to animals which feed on animal and plant matter.
PARAMETER	Values or physical properties which describe the characteristics or behavior of a set of variables.
PELAGIC	Pertaining to water of the open ocean beyond the Continental Shelf and above the abyssal zone.
PERTURBATION	A disturbance of a natural or regular system; any departures from an assumed steady state of a system.
pH	The acidity or alkalinity of a solution, determined by the negative logarithm of the hydrogen ion concentration (in gram-atoms per liter), ranging from 0 to 14 (lower than 7 is acid, higher than 7 is alkaline).
PHOTIC ZONE	The layer of a body of water which receives sufficient sunlight for photosynthesis.
PHYTOPLANKTON	Minute passively floating plant life in a body of water; the base of the food chain in the sea.

PLANKTON	The passively floating or weakly swimming, usually minute animal and plant life in a body of water.
PLUME	A patch of turbid water, caused by the suspension of fine particles following a disposal operation.
POLYCHAETA	The largest class of the phylum Annelida (segmented worms); benthic marine worms distinguished by paired, lateral, fleshy appendages provided with bristles (setae) on most segments.
PRECIPITATE	A solid which separates from a solution or suspension by chemical or physical change.
PRIMARY PRODUCTIVITY	The amount of organic matter synthesized by producer organisms (primarily plants) from inorganic substances per unit time and volume of water. Plant respiration may or may not be subtracted (net or gross productivity, respectively).
PYCNOCLINE	A vertical density gradient in a body of water, positive with respect to depth, and much greater than the gradients above and below it.
PYROXENE	A mineral group composed mainly of calcium and magnesium metasilicates.
QUALITATIVE	Pertaining to the non-numerical assessment of a parameter.
QUANTITATIVE	Pertaining to the numerical measurement of a parameter.
RADIONUCLIDES	Species of atoms which exhibit radioactivity.
RECRUITMENT	Addition to a population of organisms by reproduction or immigration of new individuals.
RELEASE ZONE	An area defined by the locus of points 100 m from a vessel engaged in dumping activities; will never exceed the total surface area of the dumpsite.
RUNOFF	That portion of precipitation upon land which ultimately reaches streams, rivers, lakes and oceans.
SALINITY	The amount of salts dissolved in water; expressed in parts per thousand ($^{o}/oo$, or ppt).
SEA STATE	The numerical or written description of wind-generated waves on the surface of the sea; ranges from 1 (smooth) to 8 (mountainous).

SHELF WATER	Water which originates in, or can be traced to the Continental Shelf, differentiated by characteristic temperature and salinity.
SHELLFISH	Any invertebrate, usually of commercial importance, having a rigid outer covering, such as a shell or exoskeleton; includes some mollusks and arthropods; term is the counterpart of finfish.
SHORT DUMPING	The premature discharge of waste from a vessel anywhere outside designated disposal sites. This may occur legally under emergency circumstances, or illegally to avoid hauling to a designated site.
SIGNIFICANT WAVE HEIGHT	The average height of the one-third highest waves of a given wave group.
SPECIES	A group of morphologically similar organisms capable of interbreeding and producing fertile offspring.
STANDING STOCK	The biomass or abundance of living material per unit volume of water, or area of sea-bottom.
SUBSTRATE	The solid material upon which an organism lives, or to which it is attached (e.g., rocks, sand).
SURVEILLANCE	Systematic observation of an area by visual, electronic, photographic, or other means for the purpose of ensuring compliance with applicable laws, regulations, permits, and safety.
SUSPENDED SOLIDS	Finely divided particles of a solid temporarily suspended in a liquid (e.g., soil particles in water).
TEMPORAL DISTRIBUTION	The distribution of a parameter over a period of time.
TERRIGENOUS SEDIMENTS	Sedimentary deposits composed of eroded terrestrial material.
THERMOCLINE	A vertical temperature gradient in some layer of a body of water, which is appreciably greater than the gradients above or below it; a layer in which such a gradient occurs.
TRACE METAL OR ELEMENT	An element found in the environment in extremely small quantities; usually includes metals constituting 0.1% (1,000 ppm) or less, by weight, in the earth's crust.

TRANSMITTANCE In defining water clarity, an instrument which can transmit a known quantity of light through a standard distance of water to a collector. The percentage of the beam's energy which reaches the collector is expressed as transmittance.

TROPHIC LEVELS Discrete steps along a food chain in which energy is transferred from the primary producers (plants) to herbivores and finally to carnivores and decomposers.

TURBIDITY Cloudy or hazy appearance in a naturally clear liquid caused by a suspension of colloidal liquid droplets, fine solids, or small organisms.

UPWELLING The rising of water toward the surface from subsurface layers of a body of water. Upwelled water is cooler and rich in nutrients; regions of upwelling are generally areas of rich fisheries.

WATER MASS A body of water, identified by its temperature-salinity values, or chemical composition, consisting of a mixture of two or more water types.

WATER TYPE Ocean water of a specified temperature and salinity; defined as a single point on a temperature-salinity diagram.

ZOOPLANKTON Weakly swimming animals whose distribution in the ocean is ultimately determined by current movements.

REFERENCES

Alton, M.S. 1972. Characteristics of the demersal fish fauna inhabiting the outer Continental Shelf and Slope off the Northern Oregon Coast. Pages 583-634 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Alverson, D.L., A.T. Pruter, and L.L. Ronholt. 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. University of British Columbia, Institute of Fisheries. H.R. MacMillan Lectures in Fisheries Series. Vancouver, British Columbia. 190 pp.

Anderson, G.C. 1972. Aspects of marine phytoplankton studies near the Columbia River, with special reference to a subsurface chlorophyll maximum. Pages 219-240 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Ballard, R.L. 1964. Distribution of beach sediment near the Columbia River. Tech. Rep. No. 98. University of Washington, Department of Oceanography, Seattle, WA. 82 pp.

Barnes, C.A., A.C. Duxbury, and B.A. Morse. 1972. Circulation and selected properties of the Columbia River effluent at sea. Pages 41-80 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Barss, W.H., R.L. Demory, and N. Ten Eyck. 1977. Marine resource surveys on the Continental Shelf and upper Slope off Washington, 1975-76. Completion Report July 1, 1975 to September 30, 1977 to Oregon Department of Fish and Wildlife. 34 pp.

Boone, C.G., M.A. Granat, and M.P. Farrell. 1978. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Evaluative summary. Dredged Material Research Program Tech. Rep. D-77-30.

Borgeld, J.C., J.S. Creager, S.R. Walter, and E.H. Roy. 1978. A geological investigation of the sedimentary environment at sites E, G, and H near the Mouth of the Columbia River. Final Report to U.S. Army Corps of Engineers, Portland District.

Braislin, D.B., D.D. Hastings, and P.D. Snavely, Jr. 1971. Petroleum potential of western Oregon and Washington and adjacent Continental Margin. Pages 229-238 in I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Am. Assoc. Petrol. Geol. Mem. 15(2).

Carey, A.G., Jr. 1972. Ecological observations on the benthic invertebrates from the central Oregon Continental Shelf. Pages 422-433 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Carlson, P.R., and C.H. Nelson. 1969. Sediments and sedimentary structures of the Astoria Submarine Canyon-Fan system, northeast Pacific. J. Sed. Petrol. 39:1269-1282.

Chang, B.D., and C.D. Levings. 1978. Effects of burial on the heart cockle Clinocardium nuttallii and the Dungeness crab Cancer magister. Est. Coast. Mar. Sci. 7:409-412.

Chen, K.Y., S.K. Gupta, A.Z. Sycip, J.C.S. Lu, M. Knezevic, and W.W. Choi. 1976. Research study on the effect of dispersion, settling, and resedimentation on migration of chemical constituents during open-water disposal of dredged materials. Dredged Material Research Project Tech. Rep. D-76-1.

CE. See U.S. Army Corps of Engineers.

Conomos, T.J., and M.G. Gross. 1972. River-ocean suspended particulate matter relations in summer. Pages 176-202 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Conomos, T.J., M.G. Gross, C.A. Barnes, and F.A. Richards. 1972. River-ocean nutrient relations in summer. Pages 151-175 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Columbia River Estuary Study Taskforce. 1977. Columbia River Estuary inventory of physical, biological, and cultural characteristics. M.H. Seaman, ed. Prepared for Columbia River Estuary Study Taskforce.

CREST. See Columbia River Estuary Study Taskforce

Demory, R.L., M.J. Hosie, N. Ten Eyck, and B.O. Fosberg. 1976. Marine resource surveys on the Continental Shelf off Oregon, 1971-74. Completion Report July 1, 1971 to June 30, 1975 to Oregon Department of Fish and Wildlife. 48 pp.

Durkin, J.T. 1975. An investigation of fish and decapod shellfish found at four dredge material disposal sites and two dredge sites adjacent to the Mouth of the Columbia River. Report to Portland District Office, U.S. Army Corps of Engineers and the Columbia Fisheries Program Office, NMFS. 29 pp.

Durkin, J.T., and S.J. Lipovsky. 1977. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix E: demersal fish and decapod shellfish studies. Dredged Material Research Program Tech. Rep. D-77-30.

_____ 1975. Baseline fish and shellfish investigations offshore of the Columbia River conducted from October 1974 through June 1975. Interim Report to the Dredged Material Research Program, Waterways Experiment Station, U.S. Army Corps of Engineers. 21 pp.

Duxbury, A.C., and N.B. McGary. 1968. Local changes of salinity and nutrients off the Mouth of the Columbia River. Limnol. and Oceanogr. 13:626-635.

Duxbury, A.C., B.A. Morse, and N. McGary. 1966. The Columbia River effluent and its distribution at sea, 1961-1963. Dept. of Oceanogr., University of Washington Tech. Rep. No. 156.

EPA. See U.S. Environmental Protection Agency.

Everitt, R.D., R.J. Beach, and A.C. Geiger. 1980. Marine mammals-fishery interactions on the Columbia River and adjacent waters. Research Proposal, Washington Dept. of Game and Oregon Dept. of Fish and Wildlife. 86 pp.

Gross, M.G. 1972a. Oceanography, a view of the earth. Prentice-Hall, Inc. 580 pp.

_____1972b. Sediment associated radionuclides from the Columbia River. Pages 736-754 in A.T. Pruter and D.L. Alverson, eds.. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

_____1967. Organic carbon in surface sediment from the Northeast Pacific Ocean. Oceanology and Limnology I:46-54.

Gross, M.G., B.A. Morse, and C.A. Barnes. 1969. Movement of near-bottom waters on the Continental Shelf off the Northwestern United States. Jour. of Geophysical Research 74:7044-7047.

Hickey, B.M., and J. Smith. 1978. Pollutant transport and sediment dispersal in the Washington-Oregon Coastal Zone. U.S. Dep. of Energy Report RLO 2225 TA 25-26.

Hobson, L.A. 1966. Some influences of the Columbia River effluent on marine phytoplankton during January 1961. Limnol. and Oceanogr. 11:223-234.

Holton, R.L., N.H. Cutshall, L.I. Gordon, and L.F. Small. 1978. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix B: water column, primary productivity, and sediment studies. Dredged Material Research Program Tech. Rep. D-77-30.

Holton, R.L., and L.F. Small. 1978. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix D: zooplankton and ichthyoplankton studies. Dredged Material Research Program Tech. Rep. D-77-30.

INPFC. See International North Pacific Fisheries Commission.

International North Pacific Fisheries Commission. 1979. Historical catch statistics for salmon of the North Pacific Ocean. Bull. No. 39. Prepared by INPFC Secretariat, Vancouver, British Columbia, Canada. 166 pp.

Johansen, K., and R. Parrish. 1979. Oil spills/oil tanker operations. Report 5: The development of petroleum resources from the outer Continental Shelf: legal management problems and capabilities in Oregon. Ocean Resources Law Center. Eugene, OR. 79 pp.

Kulm, L.D., R.C. Roush, J.C. Harlett, R.H. Neudeck, D.M. Chambers, and E.J. Runge. 1975. Oregon Continental Shelf sedimentation: interrelationships of facies distribution and sedimentary processes. J. Geology 83:145-175.

Lockett, J.B. 1967. Sediment transport and diffusion: Columbia Estuary and entrance. J. Waterways and Harbors Div., Am. Soc. Civil Eng. 93(WW4):167-175.

______1963. Phenomena affecting improvement of the Lower Columbia Estuary and Entrance. Pages 695-755 in J.W. Johnson, ed. Proceedings of Eighth Conference on Coastal Engineering.

McColgin, I., ed. 1979. Columbia River Estuary regional management plan. Adopted by the Columbia River Estuary Study Taskforce (CREST) Council.

McManus, D.A. 1972. Bottom topography and sediment texture near the Columbia River mouth. Pages 240-253 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Moherek, A.J. 1978. Flume experiments on sand, silt, and clay mixtures from the offshore dredged material disposal site Galveston, Texas. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. TR-D-78-34.

Moore, G.W., and M.D. Luken. 1979. Offshore sand and gravel resources of the Pacific Northwest. Oregon Geol. 41:143-151.

Morris, R.H., D.P. Abbott, and E.C. Haderlic. 1980. Intertidal Invertebrates of California. Stanford University Press, Stanford, CA. 690 pp.

Neal, V.T. 1972. Physical aspects of the Columbia River and its estuary. Pages 19-40 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Nelson, C.H., P.R. Carlson, J.V. Byrne, and T.R. Alpha. 1970. Development of the Astoria Canyon-Fan physiography and comparison with similar systems. Mar. Geol. 8:259-291.

Norberg, J.R. 1980. Black sand occurrences in the Columbia River Estuary and vicinity. Tech. Assistance Rep. U.S. Bureau of Mines. Spokane, WA. 15 pp.

Ogden Beeman and Associates. 1980. The Oregon ports study--1980. Oregon Dep. of Economic Development, ODCDC, and U.S. Maritime Administration.

Oliver, J.S., P.M. Slattery, L.W. Hulberg, and J.W. Nybakken. 1977. Patterns of succession in benthic infaunal communities following dredging and dredged material disposal in Monterey Bay. Dredged Material Research Program. Tech. Rep. D-77-27.

Oregon Department of Fish and Wildlife and Washington Department of Fisheries. 1979. Columbia River fish runs and fisheries 1957-1978, Status Report, Vol. 2, No. 4. 68 pp.

Pacific Fishery Management Council. 1980. Proposed plan for managing the 1980 salmon fisheries off the coast of California, Oregon, and Washington. Pacific Fishery Management Council. Portland, OR. 157 pp.

Pacific Northwest River Basins Commission. 1979. Water--today and tomorrow. Vol. II: the region. PNRBC. 47 pp.

Park, P.K., C.L. Osterberg, and W.O. Forster. 1972. Chemical budget of the Columbia River. Pages 132-134 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Pearcy, W.G. 1972. Distribution and ecology of oceanic animals off Oregon. Pages 351-377 In: A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Pequegnat, W.E. 1978. An assessment of the potential impact of dredged material disposal in the open ocean. Dredged Material Research Program, Tech. Rep. D-78-2.

Pereyra, W.T. 1972. Bathymetric and seasonal abundance and general ecology of the tanner crab, _Chionoecetes tanner_ Rathbun (Brachyura: Majidae), off the northern Oregon coast. Pages 538-582 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Pereyra, W.T., and M.S. Alton. 1972. Distribution and relative abundance of invertebrates off the northern Oregon Coast. Pages 444-474 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Peterson, W.K. 1972. Distribution of pelagic copepoda off the coasts of Washington and Oregon during 1961 and 1962. Pages 313-343 In: A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

PNRBC - See Pacific Northwest River Basins Commission.

Pruter, A.T. 1972. Review of commercial fisheries in the Columbia River and contiguous ocean waters. Pages 81-120 in A.T. Pruter and D.L. Alverson, eds. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Pruter, A.T., and D.L. Alverson eds. 1972. The Columbia River Estuary and adjacent ocean waters: bioenvironmental studies. University of Washington Press.

Richardson, M.D., A.G. Carey, J.A. Colgate, and W.A. Colgate. 1977. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix C: the effects of dredged material disposal on benthic assemblages. Dredged Material Research Program Tech. Rep. D-77-30.

Rompa, W.J., F.J. Smith, and S.D. Miles. 1979. Oregon's seafood industry: its importance to Oregon's economy. Extension Circular 965. Sea Grant Marine Advisory Program. 14 pp.

Shepard, F.P., N.F. Marshall, and P.A. McLoughlin. 1974a. Currents in submarine canyons. Deep-Sea Res. 21:691-706.

_____1974b. "Internal waves" advancing along submarine canyons. Science. 183:195-198.

Smith, J.D., and T.S. Hopkins. 1972. Sediment transport on the Continental Shelf off of Washington and Oregon in light of recent current measurements. Pages 143-180 in D.J.P. Swift, D.B. Duane, and O.H. Pilkey, eds. Shelf sediment transport.

Snyder, G.R. 1976. Effects of dredging on aquatic organisms--with special application to areas adjacent to the northeastern Pacific Ocean. Mar. Fish. Rev. 38:34-38.

Squire, J.L., Jr., and S.E. Smith. 1977. Angler's guide to the United States Pacific coast. U.S. Dep. of Commerce, National Marine Fisheries Service. 139 pp.

State of Washington. 1980. Columbia River instream resource protection program. Revised Draft Program Document. Department of Ecology.

Stefannson, U. and F.A. Richards. 1964. Distributions of dissolved oxygen, density, and nutrients off the Washington and Oregon coasts. Deep-Sea Research 11:355-380.

_____1963. Processes contributing to the nutrient distributions off the Columbia River and Strait of Juan de Fuca. Limnology & Oceanography 8:394-410.

Sternberg, R.W., J.S. Creager, W. Glessley, and J. Johnson. 1979. Stability of dredged material deposited seaward of the Columbia River Mouth. Pages 17-49 in H.D. Palmer and M.G. Gross, eds. Ocean dumping and marine pollution. Dowden, Hutchinson and Ross, Inc. 268 pp.

_____1977. Aquatic disposal field investigations, Columbia River Disposal Site, Oregon. Appendix A: investigation of the hydraulic regime and physical nature of bottom sedimentation. Dredged Material Research Program Tech. Rep. D-77-30.

Sullivan, B., and D. Hancock. 1977. Zooplankton and dredging: research perspectives from a critical review. Water Resources Bull. 13:461-467.

U.S. Army Corps of Engineers. 1980. Columbia River Estuary model-sediment fate simulation, disposal area E and jetty A. Unpublished data. Waterway Experiment Station, Vicksburg, MS.

_____1978. Atlas of Oregon coastal navigation project hopper dredge operation areas. Portland District. 83 pp.

_____1977a. Dredged Material Research Program, fourth annual report. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, MS.

_____1977b. Report of ESSAYONS and BIDDLE hopper dredging operations, Mouth of the Columbia River, Oregon and Washington, April-October 1977. U.S. Army Corps of Engineers, Portlant District. 29 pp.

_____1975. Columbia River and Lower Willamette River environmental statement. U.S. Army Corps of Engineers, Portland District.

U.S. Environmental Protection Agency. 1977. Ocean dumping: Final revision of regulations and criteria. Federal Register 42(70):2461-2490.

Walter, S.R., E.H. Roy, J.S. Creager, and J.C. Borgeld. 1979. An investigation to determine the bedload and suspended load transport over the outer tidal delta and monitor the sedimentary environment at sites A, E, and D near the Mouth of the Columbia River. Annual Report to Portland District Office, U.S. Army Corps of Engineers. 46 pp.

Whetten, J.T., J.C. Kelley, and L.G. Hansen. 1969. Characteristics of Columbia River sediment and sediment transport. J. Sed. Petrol. 39:1149-1166.

White, S.M. 1970. Minerology and geochemistry of Continental Shelf sediments off the Washington-Oregon coast. Jour. Sedimentary Petrology 40:38-54.