Natural Resources of Coos Bay Estuary

ESTUARY INVENTORY REPORT

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PREFACE

This report is one of a series prepared by the Oregon Department of Fish and Wildlife (ODFW) which summarizes the physical and biological data for selected Oregon estuaries. The reports are intended to assist coastal planners and resource managers in Oregon fulfilling the inventory and comprehensive plan requirements of the Land Conservation and Development Commission's Estuarine Resources Goal (LCDC 1977).

A focal point of these reports is a habitat classification system for Oregon estuaries. The organization and terminology of this system are explained in volume 1 of the report series entitled "Habitat Classification and Inventory Methods for the Management of Oregon Estuaries."

Each estuary report includes some general management and research recommendations. In many cases ODFW has emphasized particular estuarine habitats or features that should be protected in local comprehensive plans. Such protection could be achieved by appropriate management unit designations or by specific restrictions placed on activities within a given management unit. In some instances ODFW has identified those tideflats or vegetated habitats in the estuary that should be considered "major tracts", which must be included in a natural management unit as required by the Estuarine Resources Goal (LCDC 1977). However, the reports have not suggested specific boundaries for the management units in the estuary. Instead, they provide planners and resource managers with available physical and biological information which can be combined with social and economic data to make specific planning and management decisions.

INTRODUCTION

Coos Bay, the estuary of the Coos River, is the site of a unique set of dynamic interactions involving its tributaries, the basin through which they flow, and the ocean (Fig. 1). In historic times man has altered conditions of the estuary more rapidly than expected in nature. Future actions will continue to modify the bay, and only carefully made decisions will insure that Coos Bay continues its history as a biologically productive multiple-use estuary.

Coos Bay has been classified as a deep-draft development estuary by LCDC (1977). Under Statewide Planning Goal 16 (LCDC 1977) the local comprehensive plan will designate estuarine areas as distinct water use management units. In a deep-draft development estuary such management units must include natural, conservation, and development units.

This report is a summary of available information for Coos Bay. It addresses the bay as a system, identifying processes occurring throughout the bay, and as a set of subsystems, smaller geographic areas which are functionally or physiographically distinct. Recommendations are made concerning certain areas or processes. The report is intended to provide information useful to planners, biologists, and citizens during the designation of management units and use policies.

THE COOS BAY ESTUARINE SYSTEM

Physical Characteristics

Dimensions

Several authors have used different methods in estimating the surface area of Coos Bay (Table 1).

Table 1. Reported surface areas of Coos Bay (Percy et al. 1974).

Reference	Surface area (acres)	Measured at	Tidelands		Submerged	
			Acres	Percentage	Acres	Percentage
Johnson 1972	10,973	HW				
"	8,242	MSL				
"	5,810	LW				
Marriage 1958	9,543	area affected by by tidal action	4,569	48		
Oregon Division of State Lands (DSL) 1973	12,380	MHW	6,200	50	6,180	50

DSL (1973) estimates that 6,200 acres (50% of the surface area) is submersible land (between high water and mean low water) and 6,180 acres (50%) is submerged land (below MLW). Using these figures, Coos Bay, although larger, compares closely to Tillamook Bay in ratio of submersible to submerged land (Table 2).

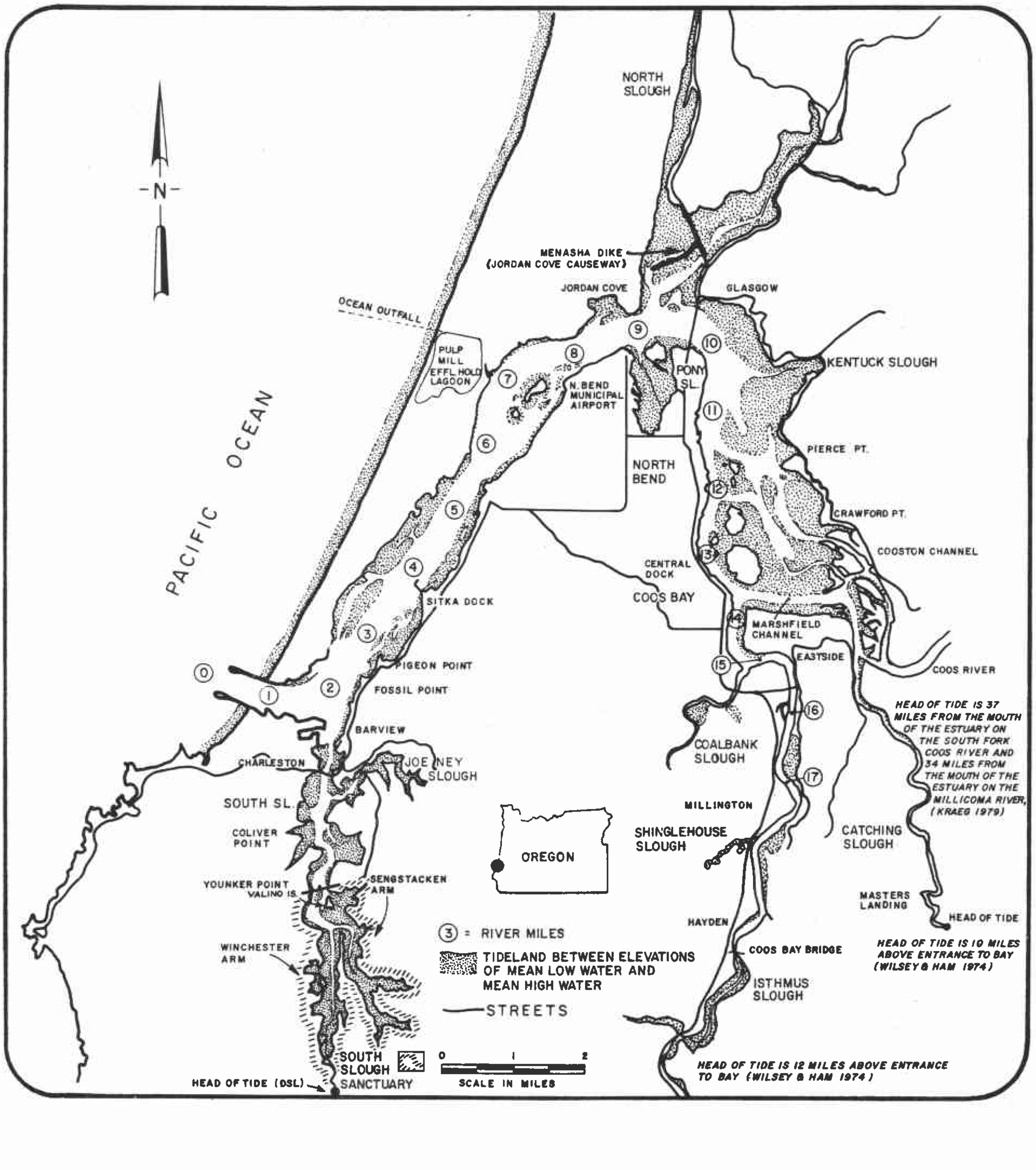


Fig. 1. Coos Bay estuary (base map from DSL 1973).

Table 2. Ratios of tideland (MHW to MLW) to submerged land (below MLW) (estimated from DSL 1973).

Sand Lake	3.0	Nehalem	0.87
Siletz	1.9	Alsea	0.84
Netarts	1.9	Coquille	0.64
Salmon River	1.6	Yaquina	0.53
Nestucca	1.4	Siuslaw	0.57
Necanicum	1.2	Columbia	0.35
Tillamook	1.0	Rogue	0.31
Coos Bay	1.0	Umpqua	0.25
		Chetco	0.13

Even the most extensive estimate of surface area (12,380 acres) covers only the area to mean high water. Much tidal marsh extends above this level and is therefore excluded in all available estimates. By including only the high marshes, at least 1,000 acres could be safely added to that estimate (Hoffnagle and Olson 1974).

Tributaries

About 30 tributaries enter Coos Bay from its 605 mi^2 drainage basin (Fig. 2) (Percy et al. 1974). The major tributary is the Coos River which is formed by the confluence of the Millicoma River and the South Fork Coos River. Head of tide extends up the South Fork Coos River approximately 32 miles from the mouth of the estuary and 34 miles from the mouth of the estuary up the Millicoma River (Kreag 1979). Other streams which contribute a much smaller amount of fresh water to the estuary enter through Catching, Isthmus, Pony, South, North, and Kentuck sloughs and Haynes Inlet. Gradients of the principal tributaries are slight for several miles allowing tidal effects to extend a considerable distance [Oregon State Water Resources Board (OSWRB) 1963]. Head of tide has been recorded for some of these slough systems, and in others the extent of salt water intrusion is limited by a tidegate, which acts as the effective head of tide under most conditions of flow. Information available on drainage areas of tributaries and location of heads of tide is summarized in Table 3.

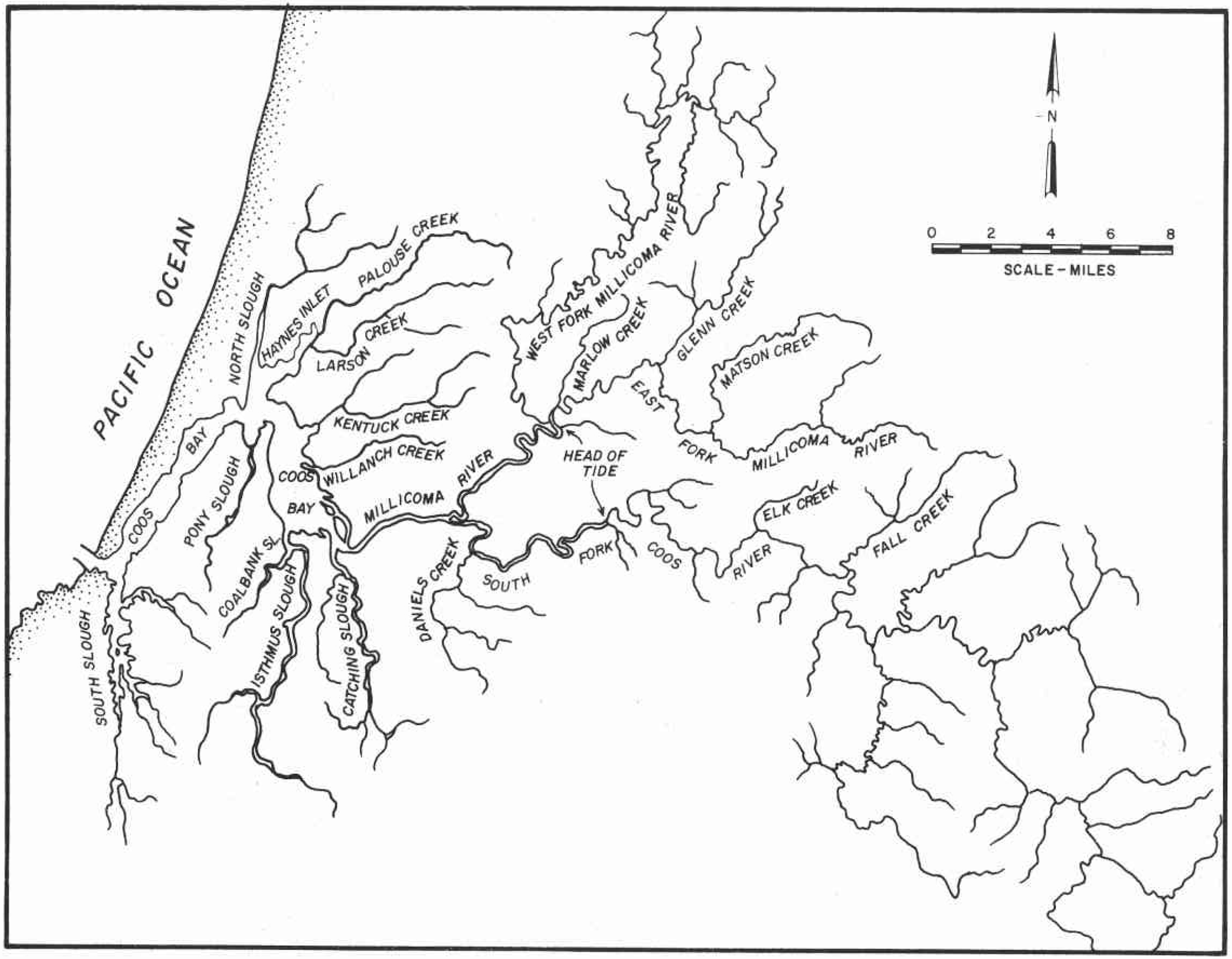


Fig. 2. Coos Bay drainage basin (USDI 1971).

Table 3. Drainage area and head of tide for Coos Bay tributaries.

Tributary	Drainage area (mi^2)	Head of tide (miles from entrance of tributary to main bay)
Coos River	415[a]	
Catching Sl.		10 mi[c]
Coalbank Sl.	6.2[a]	
Haynes Inlet	11[a]	
Isthmus SL		12 mi[c]
Kentuck	17[a]	
North	12.8[a]	
Willarch	7.8[a]	
South Sl.	26[b]	

[a] *OSWRB 1963*
[b] *Stevens, Thompson and Runyon, Inc. (STR) 1974*
[c] *Wilsey & Ham 1974*

Physiography

The physiography of Coos Bay is complex. From its mouth the narrow lower portion of the bay runs southwest to northeast to about river mile (RM) 9, measured from the mouth of the estuary. The main channel then swings to the south and the bay widens into an area of broad tidal flats. Sloughs branch off near the estuary mouth and at several locations in the upper bay. The Coos River enters the upper bay in its southeast corner about 17 mi from the mouth of the estuary. Johnson (1972) states the width at the mouth is 2,060 feet, and the average width of the bay at low tide is 1,200 feet.

Currently the U. S. Army Corps of Engineers (USACE) maintains a dredged ship channel from the entrance to RM 15 (Isthmus Slough). The channel is 45 ft deep and 700 ft wide at the entrance bar and decreases to 35 ft deep and 300 ft wide at RM 1. These dimensions continue to RM 9. From there the channel is 35 ft deep, 400 ft wide to RM 15. Two wide turning basins and an anchorage basin are located at North Bend, near the mouth of Coalbank Slough, and at RM 5.5 respectively. Shallower channels are also dredged by the USACE in the Coos River, the South Fork Coos River, the Millicoma River, and in South Slough connecting Charleston boat basin to the Coos Bay channel. Private concerns maintain a channel in Isthmus Slough to RM 17 (USACE 1976).

The physiography of the Coos estuary has been significantly altered by man. Prior to alterations, the channel across the bar at the entrance to Coos Bay was 10 ft deep and 200 ft wide (USACE 1975). The channel wound to the north with a depth of about 11 ft and width of 200 ft to the town of North Bend, then gradually decreased in width to 50 ft and in depth to 6 ft at Marshfield. Shoals were numerous.

Extensive filling and diking in the main bays, sloughs, and tributaries have changed the form and consequently the function of the estuary. Channel shifts and areas of accelerated erosion and deposition have been noted

(Dicken et al. 1961; Aagard et al. 1971). Other major alterations include the North and South jetties, the Charleston breakwater, and the Charleston small boat basin.

Bottom topography

Coos Bay shares several features with other drowned river valley estuaries. It has a "V"-shaped cross section, a relatively shallow and gently-sloping bottom, and a fairly uniform increase in depth toward the mouth (Baker 1978 [citing Schubel 1971]). NOS charts provide soundings in the navigable portions of the estuary (NOS 1978). Soundings of the bay following completion of the USACE Deep-Draft Navigation Project are available from the Portland District Engineer.

Bottom topography of South Slough can be determined from soundings made in 1977 (USACE 1977). Topography of most other shallow portions of the bay is less well known. Contours showing tidal levels such as MLLW and ELW are generally unavailable.

Water discharge

Fresh water inflow into the Coos estuary is measured only on the West Fork of the Millicoma River. Estimates of total fresh water flow at the mouth are made from extrapolations of these data. Estimated average annual discharge at the mouth of Coos Bay is 2.2 million acre-feet of fresh water (Percy et al. 1974). Using this figure as an average, a yearly maximum of 3,044,000 ac-ft and minimum of 1,560,000 ac-ft may be estimated from data presented in Percy et al. (1974) for the mouth.

Records from 1933-63 show that January is the wettest month at North Bend, averaging 9.9 in of precipitation, and July is the driest with an average 0.38 in (USACE 1975). According to USACE (1975) freshwater inflow may vary from 100,000 cubic feet per second (cfs) in winter to 100 cfs in summer. Arneson (1976) measured an even lower inflow of 35.3 cfs during September of 1973.

Runoff follows the pattern of precipitation. Soils provide a minimum of water retention, and snowfall is light so that a significant snow pack does not form (OSWRB 1963). Figure 3 suggests a one month lag in discharge response to precipitation.

Range of tide

The USACE (1978) states that mean tidal range is 6.7 ft above mean lower low water (MLLW) at the entrance to Coos Bay and 6.9 ft above MLLW at the city of Coos Bay. Predicted extreme range is 10.5 ft above MLLW. Extreme low water (ELW) is predicted to be -3.0 ft below MLLW.

Tidal range predictions are made by the National Oceanic and Atmospheric Administration (NOAA) and are based on data taken over 40 years ago (Arneson 1976). Arneson found that measured ranges at the entrance were slightly greater than predicted ranges for all seasons, although the error was usually

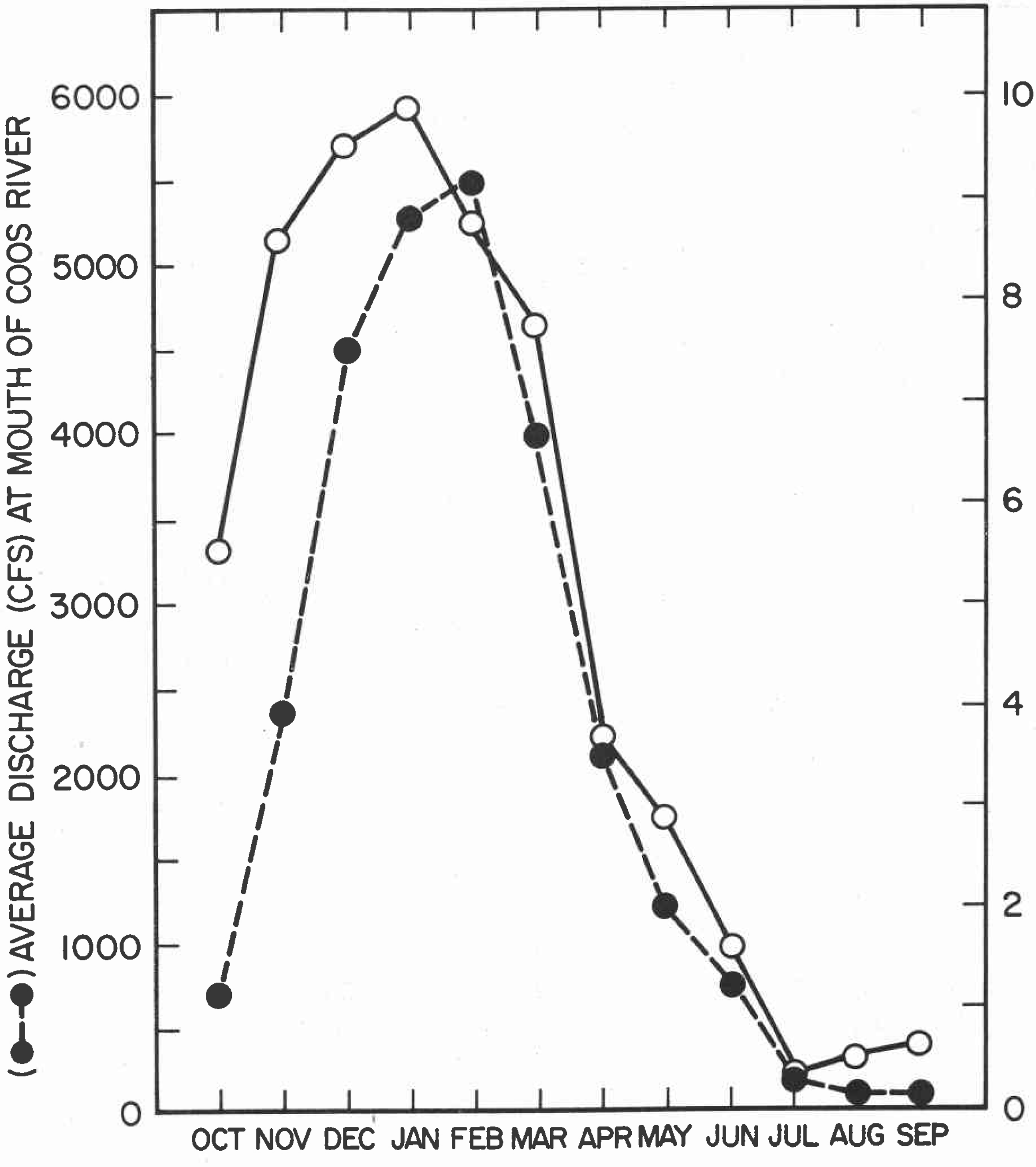


Fig. 3. Precipitation in North Bend (USACE 1975) and average monthly discharge of Coos River at the mouth (OSWRB 1963).

less than 15% . At the city of Coos Bay, Arneson (1976) consistently measured higher tidal ranges than those predicted by NOAA. He states that unusually high ranges may be attributed to river flow.

Arneson (1976) hypothesizes that tidal ranges greater than predicted mainly resulted from fill placed in the bay. Large fills have been placed on the tidelands of the upper bay, near the airport, and at Eastside since the predictions were made. Although the channel was deepened concurrently, the resulting cross-section may be more hydraulically efficient so that dampening of the tidal wave is less (Arneson 1976). The effect of further channel deepening has not been assessed.

Tidal prism

Johnson (1972) based his calculation of the tidal prism of Coos Bay (1.86 x 10^9 ft^3) on a mean tide range of 5.2 ft multiplied by a mean surface area between high and low water of 10,973 acres. The accuracy of these figures may be questionable. Compared to values for other Oregon estuaries shown in Table 4, Coos Bay is most similar to Tillamook Bay in volume of saltwater exchange.

Table 4. Coos Bay tidal prism compared with selected Oregon estuaries.[a]

Estuary	Tidal prism (ft^3)	Ratio of other estuaries to Coos Bay
Coos Bay	1.86 x 10^9*	1.0
Tillamook	2.49 x 10^9	1.3
Umpqua	1.18 x 10^9*	0.6
Yaquina	8.35 x 10^9*	0.45
Alsea	5 x 10^8*	0.3
Nehalem	4.28 x 10^8*	0.2
Siletz	3.5 x 10^8	0.2
Netarts	3.3 x 10^8	0.2
Siuslaw	2.76 x 10^8	0.2
Nestucca	1.8 x 10^8*	0.1
Coquille	1.32 x 10^8	0.07
Sand Lake	8.2 x 10^7	0.4

[a] *Values indicated by * are from Johnson (1972). All other estimates are calculated by Starr (1979) from DSL (1973).*

Time of tide

Both the high and low tides occur progressively later upbay from the mouth. Lag time at some locations seems to vary with seasonal changes in river flow (Arneson 1976). Arneson's study shows that lag times are variable and difficult to predict for different locations in the estuary.

Arneson (1976) compared his tidal measurements to predictions made by NOAA. For the mouth he discovered actual tides to be within 20 minutes of predications 80% of the time and to generally be earlier than predicted. At Coos Bay tides occurred considerably earlier than predicted. Only 25% of measured tides were within 20 minutes of NOAA predictions.

Arneson suggests the earlier tides at Coos Bay could be attributed to increases in mean channel depth that have occurred subsequent to the tidal predictions. Shallow wave theory predicts that the tidal wave should move faster at increased depth. Measurements have not been made since completion of channel deepening associated with the Deep-Draft Navigation Project. This further depth increase could allow the tidal wave to travel even faster.

Tidal circulation

The USACE (1975) states that the average tidal current at Coos Bay is 2.0 knots (3.4 ft per sec) and that flood currents of 3.5 knots (5.9 fps) have been reported. Arneson (1976) mentions that ebb currents as high as 5.0 knots (8.4 fps) have been measured, although maximum ebb measured during his study was 2.4 knots (4.0 fps).

Arneson (1976) studied the relationships of flow and velocity to maximum and minimum tidal heights to determine the character of the tidal wave. His data (Table 5) reveal that the wave is neither a true standing nor progressive wave. The tide resembles a cooscillating wave in which the tidal wave is reflected at the head of the estuary and the resulting tidal motion is the sum of the incident and reflected waves. However, studies of tidal ranges and lag times of high and low water as one progresses up the mouth show that the cooscillation theory does not strictly define Coos Bay. The complex geometry of the bay and the fact that one may consider tributaries both as sources and as inertial forces contributes to this complexity (Arneson 1976). The response of the tidal phenomena to further changes in estuarine geometry is difficult to predict.

Mixing

Burt and McAllister (1959) used a salinity gradient approach to describe mixing in Coos Bay. They classified the bay as well mixed for all months except November, when the estuary was partly mixed. They also specified a secondary classification of partly mixed for January, March, and June. Arneson (1976) applied the salinity gradient approach and the approach developed by Simmons (Dyer 1973), which uses a ratio of river flow to tidal prism, to data which he collected in 1973 and 1974. Results are shown in Fig. 4.

Both the flow ratio and salinity gradient methods classify the entire estuary as one mixing type. Arneson (1976) used salinity profiles to depict conditions along the main channel of the bay (Fig. 4). He finds a consistent change in mixing patterns occurring between RM 14 and 15 in Marshfield Channel, not far from the entrance of Coos River into the wide, shallow tidal flat area of the bay. It also appears that RM 8-9 is a zone of change. This may also be related to shape changes that occur there.

Table 5. Flow and velocity phase results (Arneson 1976).

Date	Tide	Phase lag following low or high water[a]						Range (m)
		Entrance (RM 1.06)		Coos River (RM 15)		Isthmus Slough (RM 14.22)		
		Flow	Velocity	Flow	Velocity	Flow	Velocity	
Sept. 12, 1973 (Summer)	Flood	78^o	78^o	148^o	126^o	156^o	129^o	1.79
	Ebb	87^o	81^o	100^o	130^o	--	--	-1.82
Dec. 18, 1973 (Fall)	Flood	--	--	--	--	--	--	1.33
	Ebb	81^o	87^o	--	--	90^o	49^o	-2.15
Mar. 22, 1974 (Winter)	Flood	--	--	113^o	95^o	128^o	--	1.71
	Ebb	84^o	78^o	124^o	156^o	92^o	112^o	-1.89
June 11, 1974 (Spring)	Flood	114^o	127^o	168^o	122^o	--	--	1.71
	Ebb	88^o	90^o	168^o	162^o	88^o	74^o	-1.07

[a] *360^o = 1 tidal cycle of 12.42 hours*

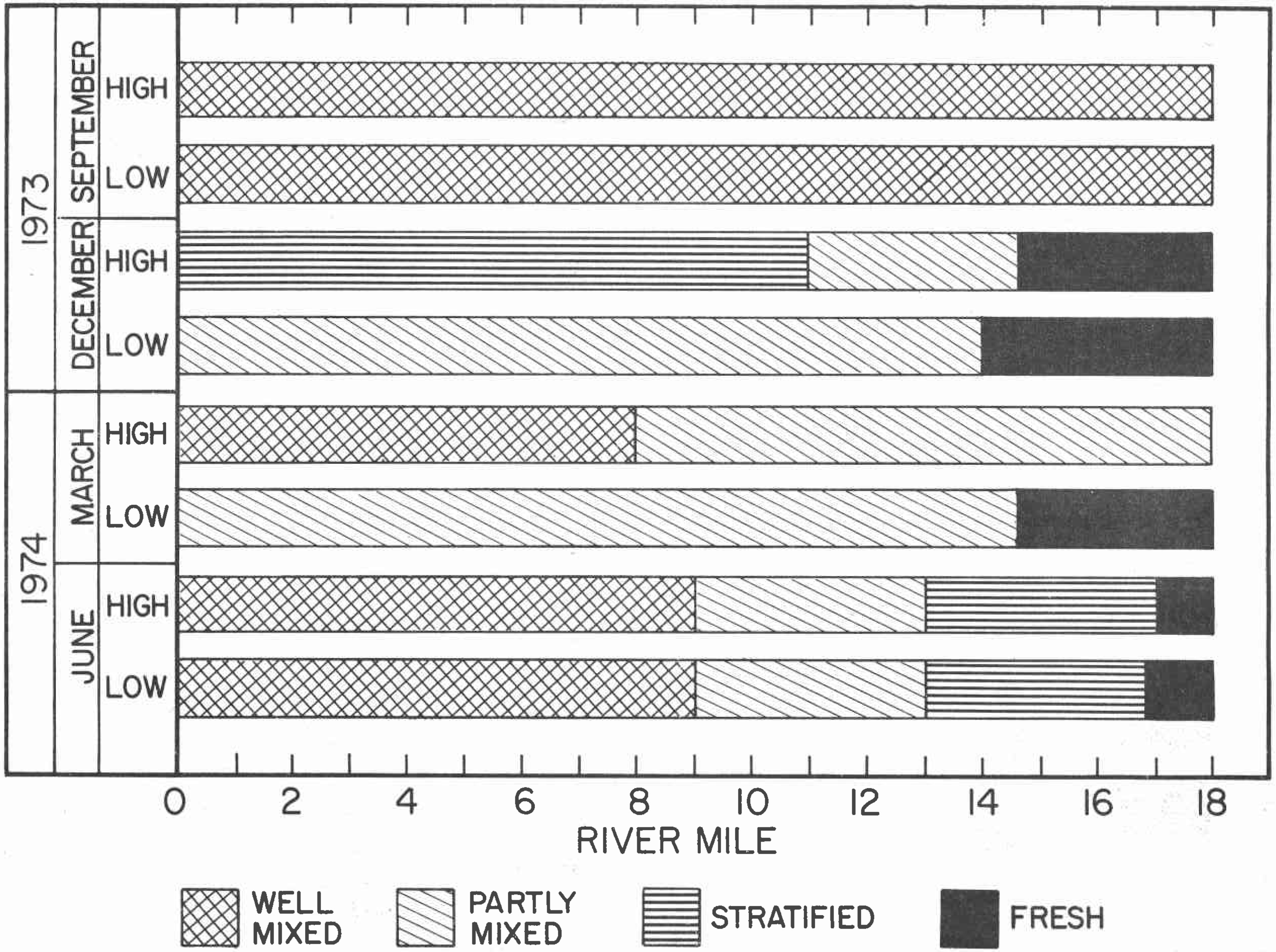


Fig. 4. Coos Bay mixing characteristics (Arneson 1976).

Flushing

Using the modified tidal prism method Arneson (1976) calculated flushing times for several points in the estuary (Table 6). His calculations for a point 27 miles from the mouth of the estuary ranged from 13.4 days at a time of high river flow and tidal range to 48.5 days at low flow and low tidal range. Although these estimates are based on only a few measurements, they demonstrate that flushing takes a number of days even under optimum flow.

Table 6. Calculated flushing rates using the modified tidal prism method (Arneson 1976).

Date	Tidal Range (ft)	Flow (cfs)	Flushing time (days)		
			RM 7.6	RM 17.3	RM 27.0
Sept. 13, 1973	7.9	28	9.7	22.9	40.3
Dec. 19, 1973	5.9	3,814	6.2	11.8	13.4
Mar. 23, 1974	7.2	1,074	8.2	14.4	15.9
June 12, 1974	3.3	431	19.0	41.3	48.5

Temperature

The temperature of Coos Bay undergoes both seasonal and diurnal fluctuations. Fresh water inflow and tidal currents are the main factors affecting temperature distribution in the estuary (Arneson 1976). Coastal upwelling causes offshore surface temperatures to be coldest during summer (Bourke et al. 1971). River temperatures are coldest in winter and warmest during summer and fall (Arneson 1976). DEQ (1978) data show that temperatures in the estuary have reached extremes of 35.6°F and 73.4°F. Seasonal temperature fluctuations are greater upbay than near the mouth of the estuary, reflecting that fluctuations in tributary temperatures are more extreme than those of the ocean.

Arneson (1976) plotted temperature vs RM for the data he collected in 1973 and 1974 (Figs. 5 and 6). His data show large longitudinal variations in September and June when entering fresh water was warmest. June data also show vertical gradients because a greater amount of fresh water was entering at that time. High tide profiles each show a significant increase at RM 8, which Arneson attributes to solar heating of the shallow water over the large tideflats of the upper bay.

In December and March the ocean and entering fresh water were nearly the same temperature so profiles were almost identical. DEQ (1978) data show that fresh water temperatures may be much colder than ocean temperatures. Different profiles would be expected under those conditions.

In summer, low streamflows and poor circulation cause high temperatures in some areas of the bay (STR 1974). High temperatures physiologically stress aquatic life. STR (1974) list high temperature as a water quality problem in Coos River, Millicoma River, North Slough, Catching Slough, and Isthmus Slough.

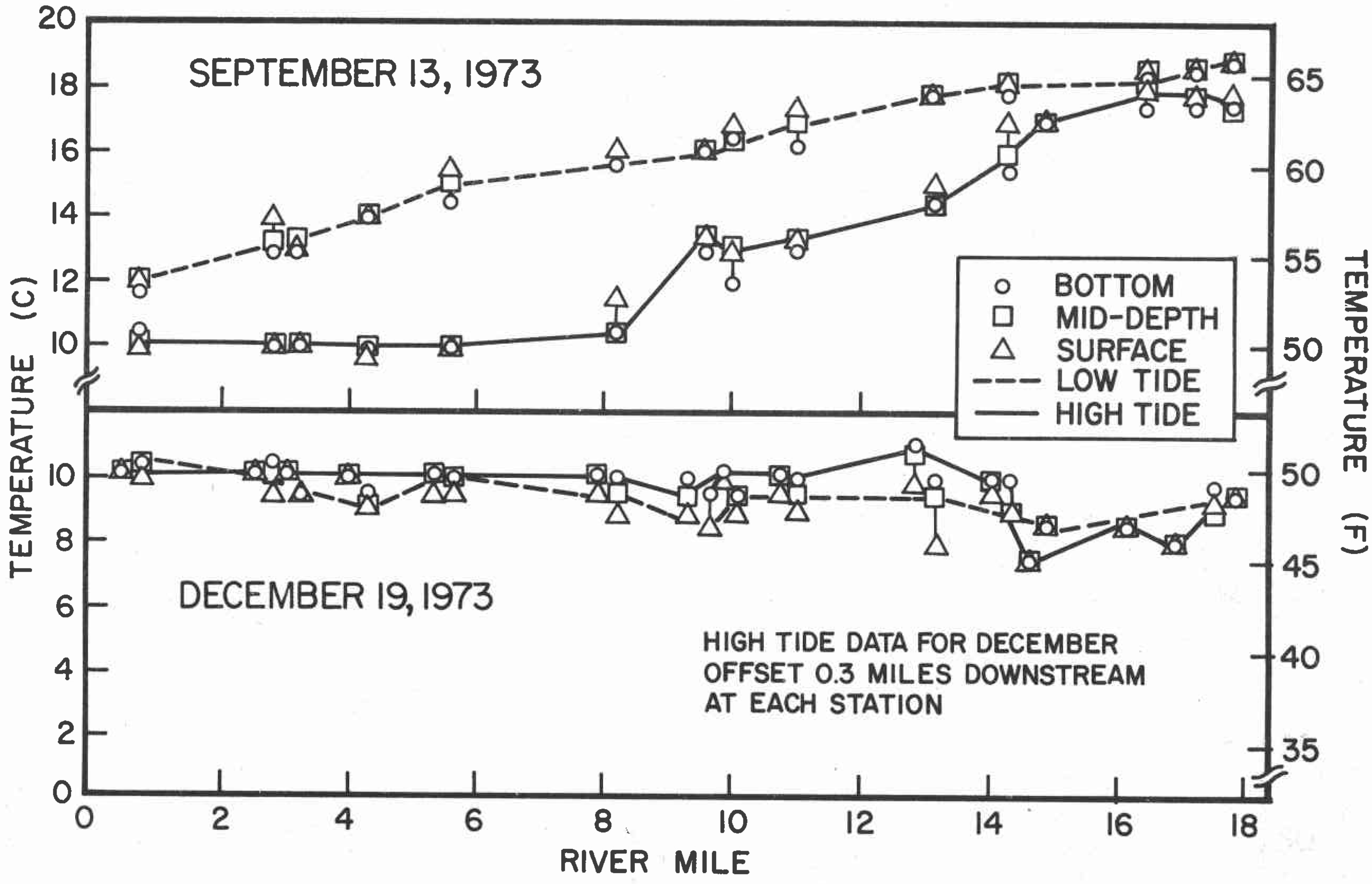


Fig. 5. Temperature vs. river mile, Coos Bay, September 13 and December 19, 1973 (Arneson 1976).

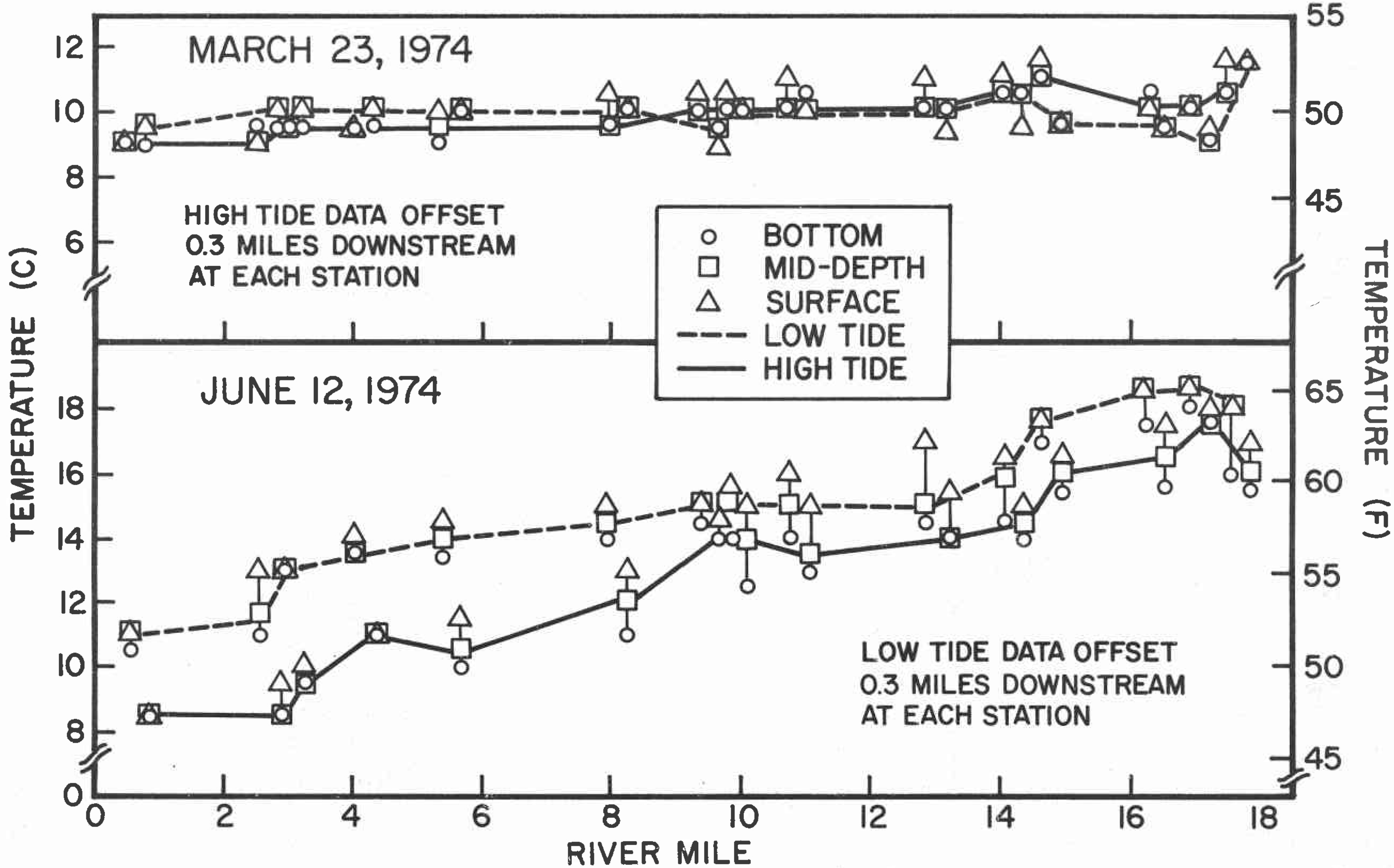


Fig. 6. Temperature vs. river mile, Coos Bay, March 23 and June 12, 1974 (Arneson 1976).

Dissolved oxygen

Dissolved oxygen (DO) is measured by DEQ as part of their regular water quality monitoring program. Others who have measured DO in conjunction with specific projects include Arneson (1976), STR (1974), and Slotta et al. (1973).

DEQ data show DO levels below the 6 mg/l standard occasionally at various locations in the bay (DEQ 1978). Measurements below standards were more frequent above RM 13 and in Isthmus Slough. STR (1974) data generally concur. Arneson (1976) sampled seasonally in 1973 and 1974. His limited data show that DO concentrations were slightly higher in December and March than in June and September. Lowest levels were recorded from Isthmus Slough. DO concentrations below the standard can kill resident fish and invertebrates and prevent migrants from utilizing the area.

Arneson (1976) mentions that DO depressions during fall have been attributed to low fresh water inflow and waste loading caused by offshore upwelling of low DO water and input of organic material, such as seafood industry waste water and bark from stored logs.

Arneson (1976) also noted supersaturation in the Coos River and in Catching Slough during June which he attributes to photosynthetic activity. Arneson attributed supersaturation observed near the mouth in December to reaeration aided by wave action.

Turbidity

Arneson (1976) found, with only a few exceptions, that low tide turbidity levels were higher than high tide levels. He interpreted this to mean that the primary cause of turbidity in Coos Bay is the sediment carried in by fresh water entering the bay. High tide turbidities increase from the mouth upstream during all seasons although this increase is very slight during times of low runoff.

USACE (1975) states the average turbidity in the bay ranges from 20 to 49 Jackson Turbidity Units. Slotta et al. (1973) found that below RM 12 dredging does not significantly increase turbidities. Above RM 12 post-dredging levels of 500 JTU have been recorded. North Slough and the area near Empire Mill are mentioned by the USACE (1975) as areas of high turbidity. Discharge of industrial waste water is listed as a probable cause of these high turbidities by STR (1974). USACE (1975) states that highest turbidity levels measured by STR in 1972 were 2,400 JTU during high tide at the site of log-dumping operations at the Empire Mill. The clearest waters were found at the entrance and near North Bend (USACE 1975).

DEQ standards specify that no more than a 10% cumulative increase in natural turbidities is allowed except for certain DEQ approved limited duration activities (OAR 340-41-325).

Coliform

DEQ has measured fecal coliform counts which exceed standards for commercial shellfish growing areas occasionally below RM 8.75 in the bay and frequently above this point. Counts exceeding general standards are frequent above RM 11.5. With a few exceptions, coliform counts in South Slough have been within shellfish area standards. STR (1974) has measured counts above the standard upbay of Jordon Point in the main bay, in North Slough, Isthmus Slough, and Catching Slough. The bay has been closed to commercial shellfish harvest above Sitka Dock by the State Health Division (Osis and Demory 1976).

Major causes of high coliform counts include improper disinfection of sewage plant effluents, inadequate subsurface disposal systems, and livestock (STR 1974).

Sediments

Coos Bay is an aggrading system--more sediment enters the bay than is removed by natural forces (USACE 1975). Prior to the channel deepening for the Deep-Draft Navigation Project, an annual average of 1.65 million yd^3 of material was removed from Coos Bay by the USACE (1976) to maintain navigation channels.

Sediments entering the bay include

1. materials, primarily silts, derived from erosion of the drainage basins of tributary streams;

2. marine sands carried into the bay by littoral drift;

3. dune sands which are blown into the bay even though the dunes have been partially stabilized by vegetation;

4. sands from wind erosion of the sandstone cliffs of the lower bay and South Slough.

The material from the entrance to RM 12 is predominantly fine sand. No shift to smaller grain size has been observed in that section following dredging. From RM 12 to RM 15 channel, sediments are primarily silts, clays, and organic fines, and the composition shifts to smaller grain sizes after dredging. Above RM 15 sediments are silty (USACE 1975).

Sedimentation is controlled by hydrology. Arneson (1976) has applied the concept of realms of deposition used by Kulm and Byrne (1976) for Yaquina Bay to the Coos. He hypothesizes a marine and a transition realm extends to RM 12 and a fluviatile realm exists above RM 12. Percy et al. (1974) estimate an average of 72,000 tons of sediment enters the bay from its drainage basin annually.

Known areas of sediment deposition in Coos Bay include the entrance to Charleston Channel, the area adjacent to disposal islands west of the North Bend Airport, Jordan Cove, east of the upper Coos Bay Channel, and at the mouths of Pony Slough, North Slough, and Haynes Inlet (USACE 1976).

In the lower portions of Coos Bay, material removed from the channel is deposited in in-bay disposal sites. During recent years the amount of material has been constant and shoaling has recurred at the same sites. USACE (1976) hypothesizes that a semi-closed sediment transport system has been operating from RM 2 to RM 12. Sediments originating upstream of RM 15 were thought to have been trapped between RM 12 and RM 15 where the channel was dredged by the Corps. Sediments from the ocean were thought to accumulate mainly below RM 2. Below RM 2 and RM 12 sediments were thought to result from redistribution of existing sediments in a cycle of removal of material from the channel, disposal of dredged material adjacent to the channel, and gradual infilling of the channel (USACE 1976). Effects of channel deepening on this sytem are unknown.

Most studies of the sediment chemistry of Coos Bay have been related to dredging and disposal of dredged material (STR 1972; Slotta et al. 1973; Arneson 1976). STR (1972) determined that sediments below RM 10 met standards for inwater disposal, whereas all materials above RM 10 failed to meet those standards. Above RM 10 volatile solids increased (Arneson 1976). USACE (1975) found the area above RM 12 in the estuary exceeded EPA standards for grease and oil, volatile solids, nitrogen, and phosphorus.

Biological Characteristics

The biology of Coos Bay has been the subject of numerous studies, including those by individual students and classes at Oregon Institute of Marine Biology (OIMB), by OSU students and faculty, and by ODFW personnel. Most of the studies are descriptive in nature. Quantitative studies of productivity and population dynamics are generally lacking.

Phytoplankton

The USACE (1975) has summarized work done by several authors on the summer phytoplankton of Coos Bay (Kilburn 1961; Ednoff 1970; Ide 1970; McGowan and Lyons 1973). Diatoms are the principal members of Coos Bay's planktonic flora. There appears to be a continuum of species from the ocean to the upper bay containing two species assemblages and a transition zone. The transition zone lies between RM 5 and 9 and is an area of high species diversity and productivity (McGowan and Lyons 1973). *Chaetoceros, Skeletonema,* and *Thalassiosira* predominate in the lower bay, while *Melosira* and *Skeletonema* are found in the upper bay.

OIMB is currently taking quantitative measurements of phytoplankton in South Slough. Preliminary results indicate definite seasonal and tidal changes in species composition.

Macroalgae

The algal flora of Coos Bay is not well described. Most of the existing information is derived from qualitative studies by Sanborn and Doty (1944) and OIMB (1970). The USACE (1975) states that attached algae are probably found throughout the bay on solid substrates and that very few marine algae are restricted to the bay environment and not found in other locations along the Pacific Coast.

The greatest variety of algal species is found near the mouth of the estuary where hard substrates providing significant attachment sites and moderate wave action support a flora similar to that of the protected outer coast (Sanborn and Doty 1944). Along the main channel there is a change from a strictly marine to a brackish water flora.

Small subtidal kelp (*Nereocystis leutkeana*) beds are located in the lower sections of the estuary, and free-floating, seasonally occurring mats of green algae sometimes cover large areas of the upper bay (Ednoff 1970).

Productivity studies of the algae of Coos Bay have not been done.

Seagrasses

Two seagrasses occur in Coos Bay--eelgrass (*Zostera marina*) and ditchgrass (*Ruppia* sp.) (USACE 1975). Approximately 1,400 acres of lower intertidal and shallow subtidal tideflats are covered by eelgrass meadows (Akins and Jefferson 1973). Large contiguous beds of eelgrass occur in the lower and upper bay, in North and South Sloughs, and in Haynes Inlet. George M. Baldwin and Associates et al. (1977) state that the eelgrass meadows of the upper bay are among the largest in the state. In the lower reaches of the estuary eelgrass often occurs in pure stands, whereas in upper, less saline, areas it is often accompanied by ditchgrass.

Tidal marsh

Tidal marsh generally occurs from lower high tide inland to the line of non-aquatic vegetation and includes both salt marsh and tidally influenced fresh marsh. The U.S. Department of the Interior (USDI 1971) states that marsh vegetation in Coos Bay developed where broad, low gradient flats of soft sediment were not too strongly stressed by waves or currents. Large present day marshes are located at the mouth of Coos River and in the slough systems--North Slough, Pony Slough, Kentuck Inlet, Isthmus Slough, and Coalbank Slough. Fringing marshes have developed along the shoreline of the main channel near Empire, around the spoil islands of the lower and upper bay, and along the undisturbed shorelines of South Slough.

Using a classification adapted from Jefferson (1975) and estimating an error of less than 10%, Hoffnagle and Olson (1974) calculated the marsh acreage of Coos Bay (Table 7). Akins and Jefferson (1973) have given a figure of 2,738 ac. of marsh for Coos Bay.

Table 7. Area of Coos Bay marshes (Hoffnagle and Olson 1974).

Marsh type	Area (acres)
Low silt marsh	71.6
Low sand marsh	289.1
Immature high marsh	1000.5
Mature high marsh	97.5
Sedge marsh	353.5
Bullrush and sedge marsh	149.8
Surge plain	285.0
Total undiked marsh	1951.9
Total diked marsh	2942.9

Prior to human alterations of the estuary and its drainage basin, vast marshes occupied the upper bay and slough systems. Hoffnagle ad Olson (1974) estimate that 90% of the salt marshes of this estuary have been diked or filled to accomodate expansion of industry or residential areas and for agriculture and for dredged material disposal sites. Eilers (1974) indicates that of the 14 estuaries examined, Coos Bay marshes have been the most severely disturbed by human activities.

Marsh species and types present in Coos Bay resemble those found in other Oregon estuaries to the north and in the Coquille to the south. Akins and Jefferson (1973) noted that south of the Coquille there is a distinct change in vegetation and marsh types.

Hoffnagle et al. (1976) studied six marsh sites in Coos Bay. The group estimated those marshes produced over 1,050,000 gm/acre/year of plant material and considered this figure to be an underestimate. Their data suggest higher marshes are more productive than lower marshes. Bullrush and sedge were found to be particulary productive species. Productivity alone may be insufficient evidence to judge the importance of a marsh. The palatability of marsh plants to consumer organisms and the importance of the plant to detritus production are examples of other considerations (Hoffnagle et al. 1976).

According to Hoffnagle and Olson (1974), "The salt marsh and bacterial and clinging forms associated with its detritus comprise a base of production for the Coos Bay Estuary, providing food and habitat for commerical fish, bivalves, crab, birds, and mammals, and life in Coos Bay in general." The marsh serves as a buffer between shorelands and estuarine waters, preventing or minimizing erosion, flooding, and pollution. Jefferson (1974) indicates that flooding poses a greater potential hazard to shorelands because vast areas of Coos Bay marshes have been diked. Areas constructed on filled marsh are the most susceptible to flooding.

Zooplankton

McGowan and Lyons (1973) directed a short sampling program during the summer of 1973. Their data show a decreasing number of zooplankton taxa along the axis of Coos Bay with increasing distance from the ocean. The lower bay appeared to have a species assemblage which included neritic zooplankters carried in by tidal action and resident species which maintained reproductive populations. Peak zooplankton numbers occurred near Empire in an area of high chorophyll values. Different species were found in the upper bay and in Coos River.

Quantitative information on Coos Bay zooplankton is sparse, and seasonal species distributions are unknown.

Invertebrates

A wide variety of ecological niches are available to invertebrates in the Coos Bay estuary. Differing substrates provide a range of attachment sites and sediments in which to burrow from the solid rock of Fossil Point to the silty, highly organic mud of Isthmus Slough. In addition to substrate variations, differing salinities, temperatures, dissolved oxygen, and other physical factors provide even more variation in conditions.

Subtidal invertebrate populations of the dredged ship channel have been studied by Parr (1974), Slotta et al. (1974), and Jefferts (1977). Jefferts (1977) found the channel infauna of the lower portions of the estuary to be more diverse than that of the upper bay channel. Species of the upper bay, such as the polychaete *Streblospio benedicti*, are generally widespread and opportunistic. Parr (1974) hypothesizes that the fauna of the upper channel are adapted to dredging and that the "weed" species occurring there require frequent disturbance to maintain their competitive advantage.

A qualitative overview of the intertidal macroinvertebrates in Coos Bay was conducted by OIMB in 1970. Many other workers have concentrated on certain taxa or on limited geographic areas of the bay. Distribution of *Corophium*, an important crustacean in the diet of salmonids and other fishes, is shown in Fig. 7. ODFW has surveyed intertidal clam and shrimp distribution in some areas and is completing surveys in other areas (Gaumer 1978) (Fig. 8-15). Hartmann and Reish (1950 described the annelid fauna of the bay with notes on distribution, and Queen (1930) studied the decapod crustaceans of the bay.

Commercially and recreationally harvested invertebrates include several species of clams, the Dungeness and red rock crabs, oysters, bay mussels, ghost shrimp, kelp worms, and mud shrimp.

Clams. Principal species of clams harvested in Coos Bay are gapers (*Tresus capax*), cockles (*Clinocardium nuttallii*), butter clams (*Saxidomus giganteus*), littlenecks (*Protothaca staminea*), softshell clams (*Mya arenaria*), and razor clams (*Siliqua patula*). Of these, all but the softshell clams are restricted in distribution to areas below the railroad bridge (RM 9). These clam species are all filter feeders. Salinity, substrate, and water circulation probably play significant roles in limiting distribution (USACE 1975).

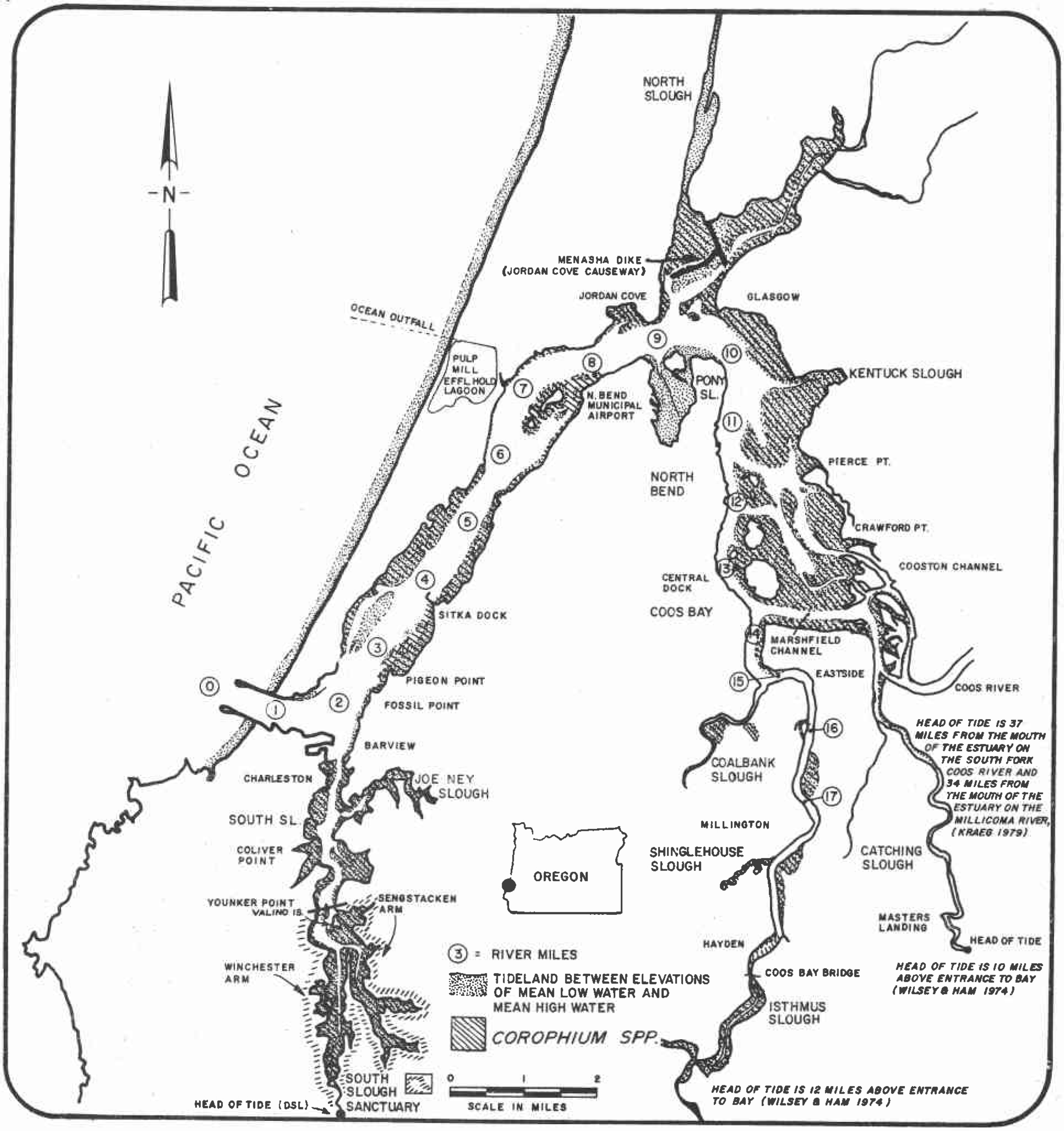


Fig. 7. *Corophium* distribution in Coos Bay (Coos Bay Planning Department 1979).

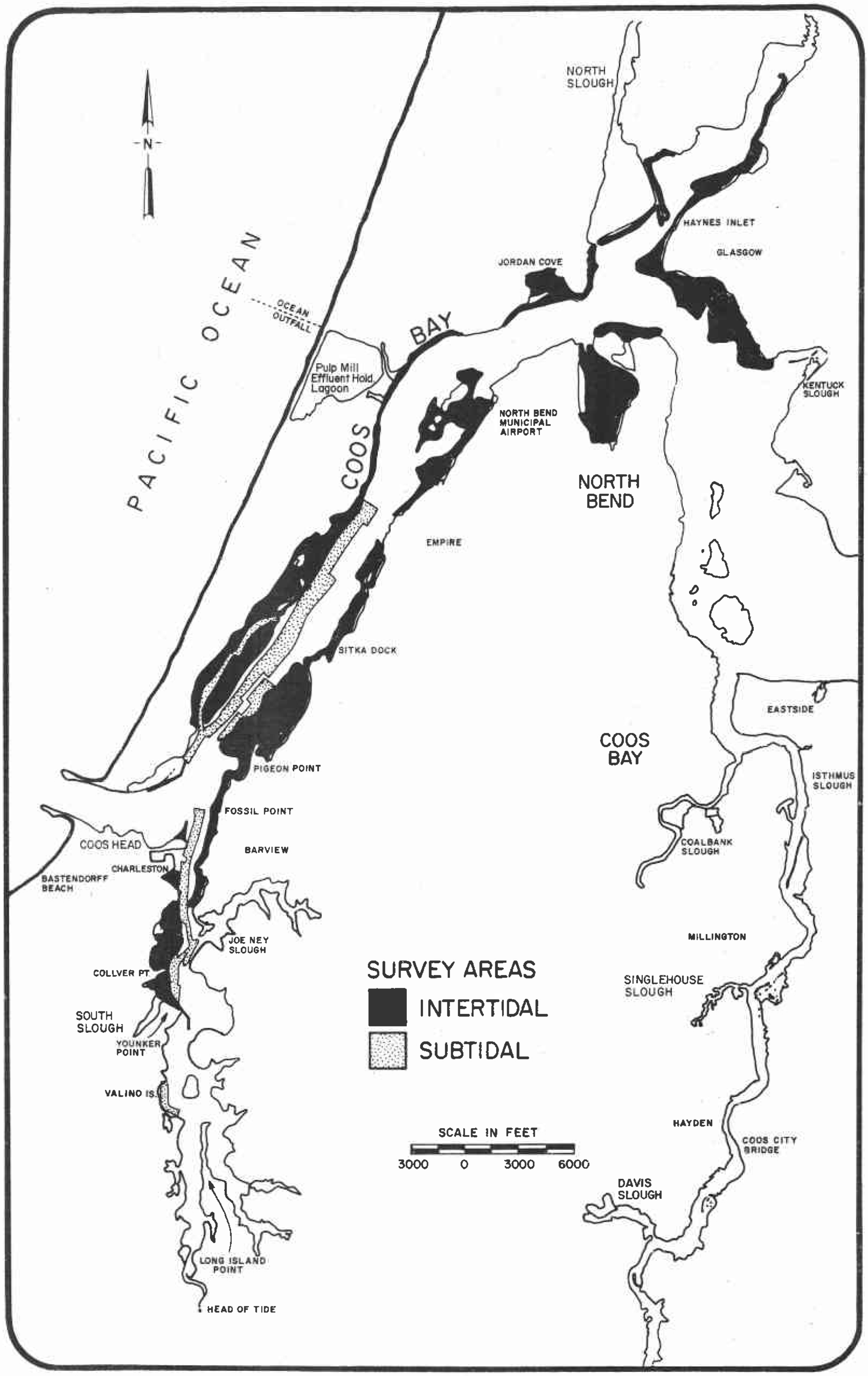


Fig. 8. Areas surveyed for clam and shrimp distribution (Gaumer 1978).

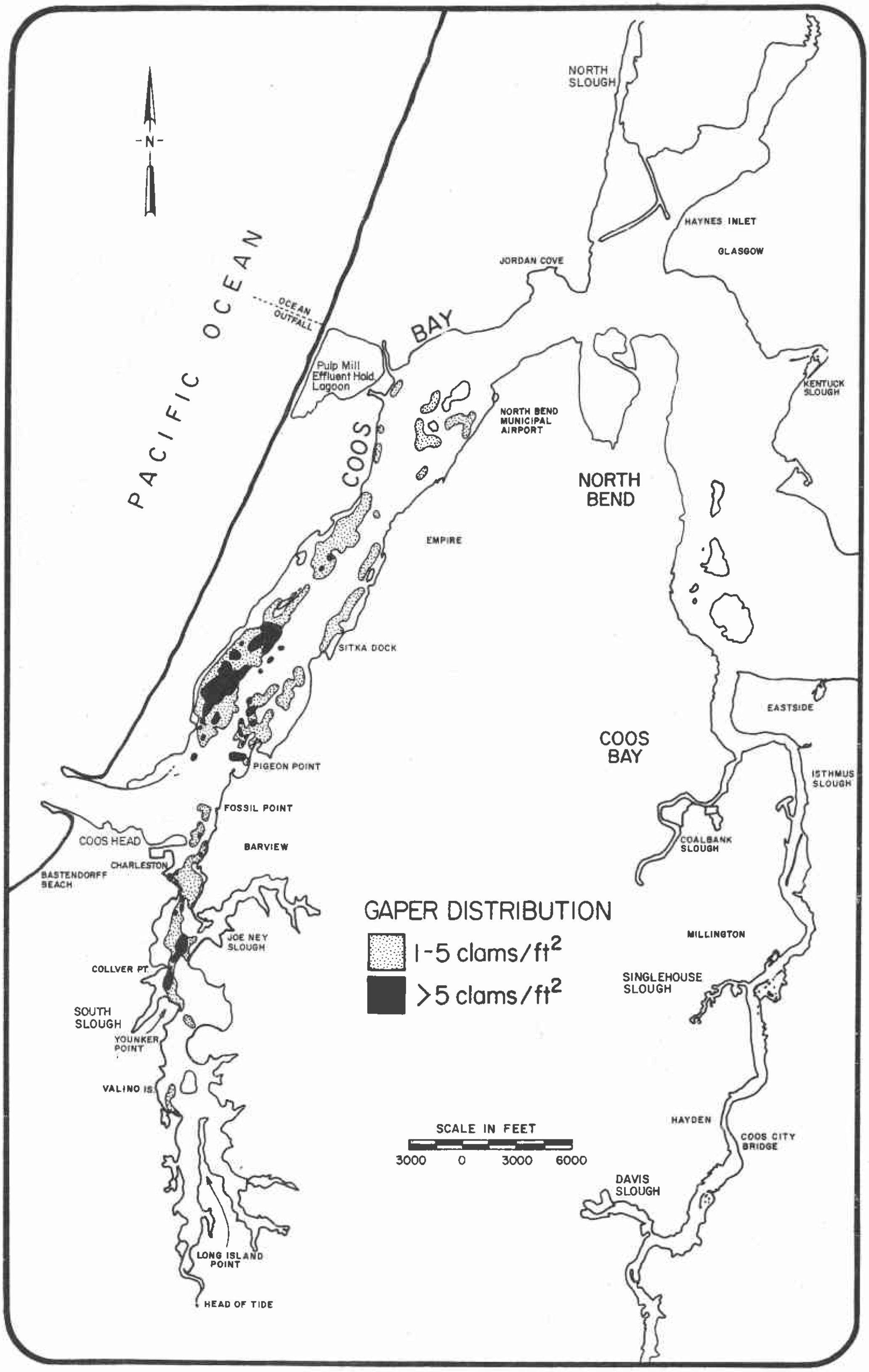


Fig. 9. Gaper distribution in Coos Bay (Gaumer 1978).

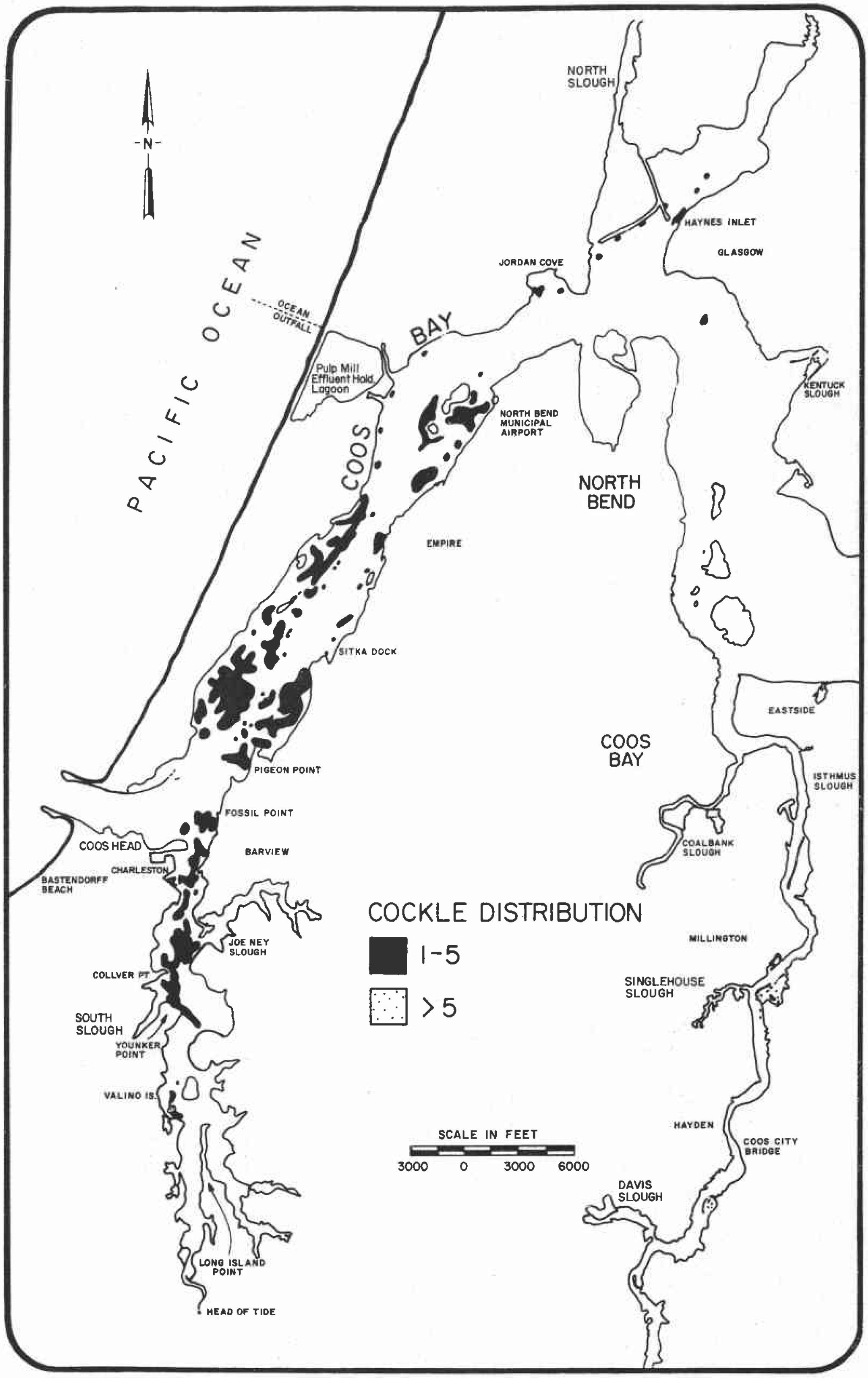


Fig. 10. Cockle distribution in Coos Bay (Gaumer 1978).

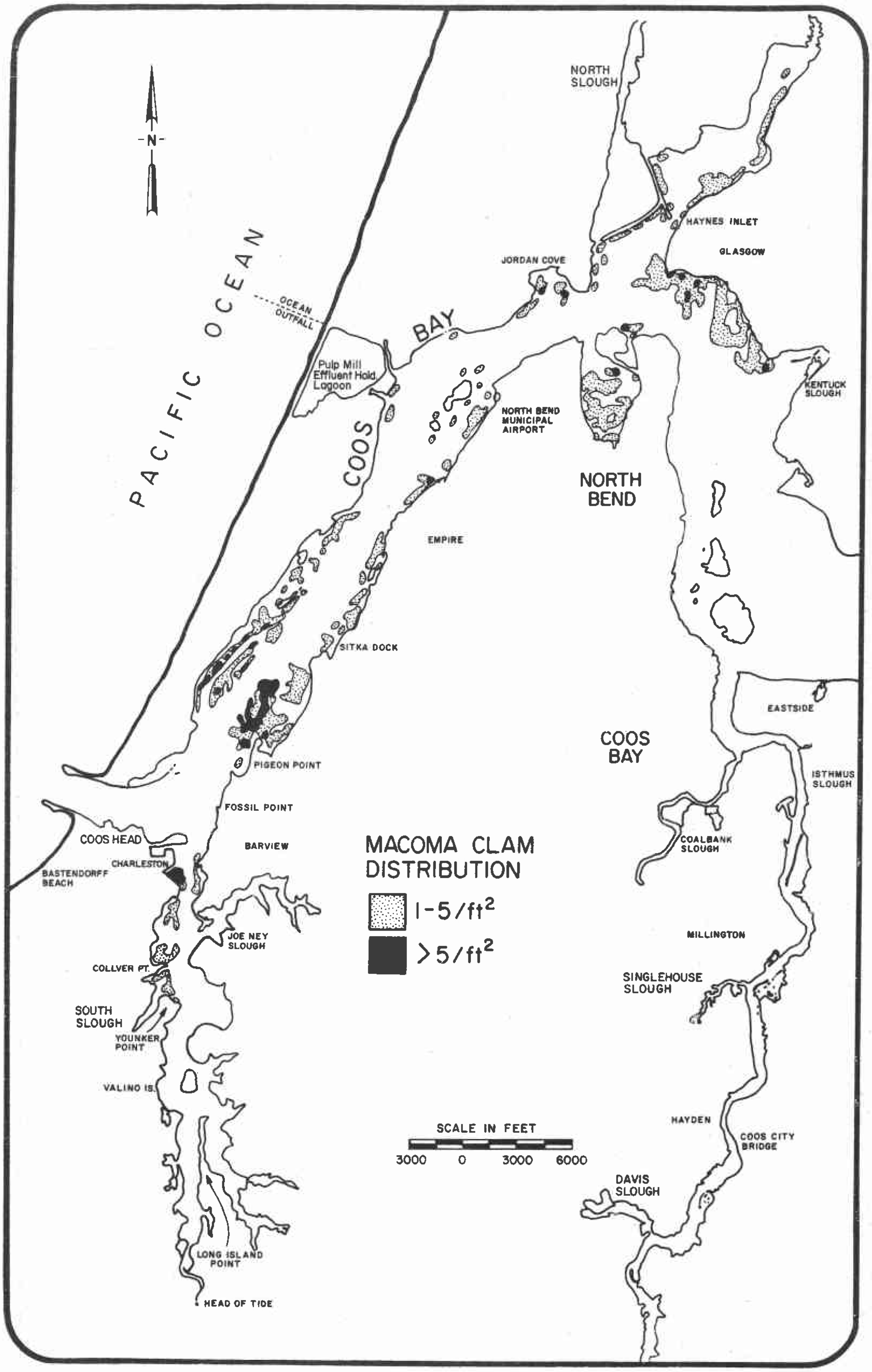


Fig. 11. *Macoma* (*Macoma irus, M. nasuta and M. balthica*) distribution in Coos Bay (Gaumer 1978).

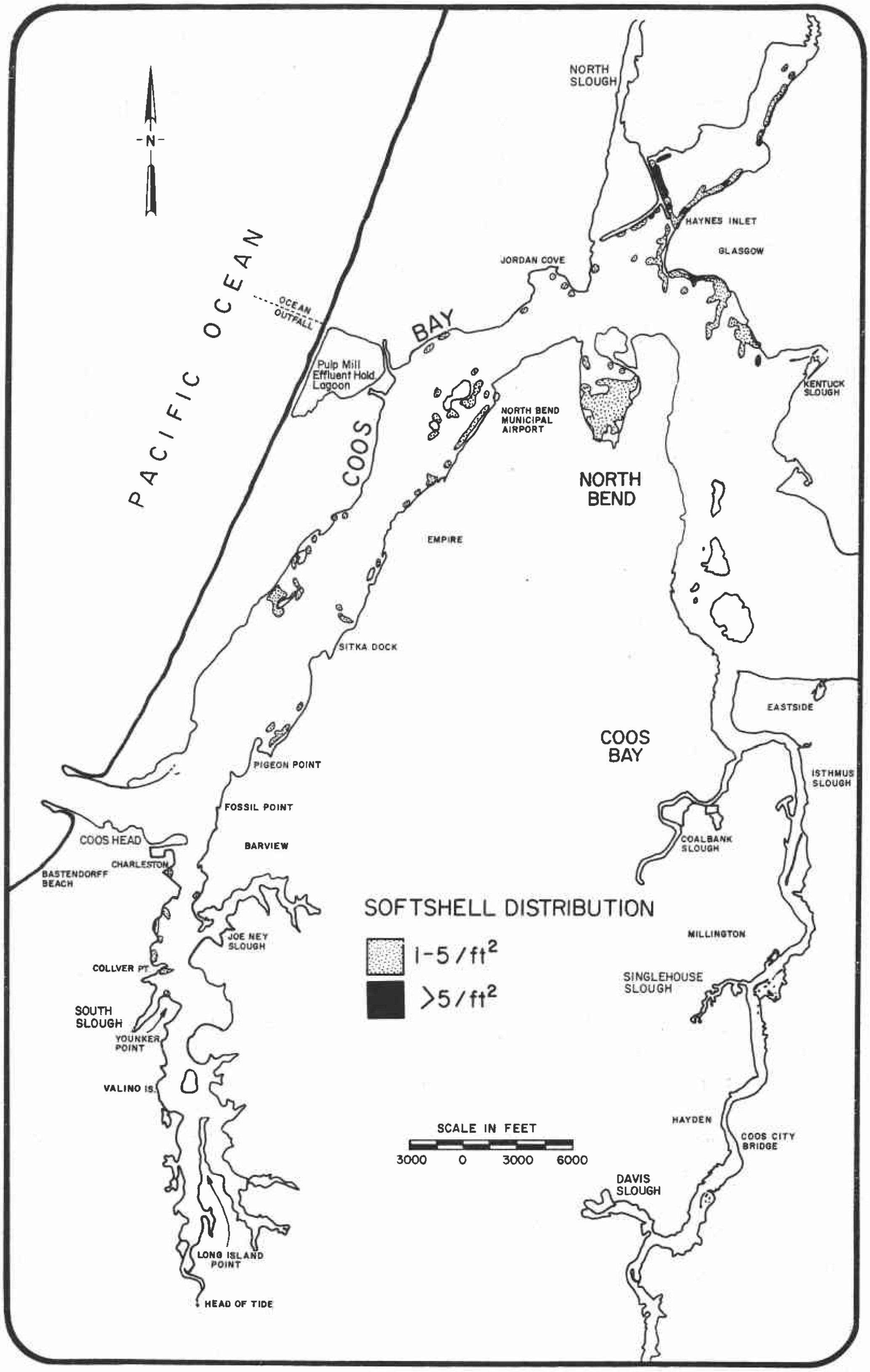


Fig. 12. Softshell distribution in Coos Bay (Gaumer 1978).

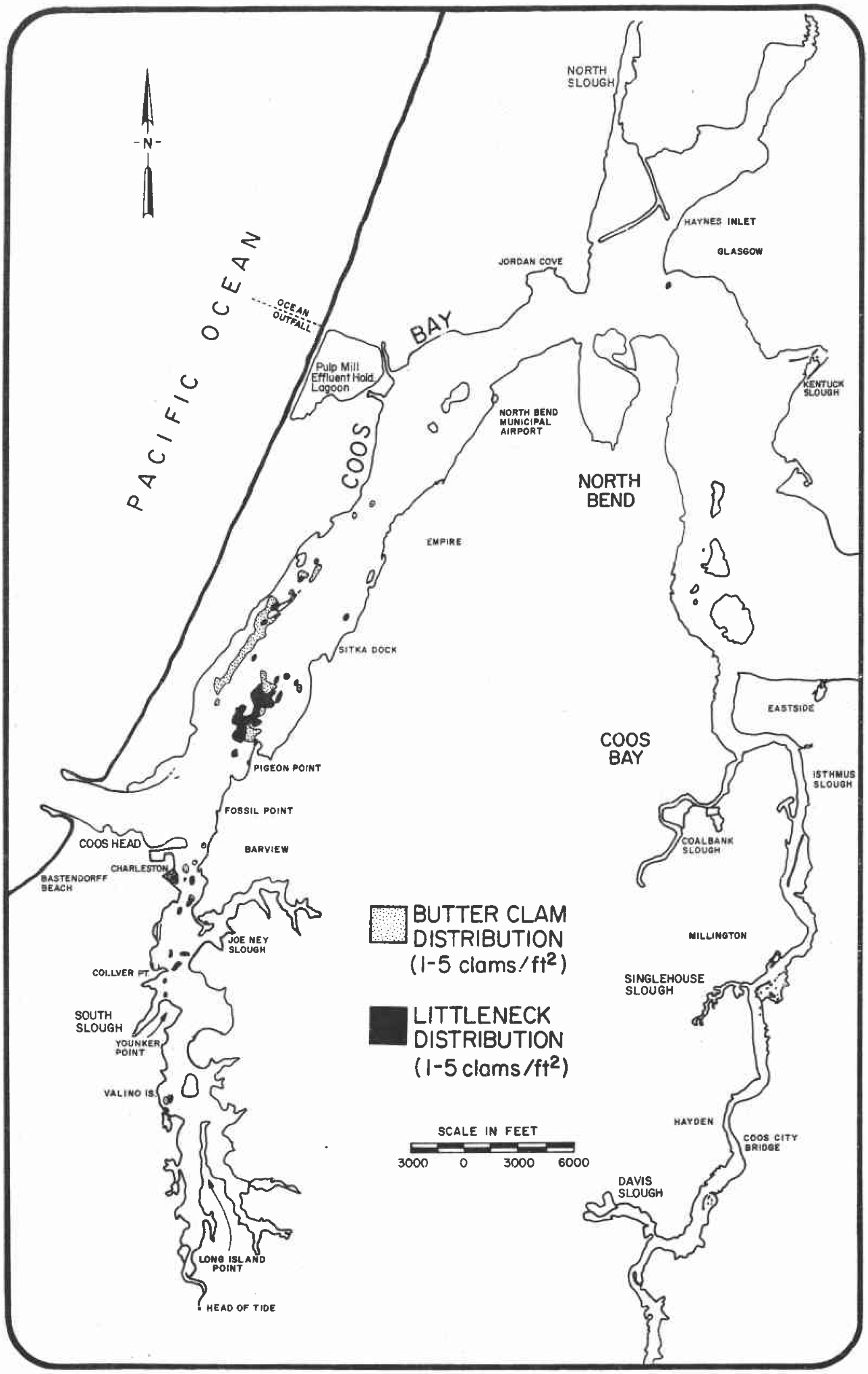


Fig. 13. Butter clam and littleneck distribution in Coos Bay (Gaumer 1978).

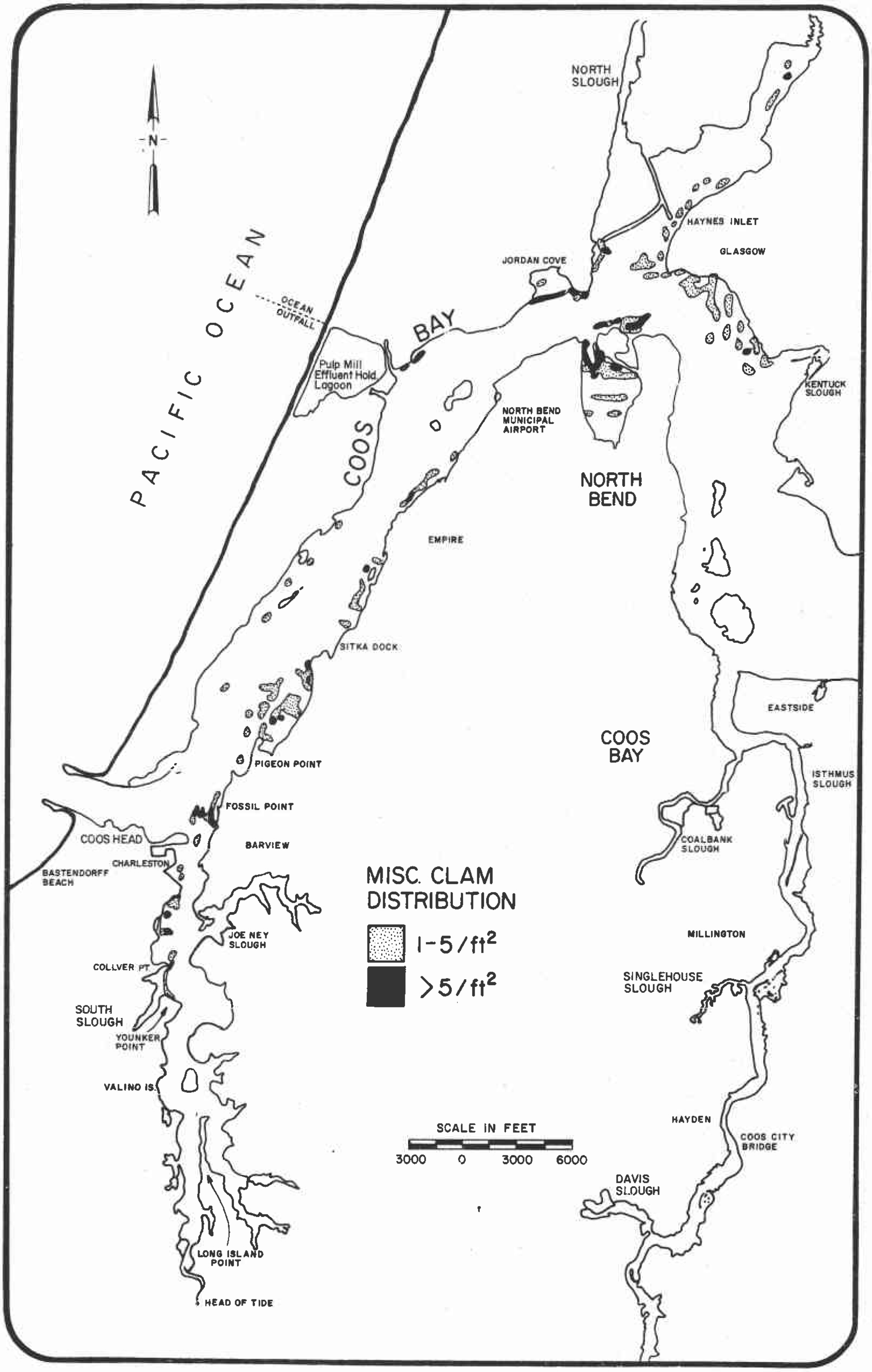


Fig. 14. Miscellaneous clam (California softshell, bodega, paddock, jackknife and rockclams) distribution in Coos Bay (Gaumer 1978).

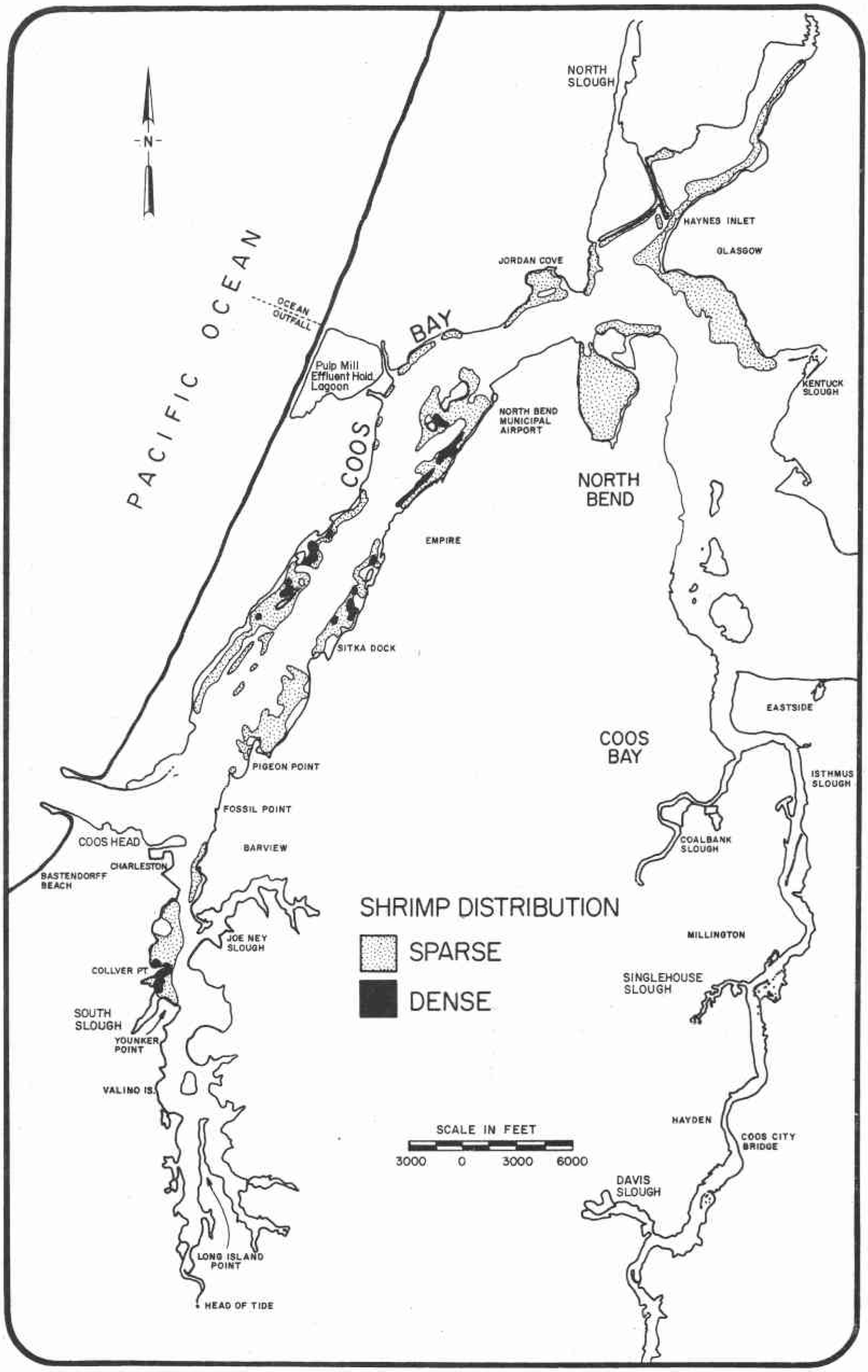


Fig. 15. Shrimp distribution in Coos Bay (Gaumer 1978).

Preliminary ODFW studies indicate that Coos Bay has extensive subtidal clam beds, including large beds of gapers and cockles (Gaumer and Lukus 1976). Principal beds are in the lower bay and lower South Slough. In 1976 one subtidal bed was investigated by ODFW to determine the feasibility of a commercial clam fishery (Gaumer and Halstead 1976). The 48-acre bed off Pigeon Point contained approximately 26.4 million clams, principally gapers and Irus clams (*Macoma inquinata*). Mean size of butter, cockle, littleneck and gaper clams was larger for each species than in a similar study in Yaquina Bay (Gaumer and Halstead 1976). A commercial harvest of 55,482 lb of gapers was taken from the Coos Bay site in 1975-76.

A 1971 estuarine resource use survey (Gaumer et al. 1973) showed that the greatest numbers of clams were taken from tideflats adjacent to North Spit and Pigeon Point and the flats just south of Charleston bridge. Menasha Dike, which separates North Slough from the main bay ranked second. Of the areas surveyed, the Menasha Dike above the railroad bridge was the principal site of softshell clam harvest. Some resource use information on major recreational clam species is contained in Table 8.

Table 8. Clam catch by tideflat users, 1971 (Gaumer et al 1973).

Clam species	Number taken	% of invertebrate tideflat catch	Primary digging area	Secondary digging area
Gaper	107,907	35.3	North Spit	Pigeon Point
Cockle	53,250	17.5	Charleston Flat	North Spit
Butter	53,288	17.4	Pigeon Point	North Spit
Softshell	45,101	14.8	Menasha Dike	North Bend
Native littleneck	15,482	5.1	Pigeon Point	Boat Basin

Razor clams maintain a fluctuating population on a wave-washed sand spit immediately north of the Charleston breakwater where they are taken recreationally (USACE 1978).

Crabs. Both Dungeness (*Cancer magister*) and red rock (*C. productus*) crabs are taken recreationally in Coos Bay. In 1971 crabs accounted for over 80% of the recreational boat fishing catch with Dungeness crabs alone accounting for 76.7% of the catch (Gaumer, Demory, and Osis 1973). Dungeness crabs are also fished commercially within Coos Bay. In-bay crab landings fluctuate, as do those of the ocean, but an average of 11,441 lb were landed from Coos Bay in 1971-74 (personal communication, Darrel Demory, ODFW, May 8, 1979). Of the 31,000 lb landed from Oregon bays in 1977, Demory (personal communication) estimates that 15,000-18,000 lb were from Coos Bay.

Both species of crabs are found subtidally throughout the bay (USACE 1975). Waldron (1958) states that Dungeness crabs have a preference for sandy or muddy bottoms, although they may be found on almost any bottom. Gaumer et al. (1973) found the lower bay to be the primary site of recreational crab fishing.

Fish Commission of Oregon studies (Waldron 1958) have shown that while crabs do move between bays and the ocean, and from bay to bay, 84% of the crabs tagged in bays were recovered within four miles of the tagging site.

The importance of the estuary as rearing ground for crabs is not understood (USACE 1975). Large numbers of crab larvae (megalops) are found in Coos Bay in late spring and early summer and are also found offshore at that time of year (Waldron 1958). Samll (0.8-2 in) Dungeness crabs are found abundantly in the upper reaches of the estuary. Hunter (1973) has shown that small Dungeness crabs seem to be more tolerant of low salinities than are large individuals.

Several other crab species inhabit the bay including the freshwater crab (*Rhithropanopeus harrissi*) of the upper bay and the shore crabs (*Pachygrapsus crassipes* and *Hemigrapsus nusus*) of rocky intertidal areas.

Oysters. While native oysters (*Ostrea lurida*) no longer inhabit Coos Bay, Pacific oysters (*Crassostrea gigas*) are grown commercially in the bay. All existing Coos Bay oyster leases are in South Slouth (Fig. 16). In 1976, 144.08 acres of oyster ground were leased in Coos Bay. About 40% (57 ac.) were actually in production at that time. Osis and Demory (1976) listed a potential ground acreage of 525 ac and indicated that siltation problems account for much of the land remaining unused. Excessive fresh water and heavy siltation sometimes cause oyster mortality in Coos Bay during winter.

The potential oyster culture area of Coos Bay extends upstream from the mouth to the lower reaches of Haynes and North Sloughs, but high bacterial counts have forced closure of commercial areas above Sitka Dock. Jambor and Rilette (1977) note the area open to oyster harvest is only about one-half of the useable oyster tideland.

According to Jambor and Rilette (1977), DEQ officials state that because high bacterial counts in Coos Bay are mainly caused by dairy and wild animal stocks, little improvement is expected. Purification of shellfish grown in polluted waters (depuration) may be one way to increase acreage in Coos Bay used for commercial oyster culture (ODFW 1976; Jambor and Rilette 1977). However, other factors such as existing clam beds and navigation rights may limit expansion of oyster culture.

Other invertebrates. Other invertebrates taken by recreationists in Coos Bay include ghost shrimp (*Callianassa californiensis*), and mud shrimp (*Upogebia pugettensis*), kelp worms (*Nereis* spp.) (Fig. 15) (Gaumer et al. 1973), and lug worms (*Abarenicola pacifica*) (personal communication, Reese Bender, ODFW, March 10, 1979). These organisms are frequently used as bait. The shrimp are primarily taken from tideflats of the lower bay while the worms are harvested in greatest abundance from Menasha Dike (Gaumer et al. 1973).

Fish

At least 66 species of fish are known to use the Coos Bay estuary (Cummings and Schwartz 1971). Fish distribution has been studied during summer months (Cummings and Schwartz 1971; Ednoff 1970) and seining efforts by ODFW in 1977 and 1978 have added further information regarding seasonal use of the bay (personal communication, Reese Bender and Bill Mullarkey, ODFW, April 4, 1979)

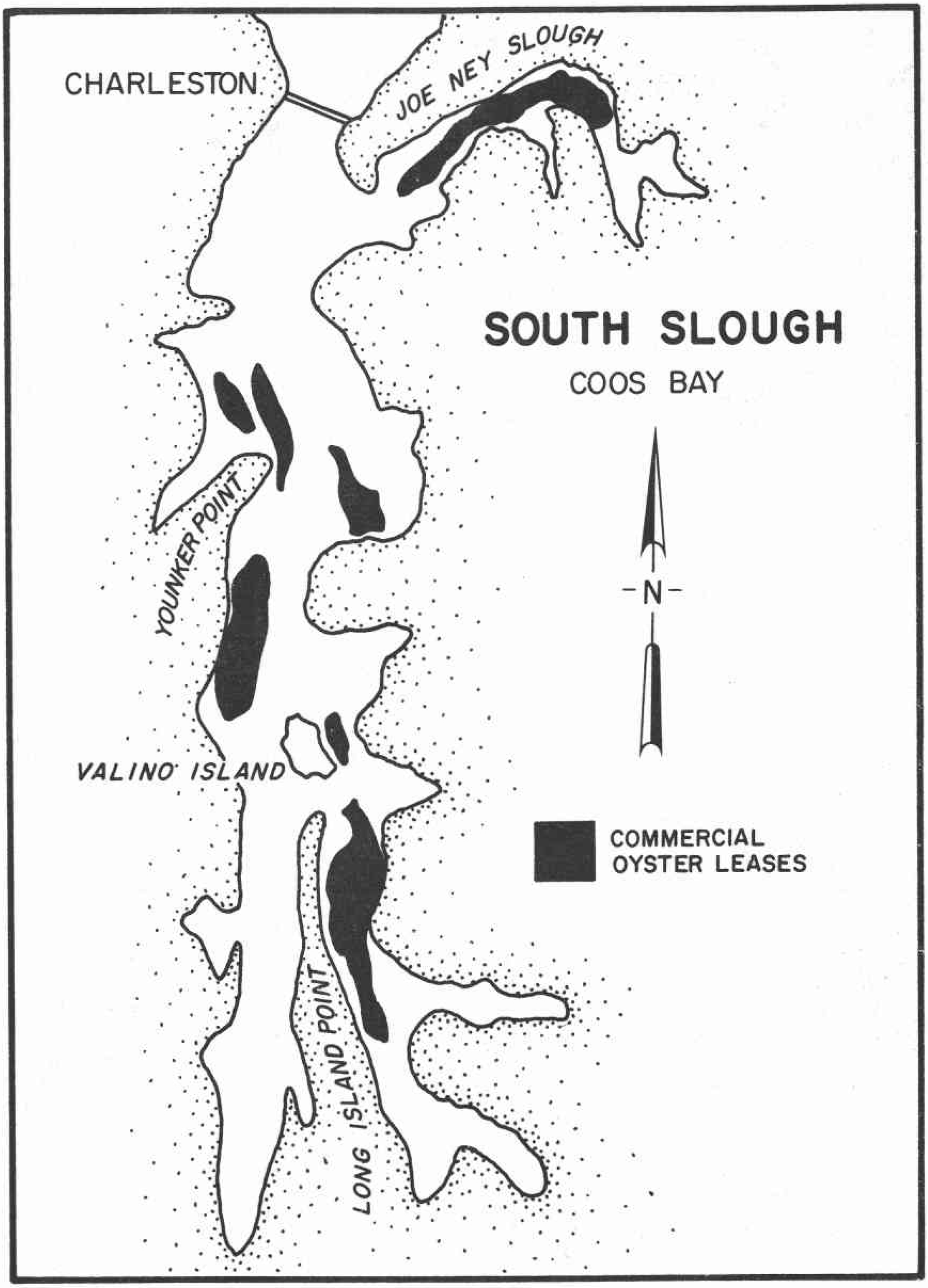


Fig. 16. Commercial oyster leases in Coos Bay (Jambor and Rilette 1977).

(Table 9), but documentation of the use of specific areas and habitats by fish species is lacking.

The greatest variety of species is found in the lower parts of the estuary (Cummings and Schwartz 1971), while the greatest numbers of fish, captured during the same sampling program, were taken near the mouth of the Joe Ney Slough and just west of Jordan Point (Hostick 1975). One might expect those species requiring high salinities to reach the upper most extent of their ranges in the bay during summer and those species requiring low salinities to extend further downbay during periods of high runoff.

The Coos system supports stocks of fall chinook salmon, coho salmon, steelhead, and searun cutthroat trout. Chum salmon are seen occasionally. Records show that a sizeable population of fall chinook salmon once inhabited the Coos system (Cleaver 1951). Gillnet catches declined from an average of 200,000 lb between 1923 and 1930 to 36,000 lb between 1930 and 1940. After the building of splash dams on the South Fork Coos River in 1941, the population declined substantially (personal communication, Al McGie, ODFW, January 17, 1979). Since removal of the dams in 1957, the population has recovered so that now approximately 5,000 chinook spawn in Coos River and its tributaries (personal communication, Bill Mullarkey, ODFW, April 14, 1979). Based on historic records, a spawning population of at least 12,000 chinook is possible when the recovery of spawning grounds and reaccumulation of spawning gravel is complete (personal communication, Mullarkey). Information on salmonids is summarized in Table 10.

In 1978 anglers caught 1,145 chinook and 24,000 coho salmon in the ocean sport fishery offshore from Coos Bay. In late summer chinook and coho are caught from the jetties. A boat fishery develops in late August in the upper bay and river and continues through the fall. In 1977, a year of drought, 604 salmon over 24 inches were caught in the Coos and Millicoma rivers, and Bender (pers. comm.) estimates another 600 jacks may have been caught. A cutthroat fishery of unknown catch also occurs in the river.

Three private hatcheries have obtained permits from ODFW for salmon release/ recapture operations (Table 11). ODFW has begun an evaluation of the private hatchery programs in Coos Bay to determine the periods and areas of residence and food habits of hatchery and wild salmonids.

Coos Bay also supports a large population of striped bass. Commercial fishing for bass has been closed in Coos Bay since 1975, but prior to the 60s, the striped bass fishery on the Coos was surpassed on the West Coast only by that of the Sacramento River in California (Hutchison 1962). Currently an active sport fishery occurs on a population of unknown size. Stripers are taken throughout the year at various places in the bay. Upriver migration of striped bass occurs in several runs from May until July. After spawning the fish move back into the bay to feed, seeking the deeper holes and channel. Although a few may go to the ocean, most of the fish probably stay in the bay all year (personal communication, Al McGie, ODFW, July 10, 1979). Young fish appear to stay upriver until the end of their first year of life.

Table 9. Distribution of fish species by subsystem (Cummings and Schwartz 1971; Hostick 1975, and Mullarkey and Bender 1979).

Species	Subsystem[a]								
	Marine (RM 0-3)	Lower Bay (RM 3-9)	Upper Bay (RM 9-17)	Riverine (RM 17-30)	South Slough	North Slough	Haynes Inlet	Isthmus Slough	Catching Slough
Leopard shark *(Triakis semifasciata)*	X								
Longnose lacetfish *(Alepisaurus richardsoni)*	X								
White seabass *(Cynoscion nobilis)*	X								
Pomfret *(Brama rayi)*	X								
Redtail surfperch *(Amphistichus rhodoferus)*	X								
Wolf-eel *(Anarrhichthys ocellatus)*	X								
Copper rockfish *(Sebastodes caurinus)*	X								
Rock greenling *(Hexagrammos superciliosus)*	X								
Tidepool sculpin *(Oligottus maculosus)*	X	X							
Mosshead sculpin *(Clinocottus globiceps)*	X								
Fluffy sculpin *(Oligottus snyderi)*	X								
Tubenose poacher *(Pallasina barbata)*	X								
Longnose skate *(Raja rhina)*	X	X							
Whitebait smelt *(Allosmerus elongatus)*	X	X							

Table 9. Continued.

Species	Subsystem[a]								
	Marine (RM 0-3)	Lower Bay (RM 3-9)	Upper Bay (RM 9-17)	Riverine (RM 17-30)	South Slough	North Slough	Haynes Inlet	Isthmus Slough	Catching Slough
Eulachon *(Thaleichthys pacificus)*	X	X							
Penpoint gunnel *(Apodichthys flaridus)*	X	X							
Pacific sandlance *(Ammodytes hexapteros)*	X	X							
Bocaccio *(Sebastodes paucispinis)*	X	X		X					
Cabezon *(Scorpaenichthys marmoratus)*	X	X		X					
Tubesnout *(Aulorhynchus flaudius)*	X	X		X					
Spiny dogfish *(Squalus acanthias)*	X	X	X						
White sturgeon *(Acipenser transmontanus)*	X	X	X						
Northern anchovy *(Engraulis mordax)*	X	X	X	XXF					
Longfin smelt *(Spirinchus dilatus)*	X	X	X						
Pacific tomcod *(Microqadus proximus)*	X	X	X						
Surf smelt *(Hypomesus pretiosus)*	X	X	X	F					
Striped seaperch *(Embiotoca lateralis)*	X	X	X	XX					
Walleye surfperch *(Hyperprosopon argenteum)*	X	X	X	XXF					
White seaperch *(Phanerodon furcatus)*	X	X	X	XX					

Table 9. Continued.

Species	Subsystem[a]								
	Marine (RM 0-3)	Lower Bay (RM 3-9)	Upper Bay (RM 9-17)	Riverine (RM 17-30)	South Slough	North Slough	Haynes Inlet	Isthmus Slough	Catching Slough
Pile Perch (*Rhacochilus vacca*)	X	X	X	XX					
High cockscomb (*Anoplarchus purpurescens*)	X	X	X						
Arrow goby (*Clevelandia ios*)	X	X	X						
Pacific pompano (*Palometa simillima*)	X	X	X						
Black rockfish (*Sebastodes melanops*)	X	X	X	XX					
Kelp greenline (*Hexagrammos decagrammus*)	X	X	X	XX					
Lingcod (*Ophiodon elongatus*)	X	X	X	XX					
Padded sculpin (*Artedius fenestralis*)	X	X	X						
Buffalo sculpin (*Enophys biason*)	X	X	X						
Sand sole (*Psettichthys melanostichus*)	X	X	X						
Pacific lamprey (*Lompetra tridentata*)	X	X	X	X					
Green sturgeon (*Acipenser medirostris*)	X	X	X	X					
American shad (*Alosa sapidissima*)	X	X	X	X	XF	X		X	XX
Pacific herring (*Clupea harengus pallasi*)	X	X	X	X	X			X	
Chum salmon (*Oncorhynchus keta*)	X	X	X	X					

Table 9. Continued.

Species	Subsystem[a]								
	Marine (RM 0-3)	Lower Bay (RM 3-9)	Upper Bay (RM 9-17)	Riverine (RM 17-30)	South Slough	North Slough	Haynes Inlet	Isthmus Slough	Catching Slough
Coho salmon *(Oncorhynchus kisutch)*	X	X	X	X	F				
Chinook salmon *(Oncorhynchus tsawytcha)*	X	X	X	XF	XF				
Cutthroat trout *(Salmo clarki)*	X	X	X	XF					
Rainbow trout *(Salmo gairdneri)*	X	X	X	X					
Topsmelt *(Atherinops affinis)*	X	X	X	X	XX		X	XX	
Bay pipefish *(Syngnathus griseolineatus)*	X	X	X	X	X		X		
Striped bass *(Roccus saxatilis)*	X	X	X	X					
Shiner perch *(Cymatogaster aggregata)*	X	X	X	XE	XXE	X	X	XX	X
Silver surfperch *(Hyperprosopon ellipticum)*	X	X	X	XE	XXF			XX	
Snake prickleback *(Lumpenus sagitta)*	X	X	X	X	XX			X	
Saddleback gunnel *(Pholis ornata)*	X	X	X	X					
Pacific staghorn sculpin *(Leptoccotus armatus)*	X	X	X	XF	XXF	X	X	XX	XX
Speckled sanddab *(Citharichthys stigmaeus)*	X	X	X	X	XX				
English sole *(Parophrys retulus)*	X	X	X	X	XX				
Starry flounder *(Platichthys stellatus)*	X	X	X	XF	XF	X	X	X	XX

Table 9. Continued.

Species	Subsystem[a]								
	Marine (RM 0-3)	Lower Bay (RM 3-9)	Upper Bay (RM 9-17)	Riverine (RM 17-30)	South Slough	North Slough	Haynes Inlet	Isthmus Slough	Catching Slough
Bay goby *(Lepidogobius lepidus)*		X	X						
Threespine stickleback *(Gasterosteus aculeatys)*		X	X	XF			X	XX	XX
Prickly sculpin *(Cottus asper)*		X	X	X					
Redside shiner *(Richardsonius balteatus)*				X	F				
Speckled dace *(Rhinichthys osculus)*				X					
Largescale sucker *(Catostomus machrochelius)*				X					

[a] *Pony Slough not included in sources used.*
X= species present according to summer sampling by Cummings and Schwartz (1971).
F= species present in ODFW 1977 seine samples. Applies only to South Slough and Riverine because data from other areas was combined by authors.

Table 10. Salmonid use of Coos Bay (Thompson etal 1972; Bender and Mullarkey 1979).

Species	Estimated population	Time of spawning migration	Spawning peak	Juvenile use of estuary	State releases
Fall chinook salmon	5,000	Sept.-Jan.	Nov.	Feb.-Oct.	--
Coho salmon	8,300	Oct.-Feb.	Dec.	Mar.-Jun.	--
Chum salmon	incidental				
Steelhead	5,000	Nov.-Apr.	Jan.-Mar.	Mar.-Jun.	100,000
Cutthroat trout	3,500	Aug.-Jan.	unknwon	entire yr.	10,000

Table 11. Private hatchery permits for Coos Bay (Cummings 1977).

Hatchery	Total permit	Permits by species		
		Chinook	Coho	Chum
Weyerhaeuser	40,000,000	10,000,000	10,000,000	20,000,000
Anadromous	10,000,000	5,000,000	5,000,000	
Calvin Heckard				5,000,000

Shad are fished commercially in Coos Bay from April 20 to June 21. A five-year (1973-77) average of 19,310 lbs of shad was taken from Coos Bay. Sport fishermen take shad from the South Coos River and Millicoma River from mid April through June by trolling from boats.

Shad tagged in the Coos River have been recovered from the Umpqua and Coquille rivers, but evidence suggests each of these rivers supports its own population of shad (Mullen 1974). Mullen (1974) estimated from tagging studies a population of over 50,762 shad in the Coos River system. However, shad too small to be caught in the gillnets were not included in the estimate.

Shad enter the bay from the ocean in the spring months and start to appear in the commercial gill net fishery when it opens in April. Spawning usually occurs in May and June in upper tidal areas of the Coos and Millicoma rivers. Juvenile shad rear in the Coos and Millicoma rivers throughout the summer. Shad begin to appear in seine hauls in lower Coos Bay during August (pers. comm., Bender). Most of the juveniles enter the ocean in the fall.

In 1978 a conservative estimate of 145 tons of herring spawned in Coos Bay between 0.6 and 13.7 miles from the mouth (Miller and McRae 1978). Spawning occurs from January through April, and herring remain in the bay through summer (pers. comm., Bender). Three areas heavily used during the 1978 spawn were Fossil Point (eelgrass, algae, rocks), lower North Spit (eelgrass), and the Ford Dock near Jordan Cove (pilings) (Miller and McRae 1978). Jackson (1979) observed heavy spawns on lower North Spit, south of Clam Island in 1979. It is possible that timing of the herring spawn is influenced by freshwater runoff so that spawning occurs farther downbay during high runoff periods (Miller and McRae 1978).

Shiner perch, redtail surfperch, striped seaperch, black rockfish, and kelp greenling are among the other fish inhabiting the bay in large numbers which are taken by sport anglers (Gaumer et al. 1973).

Distribution maps for major species have been prepared by the Coos County Planning Department.

Mammals

Resident marine mammals in the estuary are limited to the harbor seal (*Phoca vitulina*) and the harbor porpoise (*Phocoena phocoena*) (personal communication, Mike Graybill, OIMB, March 15, 1979). Approximately 120 harbor seals haul out in the Pigen Point area of Coos Bay. They use the bay for feeding, primarily on bait fish such as herring and eulachon, and have been sighted in both the upper and lower bay. There is evidence that lower North Spit serves as a pupping area (pers. comm., Graybill). Harbor porpoises live in the lower estuary where they are seen frequently from RM 1 to 3.

Non-resident marine mammals occasionally sighted in the bay include California sea lions (*Zalophus californianus*), Stellar sea lions (*Eumetopias jubata*), and rarely California gray whales (*Eschrichtius gibbosu*) and killer whales (*Orciniis orca*).

River otters are common in the Coos and Millicoma rivers (pers. comm., Bender) and have been seen in the Crawford Point area (pers. comm., Graybill) and in South Slough (Magwire 1976a). The population size is unknown.

A variety of mammals are found in Coos Bay salt marshes. Raccoon, bobcat, muskrat, mink, weasel, fox, coyote, black-tailed deer (Magwire 1976a), and striped skunk (Pinto 1972) are found in the salt marshes, and beaver are found in areas of inflowing fresh water (Magwire 1976a). The marsh is only part of the range of animals, and their abundance depends primarily on how remote and undisturbed the community is (Magwire 1976a).

The major small mammals of the marshes are vagrant shrews and deer mice. The deer mouse is most abundant in the high marsh and tends to remain close to the terrestrial environment, while the shrew uses lower marshes and is often near logs or debris. Other species of mice, shrews, voles, and the black rat use the marshes in lesser numbers. These small mammals serve as primary and secondary consumers in the terrestrial food chain (Magwire 1976a).

Birds

Although a thorough study of the use of the estuary by bird populations has not been published, observations by individuals and groups provide information on seasonal use and abundance of bird species at Coos Bay. USACE (1975) abstracted a list of birds using the bay from information published by U.S. Department of the Interior (1971). Magwire (1976a) has summarized observations by Wampole (1959), Fawver and Wampole (1971), McGie (1976), and Richer (1976). Table 12 presents a compilation of this information. In addition, a census of birds of the greater Coos Bay area is made each December by the local chapter of the National Audubon Society.

Table 12. Bird use of Coos Bay estuary (key on p. 46).

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Habitats: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Coos Head W	Coos Head S	Fossil Point to Pigeon Point W	Fossil Point to Pigeon Point S	Empire W	Empire S	Pony Slough W	Pony Slough S	Haynes Inlet W	Haynes Inlet S	Metcalf *Salicornia* Marsh W	Metcalf *Salicornia* Marsh S
Arctic loon (*Gavia arctica*)	FWSp			U				O	U	C	U	U						C	
Red-throated loon (*G. stellata*)	FWSP			U				O	O			O				O	O	O	
Red-necked grebe (*Podiceps grisegena*)	FWSp			U						O		C		O					
Brown pelican (*Pelecanus occidentalis*)	F			U				O	O										
Brandt's cormorant (*Phalacrocorax penicillatus*)	Res			C															
Pelagic cormorant (*P. pelagicus*)	Res			C				A	A	O	O	O				O	O		
Black brant (*Branta nigricans*)	Sp			A[1]	A[1]			O		A	A	R				A		U	
Harlequin duck (*Histrionicus histrionicus*)	FWSp			R		R		O	R					R		R			
Oldsquaw (*Clangula hyemalis*)	W			R				O	R										
Common scoter (*Oidemia nigra*)	W			U								R							
Surf scoter (*Melanitta perspicillata*)	FWSp			A				A	U	A	C	A	A	U	U			A	A
Red-breasted merganser (*Mergus serrator*)	FWSp			U				O	O	U		C	U	U		U			
Surfbird (*Aphriza virgata*)	FWSp					C		C	O										
Ruddy turnstone (*Arenaria interpres*)	M					U							R						

Table 12 continued.

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Habitats: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Coos Head W	Coos Head S	Fossil Point to Pigeon Point W	Fossil Point to Pigeon Point S	Empire W	Empire S	Pony Slough W	Pony Slough S	Haynes Inlet W	Haynes Inlet S	Metcalf *Salicornia* Marsh W	Metcalf *Salicornia* Marsh S
Red phalarope *(Phalaropus fulicarius)*	M			R															
Northern phalarope *(Lobipes lobatus)*	M			C										R					
Glaucous-winged gull *(Larus glaucescens)*	FWSp			C								C				0			
Herring gull *(L. argentatus)*	FW			U				0				A	A	C					
California gull *(L.californicus)*	FW			U										R					
Mew gull *(L. canus)*	FWSp			C				C	U			C	0	C	0				
Heerman's gull *(L. heermanni*	SF			C				0	U								0		
Bonaparte's gull *(L. philadephia)*	M			C				C	U				0		0		0		
Blacklegged kittiwake *(Rissa tridactyla)*	FWSp			R				0	0										
Caspian tern *(Hydroprogne caspia)*	M			U					R						R				
Common Murre *(Uria aalge)*	Res			A				U	A			0	U		U				
Marbled Murrelet *(Brachyramphus marmoratum)*	Res			R						C		C		C		U		C	C
Horned grebe *(Podiceps auritus)*	FWSp	FWSp		C															
American wigeon *(Mareca americana)*	W	W		A	A		A							A		A			

Table 12 continued.

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Subsystems: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Coos Head W	Coos Head S	Fossil Point to Pigeon Point W	Fossil Point to Pigeon Point S	Empire W	Empire S	Pony Slough W	Pony Slough S	Haynes Inlet W	Haynes Inlet S	Metcalf *Salicornia* Marsh W	Metcalf *Salicornia* Marsh S
Black-bellied plover *(Squatarola squatarola)*	FWSp	FWSp			C		C	R						C	U			R	
Semi-palamated plover *(Charadrius semipalmatus)*	M	M			C							U		U	U				
Snowy plover *(C. alexandrinus)*	Res	Res			R														
Whimbrel *(Numenius phaeopus)*	F	F			U														
Spotted sandpiper *(Actitus macularia)*	F	F				U			O						U				
Dunlin *(Erolia alpina)*	WSp	WSp			A			O	O	C	O	C	C	A	A			O	O
Sanderling *(Crocethia alba)*	FWSp	FWSp			C							C	C	O					
Baird's sandpiper *(Erolia bairdii)*	F			F	R														
Western sandpiper *(Ereunetes mauri)*	FWSp	FWSp			A														
Least sandpiper *(Erolia minutilla)*	FWSp	FWSp			A														
Willet *(Catoptrophorus semipalmatus)*	M	M			U		U												
Western gull *(Larus occidentalis)*	Res	Res		A						C		C		U		C	U	C	C
Common tern *(Sterna hirundo)*	M	M		U					R						R				
Pigeon guillemot *(Cepphus columba)*	S	S		C				U	A		U		U		U				C

Table 12 continued.

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Subsystems: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Coos Head W	Coos Head S	Fossil Point to Pigeon Point W	Fossil Point to Pigeon Point S	Empire W	Empire S	Pony Slough W	Pony Slough S	Haynes Inlet W	Haynes Inlet S	Metcalf *Salicornia* Marsh W	Metcalf *Salicornia* Marsh S
Common loon (*Gavia immer*)	FWSp	FWSp	FWSp	C				A	C	C	O	C	O	C	O	C	O	C	
Pied-billed grebe (*Podiceps dominicus*)	W	W	W	R				O	R					O		O	O	U	
Western grebe (*Aechmophorus occidentalis*)	FWSp	FWSp	FWSp	C															
Double-crested cormorant (*Phalacrocorax auritus*)	FWSp	FWSp	FWSp	C				C	U	A		U		C		O	O	U	
Common goldeneye (*Bucephala clangula*)	W	W	W	C			U	O				U		R		U		R	
Bufflehead (*B. albeola*)	W	W	W	C				O		C		U		C		C		C	
Marsh hawk (*Circus cyaneus*)	Res	Res	Res				U		O					O					
Bald eagle (*Haliaeetus leucocephalus*)	Res	Res	Res				R	R	R							R			
Red-tailed hawk (*Buteo jamaicensis*)	FWSp	FWSp	FWSp				U												
Great Blue heron (*Ardea herodias*)	Res	Res	Res		U		C	U	U	U	U	U		C	C	C	C	C	C
Green heron (*Butorides virescens*)	Res	Res	Res		U		U								O				
American coot (*Fulica americana*)	FWSp	FWSp	FWSp	A			A	U	O	C	C	C	C	A		A		O	
Killdeer (*Charadrius vociferus*)	Res	Res	Res		C			U	U	U		C	C	C	C	U			
Belted kingfisher (*Megaceryle alcyon*)	Res	Res	Res	C								U	U	C	C			C	C

Table 12 continued.

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Habitats: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Subsystems or Specific Areas: Coos Head		Fossil Point to Pigeon Point		Empire		Pony Slough		Haynes Inlet		Metcalf *Salicornia* Marsh	
								W	S	W	S	W	S	W	S	W	S	W	S
Whistling swan *(Olor columbianus)*		W					R							R					
Canada goose *(Branta canadensis)*		M					R	O											
Pintail *(Anas acuta)*		FW		A										A	C	A			
Gadwall *(A. strepera)*		FW					U							A					
Shoveler *(Spatula clypeata)*		FW		U	U									C					
Green-winged teal *(Anas carolinensis)*		FW		C	C									A	C	A	O		
Redhead *(Aythya americana)*		W		C										O					
Canvasback *(A. valisineria)*		W		C										A		C			
Blue-winged teal *(Anas discors)*		M		R															
Snowy egret *(Leucophoyx thula)*		W					R							R					
Virginia rail *(Rallus limicola)*		SpSF					U												
Long-billed curlew *(Numenius americanus)*		M			R		R							U					
Marbled godwit *(Limosa fedoa)*		FW			U									O					
Greater yellowlegs *(Totanus melanoleucus)*		FWSp			U									C	O				

Table 12 continued.

Species	Subsystems: Marine & Lower Bay	Subsystems: Upper Bay	Subsystems: Riverine	Subsystems: Channel	Habitats: Unconsolidated Shores & Flats	Habitats: Rocky Shores	Habitats: Tidal Marsh	Coos Head W	Coos Head S	Fossil Point to Pigeon Point W	Fossil Point to Pigeon Point S	Empire W	Empire S	Pony Slough W	Pony Slough S	Haynes Inlet W	Haynes Inlet S	Metcalf *Salicornia* Marsh W	Metcalf *Salicornia* Marsh S
Lesser Yellowlegs (*Totanus flavipes*)		M(F)			R														
Short-billed dowitcher (*Limnodromus griseus*)		M			U									C	C		O		
Long-billed dowitcher (*L. scolopaceus*)		M(F)			R														
Pectoral Sandpiper (*Erolia melanotos*)		M(F)					R							R					
Knot (*Calidris canutus*)		M			U		U												
American bittern (*Botaurus lentiginosus*)		Res	Res				R												
Common egret (*Casmerodius albus*)		FWSp	FWSp				C							U					
Black-crowned night heron (*Nycticorax nycticorax*)		FWSp	FWSp		U														
Sora rail (*Porzana carolina*)		SpS	SpS				R												
Common snipe (*Capella gallinago*)		Res	Res		U		U							U					
Ring-billed gull (*Larus delawarensis*)		FWSp (Res)	FWSp (Res)		C							C	C	C	C	U	U		
Mallard (*Anas platrhynchos*)			FW	A	C		C							A	C	A			
Ring-necked duck (*Aythya collaris*)			W	R										R					
Common merganser (*Mergus merganser*)			Res	U												R			

Table 12 continued.

Species	Marine & Lower Bay	Upper Bay	Riverine	Channel	Unconsolidated Shores & Flats	Rocky Shores	Tidal Marsh	Coos Head		Fossil Point to Pigeon Point		Empire		Pony Slough		Haynes Inlet		Metcalf *Salicornia* Marsh	
	Subsystems			Habitats				Subsystems or Specific Areas											
								W	S	W	S	W	S	W	S	W	S	W	S

Key (Subsystems and Habitats):

Seasonal Use:

- F Fall
- W Winter
- Sp Spring
- S Summer
- M Migrant
- Res Resident
- (Res) Some residents

Abundance:

- A = Abundant $\geq$ 50/day/observer
- C = Common 10-49/day/observer
- U = Uncommon 0-9/day/observer
- R = Rare $\leq$ 5/day/observer (includes very rarely sighted species)

Key (Subsystems or Specific Areas):

Seasonal Use:

- W = Oct. - Mar.
- S = Apr. - Sept.

Abundance:

- A = Abundant $\geq$ 50/day/observer
- C = Common 1-50/day/observer
- U = Uncommon Not seen each day
- O = Occasional
- R = Rare Not seen every year

[1] *Eelgrass beds*

Table 12 continued.

Species noted by Magwire 1976 but not by USACE 1975	C H		F P Pt, Pt		Emp		P Sl		H I		MM	
	W	S	W	S	W	S	W	S	W	S	W	S
Yellow-billed loon *(Garia adamsii)*		R										
Eared grebe *(Podiceps caspicus)*		O	C		O		O	O	C	O	C	
Emperor goose *(Anser albifrons)*											R	
White-fronted goose *(Philacte canagica)*							R					
European wigeon *(Mareca penelope)*							R					
Hooded merganser *(Lophodytes cucullatus)*									R			
Turkey vulture *(Cathartes aura)*	O	U						O				
Osprey *(Pandron haliaetus)*		O						O	O			
Black oystercatcher *(Haematopus bachmani)*	U	O										
Wandering tattler *(Heteroscelus incanun)*	U	O										
Rock sandpiper *(Erolia ptilocnemis)*		O										
Forster's tern *(Sterna forsteri)*		R										
Common crow *(Corvus brachyrhychos)*					C	C	C	C	C	C	C	C

Coos Bay is located in the Pacific Flyway for migratory waterfowl. USDI (1971) lists marshes, tideflats, and open water as prime bird habitats with some birds relying entirely on one habitat type and others using a variety of habitats.

Ducks, geese, loons, gulls, murres, and terns use the open water for resting but are commonly found near food sources in shallow water (USDI 1971). Thompson, Smith, and Lauman (1972) state mallard, pintail, wigeon, and coot are the most abundant waterfowl of the area. Surf and white-winged scoters are also found in large numbers. Waterfowl are abundant in November through March with peak populations occurring in December. USDI (1971) states that Coos Bay has 575,000 waterfowl-use days annually and 1,350 hunter-use days. The protected Pony Slough and Haynes Inlet areas receive particularly heavy use by waterfowl.

COOS ESTUARINE SUBSYSTEMS

The Coos Bay estuary can be divided into marine, bay, riverine and slough subsystems based on sediments, habitats, and geographic location (Fig. 17). Physical and biological characteristics of each subsystem are a result of the relative influence of ocean water, river water, and currents. Although the subsystems do not function independently, a separate discussion of each of the subsystems is used in considering management options.

Marine Subsystem

The marine subsystem is defined as the area between the mouth of the Coos Bay estuary and RM 2.5 (Fig. 17). The vigorous wave action it experiences helps to create and maintain the unique habitats found in this subsystem.

Alterations to the marine subsystem have been numerous. The natural channel across the Coos Bay bar averaged 10 ft in depth and 200 ft in width. The first alteration was a half-tide jetty just upbay from Fossil Pt. constructed in 1880 (USACE 1973). The North Jetty was constructed in the 1890s and reconstructed in the late 1920s, when the South Jetty was built (Lizarraga-Arciniega and Komer 1975). The entrance channel has recently been dredged to 45 ft deep and 700 ft wide at the outer bar and gradually decreases to 35 ft deep and 300 ft wide at RM 1. Previously, the depth was maintained at 40 ft over the entrance bar and 30 ft at RM 1 (USACE 1975).

The entrance channel is exposed to high waves generated by local coastal storms and swells from Pacific Ocean storms (USACE 1973). Waves up to 27 ft occur during major storms (USACE 1973). Mean tidal range at the bar is 6.7 ft with predicted extremes of 10.5 ft above MLLW and 3 ft below MLLW.

During 1973-74, high tide salinities at the mouth ranged from 30.5 ppt at the surface in December to 33.9 ppt at both surface and bottom in June (Arneson 1976). Even during periods of high runoff, high tide salinity at the mouth is similar to that of the ocean. Low tide extremes of 13.0 ppt at the surface in December and 3.33 ppt in September demonstrate the dilution effect of high runoff (Arneson 1976). Vertical salinity profiles from 1973-74 show the mouth was well mixed in June and September, stratified at high tide and partially

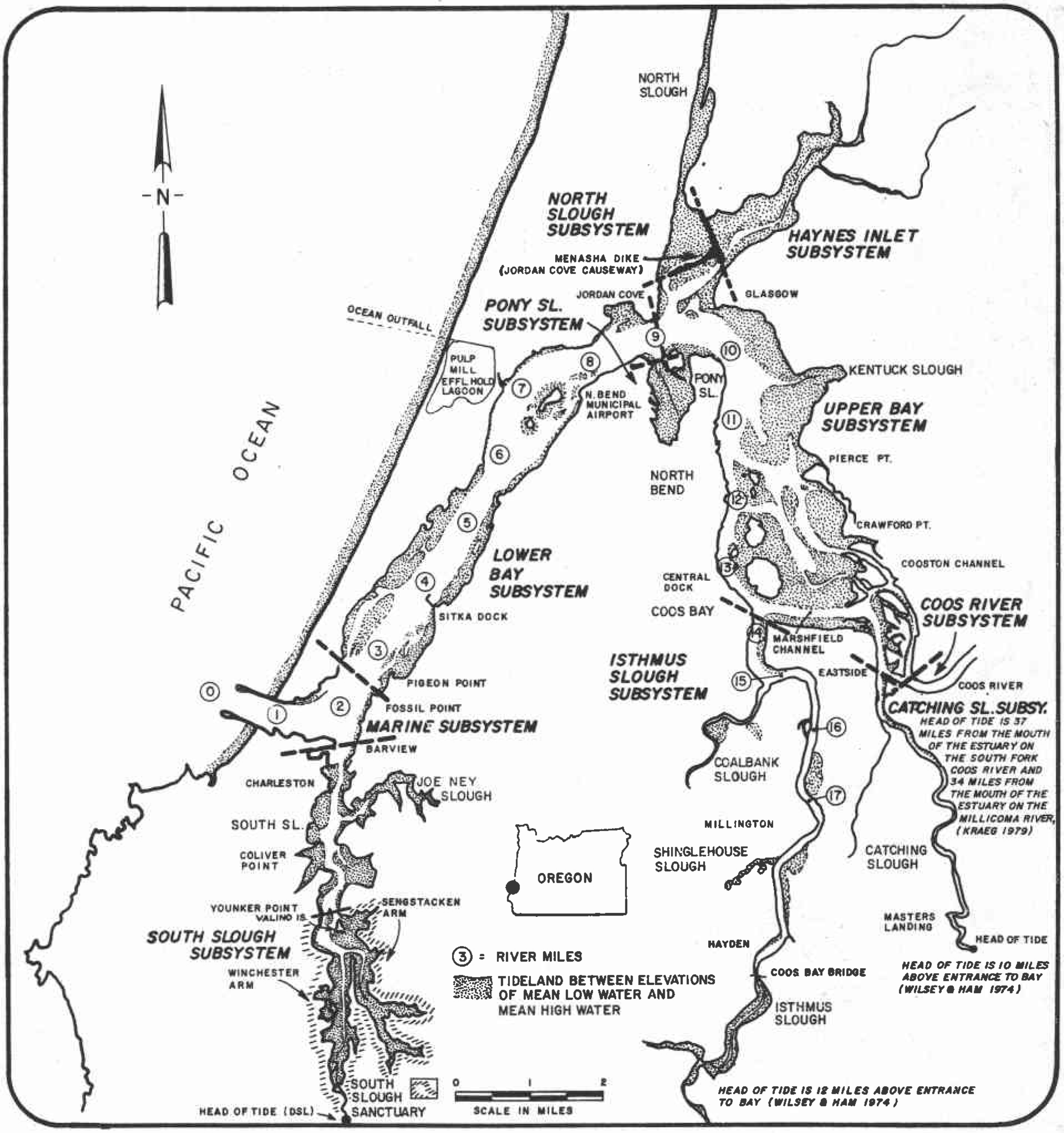


Fig. 17. Coos Bay estuarine subsystems.

mixed at low tide in December, and well mixed at high tide and partially mixed at low tide in March (Arneson 1976).

In general, the water quality of the marine subsystem is good. Temperature generally is similar at high tide to that of offshore waters and may be somewhat influenced by the temperature of the inflowing river waters at low tide (Arneson 1976). Low dissolved oxygen has occasionally been measured by DEQ near the mouth, and a DO depression was also observed by Arneson (1976) during his fall low tide measurements. Waste water from seafood processing which is discharged subtidally into the marine subsystems and upwelling of offshore waters low in dissolved oxygen may be contributing factors to low DO near the mouth (Arneson 1976).

Dredging records show that most of the materials removed from the entrance are clean sands, probably of marine origin (USACE 1975). Dredged material from this area is normally disposed at sea. Spoil from the Charleston area to about RM 10 is disposed in the estuary. The shorelines to the north and south of the entrance advanced following construction of the jetties, probably as an adjustment to a new equilibrium in an area that is experiencing no net north-south sand transport along the beaches (Lizarraga-Arciniega and Komar 1975).

Habitats and species

The marine subsystem has an exceptional diversity of habitats, including sand, cobble, boulder, and bedrock shores; sand and sand-mud flats; algal beds on unconsolidated bottoms and on bedrock; eelgrass; and subtidal unconsolidated bottom (Fig. 18).

Habitats of the north shore of the marine subsystem include the artificial boulder shores of the jetty, a narrow cobble shore, sandy shores and flats, and a flat of sand-mud substrate (Fig. 18). Little is known of the biology of this area. Seining studies have shown large numbers of Pacific herring, surfsmelt, whitebait smelt, shiner perch, and silver surfperch in the area (Hostick 1975). Feeder coho salmon have been found using the sandy area just inside the jetty. This area is just below a very productive portion of the lower bay subsystem and the salmon may be feeding on material carried in the water column as it ebbs from the productive flats (personal communication, Bill Mullarkey, ODFW, May 15, 1979).

The south shore habitats of the marine subsystem include jetty boulders, bedrock shores below the cliffs of Coos Head, small sandy shores, the boulders of the Charleston breakwater, and a transient sand bar west of the Charleston channel (Fig. 18).

The area north of the Charleston breakwater is inhabited primarily by a few species of molluscs and annelids. The sand bar west of the Charleston channel contains the only in-bay population of razor clams on the southern Oregon coast. This clam bed is heavily used by recreational diggers (USACE 1978). USACE has proposed an extension of the Charleston breakwater near the sand spit to stabilize the Charleston channel. The Corps Environmental Impact Statement for this project (USACE 1978) states the clam population will survive the planned modification.

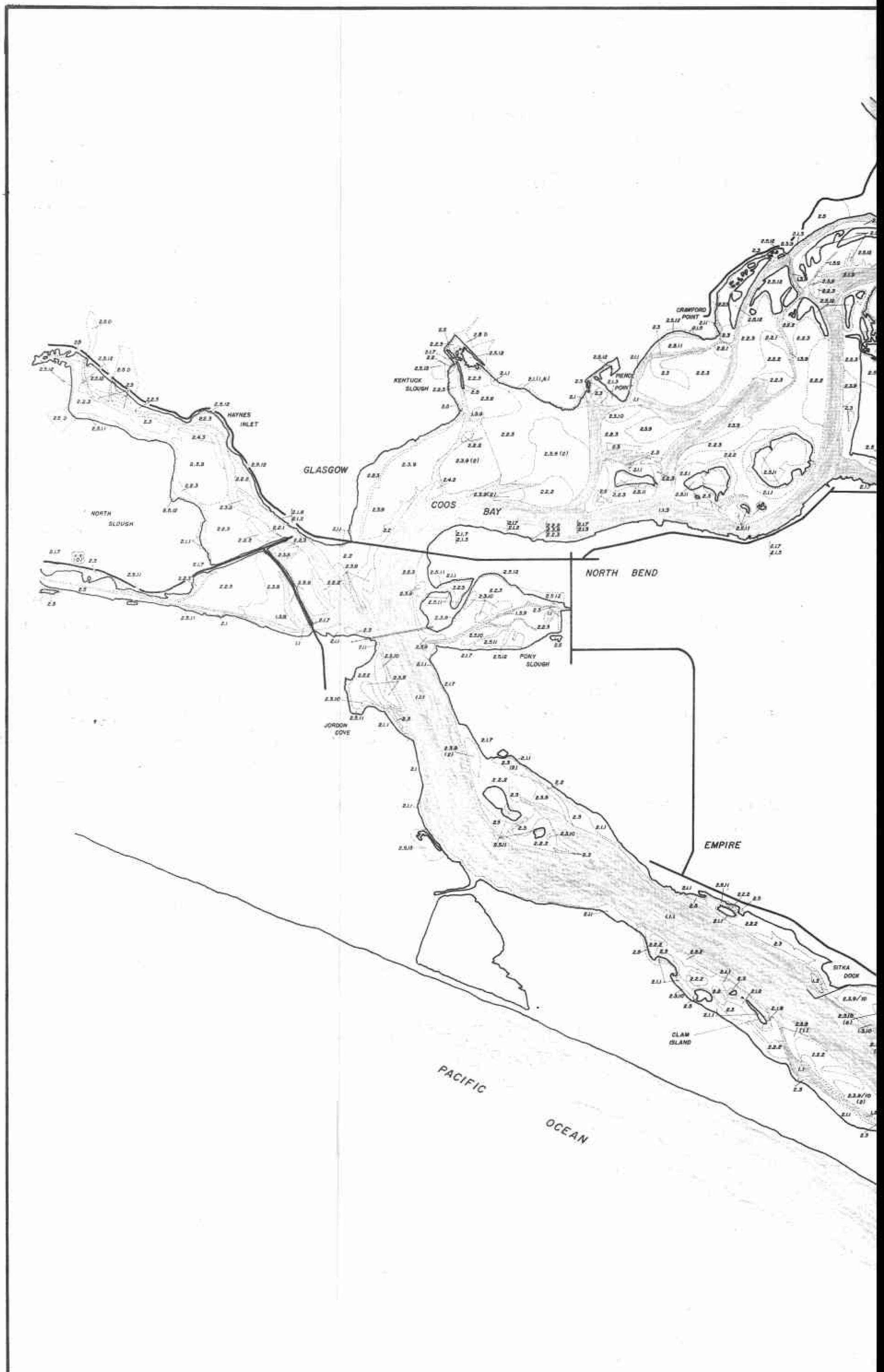
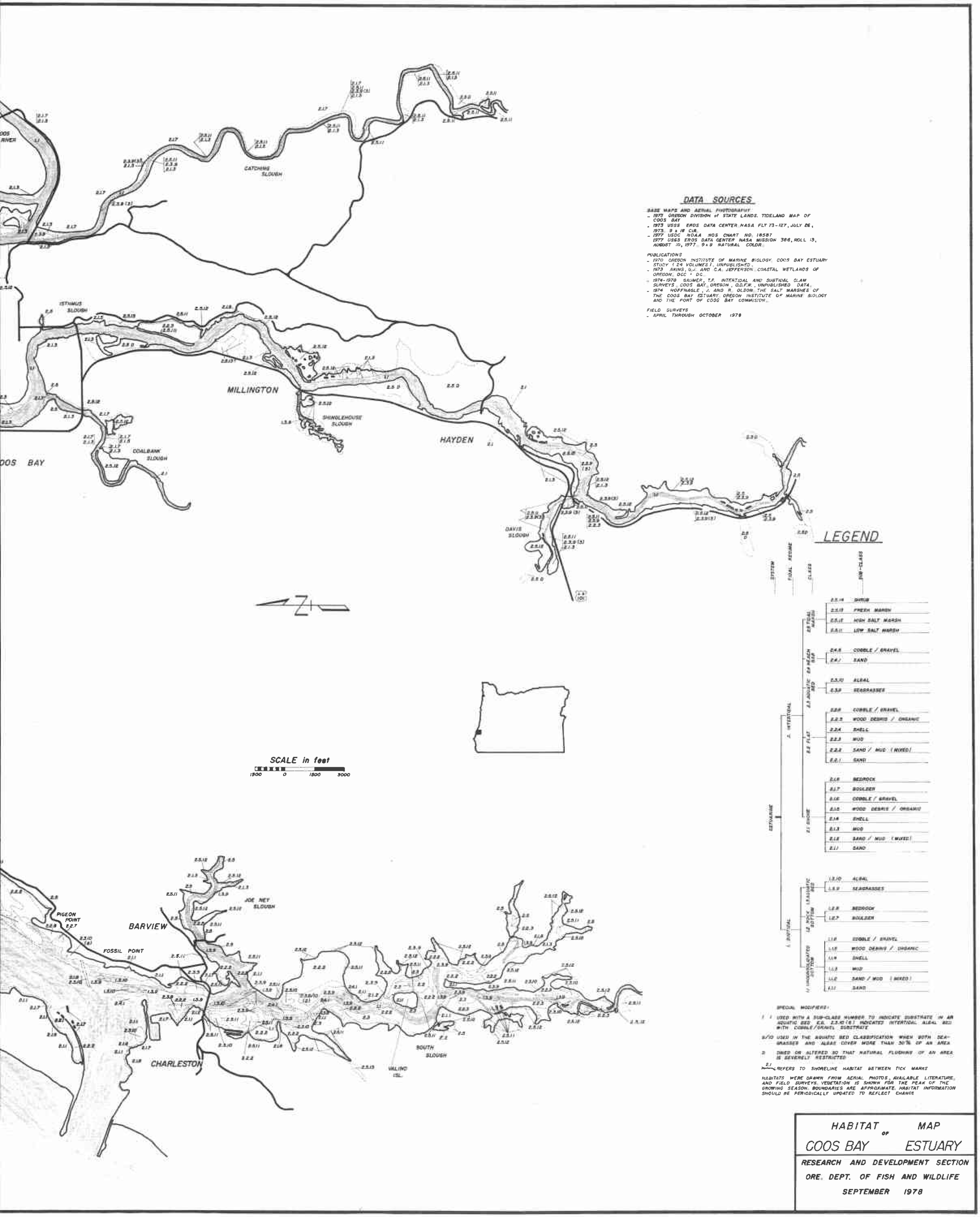


Fig. 18. Habitat map of Coos Bay.


DATA SOURCES
BASE MAPS AND AERIAL PHOTOGRAPHY
- 1975 OREGON DIVISION of STATE LANDS. TIDELAND MAP OF COOS BAY
- 1973 USGS EROS DATA CENTER NASA FLT 73-127, JULY 26, 1973. 9 x 18 CIR.
- 1977 USDC NOAA NOS CHART NO. 18587
1977 USGS EROS DATA CENTER NASA MISSION 366, ROLL 13, AUGUST 10, 1977. 9 x 9 NATURAL COLOR.
PUBLICATIONS
- 1970 OREGON INSTITUTE OF MARINE BIOLOGY. COOS BAY ESTUARY STUDY (24 VOLUMES), UNPUBLISHED.
- 1973 AKINS, G.J. AND C.A. JEFFERSON. COASTAL WETLANDS OF OREGON. OCC + DC.
- 1974-1978 GAUMER, T.F. INTERTIDAL AND SUBTIDAL CLAM SURVEYS, COOS BAY, OREGON, O.D.F.W., UNPUBLISHED DATA.
- 1974 HOFFNAGLE, J. AND R. OLSON. THE SALT MARSHES OF THE COOS BAY ESTUARY. OREGON INSTITUTE OF MARINE BIOLOGY AND THE PORT OF COOS BAY COMMISION.
FIELD SURVEYS
- APRIL THROUGH OCTOBER 1978
CATCHING SLOUGH
ISTHMUS SLOUGH
MILLINGTON
SHINGLEHOUSE SLOUGH
HAYDEN
COALBANK SLOUGH
DAVIS SLOUGH
COOS BAY
SCALE in feet
1500 0 1500 3000
LEGEND
SYSTEM
TIDAL REGIME
CLASS
SUB-CLASS
2.5.14 SHRUB
2.5.13 FRESH MARSH
2.5.12 HIGH SALT MARSH
2.5.11 LOW SALT MARSH
2.4.6 COBBLE / GRAVEL
2.4.1 SAND
2.3.10 ALGAL
2.3.9 SEAGRASSES
2.2.6 COBBLE / GRAVEL
2.2.5 WOOD DEBRIS / ORGANIC
2.2.4 SHELL
2.2.3 MUD
2.2.2 SAND / MUD (MIXED)
2.2.1 SAND
2.1.8 BEDROCK
2.1.7 BOULDER
2.1.6 COBBLE / GRAVEL
2.1.5 WOOD DEBRIS / ORGANIC
2.1.4 SHELL
2.1.3 MUD
2.1.2 SAND / MUD (MIXED)
2.1.1 SAND
1.3.10 ALGAL
1.3.9 SEAGRASSES
1.2.8 BEDROCK
1.2.7 BOULDER
1.1.6 COBBLE / GRAVEL
1.1.5 WOOD DEBRIS / ORGANIC
1.1.4 SHELL
1.1.3 MUD
1.1.2 SAND / MUD (MIXED)
1.1.1 SAND
ESTUARINE
2. INTERTIDAL
1. SUBTIDAL
2.5 TIDAL MARSH
2.4 BEACH BAR
2.3 AQUATIC BED
2.2 FLAT
2.1 SHORE
1.3 AQUATIC BED
1.2 ROCK BOTTOM
1.1 UNCONSOLIDATED BOTTOM
PIGEON POINT
BARVIEW
FOSSIL POINT
JOE NEY SLOUGH
CHARLESTON
SOUTH SLOUGH
VALINO ISL.
SPECIAL MODIFIERS:
( ) USED WITH A SUB-CLASS NUMBER TO INDICATE SUBSTRATE IN AN AQUATIC BED. E.G. 2.3.10 (6) INDICATES INTERTIDAL ALGAL BED WITH COBBLE/GRAVEL SUBSTRATE
9/10 USED IN THE AQUATIC BED CLASSIFICATION WHEN BOTH SEAGRASSES AND ALGAE COVER MORE THAN 50% OF AN AREA
D DIKED OR ALTERED SO THAT NATURAL FLUSHING OF AN AREA IS SEVERELY RESTRICTED
2.1 REFERS TO SHORELINE HABITAT BETWEEN TICK MARKS
HABITATS WERE DRAWN FROM AERIAL PHOTOS, AVAILABLE LITERATURE, AND FIELD SURVEYS. VEGETATION IS SHOWN FOR THE PEAK OF THE GROWING SEASON. BOUNDARIES ARE APPROXIMATE. HABITAT INFORMATION SHOULD BE PERIODICALLY UPDATED TO REFLECT CHANGE
HABITAT OF MAP
COOS BAY ESTUARY
RESEARCH AND DEVELOPMENT SECTION
ORE. DEPT. OF FISH AND WILDLIFE
SEPTEMBER 1978

The eastern shore of the marine subsystems has the largest naturally occurring rock habitat in the estuary. This high salinity, protected bedrock is unique to the Coos Bay marine subsystem and is rare in other Oregon estuaries. Over 40 species of plants and 100 species of animals inhabit this area in a community that resembles typical protected outer coast algal and invertebrate communities (Rosenkeetter et al. 1970). Green, brown, and red algae are well represented in the flora of Fossil Pt. (Sanborn and Doty 1944). Sponges, sea anemones, hydroids, and ribbon worms are found in this area (USACE 1975). Certain groups of annelids (sabellids, serpulids, syllids, and phyllodocids), grazing gastropods, carnivorous snails, and nudibranchs are also common.

Small kelp (*Nereocystis leutkeana*) beds occur in the tidal area just north of Coos Head, north of Charleston breakwater, and southward of Fossil Pt.

During the summer sampling, certain fishes were found only in the marine subsystem (Table 9) (Hostick 1975). These fish are commonly associated with open coastal waters. The apparent restriction of these species to the marine subsystem may be due to physiological tolerances or preference for rocky habitat. Almost all other species recorded in the estuary occur in the marine subsystem at some time during the year as residents or migrants (Cummings and Schwartz 1971).

A substantial percentage of the 1978 Pacific herring spawn in Coos Bay occurred on the rocks, algae, and eelgrass of the Fossil Pt. area (Miller and McRae 1978).

The South Jetty is a popular area for sport angling and offers the most varied species to shore fishermen (Gaumer et al. 1973). Redtail surfperch, striped seaperch, Pacific tomcod, starry flounder, and kelp greenling were the most frequently taken fish (Gaumer et al. 1973). A small fishery for chinook and coho salmon occurs from the jetties in late summer. Black rockfish, Pacific tomcod, coho salmon, and Dungeness crab are taken in large numbers in the marine subsystem by boat anglers.

Within Coos Bay, brown pelican, harlequin duck, oldsquaw, surfbird, and blacklegged kittiewake, yellow-billed loon, black oystercatcher, wandering tattler, rock sandpiper, and Forster's tern have been observed only in the marine subsystem (Table 12). Common murres and pigeon guillemots are most abundant in the bay at Coos Head (pers. comm., McGie). Bald eagle and osprey are occasionally sighted (pers. comm., McGie). Pelagic cormorant are abundant at Coos Head, and a nesting population of 12 to 15 pairs occurs on the cliffs there (Graybill 1978). Belted kingfisher and rough winged swallows also nest along the cliffs at Coos Head.

Recommendations

The marine subsystem of Coos Bay contains unique habitats not found in other sybsystems of the estuary and infrequently occurring in other Oregon estuaries. Fossil Pt. is the only naturally occurring rock in the bay exposed to vigorous wave action. Within the area are a biologically significant algal bed and subtidal kelp bed. It provides habitat for diverse invertebrates and fishes and an important spawning site for herring. It is also a valuable scenic and open-space resource. Only those low intensity uses which will not substantially alter these existing habitats and species should be permitted.

The cliffs of Coos Head, which provide nesting areas for pelagic cormorants, kingfishers, and swallows, and the tidal sand flat west of Charleston channel, whch has the only in-bay population of razor clams on the south coast, should be protected in order to maintain the diversity of habitats within Coos Bay and among Oregon estuaries.

Use policies of the marine subsystem should strive to protect water quality. It may be appropriate to restrict discharge of effluent at low tide during times of low river flow or high water temperature.

Lower Bay Subsystem

The lower bay subsystem extends along the main channel from RM 2.5 to the railroad bridge at RM 9 (Fig. 17). Although still under considerable oceanic influence, it is not as strongly affected by wave action as is the marine subsystem.

Salinity extremes recorded by DEQ in this subsystem were 34.0 ppt and 10.7 ppt at a station 1/4 mile north of Pigeon Point, compared to 34.2 ppt and 3.7 ppt at a station 1/4 mile west of the railroad bridge. During 1973-74 surface salinity from RM 2.9 to RM 8.3 at one time differed as little as 0.3 ppt at high tide during periods of low flow to as much as 14.4 ppt at high tide during periods of high flow (Arneson 1976). Surface salinity changed from 24.7 ppt to 11.5 ppt between high and low tides during high flow at RM 2.9 (Arneson 1976).

Salinity gradients indicated the lower bay was well mixed at times of low flow. During high flow the subsystem was stratified at high tide and partly mixed at low tide. During intermediate flows (March), it was partially mixed at low tide and well mixed at high tide.

Dissolved oxygen levels measured at DEQ monitoring stations in the lower bay have been above the minimum standards required for estuarine waters during the 70s (DEQ 1978). However, one sample taken near a log dump in Empire showed very low DO and high turbidity (STR 1974, USACE 1975).

Coliform counts exceeding standards for commercial shellfish harvest and even exceeding general health standards have frequently been measured at DEQ Station 6, 1/4 mile west of the railroad bridge (DEQ 1978). Counts exceeding standards at other DEQ stations in the lower bay are infrequent. Two sewage treatment plants discharge waste from the east side of the lower bay near Empire and near Pony Slough.

Pollutants discharged in the lower bay may not be rapidly flushed through the estuary. Flushing times ranged from 6.2 days in December to 19 days in June 7.6 miles from the mouth (Arneson 1976).

The sediments of the lower bay are predominantly marine sands (Arneson 1976) and probably include sands blown into the bay from the dunes.

Habitats and species

Subtidal habitats of the lower bay include the unconsolidated bottom of the dredged ship channel and adjacent area and aquatic beds in shallower areas (Fig. 18). The substrate is primarily sand (USACE 1975, Jefferts 1977). Shell and wood mixed with sand have also been reported at RM 7, 8, and 9 (Jefferts 1977).

The major alteration to the subtidal lower bay is channel dredging and associated in-bay spoil disposal. Disposal sites for the recently completed deep draft dredging project were adjacent to the channel at about RM 3, between RM 4 and 5, just below RM 6, and between RM 8 and 9.

Biological information on the subtidal lower bay is incomplete. Jefferts (1977) has examined infauna of the dredged ship channel, and ODFW has surveyed clam populations of some subtidal areas (Gaumer 1978).

Surveys west of the channel between RM 4 and 6 show scattered distributions of gaper and cockle clams and densities of 1-5 clams/ft^2 (Figs. 9 and 10) (Gaumer 1978). Butter clams were found in only a few locations in the survey area (Fig. 13) (Gaumer 1978). A 48 ac subtidal area off Pigeon Point was thoroughly surveyed to evaluate its potential for commercial clam harvest (Gaumer 1976). Population estimates for that bed were 5,648,700 gapers, 202,200 cockles, 843,000 littlenecks, and 809,200 butters (Gaumer and Halstead 1976). The bed produced a commercial gaper harvest of 11,931 lb in 1977 and 27,505 lb in 1978.

The infauna of the lower bay dredged channel has numerous species representing many groups of animals (Jefferts 1977). The fauna is more diverse and less likely to be composed of cosmopolitan species than the upper reaches of the dredged channel. Both numbers of species and numbers of individuals were found to decrease with depth in the sediment. Jefferts (1977) concluded that dredging has a relatively minor influence on the fauna of the lower reaches of the estuary, which primarily reflect the coarse sediment type rather than the effects of mechanical disturbance.

The intertidal habitats of the west side of the lower bay include large aquatic beds, sand-mud flats, sand shores, and small marshes (Fig. 18). Between RM 2.5 and 6, flats prevail. From RM 6 to RM 8 there is a narrow sand shore, and between RM 8 and 9 lies Jordan Cove with its flats, aquatic beds, and fringe of marsh.

The southwestern portions of the lower bay has been altered through the disposition of dredge spoils which form "Clam Island" and which have raised some of the shoreline above tidal level. The eelgrass beds are quite extensive and the flats are probably the most productive clamming areas in the bay. Gaper clams occur in densities of greater than 5/ft^2 over much of the area (Fig. 9) (Gaumer 1978). Cockles, butter clams, and native littlenecks are also widely distributed over the flats but occur in lesser density than the gapers (Figs. 10 and 13). Softshell clams are not found in the southernmost flat but occur from Clam Island northward (Fig. 12) (Gaumer 1978).

The southern flat was by far the most prolific site for recreational gaper harvest during a 1971 ODFW survey (Gaumer et al. 1973). Substantial numbers of cockles and butter clams were also taken there.

Above RM 6 the narrow sandy shore drops off quickly into the subtidal zone. Current through this portion of the bay is swift and scours the shores so that attached vegetation is absent. Five pile dikes were placed along this shore to retard erosion and prevent further curvature of the ship channel (USACE 1973). While this area appears barren in comparison to the flats to the south, it is an important feeding area for Englis sole, topsmelt, surfsmelt, herring, northern anchovy, and coho and chinook salmon (pers. comm., Mullarkey). Many of these fish feed on material in the water column from productive areas adjacent. Gut content analysis of salmon seined in sandy areas during August 1978 showed larval fishes were the main diet during the period sampled (pers. comm., Bender).

Jordan Cove lies between RM 8 and 9. Recreationally important clams are scarce, but ghost shrimp occur in moderate density over the entire area of flats and aquatic beds (Fig. 15). Softshell clams are sparsely distributed around the edges of the flats, and smaller species of clams are scattered across the cove (Gaumer 1978).

Just west of the railraod bridge at Jordan Point is a sandy area where ODFW repeatedly seines large numbers of fish (pers. comm., Bender and Mullarkey). The site was highest in numbers of individuals and second in numbers of species taken during seining efforts in 1970 (Hostick 1975).

Below Sitka Dock on the east side of the lower bay, there are broad algal and eelgrass beds on a sand-mud substrate with three large areas of cobble, where dredeged materials have been deposited. The cobbles form a habitat that is unique in the bay and may add niches for colonization by marine life. A high density of marine species, primarily rockfish, have been consistently found there in recent ODFW surveys (pers. comm., Bender).

Gaper clams are much less dense here than on the west side of the bay (Gaumer 1978), but the area provided recreational diggers with the second highest number of gapers taken in 1971 (Gaumer 1973). Butter clams are found among the cobbles of the spoil site (Gaumer 1978), and the Pigeon Point flat was by far the most productive butter clam area in 1971 (Gaumer 1973). Pigeon Point was also the prime site for the harvest of littleneck clams (Gaumer 1973). Ghost shrimp are also common in the area (Gaumer 1978).

The large eelgrass beds of the Pigeon Point area are of particular significance in providing food for migratory black brant. Harbor seals use one of the spoils disposal sites as a haul out area (pers. comm., Graybill). A historic seal haul out area is also located on the western shore of the lower bay just below the Ore-Aqua salmon ranching facility.

The tideflat habitats near Sitka Dock were significantly degraded by waste discharge from the Coos Head Pulp Mill which operated until 1971. Biological productivity has been increasing since closure of the mill (George M. Baldwin and Associates et al. 1977). A dense eelgrass meadow has become established southwest of the mill site, and gaper, tellen (*Tellina* sp.), cockle, *Macoma* spp., and softshell clams occur there (George M. Baldwin and Associates et al. 1977). Studies of the recovery of the flat have not been undertaken. The area is under private ownership and is not available to the public for recreation.

North of Sitka Dock, ghost shrimp, tellens, *Macoma* spp., and softshells inhabit the sand-mud flats and eelgrass beds. Flats there provided the greatest number of ghost shrimp to diggers of the areas surveyed in 1971 but were used much less heavily than the Pigeon Point flats (Gaumer 1973). Limited access and the clam distribution may influence the use pattern.

The narrow north shore of Empire, which is affected by storage of logs at the Cape Arago Lumber Company Mill, gradually widens into the broad complex of flats, aquatic beds, and small marshes southwest of North Bend Municipal Airport (Fig. 18). Qualitative studies show that the area is inhabitated by softshell clams, tellens, *Macoma* spp., and polychaete worms (Figs. 12, 14, and 11). A quantitative study of the area has recently been completed and will be available through LCDC (Gonor 1979).

Several fish species are found in the lower bay nad marine subsystems (Table 9). Other species, such as English sole are most abundant in the lower bay, although they may be found further upbay. Sampling during the summer of 1970 showed that juvenile chinook salmon and lingcod were most common at lower bay sites (Hostick 1975; Cummings and Schwartz 1971).

Most of the fish species of Coos Bay use the flats of the lower bay at some time during the year (Cummings and Schwartz 1971). Habitat has considerable bearing on types of fish present. Vegetated areas appear to exhibit greater species diversity and are preferred by surfperch, pipefish, snake prickleback, gunnel species, and starry flounder (pers. comm., Mullarkey). Many of the species are found in greatest numbers over the sandy substrates (pers. comm., Mullarkey).

The aquatic beds adjacent to the North Spit, the Roseburg Lumber Co. dock, and the aquatic beds of Jordan Cove on the west side of the lower bay and the aquatic beds to the north and south of Sitka Dock are prime herring spawning areas (Jackson 1979; Miller and McRae 1978).

A salmon release-recapture facility (Oregon Aqua Foods) is located at about RM 5.5 on the west side of the bay. Another facility, Anadromous Inc., is located at Jordan Pt. at the extreme eastern border of the lower and upper bay subsystems (Fig. 17).

The lower bay was by far the most popular boat angling area in surveys conducted in 1971 (Gaumer et al. 1973). Dungeness crabs represented 80% of the catch. Black rockfish, red rock crab, perch species, and kelp greenling were also taken in large numbers (Gaumer et al. 1973).

Most of the bird species of Coos Bay may be found in the lower bay, and several species have their prime distributions in the lower bay and marine subsystems (Table 12). The more abundant of these birds include Brandt's cormorants, pelagic cormorants, black brant, surf scoters, northern phallaropes, western gulls, glaucous-winged gulls, mew gulls, Heerman's gulls, Bonaparte's gulls, and common murres. A variety of migrant and wintering shorebirds feed on the exposed intertidal mud flats.

Recommendations

The lower bay between RM 2.5 and RM 5 is an area of exceptional natural productivity and a prime aesthetic and recreational resource. The tideflats, eelgrass, and algal beds along the western shore of this region should be considered as major tracts, which require inclusion in a natural designation as described by the LCDC Estuarine Resources Goal (1977).

Although the sandy shore between RM 6 and 8 on the western side of the bay appears unproductive because it does not have attached vegetation, it is a valuable habitat for certain species of fish. Any development occurring there should preserve the sandy substrate and water quality of the area. Use of pilings may be appropriate in the area unless subsequent reduction in current velocity changes the quality of the substrate.

Sitka Dock at about RM 3.8 is located along the eastern shore of the productive lower bay. The adjacent area was formerly degraded by waste discharges, but some evidence suggests that the nearby tidal flats are recovering. Upland uses near the Sitka Dock area are primarily residential. The location of the dock within a prime natural and recreational resource area makes the area unsuitable for industrial development, but water-dependent recreational development would appear to be appropriate.

A public boat ramp, fish processing plant, oil company docks, and a mill are located on the eastern shore at Empire. These developments contribute to degradation of the habitats. Habitat restoration or further development for water-dependent uses, preferably constructed on pilings, are possibilities for this area.

The large flats southwest of the North Bend Airport and the Jordan Cove area should be considered major tracts and protected accordingly (LCDC 1977).

In-bay spoiling of material dredged from the channel between RM 3 and RM 10 should be discontinued. This activity reduces the tidal prism and further increases filling of the estuary, which is already accelerated from upstream activities. Habitat is irreversibly lost, even with mitigation. Suitable areas should be located for upland or offshore spoil disposal.

Upper Bay Subsystem

In the upper bay subsystem Coos Bay broadens into a complex of wide shallow tidal flats adjacent to the main dredged ship channel (Fig. 18). It extends from the railroad bridge at RM 9 to the southeastern corner of Bull Island at RM 17 (Fig. 17).

Massive alterations have occurred in the upper bay. The dredged ship channel runs along the west side of the bay, and industrial activity for the Port of Coos Bay is centered there. The channel between RM 9 and the mouth of Isthmus Slough is 35 ft deep and 400 ft wide. A turning basin 35 ft deep, 800 ft wide, and 1000 ft long is at RM 12. Filling of tidelands has occurred along the western shore, south of Marshfield Channel at Eastside, and on the major tideflats, where dredged materials form several spoil islands. Much of the filling has occurred to dispose dredged material and to provide sites for industrial development. The upper bay also receives industrial wastes and is a site of log storage and handling.

The upper bay receives freshwater inflow from Coos River, Catching, Isthmus, Kentuck, and North sloughs, and Haynes and Willanch inlets. Measurements at the mouth of Kentuck Slough indicate salinity extremes of 33.7 ppt and 3.0 ppt, while extremes measured at the mouth of Marshfield Channel were 33.7 ppt and 0.5 ppt (DEQ 1978). The organisms of the upper bay are exposed to low salinity during freshets, but the water is saline during low flows.

Extreme tidal currents of 4 ft/s have been measured at North Bend, and mean currents are about 1 ft/s (Aagard et al. 1971). Mean seaward velocity of river dishcarge passing a cross section between North Bend and Pierce Pt. is less than 0.1 ft/s at times of low runoff and 3-4 ft/s during peak runoff. Seaward ebbs of 6-8 ft/s during periods of high runoff have been predicted (Aagard 1971).

Wave development over the tideflats of the upper bay is limited by the short fetch and shallow water. Before recent channel deepening, phase changes indicated high dampening of the tidal wave in the upper bay as tidal energy was spent in turbulent mixing over the wide tideflats (Blanton 1964). Mixing in the main bay was probably sufficient so that stagnation causing anoxic conditions did not occur in the main bay (Aagard et al. 1971). The effect of recent channel deepening on tidal circulation has not been evaluated.

Sediments of the upper bay main channel are sandy from RM 9 to RM 10.5, shell from RM 10.5 to RM 12, and mud from RM 12 to RM 15 (USACE 1975). The main channel adjacent to Coos Bay is the area of most active deposition of river sediments (Aagard et al. 1971). Prior to channel deepening, RM 12-15 have been dredged every three years with an average of 450,000 yd^3 of sediment removed annually (USACE 1976). Sediments removed from the main channel above RM 12 do not pass EPA pollution standards for in-water disposal of materials. The sediments of the upper bay tidal flats are primarily silty with some areas of sand near the spoils islands. Wood debris overlies the sediments in many areas (Ednoff 1970).

During the past century the Coos River has changed its course through the upper bay (Aagard et al. 1971). Formerly the main flow of the river was east of Bull Island. At the northern end of Bull Island, it bifurcated into the East Channel and the main Marshfield Channel. At that time, Catching Slough had a large tidal prism and strong tidal flushing.

Splash damming, log transportation, and dredging have increased the size of the channel to the south of Bull Island (the Cutoff) so that it now carries the main flow of the river. As recently as 1970 the channel northwest of Bull Island has been deepening and eroding the tip of the island. From 1944 to 1970 the Cooston and East channels have been stable with minimal channel migration and sedimentation (Aagard et al. 1971). The tendency for channel migration does exist, and changes in hydrographic conditions, such as major dredging projects, may have unpredicted effects on shifting river channels.

Elutriate tests of core and water samples indicate that the main ship channel above RM 12 is polluted (USACE 1976). Coliform counts at DEQ stations in the upper bay during the 70s have frequently been higher than general standards for estuarine waters. In the main shipping channel, the frequency of violations increased from the station at the mouth of Kentuck Slough to the station at the mouth of Marshfield Channel (DEQ 1978). Dissolved oxygen less than the 6 ppm standard for estuarine waters was also measured with increasing frequency (DEQ 1978). STR (1974) attributed coliform problems to the presence of municipal sewage treatment plants and DO problems to municipal sewage treatment plants, industrial wastes, and log storage.

Habitats and species

Subtidal areas of the upper bay include the deep draft dredged ship channel; the shallowly dredged Marchfield, Cooston, and East channels; and the smaller channels draining the tidal flats (Fig. 18). Most of the information available on the upper bay subtidal concerns the dredged ship channel. The ship channel presents an altered environment for colonization by estuarine species. Maintenance dredging, propellor wash, and anchor drag frequently resuspend sediments so that little attached vegetation can grow (Parr 1974).

The benthic fauna of the dredged channel represents a community that has become adapted to the stresses of frequent sediment disruption (Parr 1974). Patches of substrate missed during dredging may be important to re-establishment of benthic organisms (Slotta et al. 1974).

Streblospio benedicti, an annelid, is the dominant organism in the upper bay subtidal area (Parr 1974; Jefferts 1977). Species most frequently encountered by Parr (1974) were

Annelids:

Streblospio benedicti
Pseudopolydora kempi
Polydora ligni
Eteone lighti
Capitella (capitata) ovincola
Notomastus (Clistomastus) tenuis
Glycinde armigera

Bivalves:

Macoma inconspicua
Clinocardium nuttallii
Mya arenaria
Modiolus sp.

Pycnogonids:

Achelia nudiuscula
Achelia chelata

Amphipods:

Corophium salmonis
Corophium spinicorne
Anisogammarus ramellus

These taxa are frequently reported in the literature to be associated with polluted environments (Parr 1974). Jefferts (1977) postulated that in the upper reaches of the estuary, the high water, organic content of the sediment, and the reduced grain size have a deleterious effect on faunal diversity and depth of distribution of organisms in the sediment.

Distribution of fish and of mobile invertebrates, such as crabs, in the dredged channel has not been adequately studied. Seining near the channel in 1970 revealed that shiner perch, silver surfperch, American shad, and English sole use the area in addition to a number of less freqeuntly captured species. More silver surfperch were captured per haul at this location than in other seining sites on the estuary.

Anglers catch pile perch, striped seaperch, and white seaperch from the Coos Bay waterfront (Gaumer et al. 1973). Thirty-eight species of fish have been recorded using the upper bay during the summer (Cummings and Schwartz 1971). Many of the fish probably feed over the tidal flats and congregate in the channels at low tide.

The intertidal area of the upper bay is composed of broad, shallow tidal flats, eelgrass beds, and tidal marshes (Fig. 18). George M. Baldwin and Associates et al. (1977) calculated that tidal flats composed predominantly of mud occupied about 4.5 mi^2. Sand occurs near the spoil islands, and wood debris is common on the southern portion of the flats. A huge eelgrass-tide-flat complex stretches from the Jordan Cove causeway south to the Marshfield Channel. The northern two-thirds of this area is an extensive eelgrass meadow, the largest in Coos Bay and one of the largest in Oregon (George M. Baldwin and Associates et al. 1977). Development has altered intertidal habitats along the shoreline of Coos Bay and North Bend. Studies of invertebrate distribution and abundance have not been conducted.

At least 10 species of annelids, 10 species of molluscs, and 13 species of crustaceans have been recorded from the muddy upper bay tidal flats (USACE 1975). The sea hare (*Aglaja diomeda*) has been recorded in the bay only from upper bay eelgrass beds, and the distribution of the freshwater crab is the upper bay and riverine areas.

The only clam taken recreationally which inhabits the upper bay in large numbers is the softshell, although small cockles have also been reported there. Lugworms and ghost shrimp are the other upper bay invertebrates sought by recreationists. McConnaughey et al. (1971) divided the tidal flats and eel-grass beds into four smaller subunits in their study. Biomass results of the most common species are summarized in Table 13. Animals were the most diverse and abundant within the dense eelgrass beds. Softshells and Dungeness crabs were found in much greater concentrations in the dense eelgrass, but certain invertebrates, such as the ghost shrimp and the false mya (*Cryptomya californica*) preferred sandier substrates and areas of less eelgrass.

Log storage over the flats and channels of th upper bay is common. Log storage areas have been mapped by the Coos County Planning Department. A DEQ study (Zegers 1978) of the impact of logs grounding on tideflats at low tide included sampling sites in the Cooston Channel of the upper bay. There was a large reduction in the number of total organisms (including annelids, arthropods, and molluscs) per unit area in grounding areas compared to adjacent control sites.

It is possible to cultivate oysters (*Crassotrea gigas*) in the upper bay, but commercial harvest there is prohibited because of poor water quality.

The upper bay tidal flats are an important feeding area for shad and striped bass (Cummings and Schwartz 1971). Adult shad may spend several weeks there, and bass can be found there most of the year. Juvenile salmonids also use the area for feeding. Among the most numerous fish found in the upper bay were shiner perch, silver surfperch, shad, topsmelt, starry flounder, and English sole (Hostick 1975).

Table 13. Average sample composition (g/m^2) of most common macrofaunal invertebrates in upper bay tidal flats and eelgrass beds (McConnaughey et al. 1971)

Organism	Subunit I	II	III	IV
Mya arenaria	3.02	0.97	17.28	39.20
Tellina salmonea	1.69	3.95	2.02	2.27
Macoma baltica	0.71	1.95	0.91	0.61
Others	0.77	0.07	4.51	0.65
Clam Total	6.19	6.94	24.72	42.73
Nereis brandti	1.25	2.89	1.60	5.42
Heteromastus f.	2.26	2.48	1.88	2.49
Eteone lighti	0.53	1.04	1.62	1.08
Others	0.87	0.66	1.04	1.91
Worm Total	4.91	7.07	6.14	10.90
Corophium s.	0.71	2.62	2.05	3.53
Anisogammarus c.	0.24	0.00	0.05	0.32
Haustorius sp.	0.01	0.01	0.03	0.01
Others	0.10	0.00	0.00	0.05
Amphipod Total	1.06	2.63	2.13	3.91
Cancer magister	0.00	0.00	0.00	1.55
Callianassa c.	0.34	0.00	1.56	0.00
Tectibranch (?)	0.07	0.16	0.01	0.49
Biomass Total	12.97	16.75	34.72	59.85
Number of Samples	38	16	9	11

I. Near spoil islands, sandy substrate, high elevation
II. Mud without eelgrass
III. Areas with sparse to medium density eelgrass
IV. Areas with dense eelgrass covering.

The upper bay has not been studied as a discrete unit with regard to bird use. Western grebes, pintails, canvasbacks, buffleheads, killdeer, snipe, sandpipers, sanderlings, dunlins, herring gulls, and Bonaparte's gulls were among the more abundant birds sighted in the area during the 1977 and 1978 Audubon Christmas Bird Counts. Graybill (1978) noted a particularly large population of sandpipers on the flats of the upper bay.

In general, the upper bay intertidal area is inhabited by fewer species than either the lower bay or marine subsystems. Jefferts (1977) states "The number of species present in a community is roughly inversely proportional to the degree of environmental uncertainty." The physiological stresses of salinity and temperature fluctuations in the upper bay as well as the presence of pollution and mechanical disturbance tend to produce a community that is physically controlled. Although fewer species are present in such a community, individuals may be numerous, occur in high biomass, and be important to the overall estuarine food chain. For example, *Corophium spinicorne*, the dominant upper bay amphipod, is abundant and is important in the diet of juvenile salmonids during their seaward migration (personal communication, Paul Reimers, ODFW, March 18, 1979).

Present marshes of the upper bay subsystem are located along the eastern side of the bay at the mouths of Kentuck Slough and Willanch Inlet, on the Coos River delta islands and adjacent shores, on the northeastern portion of the Eastside peninsula, and on the spoil islands east of the main ship channel (Fig. 18). Acreage of upper bay undiked marshes was estimated by Hoffnagle and Olson (1974):

Low sand marsh	46.3
Low silt marsh	3.8
Sedge march	22.1
Immature high marsh	416.4
Mature high marsh	44.8

Most of the marsh area of Kentuck and Willanch inlets has been lost through diking (Johannessen 1961, Hoffnagle and Olson 1974). Original diking along the upper portion of Kentuck Inlet was extended and a bridge and tidegate installed. Marsh rapidly invaded the tideflat below this diking (Johannessen 1961). The diked area is currently used for a golf course. In Willanch Inlet about 100 acres have been diked and are used for agriculture, leaving only about 6 acres as marsh (Hoffnagle and Olson 1974).

Extensive marshes currently exist in the Coos River delta and on the shore across the East Channel. Marshland there has increased since the 1800s (Johannessen 1961), probably because of increased siltation (Hoffnagle et al. 1976). The marshes are primarily immature high marsh with *Deschampsia caespitosa, Carex lyngbyei,* and *Triglochin maritima* the dominant plants (Hoffnagle et al. 1976).

The marsh along the shore east of the delta islands was studied by Hoffnagle et al. (1976). The site showed rapid increase in biomass from April to a maximum in June. This site was second in net primary productivity of six marshes studied in Coos Bay with a productivity of 1007.85 $g/m^2/yr$.

Invertebrates of the Bull Island study site included the sea anemone (*Nematostella* sp.), polychaetes, crustaceans, and molluscs. The number of species reported was intermediate between a site in lower South Slough and one in North Slough (Hall 1976). Fish taken from the site include shiner perch, Pacific staghorn sculpin, starry flounder, gunnel, bay pipefish, and coho salmon. The most common birds noted were the great blue heron, barn swallow, long-billed marsh wren, and song sparrow (Magwire 1976).

In the vicinity of Eastside, diking began before 1980 (Johannessen 1961). About half of the mature high marsh remaining in Coos Bay is in Eastside (Hoffnagle and Olson 1974). Low sand marshes have colonized the edges of these islands (Hoffnagle and Olson 1974).

Losses of marshland in the upper bay have been extensive. Large areas of Kentuck and Willanch inlets, at Graveyard Pt., on the Eastside peninsula, and near sea level in the cities of Coos Bay and North Bend have been diked or filled for agriculture, industry, and dredge spoil disposal.

Recommendations

The marshes of the Coos River delta islands constitute major tracts of salt marsh, which should be included in a natural management unit as required by the Estuarine Resources Goal (LCDC 1977).

The entire eastern side of the upper bay from Jordan Point to Bull Island and west to the shipping channel is a vast complex of flats, marshes, and eelgrass beds, providing valuable habitat and a rich source of organic material for the entire estuary. George M. Baldwin and Associates et al. (1977) note "the condition of this area is critical for the overall production of the Coos Bay Estuary. Because of its biological importance, the area as a whole should be considered environmentally sensitive." The area should be managed as a single ecological unit. It definitely encompasses major tracts of tideflat and seagrass as discussed in the LCDC Estuarine Resources Goal (1977) and should be managed accordingly.

The tidal flats of the upper bay are feeding grounds for fish, including the anadromous salmonids, striped bass, and American shad. Productivity of these flats should be maintained and increased through restoration of their surface area, including removal of stored logs which ground on the flats.

Habitats along the main channel adjacent to the cities of Coos Bay and North Bend have been altered. Water-dependent uses in these areas are appropriate. Unnecessary pilings should be removed and water quality should be considered in future development. The Cooston Channel is a main artery for the passage of fish between the river and ocean. It should remain unobstructed.

South Slough Subsystem

South Slough enters the main body of Coos Bay near Coos Head, less than 2 mi from the estuary mouth (Fig. 17). It may have once been a separate estuary with its own opening to the ocean. The slough has a drainage basin of 26 mi^2 (STR 1974). Because of its proximity to the ocean, South Slough receives more marine influence than the other slough subsystems. Its north-south orientation makes it particularly susceptible to strong north-northwest winds.

The slough bifurcates into the western Winchester arm and the eastern Sengstacken arm. Major tributaries include Joe Ney and Day creeks from the east; John B. and Talbot creeks, which flow into the Sengstacken arm; and Winchester Creek, which flows into the Winchester arm.

The upper reaches of South Slough (Fig. 17) have been set aside as a research sanctuary to preserve an unaltered site for studies to improve our ability to properly manage estuarine systems. The South Slough Sanctuary was the first of its kind in the nation.

Fresh water inflow into the slough has not been measured directly. Freshwater runoff from the South Slough drainage basin has been estimated from the precipitation and runoff measured in two nearby drainage basins (Harris et al. 1979). Monthly average values ranged from 6 cfs in August to 232 cfs in February. Monthly extremes of 1 cfs and 445 cfs were estimated. Further calculations yielded a representative tidal prism of 3.3×10^8 ft^3 and implied that mixing is thorough and flushing of fresh water is rapid (Harris et al. 1979). Salinity gradients for stations at the mouth of the slough and at Younker Pt. also show the lower slough is well mixed throughout the year (Arneson 1976).

A breakwater separates South Slough from the main body of Coos Bay. A project to extend the jetty to provide additional protection to boats moored in the Charleston boat marina is currently underway. A 10-ft deep, 50-ft wide channel is maintained between the main bay channel and the Charleston Bridge. The Charleston Small Boat Basin is also dredged to dimensions of 500 ft x 900 ft in lower South Slough (USACE 1978). Studies of bottom topography have been conducted by USACE (1978) and a mathematical model, verified by field measurements, of tidal elevations, current velocities, and circulation in South Slough under calm wind and wave conditions has been constructed (USACE 1978). Bathymetric charts are on file at the offices of the South Slough Estuarine Sanctuary. Although DEQ maintains 11 water quality stations in South Slough, most of them are in the lower portion of the slough. Stations have recently been established farther up the slough in conjunction with the South Slough Estuarine Sanctuary, so comparisons should soon be possible.

At the entrance to South Slough, DEQ (1978) has measured salinity extremes of 35.3 ppt and 14.6 ppt. Extremes 0.3 miles south of Collver Pt. were 33.3 ppt and 6.3 ppt. The data suggest that highly saline water extends far into the slough at periods of low flow and that water at the head is fresh at times of high flow.

Dissolved oxygen at the stations monitored by DEQ is generally above minimum standards for estuarine waters (DEQ 1978). Arneson's data (1976) show slight depressions in DO at Younker Pt. in March and at the Charleston Bridge in December relative to surrounding stations.

Several coliform measurements greater than 70 mpn have been taken by DEQ (1978) within the Charleston Small Boat Basin and at the Joe Ney Slough Bridge. Recent work by Plotnick (1979) suggests that improper disposal of sewage from boats may be a problem in the boat basin. Septic tank leakage from dwellings not yet hooked up to the Charleston sanitary district sewage disposal system are another source of coliform. Sampling for coliform in the upper reaches of the slough has only recently begun. Counts in the Sengstacken arm are within standards for shellfish harvest, while those in the Winchester arm often exceed those standards. Livestock waste may elevate coliform counts in the upper reaches of the slough (personal communication, Delane Munson, Manager of South Slough Sanctuary, February 15, 1979).

An examination of the sediment characteristics of volatile solids, Kjeldahl nitrogen, grease and oil, and total sulfides showed that, although the outer boat basin is more exposed to flushing action, it is more highly polluted than the inner basin (Slotta and Noble 1977).

South Slough is an area of sediment deposition. Sediment movement is generally seaward and deposition occurs where movement is obstructed, such as at Valino Island and in regions of large cross sectional area (Baker 1978).

Strong winds may be a factor in sediment resuspension in South Slough as wave bases disturb the bottom (Baker 1978).

Baker (1978) found that most of the sediments of South Slough are a mixture of medium to fine sand eroded from the terrace shorelands and coarse to medium silt from fluvial input. Silty sands are the dominant sediment type over tideflats and in the channels toward the head of the slough. The uppermost reaches are generally silt. Organic content of slough sediments ranged from 0.00 ppt in channel sands to 19.77 ppt in tideflat silts (Baker 1978).

Drainage from Joe Ney Sanitary Landfill was reported to have been increasing sedimentation in South Slough, but recent measures seem to have alleviated the problem (pers. comm., Munson). Logging activities have occurred in the drainage basin which may have obscured the effects of the landfill.

Habitats and Species

The habitats of South Slough show the most variation of any slough subsystem within Coos Bay (Fig. 18). The marine influence, the coarse sediments found in the lower portions of the slough, and the relatively undisturbed nature of the upper portion provide habitats for more species of invertebrates and fish than are found in the other slough subsystems.

South Slough has a irregular shoreline, which leads to a high shoreline to surface area ratio. The area has many diverse habitats. Below the Charleston Bridge are flats of mixed substrate, intertidal and subtidal eelgrass beds, riprapped shores, sandy shores, and only a small amount of marsh. Between the bridge and Valino Island are, in addition to most of the above habitats, a small amount of bedrock shore, sandy bars, and much larger marshes. Above Valino Island the substrate becomes more silty and marshes are more prominent. Eelgrass in the channels extends far up the slough.

Because of the proximity to the ocean and its varied habitats, the number of species inhabiting South Slough is high. Ednoff (1970) recorded more total species from the mud in South Slough than in any other portion of the bay. Polychaetes and molluscs were most diverse in South Slough, but crustaceans were most diverse in the lower bay.

A rich intertidal infauna was also found by Jefferts (1977), who recorded 26 polychaetes, 10 bivalves, 4 harpacticoid copepods, and 7 amphipods. Jefferts' uppermost South Slough station had the lowest diversity of any station sampled. This station was in a backwater with a high concentration of volatile solids, a high water content in the substrate, and was dominated by a few opportunistic species. In these respects, it resembled stations in the upper bay, although the faunal assemblage was different.

Most clambeds used by recreational diggers in South Slough are north of Valino Island. Gaper, butter, cockle, littleneck, and softshell clams are taken from the tide flats. Four South Slough sites provided a total of 22.6% of the marine animals taken by tideflat users in Coos Bay in a 1971 survey (Gaumer et al. 1973). While the clam bed just south of the Charleston Bridge provided the greatest number of clams of the South Slough flats surveyed, the flat just south of the existing boat basin (the Charleston Triangle) had the highest catch per unit effort (Gaumer 1973). Clam resources of this flat have been surveyed in greater detail (Gaumer 1978). Estimates of the populations of recreationally harvested clams occurring there are 1,333,000 gapers, 348,000 cockles, 289,000 native littlenecks, 119,000 butters, and 50,000 softshells. Estimate of the total clam population was 10,078,000 (Gaumer 1978).

Of major significance is the use of South Slough for commercial oyster culture. The only oyster leases in Coos Bay are on South Slough. Leases are scattered on Joe Ney Slough and South Slough proper, except for the Winchester arm (Fig. 16). Oysters can be grown in areas throughout the estuary, but health restrictions due to poor water quality prohibit commercial oyster leases in most of the estuary.

Many of the 995 acres of undiked tidal marsh in South Slough are fringing marshes at scattered points along the slough's edges, especially in inlets and coves (Hoffnagle and Olson 1974). The largest expanses of marsh are found at the heads of various inlets and on the flats just south of the Charleston Bridge and just south of Valino Island. Low sandy marsh and immature high marsh are the major marsh types of the slough (Hoffnagle and Olson 1974).

Several areas in South Slough are reverting to marsh following the breaching of dikes or as a result of tidegate failure. Regions at the head of the Winchester arm are inundated only during high water or very high tides as a result of tidal damming of streams. These areas are termed "surge plain marshes" by Hoffnagle and Olson (1974).

The only area of bullrushes in South Slough is along part of the north bank of Joe Ney Slough (Hoffnagle and Olson 1974). At the head of Joe Ney Slough is a large, tidegated freshwater marsh with dense stands of cattail (*Typha latifolia*) (Hoffnagle and Olson 1974). Studies of this marsh site as a potential mitigation site for alterations in other portions of the estuary have been conducted and results will be available from LCDC (Gonor et al. 1979).

Two South Slough marshes of differing character were studied in detail by Hoffnagle et al. (1976). The marsh site at the upper end of the slough was vegetated primarily by *Carex lyngbyie* and *Distichlus spicata*. Its net primary productivity was estimated at 764.81 $g/m^2/yr$. A low sandy marsh in the Henry Metcalf Estuarine Preserve just south of the Charleston bridge was the other study site (Hoffnagle et al. 1976). The marine influence experienced by this marsh is probably responsible for the diversity of species observed there. Bird observations near the Metcalf marsh are summarized in Table 12.

As in other portions of the bay, the habitats of South Slough have been altered by human use. The lower slough has been a site of rapid change accompanying a growing fishing industry. The construction of the Charleston Breakwater, dredging of the channel and of the small boat basin, and filling of adjacent tidelands have all occurred within the past 25 years. In the middle and upper slough, oyster culture has added a habitat to the intertidal area. Although there have been splash dams and dikes in the upper slough, recent developments have been few.

Recommendations

While generally one would choose to concentrate development in the lower South Slough, certain features of the area deserve special attention. Of 6,200 acres of submersible land in Coos Bay, 6% of the clams harvested were from the 11.5 ac area frequently referred to as the "Charleston Triangle". Because of the density of clam populations at this site and its recreational value, it should be protected. The flats south of Charleston Bridge on the west bank also receive heavy recreational use.

Generally, the diversity of organisms present in lower South Slough and the recreational capacity of the area suggest maintaining as much diversity of habitats and uses as possible. On the east side of the lower slough is the Barview State Wayside, an areas used by recreationists. The site should be maintained for these uses.

The values of South Slough marshes accrue primarily because of the long involuted shore and many fringing marshes. Development should be planned to leave the marshes undisturbed. Although individual marshes are small, the total marsh area makes a significant contribution to the primary productivity of the estuary. The low sandy marsh just south of the Charleston Bridge on the Metcalf Preserve is the closest marsh to the mouth of the bay and is a unique habitat as a marsh under marine influence.

South Slough is the only area within Coos Bay where legal commercial oyster harvest currently takes place. That use must be carefully protected. Oyster land and water quality should be protected for oyster growth. Proper sewage disposal and management of upland uses to minimize sedimentation are particularly important for oyster production.

There are several sites in South Slough appropriate for restoration, including formerly diked areas in the upper slough and in Joe Ney Slough. Habitat improvements should be considered on the east side of the channel from north of Peterson's Seafoods to the mouth of Joe Ney Slough, where discharge of sewage and industrial pollutants has occurred.

The use of Sough Slough Sanctuary an an unaltered site for research presupposes that it will remain undeveloped and its habitats and water quality will be protected. South Slough is very directly influenced by marine waters that enter through the mouth of the bay and slough and flow through the extensive development in the Charleston area. It is imperative that existing uses and new development north of the sanctuary not degrade the water quality of the sanctuary. Approval of new development north of the South Slough should be contingent upon evidence that the development will not adversely impact the water quality of the sanctuary.

Pony Slough Subsystem

Pony Slough branches south from the main bay between RM 8 and 9. Formerly a triangular embayment, its shape has been altered by filling. Presently a narrow mouth gradually opens into a wide tidal flat which is divided by a channel. The slough is about 1 mile long and the widest point is slightly more than 1/2 mile.

Hydrological studies of Pony Slough are limited. Freshwater discharge from Pony Creek is controlled at dams on Upper and Lower Pony reservoirs. Since 1975, USCS has monitored water discharge below the lower reservoir. Records for Water Year 1976 show a total freshwater discharge of 3,010 ac-ft. Flow ranged from a minimum of 0.08 cfs in May, June, July, and September and to a maximum of 26 cfs in December (USGS 1977). Summer mean flow was between 0.27 and 1.42 cfs, and the winter mean was between 4.33 and 13.6 cfs. Water discharge doesn't necessarily coincide with precipitation because of the controlling dams.

Information regarding salinity is limited to a single set of samples taken during August 1970. These measurements showed salinities in the main channel were 30.6 ppt at the mouth and 27.9 ppt at the Virginia Blvd. Bridge on an incoming tide and 23.4 ppt at the mouth and 5.5 ppt at the bridge on the outgoing tide (Horstmann et al. 1970). This demonstrates that considerable variation can occur over one tidal cycle. Interstitial salinities fluctuate less, and standing water on the marsh may become hypersaline because of evaporation (Horstmann et al. 1970).

The sediments of Pony Slough tidal flats are mostly mud and mixed sand-mud near the channels and marsh edges (Horstmann et al. 1970). A reducing layer at depths varying from 0.2 to 11.8 in was present over most of the slough area sampled.

Water quality of Pony Slough has not been examined. Domestic waste and waste water from an adjacent car wash enter the slough. In the spring of 1970, a large accidental discharge of raw sewage entered the slough from a nearby waste treatment plant (Horstmann et al. 1970). The effects of this discharge have not been studied.

Pony Slough has a long history of human alteration. Filling for the Southern Pacific Railroad began in 1917 in the northeastern section of the slough. During World War II, 240 ac. were filled for the North Bend Municipal Airport. In 1958 filling for Pony Village shoping center began, and in 1960 filling occurred north of Virginia Street in North Bend. The southeastern portion of the slough is bordered by residences, the southern side by commercial enterprises, and the North Bend Municipal Airport lies along the western border (Fig. 17). A public boat launch is located near the mouth on the western side. Several waste outfalls empty into the slough.

Habitats and Species

Habitats of Pony Slough include subtidal areas with unconsolidated bottoms and eelgrass and intertidal mud flats, sand-mud flats, eelgrass beds, algal beds and marshes (Fig. 18).

Benthic diatoms were ubiquitous on Pony Slough tideflats and are probably a major source of productivity (Horstmann et al. 1970). Mats of green algae (*Chaetomorpha cannabinna* and *Rhizoclonium* spp.) covered large areas of the tidal flats. Blue-green algae were noted on the eastern edges of the mud flats, and brown algae (*Fucus* sp.) was present on hard substrates and in the marshes.

Dense eelgrass is distributed along the intertidal area near the slough entrance and through part of the main channel. The various types of plant communities in Pony Slough show that the area remains an important producer of organic material for Coos Bay despite extensive alterations by filling. Fringes of high marsh also occur on the east and west margins of the slough and an expanse of low sand marsh occurs on the west side (Hoffnagle and Olson 1974). Most of the marsh vegetation lies between 5.5 and 7.5 ft above MLLW (MacDonald 1967).

The plant community of the low marsh at Pony Slough is composed primarily of *Salicornia virginica* and *Distichlis spicata* (Hoffnagle et al. 1976). *Deschampsia caespitosa* and *Spergularia marina* were also noted (Hoffnagle et al. 1976). These plants evidence a change in species composition since Johannessen studied the marsh 1961. He recorded *Scirpus validus* as a significant member of the flora and did not record any *Distichlis spicata* (Johannessen 1961).

The Pony Slough marsh increases in biomass from April to July (Hoffnagle et al. 1976). Net primary productivity was lower than that of North and South slough marshes probably because of the perennial *Saliconria virginica*, which has high biomass but a low rate of production. The marshes of Pony Slough were the lowest in elevation of the marshes studied by Hoffnagle et al. (1976). Dead standing shoots disappeared quickly probably because of the frequency of inundation. *Salicornia*, although lower in productivity, is an important detritus source, and its woody perennial form stabilizes soil (Hoffnagle et al. 1976).

The Pony Slough mud flat is populated primarily by burrowing mudflat organisms (Hoffnagle et al. 1970). *Corophium spinicorne*, an important amphipod in the diet of juvenile salmonids, is widely distributed over Pony Slough tideflats. Lugworms, ghost shrimp, and clams (*Mya arenaria, Cryptomya californica*) also occur, often in very high densities (Horstmann et al. 1970). Dungeness crabs are found in lower intertidal and subtidal areas. Tideflat users harvest softshell clams and ghost shrimp at Pony Point to the west of the entrance to Pony Slough, but this accounted for only a small percentage of tideflat use on Coos Bay (Gaumer et al. 1973).

Most sampling for fishes in Pony Slough has been by otter trawl because the soft muddy substrate makes beach seining difficult. However, ODFW has seined in the lower slough for the past three years. Eleven species occur in Pony Slough (Rousseau 1972). The slough is an important striped bass feeding area. Adult striped bass feed over much of the tideflats at high tide and move in and out of the slough with the tides. Pony Slough is a popular bass angling area from May through September.

Over 100 species of birds use Pony Slough. The slough harbors the largest concentrations of wintering birds in the estuary (Rousseau 1972). Peak numbers of 7,000-9,000 wigeon and other waterfowl and shorebirds have been noted (Rousseau 1972). Thornburgh (1979) conducted weekly surveys from June 1978 to June 1979 (Table 14).

The protection from southerly winter storms offered by the sheltered Pony Slough is probably a major reason for its heavy use by waterfowl. ODFW manages Pony Slough as a refuge, where hunting is prohibted.

Table 14. Peak counts of birds occurring in Pony Slough between June 1978 and March 1979 in numbers greater than 100 per observation period (Thornburgh 1979).

	Number	Time of observed peak
Dabbling Ducks		
American Wigeon	3,526	Nov.
Pintail	1,943	Jan.
Green-winged Teal	872	Dec.
Gadwall	330	Jan.
Shoveler	209	Jan.
Diving Ducks		
Canvasback	648	Dec.
Plovers		
Killdeer	204	Jan.
Semipalmated Plover	177	July
Black-bellied Plover	151	Mar.
Medium-sized Waders		
Dowitch	220	Sept.
Sandpipers		
Dunlin	2,808	Nov.
Western Sandpiper	1,577	Sept.

Recommendations

Pony Slough is a very important striped bass feeding area in Coos Bay. It is an area of high plant and animal productivity and a critical waterfowl and shorebird habitat, which harbors the largest concentrations of wintering birds in the estuary. The entire slough should be managed as a single unit. Most of Pony Slough is a major tract of intertidal land as described in the LCDC Estuarine Resources Goal (1977) and should be managed accordingly.

In its present condition Pony Slough provides valuable and scenic open space and natural resources to the urban North Bend area and could be used in satisfying state land use Planning Goal 5 (LCDC 1977).

North Slough Subsystem

North Slough extends approximately 3 mi north from the main body of Coos Bay at RM 9 (Jefferson 1975). The slough has a watershed of 8,190 ac (OSWRB 1963). Freshwater inflow from North Creek has not been measured. Although there is a tidegate at the slough's north end, near Highway 101, it may be too high in elevation to provide good flood drainage relief (OSWRB 1963). Upland plants are found adjacent to the channel before the slough crosses under Highway 101 (Hoffnagle and Olson 1974). The lands to the east of the highway are tidegated and diked but may be of sufficient elevation to be unaffected by salt water (Hoffnagle and Olson 1974).

The hydrography of North Slough has not been studied. The Jordan Cove Causeway separates the slough from full exposure to the main bay. The dike system undoubtedly reduces tidal circulation in the slough and may be accelerating sediment deposition. The Southern Pacific railroad bed parallels the western perimeter and acts as a dike, separating the slough from the dunes and forming a barrier between salt and fresh water marshy areas.

Sediments of North Slough are fine silts and broken shells (STR 1974). Sand from the dunes is also carried into the slough by the wind. These sands sometimes clog the channel at the tidegate (OSWRB 1963). Derelict logs occur on both sides of the slough and wood chips are found under the mud surface near the mouth (Baker et al. 1970).

Water quality samples are limited to a single set of samples taken in the summer of 1971 (STR 1974). Results showed high temperatures, high coliform counts, and excessive turbidity. Temperature problems were thought to occur because of low summer stream flows and incomplete mixing. Livestock and log storage were possible sources of turbidity, and livestock waste was thought to account for the high coliform counts. Log storage no longer takes place in North Slough. A municipal water treatment plant is located on North Slough, but wastes are not discharged into the slough from this plant.

The invertebrates of North Slough tidal flats include the molluscs *Mya arenaria, Crytpomya californica, Tellina salmonea, T. Buttoni, Macoma nasuta,* and *M. balthica* (Baker et al. 1970). Softshell clams and *T. salmonea* are widely distributed in the lower, broader regions of the slough. *C. californica, Macoma nasuta* and *T. Buttoni* are found near the causeway. *Macoma balthica* is found in the narrower portion of this area. The softshell clam is the only mollusc taken by recreational diggers in this area. The Jordan Cove Causeway yielded by far the most softshell clams to recreationists in Coos Bay of areas surveyed in 1971 (Gaumer et al. 1973).

Other invertebrates with wide distributions on North Slough flats include spionid worms, (*Eteone* spp.), ribbon worms (*Paranemertes* spp. and *Cerebratulus* spp.), lugworms, bamboo worms (*Heteromastes* spp.), amphipods (*Corophium* spp.), crangonid shrimp (*Crago* spp.) (USACE 1975), and Dungeness crab (Baker et al. 1970). Ghost shrimp are found only near the causeway, and shore crab (*Hemigrapsus oregonensis*) are associated with the riprap shores. Ghost shrimp and lugworms are collected from North Slough flats by recreationists.

American shad, shiner perch, staghorn sculpin, and starry flounder were found during 1970 sampling in the slough (Cummings and Schwartz 1971). Boat and shore angling for striped bass occurs in the slough May through September. There is an upstream fishery for coho salmon which spawn in North Creek (pers. comm., Bender and Mullarkey).

Large numbers of dunlin have been observed on North Slough tideflats, and North Slough has been identified as a great blue heron feeding area (McMahon 1974). North Slough is a major feeding and resting area for redheads and other ducks.

Of particular significance in North Slough are the marshes. Large, intact, diverse marshes occur there (Akins and Jefferson 1974). Jefferson (1975) described the marshes of North Slough as the "most complete and diverse mosaic of salt marsh plant communities in all stages of succession and with ecotones to freshwater, forest, and sand dunes."

Marsh acreage mapped by Hoffnagle and Olson (1974) included 7 ac. of immature high marsh, 138.5 ac. of sedge marsh, 18 ac. of bullrush-sedge marsh and 23 ac. of low sand marsh. Of six sites studied on Coos Bay, the site on North Slough, which was an almost pure stand of *Scirpus validus*, had the highest standing crop and net primary productivity (Hoffnagle et al. 1976). The plant *Cordelanthus maritima*, which is rare in Oregon, is found within the immature high marsh of North Slough (Hoffnagle and Olson 1974). *Cotula coronopifolia*, an introduced species which thrives in areas of wood and bark accumulation, is quite common (Hoffnagle et al. 1976).

Shiner perch and staghorn sculpin were found adjacent to North Slough marshes. Harpacticoid copepods, insect larvae, small bivalves and *Corophium* spp. were major items in their diet (Hoffnagle et al. 1976).

In addition to barn swallows, long-billed marsh wrens, and song sparrows, the uncommon Virginia rail has been sighted in North Slough marshes and nesting areas for this bird were observed there by Magwire (1976b).

Recommendations

The marshes of North Slough represent major tracts as described in the LCDC Estuarine Resources Goal (1977) and should be protected (Jefferson 1975). Because these diverse marshes have remained relatively unaltered, they could serve as valuable research natural areas for baseline studies of natural processes in undisturbed ecosystems. They are particularly well suited to studies of dune encroachment, impacts of drift logs, and recovery from log storage (Jefferson 1975).

North Slough includes suitable sites for habitat restoration. Removal of derelict logs would increase the surface area available for estuarine production.

Placement of culverts beneath the Jordan Cove Causeway would increase tidal circulation to North Slough and might reverse the accelerated sediment accretion.

Haynes Inlet Subsystem

Haynes Inlet extends about 2-1/2 mi northeast from its entrance into Coos Bay just east of North Slough (Fig. 17). It has a watershed of 7,120 ac (OSWRB 1963), which is drained by Larson and Palouse creeks.

Haynes Inlet was once broad at its mouth, gradually narrowing to a system of narrow, meandering channels at its head. Larson and Palouse creeks once contained large tidal marshes and had substantial tidal prisms. Currently the mouth has been greatly restricted by the Highway 101 causeway. Marshlands on both major creeks have been diked for agricultural use, and stream flows are controlled by tidegates, which reduce the total tital prism of the inlet.

Hydrological studies of freshwater inflow and tidal circulation have not been made. Data on the water quality of Haynes Inlet is lacking, and only minimal biological information is available.

Habitats of Haynes Inlet include subtidal channels with unconsolidated bottoms; intertidal flats of sand, mud, and sand-mud mixed; eelgrass beds; low marsh; high marsh; and sand shores (Fig. 18).

In a brief qualitative survey, invertebrates of the Haynes Inlet mudflats were similar to those recorded in North Slough included (Rischen and Danielson 1970). Additional species not recorded in North Slough included several species of amphipods and the nudibranch *Hermissenda crassicornis*. The California papershell, *Lyonsia californica*, has not been recorded elsewhere in Coos Bay. An oyster farm operated there before construction of the Highway 101 Causeway. The presence of shells suggest that cockles once inhabited the sea.

Fish seined in Haynes Inlet include threespined stickleback, shiner perch, topsmelt, bay pipefish, staghorn sculpin, and starry flounder, all species with wide distributions in Coos Bay (Hostick 1975) (Table 9). Bender (pers. comm.) noted that large numbers of anchovies occur near the mouth of the inlet in September and October. Boat angling for striped bass is popular in Haynes Inlet in May through September. Shiner perch, pile perch, and striped seaperch are also taken there by shore anglers. Larson and Palouse creeks are both productive coho and steelhead streams (pers. comm., Bender). Larson Creek is used to chart coho population trends in coastal streams. It has the highest number of spawning coho of the 3 creeks surveyed by ODFW in the Coos system. A sport fishery for coho develops in October and continues until the end of steelhead season (pers. comm., Bender).

Haynes Inlet is heavily used by waterfowl. The most abundant winter species include black brant, American wigeon, ruddy duck, American coot, pintail, greenwinged teal, and mallard (Magwire 1976b). Few species appear to use the area in summer, but great blue heron are common (Magwire 1976b) and use the inlet as a feeding area (McMahon 1974).

Several hundred acres of salt marsh have been diked for agricultural use in Haynes Inlet (Hoffnagle and Olson 1974). About 150 acres of marsh remain, including immature high marsh, sedge marsh, bullrush-sedge marsh, and one of the few areas of low silty marsh mapped in Coos Bay (Hoffnagle and Olson 1974).

The watershed of Haynes Inlet has a fairly high level of both agriculture and logging (Wilsey and Ham 1974). Other human uses of the slough and adjacent uplands include a small mill and log dump, residences, light commercial use near the mouth, and a boat launch and wayside (Wilsey and Ham 1974).

Recommendations

Haynes Inlet was classlified as an area of moderate marine biological value and high terrestrial biological value by Wilsey and Ham (1974). Of particular significance are the salt marshes of the upper end of the inlet, which are listed by Jefferson (1975) as an area that should be protected for primary production in Coos Bay.

The Highway 101 causeway has changed tidal circulation within Haynes Inlet and may be contributing to accelerated accretion. It may be advisable to increase ciruclation with the main bay through a system of culverts. Leaking tidegates, especially the one controlling the entrance to Larson Creek, have necessitated recent diking to protect agricultural land from salt water intrusion. Dike material should be obtained from upland sources rather than from the adjacent channel to protect water quality and bottom characteristics, which are important for anadromous fish using these streams.

Isthmus Slough Subsystem

Isthmus Slough is a very long, narrow body of water which enters the upper southwest corner of Coos Bay at about RM 13.8 (Fig. 17). Head of tide is about 12 mi up the slough (Wilsey and Ham 1974). The drainage area of Isthmus Slough is 32 mi^2 (Arneson 1976), and major tributaries include Coalbank Slough, Shinglehouse Slough, Davis Slough, and Noble Creek.

In Isthmus Slough the deep draft navigation channel extends to RM 15 at a depth of 35 ft and width of 400 ft. Near the mouth of Coalbank Slough a turning basin has recently been enlarged to 700 ft by 1,000 ft. Major shipping activities occur in this area of the bay. A shallower channel 22 ft deep and 150 ft wide extends from RM 15 to Millington at RM 17. It is privately maintained and used primarily for log transport (USACE 1976).

Freshwater flow has been calculated for Isthmus Slough using drainage basin area and precipitation averages (Arneson 1976). In 1973-74 minimum flow was estimated at 1.4 cfs in September 1973 and maximum flow at 304 cfs. Extreme salinities of 30.6 ppt and 4.7 ppt have been measured at the Eastside Bridge over the slough. Salinities at the Coos City Bridge measured 30.2 ppt and 0.3 ppt (DEQ 1978). Downstream from Eastside a minimum salinity of 0.2 ppt has been measured, which probably indicates the influence of fresh water from Coos River.

Salinity profiles show Isthmus Slough to be well mixed at essentially all times of the year (Arneson 1976). In December, when some portions of the estuary were stratified, Isthmus Slough was well mixed at high tide and essentially fresh water at low tide (Arneson 1976). The well mixed condition of the slough may be attributed to limited freshwater inflow (Arneson 1976), even though diking has greatly reduced the tidal prism in the slough (Aagard 1971). Water temperatures as low as 46.4°F have been recorded in Isthmus Slough, while maximum temperatures of 73.4°F have occurred at upstream stations (DEQ 1978).

Isthmus Slough receives heavy industrial use for shipping, waste disposal, and log handling and storage. These uses combined with minimal flushing (Arneson 1976) and low freshwater inflow cause dissolved oxygen to be lowest in

Isthmus Slough of the stations measured in Coos Bay (DEQ 1978). DEQ data show that DO improved from 1974 to 1978, but measurements less than the minimum standards for estuarine waters still occur(DEQ 1978). USACE (1976) reports Isthmus and Coalbank sloughs are moderately to heavily polluted according to EPA standards.

High coliform counts have been recorded in Isthmus Slough. Of the stations measured by DEQ, the most frequent and severe violations occurred in Coalbank Slough and downbay from Coalbank (DEQ 1978). At the upper stations coliform less frequently exceeded standards for general health but was often over the maximum for commercial shellfish harvesting areas.

Sediments of Isthmus Slough are river-born silts (Arneson 1976). Although winter freshets do aid flushing, the slow currents of the slough and general lack of fresh water inflow contribute to the deposition of fine material (Arneson 1978). Wood chips and bark also occur in the substrate of much of the slough. Anerobic sediments are found in most areas (Thompson 1971).

Habitats and Species

The habitats of Isthmus Slough are predominantly the unconsolidated bottom in the channel, muddy shores which are sometimes covered by eelgrass beds, and marshes (Fig. 18). Log rafts are often stored and ground along the tidal flats. Consequently, the exact location of aquatic beds and marshes is subject to change as vegetation is removed and reestablishes itself.

A survey of organisms of Isthmus Slough, primarily those of the tidal flats, was conducted by Thompson (1971). Algae noted in the slough include the green (*Enteromorpha tubulosa*), reds (*Gracilaria* spp., *Antithamnion* spp., *Platythamnion* spp., *Polysiphonia* spp., and *Gigartina* spp.), and the brown (*Fucus* spp.). *Ruppia* is found in increasing abundance in aquatic beds toward the southern end of the slough in less saline water.

Invertebrates primarily include crustacean arthropods and polychaete worms. Only six molluscs are recorded from Isthmus Slough. The softshell clam is the only species taken recreationally. Historical notes show softshells were once more abundant than at present (Thompson 1971).

The arthropods found in the slough are the shrimp *Crago franciscorum* and the crabs *Cancer magister, Rhithropanopeus harrisii,* and *Hemigrapsis oregonensis* (Thompson 1971). At least eight species of amphipods and isopods are also found. The amphipods were primarily in channels under algae, and in eelgrass beds. *Anisogammarus confervicolus* became less dense with increased temperature and decreased salinity. *Corophium* spp. were found farther into freshwater than *Anisogammarus*.

The most abundant polychaete worms were the nereids, *Nereis brandti* and *N. limnicola*. *Heteromastis filiformis* and *Capitella (Capitata) ovincola* were found in reducing layers, and ampharetids and spionids were found throughout the slough. Many of the annelids found have been termed pollution indicators.

At least 11 species of fish have been seined from Isthmus Slough (Table 9).

Adult coho salmon have been seined in Coalbank Slough, and a spawning run of coho occurs in tributaries of Isthmus Slough and in Davis Slough (pers. comm., Mullarkey and Bender).

Historically Isthmus Slough has been used by striped bass which tend to seek out deep holes and channels (pers. comm., Bender). Isthmus Slough was a prime striped bass fishing area until low DO and chemical wastes apparently prevented all use of the slough by striped bass. Conditions have improved somewhat and bass are again showing up. Several age classes of stripped bass have been found south of Davis Slough which have not recently been seen in other portions of Coos Bay (pers. comm., Mullarkey and Bender). It is possible this area is critical to the bass at certain stages of their life cycle (pers. comm., Bender). In February and March striped bass fishing is popular from the banks of Isthmus Slough.

Many of the marshes in Isthmus Slough have been eliminated by diking, filling, and log storage. In Coalbank Slough alone, marshes occupied 597 ac. in 1892, and now only 57.0 ac. remain (Hoffnagle and Olson 1974). The major marshes of Isthmus Slough occur along its banks and in Coalbank, Shinglehouse, and Davis sloughs. Marshes of Coalbank Slough include a 25 ac. marsh separated from the channel by a dike with culverts and a 35 ac. marsh partially bordered by an old dike. These marshes have characteristics of sedge marshes and immature high marshes, but *Carex lyngbyei* is the dominant species present (Hoffnagle and Olson 1974).

Along the main channel of Isthmus Slough south of the mouth of Coalbank Slough lies the estuary's largest expanse of low silty marsh, which is returning to its former state after being diked (Hoffnagle and Olson 1974). Sedge and immature high marshes occur along the main Isthmus Slough channel south of the silty marsh, and bullrush-sedge marsh occurs at the south end of Isthmus Slough (Hoffnagle and Olson 1974). Sedge marshes occur in Shinglehouse Slough, and Davis Slough has marshes of bullrush and sedge. Total undiked marsh acreage of Isthmus Slough and its tributaries is 431.8 ac., which contains 62.8 ac. of sedge marsh, 64.6 ac. of low silt marsh, 219.0 ac. of immature high marsh, and 85.4 ac. of bullrush and sedge marsh.

Recommendations

Hoffnagle and Olson (1974) estimated that 90% of the total acreage of Coos Bay marshes have been lost to filling or other causes since 1892. It is therefore critical that remaining marsh lands be protected from filling and diking in order to maintain habitat diversity in the estuary, as well as the flow of organic material to and from marsh communities. Significant tracts of salt marsh remain in Coalbank and Shinglehouse sloughs and should be preserved for primary production (Jefferson 1975).

Much of Isthmus Slough can be considered degraded habitat, and restoration measures should be undertaken to restore water quality and biological production. The acreage of tide flats impacted by grounding log rafts should be minimized. Log rafts should be removed from intertidal areas wherever feasible. The inventory of logs stored in the slough at any given time and the length of residence of stored logs should not exceed the minimum levels required to keep pace with mill production. All unused pilings, derelict logs, and wood debris should be removed. Breaching of several partially diked areas of Isthmus Slough should improve circulation, water quality, and the flow of materials between these areas and the other portion of the subsystem. The 35-ac. marsh in Coalbank Slough and the low silty marsh east of the channel just south of Eastside should also be considered for restoration through dike removal.

Increased circulation to the 25-ac. Coalbank Slough marsh should be considered to improve the exchange of organic materials with the remainder of the estuary.

Davis Slough and the section of Isthmus Slough above it should remain free of log storage or other uses which would further degrade water quality in the subsystem. Log storage has been gradually phased out in upper Isthmus and Davis sloughs, and during the same period water quality has improved significantly. This recovery and the poor circulation in these upper reaches suggest the area may be particularly important in maintaining the water quality of Isthmus Slough.

Catching Slough Subsystem

Catching Slough enters the main body of Coos Bay just west of the mouth of Coos River (Fig. 17). It is fed by several small streams and is about 10 mi long from its mouth to its head (Wilsey and Ham 1974).

In the late 1800s, Catching Slough was an area of vast tidal marshes and a large tidal prism. Strong tidal flushing was responsible for maintaining depths of 18 to 20 ft at the confluence of the Catching Slough channel and the Marshfield Channel. By the 1940s diking of Catching Slough for agricultural purposes had decreased tidal transport and velocity through Marshfield Channel (Aagard 1971).

Little is known of the physical or biological processes of Catching Slough. Freshwater inflow is unmeasured, but STR (1974) state that because of low summer flow, tidal circulation during summer in Catching Slough is a simple exchange of water from the main bay.

In a single series of summer water quality samples, high temperatures, probably resulting from low summer flows, were noted (STR 1974). Fecal coliform increased from the mouth toward the head of the slough (STR 1974) and could be expected to be greater at times of high runoff.

Habitats of Catch Slough include the subtidal channel, narrow muddy shores, eelgrass or ditchgrass beds, fringing tidal marshes, and rip-rapped shores (Fig. 18). Typically these habitats occur in narrow bands zoned from lowest to highest as listed. The tidal marshes are the only Catching Slough habitat that have been studied.

Tidal marshes of Catching Slough once totalled 1,600 ac., but through extensive alterations for agricultural use, only fringing marshes of bullrush and sedge totalling less than 50 ac. remain (Hoffnagle and Olson 1974).

Distribution of invertebrates in Catching Slough has not been studied. Large numbers of juvenile American shad have been seined from Catching Slough

(Hostick 1974). Coho salmon and steelhead spawn in the upper reaches of the slough (pers. comm., Mullarkey and Bender). Other fish seined from the slough include species with wide distributions in the upper bay and sloughs, such as shiner perch, staghorn sculpin, threespine stickleback, starry flounder, and bay pipefish (Cummings and Schwartz 1971). Water in the upper part of the slough apparently is sufficiently fresh to maintain significant numbers of largescale suckers. Recent gill netting surveys by ODFW have shown the area is also used by striped bass.

Recommendations

Materials needed for dike repair should be obtained from upland sources rather than by dredging in the slough. Dredging can convert productive intertidal areas into less productive subtidal habitats and degrade surrounding habitats. Consideration should be given to restoring a portion of the large amount of diked tidal land to estuarine production. Derelict pilings previously used for log storage should also be removed.

Catching Slough supports good runs of coho salmon in Catching, Selander, and Wilson creeks. Recent sampling suggests the slough may also be an important area for 5- and 6-year-old striped bass. Isthmus Slough is the only other area where concentrations of this age group of striped bass have been found, but Isthmus Slough may be unsuitable for the fish during the summer due to low DO. Water quality in Catching Slough should be maintained and improved for fish and other organisms dependent upon the area. Catch Slough has good potential for recreational fishing, and public use may be improved with increased access.

Coos Riverine Subsystems

There are several riverine subsystems in the Coos Bay estuary, including the Coos and the South Fork Coos rivers and Millicoma river, which enters the Coos River. Tidewater extends more than 11 mi upstream from the boundary of the upper bay subsystem (Fig. 17) on the South Fork Coos and 10.6 mi upstream on the Millicoma River (Wilsey and Ham 1974).

The riverine subsystems provide important fish habitats. Shad are entirely dependent on the area during the first 6-12 months of life and part of their second year. Coho and steelhead can be found in the spring enroute to their spawning grounds. The Coos system is a major freshwater rearing area for chinook, especially during their first year. Juvenile cutthroat also rear in the system, and adults return in late summer to spawn. The lower portions are also used by starry flounder and staghorn sculpin. Prickly sculpin and shiner perch occur in the upper portions. Other species found in the riverine subsystems include red-sided shiners and largescale suckers. Shiner perch and largescale suckers are important forage fish for striped bass (pers. comm., Bender).

This section of the estuary is a popular fishing area for shad (May-July), striped bass (year-round), cutthroat (August-October), coho and chinook (September-November), and steelhead (November-March). Commercial shad fishing takes place on the lower Millicoma, South Fork Coos, and throughout the Coos River.

Recommendations

Generally there is little specific information on other biological and physical characteristics of the riverine subsystems. The habitat map (Fig. 18) does not depict habitats far beyond the upper bay subsystem. However, the Coos riverine subsystems are similar to the tidewater areas of other coastal rivers, and many of the same general considerations should be made in developing management strategies.

The Coos Bay riverine subsystems should be managed as units to prevent the piecemeal destruction of shoreland habitats. Riprap, bulkheads, and docks can destroy riparian vegetation, which is important for fish and terrestrial animals. Docks can reduce the productivity of aquatic plants by shading. Riparian vegetation should be protected as suggested in the implementation of the LCDC Coastal Shorelands Goal (LCDC 1977). New homes and other structures should be placed a sufficient distance from the shore so that bank stabilization measures are not required. This will also help reduce flooding and erosion caused by encroachment into the floodway fringe. Non-structural solutions to erosion and flooding are also encouraged in the LCDC Coastal Shorelands Goal. Bank stabilization should only be allowed as part of an overall stream corridor management plan.

Dredging during July and August will have the least detrimental impact on the riverine fisheries. Spawning and larval development of shad and striped bass occur in the spring (April-June). After September, the tidewater sections are used extensively for sport fishing.

Pollutants discharged into the riverine sections of estuaries can be particularly detrimental to estuarine water quality since flushing times are extremely long much of the year, and all material from the upper estuary may affect the rest of the system downstream. Adequate waste treatment facilities are needed to prevent pollution of the riverine subsystem. Particular care must be excercised to prevent oxygen depletion and high water temperatures, which can stress fish, and to maintain minimum stream flows. Logging and other activities which cause erosion within the riverine subsystems and in the upper watershed should be carefully regulated to prevent rapid filling, which has occurred in many Oregon estuaries as a result of these activities.

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