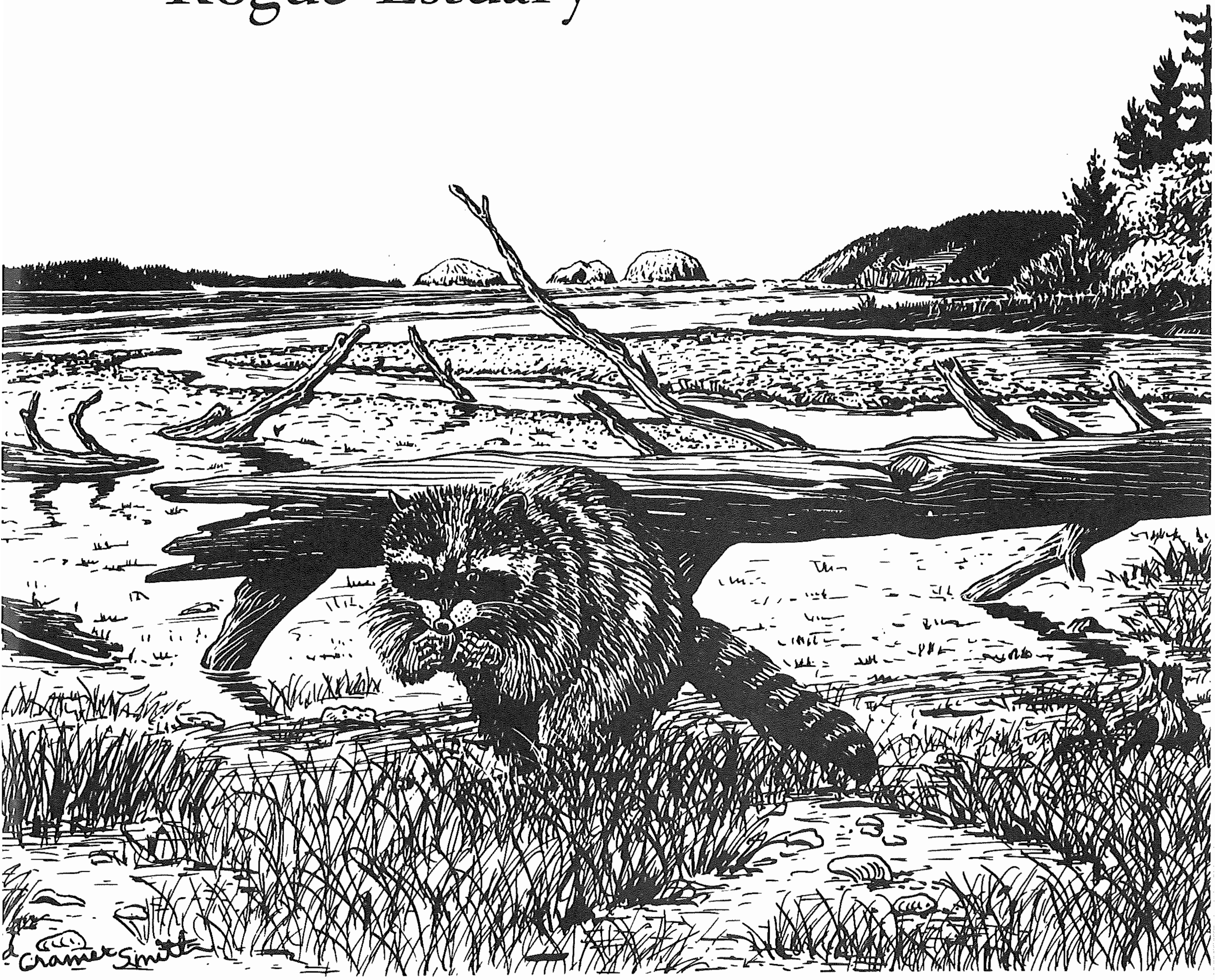
Natural Resources of Rogue Estuary



ESTUARY INVENTORY REPORT

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FINAL REPORT

ESTUARY INVENTORY PROJECT

OREGON

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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 in fulfilling the inventory and comprehensive plan requirements of the Land Conservation and Development Commission's Estuarine Resources Goal (LCDC 1977b).

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 1977b). 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.

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THE ROGUE ESTUARINE SYSTEM

Introduction

The Rogue estuary (Fig. 1) on the southern Oregon coast is short and small, although the Rogue River drainage ranks second in size among coastal rivers. Only the Columbia River basin is larger. The estuary provides habitat and passageway for many species of anadromous fish but lacks tideflats and tidal marsh which are common in estuaries to the north. Seasonal variations in freshwater flow strongly influence the characteristics and processes of the estuary.

The city of Gold Beach (population about 1,500) is located on the southern shore. The Port of Gold Beach has promoted the development of oceangoing navigation. Jetties, dikes, and boat basins have extensively altered the lower estuary. The Oregon Land Conservation and Development Commission classified the Rogue as a shallow draft development estuary in recognition of the navigational development (LCDC 1977a). The classification provides for a diversity of uses of the estuary, while the Estuarine Resources Planning Goal (LCDC 1977b) also requires protection of important habitats, productivity, water quality, and unique features. This report discusses the historical changes and natural resources of the Rogue estuary and makes planning recommendations to protect and enhance the estuary.

Historical Changes

Recent development of the Rogue for oceangoing navigation has met with limited success. Originally the mouth of the Rogue River was virtually unnavigable with controlling depth over the entrance bar between 2 feet in late summer and 9 feet in winter [U. S. Army Corps of Engineers (USACE) 1975]. The Rogue River jetties were completed in 1960 by the USACE to stabilize the position of the entrance. The jetties were built 1,000 feet apart to

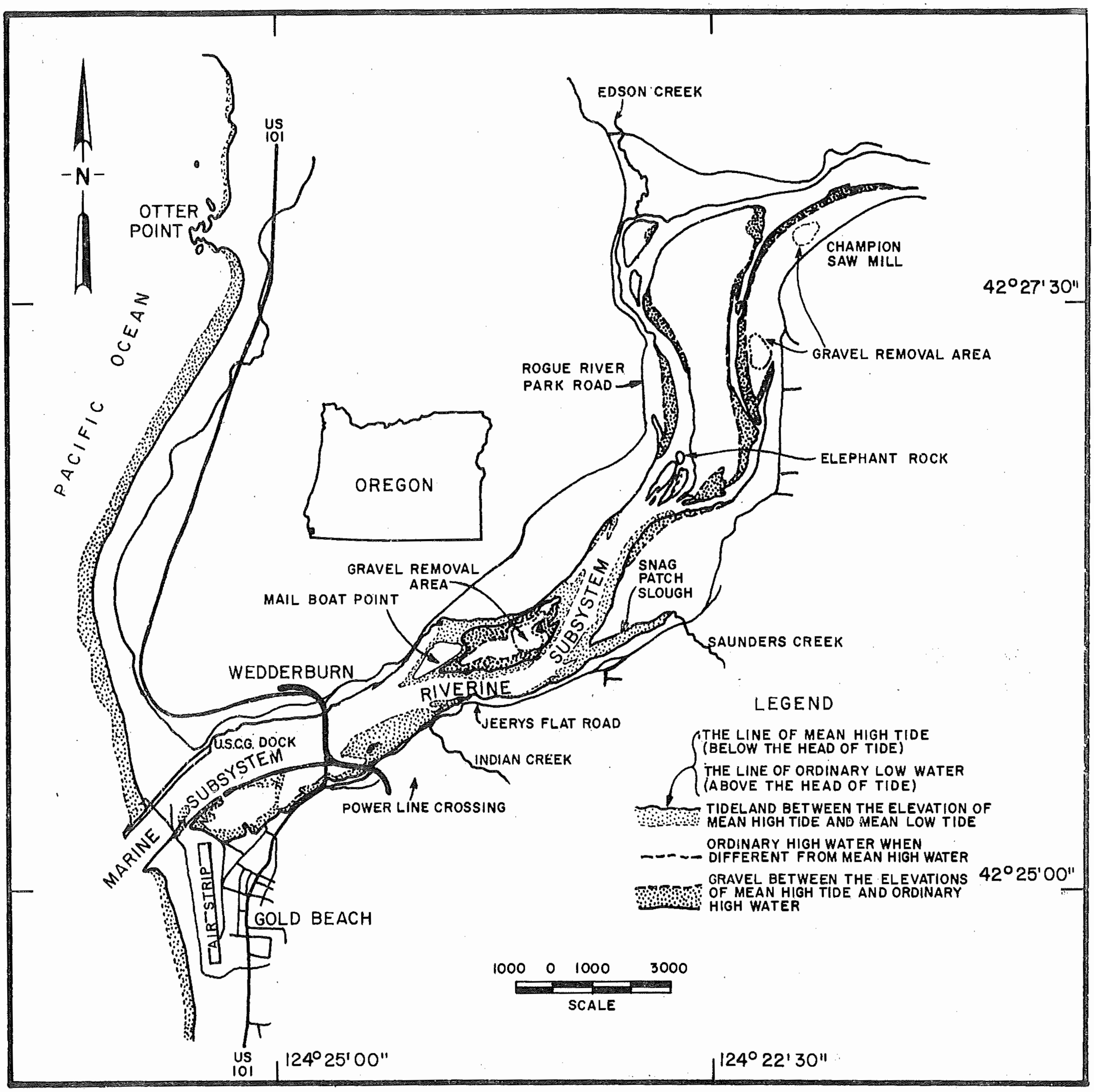

Fig. 1. Rogue estuary and subsystems [Oregon Division of State Lands (DSL) 1973].

to accommodate winter flooding, and a 13-foot channel was dredged in 1961 with a turning basin on the north side of the river.

Natural seasonal shoaling continued to be a navigational problem soon after the project was completed. A breakwater dike from the highway 101 bridge tangent to the south jetty was proposed as a solution. The dike was designed to increase scouring by narrowing the river channel and increasing the current. The project was initiated in 1964 but was abandoned by the USACE due to record floods. Shoaling was so severe in 1970 that lumber barge traffice was halted, and the USACE hopper dredge Pacific could not enter the estuary for maintenance dredging. In 1971 the Port of Gold Beach resumed work on the project and completed construction 2 years later. To date the shoaling problem has not been alleviated. A study was recently funded through the USACE to seek a new solution. An average of 112,000 yd^3/yr must be dredged from the shoals to maintain the waterway (USACE 1975).

The dike also served as a breakwater for the large shallow area to the south. The Port has developed part of the area as a marina. The USACE dredged a 10-foot deep entrance channel and turning basin into the new marina. The basin entrance is also plagued by annual sedimentation (USACE 1975).

The northern shore has been extensively riprapped, and there are several boat moorages. The Mail Boat and other commercial jet boats make regular trips up the river from the estuary. Other developments include the U. S. Highway 101 bridge abutments and gravel removal from a high bar in the upper estuary.

Physical Characteristics

The Oregon Department of Fish and Wildlife (ODFW) has collected physical data on the Rogue estuary as part of an ongoing program to assess salmon populations in the river system. Much of the data remains unpublished. USACE has also collected sediment and depth data. Tides, currents, and circulation patterns have not been extensively surveyed.

Drainage basin and freshwater flow

Nearly half of the large (5,100 mi^2) Rogue River drainage basin lies within the coastal mountains of the Klamath Range. Headwaters rise from the inland mountains of the Klamath and Cascade ranges. The upper Rogue River has been dammed in several places to provide irrigation water and flood control and to supplement summer flow. The dams have not significantly altered the flow pattern at the mouth (Percy et al. 1974). The recent additions of Lost Creek and Applegate dams may have a greater effect on the future flow patterns. Mean monthly flows for the Rogue River ranged from 16,400 cfs in January to 1,200 cfs in September (Table 1). The average flow in the Rogue is slightly less than in the Umpqua River, but the flow pattern is similar. Compared with other coastal rivers, the Rogue and Umpqua have a smaller ratio between average monthly high flow and low flow.

Shape and dimensions

The Rogue estuary follows the shape of the river channel. Extreme flood tides extend 4.5 miles upstream. In the upper end of the estuary, the channel splits around a large island. Most of the island is above ordinary winter flow levels. A wide area near the mouth is bisected by the Port of Gold Beach dike. The shallow area of the boat basin is essentially cut off from the currents of the deeper channel to the north.

The Rogue is one of the smallest Oregon estuaries. DSL (1973) computed an area of 627 acres at mean high tide. Actual estuarine area is about three times greater, since tides extend further upstream than DSL measured, and high flows during winter submerge some of the higher gravel flats that remain exposed during low flows (the darkly shaded areas in Fig. 1).

Table 1. Median monthly discharge at the mouth of the Rogue River (USACE 1975).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Discharge (cfs)	16,400	15,550	12,200	10,700	8,100	5,100	2,100	1,400	1,250	2,850	6,650	11,950

Depths of the Rogue channel vary greatly. ODFW (1979) measurements indicate minimum depths at low tide range from 23 ft along the north jetty to just over 5 ft in cross sections near the boat basin and Elephant Rock (Fig. 1).

Tides

The mean high tide on the Rogue is 4.9 ft (Johnson 1972). Tides of this range extend about 4 miles from the mouth to a riffle below Edson Creek. The mean higher high water (MHHW) is 6.7 ft, and many summer tides extend to another riffle at river mile (RM) 4.5 (above Edson Creek near the Champion sawmill) (Fig. 1). During winter the increased flow probably reduces the penetration of the tide, but the effect has not been measured. The tidal prism (volume of water between MLW and MHW) is estimated to be 1.6×10^8 ft^3 (Johnson 1972). During high river flows, the volume of incoming water during a tidal cycle is several times greater than the tidal prism. Even summer flows produce a volume nearly as large as the tidal prism (USACE 1975) to match the incoming tide, which is unusual for most Oregon estuaries.

Salinity and mixing

Salinity intrusion in the Rogue estuary is limited, compared to other estuaries of similar surface area. This is due to the steep river gradient and the high volume of river discharge.

The ODFW (1979) has collected extensive salinity data in the Rogue channel for several years. However, seasonal salinity distribution and mixing patterns have not been determined. Saltwater intrusion reached RM 3.6 once in 1977. However, in the other years the maximum extent of saltwater intrusion was RM 2.7. A riffle located just above the mouth of the Snag Patch Slough (Fig. 1) probably represents the first barrier to marine water during low river flows and tides less than 6 ft (ODFW 1975).

Salinity data show that the Rogue estuary is never fully mixed. Even during low flow the surface salinity was less than 10 ppt while bottom salinity usually approached ocean levels at 28-31 ppt throughout the extent of the salinity wedge. The partially mixed wedge of saline water commonly extended to RM 2.2 at high tide and to RM 1.9 at low tide.

During fall, winter, and spring when the river flow at Agness from the Rogue and Illinois was greater than 7,000 cfs, the system was two-layered, having a distinct transition between the wedge of salt water and the surface freshwater. The salt wedge generally did not penetrate further than the base of the north jetty at high tide.

Salinity in the Rogue estuary is related not only to river flow and tides but also to the formation of a sand spit at the mouth. Boyce (1979) found two separate relationships between flow and bottom salinity. In 1975 when the spit restricted flow, the fall salinity levels were lower than the early summer levels at the same flow.

The salinity gradients within the estuary and water column probably influences the distribution of adult and juvenile fish. Boyce (1979) demonstrated that bottom salinity and flow also influenced the population of two benthic crustaceans (*Corophium* and *Anisogammarus* spp.) which are important in the diets of salmonids. The average seasonal distribution of bottom salinity for the entire estuary is shown in Fig. 2.

Water quality

Estuarine water quality of the Rogue appears within acceptable limits established by the Oregon Department of Environmental Quality (DEQ), even during low flow. A few random water quality measurements were taken by DEQ (1978) at four stations in the estuary. ODFW also monitored temperature, dissolved oxygen, and nutrients from 1974 to 1978 (Cramer and Martin 1978).

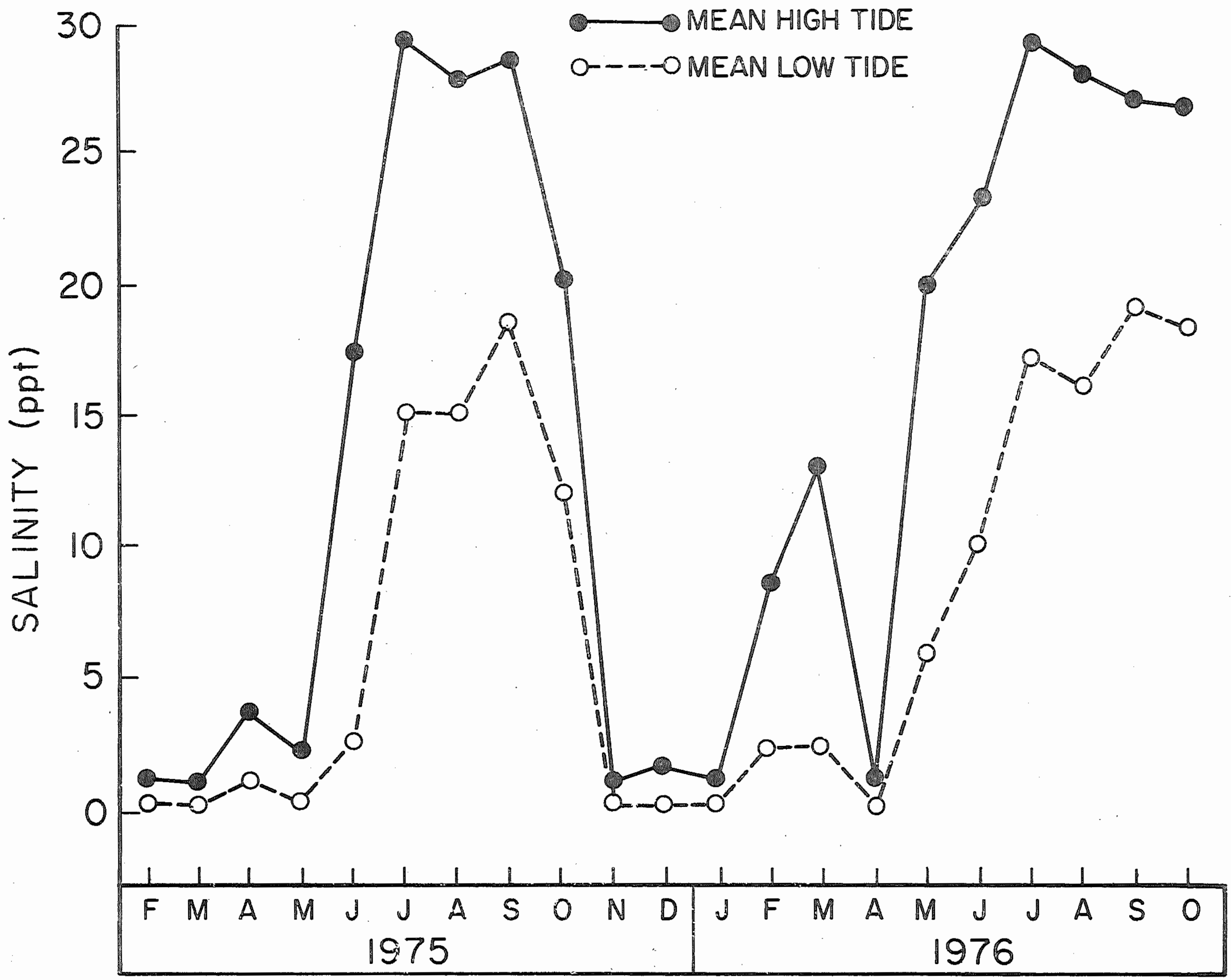

Fig. 2. Mean bottom salinity during mean high and low tides in 1975 and 1976 (Lichatowich and Martin 1977).

A few temperature and salinity measurements were available for the boat basin behind the protective dike (Crumley 1978). The basin is more vulnerable than the rest of the estuary to contamination because of restricted flushing. Three tidal cycles are required to flush the basin (Slotta and Noble (1977). Flushing in the main estuary has not been studied but is probably much more rapid during high river flows. During low flow flushing is retarded by the formation of a sand spit inside the jetties. But even flushing during low flow is more rapid than in most Oregon estuaries due to the large volume of incoming freshwater and the short distance from head of tide to the mouth.

From April 1975 to October 1976 dissolved oxygen concentrations in the estuary were generally above 80% of the saturation level (Lichatowich and Martin 1977). Cramer and Martin (1978) reported surface, mid-depth, and bottom concentrations at 3 stations. Surface concentration was only less than 6 mg/l on one occasion in December 1976 (at low flow). The concentration of dissolved oxygen at mid-depth and bottom was generally below 6 mg/l. A bottom concentration of only 1 mg/l occurred in December 1976. Low concentrations at the bottom were also reported in the upper estuary during low flow, indicating an accumulation of organic material on the bottom when currents were reduced (Lichatowich and Martin 1977).

The temperature distribution in the Rogue is affected by the two-layered and partial mixing conditions. Cool ocean water concentrates on the bottom, while surface water temperature fluctuates with river temperatures (ODFW 1979). Unlike most Oregon estuaries, the Rogue lacks extensive intertidal areas capable of direct absorption or loss of heat. The bottom temperatures during summer were never 68 F except at the upper end of the estuary. The surface temperature during summer often exceeded that value.

The nutrient data for the Rogue (Lichatowich and Martin 1977), suggest that the river carries a large amount of phosphates into the estuary. High river flow was accompanied by higher phosphate concentrations at the bottom. The phosphate concentration was lower at the mouth of the estuary than upstream during lower flows in the summer. Nutrient concentrations are affected by the extent of phytoplankton production. The concentration of phosphate was lowest at the surface, possibly indicating a significant uptake of nutrients by phytoplankton.

Sediment transport

The sediments in the Rogue River estuary are primarily terrestrial. River flow and shoal formation restrict deposition of ocean sands to the mouth of the estuary. When river flow is high most suspended sediments carried by the river are transported beyond the mouth. The Rogue also transports gravel along the bottom at high flow. When river flow decreases in summer and early fall, estuarine deposition of riverborne sediments increases. Those sediments accumulate over the gravel base in the upper estuary.

A sand sill often forms at the entrance along the south jetty. The shoal or spit forms as normal ocean swells shift from south to north with the onset of summer and decreased river flows. A southward littoral drift results, depositing the sand at the estuary mouth. Waves also move material along the south jetty and into the entrance of the boat basin (USACE 1975). The main shoal can extend most of the distance between the jetties. It is usually partly removed by maintenance dredging but may remain until it is eroded by floods. Winter floods up to 400,000 cfs can transport a million yd^3 of sand and gravel (USACE 1975). Such floods remove all fine sediments which accumulate in the estuary over the summer.

Biological Characteristics

Two biological surveys have been conducted on the Rogue estuary. An ongoing ODFW study sponsored by the USACE concerns the population and ecology of adult and juvenile salmonids in the Rogue system. The estuarine environment and the production of two benthic organisms consumed by salmonids in the estuary are important aspects of the study. Oregon State University has also sponsored a study of marine mammals in the Rogue, which includes their feeding behavior and impact on the recreational fishery. Data on plant production, plankton, general benthic communities, non-salmonid fish species, and birds are limited.

Plants

Phytoplankton, algae, marsh plants, and organic material carried downriver provide the base of the food chain in the Rogue. The Rogue lacks seagrass beds and large tracts of marsh commonly associated with many Oregon estuaries to the north. There are a few areas of sparsely vegetated intertidal gravel marsh (Akins and Jefferson 1973) and beds of macro-algae attached to the extensive intertidal cobble substrate. Primary production rates of the various plant groups and nutrient sources have not been studied in the Rogue estuary.

Invertebrates

The benthic communities of the Rogue probably differ from those in many other Oregon estuaries because they must tolerate strong currents, unstable gravel sediments, and low salinity in the winter or recolonize each summer. The Rogue lacks bay clams and probably lacks ghost (*Callianassa californiensis*) and mud shrimp (*Upogebia pugettensis*). Larger invertebrates, such as crabs and true shrimp, that can move about use the estuary when conditions are favorable. Dungeness crab (*Cancer magister*) are caught in the estuary during late summer and fall.

ODFW has sampled invertebrates at four locations monthly for three years (Boyce 1979). The sampling revealed large populations of amphipods. *Corophium spinicorne*, a tube dwelling amphipod, was the most abundant species, followed by *Anisogammarus confervicolus*, a common, free-swimming gammarid amphipod. A few other species of the same two genera were also found. The size of the populations peaked during the summer, but the actual numbers sampled varied greatly from year to year at the different sites. Sometimes shallow areas had larger populations, and at other times the channel stations were more densely populated. Some of the physical conditions most closely related to the population levels were the timing of spring freshets, river flow, bottom salinity, and the accumulation of sediment on the gravel substrate (Boyce 1979). Other factors, such as predation and dissolved oxygen, could also have been involved. The amphipods were a common food of juvenile salmonids in the Rogue.

Fish

The fisheries associated with the Rogue River changed considerably over the years. There was a river-based commercial gillnet fishery for salmon until 1936 (Cleaver 1951). Sport fishing for salmon and steelhead takes place primarily offshore or in the river. Cutthroat trout are fished in the estuary. Fishing for marine species such as perch, smelt, and flounder is increasing in popularity.

Few fish in the Rogue estuary are permanent residents. Fish surveys have concentrated on salmonids, and little information other than angling data has been collected on other species. Runs of spring and fall chinook salmon and summer and winter steelhead are greater in the Rogue than any other coastal river in Oregon except the Columbia (Percy et al. 1974). Coho salmon, searun cutthroat, and a small population of chum salmon also occur in the Rogue. Spawning and upstream migration periods of adult anadromous fishes in the Rogue are shown in Fig. 3.

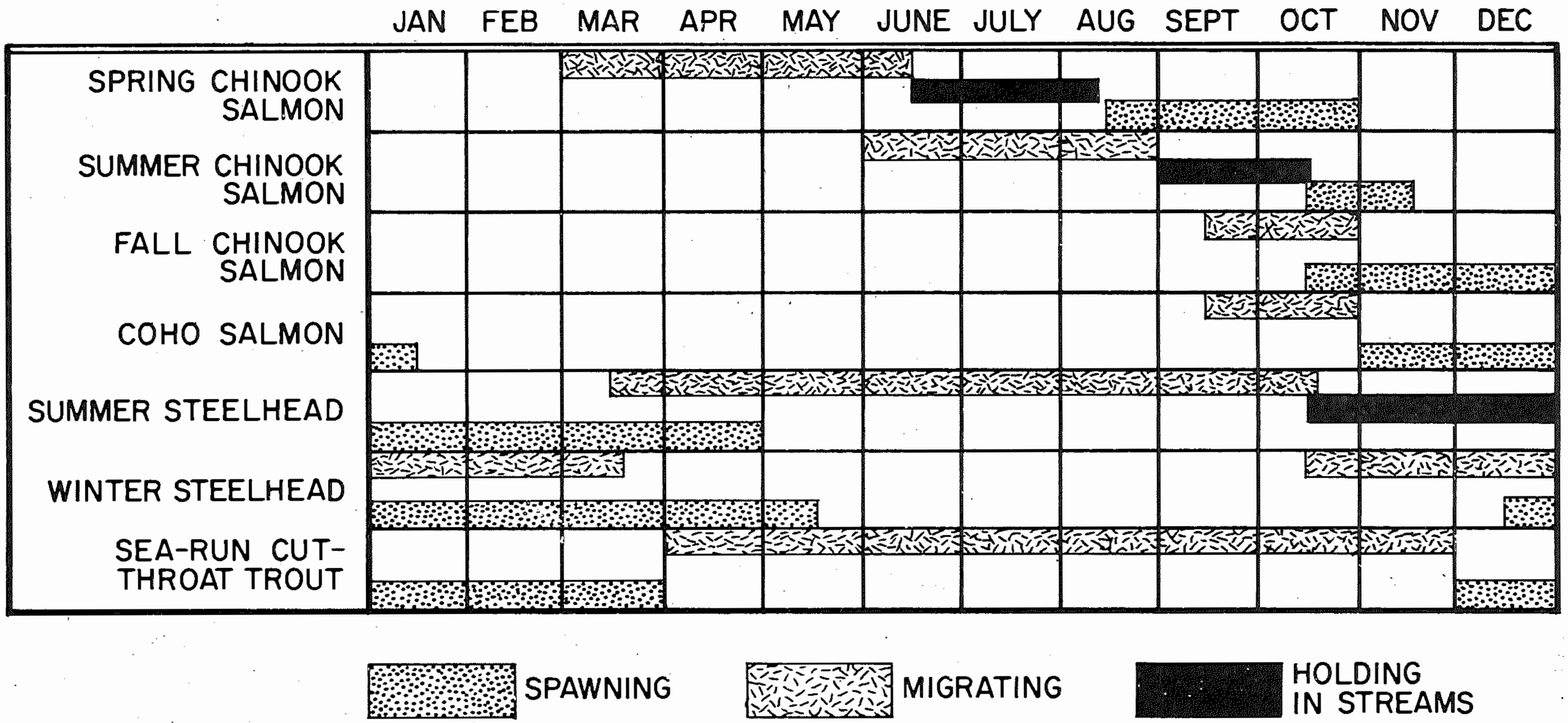

Fig. 3. Spawning and migration of adult salmonids, Rogue Basin. Dotted lines indicate presence of adult fish in the streams. Dashed lines denote migration period. Spawning periods are indicated by a solid line (Thompson and Fortune 1970).

Tomasson (1978) found that cutthroat trout mostly remain in the estuary prior to their first spawning rather than entering the ocean, and many reared in the estuary two seasons before spawning. More than 90% of the cutthroat caught in the estuary were first time migrants. Tomasson felt that the young age structure of the trout population may be an indication of heavy predation or overfishing. Juvenile chinook also rear in the estuary (Boyce 1979).

Marine fish such as shiner perch, surf smelt, and starry flounder come into the estuary during the summer. Some perch species spawn or bear their young in the estuary. Starry flounder feed in the estuary and may enter fresh water above tidal influence. Smelt and lamprey migrate through the estuary and spawn in the river system. About 100,000 adult shad migrate into the Rogue River (Riikula 1977), but there is no commercial fishery and little sport fishing for shad. Lingcod, stickleback, herring, and sturgeon also occur in the estuary. Several other fish species probably occur in the Rogue, but there has been no general sampling to determine the species or their seasonal distribution.

Birds and mammals

The Rogue estuary is not a major site for migrating waterfowl and shorebirds due to the lack of tideflats and marshes. There are two nearby great blue heron rookeries, and herons feed all along the shores of the estuary (Riikula 1978). Brown pelicans, an endangered species, are regular late summer and early fall residents in the estuary. This is probably the largest concentration of pelicans found along the Oregon coast. Ospreys and eagles also hunt in the estuary and nest nearby.

The Rogue regularly has the largest sea lion population of any Oregon estuary except the Columbia. Bruce Mate and Thomas Roffe of Oregon State University have been studying the population and their feeding behavior in the

Rogue since June 1976, and a final report may be completed by the end of 1979. California sea lions are common from October to June. Peak counts of 70 occur in the spring. Stellar sea lions are much less numerous in the estuary, but occur regularly from January through October. A maximum of six have been counted in the estuary. Most sea lions have been sighted in tidewater, although they have occasionally been seen as far as 30 miles upstream. Preliminary analysis indicates that Pacific lamprey are a major food item along with a variety of other fish (conversation May 10, 1979, with James Harvey, Oregon State University, Newport).

Harvey also said harbor seals were observed in the estuary feeding, resting and molting. The seals were present all year but were most abundant in the spring; 80-100 seals on the shore have been counted. The fewest were seen during summer when the adults were bearing their pups. Other marine mammals occasionally stray into the estuary but are not regular residents.

Terrestrial mammals also make extensive use of the estuary. Deer, bear, beaver, otter, muskrat, mink, bobcat, and coyote are common near the upper estuary and throughout the Rogue River basin (Riikula 1977).

ROGUE RIVER ESTUARINE SUBSYSTEMS

The Rogue River estuary can be divided into two major subsystems based on physical gradients and human modifications. The lower estuary is a marine subsystem with high salinities during summer and strong currents throughout the year. The riverine subsystem in the upper estuary also has strong currents but lower salinities. The Rogue lacks large bay or slough subsystems with broad intertidal areas and reduced currents typical of larger drowned river estuaries on the northern Oregon coast.

Marine Subsystem

The marine subsystem extends between the mouth of the estuary and the Highway 101 bridge at RM 1.0 (Fig. 1). More than 80% of the estuarine area is included in this subsystem. It covers approximately 335 ac but only 60 ac are intertidal (Table 2). Most of the development within the Rogue estuary is located in the marine subsystem.

Table 2. Approximate acreage of intertidal and subtidal habitats in the Rogue estuary (ODFW 1978).

	Marine subsystem		Riverine subsystem		Entire estuary
Subtidal	275		555		830
Intertidal	60		1,125		1,185
Below MHW		60		205	205
Above MHW		-		920	920
Total	335		1,680		2,015

Physical characteristics and alterations

The marine subsystem is almost continually influenced by the ocean. During low flow the water is partially mixed and bottom salinity and temperature are generally similar to the ocean, while the surface water is less saline and warmer in the channel. The water in the boat basin may be well mixed or predominantly ocean water. Crumley (1978) reported higher surface salinity in the basin than in the adjacent channel. During high flow the marine subsystem is two-layered or often entirely fresh at low tide.

Approximately 13 ac of intertidal and 14 ac of subtidal land was filled between 1960 and 1972 (DSL 1972). Fills included the dike, marina, and the development and riprap along the north shore. The dike created two separate environments, which are very different from what previously existed. The current in the channel is probably stronger throughout the year, while circulation in the protected basins is restricted to a single small opening. The basin has historically been a shallow subtidal and intertidal area with unrestricted circulation.

One of the main historic characteristics of the marine subsystem was its fluctuating channel locations and spits. Most of that variability has been eliminated by the jetties. Prior to completion of the jetties and training dike, the Rogue channel was located south of its present location and a south spit formed (Fig. 4) (Lizarraga-Aciniega and Komar 1975). The main channel was once also located to the north, under the highway 101 bridge. The dike crosses a shallow, subtidal remnant of an intertidal island that was formerly under the bridge. A small slough near Indian Creek on the south shore was cut off by the upper end of the dike. In addition, a broad intertidal shore was removed during construction of the north jetty.

Habitats and species

The habitats of the marine subsystem (Fig. 5) can be divided into three areas: the main channel, the subtidal areas behind the dike, and the intertidal habitats. There has not been adequate sampling to classify the subtidal substrate, but the channel is probably partly sand and partly cobble/gravel. Subtidal sediments in the boat basin may range from mud to sand.

Despite assumptions of poor sediment quality, Slotta and Noble (1977) found the Rogue boat basin was less polluted than other Oregon coastal marinas. Only a small portion of the basin is currently utilized for moorage. This probably accounts for the present quality of the sediments. Benthos have not been sampled in the boat basin. Reduced currents may enable that habitat to accomodate a higher diversity of benthic species than the channel.

The substrate of the channel downstream from the Coast Guard dock was predominantly sand and sulfide mud (Boyce 1979). Benthos in this area were

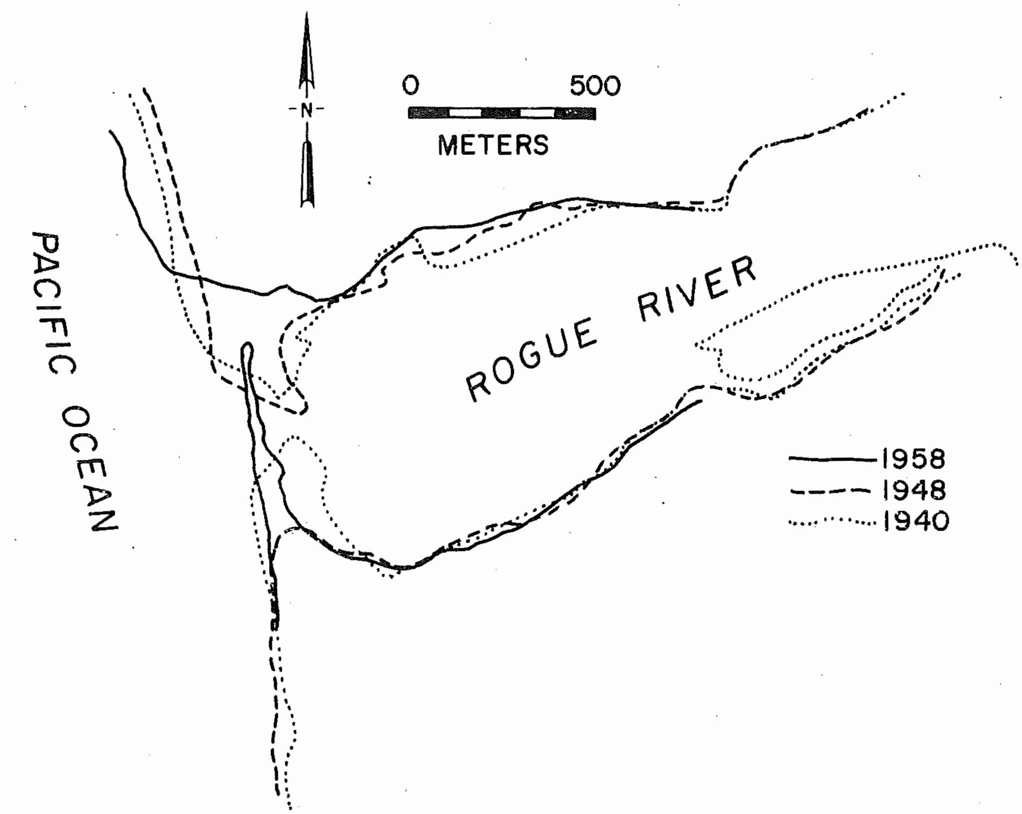

Fig. 4. Migrations of the mouth of the Rogue River prior to jetty construction (Lizarraga-Areienaga and Komar 1975).

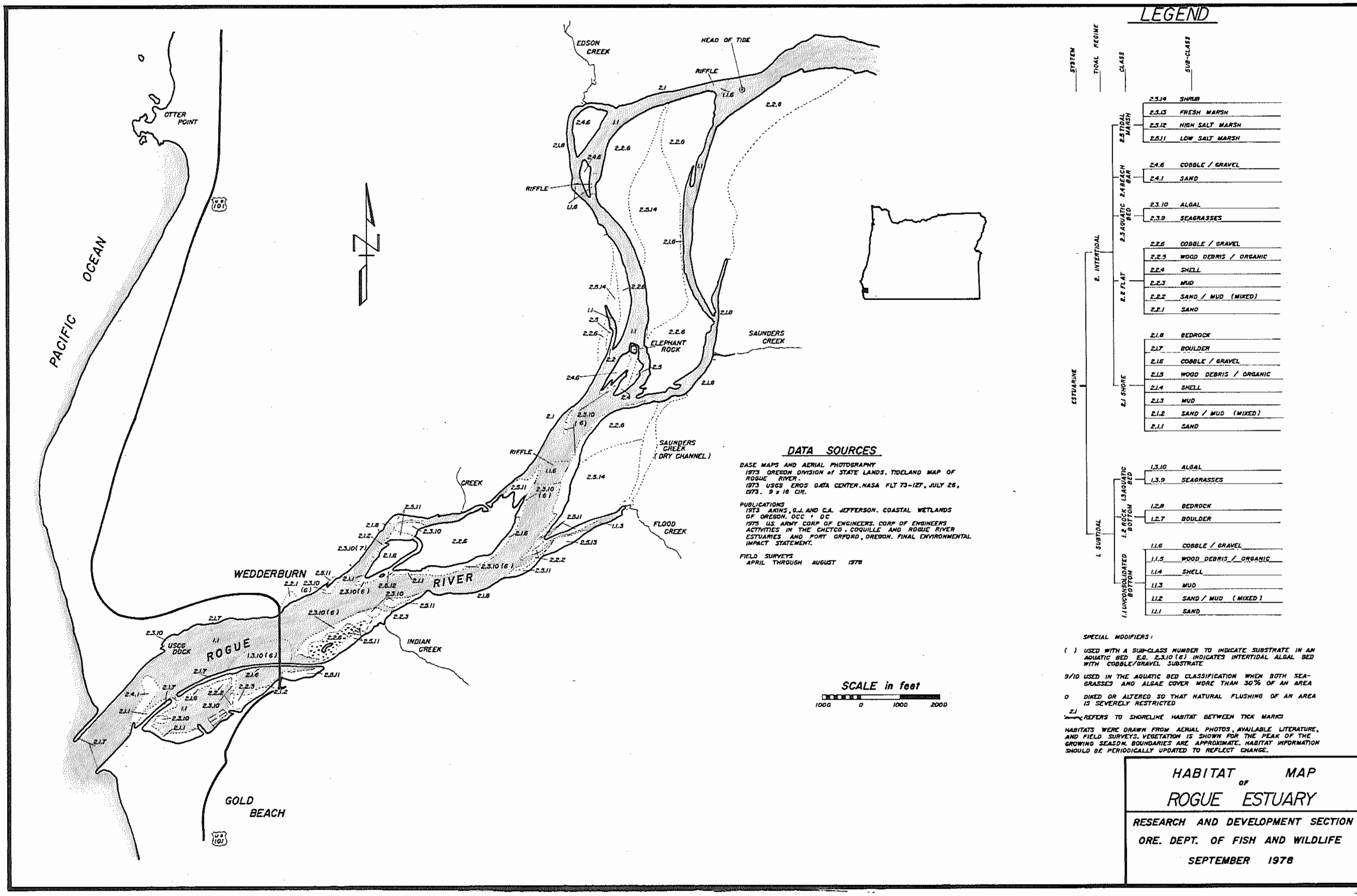

Fig. 5. Habitat map of Rogue estuary (ODFW 1978).

principally polychaetes. Sand and fine gravel substrate containing *Anisogammarus* spp. and *Corophium* spp. which are important in the diet of salmonids, were found in the marine subsystem upstream from the Coast Guard dock.

Most of the intertidal area in the marine subsystem is behind the dike. Although the intertidal area is small, there is a high diversity of habitat types, including sand and cobble/gravel shores, mud and mixed sand/mud flats, algal beds, and a low fringing salt marsh (Fig. 5). Such areas provide shallow habitat where small fish can rear and birds feed and may make a significant contribution to the productivity of the estuary.

Flushing is limited in the area behind the dike, especially at the eastern end. There is a long, shallow fill from the dike to the shore which has only a small opening. The shore along the fill is intertidal, and much of the area east of the fill is subtidal. On warm summer days the water which ponds in the area could become depleted of oxygen. No physical or biological data have been reported for the area.

Two specific intertidal areas outside of the diked area were noted by ODFW as locations where marine and anadromous fish congregate. One is a small tideland area along the north shore near the Coast Guard dock. It is the only undiked shoreland remaining in the marine subsystem. The intertidal shore forms a cove protected from swift channel currents. The other area is along the eastern edge of the spit that forms inside the jetties (Fig. 5). It is also out of the main current.

Small south coast estuaries unaltered by jetties typically form a sill or shoal at the mouth during summer low flow (blind estuaries). The sill inhibits flow to the ocean, forming an impoundment which inundates low shorelands and increases the productive area of the estuary. Reimers (1973) suggests this process in the Sixes River estuary may also enhance estuarine productivity by trapping nutrient-rich ocean water. Juvenile fall chinook that reared in the estuary throughout the summer and fall had the highest adult returns to the Sixes River (Reimers 1973).

The historic shoaling at the mouth of the Rogue which occurred before construction of the jetties may have increased estuarine productivity, providing more food to enable juvenile chinook salmon to attain optimal size prior to ocean migration.

A comparison of 1945 and 1975 adult scales indicate that juvenile spring and fall chinook spend much less time rearing in the Rogue estuary than they did 20 years ago. It is possible that channelization at the estuary mouth has reduced estuarine productivity and, consequently, decreased the period of residence by juvenile chinook salmon. If, as Reimers' (1973) data suggest, an extended period of estuarine rearing increases the probability that juveniles will return as adults, then extensive modifications to the mouth of the Rogue may have had significant impacts on chinook populations in the river.

The marine subsystem of the Rogue estuary serves not only as a passageway and potential rearing area for salmonids but also provides habitat for a variety of marine species (Table 3). Surf smelt (*Hypomesus pretiosus pretiosus*), northern anchovy (*Engraulis mordax mordax*), Pacific herring (*Clupea harengus pallasi*) and shiner perch (*Cymatogaster aggregata*) are abundant below the bridge during periods of high salinity in late summer and fall (ODFW 1975). These species are utilized for human consumption and bait, and are important in marine food webs as intermediate processors of zooplankton and food for larger fish (Hart 1973). Anglers catch them from docks and jetties in the lower estuary. Rockfish and surfperch prefer the rocky jetty habitat, where they are also caught by shore anglers (Gaumer et al. 1973).

Table 3. Fish species of the Rogue estuary (Riikula 1977).

Game Fish	Non-game Fish
Summer steelhead	Anchovy
Winter steelhead	Surf smelt
Fall chinook	Herring
Spring chinook	Red-tail surf perch
Sea-run cutthroat trout	Silver surf perch
Shad	Spot-fin perch
Coho	Striped perch
Green sturgeon	Starry flounder
White sturgeon	Tom cod
Chum salmon	Lingcod

Management recommendations

Management of the resources in this highly modified portion of the estuary should follow the concept of diversity outlined by LCDC (1977b) in the Estuarine Resources Goal. The goal emphasizes that a diversity of habitats and resources within Oregon estuaries should be protected to maintain future options and prevent irreversible damage to the ecosystem. Past alterations may already have resulted in critical losses. The few undisturbed intertidal and shallow subtidal habitats remaining in the lower estuary should not be altered except as part of a restoration project. These areas may be vital to salmonids and marine fish largely restricted to the marine subsystems. The spit that forms inside of the jetties and the shore near the Coast Guard station are two such areas.

The shallow subtidal land outside the basin dike (where the island was formerly located) is also a potentially important fish rearing area that should not be dredged or filled.

The boat basin provides a protected, highly saline environment that is unique within the Rogue estuary. The basin habitats may contribute significantly to the productivity of the estuary. If the boat basin is utilized to its full capacity improved flushing may be necessary to maintain high quality water and sediments.

Tidelands within the boat basin, particularly along the eastern end, should not be dredged or filled. Algal beds, mudflats, and fringing marsh along the shore within the basin may be especially important, since most of these natural habitat types were lost from the marine subsystem when the boat basins, channel and jetty were constructed. Waste water outfalls within the subsystem should be eliminated.

Important water-dependent development sites include the port facilities and the northern shore in Wedderburn. The moorage area of the boat basin should only be expanded if demand for boat storage can not be accommodated at adjacent shoreland facilities.

Riverine Subsystem

The riverine subsystem includes the area of the estuary from the U. S. Highway 101 bridge to the head of tide at RM 4.5 (Fig. 1). Relatively little development has occurred within this section of the Rogue. More than half of the riverine area is gravel bars and shrub wetland above MHW flooded during higher tides and high river discharge.

Physical characteristics and alterations

During most of the year, river discharge is high enough to prevent saline water from entering the riverine subsystem (ODFW 1979). When flow is low saline water penetrates upstream in a wedge and partially mixes with freshwater. Shallow areas generally remain freshest.

The main river channel has historically shifted and branched around low islands with shrubs. The subsystem contains deep holes and shallow areas which become riffles at low tide. High tides which are lower than MHW do not penetrate beyond the second riffle above Elephant Rock (Fig. 5). Higher high tides extend to a third riffle at RM 4.5.

Floods are the primary modifiers of the riverine subsystem, but jet boat traffic during the summer may also alter the sediment and gravel deposition at riffles. Major dams on the Rogue may reduce future flood levels and their influence on the riverine subsystem.

Habitats and species

There is twice as much subtidal area in the riverine subsystem than in the marine subsystem (Table 2). The three riffle areas have a cobble/gravel substrate (Fig. 5). Most other areas of the channel are also probably cobble/gravel. Areas away from strong currents, where silt is deposited during the summer and fall and bottom salinities are sufficiently high, provide suitable habitat for amphipods in the lower riverine subsystem. In the ODFW benthic survey the sampling station furthest upstream was at RM 2.2, which is normally the upper limit of salt water intrusion (Boyce 1979). Much of the channel and lower intertidal areas below this point contain productive habitat for *Corophium* spp. and *Anisogammarus* spp. Boyce also hypothesized that during periods of very low flow, such as occurred in 1977, salinities may be high enough to permit amphipods to colonize areas further upstream.

The subtidal habitat is a prime feeding and rearing area for fish. Juvenile chinook and coho salmon and cutthroat trout are often abundant in this area. Chinook are present from May through October, and cutthroat are present year-round (Cramer and Martin 1978; Tomasson 1978). The small, generally migratory threespine stickleback (*Gasterosteus aculeatus*) and the small, freshwater redside shiner (*Richardsonius balteatus*) are also often abundant. These species are commonly preyed upon by larger fish. Shiner perch, surf smelt, and Pacific herring are also present during summer. White and green sturgeon occupy the deeper holes throughout the year.

The intertidal areas generally fall into two categories: "summer intertidal"--tidally influenced during low flow and submerged during high flow; "winter intertidal"--tidally influenced only during high flow and always exposed during low flow. The DSL (1973) tideland maps were the only available maps that make such a distinction. DSL used MHW rather than MHHW to define the lower tidelands, so the actual summer intertidal area should be somewhat greater than the 205 ac estimated in Table 2. The upper intertidal boundary is drawn at the ordinary high water line. The estuarine habitat classification (ODFW 1978) does not specifically make those intertidal distinctions, but generally the cobble/gravel flats and shrub tidal marsh are winter intertidal habitats. They are found both as islands and as broad areas along either shore (Fig. 5). The dense shrub areas may contribute nutrients and organic material to the estuary, but this has not been studied. The shrubs provide habitat for the terrestrial wildlife that use the estuary.

There is a large gravel removal site on the north side of the estuary on what was once an island. A road constructed to the area has diked off the old road way. The gravel pit probably was formerly shrub marsh. The gravel flats are often sparcely vegetated by herbaceous plants and pioneering shrubs, such as willow, but these flats are probably more critical as a flood way than as primary production sites. The use of these areas by fish when flooded has not been documented.

The summer intertidal areas contain a wider variety of habitat types. At the lower end of the riverine subsystem (RM 1.2) on the south shore is an intertidal flat and island (Fig. 5). The intertidal island was formerly part of a peninsula that extended below the bridge and separated a slough from the main river. The slough emptied into the area currently occupied by the boat basin. A road extended along the peninsula, and the land was probably used for pasture. Floods and construction of the dike reduced the peninsula to the present island.

The shallow channel behind the island is submerged during winter flows. The island has a gravel base that is covered with a layer of fine sediment and an intertidal algal bed grows there during the summer. Akins and Jefferson (1973) described part of the island as an intertidal gravel marsh characterized by spike rush (*Eleocharis* sp.) and scattered forbs growing on a gravel substrate. Unlike the densely vegetated high marshes of bays and sloughs in many Oregon estuaries, this marsh type is unique to a few south coast estuaries. The largest remaining example in the Rogue is located in the low salinity intertidal zone of this island.

Another major intertidal area is located on the north shore, slightly upstream (Fig. 5). Mail Boat Point, the tip of the much larger island is a site where juvenile salmon and cutthroat congregate. Peak abundance occurs during July and August (Cramer and Martin 1978). Mail Boat Point has a gravel substrate like other shores and flats in the Rogue River estuary, but its location between the river channel and the mouth of the north slough slows the current and increases sediment deposition. There are beds of *Corophium* amphipods in the fine sand and mud. Productive algal beds occur on the gravel and fringing low marsh is found along the shore (Fig. 5).

The mouth of Snag Patch Slough is on the south shore (RM 1.5) and leads directly from Flood Creek during summer (Fig. 5). The DSL tideland map of the Rogue River (Fig. 1), misnames Flood Creek as Saunders Creek. Snag Patch Slough is the most densely vegetated marsh in the estuary. It has a mud substrate and is bordered by low fresh marsh. This slough provides excellent habitat for juvenile fish, terrestrial wildlife, and waterfowl (Riikula 1977). Saunders Creek enters the estuary at RM 1.9 into the south channel of the river (Fig. 5). During high winter flow, Saunders Creek also empties into Snag Patch Slough through a channel that cuts through a gravel flat used as pasture.

There have been no major alterations of the habitats of Saunders Creek channel and Snag Patch Slough. There are gravel bars downstream from Elephant Rock that are important estuarine habitats. Most of the remaining summer intertidal habitats are cobble/gravel shores. Freshwater predominates in the vicinity of these upper shores. Like river shores, these areas may be important for secondary production and fish rearing. The invertebrates of the upper shores have not been surveyed. These shores and lower riverine habitats are subject to frequent disturbance during summer from waves and occasional turbidity caused by jet boat traffic. The effects of the waves has not been documented.

Management recommendations

Perhaps the most important characteristic of the upper estuary is change. The river boundaries and channels constantly fluctuate with seasonal variations in river flow. Although dams constructed on the upper Rogue River will have a moderating influence during flood conditions, river levels and channel courses will continue to vary. The riverine portion of the estuary including the upper tidelands and present side channels or flood channels, such as by the road dike to the gravel pit, should not be obstructed to reduce erosion during floods and to maintain their productivity.

The intertidal flat and island along the south shore above highway 101 should be protected. The gravel marsh is a unique habitat in the Rogue and should be preserved to maintain diversity in the estuary. The algal beds and benthic organisms associated with the fine sediment provide food for fish. Although the island and much of its vegetation is scoured to the gravel base during winter floods, fine sediments again accumulate and the marsh, algal, and benthic communities are renewed when the river subsides. This periodic scouring may also contribute important organic material to the estuarine system.

If the island were stabilized or removed from seasonal and tidal cycles, vital and productive habitat would be lost.

The habitats at Mail Boat Point, the north slough, and the island dividing the river channel from the slough should be preserved. The shallow, protected waters of the slough are productive and should not be disturbed. The eddies and slack water areas around the island are productive habitats for benthic organisms and the fish that feed on them. To protect the dynamic relationship between river and island, potential river channels should not be blocked and island banks should not be diked.

The shoreline gravel areas in the mid and upper estuary are important for amphipod production. Since the channel is scoured by high flows during winter, these protected areas are probably critical for overwintering adult amphipods. Alteration of these gravel habitats will have an adverse impact on the amphipod populations, which could, in time, influence production of juvenile salmonids.

Slough and creeks entering the riverine subsystem, including Indian, Saunders, and Edson creeks, should not be filled or diked. The south channel connecting Saunders Creek to Snag Patch Slough during winter floods should also remain unobstructed. Snag Patch Slough and its productive marsh are valuable habitats for aquatic and terrestrial species and should be protected.

SUMMARY AND RESEARCH RECOMMENDATIONS

The Rogue is not a typical Oregon estuary. It is dominated by river flow which enters the estuary along a steep gradient which creates strong currents. The Rogue is the largest coastal river other than the Columbia; yet its estuary is among the smallest and lacks extensive productive tideflats, eelgrass beds and salt marshes. The estuary can be divided into a marine and a rivering subsystem. The marine subsystem is highly altered.

The Rogue is noted for its salmon and steelhead runs, although several other species of fish live in or migrate through the estuary. Jetties and a breakwater were recently constructed to make the bar navigable for fishing boats and barges. While this development may have improved access to ocean fishing, it may have also reduced the productive rearing habitat for the young chinook salmon by altering sedimentation and nutrient cycling patterns.

Ongoing studies by the ODFW have produced extensive physical and biological data for the estuary channel and immediate shores. However, little sampling has occurred in the shallow boat basin area behind the breakwater. This was probably among the most important areas for fish rearing prior to the dike and marina development, and even now it may be an important habitat for other fish. The diked off area is the most probable site of future development. A seasonal survey of the physical and biological characteristics within the boat basin should be initiated as soon as possible to detemrine its flushing capability, productivity and significant habitats. Such research could point to ways to keep the area productive or restore its productivity, while still permitting development of water-dependent facilities in the basin.

Further research on the high gravel flats and shrub marsh is also needed. Little is known about their productivity or importance as fish habitat during high flow.

The freshwater benthic communities in the upper riverine portion should be surveyed and compared with samples from the river and lower riverine areas nearby and similar sections of the Chetco estuary. Comparisons of benthic species in these areas with stomach contents of key fish species in the estuary would be very useful in assessing the importance of the freshwater habitats. The effects of jet boat traffic on benthic invertebrates and fish should also be examined.

Annual shoaling frequently causes hazardous bar conditions and limits the potential of the Rogue as a port. Some new water-dependent development may be appropriate in the boat basin or the riprapped north shore at Wedderburn. High flow hydraulic characteristics restrict the desirability and possibility of development in the riverine subsystem. Undredged marine habitats are scarce and are important feeding areas for fish. They should be protected from future dredge and fill. Riverine habitats should be permitted to change with the course of the river.

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