Natural Resources of Chetco Estuary

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THE CHETCO ESTUARINE SYSTEM

Description of the Area

The Chetco estuary (Fig. 1) is located 5 miles north of the Oregon-California border at the base of the Klamath Mountains. It is one of the smallest estuaries in Oregon. The city of Brookings (population about 2,700) is on the north side of the estuary, and Harbor (population about 2,100) is on the south side. The Chetco estuary is strongly influenced by seasonal fluctuations in river discharge. It has also been highly modified for navigation by jetties, marinas, and a dike.

The steep gradient of the Chetco River bed severely restricts the extent of tides, and mountainous terrain limits the size of the estuary. Although the Chetco drainage area (359 mi^2) is comparable to north coast estuaries like Yaquina, Siletz, and Nestucca, its surface area (about 175 acres) is much smaller. The estuary is mostly subtidal. The ratio of submerged land to tideland is greater than any other Oregon estuary (DSL 1973).

The Oregon Land Conservation and Development Commission (1977a) classified Chetco as a shallowdraft development estuary. The classification permits navigation and water-dependent development but requires protection of important habitats, productivity, water quality, and unique features.

Historical Changes

The major physical alterations to the Chetco estuary have resulted from the recent construction of entrance jetties and two boat basins below the Highway 101 bridge (Fig. 1). Congress authorized the jetties in 1945 to stabilize the depth and location of the mouth [U.S. Army Corps of Engineers (USACE) 1973]. USACE completed the two jetties and dredged a 120-ft wide navigation channel in December 1957. In 1958 local interests constructed a protective dike approximately 1,000-ft long on the southern shore near the

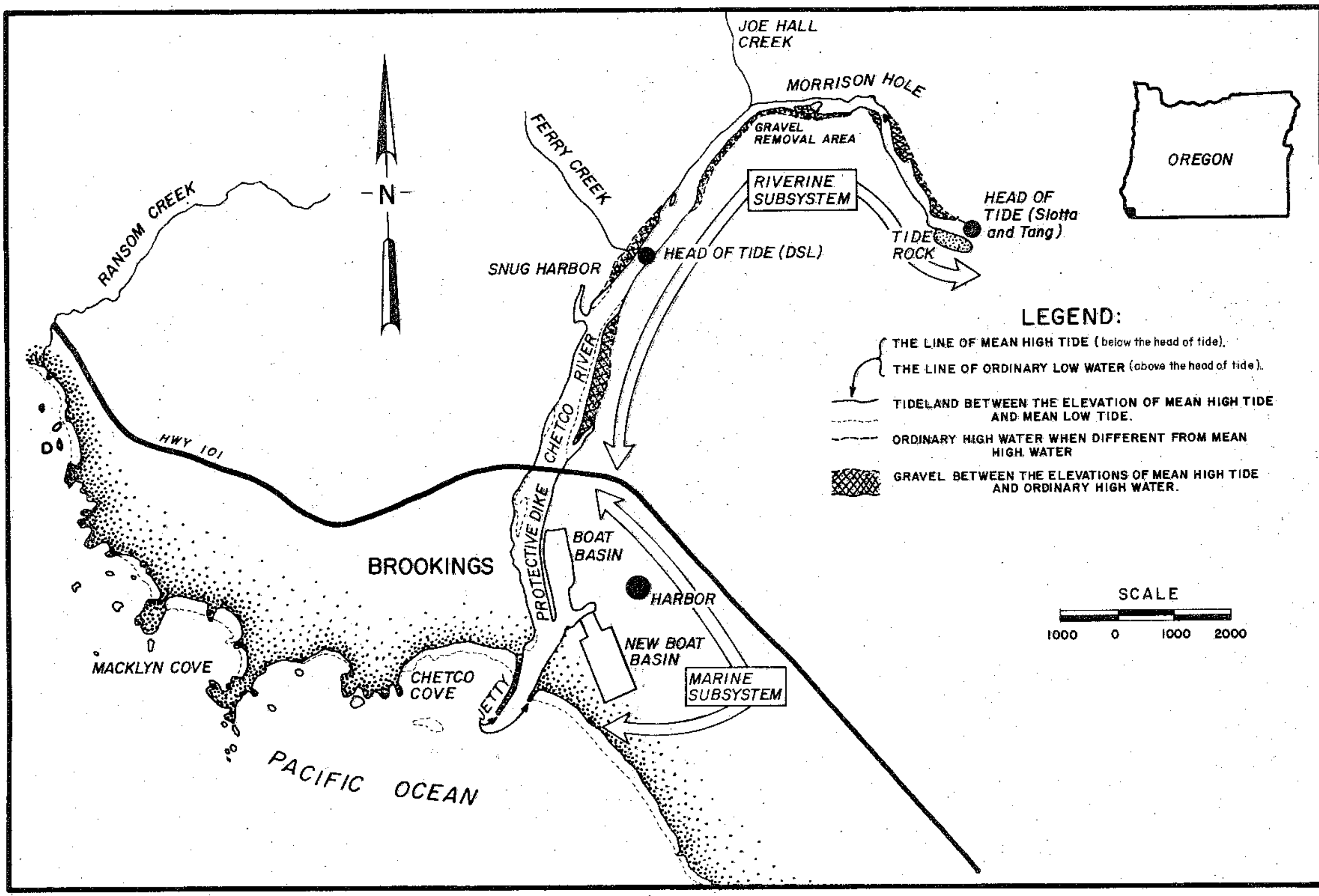

Fig. 1. Chetco estuary and estuarine subsystems [basemap from Division of State Lands (DSL) 1973].

mouth and dredged a boat basin behind it. Moorages in the boat basin were increased in 1959 and again in 1963. In 1968 the north jetty was elevated and extended 450-ft to eliminate shoaling problems and rough seas in the estuary. Between 1968 and 1970 the navigation channel was deepened to 14 ft, and USACE assumed responsibility for maintaining 12-14 ft depth in most of the boat basin and for further development of the protective dike. Between 1974 and 1976 a second and larger boat basin was constructed south of the first basin (Fig. 1). The same entrance to the channel is used for both boat basins. Development of the Port of Brookings involved the filling of a shallow lagoon south of the jetty. It had been the only major shallow area in the estuary. The effects of these alterations are discussed in the marine subsystem section.

Gravel removal is a major use of the Chetco River system. One company is located below the head of tide on a high gravel bank across from the mouth of Joe Hall Creek (Fig. 1). Temporary gravel dikes are constructed around the removal area in order to minimize pollution.

Physical Characteristics

Slotta and Tang (1976) constructed a physical model of the Chetco estuary based on extensive field data. This and other information provide a relatively complete physical characterization of the estuary.

River discharge, tides, and mixing characteristics

Estimated median monthly discharge varied from 3,700 cubic feet per second (cfs) in February to 60 cfs in September (USACE 1975). The record high flow measured at a gauge established at river mile (RM) 10.7 in 1970 was 65,800 cfs and low flow was 45 cfs. Slotta and Tang (1976) found a corresponding seasonal variation in mixing, ranging from highly stratified in February to well mixed in September (Table 1). They also measured cross sections and tidal fluctuation in the estuary and determined that tides extend approximately 3.5 miles up river near Tide Rock (Fig. 1), twice as far as previously estimated by the DSL (1973). Winter flow slightly reduces the upstream extent of tide. Slotta and Tang (1976) found the tidal prism ranged from 3.2×10^7 ft^3 during low flow to 2.6×10^7 ft^3 at high flow (Fig. 2). The new boat basin built in 1975 represents 15% of the tidal prism. The mean tidal range is 5.1 ft and the diurnal range is 6.9 ft. (Johnson 1972). Slotta and Tang (1976) predicted the construction of the boat basin would not change tidal elevations upstream.

Table 1. Chetco River estuary classification (Slotta and Tang 1976).

Date	Flow ratio[a]	Classification	Salinity gradient[b]	Classification	Flow (cfs)
2/06/75	18	Highly stratified	No salt water observed	Unclassified	14,000
6/18/75	0.4	Partially mixed	≐ 0	Well mixed	300
9/16/75	0.15	Well mixed	≐ 0	Well mixed	
1/20/76	3.87	Highly stratified	35	Highly stratified	

[a] *Flow ratio is the ratio of river flow per tidal cycle to tidal prism.*
[b] *Salinity gradient is the difference between surface and bottom salinities.*

Salinity and water quality

There have been few measurements of salinity or water quality in the Chetco. The Oregon Department of Environmental Quality (DEQ 1978) periodically samples the water above U.S. 101 bridge. The incoming water from the Chetco River is generally almost saturated with dissolved oxygen. Temperature varied seasonally from 44.6 F to 75.2 F. The upstream extent of salinity has not been determined but would change dramatically with flow. During high flow the estuary is either entirely fresh or stratified (Table 1).

Maintenance of water quality in the boat basins is a major concern of the DEQ and U.S. Environmental Protection Agency (EPA). The flushing rate from the

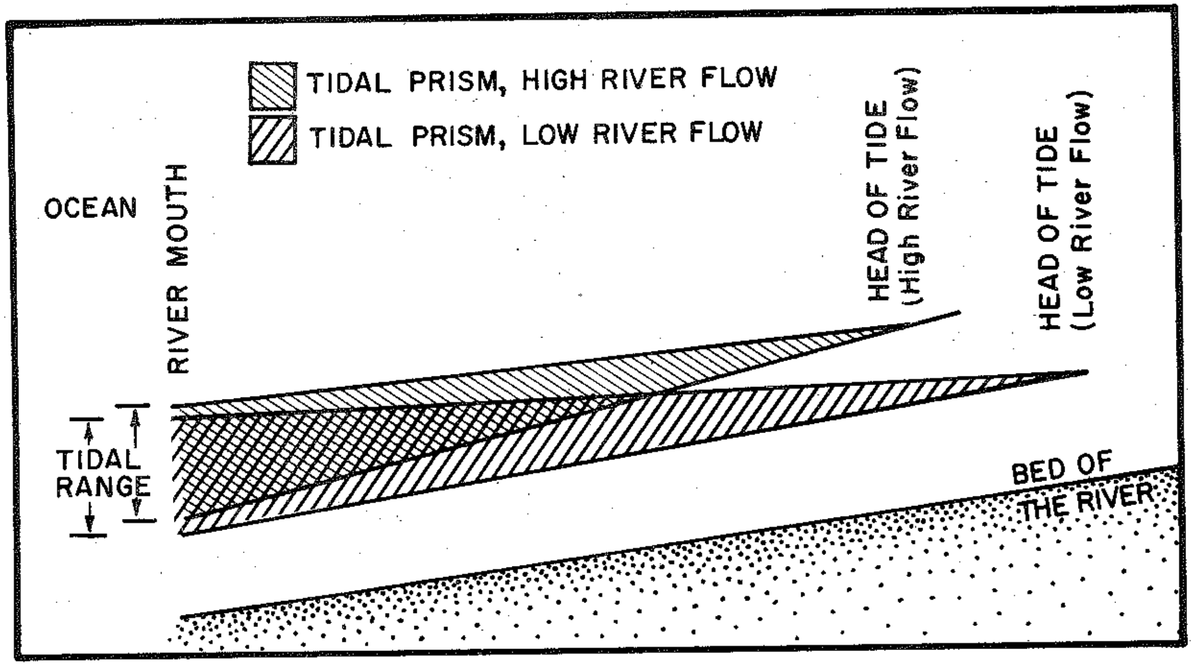

Fig. 2. High and lower water levels in the Chetco River under high and low river flow conditions (Slotta and Tang 1976).

basins is slow, and there is a high potential for build up of pollutants.

Sediments

Sedimentation processes in the Chetco estuary and other small, south coast estuaries show dramatic seasonal variations with hydrographic conditions. Most sediments in the estuary are derived from upstream sources (USACE 1973). During high winter flows, heavy loads of suspended sand and gravel are flushed into the ocean. As flows decrease in the spring, however, shoaling rapidly occurs at the mouth of the boat basin and in the entrance of the dredge channel. Gravel and course sands from the river accumulate at the boat basin (Montagne-Bierly 1978). Shoaling at the channel forms a bar of marine sands, which are transported in the ocean by the southward littoral drift during northerly winds in spring and summer. The shoal typically develops on the south side of the north jetty and at the tip of the south jetty (USACE 1973). These shoal areas are the sites of annual maintenance dredging by USACE.

The annual decrease in river flow allows accumulation of a thin layer of silt and clay over the gravel base in the upper estuary. These finer particles provide a substrate for burrowing benthic organisms, and thus play an important role in increasing food supply during this period. This surface layer of mud is quickly flushed from the estuary as the rainy season begins and river flow increases.

Biological Characteristics

There is little information about the plant and animal communities of the Chetco estuary. The habitats are very different from those of north coast estuaries, but similar to the Rogue estuary and other small south coast estuaries. There is no eelgrass and only a few acres of low salinity, inter-tidal gravel marsh in the estuary (Akins and Jefferson 1973). Phytoplankton and macroalgal production may be the most significant sources of organic material. Algae is attached to the rocky and gravel substrates. Bay clams have not been found in the Chetco estuary (Gaumer et al. 1973). Although benthic communities have not been sampled, *Corophium* sp. have been observed in the fine sediments.

Most of the data on fish species in the estuary were obtained from sport and commercial harvest records. Several species of salmonids utilize the Chetco estuary. Cutthroat trout (*Salmo clarki*) and juvenile fall chinook (*Oncorhynchus tshawytscha*) live in the estuary from spring through fall (Fig. 3). Considering data from other south coast estuaries (Reimers 1973), Chetco estuary may provide important rearing habitat for juvenile fall chinook. The spawning populations of salmon in Oregon have generally declined during this century, and the destruction of productive estuarine rearing areas may be a significant factor. Fall chinook and winter steelhead (*S. gairdneri*) smolts from the Chetco River are raised in the Elk River Hatchery and released into the Chetco River to supplement wild stocks. Coho salmon (*O. kisutch*) also pass through the estuary during adult and juvenile migrations. Twenty-seven marine fish species have been caught in the estuary during summer (Gaumer et al. 1973). The occurrence of selected fish species in the estuary is shown in Fig. 3.

The distribution of plants and animals is discussed in the subsystem section.

CHETCO ESTUARINE SUBSYSTEMS

The Chetco estuary can be divided into a marine and a riverine subsystem (Fig. 1). The marine subsystem is located below the U.S. 101 bridge. Nearly half of the estuarine area is in the marine subsystem, but the habitats have been drastically modified by development. The river subsystem between the U.S.

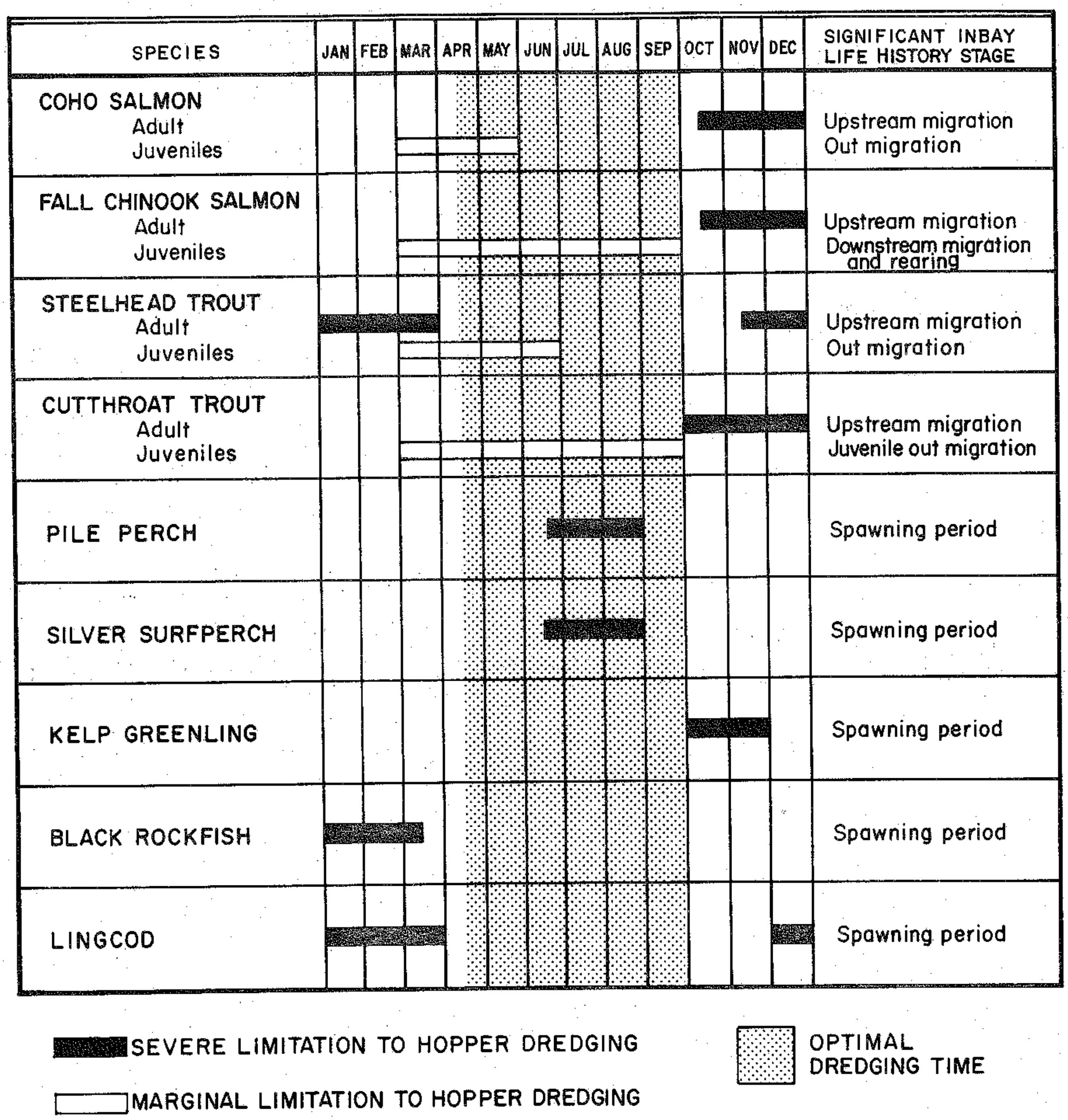

Fig. 3. Important fish species of Chetco estuary (Montagne-Bierly Assos. Inc. 1978).

101 bridge and Tide Rock contains a much larger intertidal area, which includes the seasonally flooded cobble/gravel flats along the banks.

Marine Subsystem

The marine subsystem is 94% subtidal, but there are two distinct environs, the main channel and the boat basins (Table 2).

Table 2. Estimated acreage for intertidal and subtidal lands in the Chetco estuary (estimated from ODFW 1978).

	Marine subsystem		Riverine subsystem		Entire estuary	
Subtidal	73		63		136	
Channel		37		63		100
Boat basins		36		0		36
Intertidal	4.5		34.5		39	
Below MHW		4.5		8.5		13
Above MHW		*		26		26
Total	77.5		97.5		175	

<0.5 ac.

Alterations and existing physical characteristics

The installation of dikes and jetties at the mouth channelized the estuary, removing productive tidelands and shallow submerged lands. Prior to construction of the jetties and dikes, a lagoon extended south behind a sand spit at the mouth of the Chetco River (Fig. 4). Before the mouth was stabilized, a sand sill formed at the outlet during the summer months. A similar condition occurs annually on the Sixes, Elk, Pistol, and Winchuck estuaries. Sill formation restricted tidal and river flow through the mouth, flooding low shorelands in the estuary. With the increase in flow during winter, the river eventually broke through the sill or the spit (Lizarraga-Arciniega and Komar 1975). Reimers (1973) suggested that sill formation on Sixes estuary may enhance estuarine production.

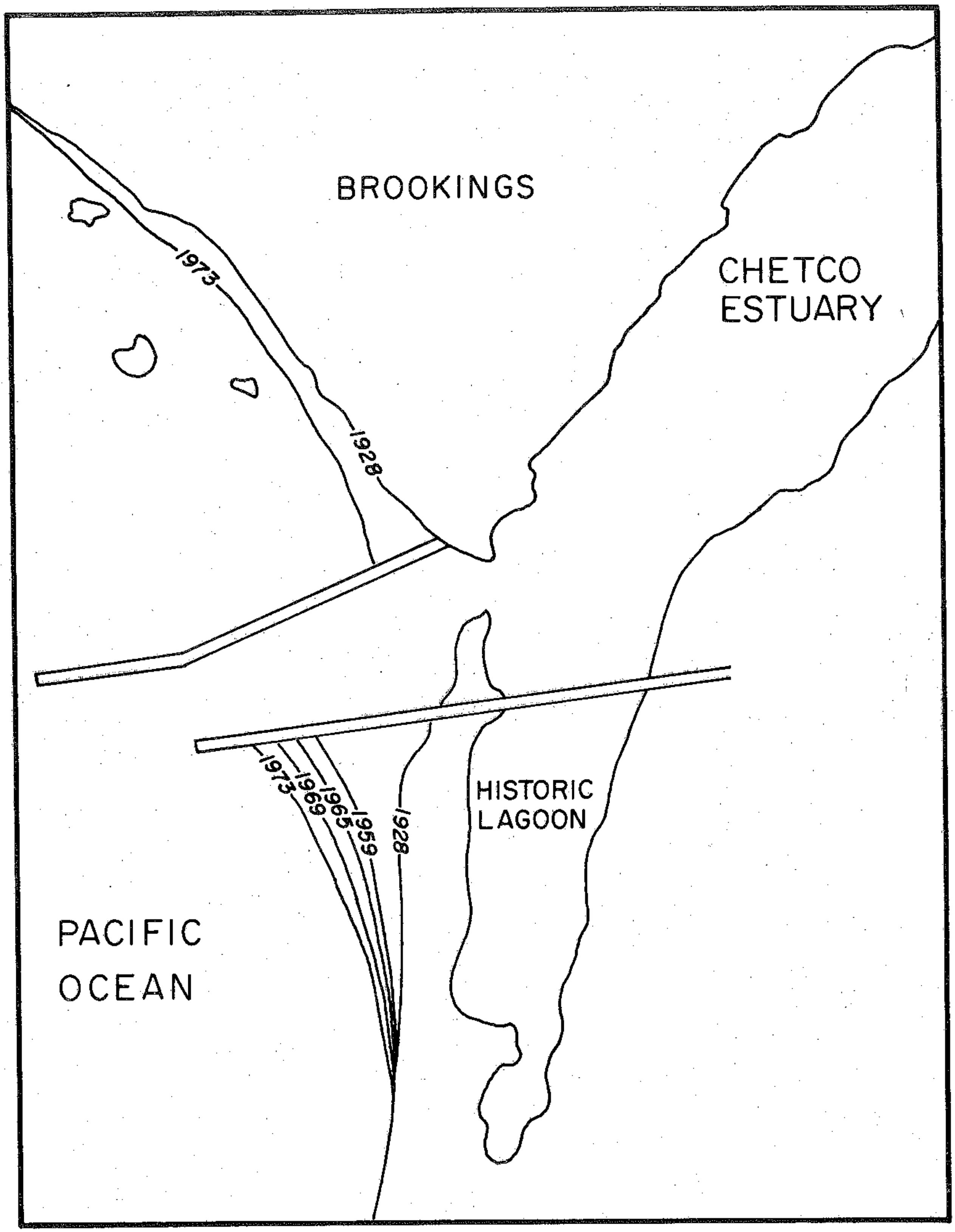

Fig. 4. Shoreline accretion around Chetco River 1928-1973 (Lizarraga-Achiniega and Komar (1975).

Construction of the boat basins and placement of fills in the estuary eliminated the lagoon and blocked the mouths of Tuttle, Delevan, Fredericks, Foster, Bishop, and Fish House creeks [State Water Resources Board (OSWRB) 1963]. A comparison of the estimated historic area of the marine subsystem, based on a 1891 navigation chart (DSL 1973), indicates about 109 acres were filled. This includes the lagoon (51 acres), tideland along the channel (36 acres), and subtidal land in the channel (22 acres), which were filled during construction of the first boat basin. The boat basins created 36 acres of subtidal habitat with a different circulation pattern and flushing characteristics. In total, the marine subsystem area is presently about half of its historic size.

The orientation of the boat basins' entrance to the channel and the protective dike prevents most of the mixed or fresh upstream water from entering the marinas. Sometimes freshwater seepage into the marinas is significant, however. The prevalance of ocean water in the boat basins may help to protect water quality during summer months despite long flushing periods. A similar situation exists in the Rogue estuary, where salinities and dissolved oxygen were higher and temperatures were lower in the boat basin than in the main channel during the summer (Crumley 1978). Slotta and Tang (1976) estimated the new boat basin would require 2-4 days (4-8 tidal cycles) to flush, depending on the river flow and tidal range.

Water quality in the old boat basin has generally been adequate, but occasional problems due to stagnation have been recorded in the summer. In July and August 1969, fish kills in the boat basin were attributed to (1) an abundance of herring, anchovy, and smelt in the bay; (2) low dissolved oxygen concentration; (3) warm water temperature; and (4) drainage of highly organic waste water from a wood chip pile into the barge turning basin (Montagne 1969).

Slotta and Tang (1976) predicted water quality could become a problem in the new boat basin during summer and fall periods when flows are extremely low and temperatures are high.

Water quality in the river channel is affected mainly by maintenance dredging in the summer, which increases turbidity. Channel currents below the boat basin are stronger because of the development (Slotta and Tang 1976).

Subtidal habitats and species

There are three major subtidal environments in the marine subsystem: the boat basins, the dredged channel below the boat basin entrance, and the undredged channel above the boat basin.

The boat basins encompass nearly half of the marine subsystem. The sediment of the boat basins probably remains predominantly sand. An increasing silt component may occur in the areas with weak currents. Slotta and Noble (1977) predicted sediment quality in the older boat basin to be among the poorest of Oregon coastal marinas due to a slow flushing rate. However, sediment samples indicated pollution indices were within acceptable limits.

The marine conditions inside the basin provide a habitat for marine fishes that enter the estuary during the summer, including large populations of northern anchovy (*Engraulis mordax*), surf smelt (*Hypomesus pretiosus*), and Pacific herring (*Clupea harengus pallasi*). These species and shiner perch (*Cymatogaster aggregata*), walleye surfperch (*Hyperprosopon argenteum*), American shad (*Alosa sapidissima*), and cutthroat trout were caught by shore anglers that fished in the boat basins (Gaumer et al. 1973).

Historically, the lagoon and sill formation at the mouth of the estuary, which were eliminated by the port development, may have been important to the growth and survival of fall chinook salmon that reared in the estuary during the summer (Reimers 1973). Chinook life history data collected from the Rogue system before the jetties and channel were constructed indicated survival was higher among juveniles that reared in the estuary than those that quickly passed from river to ocean. Since the development, juvenile chinook no longer rear in the Rogue estuary for a significant length of time (ODFW 1975). Extensive modifications of the Chetco estuary may have had a similar impact on estuarine rearing and survival of fall chinook salmon. The benthic invertebrates and vegetation in the boat basins have not been surveyed.

The channel from the mouth to the boat basins is maintained at a 14-ft depth, although shoaling occurs. The sediment is predominantly course sand with some gravel. There have been no biological surveys of the benthic fauna, but the strong current regime and frequent mechanical disturbance by dredging may limit the abundance and diversity of benthic species in the channel. Low light levels due to channel depths and high turbidity may prevent algae from growing on available gravel substrates.

The undredged channel between the boat basins and Highway 101 bridge is shallower and has a predominantly gravel substrate, which is seasonally covered with algae, principally green algae (*Enteromorpha* sp.). The clumps of long filaments, characteristic of this species, may function somewhat like eelgrass by affording protection and food for invertebrates and small fish and reducing currents, which increases sediment deposition.

Several fish species generally associated with rocky habitats are present in the lower Chetco estuary. Striped sea perch (*Embiotoca lateralis*), silver surfperch (*Hyperprosopon ellipiticum*), red-tailed surfperch (*Amphistichus rhodoterus*), pile perch (*Rhacochilus vacca*), kelp greenling (*Hexagrammos decagrammus*), black rockfish (*Sebastes melanops*), and lingcod (*Ophiodon elongatus*) are among the most abundant species caught by anglers (Riikula 1971; Gaumer et al. 1973). Spawning and larval development periods differ for each species. Spawning periods of several species are shown in Fig. 3. During spawning, individuals may be less able to tolerate stresses in their environment, such as degraded water quality.

Other animals in the channel during summer include harbor seals (*Phoca vitulina*) and dungeness crab (*Cancer magister*).

Intertidal habitats and species

There are less than 5 acres of intertidal habitat in the marine subsystem. The jetties, dike, and marina have created long boulder and cobble/gravel shores. *Fucus* sp. and other algal species are attached to the rocky substrate. The composition of these estuarine rocky intertidal communities probably differ from outer coastal animal and plant communities due to reduced wave energies and periods of reduced salinities at the mouth of the estuary. The diverse assemblage of species is normally attached to rocky habitats providing an important food source for marine fishes (USACE 1975). Communities of these Chetco shores have not been surveyed.

The natural intertidal habitats of the marine subsystem include bedrock and gravel shores, one gravel flat, and algal beds attached to bedrock and gravel (Fig. 5). One of the algal beds is located on the gravel flat. Silty sediments accumulate in the gravel during summer. During a habitat survey in 1978, large colonies of tube dwelling amphipods, *Corophium* sp., were observed in the silt. *Corophium* are often the primary food of juvenile chinook salmon rearing in estuaries (Reimers 1973).

Management recommendations

Habitat losses and channelization of the river mouth have greatly altered the marine susbystem of the Chetco estuary. Among the more important unaltered habitats remaining in the lower estuary are the undredged, vegetated channel

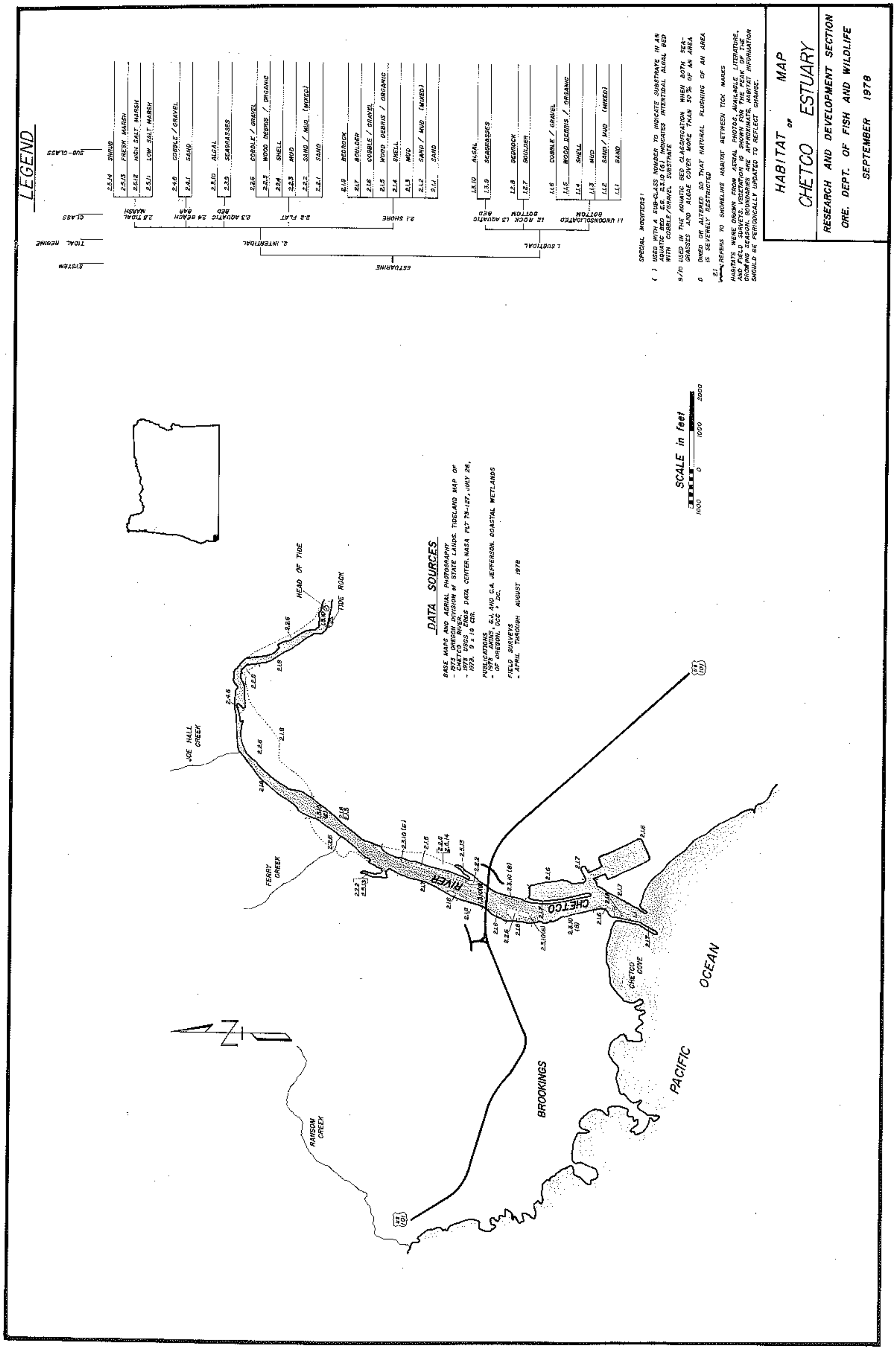

Fig. 5. Habitat map of Chetco estuary (ODFW 1978).

and intertidal habitats above the boat basin. The development of amphipod populations during the summer coincides with the downstream migration of juvenile chinook salmon. Those areas may provide the only remaining suitable rearing habitats for chinook. We recommend that dredging and filling not be permitted above the boat basin entrance so that these habitats will remain undisturbed.

Activities which can degrade water quality, such as dredging, could reduce the reproductive capacity of adults and the survival of juveniles of some estuarine fish species. During the summer and fall, when flushing takes longer and fish are utilizing the estuary during critical periods in their life cycles, those activities should be controlled to prevent adverse impacts on fish populations and their food sources.

The boat basins are important habitats in the Chetco because they represent a very large percentage of the tidal prism and provide an environment that is more highly saline than the estuary outside the dike. The basins are also popular for bank fishing. The basins will probably sustain large fish populations as long as water quality is maintained. Therefore, discharge of pollutants from sewage, fish processing plants, mills, boats, and other sources should be strictly controlled. If sources of pollution cannot be adequately controlled, the boat basins should be modified to improve the flushing. The new boat basin was built with the condition that such modifications would be made if needed (Slotta and Tang 1976).

The extensive port development leaves little, if any, potential area for habitat restoration. This further emphasizes the need to protect unaltered habitats and water quality of the marine subsystem.

Riverine Subsystem

The riverine subsystem extends from the Highway 101 bridge to the head of tide near Tide Rock (Fig. 1). It appears that salinity concentrations beyond Ferry Creek at RM 1.6 are near zero except during low flow at high tide (conversation, December 7, 1978, with Al Mirati, ODFW, Gold Beach). Water quality of the riverine subsystem reflects the water quality of the Chetco River. Random water samples taken by the DEQ (1978) show acceptable water quality except for excessive turbidity during high runoff.

Subtidal habitats and species

The majority of intertidal habitats of the riverine subsystem are contained along the narrow shoreline of the channel. The tidelands during summer flow comprise approximately 8.5 acres or nearly twice the area of tideland that is currently found in the marine subsystem (Table 2). The riverine intertidal area is unique because areas that are intertidal during summer are subtidal during high winter flow as a result of the steep river gradient. There are also four long gravel flats totalling approximately 26 acres that are above the low flow level of MHW but are below the level of ordinary high water of winter flow (Fig. 5). These flats are periodically flooded during heavy flows, but due to their elevation, they are normally exposed during the productive summer months.

The high gravel flats are often sparsely vegetated by freshwater spike rushes (*Eleocharis* sp.) during summer when these areas are exposed (Akins and Jefferson 1973). If the density of vegetative cover is more than 30%, the flats could be classified as intertidal fresh marsh, as in the case of the gravel flat above the Highway 101 bridge on the south shore. Other gravel flats grow pioneer shrub vegetation, predominantly willow (*Salix* sp.). The shrub growth is also sparse. Winter floods scour accumulated fine sediment and most vegetation from the Chetco gravel flats. Plant production from these seasonally vegetated flats may be a significant source of organic material for the estuary.

The summer intertidal habitats are predominantly gravel shores (Fig. 5) covered by algae and fine sediments, as in the marine subsystem. There are two small mud/sand flats removed from the main flow of the river. One of these is Snug Harbor (Fig. 1), a small slough on the north bank that is used as a boat moorage. The second intertidal mud-sand flat is just above U.S. 101 bridge on the south shore below a small intertidal gravel marsh (Fig. 5). These areas are also likely to be fish rearing areas.

The upland areas bordering the riverine subsystem are either steep bedrock hills or river terraces, which are used as pasture and residential property. Some shores have been riprapped to prevent bank erosion (Fig. 5). Gravel is removed from one gravel flat in the estuary. The effect of gravel removal on the estuarine habitat is not known.

Management recommendations

The shallow vegetated areas of the channel, intertidal algal beds, and marshes probably provide important sources of plant production and fish rearing habitat in the Chetco. To protect the productivity of this small estuary, dredging should not be permitted in the riverine subsystem. Permanent dikes, fills, and riprap should be prohibited on the gravel flats. This would not only prevent additional habitat loss, but these alterations would probably cause strong currents in the Chetco during winter to shift and erode other areas. Pastureland and residential land behind the gravel flats could be directly protected with riprap with less impact upon the estuary. Gravel removal should be restricted to its present location in the estuary and to river locations until the effects on the estuarine system and fish habitat are determined.

SUMMARY AND RESEARCH RECOMMENDATIONS

The Chetco estuary is among the smallest in Oregon; yet its drainage basin is comparable in size to larger estuaries of the north coast. The area near the mouth of the estuary has been extensively modified by jetties, a navigation channel, a dike, boat basins, and filling. Maintenance of the navigation channel requires annual dredging due to natural sedimentation in the estuary. The boat basins comprise over 20% of the estuarine area.

The Chetco can be divided into two subsystems: a marine subsystem below the U.S. 101 bridge, which includes the boat basins, and a riverine subsystem above the U.S. 101 bridge. Both subsystems are predominantly subtidal. In the riverine subsystems all of the subtidal area is within the natural Chetco river channel. There are no eelgrass beds, salt marshes, or clam beds in the estuary. Seasonal algae and other plants are the primary vegetation on and in the gravel substrate. The seasonal fluctuations in freshwater inflow and water velocity have a strong bearing on the estuarine habitats, but there is little specific data on the biological communities.

Since the lower estuary has already been developed as a harbor, management of the estuary should be focused on maintaining water quality in the boat basins and avoiding major dredge or fill projects upstream from the boat basin. The boat basins accommodate numerous fishes during summer. The upstream habitats are probably also important rearing areas for chinook salmon and other fishes.

Management of the Chetco estuary could be aided by research on a number of topics. Jetty extension and channel deepening have been proposed by the USACE (1977). An assessment of the potential affects of those alterations is based on a very limited understanding of the biology of the Chetco. Channel deepening usually increases the current, which could alter habitats in the area. The relation between the accumulation of sediment and algae on the cobble gravel bottom and shore to the summer currents should be studied. The seasonal productivity of the algae and the benthic invertebrates associated with the habitats of algal beds and gravel also need to be determined. The use of these and other habitats by fish for feeding should also be examined. A comparison of the habitats and species in jettied and unjettied systems of the south coast might provide important clues to the impact of navigational development. Very little is known about the major sources of organic material that are produced and utilized in these small river-dominated systems with gravel substrate.

Regardless of further jetty development, seasonal comparisons of the benthic plant and animal communities of the various habitat types in the Chetco (including seasonally inundated gravel bars) would be very useful for planning and for evaluating site-specific proposals. In particular, the impact of gravel removal from the river and estuary on habitats and animal communities should be studied. A seasonal survey of salinity, temperature, and dissolved oxygen concentrations should also be completed for the Chetco, since these parameters have a basic influence on the plants and animals present.

The role of estuaries in fish production is of considerable importance in making decisions about development. Further research is needed in the Chetco estuary to determine the extent and location of rearing by juvenile salmonids. Studies of fish food organisms in particular habitats are especially needed. The seasonal utilization of the Chetco estuary by marine fish should also be surveyed.

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