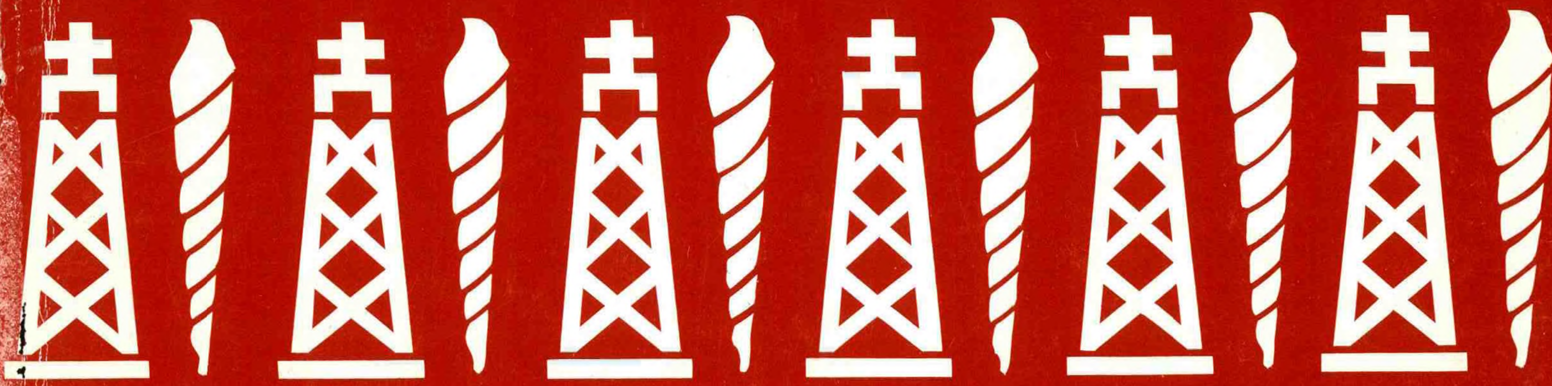

A PLAN FOR PROTECTING THE NATURAL RESOURCES OF COOS BAY, OREGON FROM OIL SPILLS

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I. INTRODUCTION

The Coos Bay estuary is located on the southern Oregon coast approximately 212 miles south of the Columbia River and about 124 miles north of the California border. It is the second largest estuary in Oregon accounting for about 27 percent of the state's total estuarine resources. Its surface area is 10,973 acres at high tide and 5,810 acres at low tide. Tidelands cover approximately 4,569 acres including 2,738 acres of tidal marsh and 1,400 acres of eelgrass beds. It is a highly complex system comprising numerous sloughs and bays and some thirty tributaries - the major one being the Coos River. The bay drains a total area of 605 square miles and yields 2,200,000 acre feet of fresh water annually.

The natural environment of the estuary supports a tremendous diversity of flora and fauna. The extensive shallow tidal flats provide excellent habitat for a variety of shellfish and important feeding and spawning areas for some 65 species of fish. The large beds of eelgrass and the shallow protected bays attract tremendous numbers of waterfowl providing the best resting area in the southern Oregon portion of the Pacific Coast flyway. Of particular biological importance is the South Slough Estuarine Sanctuary, a pristine area of undisturbed tidal marshes and tide flats which furnishes essential habitat for a multitude of organisms. Commercially important activities such as clam harvesting, oyster culture, salmon aquaculture, fisheries and the fish processing industry are directly dependent on a natural productivity of the bay. In addition, natural resources support extensive recreational activities such as fishing, boating, sightseeing, clamming, crabbing, picnicking, and nature viewing which enhance the local quality of life and attract tourists to the area.

The economy of the Coos Bay area has been closely tied to the natural resources associated with the estuary, and it is likely that future developments will also be estuary dependent. Consequently, the importance of maintaining the vitality of this estuarine system cannot be overemphasized. Whereas it took thousands of years to evolve the dynamic, delicately balanced systems of chemical, biological, and physical interactions, it has taken man through activities such as logging, dredging, diking and filling, less than 100 years to produce tremendous alterations in this system. Water dependent commercial activities and estuarine development actions, therefore, pose a continual threat to the integrity of the Coos Bay estuarine environment and to the survival of the organisms dependent upon it. Within this context, it is not difficult to imagine the disastrous consequences a large oil spill resulting from such activities could have on the Coos Bay estuary. Commercial fishing and shellfish harvest would be interrupted or ruined, recreational activities curtailed, and very important estuarine habitat lost for years. Most Oregonians who take particular pride in the natural environment would agree that we cannot afford to let this happen.

To date, a combination of good luck and limited oil tanker traffic has spared Oregon's environment for the most part. There have, of course, been many oil spills but no major disasters. Of the documented incidents, the most extensive was a 26,000 gallon TOYOTA MARU oil spill which occurred on the Columbia River in 1978. Fortunately, the spill caused limited apparent damage. It did, however, focus the attention of the state of Oregon on the extreme vulnerability of our natural resources to such incidents. It was clear that if sensitive areas are to be protected in the future, plans must be formulated prior to the occurrence of a spill rather than during or after. As a consequence, the Oregon Department of Environmental Quality sought and obtained federal funding to develop a resource protection plan for the Columbia River. The plan entitled, An Oil Spill Protection Plan for the Natural Resources of the Lower Columbia and Willamette Rivers, was completed in 1979. It identified sensitive natural resources and suggested suitable protection methods.

The success of that document, as judged by its favorable reception, led the state to seek further funding to do similar studies for the Oregon Coast. Although the entire coast is highly vulnerable, Coos Bay and Yaquina Bay were singled out for protection plans because they are significant deep-water ports and, therefore, more likely to have shipping related spills. Ultimately, it is hoped that protection plans will be developed for the entire coastal area. The plan for Yaquina Bay was completed in August, 1982.

The present study of Coos Bay is thus an extension of these earlier planning efforts. The major working premise is that any oil discharged into the marine or fresh water environment would inevitably affect both natural and man-made resources. Consequently, the rapidity and effectiveness of the oil spill response is of prime importance in averting potentially serious damage. The key to a fast response is contingency planning which includes notification procedures, delegation of authority, personnel and equipment deployment, and prior identification of all potentially affected resources. As suggested earlier, the latter component is often left out of contingency plans, therefore, the major thrust of this study is to:

1. Identify and rank by priority all vulnerable resources in the study area.

2. Designate specific areas for protection and determine how physical processes will effect their vulnerability.

3. Suggest suitable protective, cleanup, and response measures.

4. Map resource locations, boom sites, containment areas, and access points.

5. Suggest data needs or technical improvements.

6. Supplement present oil spill contingency plans.

The following narrative describes how to use the protection plan. The text is divided into two main parts. The first part outlines in detail the background information needed to understand the Coos Bay estuarine system, how oil will affect it and how oil can be expected to act under different circumstances. The second part describes appropriate spill response measures.

II. BACKGROUND

A. Potential for Spills

Spilled oil represents an ever present threat to the integrity of the environment. Any time petroleum products are transported, handled, stored or utilized for fuel, the potential for spills exists. The U.S. Academy of Sciences estimates that 75 percent of all spills are directly or indirectly attributable to human error. Equipment failure or malfunction accounts for most of the other 25 percent. The obvious implication of this is that even if the technology was perfect, oil spills resulting from error or negligence could still threaten our environment. When we consider that the movement of petroleum from the oil field to the consumer may require from 10 to 15 transfers and as many as 6 different transportation modes, it becomes readily apparent why spills occur so frequently, and will continue to occur into the foreseeable future.

A breakdown of the sources for spills by volume shows 31 percent entering the marine environment from river and urban runoff, 22 percent from oil tanker operations, 9.8 percent from other transportation activity and 3.3 percent from tanker accidents. The total volume does not necessarily indicate the size of the threat, however. For an estuary like Coos Bay, a single large spill would probably have a much greater effect than the continuous, low level of oil pollution one would expect from urban runoff. Consequently, shipping operations such as the transferring of fuel products very likely represent the single, largest threat to the system. Road spills and rail spills pose a second important but smaller individual threat, and if the above percentages hold true for Coos Bay, tanker or transport ship accidents appear to be a minor threat. Nonetheless, accidents such as collisions or groundings should not be discounted from the planning process since the largest and most environmentally damaging incidents frequently are the result of an accident.

1. Shipping Spills

Determining the magnitude of the threat spill incidents pose is unfortunately quite difficult. In 1982, the Port of Coos Bay recorded 4,216,743 short tons of products carried by vessel traffic. Of this, 221,819 tons were petroleum products or about 6 percent. Over 90 percent were forest product related cargoes, suggesting that the risk of spills from oil tanker traffic is very low. Any ocean-going cargo ship, however, carries enough oil to cause serious damage to a confined area such as an estuary, so that all cargo vessel traffic must be considered potential oil spillers.

In 1982, the Coos-Curry Council of Governments prepared an environmental impact statement for the North Bay Industrial Park in which an attempt was made to assess the risk of oil spills in Coos Bay as a result of shipping activities.

Utilizing the fact that there were no recorded oil spills in the estuary greater than 2.4 barrels from 1975 to 1980 and assuming an average of 12 oil tanker calls a year to the proposed port, they were able to extrapolate, using data from other U.S. ports, that the risk of a spill greater than 2.4 barrels was once every 15.4 years. This data does not include present shipping traffic so the risk would be increased correspondingly, but it obviously demonstrates that the possibility for oil spills of any significant size is small and that a major spill would be very unlikely. Nonetheless, one large spill, however remote the possibility, would devastate the estuary and consequently the knowledge that the threat is small does not negate the need to be prepared. Since it appears that the most likely threat would come from oil product transferring, good prevention and containment practices must be emphasized. This will be particularly important if shipping activities increase in the future as projected by the Port of Coos Bay.

The probability of accidents such as collisions occuring appears extremely low given present shipping activities and past history. The narrow Southern Pacific Railroad bridge represents the most serious threat to shipping safety, and consequesntly a potential spill site, but such an incident has yet to occur. Again, should shipping activities increase, the risk of accidents will increase proportionately.

2. Road and Rail Spills

With roads lining much of the bay, the possibility of a road spill is always present. In areas where the heavily travelled Highway 101 is adjacent to the bay, such as the causeway between North Slough and Haynes Inlet, the 101 bridge and Isthmus Slough, there is a continuous threat from accidents. A spill at any of these locations could cause serious damage to the local environment and protection measures would be needed. Specific responses for each area are listed in Section III C.

Similarly rail spills pose a potential threat to the Coos Bay estuary. The section along North Slough, the bridge at river mile 9, and the section of track along Isthmus Slough are the locations where a spill incident would most likely enter the estuarine system. Again the local area could be seriously affected and protection measures would be needed.

B. Resource Priorities

The methods employed to determine the importance and the protection priority of a resource were adopted from guidelines set forth by the U.S. Environmental Protection Agency publication, Handbook for Oil Spill Protection Clean-up

Priorities and by the Oceanographic Institute of Washington's document entitled, An Evaluation of Oil Spill Clean-up Capabilities in the Columbia River Basin System.

The important potentially sensitive area of Coos Bay can be divided into five general categories:

1. Natural ecosystems, which includes: critical habitats, endangered species, reproductive and rearing grounds, wildlife concentration areas, salt marshes, and mud flats.

2. Resource management areas, which includes: aquaculture sites, wildlife refuges, historical locations, and areas used for educational purposes.

3. Consumptive water usage which would include: industrial process and cooling water, fish rearing supplies, and aquarium usage.

4. Recreational areas, which include: parks, boat launches, beaches, diving areas, boating areas, and fishing and hunting sites.

5. Water dependent industrial and commercial sites such as: log storage, waste disposal, marinas, commercial fishing areas and beachfront properties.

The overall sensitivity of an area to oil contamination is based on four complex and interrelated factors: (1) environmental-ecological, (2) aesthetics, (3) economic, and (4) social.

An area which is important for all four reasons would obviously have a high priority. Generally speaking, natural areas fall in this category and are given the highest protection priority since they have no ability to protect themselves, may be impacted for a long time period, and because cleanup is usually not feasible or desirable. Within this framework, recreational facilities such as parks are given a lesser priority and industrial or commercial facilities are designated as low priority.

Using the above rationale, the following priority scheme is proposed:

Priority 1 -- Critical habitats important for the preservation of a species.
Endangered species as identified by the Endangered Species Act.
Reproduction and rearing areas for all organisms.

Priority 2 -- Wildlife concentration areas such as resting and feeding sites.

Priority 3 -- Private/governmental aquaculture facilities such as fish hatcheries and research stations.

Priority 4 -- Recreation facilities such as parks and marinas.

Priority 5 -- Water dependent industries such as log storage.

As can be seen on the Resource Chart Appendix D, general areas are prioritized as are specific resources. Since seasonality could affect a resource priority, specific resources are also prioritized on a seasonal basis. Thus a fish concentration area could have a Priority 2 rating in the fall and winter and have a Priority 1 rating during the spawning season in spring.

There may also be overriding economic and safety factors which would alter the priority structure. An event which threatens human life would certainly override ecological factors. Similarly, a spill which might economically cripple an area could change the priorities. Decisions on protection measures would have to be made on a case-by-case basis.

C. Physical Factors Affecting Oil Spill Movement

Oil movement and behavior in an estuary like Coos Bay is controlled by a complex interaction of physical processes including: tidal activity, weather patterns, winds, seasonal flows of the Coos River and numerous tributaries, air and water temperatures and the type of petroleum product. Under most circumstances, the major processes to consider are the tides and winds which cause significant surface currents in many places in the estuary.

1. Tidal Action

The tides of Coos Bay are of the mixed semi-diurnal type with paired highs and lows of unequal duration and amplitude. The mean tidal range at the entrance is 6.7 feet, the extreme is 10.5 feet and the extreme low is minus 3 feet. The tidal range increases upstream to the city of Coos Bay where the mean range is 6.9 feet. The time difference between peak tides at the entrance and Coos Bay is about 40 to 90 minutes.

Currents resulting from tidal action range up to a predicted 6.0 feet per second at the entrance. In the shipping channel, currents range from 1 to 4 feet per second with the strongest currents occurring in the lower bay. Maximum ebb current velocities are somewhat greater than maximum flood current velocities particularly during the winter months when river runoff is high. Strong tidal flows are found at the entrances to all the bays and sloughs in the estuary particularly South Slough, North Slough, and Haynes Inlet where currents typically range from 1 to 3 feet per second. The following table provides some average current velocities for different locations in the bay and the projected water parcel movements during a six hour tidal cycle. The averages were determined from a very limited number of

TABLE 1. AVERAGE CURRENT VELOCITIES AT SELECTED SITES

High Slack to Low Slack: 6 hours plus or minus 40 minutes.

Tide Range: Mean 6.7 feet, extreme high 10.5 feet, extreme low minus 3.0 feet

Time Lag: 40 minutes difference between the entrance and the city of Coos Bay.

Location (Main Channel)	River Mile	Average Maximum Current Velocity in ft. per second		Estimated Distance in Miles Traveled by a Parcel of Water During 6-Hour Tidal Cycle	
		ebb tide	flood tide	ebb	flood
Entrance	0	3.7	3.0	9.6	7.8
Pigeon Point	2.5	4.0	3.5	10.4	9.1
Empire	5.5	3.2	1.5	8.3	3.9
North Bend	8.0	1.5	1.2	3.9	3.1
Sloughs and Bays					
South Slough	2.0	3.0	2.5	7.8	6.5
Pony Slough	9	0.8	0.6	2.1	1.6
North Slough	9	2.0	2.0	5.2	5.2
Haynes Inlet	9.5	2.0	2.0	5.2	5.2
Isthmus Slough	14.0	1.0	1.0	2.6	2.6
Coalbank Slough	14.6	1.2	1.2	3.1	3.1
Marshfield Channel	15	2.0	1.5	5.2	3.9
Catching Slough	16	1.5	1.5	3.9	3.9

measurements so that considerable variation can be expected at any given time. Detailed current measurement data are located in Appendix C.

The estimated distance a water parcel could move upstream or downstream during the time between slack waters was calculated from the following formula:

$$\text{horizontal displacement (HD)} = \frac{2VT}{pi}$$

where:

V = maximum tidal current in feet/second
T = time in hours from low slack to high slack in hours
pi = 3.1416

Thus if the tidal velocity is 3 feet per second and it is 6 hours between slack waters, the calculation would be: horizontal displacement = 3.0 feet per second X 3600 seconds per hour X 6 hours X 2 divided by 3.1416 X 5280 feet per mile. There are obvious limitations to the use of this equation. First, since tidal current velocities decrease upstream, the estimated travel distance upstream will be more than the actual movement. Likewise, the estimated downstream reach will be less than the actual movement. Second, wind is not considered and moderate to strong winds could have a very pronounced effect on oil movement. Third, the tidal currents will vary daily according to the tidal cycle. Nevertheless, use of this equation will give the oil spill response coordinator a general indication of expected oil slick movement.

The change in current velocity over the 6 hour period between slack waters can be plotted on a graph, see Figure 1. This curve can then be used to estimate the tidal current velocity at a given point during the cycle. For example, at one hour before and after slack water, the current will be 50 percent of the maximum. At 2 hours before and after slack water, the current will be about 90 percent of the maximum velocity.

On this same graph (Figure 1), one can also determine approximately how far a parcel of water will move during a six hour interval. For example, with a maximum current velocity of 3.2 feet per second, one can calculate using the equation $HD = \frac{2VT}{3.1416}$ that the horizontal displacement will be 8.2 miles. If a spill occurred 2 hours after slack water, the distance moved using the graph would be 8.2 - 2.0 = 6.2 miles. Obviously, these values are very rough since wind and decreasing upstream current velocity are not considered.

The strength of the tidal currents for a given location will also vary according to the height of the tide with spring

Figure 1: Current velocities vs. travel distance for a parcel of water

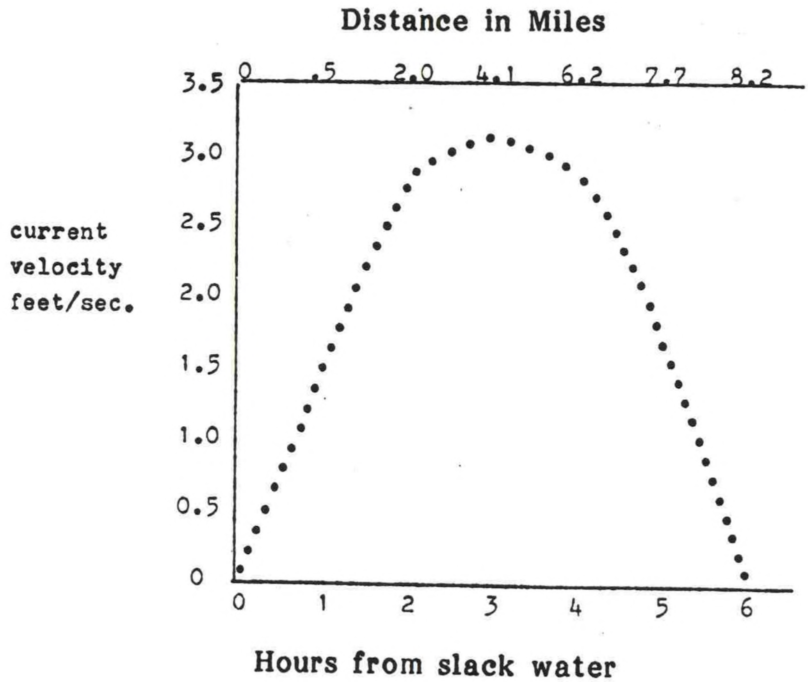
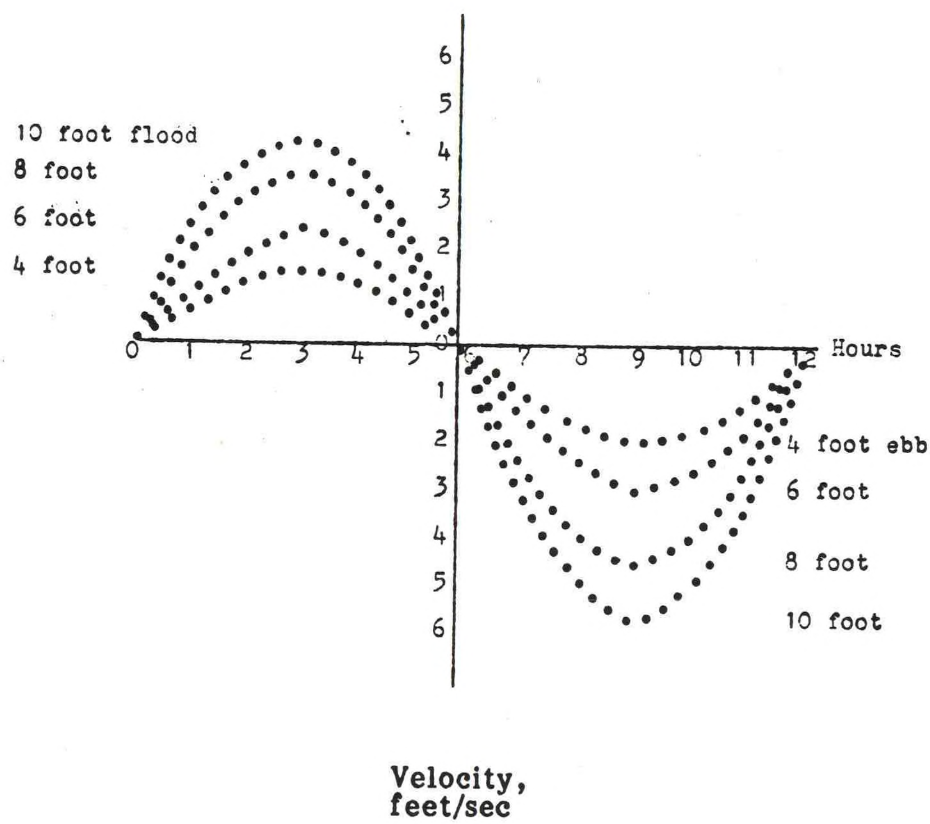


Figure 2: Variations of current velocity relative to selected tidal ranges



Adapted from: <u>Tidal Current Tables, 1981.</u>

tides causing much greater currents than neap tides. Figure 2 demonstrates the type of variations of velocities which can be expected. The difference between a 10 foot tide and a 4 foot tide can be more than 3 feet per second and could mean the difference between the success or failure of an oil boom.

Using this chart, the equation, and the graphs, one ought to be able to make a fair prediction of how tides will affect oil movement in Coos Bay. The response team should also be able to use this information plus the current measurements at the various boom sites to determine how effective an oil boom will be and during what times it will be most efficient. Considering that the strongest boom will lose its effectiveness at currents of over 1.5 feet per second, it is apparent from the first graph that when currents are strong, the period of effective use will only be about 2 hours during each tide change. In an area with strong currents, the response team will have to consider diversionary booming or some other form of response.

The tidal currents of Coos Bay will cause significant oil spill response problems which will have to be evaluated very carefully by the on-scene coordinator on a case-by-case basis. In some instances, the value of placing an oil boom may be negated by the amount of time it will be effective and by the fact that the boom will have to be moved every six hours. Difficult decisions will have to be made. The information provided here is meant to help facilitate those decisions, but not make them.

2. Circulation Patterns

At least two studies have attempted to describe the circulation patterns of the Coos Bay estuary. Both of these were related to the path of effluent discharged from the area's three sewage treatment plants; Coos Bay, at river mile 13.5.; North Bend, at river mile 7.5; and Empire, at river mile 5. They have some general application to the oil spill situation with the exception that oil for the most part floats and is thus influenced by winds and surface currents whereas effluent readily mixes in the water column and is thus less susceptable to wind activity and may be subjected to different current patterns.

The first study undertaken in August, 1980, by Carr and Furfari used both drogues and dye to trace effluent movements. The results of this effort showed that the movements of both the drogue and the dye corresponded closely to the shipping channel. Since measured tidal currents are greatest in the channel, these results are as expected. It is interesting to note that the dye stayed in a relatively uniform narrow band at all sites rather than spreading. The only variation occurred at the Empire sewage treatment plant where introduced dye stayed quite close to the shoreline downstream and actually passed under the Sitka dock instead of moving westward into the shipping channel.

A second effort, in 1982 by Jackson and Glendening employed a computer model of the Coos Bay hydraulic system. Tables 2 through 6 show the hydraulic model predictions for an incoming tide, outgoing tide, and net water movement during various river regimes. The general accuracy of the model was independently confirmed by a series of dye experiments at various points in the estuary.

The incoming and outgoing flow patterns show nothing out of the ordinary. But the net water movement over a 24-hour period presents some interesting data. In the upper bay, during low and moderate river flows, there is a definite circular pattern, suggesting that oil spilled near the port area could circulate around the upper bay to the highly sensitive shallows and not move down bay as quickly as current measurements would suggest.

This apparent circulation anomaly is the result of the tremendous variation in the seasonal flows of the Coos River. Records show that flows range from less than 100 cubic feet per second (cfs) in the summer and fall to nearly 100,000 cfs in the winter. Thus during low river flows, the volume of salt water intruding into the estuary overwhelms the flow of fresh water and results in the above described circulation pattern in the upper bay. Under this condition, tidal action forces mixing of the fresh and salt water to the extent that on a given cross section through the estuary, the salinity is essentially constant from top to bottom. With this flow regime, there is a general slow net drift of water outward at all depths measured at about one-tenth of a knot. The back and forth tidal motion is superimposed on this slow, outward drift.

During the winter when river discharge is high, fresh water flowing downstream partially overrides the more dense saline water forced inland by the tides and results in the circulation pattern seen in Table 6. Although salinity is least at the surface due to the dilution from fresh water and is greatest near the bottom, salinity changes in the vertical direction are usually gradual throughout the bay. With this regime, there is an upstream movement of saline water at the bottom with a superimposed back and forth tidal movement and a downstream movement at the surface.

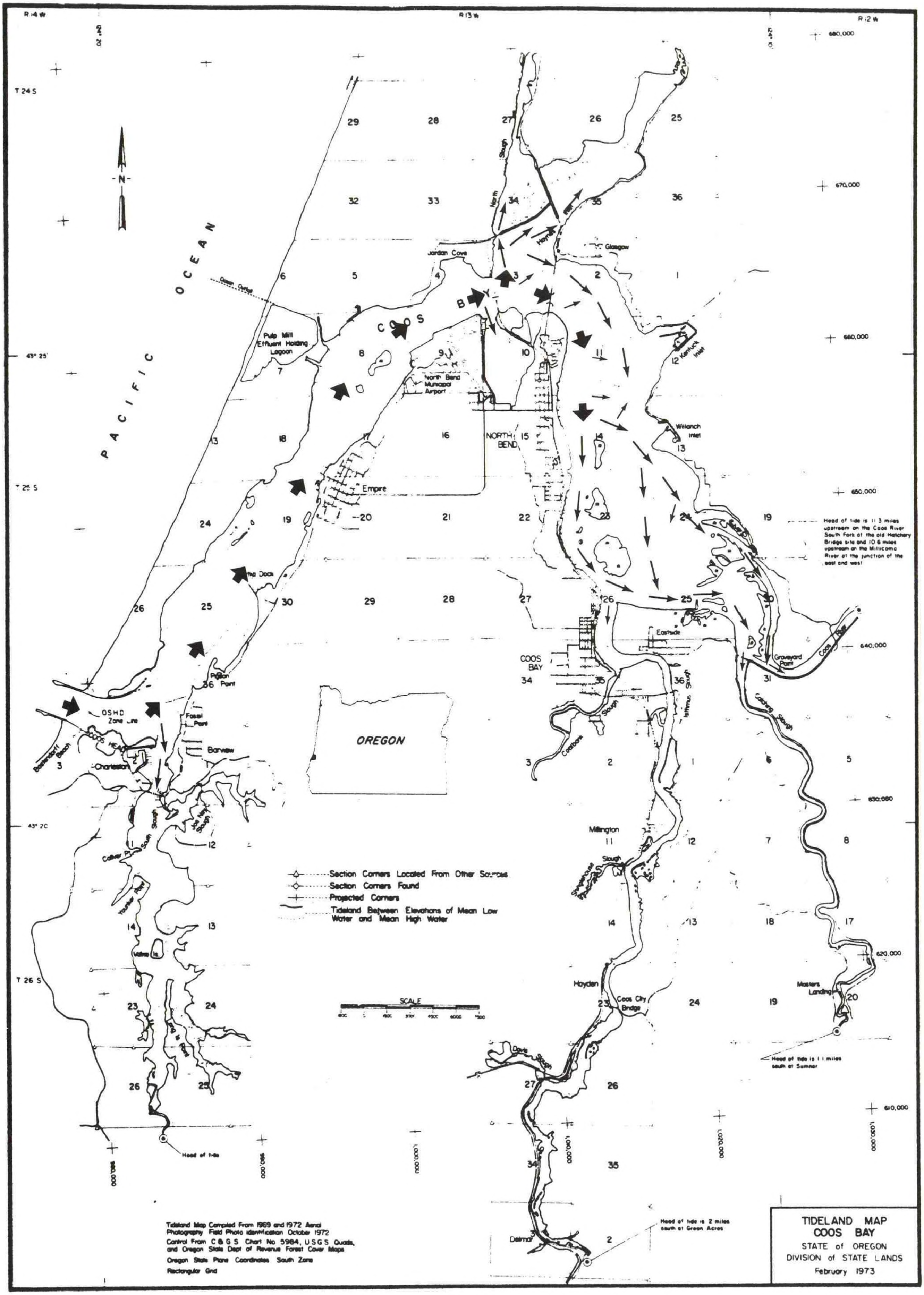


Table 2

Hydraulic Model Prediction Showing Channels of Flow for Incoming Tide

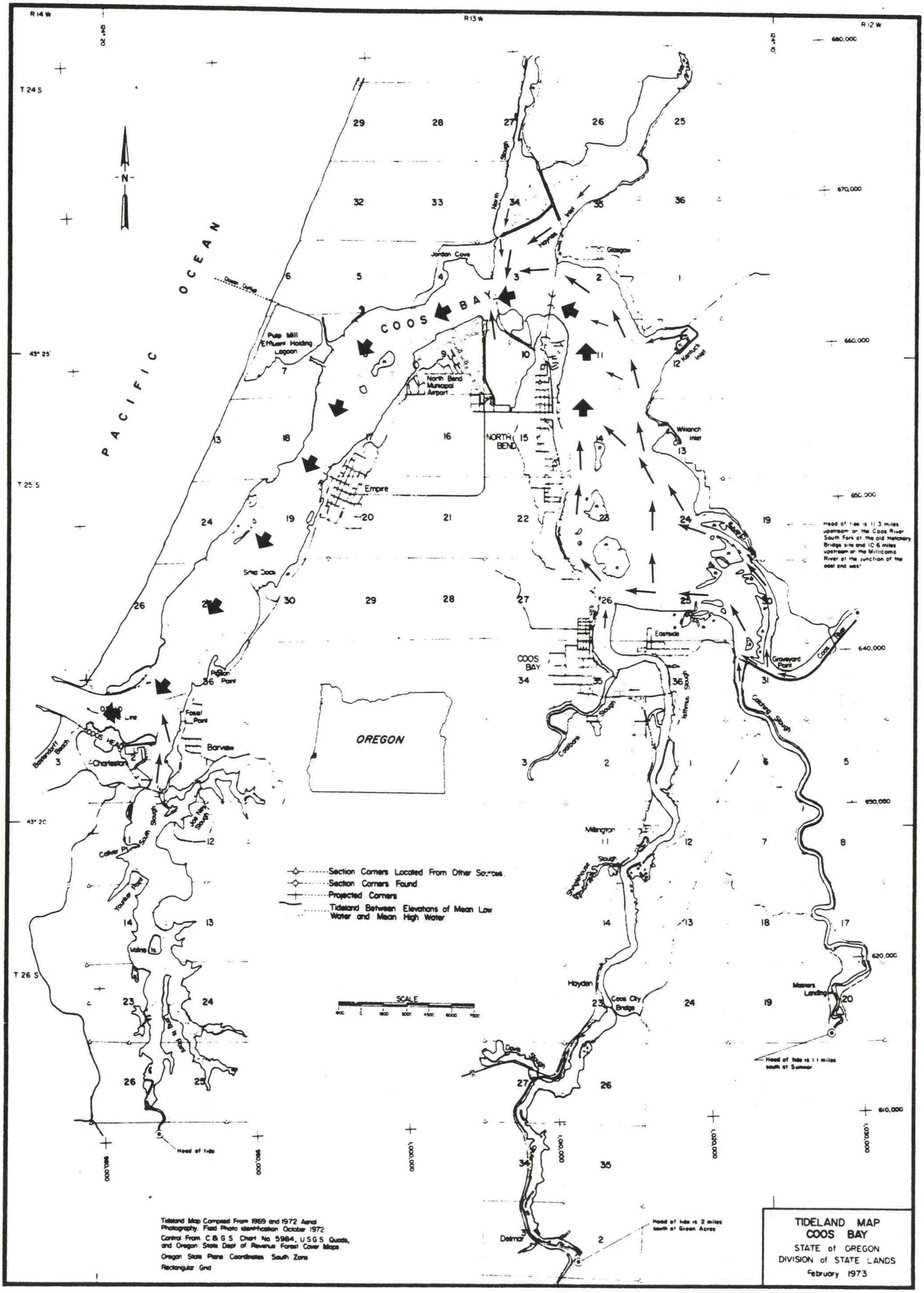


Table 3

Hydraulic Model Prediction Showing Channels of Flow for Outgoing Tide

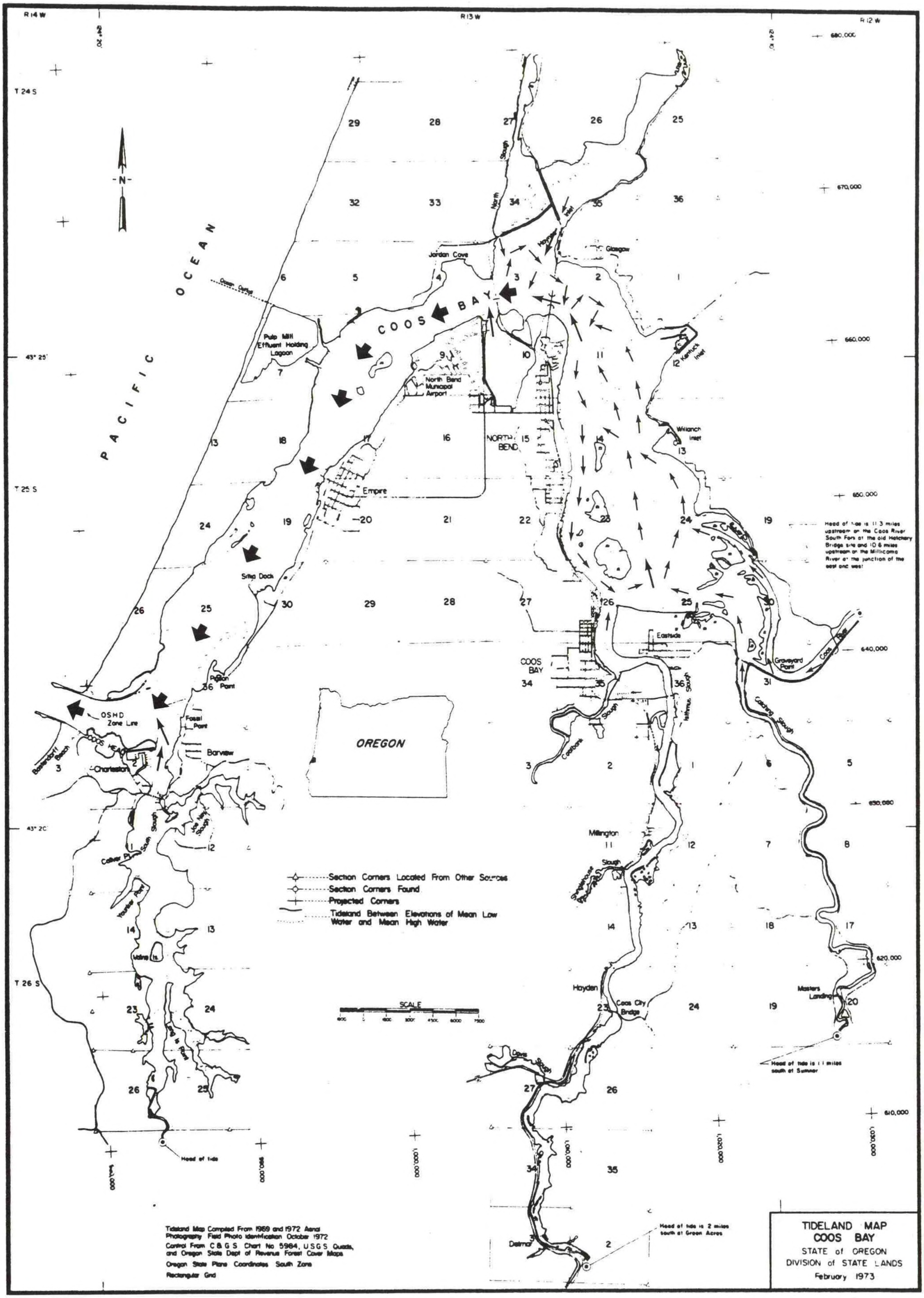


Table 4

Hydraulic Model Prediction Showing Direction of Net Water Movement in 24 Hours When Inflow From the Coos River is 30 Cubic Feet per Second

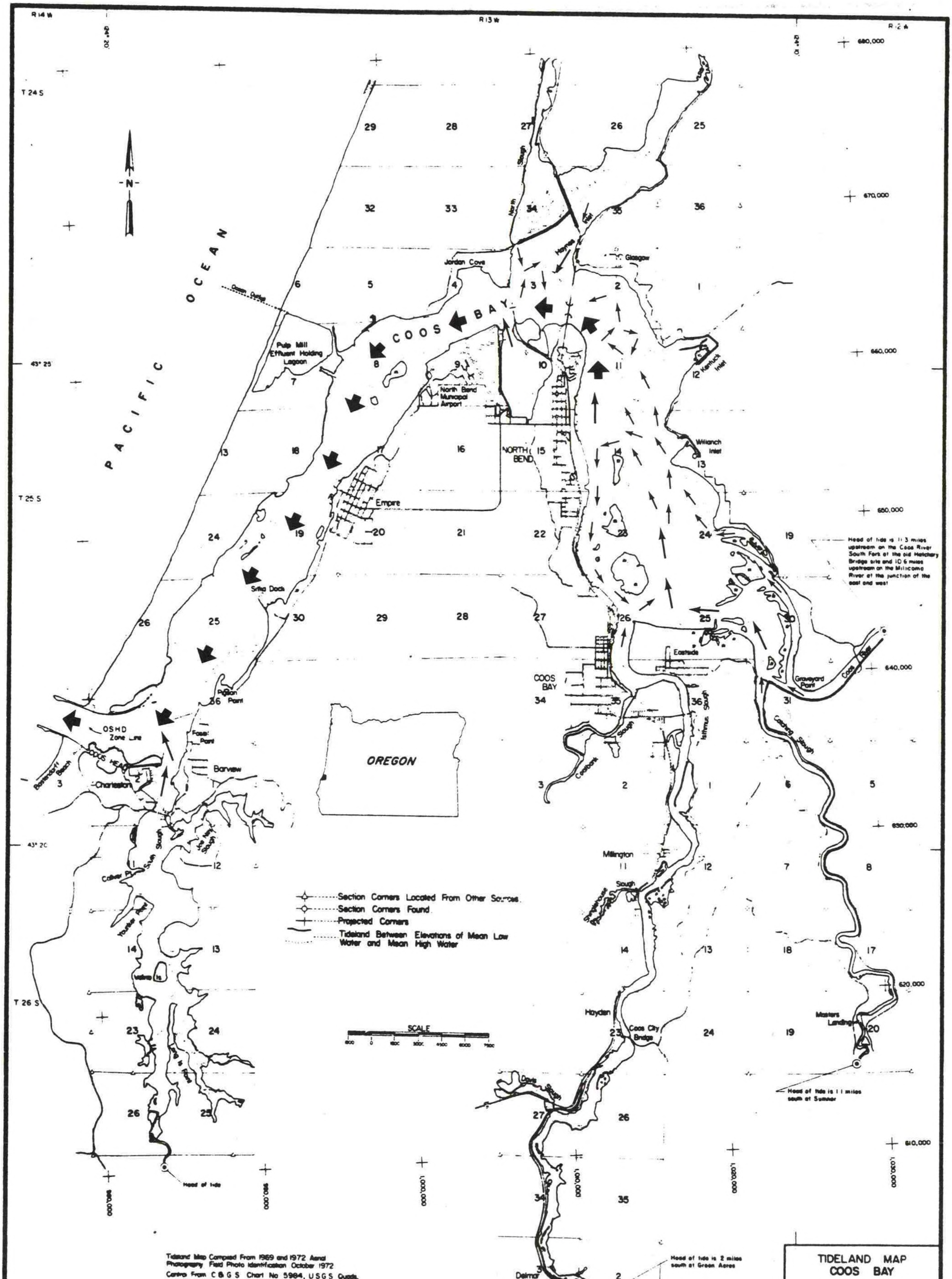


Table 5

Hydraulic Model Prediction Showing Direction of Net Water Movement in 24 Hours When Inflwo From the Coos River is 500 Cubic Feet per Second

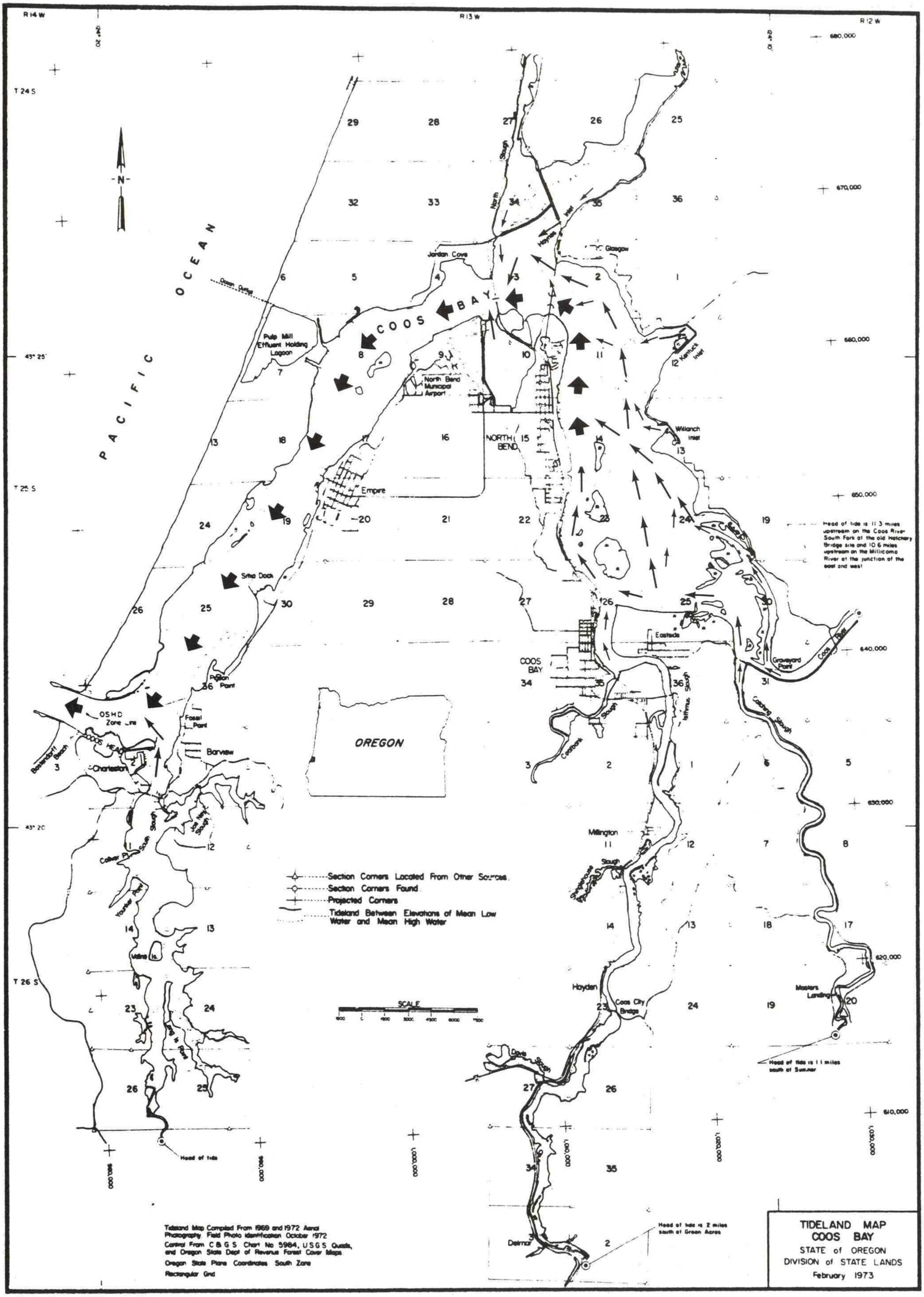


Table 6

Hydraulic Model Prediction Showing Direction of Net Water Movement in 24 Hours When Inflow From the Coos River is 2500 Cubic Feet per Second

Flushing rates for 2 sites in the Coos Bay estuary were calculated by Arneson in 1976 (see Table 7). His values show that the flushing rate for the upper bay at river mile 17.6 is about twice as long as for the middle bay at river mile 7.6. More importantly, he demonstrates that the flushing rate for the upper bay can show nearly a four fold variation between high and low river flows. It is important to note that calculations for flushing rates assume complete mixing in the water column and floating oil would ordinarily move more quickly. Nevertheless, Arneson's data are useful to the extent that they show the considerable influence river flow has on the system.

TABLE 7. FLUSHING RATES

Date	Tidal Range (feet)	Coos River Flow (cfs)	Flushing Time Days River Mile 7.6	Flushing Time Days River Mile 17.6
9-13-73	7.9	28	9.7	22.9
12-19-73	5.9	3,814	6.2	11.8
3-23-74	7.2	1,074	8.2	14.4
6-12-74	3.3	431	19.0	41.3

Under average flow conditions and tidal conditions, we can expect roughly a 2 to 4 day residence time for oil spilled at river mile 7.6 and a 7 to 10 day residence time for a spill at river mile 17.6, but it is obvious that extreme conditions could alter the pattern significantly. Furthermore, it is apparent that protection efforts are going to be more important in the summer when oil would tend to linger in the upper bay.

3. Weather Conditions

Seasonal weather conditions can have a significant impact on spilled oil behavior. On the Oregon Coast conditions are highly variable particularly during the winter months. Frequent, intense winter storms associated with the strong on-shore push of water from prevailing southerly winds, high wave action and low air pressure can result in storm surges which cause significant variations from predicted high and low tides. The response team must be aware of these conditions and be prepared to alter the response accordingly.

a. Winds

Coos Bay experiences strong northwest and southeast winds during the winter months and moderate to strong north to northwesterly winds in the summer. The strongest winds occur during the winter months from ocean storms generated primarily in the south. Wind generated waves will be highest when the fetch is longest. Consequently, southwest and southeast winds can be expected to produce significant wave activity in the northern ends of the bay, the northeast side of North Spit, Jordon Cove, North Slough, Haynes Inlet, Glasgow and Kentuck Inlet. Northerly winds can be expected to produce significant waves along the Coos Bay harbor, North Bend shore, Empire, Pigeon Point, and Charleston areas. Winds of 30 miles per hour will produce waves heights of over 2 feet in the lower bay in the more exposed areas negating the effectiveness of most oil booms. Besides producing waves, winds can also push oil across the surface of the water and drive it into areas not ordinarily impacted by tidal current actions and the resultant breaking waves will push oil far up the beach. As a consequence, winds play a significant role in planning the oil spill response effort. Whereas winds may make booming difficult, they could also serve to concentrate oil in certain sections and result in easier corraling and pickup. Since these conditions cannot be predicted, the on-scene coordinator will have to make appropriate decisions dependent upon the conditions (see Appendix B for wind and weather data). A further discussion on the effects of winds on certain areas will be undertaken in Section II F.

b. Air and Water Temperatures

Both air and water temperatures can play a part in the behavior of spilled oil. High air temperatures will increase the evaporation rate of the volatile components of an oil and disperse its total volume. Since the lighter, more volatile parts are more toxic to aquatic life, the toxicity of the oil will be significantly decreased. The heavier oil which remains will sink faster and this may hinder recovery and impact benthic fauna.

Cold air and water temperatures may slow oil movement and help protection efforts but prolong the oil's toxic effects. Extreme cold temperatures which result in ice formation, however, will physically hinder the response and cleanup efforts.

The climate of the Coos Bay area is marked by rather mild and fairly uniform air temperatures. The average temperature in January is 45° F while in August it is 59° F (see Appendix B). As a consequence, air temperatures will probably not be a major factor under most circumstances, but will usually result in some evaporation. Likewise, water temperatures are fairly constant, except in the upper bay in late summer, and should have little impact on oil behavior.

4. Properties of Oil

The physical and biological effects of an oil spill as well as the behavior of the slick and the efficiency of various cleanup methods are strongly influenced by the type of oil spilled. The characteristic physical and chemical properties of the oil type largely determine the thickness and spreading rate of the slick, the formation of emulsions, and consequently the most practical cleanup techniques.

There is considerable evidence that the nature of biological damage resulting from an oil spill is also directly related to the oil type. The capacity of an oil to smother and dislodge organisms is determined by its physical characteristics while toxicity is more closely related to its chemical composition. For example, spills of heavy fuel oils and some crude oils may result in damage to intertidal organisms due to smothering or displacement from shoreline surfaces. On the other hand, light fuel oils have a higher proportion of aromatic hydrocarbons than heavier fuel oils and are generally more toxic to aquatic organisms.

The spreading of an oil slick and a subsequent break-up of the oil film as well as the rate and extent of emulsification, evaporation, and biodegradation processes are determined by the physical and chemical properties of the spilled oil. The characteristics of oil which affect its behavior on water and the efficiency of cleanup operations include specific gravity, surface tension, viscosity, pour point, flash point, solubility in water and changes in these parameters with time. These same characteristics also determine the extent to which oil will be absorbed into the sediments, vegetation, and the cells of living organisms. The lighter oils tend to be more readily absorbed, hence their greater toxicity to aquatic life and greater propensity to remain in the sediments. The following table provides information about the various kinds of oil and their impacts.

TABLE 8. PROPERTIES OF OIL

Type	General Classification	Specific Gravity	API Gravity	Viscosity	Flash Point °C	Substrate Penetration	Toxicity
Gasoline	Light Distillates	0.65-0.75	60	4-10	-40	very high degree in all marshes and most tide flats.	very high direct and indirect toxicity
Jet Fuel		0.8	48	1.5	55		
Kerosene		0.8	50	1.5	55		
Diesel	Heavy Distillates	0.85	30	15	55	very low degree in all marsh types.	little chemical effect, serious physical interference
No. 2		0.85	30	15	55		
No. 4		0.9	25	50	60		
No. 6		0.98	10	300-3000	80		
Bunker		0.98	10	300-3000	80		
Crude	Crude Oil	0.8-0.95	5-40	20-1000	variable	highly variable	highly variable

D. The Impacts of Oil on the Biota of Coos Bay

Oil and its various components impact living organisms in a wide variety of ways. Possible direct effects include:

1. Death by coating and asphyxiation,

2. Death by contact poisoning,

3. Death by exposure to water soluble compounds,

Possible indirect effects include:

1. Food reduction,

2. Contamination,

3. Habitat displacement, thereby causing crowding and increased vulnerability to predation,

4. Reproductive failures,

5. Physical, chemical and behavioral changes, and

6. Incorporation of sublethal amounts of oil into tissues resulting in reduced resistance of the organisms to infection or stress.

The complex biological structure of Coos Bay is such that one or all of the above factors could affect a wide variety of organisms - perhaps destroying entire food webs. Such reactions would be impossible to accurately predict, but it is not difficult to project how the destruction of plankton populations by oil, for example, would affect the larval fish and shellfish which feed on the plankton, the adult fish which feed on the larvae, and waterfowl and marine mammals which feed on the fish.

Biological systems are remarkably flexible and may ultimately overcome the effects of oil spills given sufficient time but recovery is usually slow. For those species or habitats which are few in number, regeneration may be impossible. It is, therefore, essential that the particularly sensitive resources such as rare or endangered species, unique habitats, etc. be given all possible protection.

In the Coos Bay area, there are numerous unique and/or highly sensitive habitats. They will be discussed individually in the next section. With respect to rare or endangered species, there are no invertebrates or fish that are in danger of extinction. There are several species presently found in Coos Bay that are slowly decreasing in numbers including the large moon snail, Polinices; several species of polychaete worms; and the rat-tailed sea cucumber, Paracaudina. The significance of organisms such as these is that they provide stability to the ecosystem through diversity. As the numbers of species decreases, the susceptibility of the remaining populations to change becomes greater. In this sense, oil spills which frequently impact shallow water areas, where the greatest concentrations of estuarine organisms occur, pose a very real threat to the overall system.

There are a number of terrestrial species in the area which are considered either rare, endangered, or threatened. Their close association with the estuary makes them highly susceptible to the effects of oil. These include:

1. The Bald Eagle which is considered threatened and is known to use the estuary for feeding.

2. The Osprey whose status is unknown but migrates through the area between April and October and fishes in the estuary.

3. The Peregrine Falcon which is considered endangered and has been sighted in the area. It feeds in the marsh habitats from August to April.

4. The Brown Pelican which is listed as endangered, has been sighted feeding in the estuary from June to October.

5. The Snowy Plover which lives in the sands of North Spit. Its status is unknown, but it feeds on the tide flats beaches of North Spit and is thus subject to possible oil impacts.

6. The White-footed Vole, a small, mouse-like animal which is considered rare and feeds along stream banks in the estuary.

E. Significance of Various Estuarine Habitats and the Probable Impacts of Oil upon Them

The various shoreline types and the associated habitat will be described in descending order of sensitivity. Table 9 compares the relative value of Oregon's estuarine areas.

TABLE 9. ESTUARY VALUES IN OREGON

Estuary Values	Submerged Lands	Coastal Tide Lands	Eel Grass	Coastal Salt Marsh
Relative Area	very small	very small	very small	very small
Renewable	no	no	yes	no
Vulnerability	very high	very high	very high	very high
Resiliency	fair	poor	good	poor
Diversity	very high	high	high	moderate
Social Importance:				
1) Commercial	moderate	moderate	low	low
2) Recreational	very high	very high	high	moderate
Vulnerability of Animals	variable	very high	high	very high
Diversity of Species	very high	very high	very high	high

1. Tidal Marshes

a. Description

The tidal marsh vegetation type is composed of those communities of vascular, aquatic and semi-aquatic vegetation rooted in poorly drained, poorly aerated soil, which may contain varying concentrations of salt and which occur from low or high water inland to the line of nonaquatic vegetation.

The major marsh areas in Coos Bay are found in the upper reaches of South Slough, North Slough, Haynes Inlet, on the west side of Pony Slough, adjacent to Cooston Channel, Isthmus Slough and its tributaries, Coalbank Slough, Shinglehouse Slough, and Davis Slough. These important habitats are indicated on the vegetative map Appendix E and on the Oil Sensitive Resource Chart.

b. Importance

Tidal marshes are usually the most productive area in the estuary. The extensive plant production supplies food material to much of the bay and supports a wide range of organisms such as clams, crabs and polychaetes which in turn are food for fish, birds and mammals who also use the same areas for nurseries, feeding, protection, and nesting. In Coos Bay, much of the tidal marsh has been lost thereby emphasizing the importance of protecting that which remains.

c. Effects of Oil

Oil can cause severe problems in marshes by adhering directly to the plants and also by contaminating the sediments. Because there is little or no flushing in these areas, oil may remain for many years effectively destroying the most important primary production areas of the bay and impacting all the terrestrial and aquatic organisms which use the marsh.

2. Tidal Flats

a. Description

Tidal flats include that area of land covered and uncovered by the daily tidal cycle. Tide flats consist of sediments; primarily gravel, sand, silt, and clay, washed into the estuary by the coastal rivers and the sea. In Coos Bay, extensive tidal flats occur in the South Slough, along the east side of North Spit, at the dredge spoil islands near the North Bend airport, in North Slough, Haynes Inlet, Pony Slough, and in the large expanse from Glasgow to Marshfield Channel. In addition, large eelgrass beds are found adjacent to the tidal flats in South Slough, the shallows between Barview and the Sitka dock, Pony Slough, Haynes Inlet and the area between Reese Point and Kentuck Inlet. These areas may well be the most productive part of the estuary.

b. Importance

The tide flats of Coos Bay support significant algal populations responsible for primary production, and as mentioned above, extensive eelgrass beds in some locations. There are large numbers of benthic invertebrates such as clams, worms, and shrimp in the tide flat areas. The variety of organisms increases in eelgrass areas because of the greater stability and protection. Invertebrate populations support grazing of both birds and fish and are seasonally very important for migratory waterfowl and juvenile fish. The flats are also important as haul out areas for seals.

c. Oil Impacts

Oil can have long term persistence on tide flats due to the lack of waves and currents. It can also become incorporated into the sediments and have long term deleterious effects on the burrowing invertebrates and the many organisms that directly or indirectly depend on them for food. In Coos Bay the biological diversity and exposure of the flats will make these areas susceptible to damage from any kind of oil intrusion.

3. Rocky Shores

a. Description

Rocky shores include the areas of rocky substrate paralleling the edge of the bay. In Coos Bay, this encompasses the two jetties at the entrance, the constructed banks at Charleston Harbor, the airport dikes, the dikes along the North Bend and Coos Bay harbors, the highway dikes at Haynes and North Slough, and the diked areas in the lower parts of Isthmus, Coalbank, and Catching Sloughs and the lower Coos River.

b. Importance

Because of the protection afforded by the cracks in the rocks, these can be very rich ecologically, providing a good habitat for many macroinvertebrates plus substrate for algae and attachment sites for barnacles and mussels. The rocky shores in the lower bay are particularly important for this reason.

c. Oil Effects

Oil in this habitat can physically smother the numerous attached plants and animals and result in the removal of natural habitat for new colonizers. Without wave action, the oil can persist for long periods.

4. Silt and Sand Beaches

a. Description

These consist of beach areas occasionally inundated by tides. They are rare in Coos Bay, but, of course, common on the ocean side of the bay entrance.

b. Importance

Beaches are usually not highly productive since species diversity and density are quite low. The major value is for public use. However, there are some important clam beds as noted on the Resource Chart. Likewise, the beaches near Coos Bay on North Spit are used by the Snowy Plover, a rare shorebird species in Oregon.

c. Impacts

Oil on a beach can cause significant problems to the limited species present and impact important recreational areas. If the oil filters deeply into the sand, its effects can be long term.

5. Mud Banks

a. Description

Those areas of shoreline within the bay consisting of relatively steep mud or clay banks exposed to tidal action. These areas occur frequently along much of the Coos Bay shoreline, particularly in the sloughs.

b. Importance

The mud banks provide habitat for a limited variety of burrowing organisms, such as worms, amphipods, etc. These in turn provide food for foraging fish and water fowl.

c. Impacts

Oil can be expected to cling to these banks as tide waters recede and cause significant damage to the organisms which inhabit them and the predators which feed there.

6. Open Waters

a. Description

Open waters consist of those parts of the estuary continuously covered by water and include those parts of the sloughs not exposed during low tide.

b. Importance

In Coos Bay, the open waters support populations of phytoplankton, zooplankton, fish, marine mammals, feeding waterfowl, and are an important migratory route for anadromous fish.

c. Impacts

On open water, the oil could cause significant damage to planktonic organisms and this in turn would affect many fish species. Waterfowl, such as raptors, which feed on the fish could also be impacted as could other waterfowl which depend on the estuary for resting and feeding.

F. Specific Sensitive Areas - Description, Probable Effects of Oil, Susceptibility to Spills

1. Lower Bay

a. Description

The lower bay includes that area from the entrance of Coos Bay to river mile 9 at the railroad bridge. It encompasses a lower marine system up to river mile 2.5 which is essentially oceanic in character because of the vigorous wave activity, and an estuarine system from river mile 2.5 to river mile 9.0. There is a large diversity of habitat within this area supporting a tremendous variety of organisms. Available habitats include sand, cobble, boulder and bedrock shores; sand and sand-mud flats; algal beds on unconsolidated bottoms and on bedrock; eelgrass; and subtidal unconsolidated bottom. Particularly sensitive areas include the rocky area near Fossil Point, the shallows on the western side of the bay along North Spit from river mile 2 to river mile 5, the shallows on the eastern side of the bay from Fossil Point to the Sitka dock, and Jordan Cove.

b. Oil Effects

Oil could have significant effects on the diverse communities inhabitating the shallow tidal areas and rocky shores of the lower bay. In shallow areas where tidal currents are weak, oil could be expected to linger and cause long-term damages, whereas, in the rocky exposed areas, oil would weather fairly quickly. Organisms inhabiting deeper water would likely not be affected, but those which live in the surface waters or in the shallow intertidal areas would most certainly suffer damages which could have adverse ramifications for the entire estuary.

c. Spill Susceptibility

The lower bay is going to be susceptible to spills which occur anyplace in the estuary or in the near-shore ocean area. The railroad bridge represents the greatest hazard to ships and thus the most likely spill site for either a ship or a railroad accident. Other possible spill scenarios include collisions, grounding, explosions and refueling accidents. Even though the possibilities of such occurrences are quite small, as stated in Section IIA, accidents can and do happen. The largest threat to the lower bay environment would result from a spill which occurred on an incoming tide near the mouth of the bay since strong tidal currents and high waters would carry oil up onto the sensitive intertidal areas. A spill in the lower bay with an outgoing tide would be less threatening because of the strong ebb currents. However, a spill at the railroad bridge on the outgoing tide would not flush all the way out of the system on one tide cycle and thus represents a threat to the lower bay as the tide reverses. Such a spill would take 3 to 4 days at least to flush out of the system.

Increased shipping traffic and proposed future developments along North Spit such as a bulk oil storage facility, various shipping terminals, and an oil rig fabrication yard represent potential future threats to the lower bay system.

2. South Slough

a. Description

Located at about river mile 2, South Slough is the most important natural area of the Coos Bay system. Because of its relatively untouched character, irregular shoreline, and close proximity to the ocean, it has the widest variety of habitats and largest species diversity in the estuary. The numerous fringing marshes, tide flats and eelgrass beds in the upper and middle slough provide excellent habitat and feeding areas for numerous benthic organisms, fish, waterfowl, and estuarine related terrestrial animals. In addition, South Slough contains the most productive clam beds in the estuary and some commercial oyster culture facilities.

b. Oil Effects

The sensitive nature of South Slough, its tremendous importance to the overall estuarine system, and its significance as one of the few estuarine sanctuaries in the nation makes protection of the area from oil spills of utmost importance. The damage to natural resources wrought by large amounts of oil in the slough would be incalculable and the possibilities of adequately cleaning it are very poor due to its shallow nature, irregular shape, and limited access. As a consequence, all efforts must be expended to keep oil out of the area.

c. Spill Susceptibility

There appear to be several possible ways in which oil spills could affect South Slough. The most likely prospect would be a spill in the Charleston boat basin because of the sheer number of boats and the refueling operations. In most cases such spills would be relatively small but larger vessels with fuel capabilities up to 30,000 gallons do use this facility and a spill of that magnitude would cause considerable damage.

A second possibility would be a major spill on the bar. Should this occur on an incoming tide, a portion of the oil can be expected to enter South Slough and protection would be needed. Strong south winds as often occur in the winter might help keep oil out of the slough, but tidal currents are the primary moving force.

A third possibility would be a spill up bay from South Slough. On an outgoing tide, strong tidal currents coming out of South Slough would probably prevent oil from entering unless high north winds were present. On an incoming tide, the oil would go farther up bay. Although it would eventually come back down bay, the chance of it entering the slough appears small.

Road spills at the Charleston bridge also present a continuous threat. Although volumes would not be large, the prospects for protecting the slough on an incoming tide would be very poor.

3. Pony Slough

a. Description

Pony Slough branches south from Coos Bay between river mile 8 and 9. It is about 1 mile long and 1/2 mile wide at its widest point. It has been much altered by man but still retains some important subtidal and intertidal habitats of eelgrass beds, algal beds, mud flats, and marshes. A number of burrowing mud flat organisms occur here, including amphipods, ghost shrimp, clams, and dungeness crabs. It is also an important striped bass feeding area, but perhaps its most important function is as a protected resting and feeding area for wintering and migratory waterfowl.

b. Oil Effects

Because of its shallow nature, oil pushed into the slough by high tide could be stranded on the mud flats and cause considerable damage to the benthic habitat and its associated fauna. Waterfowl which are highly susceptible to oil could be severely impacted. Possibilities for an effective non-damaging cleanup are slight due to its shallowness.

c. Spill Susceptibility

The possibility of a spill actually occurring in Pony Slough is very small. A spill at the airport, along the Cape Arago Highway or in Pony Creek could potentially impact the slough, but the prospects particularly for a major land related spill appear remote.

Spills which occurred in the main shipping channel up bay or down bay from Pony Slough might impact the area. A flood tide and strong northerly winds could bring some oil into the slough and, consequently, protection efforts should be implemented under those conditions.

4. North Slough

a. Description

North Slough extends approximately 3 miles north of the main body of Coos Bay at river mile 9. It has a watershed of 8,190 acres. The extensive tidal flats have good populations of clams, worms, amphipods, shrimp and dungeness crabs. Major fish include shad, shiner, perch, staghorn sculpin, and starry flounder. There is a summer fishery for striped bass and there is a small fall run of Coho salmon. North Slough provides resting and feeding area for numerous waterfowl including dunlin, great blue heron, and a number of ducks. Of particular importance, are the marshes located in the upper part of the slough which are characterized as large, intact, and diverse.

b. Oil Effects

As with the other sloughs, North Slough's shallow nature makes it both susceptible to oil and impractical to cleanup. Much of the tidal flat area would be impacted as would the tidal marshes. Poor circulation would hold oil in the area for a long time, intensifying the impact.

c. Spill Susceptibility

North Slough would be particularly susceptible to spills which occurred on a flood tide from river mile 1 to 9. A combination of flood tide and strong south winds would likely send large amounts of oil into the slough.

The slough is also susceptible to spills occurring on Highway 101 which bounds the east side and from the Southern Pacific railroad on the west side.

5. Haynes Inlet

a. Description

Haynes Inlet extends about 2 1/2 miles northeast from its entrance into Coos Bay just east of North Slough. It has a watershed of 7,120 acres. The extensive shallows and tide flats support populations of organisms very similar to North Slough. There is a good run of Coho salmon which utilize Larson Creek and to a lesser extent Palouse Creek. Haynes Inlet is heavily used by waterfowl in the winter, but only lightly used in the summer. Much of the original marshland has been diked, but about 150 acres still remain.

b. Oil Effects

The effects of oil on Haynes Inlet will be similar to those of Pony Slough and North Slough. A large open-expanse of shallow water with poor circulation means oil would remain in the inlet for a long time.

c. Spill Susceptibility

The susceptibility of Haynes Inlet to oil is basically the same as North Slough with 2 exceptions. First, rail spills pose a much smaller threat. Second, south winds present a greater threat in that the broad expanse of water within the inlet would allow for significant wind movement of oil into the upper, more sensitive reaches.

6. Isthmus Slough

a. Isthmus Slough is a long, narrow channel which enters Coos Bay at about river mile 13.8. The head of tide is about 12 miles up the slough. Major tributaries include Coalbank Slough, Shinglehouse Slough, Davis Slough, and Noble Creek. A deep-draft channel 35 feet deep and 400 feet wide extends up the slough about 1.5 miles. Beyond that, a 150 foot wide 22 foot deep channel extends another 2 miles. The slough receives heavy industrial use for shipping, waste disposal, and log handling and storage. The water quality has suffered as a consequence and the diversity of organisms is lower than in other areas. Most organisms are crustaceans, arthropods, and polychaete worms. There are 6 recorded species of mollusks and 11 species of fish. Many of the historically important marshes of the area have been filled in, but important tracks of salt marsh still remain in Coalbank and Shinglehouse Sloughs.

b. Oil Effects

Poor circulation means that oil spilled in Isthmus Slough could remain for some time. The few remaining marshlands could be severely impacted and should be protected.

c. Spill Susceptibility

The shipping activity in the lower 3 miles of the slough suggests the potential for spills. This potential can probably be considered low since traffic moves very slowly and there are no refueling areas. Any spills occurring on an incoming tide, however, could have serious consequences.

A greater threat probably exists from spills that might occur in the Coos Bay harbor. An incoming tide could be expected to send oil up the slough. The threat also exists from road spills on Highway 101 which follows Isthmus Slough for several miles.

7. <u>Catching Slough</u>

a. Description

Catching Slough enters the main body of Coos Bay just west of the Coos River. It is about 10 miles from its mouth to the head of the tide. Once an area of vast tidal marshes totaling 1,600 acres, diking for agricultural purposes has reduced this to 50 acres. Organisms inhabiting the slough are similar to those found in Isthmus Slough. It supports good runs of Coho salmon and may be an important area for 5 to 6 year old striped bass.

b. Oil Effects

Poor circulation means that oil spilled in or adjacent to Catching Slough could remain for long periods of time and cause significant damage to natural resources.

c. Spill Susceptibility

Spills occurring in the Coos Bay harbor on an incoming tide could potentially impact Catching Slough. With the exception of very high tides, effects would probably be minor. Road spills perhaps represent a greater threat, but large volumes of oil would not be expected from such incidents.

8. Coos River Area

a. Description

This area includes the Coos River, Millicoma River and their tributaries. The lower parts of both these rivers are important for log storage and provide important habitat for numerous fish.

b. Oil Effects

The natural resources of this area are such that spilled oil would have minimal effects. Logs stored in the area, however, could be coated with oil.

c. Spill Susceptibility

Except for periods of very low river flow, spills in the bay proper would probably have minimal effects on the riverine system. A more serious threat is probably posed by road spills or industrial spills at the mills in the upper headwaters of both the Millicoma and the Coos River.

9. Upper Bay

a. Description

The upper bay broadens into a complex of wide, shallow tide flats adjacent to the main dredged ship channel extending from river mile 9 to river mile 17. Subtidal areas of the upper bay include the deep draft dredged channel from river mile 9 to Isthmus Slough; the shallowly dredged Marshfield, Cooston and East Channels; and the smaller channels draining the tide flats. The intertidal area is composed of broad, shallow tide flats, eelgrass beds and tidal marshes. The flats provide important habitat for worms, mollusks, and crustaceans; feeding area for shad, striped bass and juvenile salmonids; and resting and foraging area for numerous waterfowl. Although the diversity of organisms may be less than in the lower bay, the biomass is high and it is thus vital to the overall estuarine system. There are also some commercial oyster culture activities getting underway near Kentuck Inlet and the mouth of Haynes Inlet.

The most concentrated industrial activity in the estuary occurs along the shipping channel. The primary activity centers around forest products and to a lesser extent petroleum products. Fringing the shallows are extensive areas of log storage.

b. Oil Effects

The vast areas of tidal flats and its associated fauna and the oyster culture facilities will be severely impacted by an oil spill. The effects could be long-term and have far-reaching consequences for the estuary as a whole. Industrial activities on the other hand, would not be greatly impacted. There are no water intakes in this area. The most important consequences would be the oiling of stored logs and the vast number of pilings which support the various dock areas. Cleaning these areas would be very difficult and consequently, oil clinging to logs and pilings would leach into the system for a long time.

c. Spill Susceptibility

The most likely spill situation would be an accident at the railroad bridge where the restricted passageway represents a real threat to ship passage. Should a spill occur at this point on a flood tide, the upper bay would be severely impacted.

Refueling accidents represent the second most serious threat. Other accidents including collisions and groundings in the port area represent less likely situations. In all cases, the upper bay would be affected. As suggested earlier by circulation studies, a spill in the port area would affect the entire upper bay on both incoming and outgoing tides due to the circular circulation pattern. See the circulation maps Tables 2 through 6.

G. Other Resources Potentially Impacted by Oil

1. Archaeological Sites

Archaeological research in Coos Bay has been limited. There are, however, approximately 20 known sites with evidence of early occupation. These have been identified on the Oil Sensitive Resource Chart. Those sites located in intertidal areas face the greatest threat from oil spills. The ancient materials owe their preservation to the mud and water environments and activities associated with oil spill response such as mechanical cleanup of contaminated areas could physically disturb artifacts as well as disturb their historical context. Oil would also contaminate materials making carbon-dating, restoration, and preservation impossible.

Protection of archaeological sites would be very difficult. If a site or sites appears threatened, a professional archaeologist familiar with the area should be included in the response effort. The archaeologist could identify site locations, assess the damage, decide whether or not cleanup techniques would impact the cultural deposits, and monitor any recommended cleanup to ensure that minimal destruction occurs.

2. University of Oregon Institute of Marine Biology

This unique teaching and research facility is important not only to the town of Charleston and the Coos Bay area but to the state of Oregon as well. Having such a facility near the scene of a spill offers the advantage of having highly trained scientists and students available to do spill related studies immediately. On the other hand, experiments already in progress in the estuary could be disrupted or ruined resulting in considerable loss of time and money.

3. Marinas

There are 3 moorage facilities in the Coos Bay estuary. The Port of Coos Bay Moorage Basin at Charleston accounts for most of the moorage space with 558 permanent berths. Hansen's Landing in South Slough has 100 permanent spaces and the city of Coos Bay Moorage at river mile 14 has 18 permanent berths with 5 transient spaces. There is no question but that oil in these basins would require extensive cleanup of the effected boats. Adequate protection will be difficult. If a boom could be successfully deployed at the entrance to South Slough, however, as suggested in the Response Section III C, then both the port's facilities and Hansen's Landing would be protected. Otherwise the western portion of the port's moorage could be boomed near the boat ramp to protect part of the boats. The eastern portion could not easily be boomed. Hansen's Moorage could be protected by a boom at Joe Ney Slough. The city of Coos Bay Moorage could probably not be protected.

4. Aquaculture

There are 2 salmon sea ranching ventures located in the Coos Bay estuary. Both facilities are owned by Anadromous, Inc. and both draw bay water off the bottom for use in rearing salmon. Since they have no alternative sources of water, the presence of oil near their intakes poses a very serious threat to their operations particularly if the oil is mixing in the water column or sinking to the bottom. It appears that little could be done to protect these intakes but both should be evaluated to determine if an appropriate protection strategy can be devised.

Oyster culture in Joe Ney Slough could also be seriously threatened by spilled oil. It appears that booming Joe Ney Slough is practical and this probably offers the best hope for protection of the oyster areas. The oyster culture areas in the Upper Bay could not be protected.

5. Recreation

Recreational activities such as fishing, clamming, boating and beach use could be severely impacted by a major spill on the bay. The economic consequences to the area with respect to tourist trade could be adverse and long-term if resources remain unusable or unsightly. Prevention of spills and protection of resources represents the most appropriate approach to maintaining the recreational value of the area.

There are 3 state parks near the entrance to Coos Bay at Cape Arago and a county park along the south jetty. A large spill on the ocean side of Coos Bay or within the bay itself could severely impact the beaches and rocky intertidal areas of these parks, damaging important habitat and ruining their recreational value.

6. Log Storage

The upper bay and the various sloughs are used extensively for log storage. Estimations are that 320 to 350 acres of logs are stored in the estuarine areas. The largest numbers are stored in Isthmus Slough and the lower Coos River. There are also logs stored along much of Marshfield Channel and Cooston Channel and along the dredge spoil islands opposite the port area. Oil spilled in the bay could contaminate these logs and cleanup would be required before they could be used, thus incurring considerable expense. On the other hand, log booms can be effective oil barriers if currents and winds are minimal. Thus although little could be done to protect the logs, they could offer some protection of shoreline areas. Under some circumstances, it might be possible to move log booms to areas needing protection.

H. Data Needs

Coos Bay has been extensively studied. The available information on natural resources seems to be more than adequate for oil spill response needs. On the other hand, data on physical processes, particularly tidal current velocities, is limited (see Table 1), and this restricts our ability to accurately predict oil movements. Coincidentally, the National Oceanic and Atmospheric Administration's National Ocean Survey conducted current velocity studies in Coos Bay in the fall of 1982, and the data obtained from that survey when it is available may help fill the gaps, and it will be appended to this report.

III. OIL SPILL RESPONSE

A. Sensitive Resource and Response Chart Use

Extensive mapping of the natural resources of Coos Bay was completed during the development of the Coos Bay Estuary Management Plan in 1980, by Wilsey and Ham and the Coos-Curry Council of Governments. Reproductions of these maps are included in Appendix E, for reference to specific sites and organism relationships. A major difficulty associated with such mapping is the extreme complexity of the biological community, particularly in the tide flat areas. To represent such complexity accurately involves either highly detailed maps or a large number of maps, neither of which, for obvious reasons, is suited to an emergency response situation. As a result, a Sensitive Resource Map was developed for use by the spill response team.

The "Oil Sensitve Resources of Coos Bay Chart" shows four generalized sensitive natural areas as indicated by four different patterns. The first three categories, shellfish habitat, marshes, and fish habitat are fairly self-explanatory. The fourth component, important intertidal areas, is a catch-all for those locations which may contain a variety of vulnerable resources, including such things as marshes, eelgrass beds, shellfish beds, benthic organisms, tidal flats, juvenile fish nurseries, waterfowl resting and feeding areas, and a host of other biological entities. The four categories can and do overlap.

The Coos Bay estuary is divided into nine geographic areas which can be referenced to the table at the bottom of the chart. Likewise, all man-made structures which could be impacted by oil such as marinas, and water intakes are identified by symbols and letters. The table lists all the potentially sensitive resources of Coos Bay and their distribution by river mile, area number, and letter. The relative importance of a particular resource as judged by organism concentration and sensitivity is indicated on a scale ranging from very high to low.

On the right hand side of the table is a column which indicates the seasonal sensitivity of a resource and its priority for protection. Section IIB, provides the details as to how these criteria were determined.

An "Oil Spill Response Chart" was also developed to provide the information needed to protect the identified sensitive areas. On it are indicated boom sites, possible diversion locations, boat launches, road access areas, and the location of tide gates. The area numbers, letters, and symbols can be referenced to the key at the top of the chart which contains information about each area such as boom sites, length of boom needed, tidal currents, vulnerability, sensitivity, and nearby access. A detailed description of the protection measures is contained in Part C.

The two charts contain the heart of the protection plan (see Appendix D). The on-scene coordinator should be able to look at them and obtain a general idea as to the type of strategy he will need to employ. Unfortunately, there are numerous variables which can affect the response and must be considered on a case-by-case basis. Such factors as winds, tides, location of spill, type of oil, amount spilled, and weather conditions must all be evaluated before an effective response can be initiated. The Background Section of the report attempts to deal with these problems and should be studied carefully so that informed decisions can be made.

B. Protection Measures

1. Prevention

The first line of defense against oil spills is prevention. The importance of prevention especially for the Coos Bay area cannot be over-emphasized. Properly maintained equipment, adequate cleanup systems, rigorous inspection programs for ships, oil transport vehicles, oil handling facilities and industries, and thorough training programs for individuals who handle oil products all make essential contributions to the prevention of oil spills. In addition, appropriate land use planning can assure that new facilities for petroleum storage and transfer are not located in areas of critical and/or fragile resources.

2. Containment

In spite of efforts to implement prevention measures, spills do happen. Since 75% of all spills are due to mishandling, we can assume that most spills will occur at docks or terminals. Thus the second line of defense and a highly critical one for Coos Bay is containment of the oil at the spill site. The potential for containment in such areas is quite high. With proper equipment in ready condition and operators who are adequately trained, loss to the dynamic estuarine environment can be minimized. All areas that have oil handling facilities or vessels with large fuel capacities must be well prepared to respond immediately to spills with containment devices such as: booms, absorbent materials, oil barriers, and air and water hose sprays either permanently in place or readily available for immediate deployment.

3. Protection

In an area such as Coos Bay with broad expanses of highly sensitive tidal areas, strong tidal currents, and frequent winds, the rigorous implementation of the first two defense mechanisms is of paramount importance. Even with maximum efforts, however, the possibility for oil escapement to the open estuaries still exists. Accidents in the shipping channel such as groundings or collisions and large spills at the dock areas which might overwhelm the capacity of containment equipment, all pose threats to the system. Although the chances of such accidents may be small, the potential exists and will increase in proportion to the projected increase in vessel traffic. Thus it is also vitally important to have schemes for protecting the environment as a third line of defense.

There are several methods commonly used to protect sensitive areas:

a. Containment Devices

The most common way to protect a sensitive location is by creating a barrier to surface oil movement using devices such as oil booms. This assumes that the oil will be less harmful if it impacts some other area. The present day oil boom, however, is usually only effective in currents of less than one knot and waves less than two feet high. When these conditions are exceeded, the same boom can be used in a diversionary manner by deploying it at some angle to the current in a diagonal, chevron, or cascading pattern. This method may be used to divert oil away from a sensitive spot or to divert oil into a suitable containment spot where it can be picked up with sorbent materials or oil skimmers.

b. Dispersants

Chemicals which cause the surface area of an oil film to greatly increase may be used to protect shorelines, reefs or natural aquatic resources, and areas such as fishing banks or oyster beds. This is accomplished by applying a dispersant on the oil slick sufficiently distant from the sensitive area to avoid an effect from either the dispersant or a dispersed emulsified oil. Although the technology of dispersants has greatly improved and they are no longer as toxic to aquatic life as they once were, they are still generally only useful in open ocean situations. A dispersant would rarely be recommended for use in a confined area such as a bay because it would drive the oil onto sensitive shoreline areas and concentrate the toxic components of the oil.

In addition, the Oregon Department of Environmental Quality's oil spill regulations contained in the Oregon Administrative Rules, Chapter 340, Division 47, Section 020 prohibit the use of chemicals to disperse oil.

c. Other Methods

Other materials which are sometimes used to protect areas from the effects of oil spills include: sinking agents, flocculents, burning agents, and absorbent materials. All of these have limited application. Sinking agents have been successfully used in deep water situations, but would rarely be useful in an estuary where sinking would blanket important benthic habitat. They are now prohibited by federal law. Burning agents are generally technologically and environmentally unacceptable. For small spills, flocculents and absorbents may be very useful, but large volumes of such materials cause significant retrieval and disposal problems.

The use of any of the above materials must be carefully considered on a case-by-case basis weighing the benefits against the possible harmful effects. Because of the confined nature of Coos Bay, it appears that oil booms and possibly absorbent materials are the only feasible protection devices.

With this in mind, the protection plan represented on the chart appears to be the most practical approach to the protection of Coos Bay's natural resources. Considering the fact that it is impossible to predict all situations, the plan represents an ideal situation by indicating all places where booming and protection are desired. In reality, it will probably not be possible to boom all the designated sites and decisions will have to be made according to actual spill conditions as to what priority areas should or need to be protected.

C. Specific Sensitive Areas

1. Lower Bay Response

The lower bay unfortunately presents very few opportunities for response or for resource protection. With the exception of South Slough, all the sensitive areas of the lower bay are unboomable due to their exposure to winds and currents and their broad expanses which would require much more boom than is currently available. Safe navigational procedures and other preventative tactics appear to be the only way to ensure protection of this area.

2. South Slough Response

The obvious approach to protection would be to attempt to boom the slough at the Charleston bridge. Current measurements indicate however, that tidal currents of from 2 to 4 feet per second can be expected during tide changes and this would negate the value of any boom except during the 2 hours near slack water. Once oil has moved south past the bridge, the bay widens quickly so that booming here would be unrealistic. As a consequence, it appears that the best chance for protection is to boom the entrance of South Slough to the main channel. It would require at least 600 yards of boom and could be appropriately done if winds were out of the south or with relatively light north winds. With strong north winds, this site would be unfeasible.

The second most desirable approach would be to use a series of cascading booms starting in front of the boat basin and attempting to divert oil into the shallows just south of the boat basin where it would be contained and removed with a skimmer. This approach would require about 1,000 yards of boom.

If these schemes failed, the last hope might be to try to boom South Slough at Collver Point using about 600 yards of boom. At the same time, efforts would have to be made to boom Joe Ney Slough at its entrance using 200 yards of boom.

In any event, the importance of South Slough justifies a response effort at all times. The storage of 1,000 yards of oil boom in Charleston which could be ready for immediate deployment might facilitate a timely and appropriate response.

3. Pony Slough Response

The best response would be to deploy boom at the entrance to the slough since tidal currents are fairly weak. Here the prospects of successfully deploying a boom appear good unless wind driven waves of over 2 feet in height were present. Approximately 300 yards of boom would be needed. Because of waterfowl use, this should be considered a high priority area in the winter and a second priority in the summer. Under some circumstances, it would be advisable to attempt to scare the waterfowl out of the area.

4. North Slough Response

North Slough will need protection from spills that occur in the lower bay on a flood tide. It will be particularly susceptible when the tide range is large and when there is south winds, usually in the winter. The ideal boom site would be at the causeway bridge, but tidal currents are strong at this site and an oil boom would likely fail. Thus, the best approach appears to be to anchor a series of cascading booms outside of the entrance to divert oil into the shallows east of the bridge where poor circulation might allow for its recovery and pickup. Approximately 600 yards of boom would be needed.

Should a spill occur on the highway or railroad, the most appropriate response would be to boom off the narrow upper end of the slough to protect the marshes. About 100 yards of boom would be needed for this effort. North Slough could be considered to be most sensitive in the winter and spring, but protection is important at all times.

5. Haynes Inlet Response

As with North Slough, Haynes Inlet will need protection from spills that occur in the lower bay on a flood tide, being particularly susceptible when the winds are from the south and tide range is large. Strong tidal currents will prevent the booming of the entrance and again a series of cascading booms will be needed to divert oil west into the shallow area along the causeway where containment and retrieval might be possible. Approximately 600 yards of boom will be needed. The most sensitive season will be winter and spring.

6. Isthmus Slough Response

To protect the upper, more sensitive areas of Isthmus Slough, it is recommended that the slough be boomed at about river mile 15.5 below the bridge, using about 200 yards of boom. It is also recommended that Coalbank Slough be boomed at its mouth near the railroad bridge. Less than 100 yards of boom will be needed at this site. With a large number of stored logs in the area, log booms might be utilized for protection.

7. Catching Slough Response

The upper reaches of Catching Slough could easily be protected by booming it about 1/2 mile upstream from the bridge at the Coos River highway. Approximately 100 yards of boom would be needed.

8. Coos River Response

For spills that occur in the Coos Bay proper, the Coos River system would have a low priority for protection. Should a spill occur in the river itself, however, booming the river to prevent downstream movement of oil into the estuary would be desirable. The location of this boom would be dependent upon the spill location. Road access to both sides of the lower river presents good prospects for booming and recovery. Downstream currents are strong and the best approach would be to try to divert oil to a pickup point using a boom placed at an angle.

9. Upper Bay Response

Efforts to protect the upper bay will be greatly hampered by the sheer size of the area. Natural circulation patterns, winds, tidal currents make any efforts to protect the vast open spaces of the tidal flats nearly impossible. Certain restricted sites can be boomed such as Isthmus Slough, Catching Slough, Cooston Channel, Kentuck Inlet, and Willanch Inlet, but most areas are in effect, unprotectable. As a consequence, appropriate spill prevention measures and deploying readily available response equipment represent the best response effort.

D. Recovery

Once an oil spill has been contained and sensitive areas are protected, the contained oil must be recovered before it has an opportunity to escape into the environment again. Usually this involves a combination of various physical methods depending on the situation. These include:

1. Skimmers which, as the name implies, are used to skim oil off the surface of the water. They come in a large variety of shapes and sizes varying from small unmanned machines to large self-propelled manned apparatus.

2. Sorbents which act through the process of absorption and adsorption to selectively remove oil from water. These can be natural or synthetic but are usually only practical in small areas because of the expense of recovery and disposal.

Decisions regarding recovery techniques will have to be made according to the circumstances but any methods used must be environmentally acceptable.

E. Cleanup and Removal

It is rare when oil spilled on water can be completely contained and recovered before some of it reaches the shoreline. Cleanup of the shoreline areas is considerably more difficult and time consuming than containment and recovery operations on water. It should be emphasized that the physical removal of oil from some types of shoreline may result in ecological and/or physical damage far in excess of that which would occur if oil removal were left to natural processes. The decision to initiate cleanup and restoration activities on oil contaminated shore areas should be based on careful evaluation of social, economic, aesthetic, and ecological factors.

When oil has polluted beaches in a populated area or areas of recreational use, priorities and pressures for cleanup may differ from the priorities associated with remote or uninhabited coastline areas. If a shoreline area is heavily used by the public, the length of time necessary for the removal of oil by natural processes may be unacceptable and cleanup action will be required despite its possible ecological implications. Under most circumstances, however, biologically sensitive shoreline types should be given the highest priority for protection and cleanup measures. The following pages outline appropriate cleanup measures for the estuarine habitats described in Part II E.

1. Tidal Marshes

Due to their shallow nature, many of the tidal marshes of Coos Bay have very poor water accessibility which will make any type of oil cleanup response difficult. In most cases, the do nothing approach may actually be the best, since efforts to cleanup frequently cause more severe damage to the plants and sediments than the oil itself. If some cleanup is necessary, the best method is low pressure water flushing conducted from boats during high tide. Under certain circumstances, hand cutting of oiled vegetation may be possible, but it is not usually recommended because of the severe disturbance caused by trampling.

If there are large accumulations of oil, trenching may be necessary to drain the oil out to the recovery area. Under all circumstances, a professional biologist should be consulted before any action is taken.

2. Tidal Flats

The tide flats of Coos Bay will be particularly hard to protect and cleanup due to their exposure to wind, waves and currents. In some cases, tidal currents may be sufficient to carry oil back off the flats where it can be collected. If cleanup is needed, heavy equipment and large crews should be avoided because of the damage such activities can inflict to the fragile ecology. Instead, low pressure water flushing with small crews would be most desirable.

Once again the do nothing approach may be the best alternative and consultation with a trained biologist is mandatory before any action is taken.

3. Rocky Shores

Although it is usually tempting to sand blast or steam clean rocks, these methods should be avoided unless absolutely necessry because of the great damage to the surviving organisms. If cleanup is deemed necessary, low pressure water flushing is the recommended method.

4. Silt and Sand Beaches

It is probably best not to cleanup here unless the public demands it. Large tar balls can be removed by hand, and small accumulations can be raked. Earth movers and bulldozers should be avoided unless absolutely necessary.

5. Mud Banks

Cleaning should be avoided unless large accumulations are clinging to the banks and leaching back out with the changing tide. Under such circumstances, flushing with low water pressure can be attempted. High pressure water jets which might erode the banks should be avoided.

6. Open Waters

Cleaning methods are limited to corralling oil and picking it up with skimmers. A possible strategy would be to protect those inlets which can be boomed and allow the tidal river currents to disperse remaining oil.

F. Available Oil Spill Equipment and Expertise

1. Equipment

A comprehensive listing of the oil spill response equipment which was present in 1982 at the various Oregon coastal ports is given in Appendix A. Although it appears to be an extensive amount of material, close examination reveals that only a part of this equipment is located in the Coos Bay area. A spill of any significant size would, therefore, require that response gear be air-lifted, trucked, and boated in from the Astoria and Portland areas. The lag time associated with getting equipment on-scene will seriously hinder the success of any response effort. Coos Bay is fortunate in that there is an airport and a Coast Guard Air Base adjacent to the estuary. Such a site will provide excellent facilities for a command post and staging area for a major response effort. Unfortunately, except for that gear which can be air-lifted in, it's likely that at least one 6-hour tide cycle will have elapsed before most of the necessary equipment and crews can be on-scene. During this time, considerable environmental damage could occur.

With the risk of oil spills being quite low, the expense of maintaining enough equipment to respond to a large oil spill would be difficult to justify. Hence, the lag time will probably continue to be a reality. Shipping activities are expected to expand however, and consequently serious consideration should be given to developing better local response capabilities. As emphasized in this study, many of the sensitive areas of Coos Bay cannot be adequately protected unless the response is timely and appropriate.

Stockpiling equipment provides better assurance that the response will be timely. In particular, more boom is needed along with better oil retrieval capabilities. A large, floating self-propelled skimmer capable of chasing oil in the bay would be an especially appropriate addition to the local response system.

2. Expertise

In Coos Bay, the U.S. Coast Guard has trained personnel who provide initial response, assessment, coordination and surveillance services for all spills in estuarine or coastal waters. The local station at the North Bend airport serves this function but their resources are limited. At present the Marine Safety Detachment has one man and the Marine Environmental Protection group has three men with training in oil spill response. For a major spill, the response team from the Portland Coast Guard would be called as would the Pacific Strike Team from San Francisco. A two to three hour time lag can be expected before their arrival on-scene.

Actual equipment deployment and cleanup would be provided by private contractors using crews of highly trained specialists. The equipment and people, as stated earlier, must also come from Portland and a six (6) hour time lag can be anticipated. Even if equipment were available at Coos Bay, trained people would be needed to operate and deploy it. It has been suggested that local people such as police, fireman, fisherman and the National Guard could be trained to provide an initial response pending the arrival of people from Portland. With appropriate planning this may well be a good way to compensate for Coos Bay's relative isolation. Training is absolutely necessary, however, and it costs time and money. A strong commitment would have to be made by the people of the area to develop such a response capability.

IV. SUMMARY AND CONCLUSIONS

This report represents an attempt to consolidate all the currently available information on Coos Bay which might pertain to an oil spill response situation and to provide guidelines for those whose responsibility it is to deal with the complex, response related activities. The information provided is assumed to be fairly complete. The major exception is the data on tidal current velocities which is limited by the small number of actual field measurements.

The core of the protection plan is contained on the two large charts (in the back pocket) and in the Appendix which depict the important vulnerable resources and how they might best be protected. On one chart the sensitive resources are located, briefly described, and prioritized according to their seasonal sensitivity and relative importance. On the second chart, boat launches, access points, suggested boom sites, and diversion locations are depicted. The extensive narrative is divided into two main parts. The first provides background information on the Coos Bay estuary, the potential for oil spills, the effects oil will have on sensitive resources and how physical processes will influence the spill response. The second section outlines the actual response strategies including protection measures, boom sites, cleanup and removal techniques, and available equipment and expertise.

The booming scheme detailed in Section III C represents an ideal response situation since all places where protection is desirable are indicated for booming. It is done by section so that response can be localized. During actual spill conditions, the size of a spill, its location, the type of oil, weather conditions, etc., will all be important factors in determining what can and should be done. In Coos Bay several problems exist which will make oil spill response particularly difficult. These are:

1. The tidal action and its associated tidal currents will make protecting some locations nearly impossible.

2. Oil spill response equipment and personnel in the local area are limited. Materials and people will have to be brought in from Portland and other areas and this will result in delayed response.

3. Extensive areas of highly sensitive and exposed natural resources exist in Coos Bay where protection would be very difficult even under the best of circumstances.

The probability of a major spill happening at the present time is fairly low, however, should such an event occur, the scope of the above problems is such that protecting all of Coos Bay's resources would be physically impossible and the consequences would be disastrous. The plan stresses the need to develop good handling, safety, and spill prevention techniques as the best approach to protecting the estuarine environment. Adequate containment capabilities at all docking facilities is emphasized as a second line of defense. Should oil escape into the bay, the plan is designed to provide the appropriate information and guidelines so that the difficult, decision making process will be easier and less time consuming, thereby assuring that the response effort would proceed in the most efficient manner possible.

V. RECOMMENDATIONS

1. It is strongly recommended that efforts be made to reduce the response time between the occurrence of a spill and the arrival of necessary equipment and personnel. Industry, business, and the local community should investigate the feasibility of:

    a. Establishing a local oil spill cooperative.

b. Providing more response gear in the general area including more oil boom and at least one large, floating self-propelled skimmer.

c. Training local people for emergency response.

2. All efforts must be made to assure that adequate safety measures are observed at all docking and fueling facilities.

3. All docks and fueling facilities must have spill containment equipment available in ready condition with personnel trained in its appropriate usage.

4. It is recommended that the Coast Guard investigate the possibility of conducting a simulated oil spill in the Coos Bay area in order to evaluate present response capabilities.

5. This plan should be updated whenever changes in shipping traffic occur, when changes in environmental conditions occur, when more data is available, or when changes in spill prevention and cleanup techniques occur.

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VII. APPENDICES

Appendix A. Available Oil Spill Response Equipment on the Oregon Coast - 1982. Courtesy of the U.S. Coast Guard, Portland District.*

Astoria Area

1.	U.S. Coast Guard - Astoria Air Station	-	1000' Kepner Sea Curtain 160' sorbent boom 2 - 40# bales of sweep 6 - 40# bales 3M-156 pads
2.	Nat'l Marine Fisheries Service-Hammond	-	2 research vessels
3.	Astoria Flight Service	-	Cessna 172 Piper Aztec Piper Comanche 260 Piper Cherokee 140
4.	Knappton Towboat Co.	-	1000' Kepner Sea Curtain 40 - 40# bales 3M pads 2 deployment boats
5.	Standard Oil-Astoria	-	5 - 40# bales 3M pads

Tillamook

1.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales 3M-156 pads

Cape Disappointment

1.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales of 3M-156 pads

Depoe Bay

1.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales 3M-156 pads

*This information is subject to frequent change. For updates, the Coast Guard office in Portland should be contacted.

Yaquina Bay

1.	Georgia-Pacific Corporation-Toledo	-	600' Kepner containment boom 24 - 45# bales sorbent oil chips 400' sorbent oil boom
2.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales 3M-156 pads
3.	Newport Aviation	-	1 - Cessna 310 1 - Piper Turbo Arrow 1 - Cessna C 172 1 - Cessna C 177 1 - Piper PA28 117 1 - Piper PA28 181

Siuslaw River

1.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales 3M-156 pads

Umpqua River

1.	International Paper-Gardiner	-	240' sorbent oil boom 3 - 20# bales 3M-156 pads
2.	U.S. Coast Guard	-	80' sorbent boom 1 - 40# bale of sweep 4 - 40# bales 3M-156 pads

Coos Bay Area

1.	Coos Head Timber Co.	-	70' Acme floatation coral 18-25# bales 3-M 240 pillows
2.	Fibrex and Shipping Co.	-	500' Acme containment boom
3.	Georgia-Pacific Corp.	-	Acme Skimmer 100 gpm 100' Acme floatation corral 1 oil mop 14E
4.	Oregon Coast Towing Co.	-	500' Kepner containment boom 200' sorbent oil boom 2 deployment boats 48# sorbent oil swabs 600# sorbent oil chips 4 - 40# bales 3M 100 rolls 3 - 17# bales 3M 126 sweeps 22 - 20# bales 3M 156 pads

5. Texaco Inc. - 500' Kepner containment boom
200' sorbent oil boom

6. Standard Oil Co. - 500' Kepner containment boom
6 - 20# bales 3M-156 pads
80' Conweb sorbent boom
4 - 80# Conweb blankets

7. Weyerhaeuser Co. - 100 gpm Acme oil skimmer
240' sorbent oil boom
4 - 47# bales 3M-240 pillows

8. Coos Aviation - Cessna 152's
Cessna 172
Cessna 182
Cessna 210
Cessna 337

9. N. Bend Air Station-USCG - 1000' Kepner sea curtain
160' sorbent boom
2 - 40# bales of sweep
6 - 40# bales 3M-156 pads

Chetco River

1. Coast Marine Const. Inc. - 170' sorbent oil boom
1 - 100 gpm Acme skimmer

2. U.S. Coast Guard - 80' sorbent boom
1 - 40# bale of sweep
4 - 40# bales of 3M-156 pads

This Plate was provided through the courtesy of The Portland District, U.S. Army, Corps of Engineers.

PLATE I. JANUARY AND JULY WIND ROSES FOR SELECTED SITES

TABLE 10. NORTH BEND WINDS AND AIR TEMPERATURES

	AIR TEMPERATURES					WINDS	
Month	Daily Maximum	Daily Minimum	Monthly	Record Highest	Record Lowest	Velocity (mph)	Prevailing Wind Direction
January	52.0	38.3	45.2	74	17	12.3	SSE
February	53.7	40.0	46.9	78	21	10.3	SE
March	54.5	40.4	47.5	88	28	10.7	SE
April	57.2	42.8	50.0	88	31	11.4	SE
May	60.7	46.8	53.8	94	34	12.4	NNW
June	64.0	50.0	57.0	86	40	11.4	NNW
July	66.1	51.9	59.0	84	41	14.5	NNW
August	67.2	51.9	59.4	84	42	11.3	NNW
September	66.6	50.2	58.4	92	37	9.2	NNW
October	63.1	47.1	55.1	90	31	8.3	SE
November	57.6	42.8	50.2	76	26	9.2	SE
December	54.0	41.1	47.6	69	26	10.7	SE
Yearly Average	59.7	45.3	52.5	94	17	11.0	SE

SOURCE: U. S. Dept. of Commerce, Weather Bureau, Climatological Survey.

APPENDIX C: TIDAL CURRENT MEASUREMENTS

Coos Bay Tidal Currents Main Channel

Location	River Mile	Date	Tidal Range	Velocity in FPS Ebb	Velocity in FPS Flood	Source
Coos Bay Entrance	0	9-12-73	6.0'	3.6	3.6	Arneson, '67
"	0	12-18-73	7.5'	4.0	-	"
"	0	3-22-74	5.3'	4.3	2.6	"
"	0	6-11-74	5.0'	3.0	3.0	"
Coos Bay Entrance	0	-	-	3.7	3.0	Current Tables
north side	0	10-22-76	8.2'	4.0	3.8	USACE, Butler '78
middle	0	"	8.2'	6.0	4.2	
south side	0	"	8.2'	2.0	2.2	
Pidgeon Point						
west side	2.5	10-22-76	8.2'	4.0	3.7	USACE, Butler '78
middle	2.5	"	8.2'	4.1	3.5	
east side shallow	2.5	"	8.2'	2.9	3.4	
Empire	5.5	8-27-80	8.0'	avg.	avg.	Carr, '81
"				3.2	1.5	
"				1.2-5.8	1.0-2.2	
North Bend						
north side	8.0	3-78	-	1.8	1.4	Goner, '79
south side				1.1	1.1	
North Bend	11.0	9-25-83	3.1'	0.8	0.4	Sutherland et al, '82
Charleston Bridge	2	10-22-76	8.2'	3.1	3.1	USAE, Butler '78
Yonker Point	1.5 mi. south	11-22-76	8.2'	4.2	2.2	
Charleston Bridge	2	8-25-81	2.7'		1.13	Sutherland, '81
"			"		1.79	
"			"		1.94	
"			"		2.52	
"		8-27-81	3.0'		2.6	Sutherland, '81
"		"	3.0'	2.9	-	
Charleston Bridge	2	9-26-82	2.4'	0.3		Sutherland, '82
				0.4		
				0.7		
				0.4		
Pony Slough	9	8-26-81	2.4'	0.8		
mouth		8-27-81	3.0'		0.6	"
		9-25-82	2.3'	0.5		

Location	River Mile	Date	Tidal Range	Velocity in FPS Ebb	Velocity in FPS Flood	Source
North Slough bridge	9	8-27-81	3.0'	1.9		Sutherland, '81, '82
		9-25-82	2.3'	0.4		
Haynes Inlet bridge	9.5	8-27-81	3.0'	1.9		"
		9-25-82	2.3'	0.6		
Isthmus Slough mouth	14	9-12-73	8.0'	1.2	1.2	Arneson, '67
		3-22-74	8.0'	1.2	0.8	
		12-18-73	4.6'	0.6	-	
		6-11-74	5.6'	0.9	0.4	
		8-26-81	2.4'	1.3		Sutherland. '81, '82
		9-25-82	2.3'	0.6		
Coalbank Slough mouth	14.6	8-26-81	2.4'	1.6		
		9-25-82	2.3'	0.3		"
Marshfield Channel	15	8-26-81	2.4'	2.2		
		9-25-82	2.3'	0.2		"
Catching Slough mouth	16	8-26-81	2.4'	1.8		
		9-25-82	2.3'	0.8		"
Coos River mouth	16	8-26-81	2.4'	1.7		
		9-25-82	2.3'	0.6		"
		9-12-73	8.0'	2.3	2.1	
		3-22-74	7.0'	2.7	2.0	
		6-11-74	5.6'	2.3	1.6	

APPENDIX D. SENSITIVE RESOURCE AND RESPONSE CHARTS

The Oil-Sensitive Resources Of Coos Bay

RESOURCE AREA	1 LOWER BAY	2 SOUTH SLOUGH	3 PONY SLOUGH	4 NORTH SLOUGH	5 HAYNES INLET	6 ISTHMUS SLOUGH	7 CATCHING SLOUGH	8 COOS RIVER	9 UPPER BAY	SEASONAL PRIORITY W	Sp	S	W
RIVER MILE	0-9	2.0	9.0	9.0	9.5	14.0	16.0	16.0	9-14				
BIOLOGICAL RESOURCES													
I. HABITATS													
Tidal marshes	--	H	VH	VH	H	VH	M	--	VH	H	H	H	H
Tidal flats	VH	VH	VH	VH	VH	L	L	--	VH	H	H	H	H
Eelgrass beds	VH	VH	VH	H	VH	H	L	--	VH	H	H	H	H
Rocky shores	VH	M	L	M	M	L	L	L	L	M	M	M	M
Silt & sandy beaches	M	M	L	L	L	L	L	--	L	L	L	L	L
Mud banks	L	M	M	M	M	M	M	M	M	L	L	L	L
Open waters	M	H	H	M	H	M	L	M	H	L	L	L	L
II. ORGANISMS													
Shellfish													
clams	VH	VH	VH	VH	VH	M	L	--	VH	2	1	1	2
crabs	H	VH	VH	H	VH	M	L	--	VH	1	1	1	2
shrimp	H	VH	VH	H	VH	M	L	--	VH	2	1	1	2
oysters	--	VH	--	--	--	--	--	--	--	2	1	1	2
other	VH	VH	VH	VH	VH	M	L	--	VH	2	1	1	2
Benthos	VH	VH	VH	VH	VH	H	M	--	VH	2	2	2	2
Plankton	VH	VH	VH	VH	VH	H	H	M	VH	2	2	2	2
Fish													
Salmonids													
juveniles	VH	VH	M	M	M	L	L	M	VH	1		1	1
adults	H	H	L	M	H	L	L	VH	H	2	2	2	
non-Salmonids													
juveniles	H	H	H	H	H	M	M	M	H	1	1	1	1
adults	H	H	H	H	H	M	M	H	H	2	2	2	2
Marine mammals	H	H	L	L	L	--	--	--	L	2	2	2	2
Birds - water dependant													
migratory	H	VH	VH	H	VH	H	M	M	H	1	1		
non-migratory	H	VH	H	H	H	M	M	L	H	1	1	1	1
COMMERCIAL & OTHER RESOURCES													
Archeological sites	H	H	--	M	M	M	M	H	H	1	1	1	1
Aquaculture	VH	VH	--	--	--	--	--	--	H	2	1	1	2
Water intakes	VH	--	--	--	--	--	--	--	--	3	3	3	3
Parks	H	VH	M	--	--	--	--	--	--	4	4	4	4
Fishing areas	H	H	L	H	H	M	M	H	H	4	4	4	4
Marinas & boats	--	H	--	--	--	--	--	--	M	5	5	5	5
Log storage	--	--	--	--	--	H	H	H	H	5	5	5	5
OVERALL AREA PRIORITY	2	1	3	4	5	7	8	9	6				
PROTECTION MEASURES													
Prevention	X	X	X	X	X	X	X	X	X				
Containment	X	X	X	X	X	X	X	X	X				
Boom sites	--	2A 2B 2C 2D	3A	4A 4B	5A	6A 6B	7A	8A	9A 9B 9C				

RELATIVE RESOURCE VALUES
- VH - very high
- H - high
- M - moderate
- L - low

□ MARINAS
- a. Charleston
- b. Hansons
- f. Coos Bay

△ OYSTER CULTURE
- c. Qualmans

○ SALMON RANCHING
- d. Anadromous
- e. Anadromous

■ LAUNCH SITES

▲ ARCHEOLOGICAL SITES

◆ OIL STORAGE & TRANSFER

(2) RIVER MILES

SHELLFISH HABITAT

MARSH

IMPORTANT INTERTIDAL HABITAT

FISH HABITAT

Oil Spill Response Chart #1

LAUNCH SITES
- LS 1 -- 4 lane paved
- LS 2 -- 1 lane paved
- LS 3 -- 1 lane gravel
- LS 4 -- 1 lane paved
- LS 5 -- 1 lane gravel

BOOM SITES

MARINAS
- a -- Charleston Boat Basin
- b -- Hanson's Moorage
- f -- City of Coos Bay

OIL TRANSFER AND STORAGE SITES

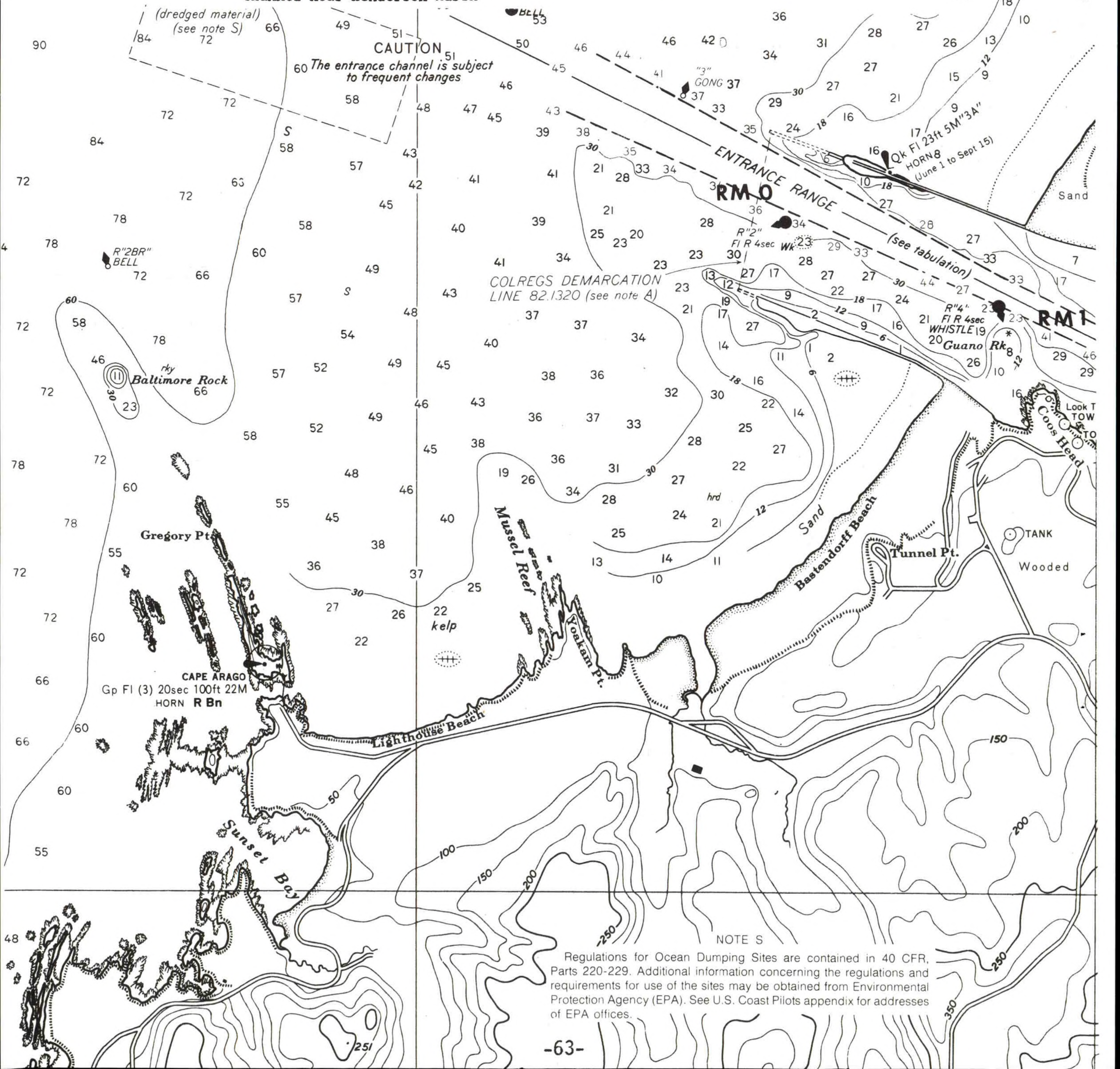
POSSIBLE CONTAINMENT SITES

SALMON RANCHING
- d -- Anadromous Inc.
- e -- Anadromous Inc.

OYSTER CULTURE
- c -- Qualman's

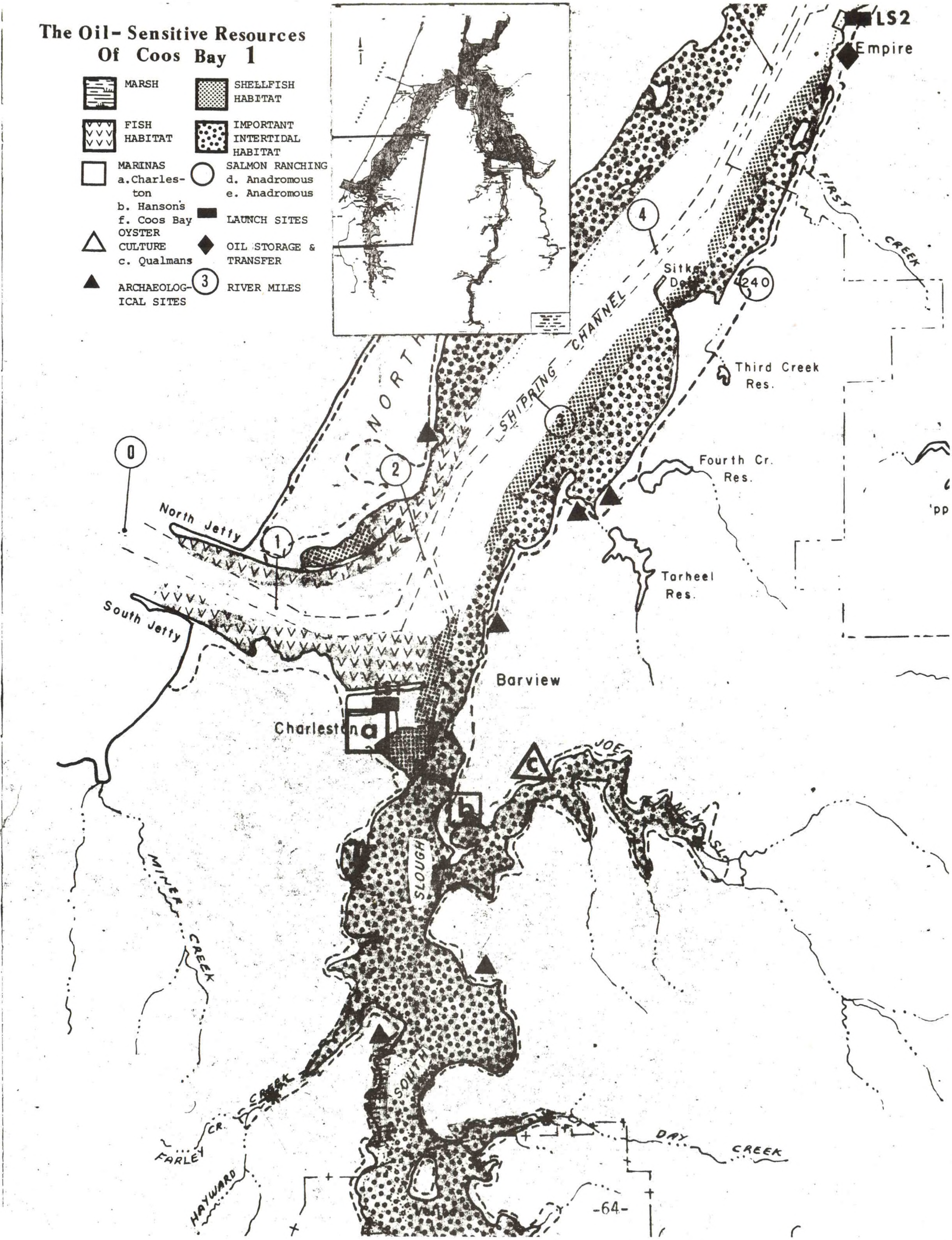
AREA 1 - LOWER BAY (river mile 0-9)

Vulnerability: high on incoming tides, upper areas vulnerable to south winds, lower areas vulnerable to north winds
Sensitivity: high during all seasons in shallows and tide flats
Access: Charleston Boat Basin, Empire, North Spit Road
Currents: 2-4 feet/second
Boom sites: no practical sites
Containment: possible sites at dredge spoil islands near airport and across the channel near Henderson Marsh



NOTE S

Regulations for Ocean Dumping Sites are contained in 40 CFR, Parts 220-229. Additional information concerning the regulations and requirements for use of the sites may be obtained from Environmental Protection Agency (EPA). See U.S. Coast Pilots appendix for addresses of EPA offices.


The Oil- Sensitive Resources
Of Coos Bay 1
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charles-ton
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOGICAL SITES
RIVER MILES
LS2
Empire
FIRST CREEK
Sitka Dock
Third Creek Res.
Fourth Cr. Res.
Tarheel Res.
NORTH
SHIPPING CHANNEL
North Jetty
South Jetty
Barview
Charleston
JOE NEY SL.
SLOUGH
SOUTH
MINER CREEK
CREEK
FARLEY CR.
HAYWARD
DAY CREEK

Oil Spill Response Chart #2

AREA 2 - SOUTH SLOUGH (river mile 2)

Vulnerability: high on incoming tides, high with north winds
Sensitivity: very high during all seasons
Access: Charleston Boat Basin
Currents: 1-4 feet/second

MARINAS
- a -- Charleston Boat Basin
- b -- Hanson's Moorage
- f -- City of Coos Bay

OIL TRANSFER AND STORAGE SITES

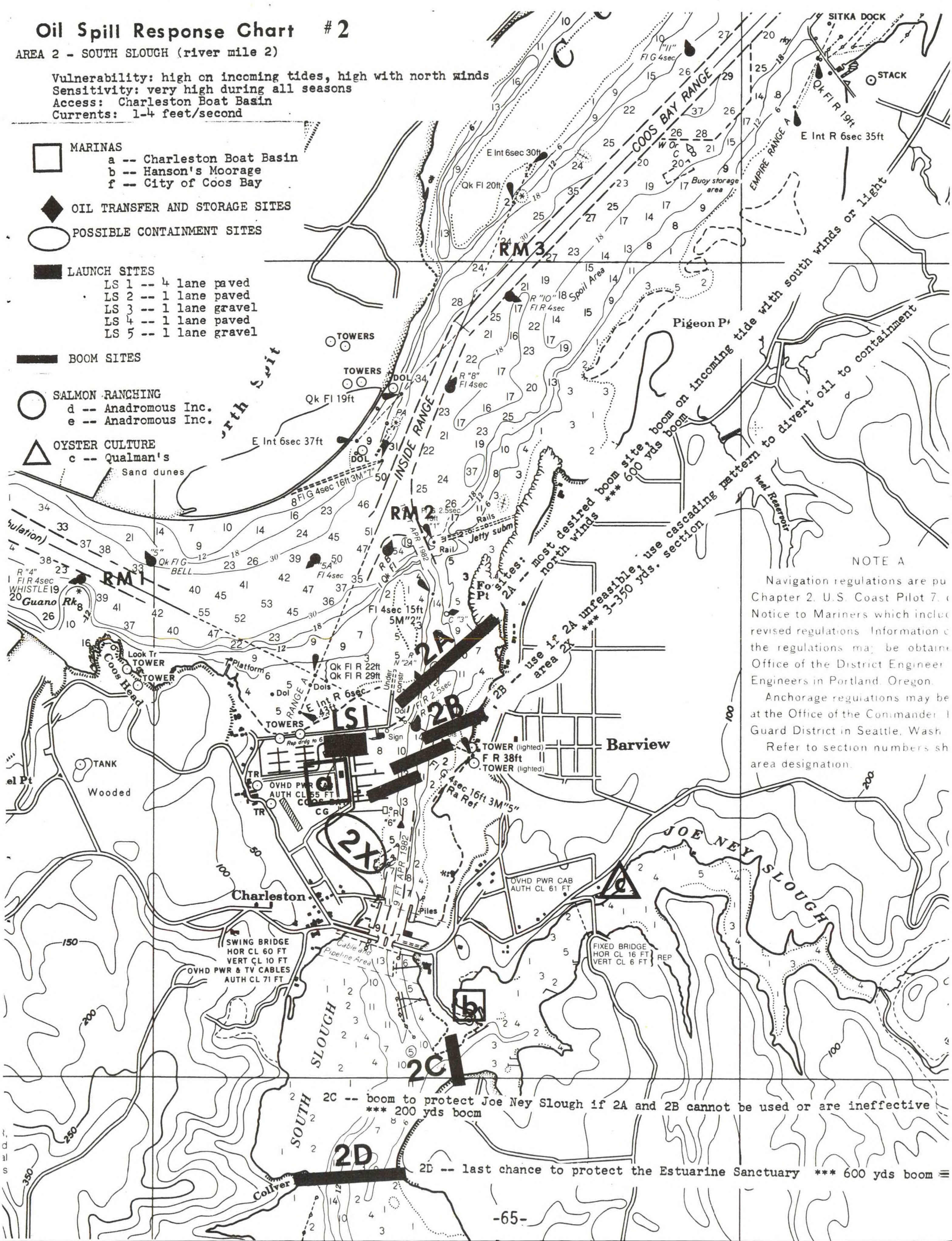
POSSIBLE CONTAINMENT SITES

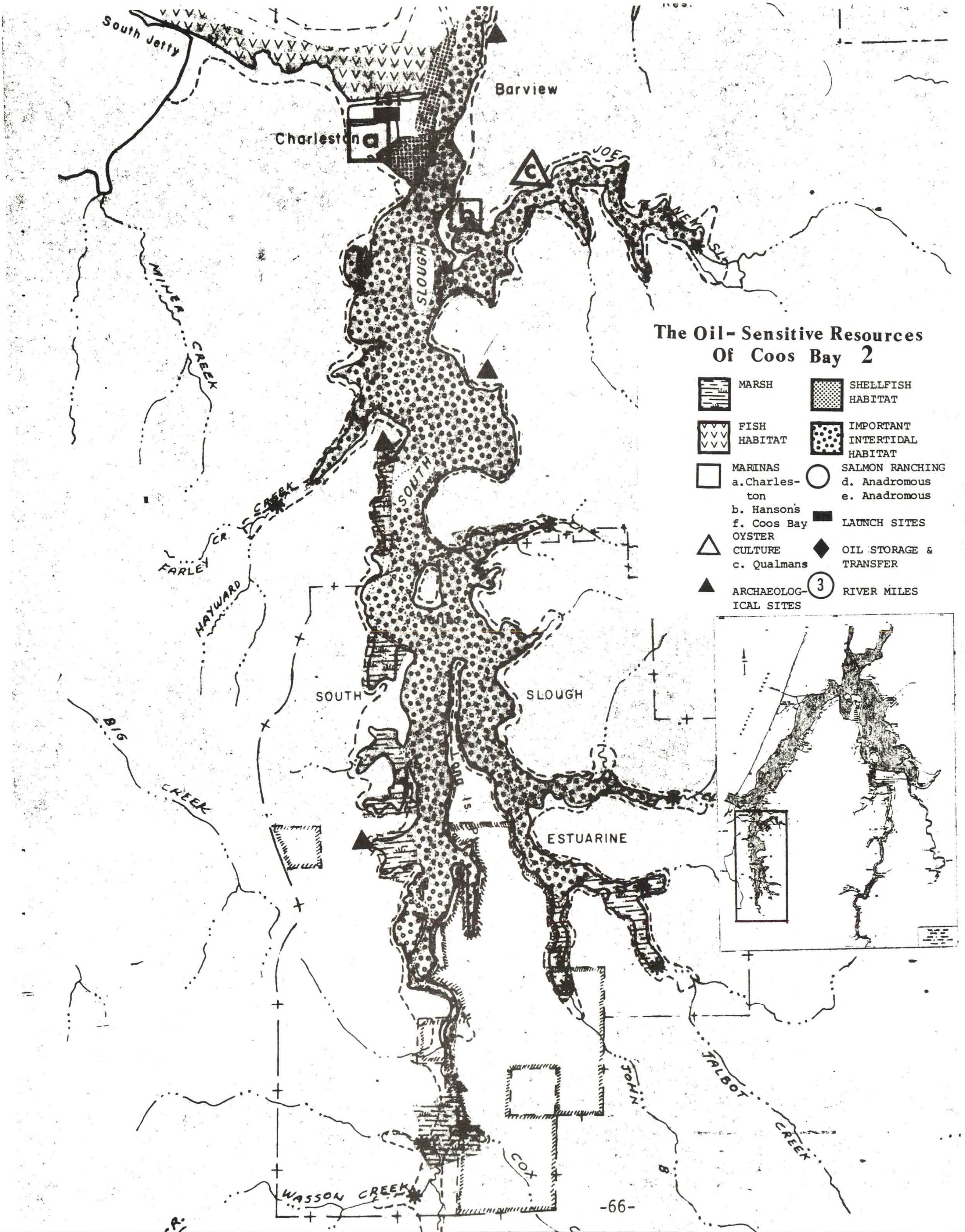
LAUNCH SITES
- LS 1 -- 4 lane paved
- LS 2 -- 1 lane paved
- LS 3 -- 1 lane gravel
- LS 4 -- 1 lane paved
- LS 5 -- 1 lane gravel

BOOM SITES

SALMON RANCHING
- d -- Anadromous Inc.
- e -- Anadromous Inc.

OYSTER CULTURE
- c -- Qualman's

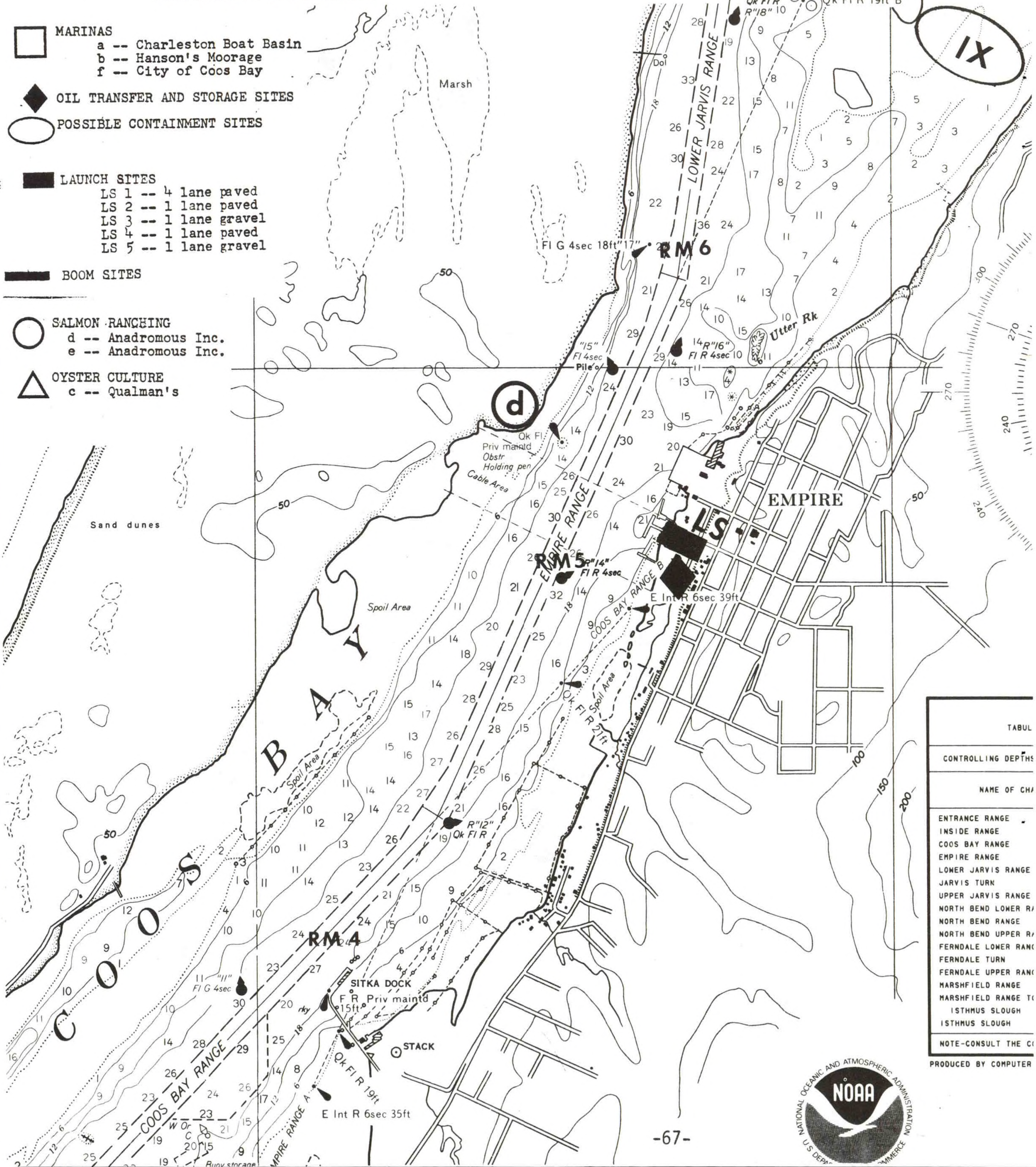


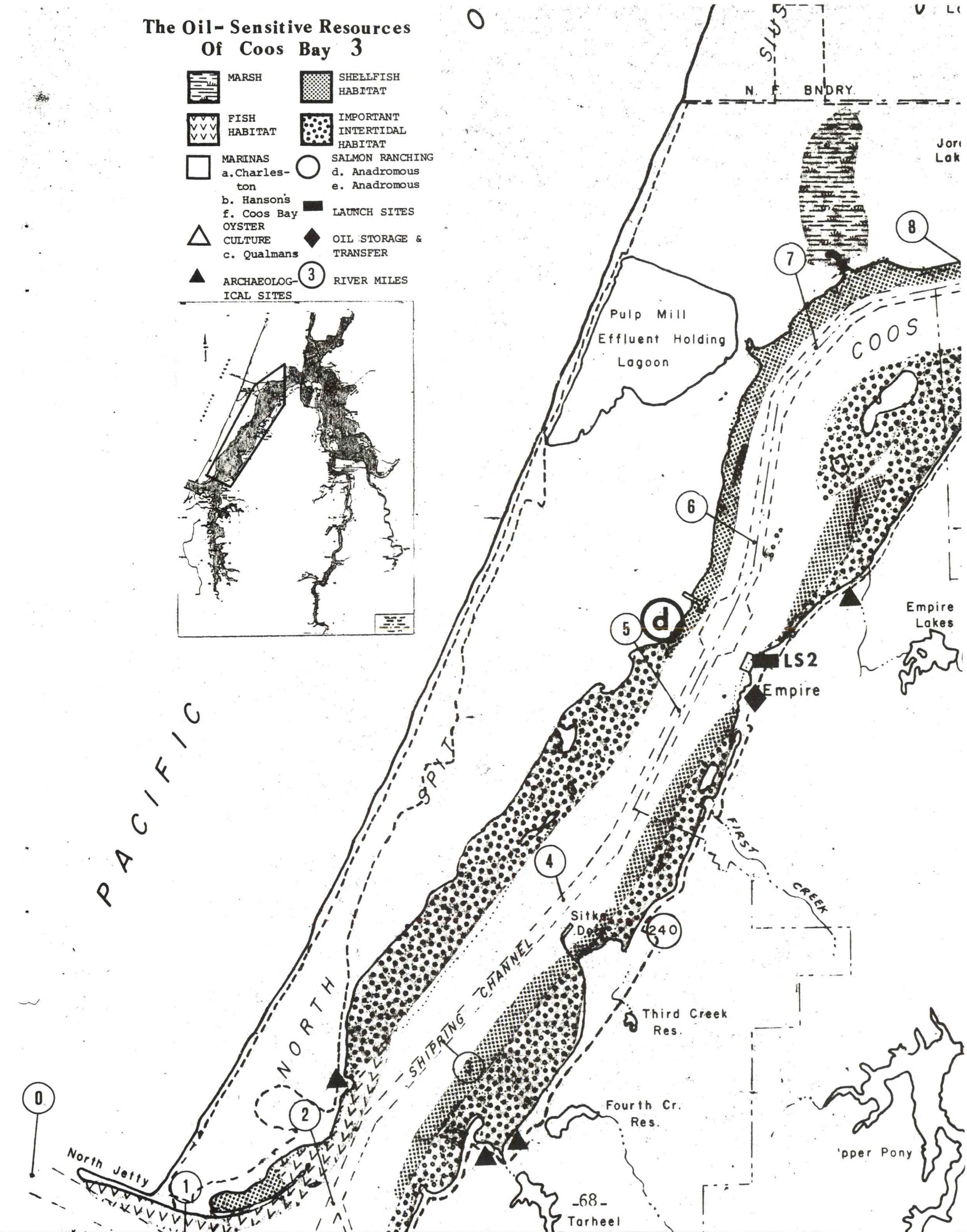

The Oil-Sensitive Resources
Of Coos Bay 2
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charles-ton
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOG-ICAL SITES
3
RIVER MILES
South Jetty
Barview
Charleston
JOE NEY SL.
SLOUGH
SOUTH
MINER CREEK
CREEK
FARLEY CR.
HAYWARD
BIG CREEK
SOUTH
SLOUGH
ESTUARINE
JOHN B.
TALBOT CREEK
COX
WASSON CREEK

Oil Spill Response Chart #3

AREA 1 - LOWER BAY (river mile 0-9)

Vulnerability: high on incoming tides, upper areas vulnerable to south winds, lower areas vulnerable to north winds
Sensitivity: high during all seasons in shallows and tide flats
Access: Charleston Boat Basin, Empire, North Spit Road
Currents: 2-4 feet/second
Boom sites: no practical sites
Containment: possible sites at dredge spoil islands near airport and across the channel near Henderson Marsh




The Oil- Sensitive Resources
Of Coos Bay 3
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charles-ton
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOG-ICAL SITES
3
RIVER MILES
N. F. BNDRY
Pulp Mill
Effluent Holding
Lagoon
COOS
PACIFIC
NORTH SPIT
SHIPPING CHANNEL
Empire
Lakes
LS2
Empire
FIRST CREEK
Sitka
Dock
240
Third Creek
Res.
Fourth Cr.
Res.
'pper Pony
North Jetty
Tarheel
0
1
2
4
5
6
7
8
d

Oil Spill Response Chart # 4

LAUNCH SITES
- LS 1 -- 4 lane paved
- LS 2 -- 1 lane paved
- LS 3 -- 1 lane gravel
- LS 4 -- 1 lane paved
- LS 5 -- 1 lane gravel

BOOM SITES

MARINAS
- a -- Charleston Boat Basin
- b -- Hanson's Moorage
- f -- City of Coos Bay

OIL TRANSFER AND STORAGE SITES

POSSIBLE CONTAINMENT SITES

SALMON RANCHING
- d -- Anadromous Inc.
- e -- Anadromous Inc.

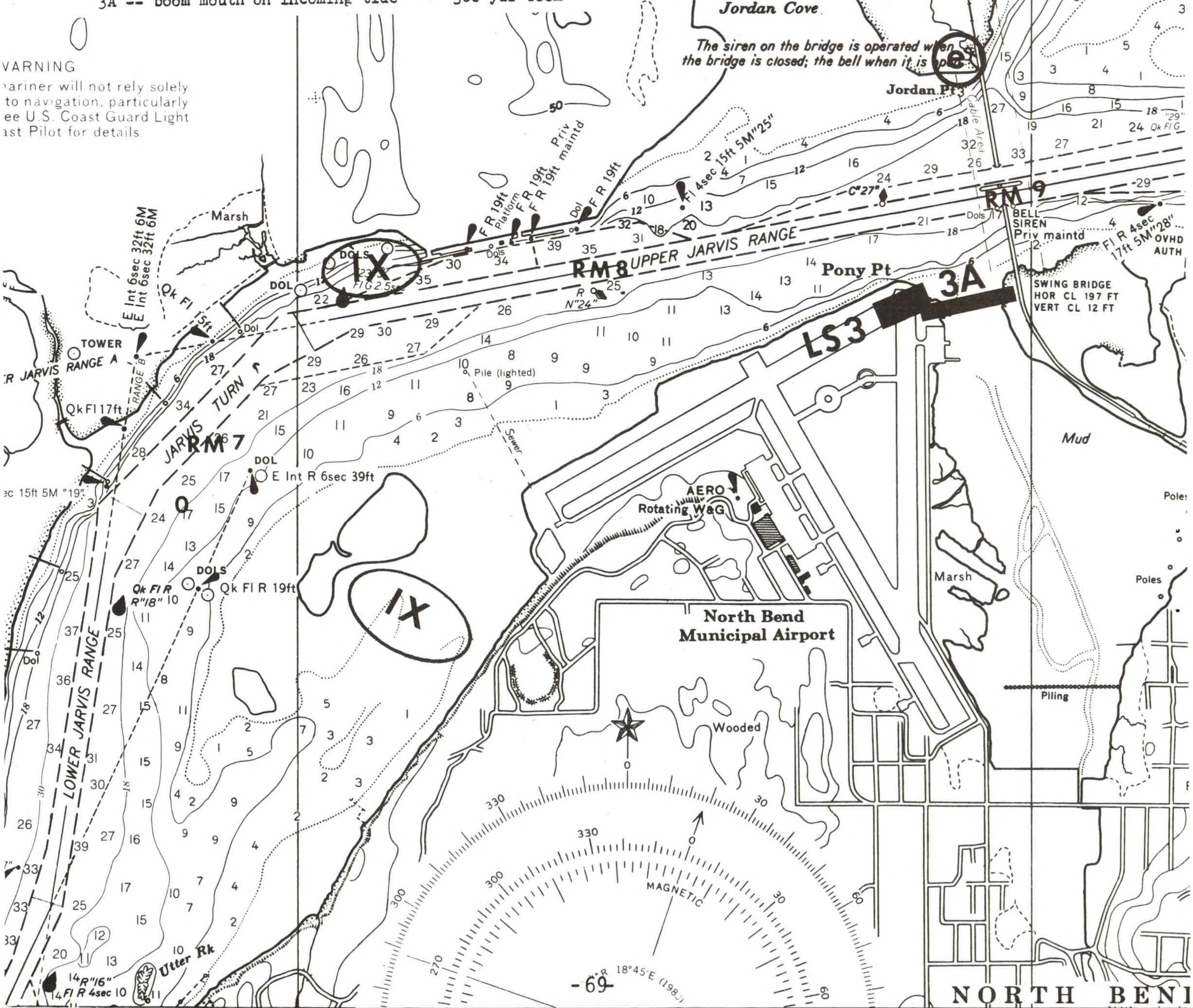
OYSTER CULTURE
- c -- Qualman's

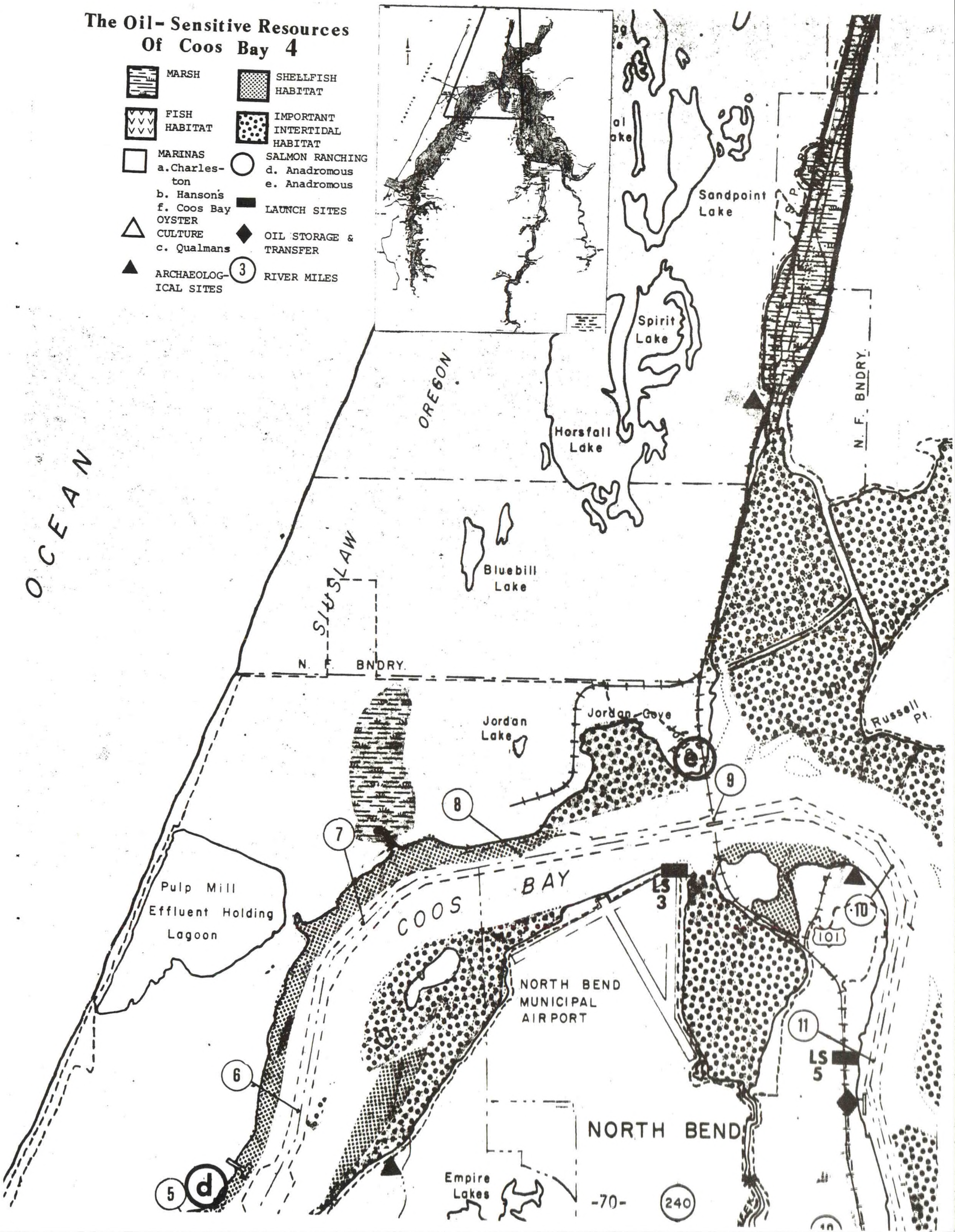
AREA 1 - LOWER BAY (river mile 0-9)

Vulnerability: high on incoming tides, upper areas vulnerable to south winds, lower areas vulnerable to north winds
Sensitivity: high during all seasons in shallows and tide flats
Access: Charleston Boat Basin, Empire, North Spit Road
Currents: 2-4 feet/second
Boom sites: no practical sites
Containment: possible sites at dredge spoil islands near airport and across the channel near Henderson Marsh

AREA 3 - PONY SLOUGH (river mile 9)

Vulnerability: high during incoming tides and high during north winds
Sensitivity: high during the winter because of waterfowl, moderately high during the rest of the year
Access: access road along the east side of the airport with gravel boat ramp at mouth of slough
Currents: 0.5-1 feet/second
Boom sites:
3A -- boom mouth on incoming tide *** 300 yds boom




The Oil- Sensitive Resources
Of Coos Bay 4
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charleston
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOGICAL SITES
RIVER MILES
OCEAN
OREGON
SIUSLAW
N. F. BNDRY.
N. F. BNDRY.
Sandpoint Lake
Spirit Lake
Horsfall Lake
Bluebill Lake
Jordan Lake
Jordan Cove
Russell Pt.
Pulp Mill Effluent Holding Lagoon
COOS BAY
LS 3
LS 5
101
NORTH BEND MUNICIPAL AIRPORT
NORTH BEND
Empire Lakes
240
5
6
7
8
9
10
11
d
e

Oil Spill Response Chart # 5

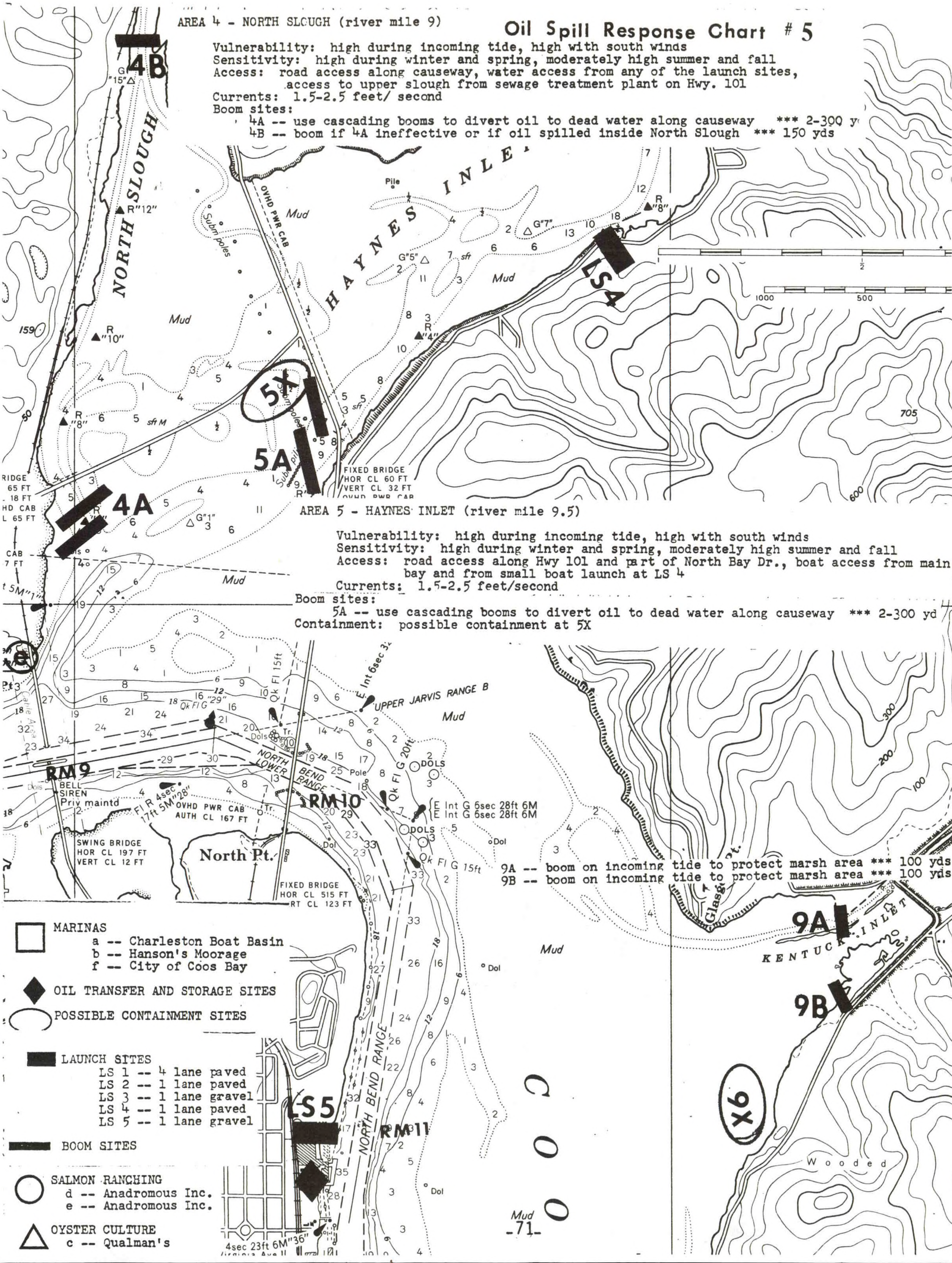
AREA 4 - NORTH SLOUGH (river mile 9)

Vulnerability: high during incoming tide, high with south winds
Sensitivity: high during winter and spring, moderately high summer and fall
Access: road access along causeway, water access from any of the launch sites, access to upper slough from sewage treatment plant on Hwy. 101
Currents: 1.5-2.5 feet/ second
Boom sites:
4A -- use cascading booms to divert oil to dead water along causeway *** 2-300 y
4B -- boom if 4A ineffective or if oil spilled inside North Slough *** 150 yds

AREA 5 - HAYNES INLET (river mile 9.5)

Vulnerability: high during incoming tide, high with south winds
Sensitivity: high during winter and spring, moderately high summer and fall
Access: road access along Hwy 101 and part of North Bay Dr., boat access from main bay and from small boat launch at LS 4
Currents: 1.5-2.5 feet/second
Boom sites:
5A -- use cascading booms to divert oil to dead water along causeway *** 2-300 yd
Containment: possible containment at 5X

9A -- boom on incoming tide to protect marsh area *** 100 yds
9B -- boom on incoming tide to protect marsh area *** 100 yds



MARINAS
a -- Charleston Boat Basin
b -- Hanson's Moorage
f -- City of Coos Bay

OIL TRANSFER AND STORAGE SITES

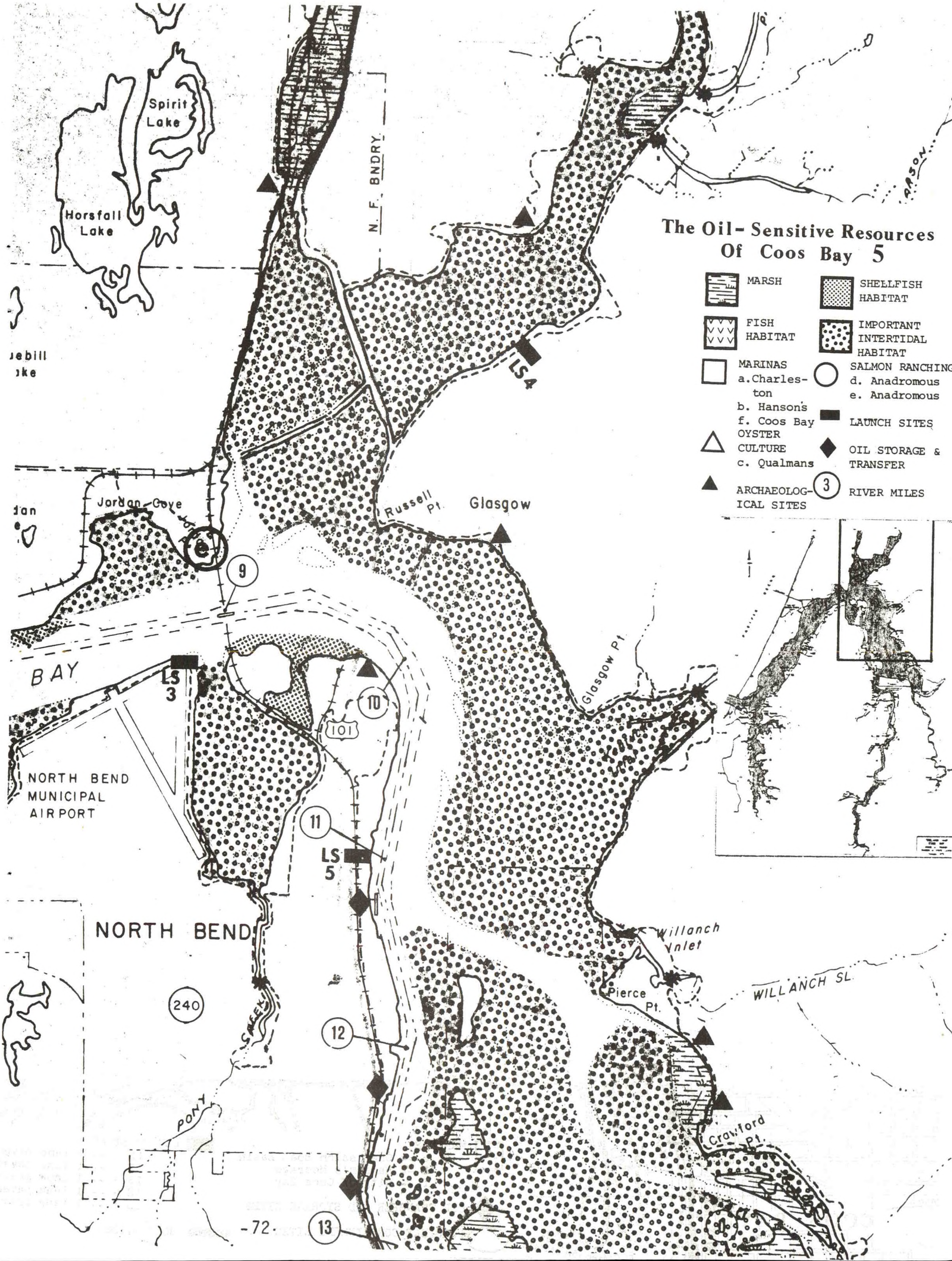
POSSIBLE CONTAINMENT SITES

LAUNCH SITES
LS 1 -- 4 lane paved
LS 2 -- 1 lane paved
LS 3 -- 1 lane gravel
LS 4 -- 1 lane paved
LS 5 -- 1 lane gravel

BOOM SITES

SALMON RANCHING
d -- Anadromous Inc.
e -- Anadromous Inc.

OYSTER CULTURE
c -- Qualman's


The Oil-Sensitive Resources
Of Coos Bay 5
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charleston
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOGICAL SITES
RIVER MILES
Spirit Lake
Horsfall Lake
N. F. BNDRY
Jordan Cove
Russell Pt.
Glasgow
Glasgow Pt.
LS 4
LS 3
LS 5
BAY
NORTH BEND MUNICIPAL AIRPORT
NORTH BEND
240
101
PONY
CREEK
Willanch Inlet
WILLANCH SL.
Pierce Pt.
Crawford Pt.
9
10
11
12
13

AREA 9 - UPPER BAY (river mile 9-14)

Oil Spill Response Chart # 6

Vulnerability: very high during incoming tides especially during low river flow periods also high during outcoming tides because of circulation patterns

Sensitivity: moderately high year around

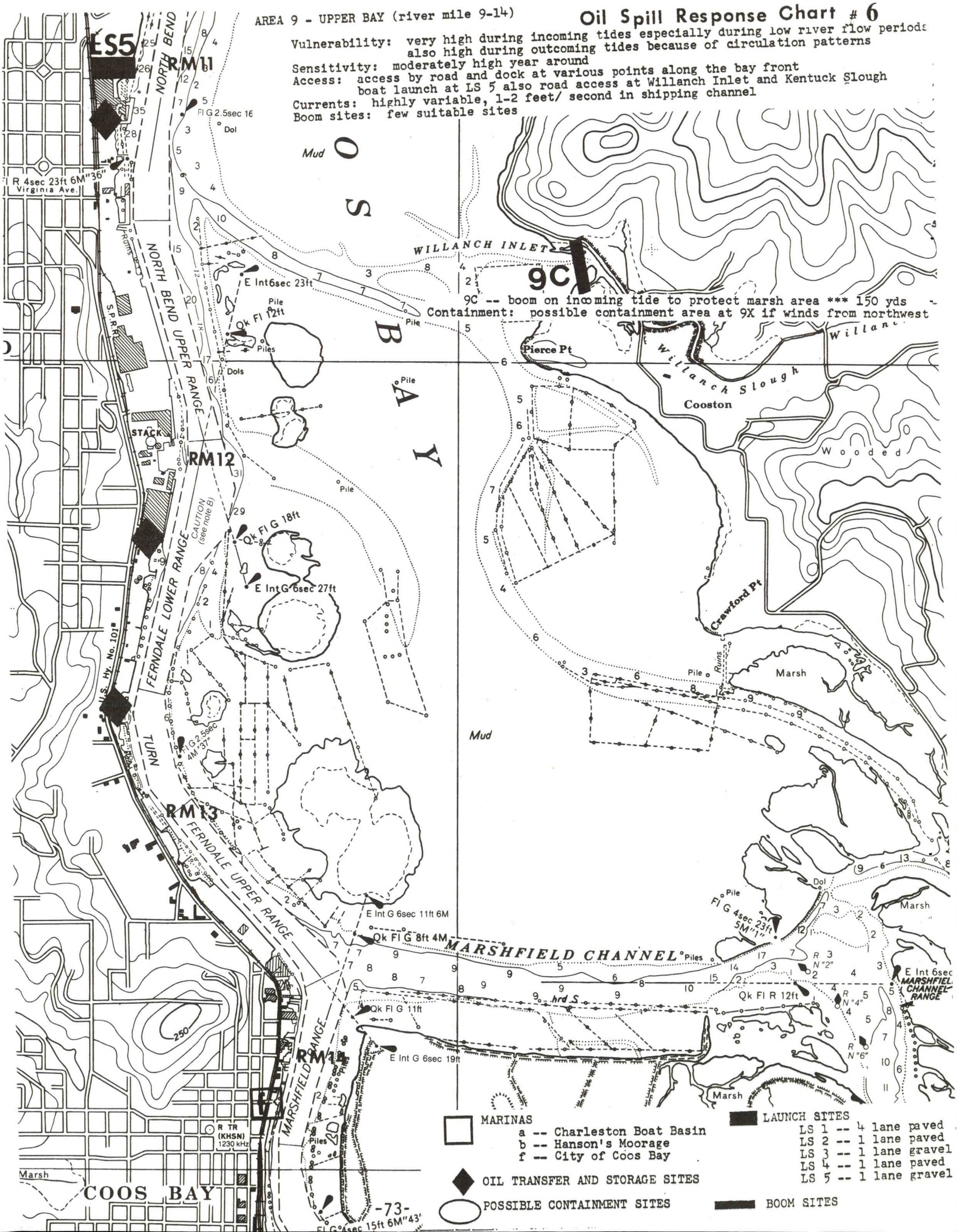
Access: access by road and dock at various points along the bay front boat launch at LS 5 also road access at Willanch Inlet and Kentuck Slough

Currents: highly variable, 1-2 feet/ second in shipping channel

Boom sites: few suitable sites

9C -- boom on incoming tide to protect marsh area *** 150 yds

Containment: possible containment area at 9X if winds from northwest



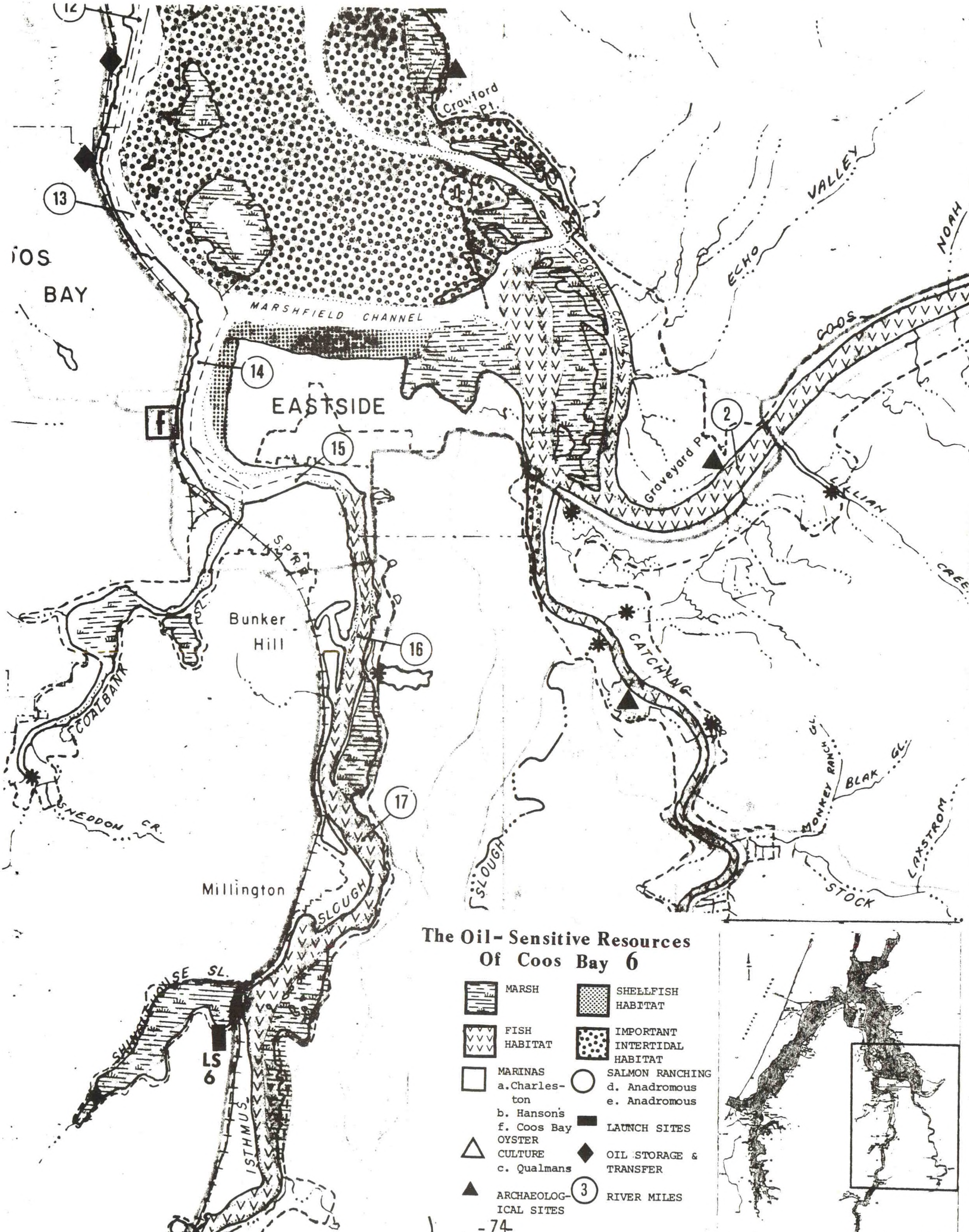
MARINAS
a -- Charleston Boat Basin
b -- Hanson's Moorage
f -- City of Coos Bay

OIL TRANSFER AND STORAGE SITES

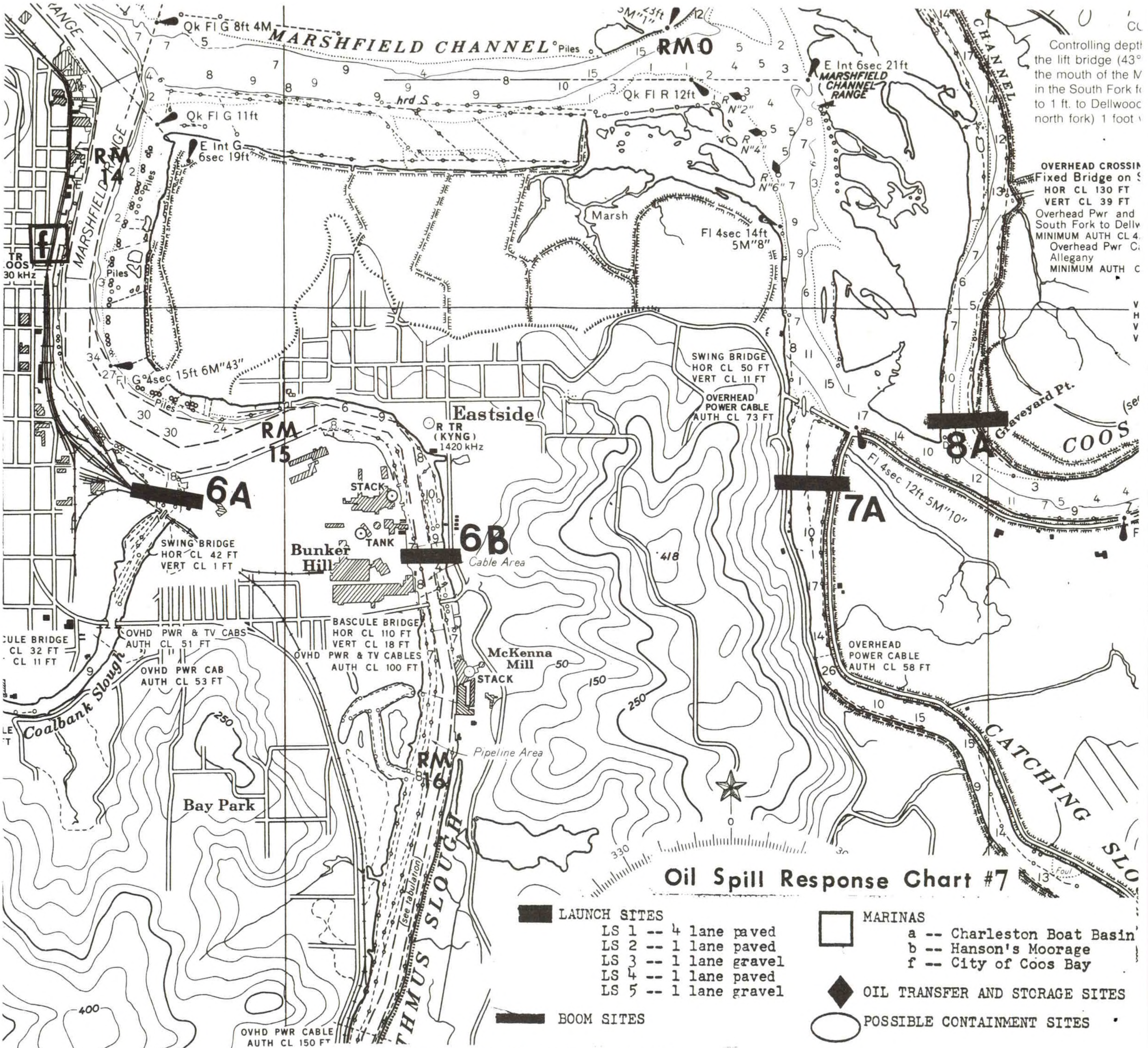
POSSIBLE CONTAINMENT SITES

LAUNCH SITES
LS 1 -- 4 lane paved
LS 2 -- 1 lane paved
LS 3 -- 1 lane gravel
LS 4 -- 1 lane paved
LS 5 -- 1 lane gravel

BOOM SITES



12
13
14
15
16
17
2
BAY
Crawford Pt.
ECHO
VALLEY
NOAH
MARSHFIELD CHANNEL
COOS
EASTSIDE
f
Graveyard Pt.
LILLIAN
CREE
SPRR
Bunker Hill
CATCHING
COALBANK
SNEDDON CR.
Millington
SLOUGH
ISTHMUS
LS 6
MONKEY RANCH GL.
BLAK GL.
LAXSTROM
STOCK
The Oil-Sensitive Resources Of Coos Bay 6
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a. Charleston
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOGICAL SITES
3 RIVER MILES



AREA 6 - ISTHMUS SLOUGH (river mile 14)

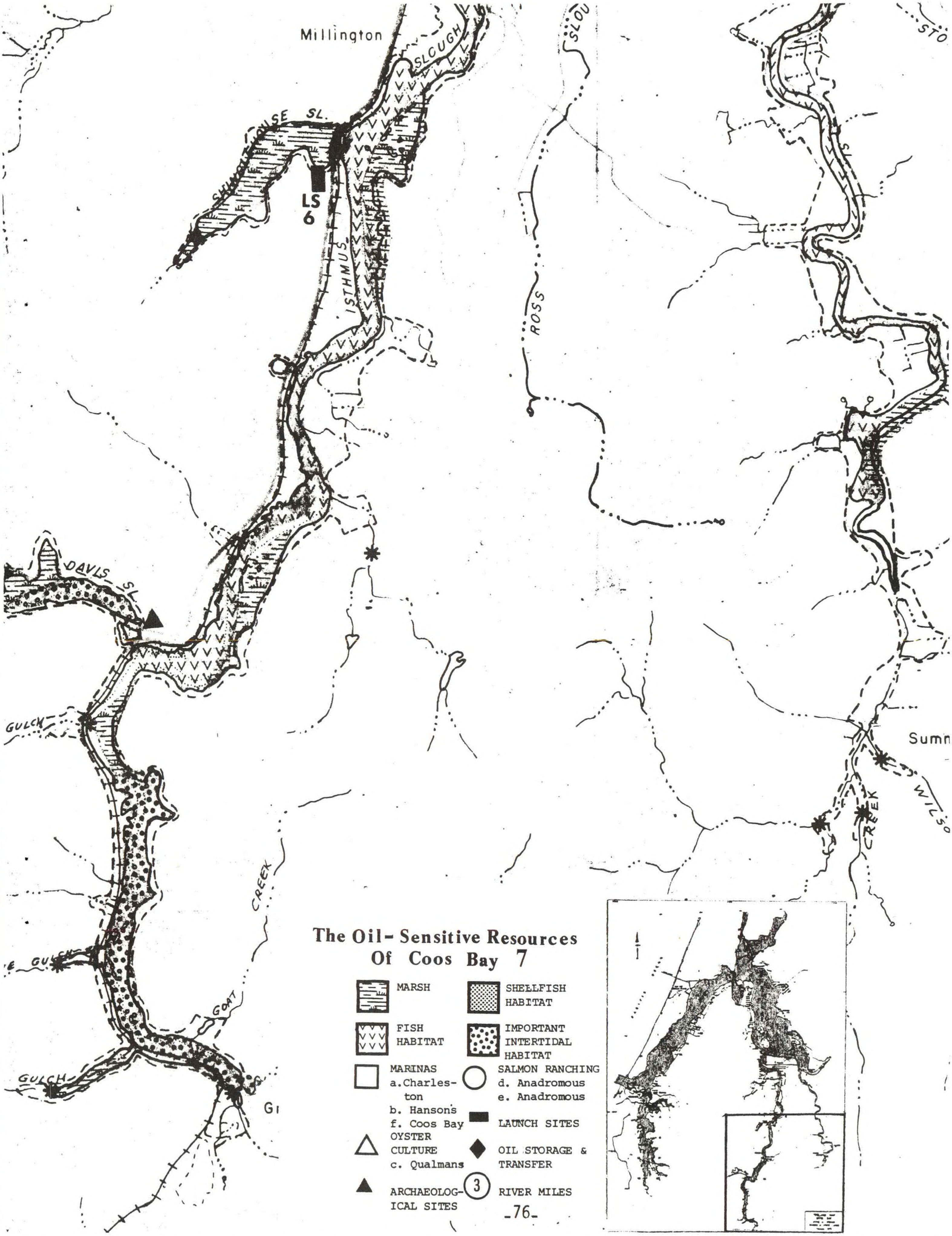
Vulnerability: high with incoming tide, high with north winds
Sensitivity: moderately high in spring, moderate in summer, fall and winter
Access: Road access at various points along Hwy. 101, small boat launch at Shinglehous
Slough LS 6, major water access from main bay
Currents: 1-1.5 feet/second
Boom sites:
6A -- boom on incoming tide to protect marshes *** 100 yds
6B -- boom on incoming tide to protect upper slough ***200 yds

AREA 7 - CATCHING SLOUGH (river mile 16)

Vulnerability: moderate on incoming tide, increased vulnerability with low river flows
Sensitivity: moderate in spring, low during other seasons
Access: Road access on both sides of slough, no boat launches, water access from bay
Currents: 1-1.5 feet/second
Boom sites:
7A -- boom on incoming tide to protect upper marshes *** 100 yds

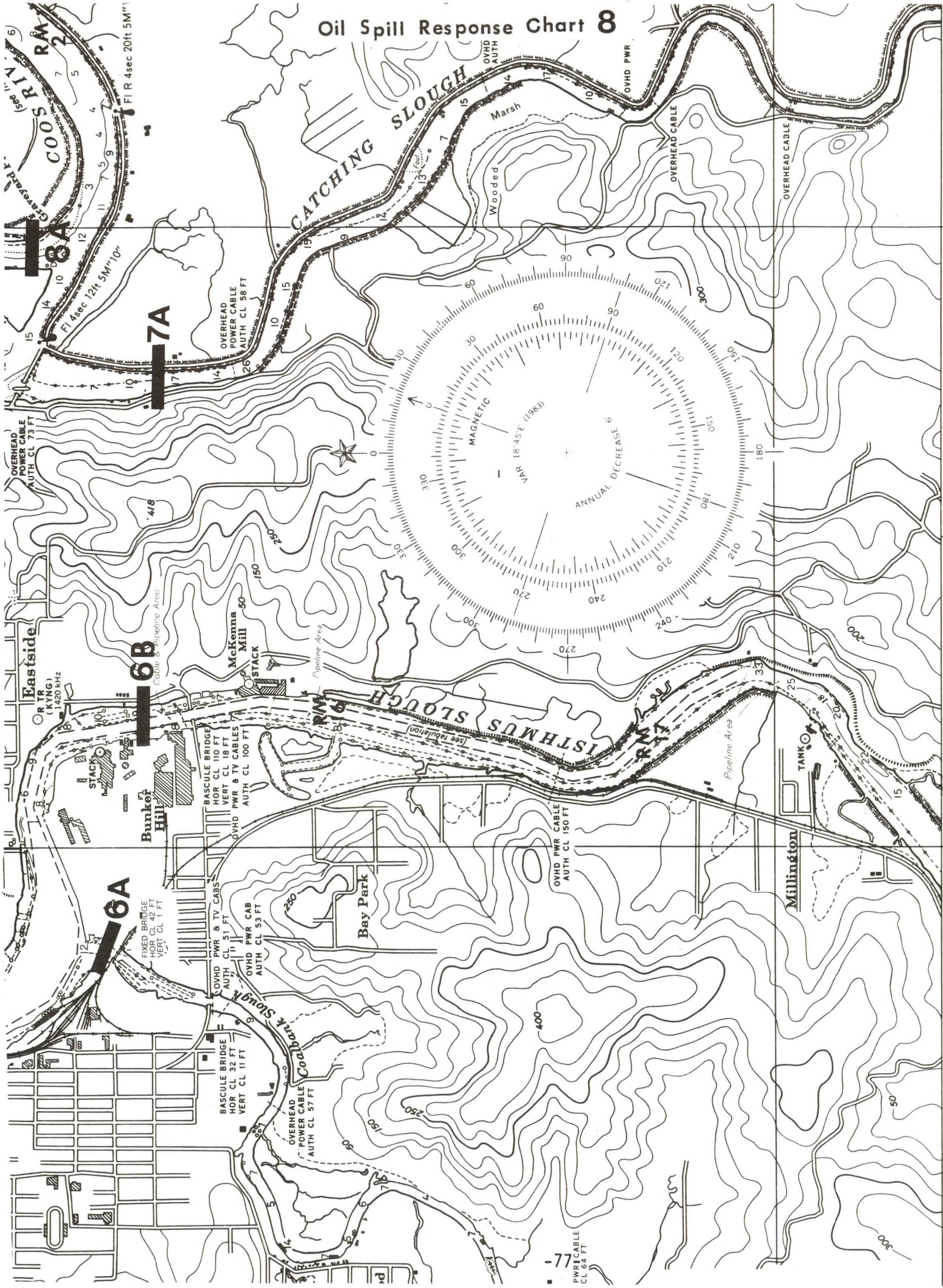
AREA 8 - COOS RIVER (river mile 16)

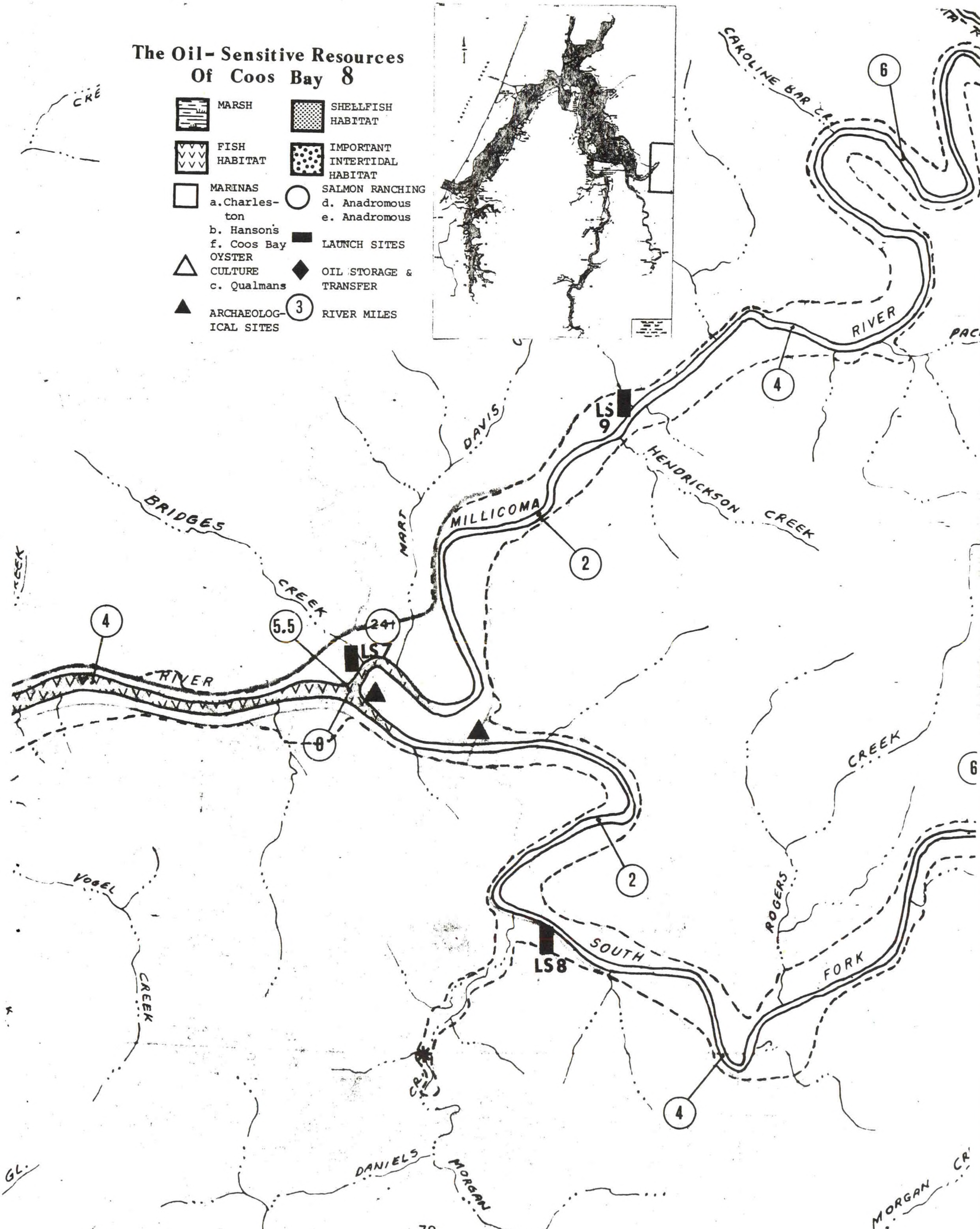
Vulnerability: low unless oil spilled in river upstream
Sensitivity: low during all seasons
Access: Road access on both sides of river to fork, road access on each fork, three
one lane boat launches LS 7, LS 8, LS 9
Currents: dependant on flow
Boom sites: none on river, if oil spilled in river boom site would depend on spill sit
8A -- Cooston Channel - this site should be boomed at all times during low flows
in the Coos River.



The Oil- Sensitive Resources Of Coos Bay 7

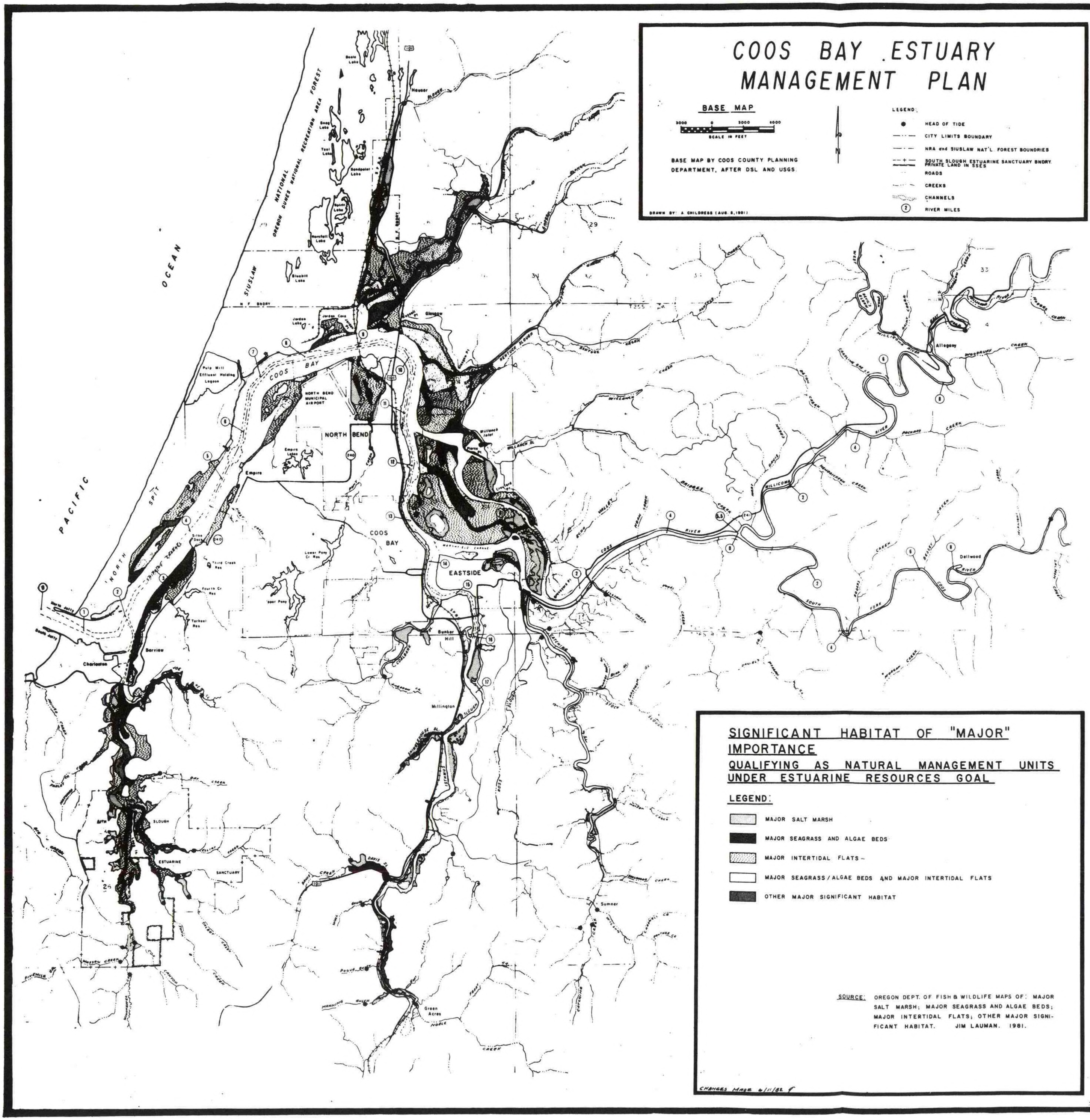
Oil Spill Response Chart 8

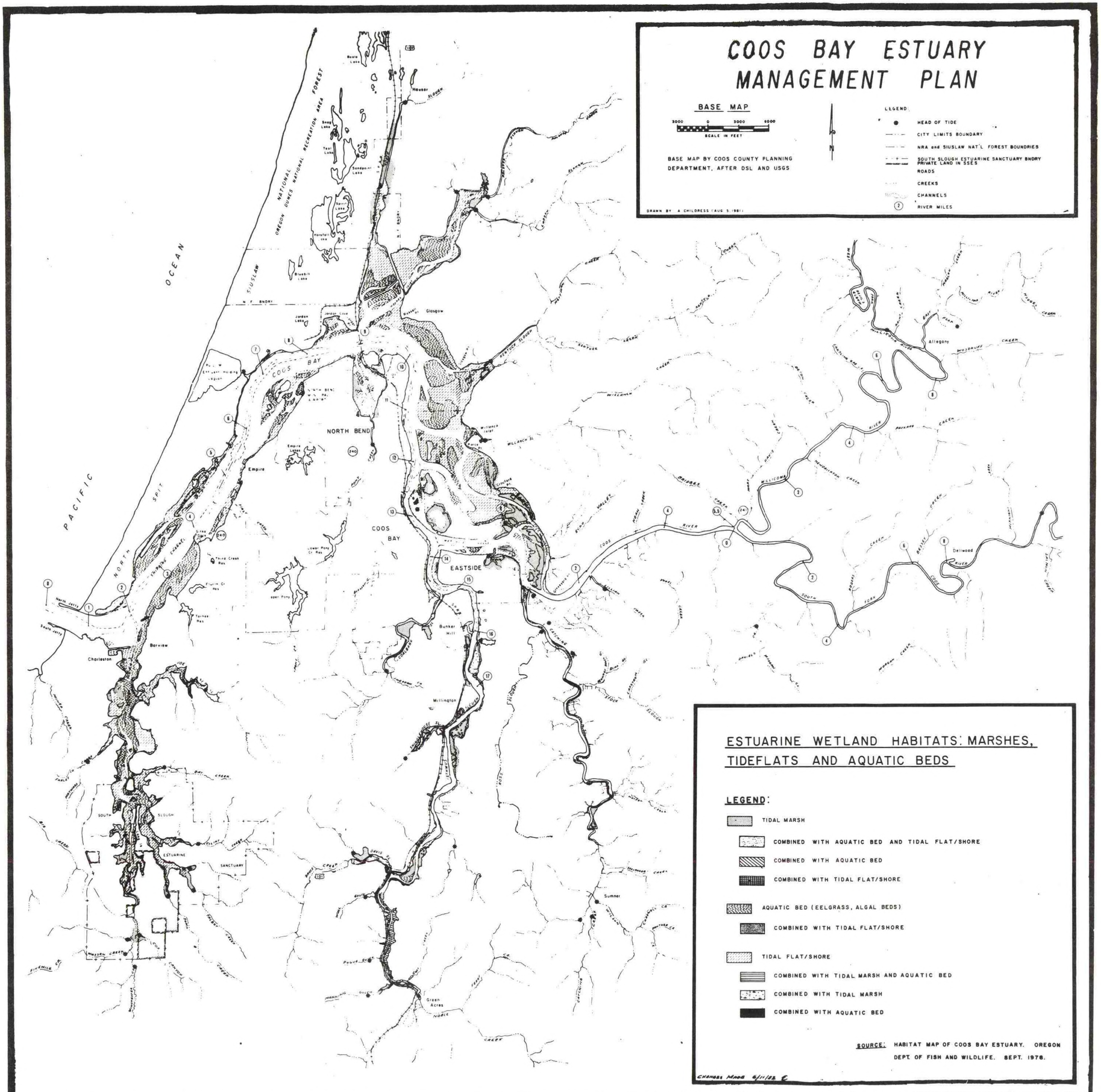


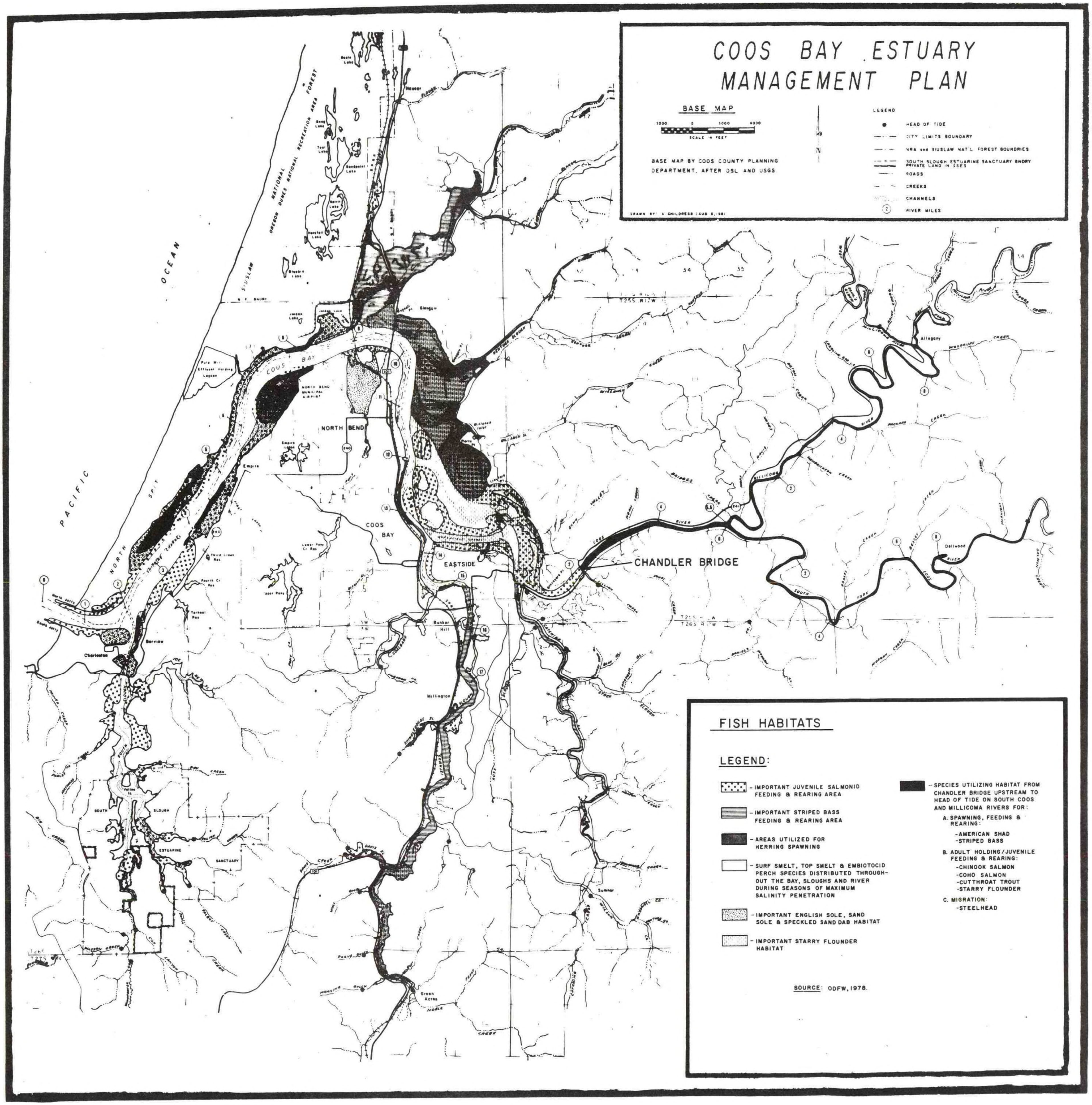


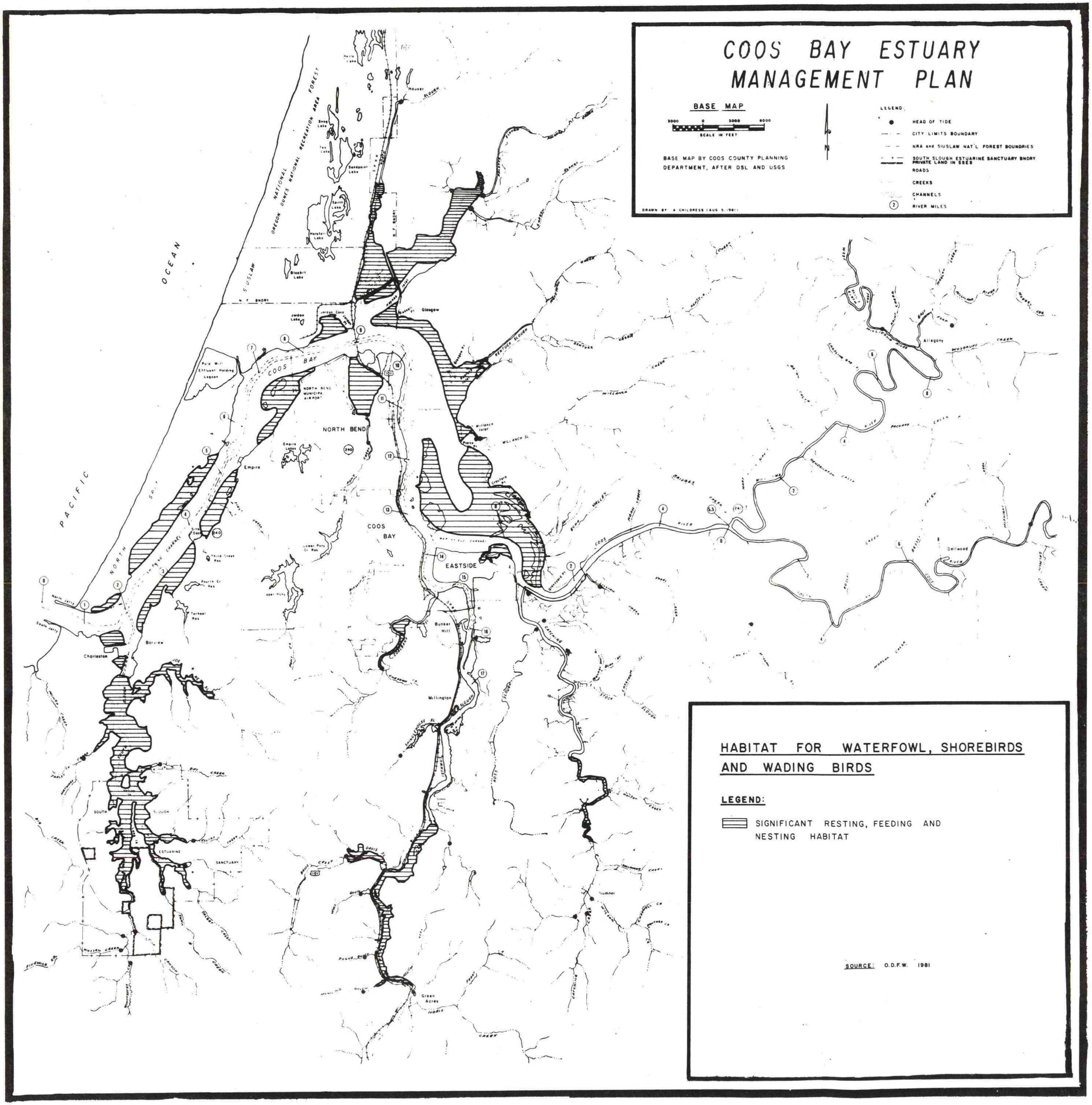
The Oil- Sensitive Resources
Of Coos Bay 8
MARSH
SHELLFISH HABITAT
FISH HABITAT
IMPORTANT INTERTIDAL HABITAT
MARINAS
a.Charles-ton
b. Hanson's
f. Coos Bay
SALMON RANCHING
d. Anadromous
e. Anadromous
LAUNCH SITES
OYSTER CULTURE
c. Qualmans
OIL STORAGE & TRANSFER
ARCHAEOLOGICAL SITES
3
RIVER MILES
CAROLINE BAR CR
6
RIVER
4
LS 9
DAVIS
HENDRICKSON
CREEK
MILLICOMA
2
BRIDGES
CREEK
MART
4
5.5
24
LS7
RIVER
0
CREEK
6
2
ROGERS
SOUTH
FORK
LS8
VOGEL
CREEK
4
CR.
DANIELS
MORGAN
GL.
MORGAN CR

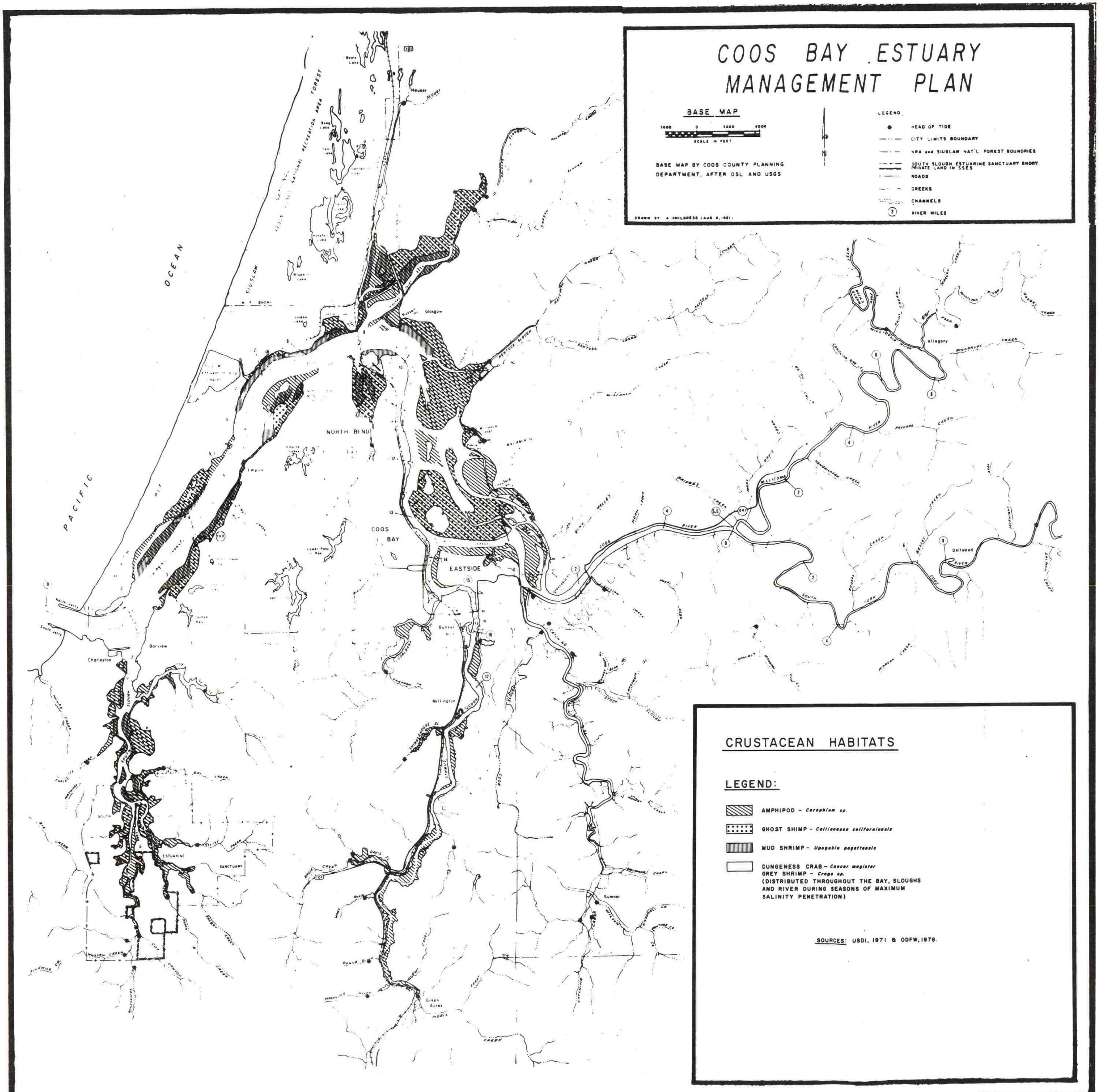
APPENDIX E. NATURAL RESOURCE MAPS

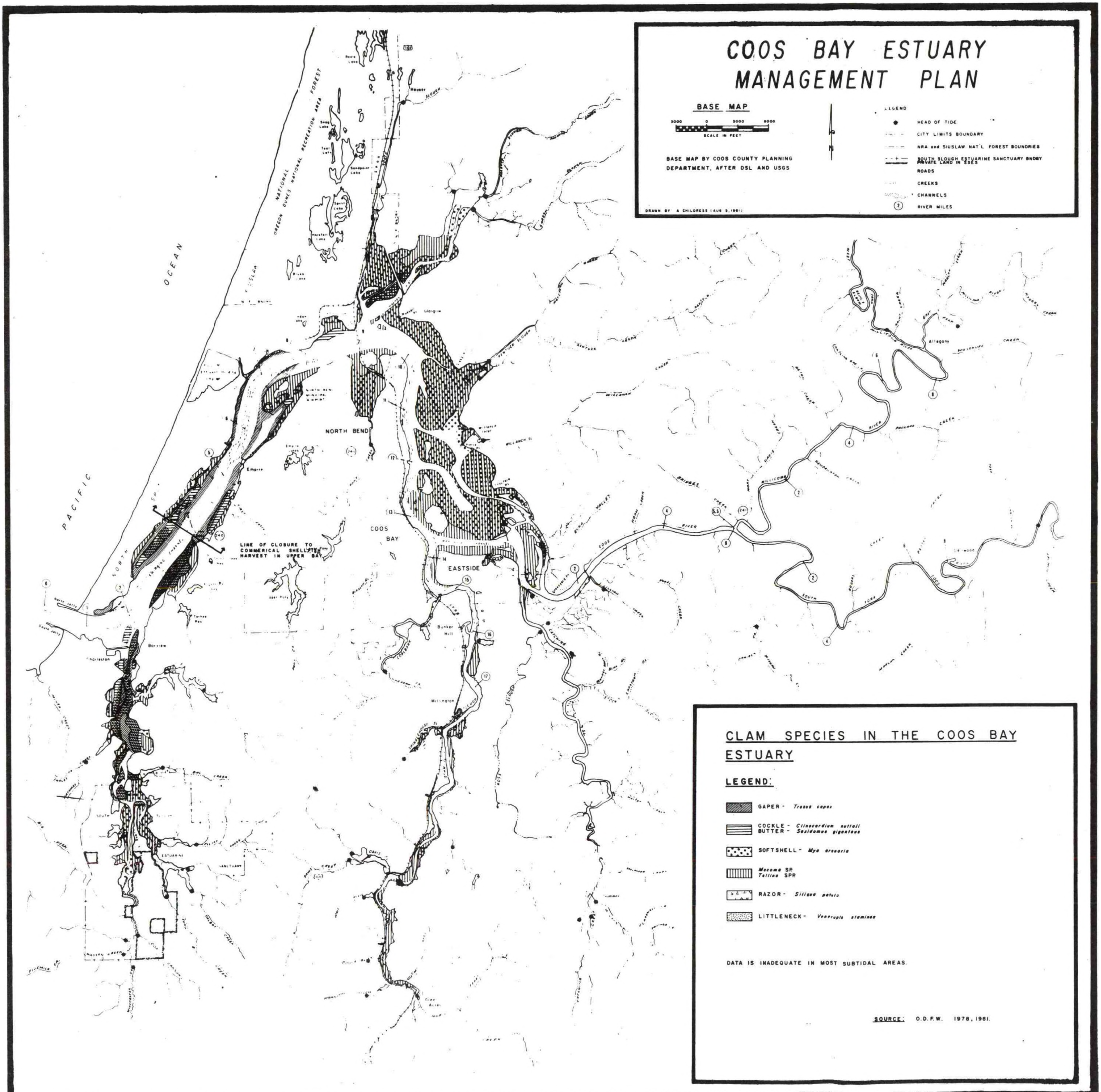

COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING
DEPARTMENT, AFTER DSL AND USGS.
DRAWN BY: A CHILDRESS (AUG. 5, 1981)
LEGEND:
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L. FOREST BOUNDRIES
SOUTH SLOUGH ESTUARINE SANCTUARY BNDRY.
PRIVATE LAND IN SSES
ROADS
CREEKS
CHANNELS
RIVER MILES
PACIFIC
OCEAN
NORTH SPIT
COOS BAY
NORTH BEND
NORTH BEND MUNICIPAL AIRPORT
EASTSIDE
Empire
Charleston
Barview
Bunker Hill
Millington
Glasgow
Allegany
Dellwood
Sumner
Green Acres
SIGNIFICANT HABITAT OF "MAJOR" IMPORTANCE
QUALIFYING AS NATURAL MANAGEMENT UNITS UNDER ESTUARINE RESOURCES GOAL
LEGEND:
MAJOR SALT MARSH
MAJOR SEAGRASS AND ALGAE BEDS
MAJOR INTERTIDAL FLATS
MAJOR SEAGRASS/ALGAE BEDS AND MAJOR INTERTIDAL FLATS
OTHER MAJOR SIGNIFICANT HABITAT
SOURCE: OREGON DEPT. OF FISH & WILDLIFE MAPS OF: MAJOR SALT MARSH; MAJOR SEAGRASS AND ALGAE BEDS; MAJOR INTERTIDAL FLATS; OTHER MAJOR SIGNIFICANT HABITAT. JIM LAUMAN. 1981.
CHANGES MADE 6/11/82


COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
3000 0 3000 6000
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING
DEPARTMENT, AFTER DSL AND USGS
DRAWN BY A CHILDRESS (AUG 5 1981)
LEGEND
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L FOREST BOUNDRIES
SOUTH SLOUGH ESTUARINE SANCTUARY BNDRY
PRIVATE LAND IN SSES
ROADS
CREEKS
CHANNELS
RIVER MILES
ESTUARINE WETLAND HABITATS: MARSHES,
TIDEFLATS AND AQUATIC BEDS
LEGEND:
TIDAL MARSH
COMBINED WITH AQUATIC BED AND TIDAL FLAT/SHORE
COMBINED WITH AQUATIC BED
COMBINED WITH TIDAL FLAT/SHORE
AQUATIC BED (EELGRASS, ALGAL BEDS)
COMBINED WITH TIDAL FLAT/SHORE
TIDAL FLAT/SHORE
COMBINED WITH TIDAL MARSH AND AQUATIC BED
COMBINED WITH TIDAL MARSH
COMBINED WITH AQUATIC BED
SOURCE: HABITAT MAP OF COOS BAY ESTUARY, OREGON
DEPT. OF FISH AND WILDLIFE, SEPT. 1978.
PACIFIC
OCEAN
NORTH SPIT
OREGON DUNES NATIONAL RECREATION AREA
SIUSLAW NATIONAL FOREST
COOS BAY
NORTH BEND
COOS BAY
EASTSIDE
Empire
Charleston
Barview
Glasgow
Hauser
Bunker Hill
Millington
Allegany
Dellwood
Sumner
Green Acres
SOUTH SLOUGH
ESTUARINE SANCTUARY
COOS RIVER
MILLICOMA
SOUTH FORK
NORTH SLOUGH
KENTUCK SLOUGH
WILLANCH SL
CATCHING SLOUGH


COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING
DEPARTMENT, AFTER DSL AND USGS
LEGEND
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L FOREST BOUNDRIES
ROADS
CREEKS
CHANNELS
RIVER MILES
PACIFIC
OCEAN
NORTH SPIT
COOS BAY
NORTH BEND
COOS
BAY
EASTSIDE
CHANDLER BRIDGE
FISH HABITATS
LEGEND:
-IMPORTANT JUVENILE SALMONID FEEDING & REARING AREA
-IMPORTANT STRIPED BASS FEEDING & REARING AREA
-AREAS UTILIZED FOR HERRING SPAWNING
-SURF SMELT, TOP SMELT & EMBIOTOCID PERCH SPECIES DISTRIBUTED THROUGH-OUT THE BAY, SLOUGHS AND RIVER DURING SEASONS OF MAXIMUM SALINITY PENETRATION
-IMPORTANT ENGLISH SOLE, SAND SOLE & SPECKLED SAND DAB HABITAT
-IMPORTANT STARRY FLOUNDER HABITAT
-SPECIES UTILIZING HABITAT FROM CHANDLER BRIDGE UPSTREAM TO HEAD OF TIDE ON SOUTH COOS AND MILLICOMA RIVERS FOR:
A. SPAWNING, FEEDING & REARING:
-AMERICAN SHAD
-STRIPED BASS
B. ADULT HOLDING/JUVENILE FEEDING & REARING:
-CHINOOK SALMON
-COHO SALMON
-CUTTHROAT TROUT
-STARRY FLOUNDER
C. MIGRATION:
-STEELHEAD
SOURCE: ODFW, 1978.


COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING DEPARTMENT, AFTER DSL AND USGS
LEGEND:
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L FOREST BOUNDRIES
SOUTH SLOUGH ESTUARINE SANCTUARY BNDRY
PRIVATE LAND IN SSES
ROADS
CREEKS
CHANNELS
RIVER MILES
HABITAT FOR WATERFOWL, SHOREBIRDS AND WADING BIRDS
LEGEND:
SIGNIFICANT RESTING, FEEDING AND NESTING HABITAT
SOURCE: O.D.F.W. 1981
PACIFIC
OCEAN
NORTH SPIT
COOS BAY
NORTH BEND
EMPIRE
EASTSIDE
Charleston
Barview
Bunker Hill
Millington
Glasgow
Allegany
Dellwood
Green Acres
SOUTH SLOUGH
ESTUARINE
SANCTUARY


COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
3000 0 3000 6000
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING
DEPARTMENT, AFTER DSL AND USGS
LEGEND
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L FOREST BOUNDRIES
SOUTH SLOUGH ESTUARINE SANCTUARY BNDRY
PRIVATE LAND IN SSES
ROADS
CREEKS
CHANNELS
RIVER MILES
DRAWN BY: A CHILDRESS (AUG 6, 1981)
PACIFIC
OCEAN
NORTH BEND
COOS
BAY
EASTSIDE
Charleston
Barview
Glasgow
Allegany
Dellwood
Millington
Bunker Hill
Sumner
Green Acres
ESTUARINE
SANCTUARY
CRUSTACEAN HABITATS
LEGEND:
AMPHIPOD - Corophium sp.
GHOST SHIMP - Callianassa californiensis
MUD SHRIMP - Upogebia pugettensis
DUNGENESS CRAB - Cancer magister
GREY SHRIMP - Crago sp.
(DISTRIBUTED THROUGHOUT THE BAY, SLOUGHS
AND RIVER DURING SEASONS OF MAXIMUM
SALINITY PENETRATION)
SOURCES: USDI, 1971 & ODFW, 1978.


COOS BAY ESTUARY
MANAGEMENT PLAN
BASE MAP
3000 0 3000 6000
SCALE IN FEET
BASE MAP BY COOS COUNTY PLANNING
DEPARTMENT, AFTER DSL AND USGS
DRAWN BY A CHILDRESS (AUG 5, 1981)
N
LEGEND
HEAD OF TIDE
CITY LIMITS BOUNDARY
NRA and SIUSLAW NAT'L FOREST BOUNDRIES
SOUTH SLOUGH ESTUARINE SANCTUARY BNDRY
PRIVATE LAND IN SSES
ROADS
CREEKS
CHANNELS
RIVER MILES
PACIFIC
OCEAN
OREGON DUNES NATIONAL RECREATION AREA
NATIONAL FOREST
NORTH BEND
COOS
BAY
EASTSIDE
Empire
Barview
Charleston
Bunker Hill
Millington
Allegany
LINE OF CLOSURE TO
COMMERICAL SHELLFISH
HARVEST IN UPPER BAY
CLAM SPECIES IN THE COOS BAY
ESTUARY
LEGEND:
GAPER - Tresus capax
COCKLE - Clinocardium nuttali
BUTTER - Saxidomus giganteus
SOFTSHELL - Mya arenaria
Macoma SP.
Tellina SPP.
RAZOR - Siliqua patula
LITTLENECK - Venerupis staminea
DATA IS INADEQUATE IN MOST SUBTIDAL AREAS.
SOURCE: O.D.F.W. 1978, 1981.