THE TIDAL MARSHES OF JEFFERSON COUNTY, WASHINGTON

Prepared for

JEFFERSON COUNTY PLANNING DEPARTMENT
PORT TOWNSEND, WASHINGTON

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ACKNOWLEDGEMENTS

This report was made possible through the generous help of a number of persons. The authors wish to thank particularly the Jefferson County Board of Commissioners, Carroll M. Mercer, A. M. O'Meara, and B. G. Brown; the Jefferson County Planning Department, David Cunningham, Director, and Tom Aumock, Assistant Planner.

Eight students from The Evergreen State College in Olympia, Washington, participated in much of the background research and field work involved in this study. Their work was invaluable in obtaining data for this study, as was the supervision and guidance of Dr. Peter B. Taylor of the faculty of the College.

Dr. Ron Phillips of Seattle Pacific College, and Roy Metzgar of the Puget Sound Governmental Conference provided additional views on the biological and planning aspects, respectively, of this study.

Finally, a historical perspective on the marshes and access to privately-owned marshes were made possible through the cooperation of a number of local residents, including Dr. John Taylor, Chuck Gunstone, R. W. Evans, Mrs. Ken Harris, Frank Hart and Milt Philbrook of Pope & Talbot, Inc.

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INTRODUCTION

WHAT IS A TIDAL MARSH?

A tidal marsh is a bed of rooted vegetation which at some time of the year is covered by tidal waters. In most cases the tidal water is seawater and the plants inhabiting the marsh are species adapted to the presence of the seawater. In estuarine areas where freshwater streams flow into seawater, the rising tide may push the freshwater back up the creeks, creating a tidal variation in freshwater levels and causing the vegetation to be alternately submerged and exposed.

SCOPE

The eastern portion of Jefferson County, Washington, [see Figure 1] has approximately 30 tidal marshes, including both estuarine tidal marshes with streams flowing through them, and non-estuarine tidal marshes which are usually located on a point or spit along the shoreline. This report is concerned with 20 of those marshes, the locations of which are shown on a map of the County shown in Chapter 3 [see Figure 18, page 25]. The report does not include the larger estuaries or one marsh on the Naval Annex on Indian Island. The western portion of the county with Pacific Ocean shoreline is excluded because the entire shoreline is part of the Olympic National Park and the Hoh Indian Reservation, and is therefore not within the County's jurisdiction.

PURPOSE

Jefferson County, in the decision-making process created by the Shoreline Management Act of 1971 (RCW 90.58), has been and continues to be faced with a number of proposals regarding actions on tidal marshes. Decisions of this nature must be made with a knowledge of the natural process involved, and how they affect the value of the tidal marsh. It is the purpose of this study to provide the County with a description of the processes that occur in and because of tidal marshes, and to evaluate the importance of the tidal marshes in the county insofar as possible within the context of a study of limited time and budget.

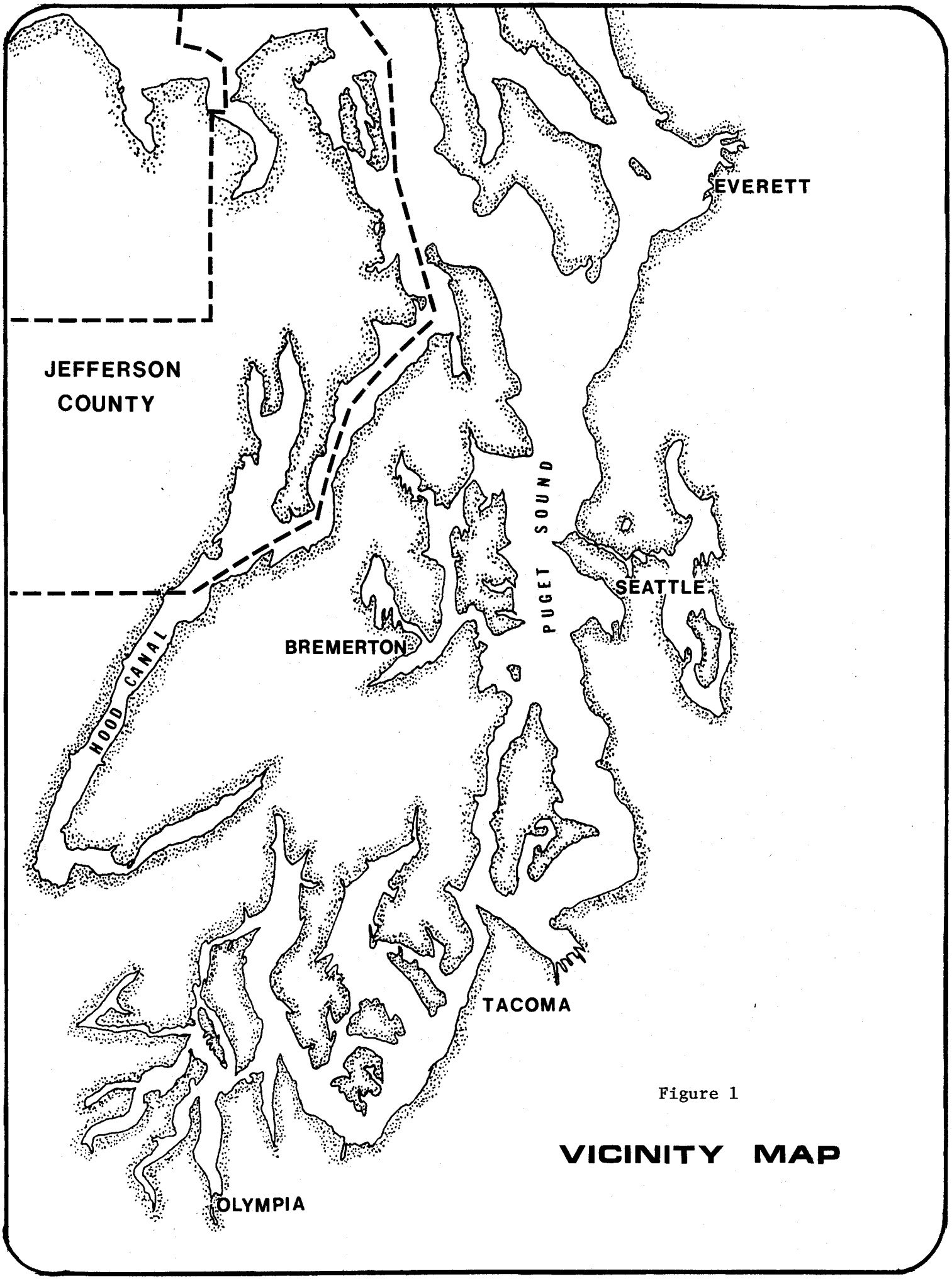
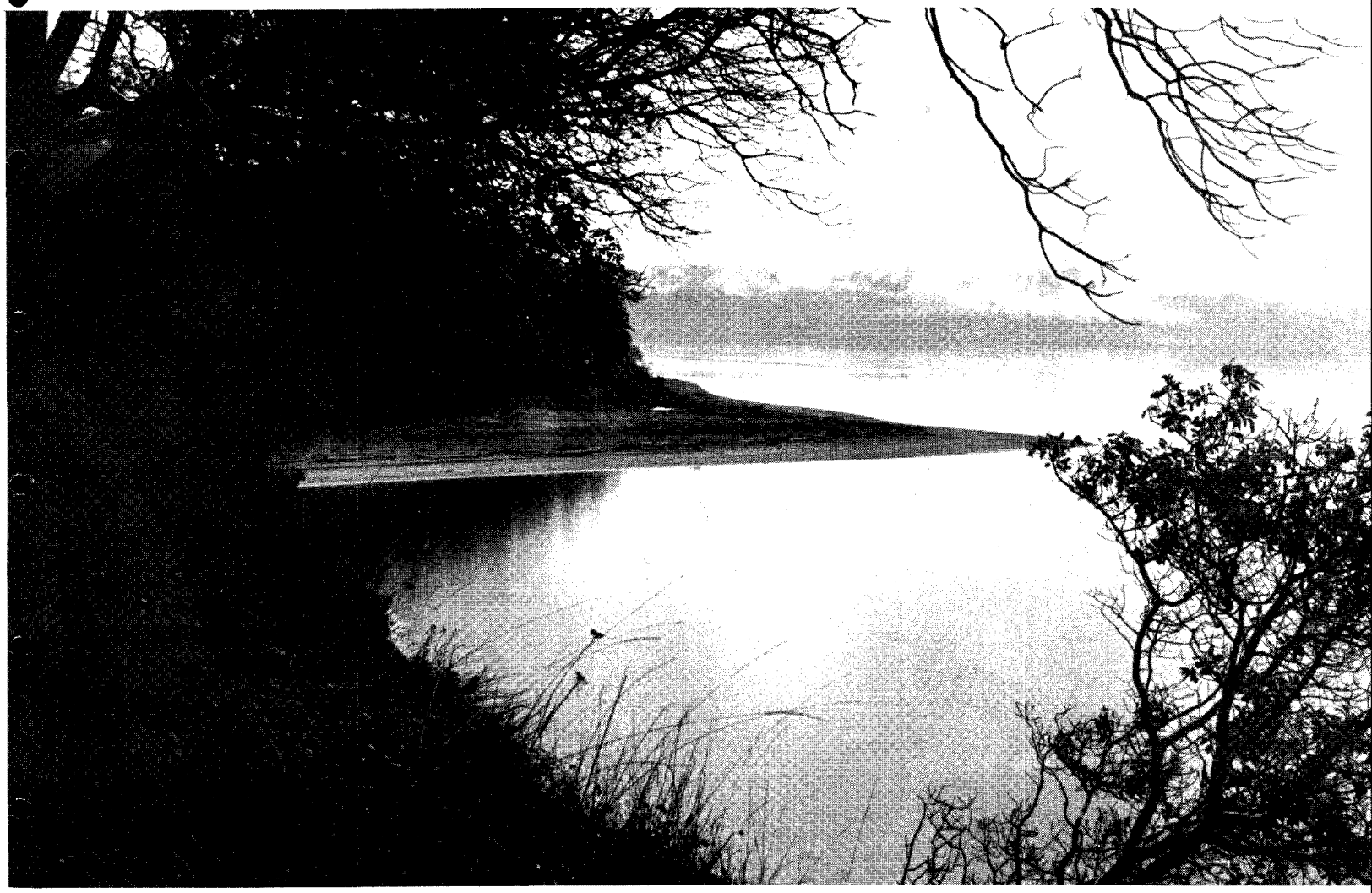


Figure 1

VICINITY MAP



1: Tidal Marsh Dynamics

CHAPTER 1

TIDAL MARSH DYNAMICS

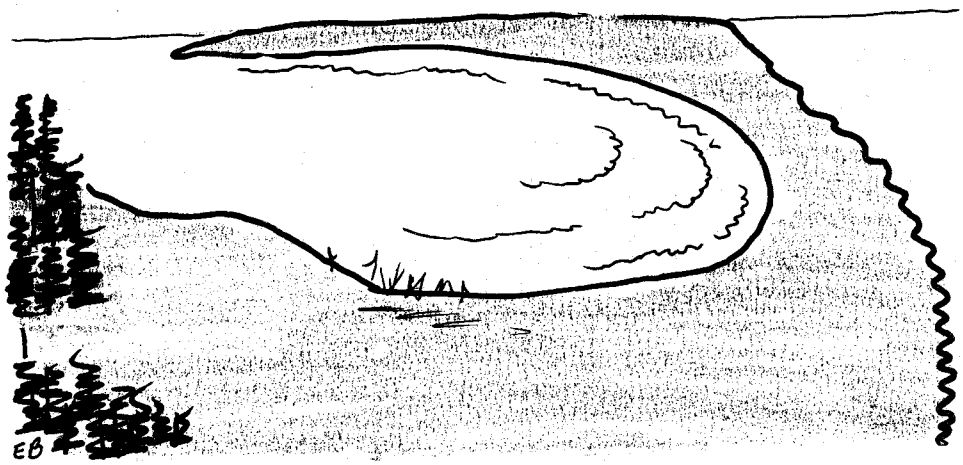
FORMATION AND PHYSICAL CHARACTERISTICS

The formation of the non-estuarine tidal marshes of Jefferson County begins with the erosion of high banks along the shoreline. These banks, composed of gravel, sand, and clay deposited by retreating Pleistocene glaciers are termed "feeder bluffs." The material eroded from the bluffs, particularly the sand and gravel, is carried along the shoreline by wave action in the direction of the prevailing wind. The material collects in an "accretion terminal" in the form of a spit, open point, closed point, stream barrier beach or bay barrier beach.

As these formations develop they enclose a lagoon on their landward side. These lagoons may be open to tidal action to some extent, depending upon the state of development of the accretion terminal. In the case of the open spits [see Figure 2] the water in the lagoon is freely exchanged with the

Figure 2

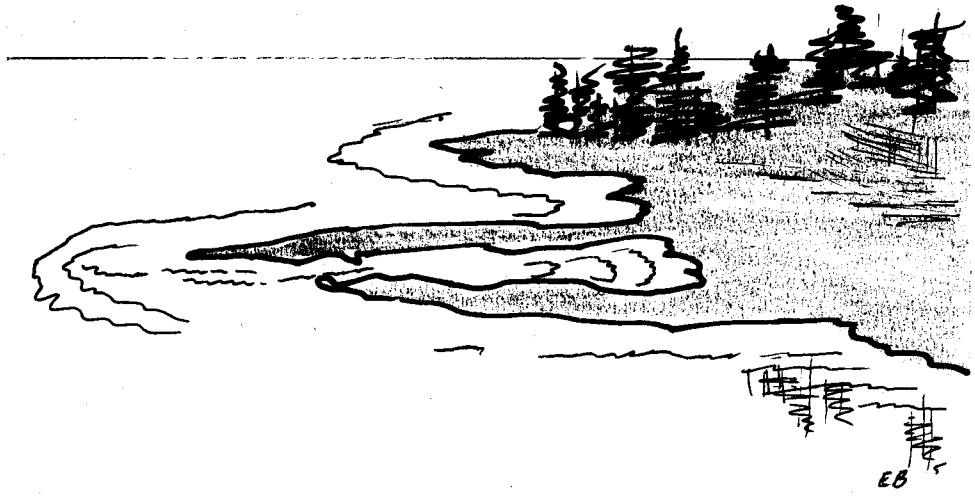
Spit



surrounding marine water (examples: Hadlock, South Point). Open points [see Figure 3] exchange with the marine environment through the tidal inlets between the growing end of the point and the bluff (examples: Kala Point, Fisherman's Point). Closed points [see Figure 4] have accreted to the extent

Figure 3

Open Point

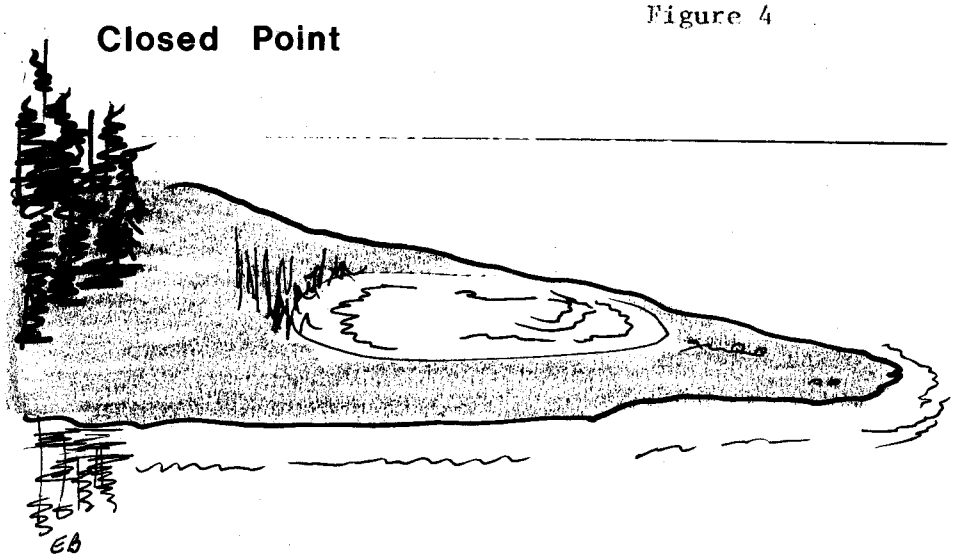


that they have closed off their tidal inlet (examples: Chevy Chase North, Beckett Point). Water exchange with the marine environment, if any, must occur by means of seepage through the point and/or splash from high waves. Stream barrier beaches [see Figure 5] have an open channel through the berm maintained by the flow of fresh water from the uplands (examples: Thorndyke Bay, Squamish Harbor). Bay barrier beaches [see Figure 6] have little or no input of freshwater, and their channel is subject to obstruction by drifting sediment (example: Gardiner).

The water in the lagoon behind a point or spit contains suspended fine sediment, as does the surrounding marine water. This sediment is held

Figure 4

Closed Point



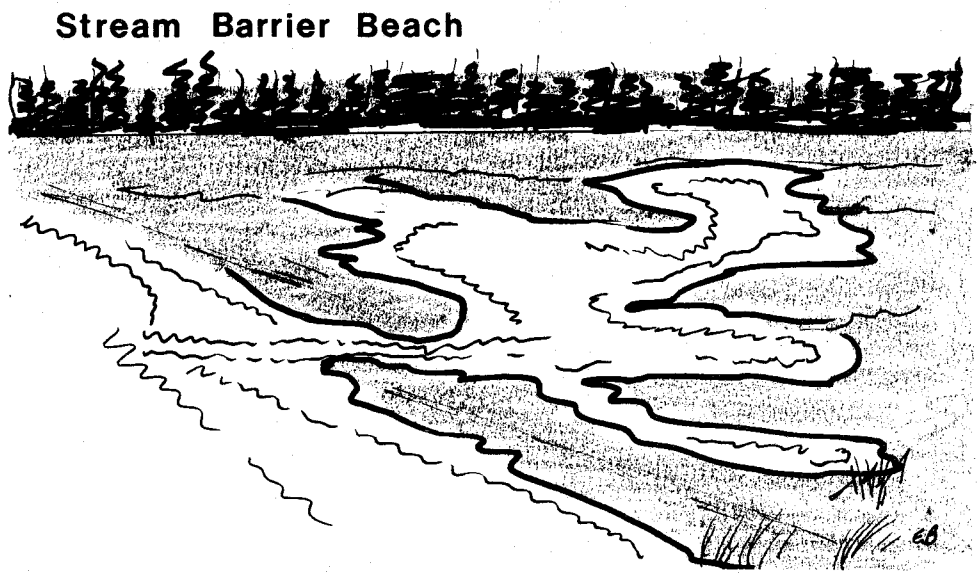


Figure 5

in suspension by the movement of the water. When the water movement is slowed down by the protection of the lagoon, it is no longer able to hold the sediment, and that sediment--usually fine sand, silt or clay--settles out inside the lagoon. These deposits of fine sediment become a substrate (underlying soil or other material) in which tidal marsh plants can colonize. [See PLANT COLONIZATION.]

The estuarine marshes located at the mouths of large streams and rivers, develop in deposits of sediment eroded from the uplands and carried downstream, rather than in accretion terminals of the longshore transport and

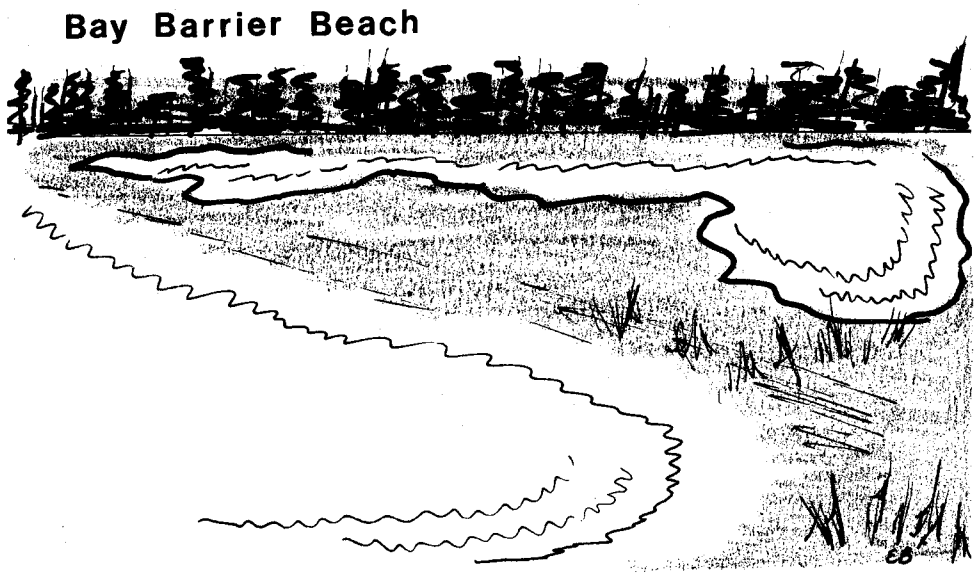


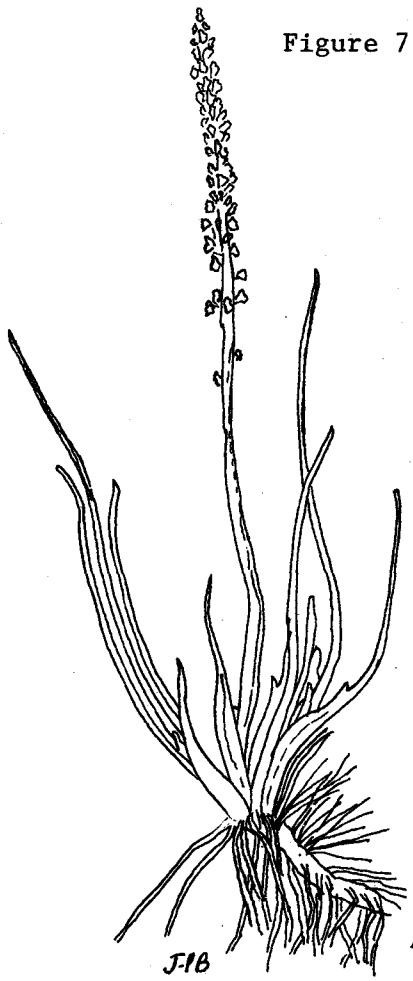
Figure 6

deposit of glacial material (examples: mouth of Duckabush River, mouth of Salmon and Snow Creeks). If the stream is still flowing fairly rapidly as it reaches seawater, it may carry gravel with it; otherwise it carries suspended sand or silt which is deposited near the mouth of the stream. The deposit occurs either physically by the inability of the slow-moving water to hold the sediment in suspension, or chemically by flocculation and settling of fine sediments caused by contact with the salt in seawater. These sediments often form a delta containing numerous drainage channels. The delta is another site for colonization by tidal marsh plants.

PLANT COLONIZATION

When the sediments have been deposited up to a tide level that is uncovered slightly less than half the time (a tide level of +7.4 feet mean lower low water [MLLW] at the Nisqually Delta as measured by Tripp and Rosenberg [1974] which would correspond to between +4.0 and +5.0 feet in the Port Townsend area and between +5.0 and +6.0 feet in Hood Canal) it is possible for a few species of plants to take root. These species must be tolerant of the tidal stress which includes the salt in the seawater which would kill most plant species, the shifting of sediments and the continual covering and uncovering by the tides.

Figure 7

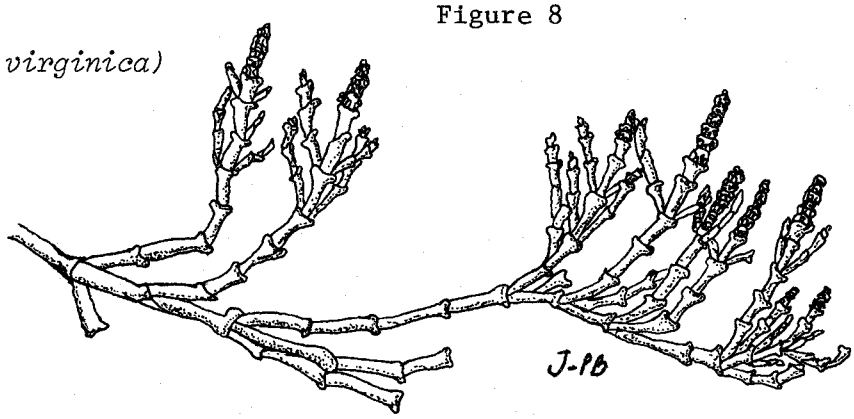


Only a few species of plants are able to tolerate those conditions and grow on previously bare tideflats. One of these is arrowgrass *(Triglochin maritimum)* [see Figure 7] a tall, grasslike plant that grows in clumps or colonies on the mudflat. Although it is a flowering plant, producing seeds for reproduction, arrowgrass can also spread by means rhizomes (root-like underground stems). This method of spreading is common in many otherwise unrelated species of tidal marsh plants. It is an important factor in tidal marsh development because (1) it allows plants to colonize a tideflat under conditions in which a seed may not be able to germinate and grow, and (2) the rhizomes act to stabilize the sediment to allow for other individuals or species to take root.

The arrowgrass clumps, sometimes very noticeable as they grow many yards from shore, increase in size as their rhizomes spread outward. As several colonies grow together they form small islands of vegetation in the mudflat.

Arrowgrass *(Triglochin maritimum)*

Figure 8



Pickleweed *(Salicornia virginica)*

Pickleweed *(Salicornia virginica)* [see Figure 8] is another plant with the ability to colonize the tideflat. It generally grows on sand or sandy silt, while the arrowgrass grows on silt. The pickleweed is a low-growing fleshy, branching plant that also spreads by rhizomes. It is often found growing in narrow bands along the edge of a tideflat and has the ability to creep out over the tideflat, moving the marsh farther and farther out onto previously unvegetated tideflat.

PLANT SUCCESSION AND MARSH TYPES

The vegetation growing in the marsh and moving in after the first colonizing species is able to grow because of the changes which the colonizers have brought about. The initial colonizers, arrowgrass and pickleweed, slow the movement of sediment-laden water, and the sediment is deposited around their stems. As dead stems and leaves fall around the plant in the form of detritus (fragmented or decaying organic material) they accumulate with the deposited sediment to build up the elevation of the substrate and reduce the frequency and duration of tidal submergence. (Some of the detritus is exported from the marsh to the marine environment as will be discussed later in this report.) When the tidal stress is decreased, the marsh becomes favorable for invasion by other species. The early colonizing plants also prepare the substrate by sending roots into the soil and aerating it. In addition, remaining organic material containing dead stems and leaves adds nutrients to the soil and promotes future plant growth. The process of plants moving into an area in which other species have lived previously is termed plant succession.

Saltgrass *(Distichlis spicata)* [see Figure 9] is one of the most common species in the tidal marshes in the Northwest. This short species of grass will often grow with the pickleweed in a thick carpet on the lower marshes. In some higher marshes an area may be vegetated almost exclusively by saltgrass.

Alkali grass *(Puccinellia distans)* [see Figure 10] is another species found in both low and high marshes. Growing in clumps, this tall grass stands

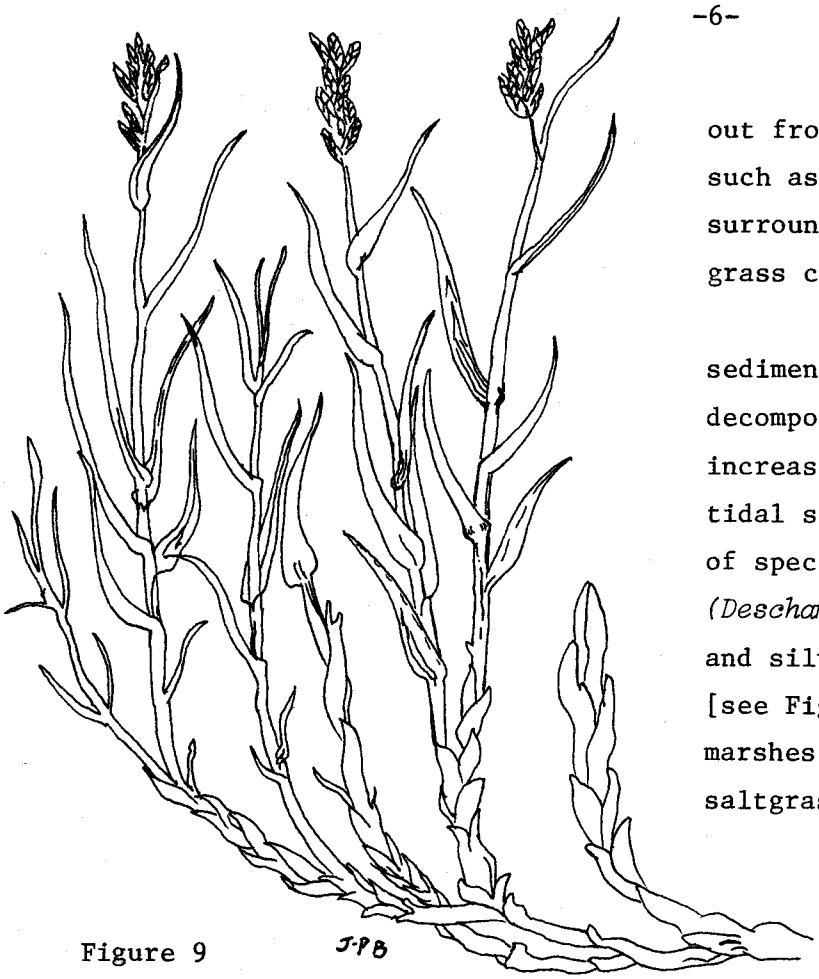


Figure 9

Saltgrass *(Distichlis spicata)*

out from among the shorter vegetation such as saltgrass and pickleweed, which surround it. In some locations alkali grass colonizes bare sand.

As the plants cause more sediment and detritus (fragmented or decomposing organic material) to increase the elevation and decrease the tidal stress still more, the diversity of species increases. Tufted hairgrass *(Deschampsia caespitosa)* [see Figure 11] and silverweed *(Potentilla pacifica)* [see Figure 12] are common in the higher marshes, growing with the pickleweed and saltgrass.

In some higher marshes, patches occur in which the soil has not built up to the level of the surrounding marsh. These areas, lower and damper than their surroundings, are vegetated by rushes *(Juncus* spp.) [see Figure 13]. Patches are sometimes found that are so much lower than their surroundings that the degree of tidal submergence prevents most vegetation from growing. These areas, called salt pans, will often have a thin film of algae on them.

The development of the vegetation in tidal marshes influences the drainage of water from the marshes with the receding tide. In low marshes, at or slightly above

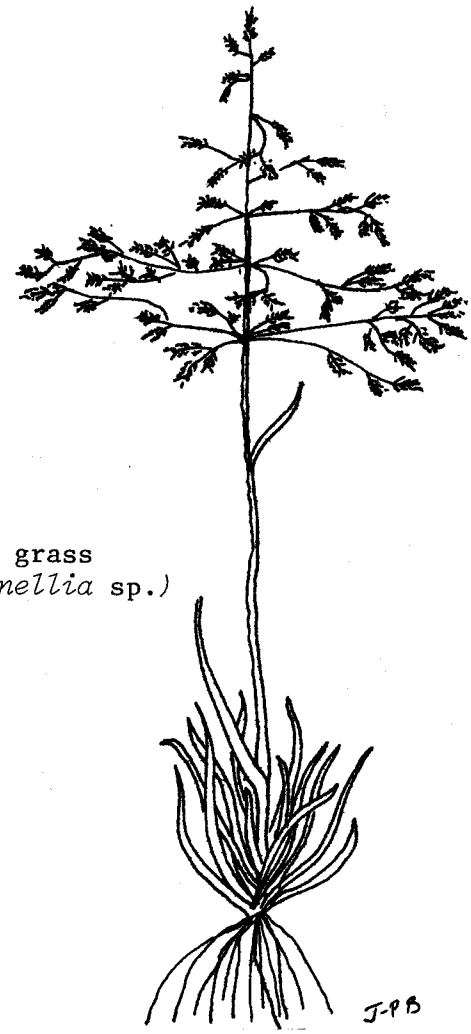


Figure 10

Alkali grass
(Puccinellia sp.*)*

the level of the adjacent tideflat, the drainage is diffuse, running in sheets from the marsh to the tideflat. As the marsh develops and increases in elevation, the drainage is channeled around clumps of vegetation into tidal creeks. These creeks meander through the marsh, gradually changing their course as one bank erodes and another accretes. They are important in that they transport nutrients into the marsh and organic material out and, as will be discussed in the following section, they are an important habitat for fish and invertebrates.

In particularly sandy or gravelly areas such as the higher berms of points and spits, gumweed *(Grindelia integrifolia)* and dune grass *(Ammophila arenaria)* are found. These plants are not influenced by the tides as much as they are by spray from waves.

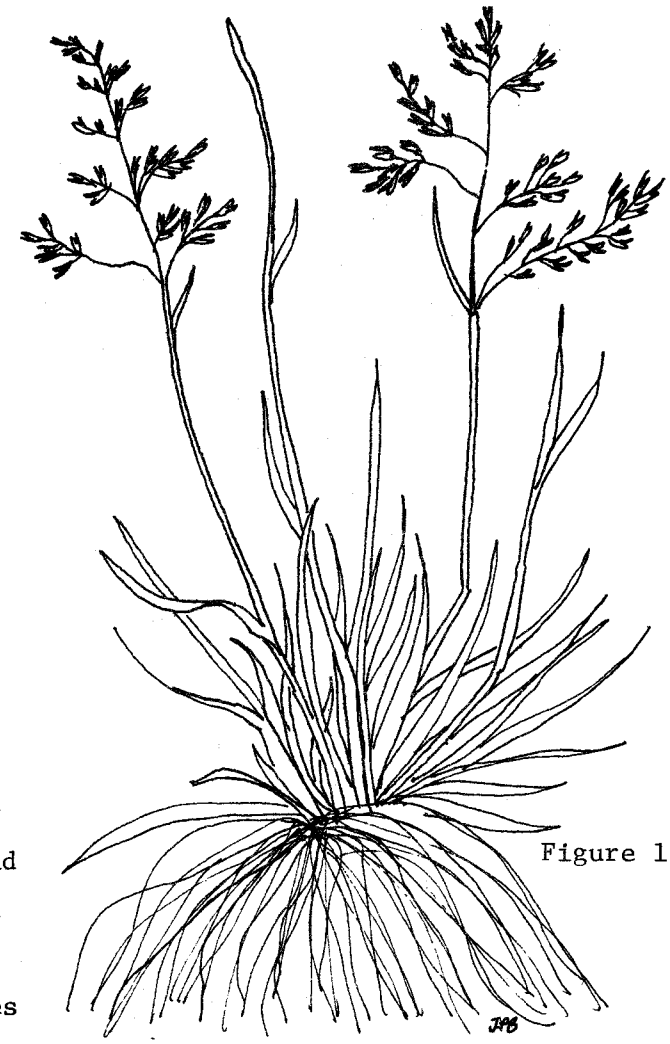


Figure 11

Tufted hairgrass *(Deschampsia caespitosa)*

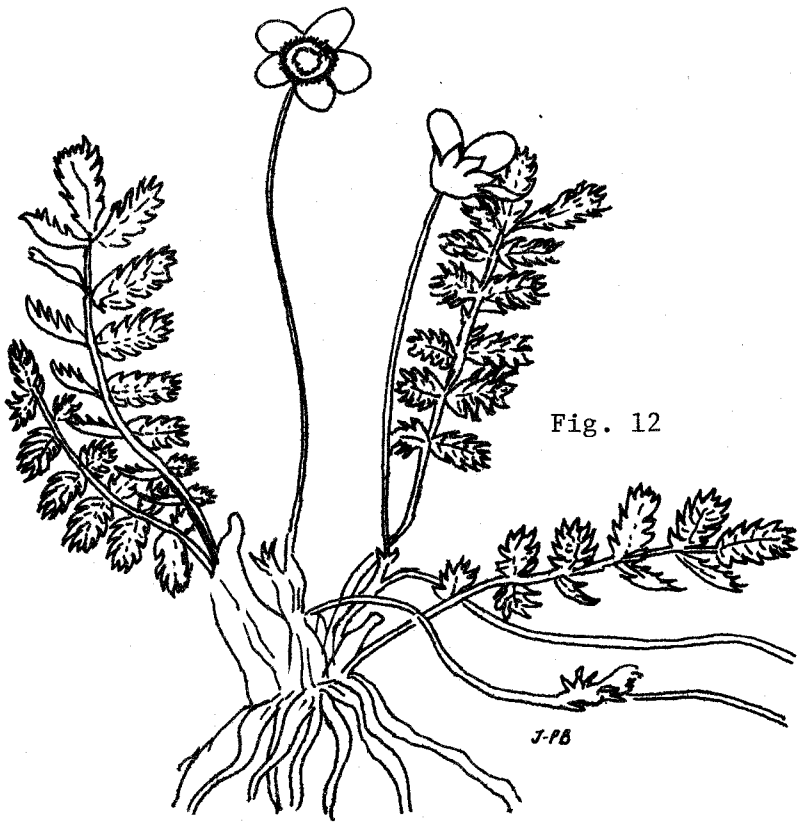


Fig. 12

Silverweed
(Potentilla pacifica)

While not truly a marsh plant community, these plants are notable in that they are characteristic of the berms, growing among driftwood on the outer edge of most of the County's non-estuarine tidal marshes. Because they are higher in elevation that the marsh inside the point, they are usually the only vegetation on the point visible if an observer approaches by water.

The plant communities or species which grow together have not, until recently, been studied in Northwest tidal marshes.

A recent study of the vegetation of Oregon's salt marshes (Jefferson, 1975) has resulted in the designation of 29 plant communities grouped into six marsh types. [See Appendix A for complete listing of plant communities.] The six marsh types are based on physical characteristics, including elevation and substrate type, as well as vegetational characteristics. Of the six marsh types that were described for Oregon, four have been distinguished in Jefferson County as major types. They include Low Silty Marsh, Low Sandy Marsh, Immature High Marsh, and Mature High Marsh.

Low Silty Marshes are found on relatively flat silty or muddy areas, adjacent to bare tideflats with similar sediment types. There is little elevation difference between the marsh and the tideflat. Drainage does not flow through tidal creeks, but diffusely through the marsh. The dominant plant species in the Low Silty Marshes in Jefferson County is pickleweed. Clumps of arrowgrass are common, especially around the lower margins; sand spurry also grows in the mud. Examples of Low Silty Marshes in Jefferson County include those at Scow Bay (both sides of the road) and Quilcene Bay.

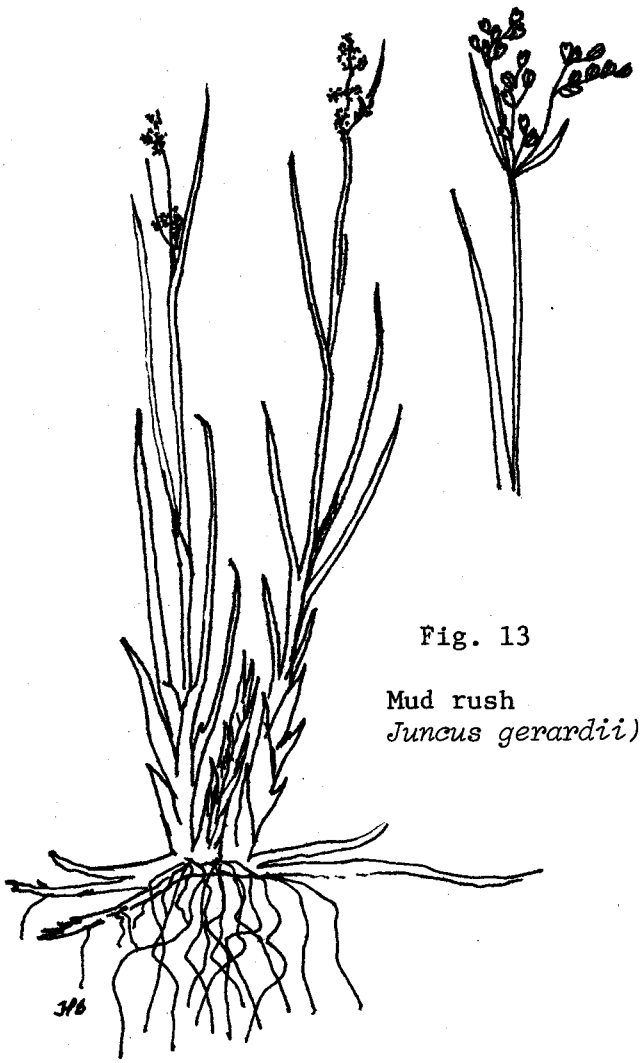


Fig. 13

Mud rush
Juncus gerardii)

Low Sandy Marshes also occur adjacent to and slightly higher than the tideflat but in sand. These marshes are not as common in Jefferson County as are the Low Silty Marshes, but can be found on the leeward side of a sand spit, such as the spit north of South Point, or inside an open point in which the substrate has a high percentage of sand, such as Kala Point. Pickleweed and saltgrass are the most common plant species found in Jefferson County's Low Sandy Marshes with jaumea and sand spurry also present.

Immature High Marshes can be recognized by their abrupt rise of two or more feet above the tideflat or several inches above the adjacent low marsh. Soil is silty

with organic material. The pickleweed and saltgrass, found on the lower marshes, are joined by tufted hairgrass, silverweed, and rush on the Immature High Marshes. Drainage is through deep, often winding, tidal creeks. This marsh type can easily be seen in the eastern section of South Indian Island County Park.

Mature High Marshes are found on substrates with a great deal of peat, organic material created by years of decaying vegetation. Drainage is through deep tidal creeks, and the edge of the marsh rises steeply, three feet or more above the tideflat, or rises a shorter distance above adjacent marsh. Pickleweed and saltgrass are present as in the other marsh types, but gumweed and silverweed are very common, and tufted hairgrass is present as well. This marsh type often abuts the berm and its characteristic vegetation. Mature High Marshes can be observed at Thorndyke Bay just inside the berm, and at Quilcene Bay, adjacent to the county road and a gravel fill.

The lower marsh types, as they build up sediment and peat, gradually become higher marsh types. Radio-carbon dating in Oregon marshes indicated that it may take from approximately 300 to 800 years to build up a high marsh from original colonization of arrowgrass on the tideflat.

Although Jefferson (1975) lists Sedge Marsh and Bullrush and Sedge Marsh as two of the six major vegetational marsh types in Oregon's salt marshes, they were not found to be very extensive in Jefferson County marshes. Sedge *(Carex lyngbei)* [see Figure 14] and bulrush *(Scirpus)* [see Figure 15] plant communities do occur in the marshes at Squamish Harbor, Thorndyke Bay, Black Point and other areas in which the salinity (salt content) of the water is diluted by freshwater. In these areas, however, the vegetation is often quite diverse, relative to most of the tidal marsh vegetation types, and includes, besides the sedge and bulrush, creeping bentgrass *(Agrostis alba)*, silverweed *(Potentilla pacifica)*, Baltic rush *(Juncus balticus)*, soft rush *(J. effusus)*, and where the salinity is extremely low, cattail *(Typha latifolia)*. Dr. Jefferson stated (personal communication, April 23, 1975) that "...areas of heavy freshwater runoff have, indeed, a confused pattern..." For this reason, this report combines the Sedge Marsh, Bulrush and Sedge Marsh, and other freshwater influenced tidal marsh vegetation under the heading Brackish Water Marsh and they are mapped as Brackish on the vegetation maps in Chapter 3.

TIDAL MARSH PRODUCTIVITY

Tidal marsh plants, like all other green plants, use the sun's energy to convert inorganic substances (water and carbon dioxide) into organic materials (simple sugars). The process by which plants produce the organic material is called photosynthesis. Primary productivity refers to the rate at which the plants produce organic material from inorganic substances.

Because all living things are ultimately dependent on organic material produced by green plants, the productivity of a group of plants is an important factor in determining how many and what kind of organisms will live in an area. Tidal marshes, being a transition area between the land and the sea, contribute to both of these environments. In comparison with other producers of both the land and the sea, tidal marshes have environmental conditions that are conducive to a high productivity rate.

Algae is a major primary producer in the marine environment, in the forms of one-celled drifting plankton or large attached algae such as kelp. The production of algae is very seasonal, however, and is further limited by deep and/or turbid water, preventing penetration by sunlight. Some species in the tidal marshes are year-round producers, and their location in the intertidal zone assures an adequate supply of sunlight.

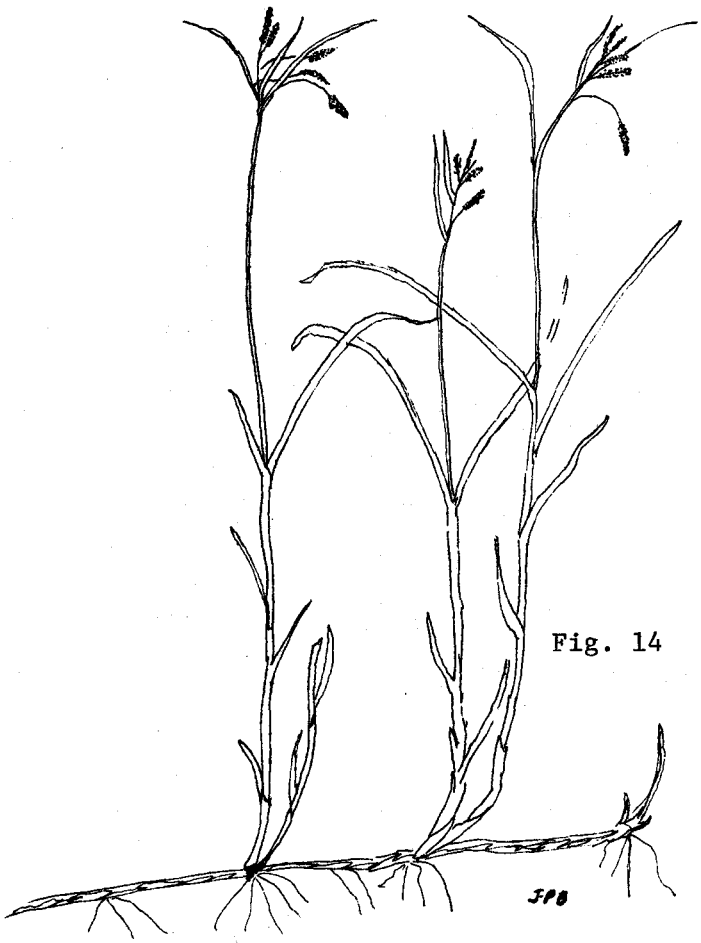


Fig. 14

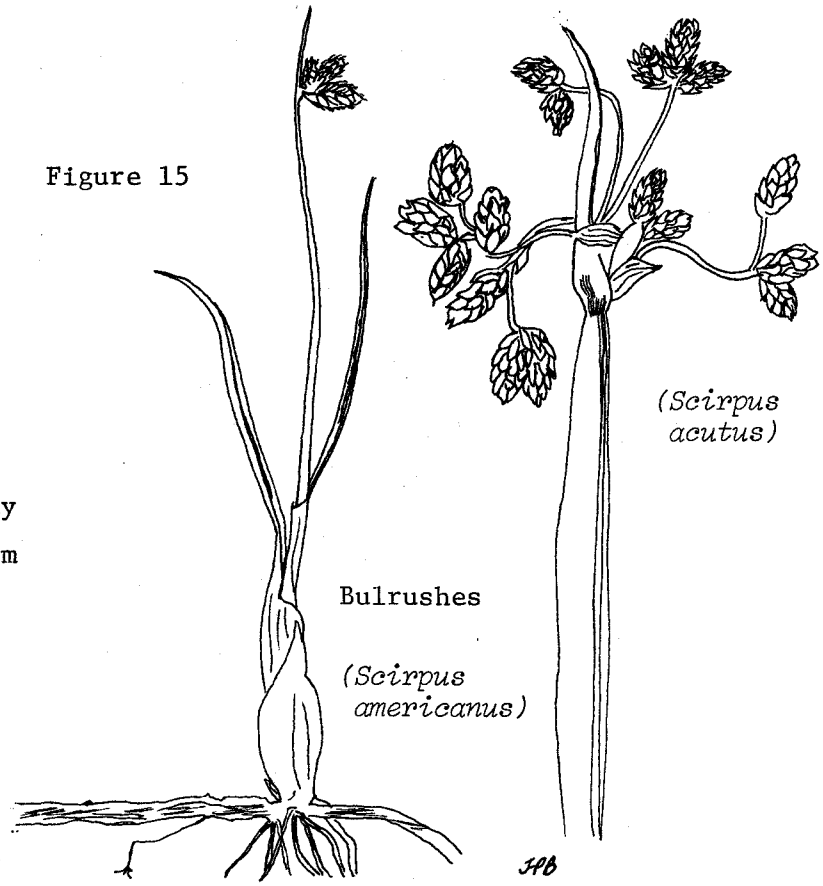
Sedge *(Carex lyngbei)*

Terrestrial plants, grasses, trees, etc., also have adequate available sunlight, but their productivity can be limited by the level of inorganic nutrients in the soil. In order to assure plentiful nutrients in agricultural crops, a farmer must subsidize the crops with chemical fertilizers and, of course, a generous supply of petroleum energy to run tractors for fertilizing, cultivating and other activities necessary to assure a high yield. In the tidal marsh the high yield is produced with no input of energy or nutrients by humans. The nutrients, phosphates and nitrates, are available in the seawater which floods the marsh, and the energy subsidy is provided by tidal action (Odum, 1961, 1971).

In order to compare the productivity of the tidal marshes with that of other vegetation types, measurements were made during this study, with estimates derived from those measurements included in Table 1.

Data presented for Jefferson County tidal marshes must be considered tentative. They are based on measurements made from April 16 to June 6, 1975, and extrapolated over an assumed 104-day growing season, beginning April 16, peaking June 6, and ending July 28. The estimate of the growing season is probably short, since the actual "growing degree days" for Port Townsend do not peak until August, and continue into October at a higher rate than in May (Washington State University Cooperative Extension Service, 1972). The data also do not account for factors such as grazing by herbivores and tidal action which would remove live material from the marsh. Thus the figures presented are a very conservative estimate of the actual rate of production.

Figure 15



EXPORT OF PRODUCTIVITY

The relatively high rate of productivity of the salt marshes might at first seem to be of little consequence. Even though a marsh is a higher producer than a cornfield humans do not directly harvest the vegetation in the marsh. The importance of the marsh productivity is that the solar energy that is fixed by the marsh plants does not remain in the marsh. A combination of physical and biological factors act to remove some of the productivity from the marsh and to convert it to other forms.

Most of the organic matter produced in the marsh is not consumed in the form of live plants. A notable exception would be those marshes that are used for grazing by cattle or deer. Another exception is the grazing by water birds such as brant on the marsh plant, pickleweed. Flocks of up to several

TABLE 1

NET DRY MATTER PRODUCTION

	GRAMS/SQ. METER/YEAR
Wheat Field (World Average)	288[1]
Rice Field (World Average)	511[1]
Eelgrass Bed (Puget Sound)	581[2]
Sugar Cane (Hawaii)	2711[1]
Tidal Marsh (Louisiana)	1544[3]
Tidal Marshes - Jefferson County, Washington[4]	
Low Silty Marsh	448
Low Sandy Marsh	738
Immature High Marsh	1041
Mature High Marsh	283
Sedge Marsh	2000

[1]Odum, 1971.

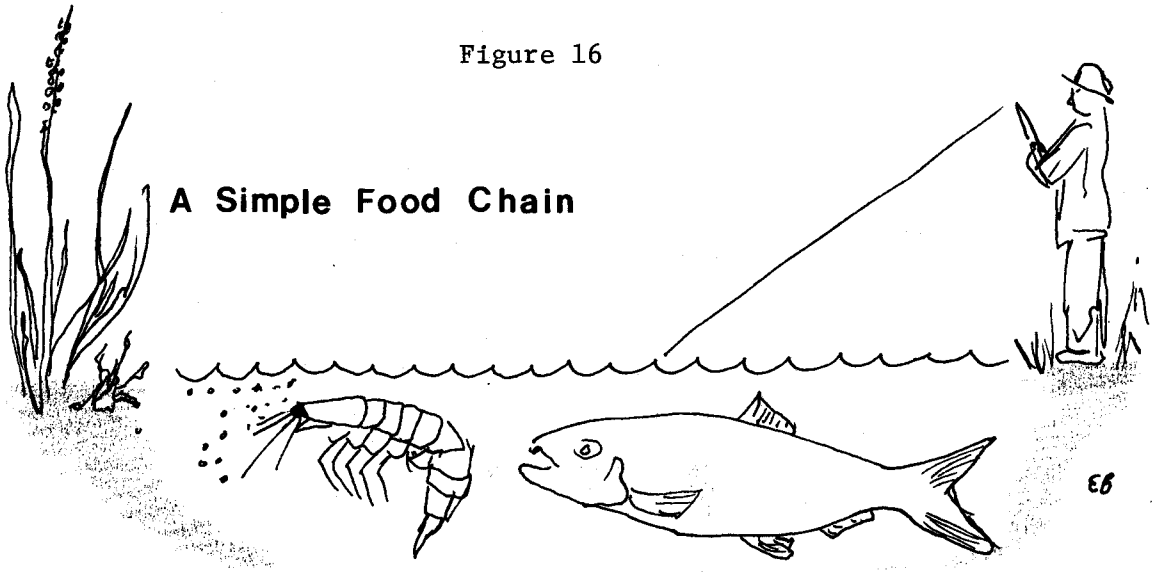
[2]Phillips, 1969.

[3]Day, et al., 1973.

[4]Data from Jefferson County tidal marshes must be considered tentative. Measurements were made during 52 days and extrapolated over an assumed 104-day growing season. Because the growing season is actually much longer and other factors such as grazing by herbivores and tidal action were not considered, the estimate is conservative, and actual productivity may be much higher.

hundred brant can be observed in tidal marsh lagoons where they utilize the pickleweed. In most cases, however, the plant leaves and stems are converted to detritus which can be used as food by a greater number of marine animals. The detritus is washed from the marsh into the marine environment by the action of the tides. In the drainage ditches of the marsh and the adjacent mudflats, amphipods (beach hoppers) may be observed feeding on the detritus. Other detritus feeders in the mudflat include mollusks (such as clams and snails), insects, and polychaete worms. These animals in turn, become food for larger animals including fish and birds, in a series of feeding relationships called a food chain. (A simplified food chain is illustrated in Figure 16. Figure 17 illustrates a number of marsh-based feeding relationships.) A simple food chain observed is illustrated as follows: marsh plants are converted to detritus which is consumed by amphipods. The amphipods are eaten by small fish such as the sand lance (field observation, March, 1975). Sand lances become food for coho and chinook salmon (Hart, 1973) which may be harvested by humans.

Figure 16



Many marine animals outside the marsh and adjacent mudflat are detritus feeders. These include the commercially valuable crustaceans, Dungeness crabs and shrimp. Oysters also utilize detritus as a major portion of their food (Galtsoff, 1964). Many non-commercial, bottom-dwelling animals, including mollusks, crustaceans and worms, feed on detritus and are then consumed by bottom fish, such as English sole, starry flounder, and Pacific cod (Hart, 1973). These fish are caught by both commercial and sport fishermen. [See Appendix A, Table A-3 for list of invertebrate species inhabiting tidal marshes, and Table A-4 for list of fish found in tidal marshes at high tide.]

MARSH-BASED FOOD WEB

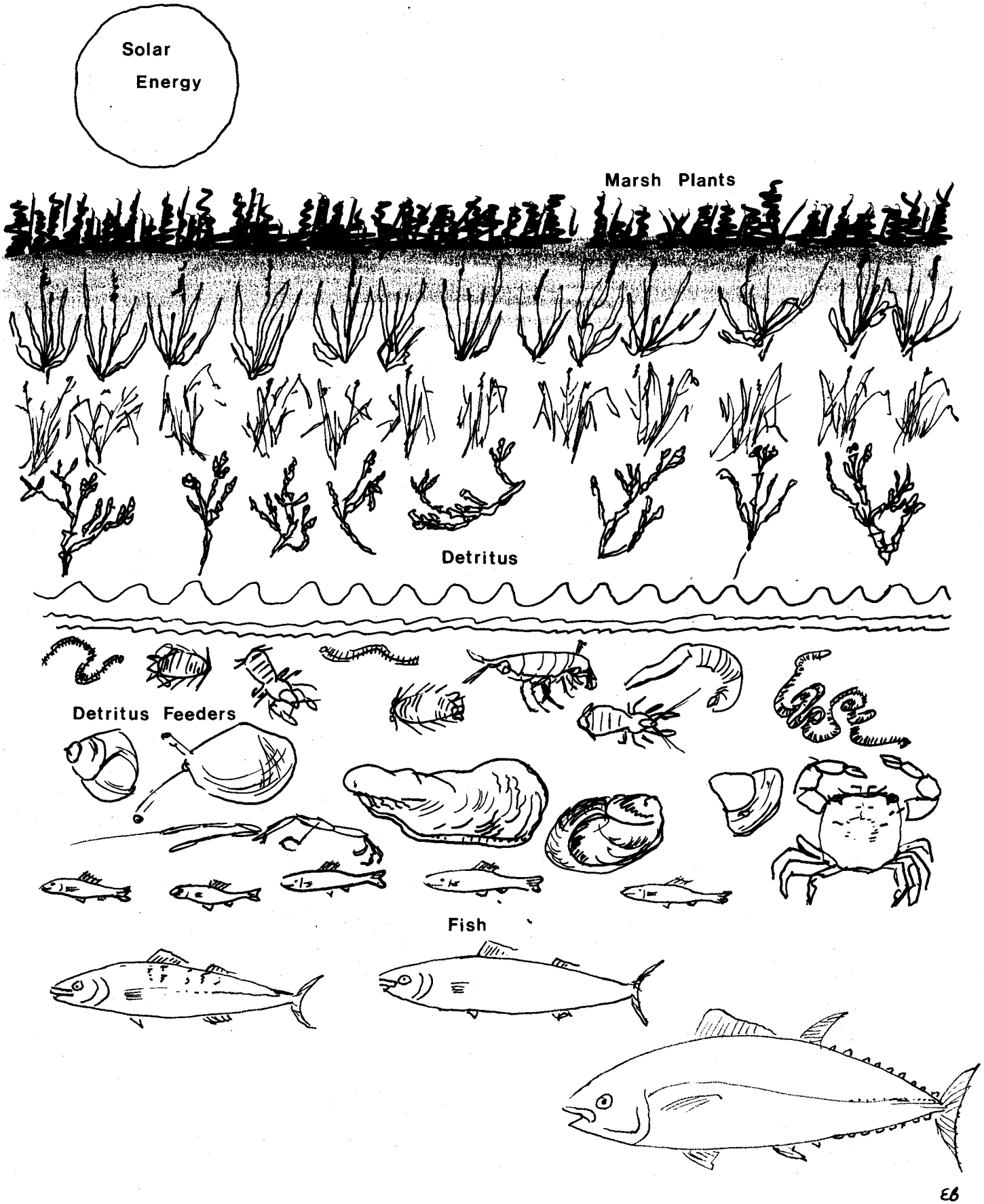


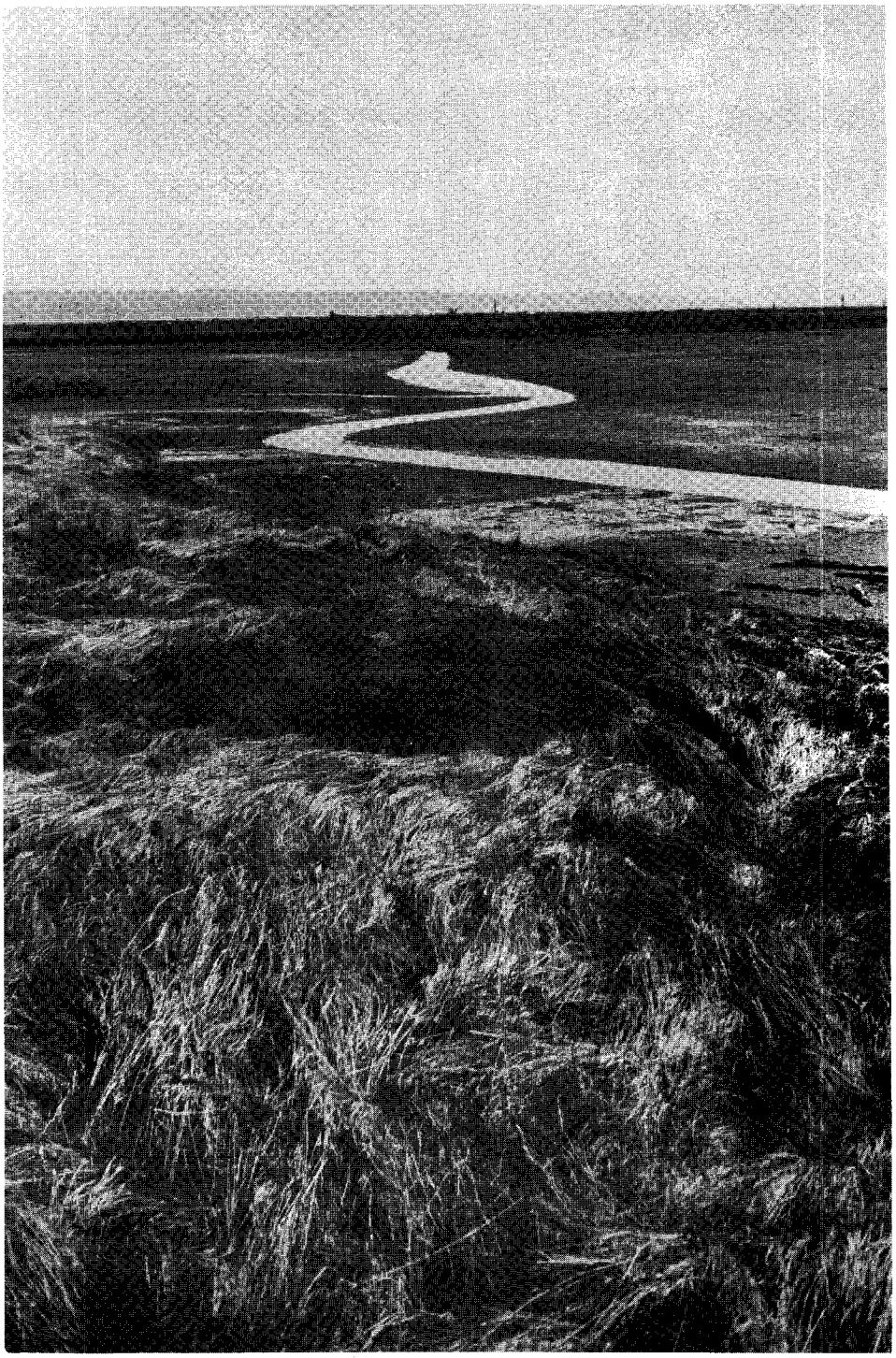
Figure 17

Some of the deeper bottom-dwelling detritus feeders are eaten by diving ducks, including scaups, scoters and goldeneyes. "Puddle ducks," or dabbling ducks, such as mallards, pintails and canvasbacks, consume detritus feeders in the shallower mudflats and drainage sloughs of the marshes. The dabbling ducks are taken in the sport harvest by hunters, and duck blinds and shotgun shells remain in the marshes throughout the year as evidence of autumn duck hunting activities.

Other birds which eat detritus feeders in the tidal marsh include gulls, shorebirds (sandpipers and killdeer) and great blue herons.

The importance of the tidal marshes to the Puget Sound ecosystem has not been studied on a quantitative level. It has been stated, however, that in estuaries with a high level of turbidity in the water, productivity of phytoplankton (microscopic drifting plants) is reduced and the role of the marsh vegetation in the biological productivity of the estuary becomes greater (Green, 1973). Puget Sound and its adjacent waters can be considered an estuarine system, with many sources of freshwater bringing with them suspended particles which create a high level of turbidity, thus increasing the relative importance of the marsh productivity.

It should also be noted that the productivity of the phytoplankton is considerably reduced in the winter, when the phytoplankton population level is depressed and sunlight at its minimum. At this time, however, the storms and high tides carry organic detritus from the marsh into the marine environment, where it can partly compensate for the reduced availablity of food produced by phytoplankton.



2: The Value of the Tidal Marsh

CHAPTER 2

THE VALUE OF THE TIDAL MARSH

Extensive research has been and is being conducted into the processes that occur in tidal marshes and the value of the marshes. Most of that research has been on the Atlantic coast where tidal marshes cover a much larger area and have therefore been involved in more land use conflicts. There is little existing literature describing or evaluating the small amount of tidal marshland on the west coast. The tidal marshes of the Puget Sound area have gone virtually unstudied.

Fortunately, the processes which occur in the marshes of Jefferson County have parallels in some of the more thoroughly studied marshes, and it can be seen that the marshes fulfill certain functions which directly or indirectly are beneficial to humans. The first three of the functions in the following discussion can be quantified by measuring their determining factors. The other functions, while not easily quantifiable, are nevertheless important in any discussion of the value of tidal marshes to society.

FUNCTION: BIOLOGICAL PRODUCTIVITY AND EXPORT

This function was discussed in more detail in the preceding chapter, but will briefly be reviewed here. The plants of the tidal marsh have a high rate of productivity; that is, they are very efficient at converting inorganic materials into organic materials. The unique position of the tidal marsh, at the interface between the land and the sea allows the organic material to be exported through both physical processes (e.g., tidal action) and biological processes (e.g., feeding relationships) to both the terrestrial and the marine environments. Many of the animals involved in marsh-based food chains are species which are commercially or recreationally valuable.

FUNCTION: HABITAT FOR FISH AND WILDLIFE

The significance of the marsh as fish and wildlife habitat relates to both its high biological productivity assuring an abundance of food for animals, and its position in the land-sea interface providing a diversity of habitat types within a small area.

Many species of waterbirds and shorebirds utilize the marsh for feeding and nesting at different times of the year. The Puget Sound area in general, and its tidal marshes in particular, support large populations of waterbirds in the fall and winter. Several of Jefferson County's tidal marshes are duck hunting areas.

The expanses of marsh and adjacent flats uncovered at low tide attract raccoon, skunk and muskrat for feeding, while the higher marshes provide habitat for small burrowing rodents. Deer are also common visitors to the marsh, and two large tidal marsh areas in Jefferson County (Dosewallips and Duckabush deltas) are utilized by herds of elk.

At high tide, when the tidal creeks are filled with water, fish come in from immediately offshore. Species observed or collected during this study include sand lance, sculpins (various species), starry flounder, three-spined stickleback and juvenile chum salmon. The importance of the marsh sloughs to juvenile salmon deserves special mention. Pink and chum salmon migrate into salt water immediately after hatching. They generally remain in shallow water in order to avoid larger predatory fish and to find a food source for which they will have little competition (Gerke and Kaczynski, 1972). The shallows associated with tidal marshes present a favorable habitat for the juvenile fish. Its potential for utilization by juvenile salmon "does not require that the salmon be produced in an immediately adjoining stream," (Ray Johnson, Fisheries Biologist, Washington Department of Fisheries, personal communication).

FUNCTION: BUFFER AGAINST EROSION

A geo-hydraulic classification of Puget Sound area shorelines (Bauer, 1975) recognizes three basic types: Class I, or accretional dry beaches; Class II, or marginal dry beaches; and Class III, or erosional wet beaches. Bauer estimates that eroding beaches exceed accreting beaches by a ratio of 20:1.

Eroding beaches and their adjoining eroding banks present problems to waterfront property owners who may find their property decreasing in size with each winter storm. Costs for protecting a bank with a bulkhead can exceed $200 per linear foot of shoreline (U. S. Department of the Army, Corps of Engineers, 1973) and average $50 per linear foot for a concrete bulkhead (Russell Trask, Waterfront Developers, Inc., personal communication, depending on bulkhead type, bulkhead material and offshore topography. A tidal marsh and its associated shoreform act as a natural bulkhead in protecting the shoreline against erosion, and when preserved can save a property owner considerable cost.

Most of the berms seaward of the tidal marshes in Jefferson County have a high gravel content. The gravel is very porous, allowing water to pass through it and absorbing the energy of the waves that would otherwise cause erosion and undercutting of the bank.

FUNCTION: WATER QUALITY MAINTENANCE

The waters of Puget Sound typically have a high level of turbidity, or cloudiness. Often this turbidity is due to suspended sediment carried into the sound by river runoff. The turbidity can have the effect of reducing light penetration, and can therefore reduce the productivity of the phytoplankton (microscopic, drifting plants, usually one-celled). When the water containing suspended sediments covers a tidal marsh the vegetation of the marsh slows the water movement and causes the sediment to be deposited in the marsh. Thus, the marsh helps to reduce the turbidity in the surrounding water and thereby increases the total production of phytoplankton (Wass and Wright, 1969).

Another way in which the tidal marsh maintains water quality is its removal of inorganic nutrients from the water. These nutrients which include phosphates and nitrates and may have their source in sewage effluent or septic tank leachates can stimulate algae growth to such a degree that the algae overproduce and an algae bloom results. The danger in an algae bloom is that when a very large quantity is produced at one time it dies and consumes oxygen when it decays. Oxygen consumed in the decay process is unavailable for use by fish and invertebrates. In Puget Sound the algae that bloom in the presence of nutrients from sewage include two species of diatoms (one-celled algae) in open water and attached algae of the genus *Enteromorpha* in shallow water and on beaches or tideflats. The *Enteromorpha* forms a thick growth in warm weather and, besides consuming oxygen when it decays, gives off an objectionable odor.

The tidal marsh, particularly the lower marshes which are covered daily by the tides, removes the nutrients from the water just as upland plants take nutrients from the soil. It thus helps reduce the likelihood or the intensity of algae blooms. A study of a Georgia tidal marsh (Pomeroy, et al, 1972) showed that the marsh regulated the phosphate of the surrounding waters to the extent that, even though the phosphate input varied throughout the year the level of phosphate in the water remained relatively stable.

New wastewater treatment facilities are now being constructed in many parts of the United States that have the capability to remove the nutrients from sewage effluent. This form of treatment, tertiary treatment, is very costly. A recent study (Gosselink, Odum and Pope, 1975) valued the work of the east coast marshes in removing just phosphorous at between $480 and $1420 per acre per year. The report states that the marshes appear to be uniquely adapted to remove nitrogen from the water as well. This treatment of the water is expensive when done technically but is performed by the marsh for free.

It should be emphasized, however, that secondary treatment, or removal of organic solids of sewage (a relatively inexpensive process) cannot be done efficiently by a tidal marsh since it is already naturally high in organic detritus. Raw sewage would put an additional burden on the functioning of the marsh.

FUNCTION: RECREATION USE

Another important function of the tidal marsh is that of providing a setting for a wide range of recreational uses. These uses range from hunting and fishing to appreciation of the natural environment, including such activities as viewing scenery, photography and nature study. While the social value of these activities and the intrinsic aesthetic qualities possessed by tidal marshes presently cannot be easily quantified, they cannot be overlooked in assessing the overall importance of these marshes.

As noted earlier, marshes form a highly interrelated ecosystem with little capability to resist or recover from the effect of intensive human activity within the marsh. Recreational use of the marsh must then be looked at in terms of suitability, ecological suitability being measured by the degree to which a site is able to satisfy the requirements of the particular recreational use without incurring long-term, detrimental, and/or irreversible impacts (changes) to the natural system components of the site. Those uses which are best suited to a marsh environment are those which are of low intensity, causing little disruption of this sensitive environment.

ASSESSING RELATIVE VALUE

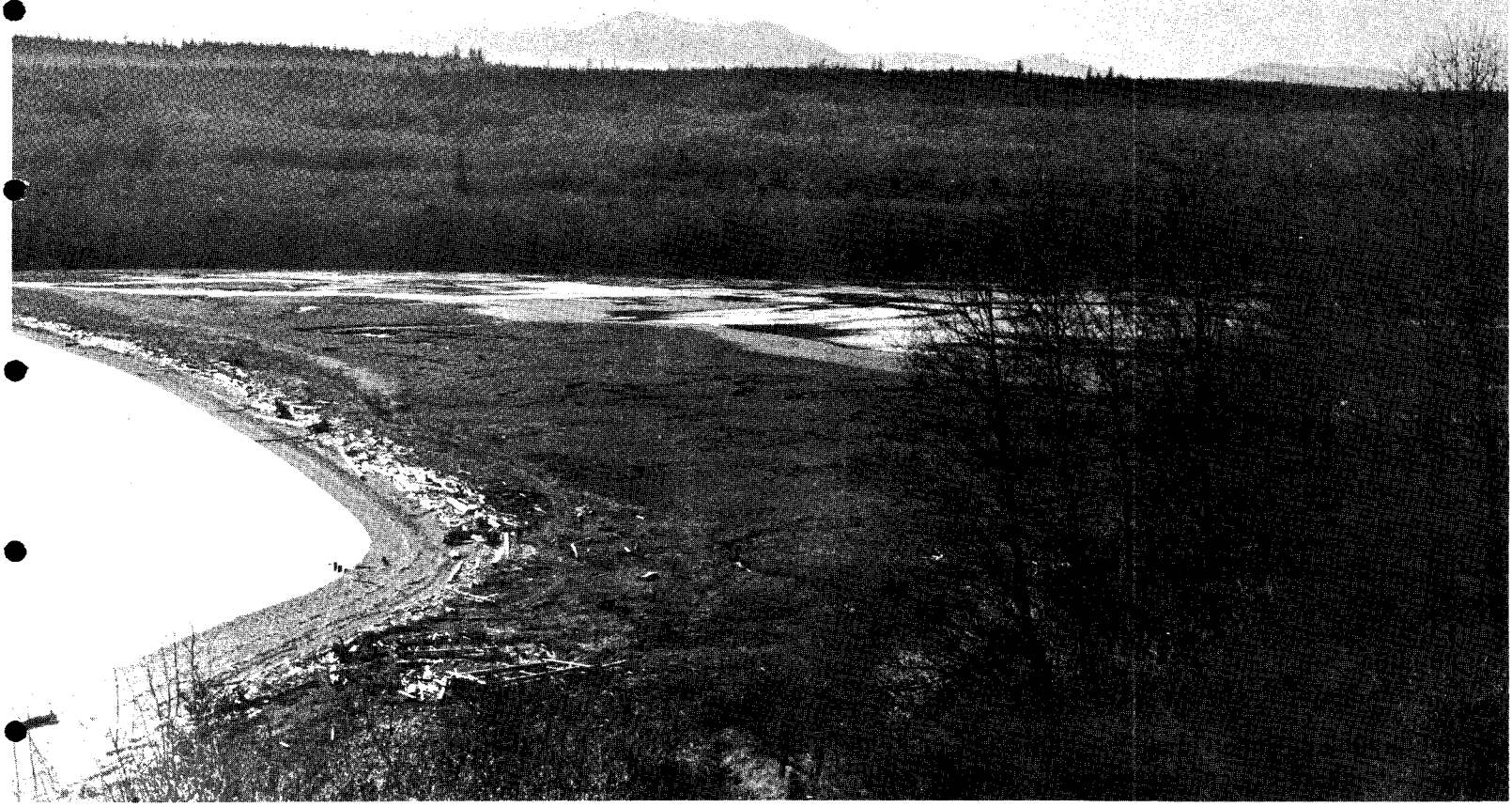
Certain factors may be used in determining on a qualitative level, the relative value of a marsh. An abundance of low marsh would make a marsh more valuable to the marine environment than would a great deal of high marsh.

Although the productivity measurements in the Immature High Marsh exceeded those of Low Sandy or Low Silty Marshes, the low marshes are covered by the tide more frequently and for a longer duration than are the higher marshes. Low marsh is thus more integrated with the marine environment and is more likely to provide food for marine animals.

Contact with the marine environment also depends on an open channel through which seawater may flow into the marsh. Those marshes which are behind a closed point, although they may have seawater in their interior lagoon, cannot freely exchange water or organic material with the marine environment, nor can marine animals utilize such a marsh at high tide, as they can a marsh inside an open point, spit, or stream barrier beach.

During this study, these and a number of other important elements in the dynamics of the tidal marsh were measured or observed to help in evaluating the importance of the marshes. The results of these measurements and observations are included in the text of this report, and in the data sheets on the individual marshes. It was also the intention of the study team to present the data in matrix form in the next chapter in order to rank the 20 tidal marshes by their relative importance. At the time of the preparation of this report, however, insufficient data was available, whether published in existing literature or gathered in this study, to prepare a matrix that would allow the user to make decisions based on a well-rounded view of the functions of the marshes.

A sample matrix that includes some of the quantifiable factors that are components of the marshes' functions is included in Appendix B along with an explanation of those factors. The matrix may be used as an outline for data that could be gathered in future evaluations of tidal marshes.



3: Jefferson County Marshes

CHAPTER 3

JEFFERSON COUNTY MARSHES

This chapter deals with the 20 specific tidal marshes which were studied for this report. Each marsh is described in a data sheet and illustrated in a map of marsh vegetation types. Figure 18 shows the location of each marsh within the county.

Most of the non-estuarine tidal marshes are small relative to river delta estuarine marshes, and account for less than the total area of their shoreform. The average area actually occupied by marsh vegetation on any one shoreform is 7.3 acres. Those areas range from 1.5 acres (Chevy Chase North Marsh) to 32.8 acres (Thorndyke Bay Marsh).

Of the vegetational marsh types studied, the most wide-spread in Jefferson County is the Immature High Marsh, which occupies 59.9 acres, or 41.1 per cent of the total marsh area. Mature High and Low Sandy Marshes follow in percentage covered, being 21.3 per cent and 20.9 per cent respectively. Low Silty Marshes cover 13.6 per cent and Brackish Water Marsh (a category including Sedge, Bulrush and Sedge and Tidal Freshwater) is a minor component of the marsh acreage in the county, covering only 3.0 per cent of the marsh area, although this figure is based on arbitrary upstream limits to measurement such as highways and culverts.

The ratio of high marsh area to low marsh area (almost 2:1) in the county suggests that much of the marsh has been present for many years before the county was settled and developed.

This study, as has been stated, does not include the five large estuarine marshes in the county. Their combined acreage, if included in the tidal marshland of Jefferson County would more than double that acreage.

Table 2 shows the breakdown of marsh types and areas for the 20 marshes studied.

Following the table are individual data sheets and vegetation maps which show the major natural features and human influences for each marsh. Also included on the data sheets is a short discussion of nearby marine

resources, information for which was obtained from field observations, government agencies, discussion with local residents, and the Washington Marine Atlas (Department of Natural Resources, 1974). The discussion of nearby marine resources is not intended to imply that they are all directly or completely dependent on the tidal marshes; however, the physical and biological relationships that integrate the marshes with the marine environment should be kept in mind as the reader considers the presence of marine resources.

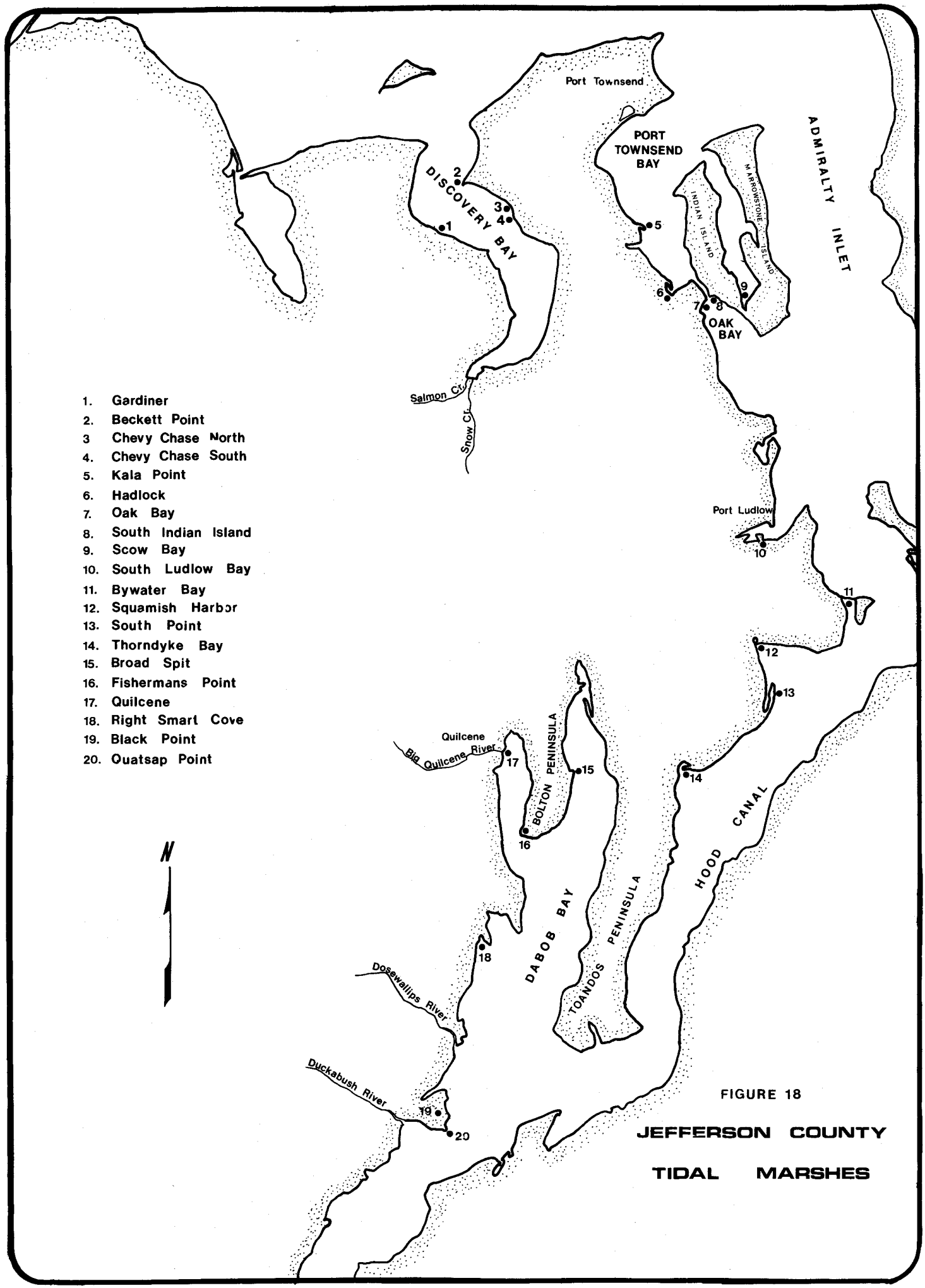


FIGURE 18

JEFFERSON COUNTY

TIDAL MARSHES

TABLE 2

JEFFERSON COUNTY TIDAL MARSH ACREAGE

NAME	Low Silty Marsh	Low Sandy Marsh	Immature High Marsh	Mature High Marsh	Brackish Water	TOTALS
Gardiner	4.2				1.5	5.7 acres
Chevy Chase South	.02		2.6	0.1		2.7 acres
Chevy Chase North	1.5					1.5 acres
Beckett's Point		6.6*				6.6 acres
Kala Point	1.1	7.2	0.2			8.5 acres
Hadlock		0.5	0.8			1.3 acres
Oak Bay		10.3				10.3 acres
South Indian Island		1.7	9.4			11.1 acres
Scow Bay	6.8		1.0			7.8 acres
South Ludlow Bay			3.4		P	3.4 acres
Bywater Bay		0.9	4.4	0.7		6.0 acres
Squamish Harbor			1.9		0.4	2.3 acres
South Point	0.7	1.0		1.4	1.4	4.5 acres
Thorndyke Bay	0.4		14.3	18.1	P	32.8 acres
Broad Spit		2.1				2.1 acres
Fishermans' Point	0.9			1.0		1.9 acres
Quilcene	4.2	0.2	10.9	2.3	0.4	18.0 acres
Right Smart Cove			1.8	0.1		1.9 acres
Black Point			9.2		0.8	10.0 acres
Quatsop Point				7.3		7.3 acres
TOTALS	19.8	30.5	59.9	31.0	4.5	145.7 acres
%	13.6	20.9	41.1	21.3	3.0	

P = Present but not measured

*NOTE: Isolation from tidal influence has made vegetation type at Beckett's Point difficult to classify, although plant community is similar to that found in Low Sandy Marsh.

Lat. 48° 3' 15" N.
Long. 122° 54' 15" W.

GARDINER MARSH

OWNERSHIP: Charles W. Gunstone Jr., S. C. Brown, Lucille M. Brown

PHYSICAL CHARACTERISTICS

The marsh is located on the west side of Discovery Bay around the edge of a lagoon protected by a barrier beach or berm. An opening in the berm allows the lagoon and the marsh to be integrated with seawater from Discovery Bay. Freshwater flow from uplands, if any, is minimal and may not be sufficient to maintain an opening in the berm if storms add sediment to the berm. A county road running perpendicular to the shoreline cuts through the marsh, with a culvert allowing water to pass through.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	4.2 acres
Brackish Water Marsh	1.5 acres
Total Marsh Area	5.7 acres

UPLAND USE: Residential, Open Space

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Littleneck clams are farmed commercially nearby in Discovery Bay. Oysters also occur intertidally and geoducks are found subtidally. This area of Discovery Bay is also the site of concentrated sport salmon fishing, and searun cutthroat trout fishing, as well as commercial gillnetting and otter trawling.

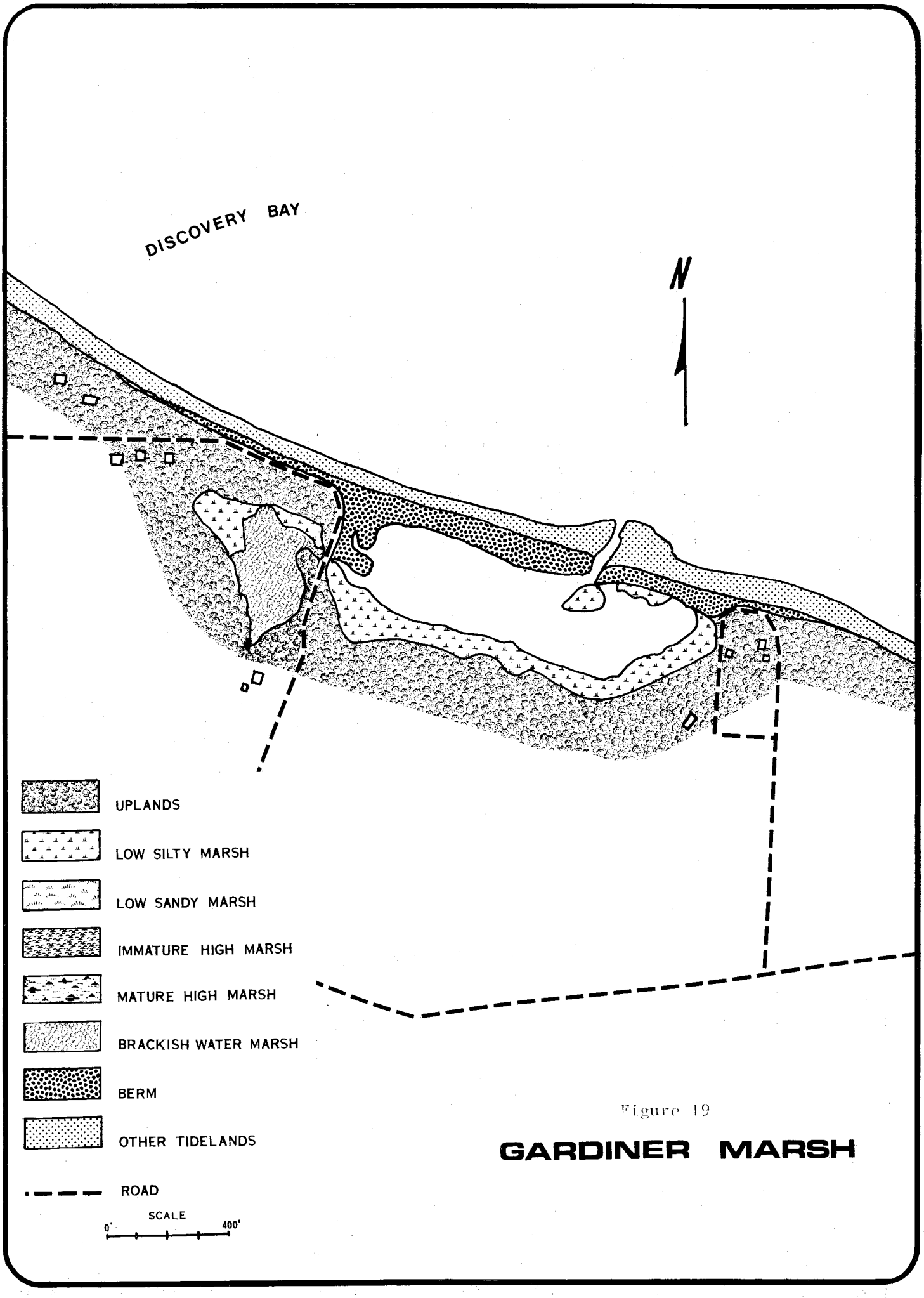


Figure 19

GARDINER MARSH

Lat. 47° 4' 45" N.
Long. 122° 53' 15" W.

CHEVY CHASE SOUTH MARSH

OWNERSHIP: Phillip Bailey, Al Raggon, James C. Young

PHYSICAL CHARACTERISTICS

This marsh is located behind a point at the base of a steep high bank on the east shore of Discovery Bay. The point is not completely closed but tidal contact with the bay is limited to flow through a small channel. Drift logs have collected inside the lagoon but marsh vegetation is growing among them.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	0.02 acres
Immature High Marsh	2.6 acres
Mature High Marsh	0.1 acres
Total Marsh Area	2.7 acres

UPLAND USE: Residential, Open Space

MARSH LAND USE: Open Space, Private Recreation

NEARBY MARINE RESOURCES

Hardshell clams occur intertidally just outside the marsh, with littlenecks commercially farmed on the tidelands of much of Discovery Bay. Sport fishermen catch salmon and searun cutthroat offshore, while commercial fishermen utilize the area for gillnetting and otter trawling. The bay nearby is also a herring spawning area.

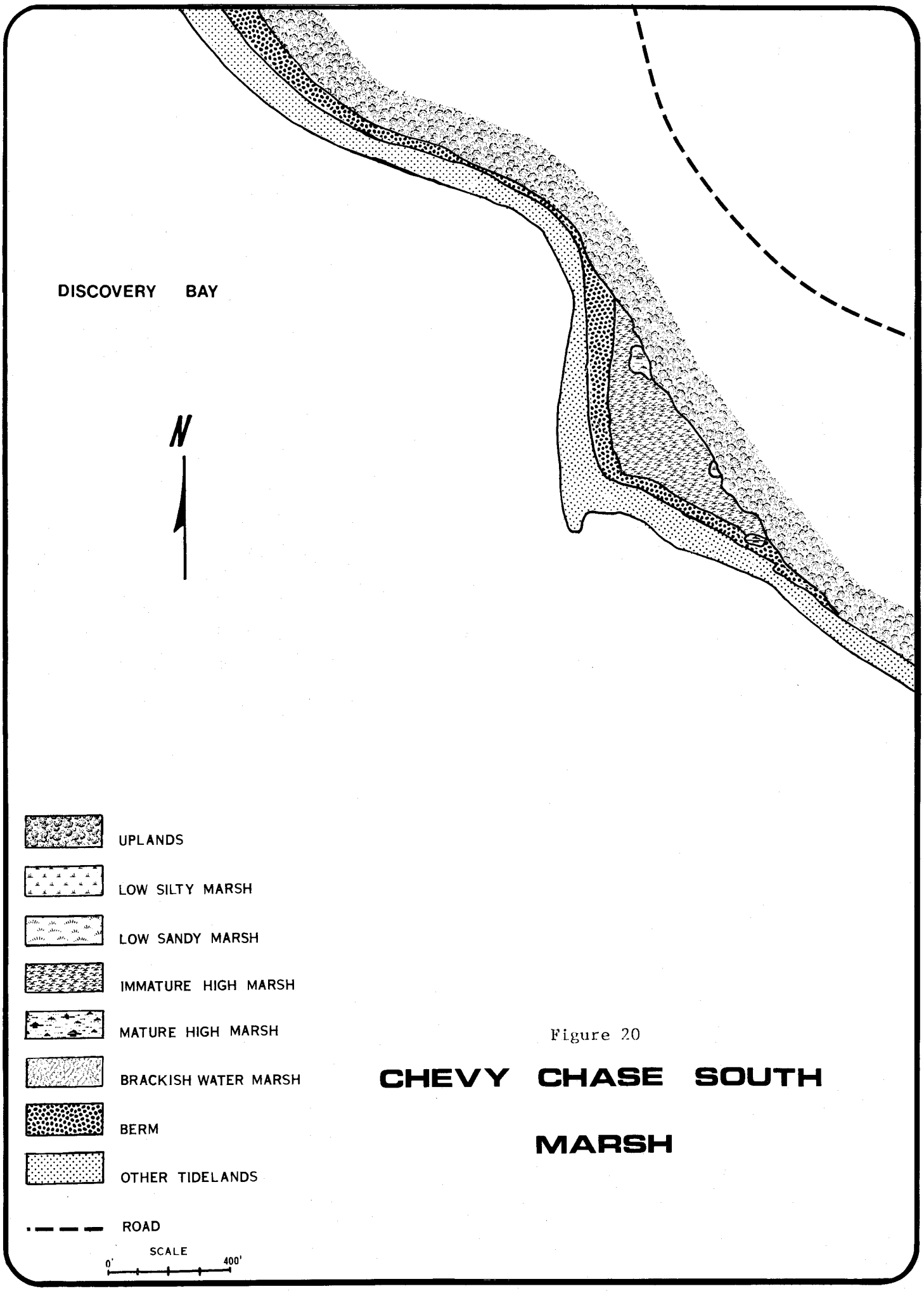


Figure 20

CHEVY CHASE SOUTH MARSH

Lat. 48° 4' 0" N.
Long. 122° 51' 30" W.

CHEVY CHASE NORTH MARSH

OWNERSHIP: Charles W. Gunstone Jr.

PHYSICAL CHARACTERISTICS

Located in the east shore of Discovery Bay, this marsh is dominated by a long narrow lagoon formed by a closed point. The lagoon and marsh now have no direct connection with the bay. Low Silty Marsh borders the lagoon on the north, west and south sides, with a steep high bank on the east side.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	1.5 acres

UPLAND USE: Open Space

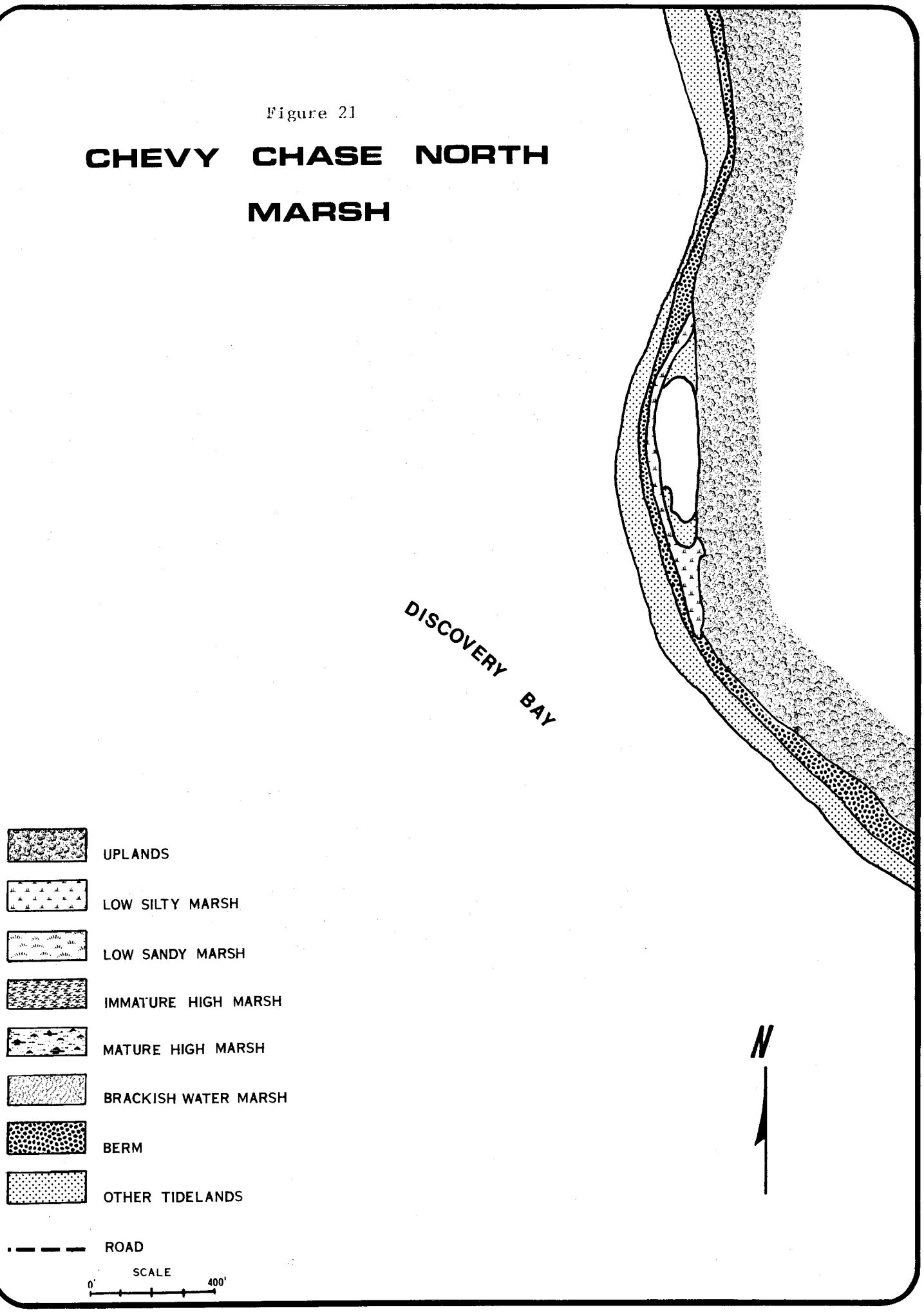
MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Commercial clam farming is conducted on the tidelands of Discovery Bay. Geoducks occur subtidally. Concentrated sport salmon fishing, sport sea run cutthroat fishing, and commercial purse seining occur immediately offshore.

Figure 21

CHEVY CHASE NORTH MARSH



Lat. 48° 3' 45" N
Long. 122° 51' 15" W

BECKETT'S POINT MARSH

OWNERSHIP: Discovery Investment Group

PHYSICAL CHARACTERISTICS

Beckett's Point, located on the northeastern part of Discovery Bay, was formerly an open point formation, with a lagoon in the interior. Residential development in the 1940's resulted in the closing off of the lagoon, which, although it supports tidal marsh vegetation, probably varies considerably in salt content throughout the year. Marsh vegetation is, therefore, isolated from the marine environment.

VEGETATIONAL MARSH TYPES

Isolation from marine influence has probably altered the characteristics of the original marsh vegetational type, making it difficult to classify. The plants present are similar to those in a Low Sandy Marsh, so they are mapped as Low Sandy Marsh; however plant communities distinguished are as follows:

Pickleweed *(Salicornia)*	5.5 acres
Saltgrass *(Distichlis)*	0.9 acres
Saltgrass/rush/alkali grass *(Distichlis/Juncus/Puccinellia)*	0.2 acres
Total Marsh Area	6.6 acres

UPLAND USE: Open Space

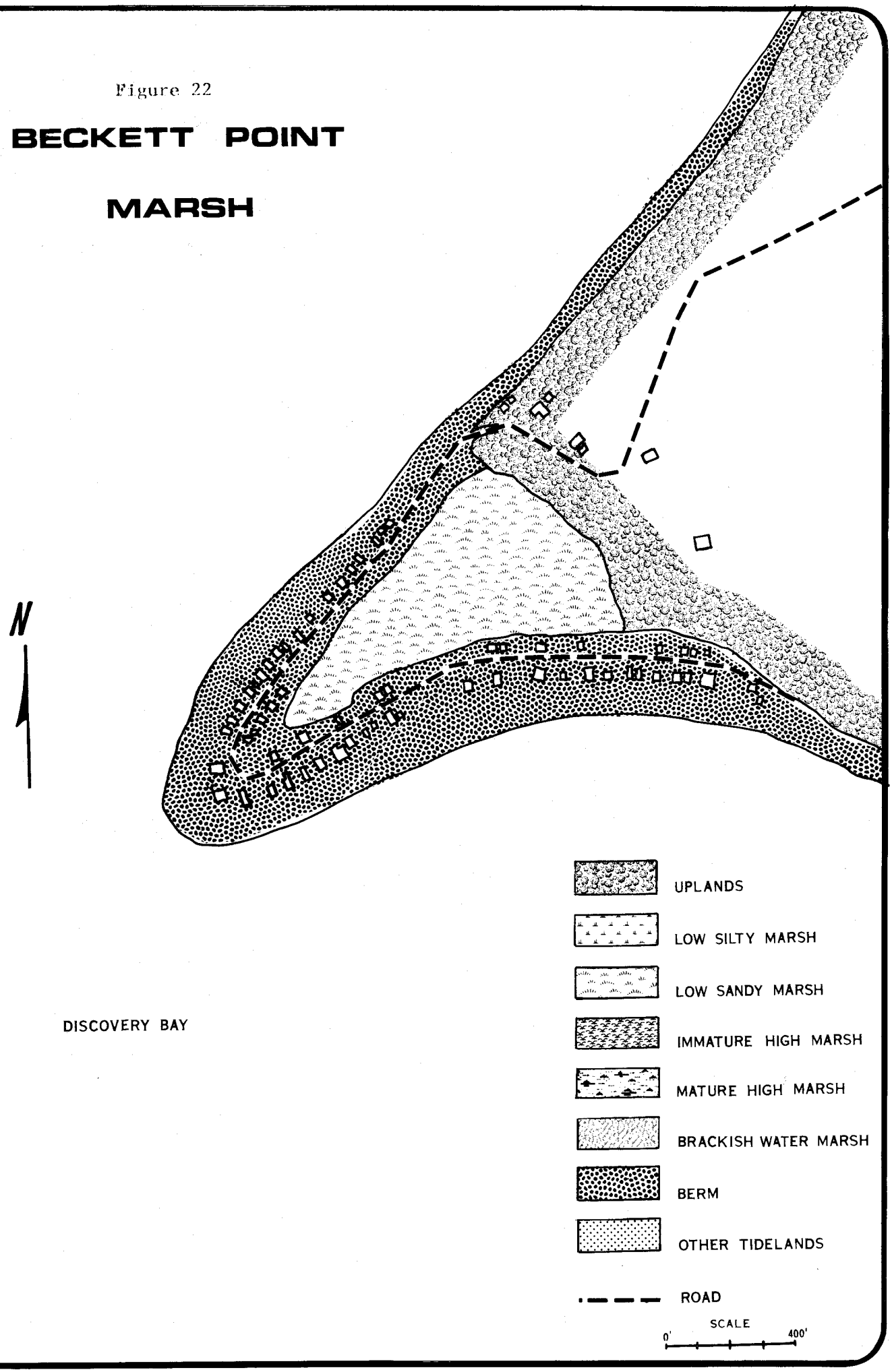
MARSH LAND USE: Recreational, with residential use on berm

NEARBY MARINE RESOURCES

Commercial clam farming is conducted on the tidelands of Discovery Bay. Geoducks also occur offshore. General sport salmon and searun cutthroat fishing occurs in the northern part of Discovery Bay as does commercial purse seining and otter trawling.

Figure 22

BECKETT POINT MARSH



Lat. 48° 3' 30" N.
Long. 122° 46' 0" W.

KALA POINT MARSH

OWNERSHIP: Jimmie Cotton, Cotton Corporation

PHYSICAL CHARACTERISTICS

Large areas of marsh have developed on the inside of this large open point (approximately 30 acres), at the base of a steep high bank, three and one-half miles south of the city of Port Townsend. The lagoon on the inside of the point empties into Port Townsend Bay on the outgoing tide through a channel large enough to form a delta as it flows over the beach. Sediment has built up high enough on the eastern tip of the point to allow for the growth of Douglas fir trees and other upland plants beyond the reach of the tides.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	1.1 acres
Low Sandy Marsh	7.2 acres
Immature High Marsh	0.2 acres
Total Marsh Area	8.5 acres

Approximately 5.5 acres of berm vegetation has developed on sand on the eastern portion of the point, which has only minor tidal influence. Also notable in this marsh is a patch of cordgrass *(Spartina foliosa)* [a species probably imported from California and seldom found in this area] which now covers some 2500-square feet (0.06 acres).

UPLAND USE: Open Space (Condominium development planned by owner)

MARSH LAND USE: Open Space, Recreational

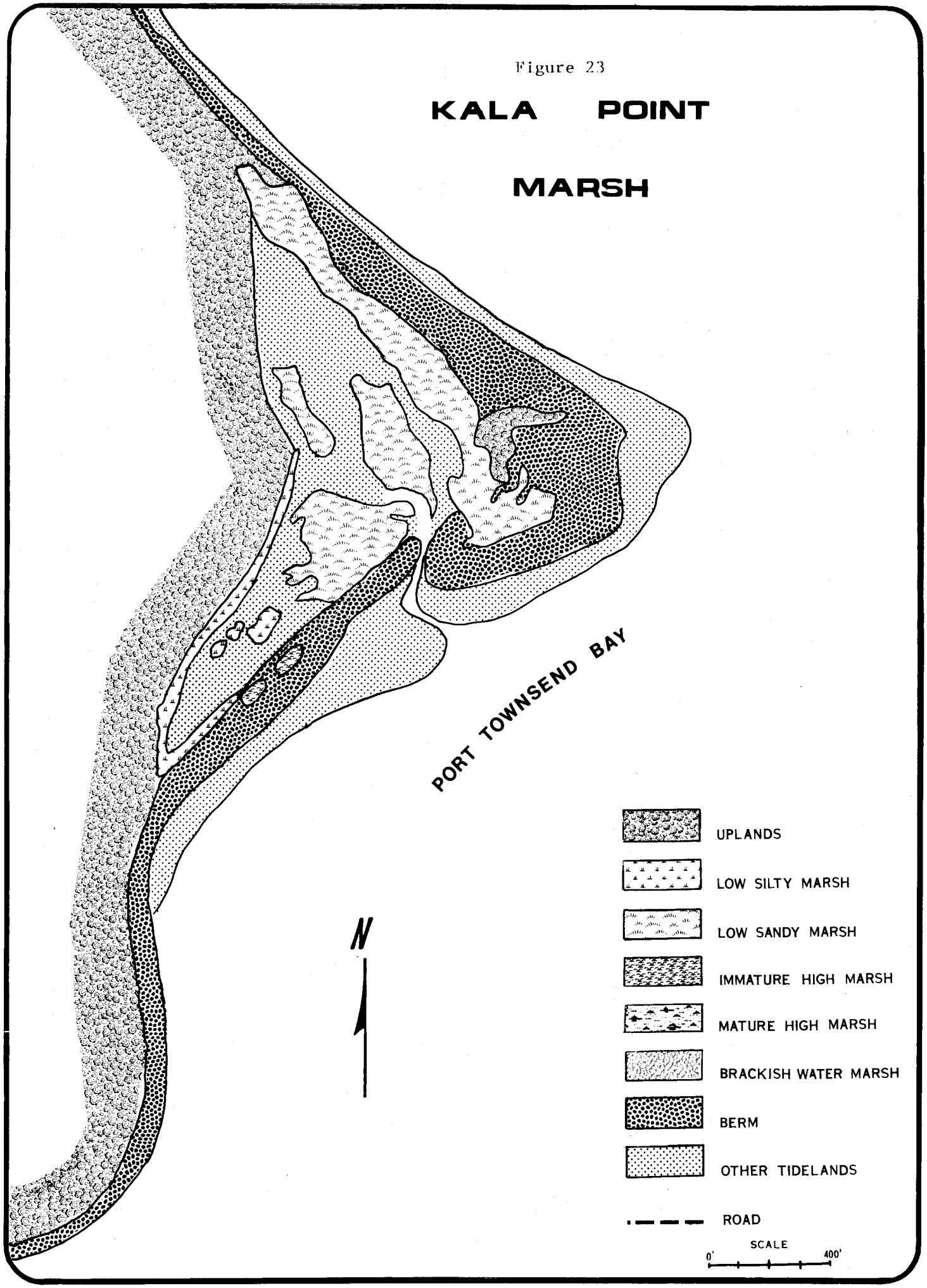
NEARBY MARINE RESOURCES

Intertidal littleneck and butter clams are harvested by recreational clamdiggers on the beach outside the point and geoducks occur subtidally offshore. Commercial fishermen use the area offshore for purse-seining and otter trawling, while sport fishermen catch searun cutthroat offshore. The eelgrass on the beach on Kala Point is used by herring for a spawning ground.

NOTE: Kala Point was used by Indians as a kitchen midden. Archeological evidence has been sampled in the past and signs of the kitchen midden are still visible.

Figure 23

KALA POINT MARSH



Lat. 47° 38' 45" N.
Long. 122° 54' 15" W.

HADLOCK MARSH

OWNERSHIP: Marie Gunstone Broders

PHYSICAL CHARACTERISTICS

The marsh is on the inner side of a 2300-foot sandspit at the extreme southern end of Port Townsend Bay. Sediment at the inner end of the embayment formed by this spit contains a large amount of wood chips and is probably low in oxygen from the decaying of these chips. Islands of sand or mud near the tip of the spit appear to be shifting but water exchange with Port Townsend Bay is not now impaired.

VEGETATIONAL MARSH TYPES

Low Sandy Marsh	0.5 acres
Immature High Marsh	0.8 acres
Total Marsh Area	1.3 acres

UPLAND USE: Residential

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Oysters and hardshell clams occur on the tidelands nearby in Port Townsend Bay. Herring spawn in the bay which is also used as a major waterfowl area. Otter trawl fishing for bottomfish is carried out in the bay

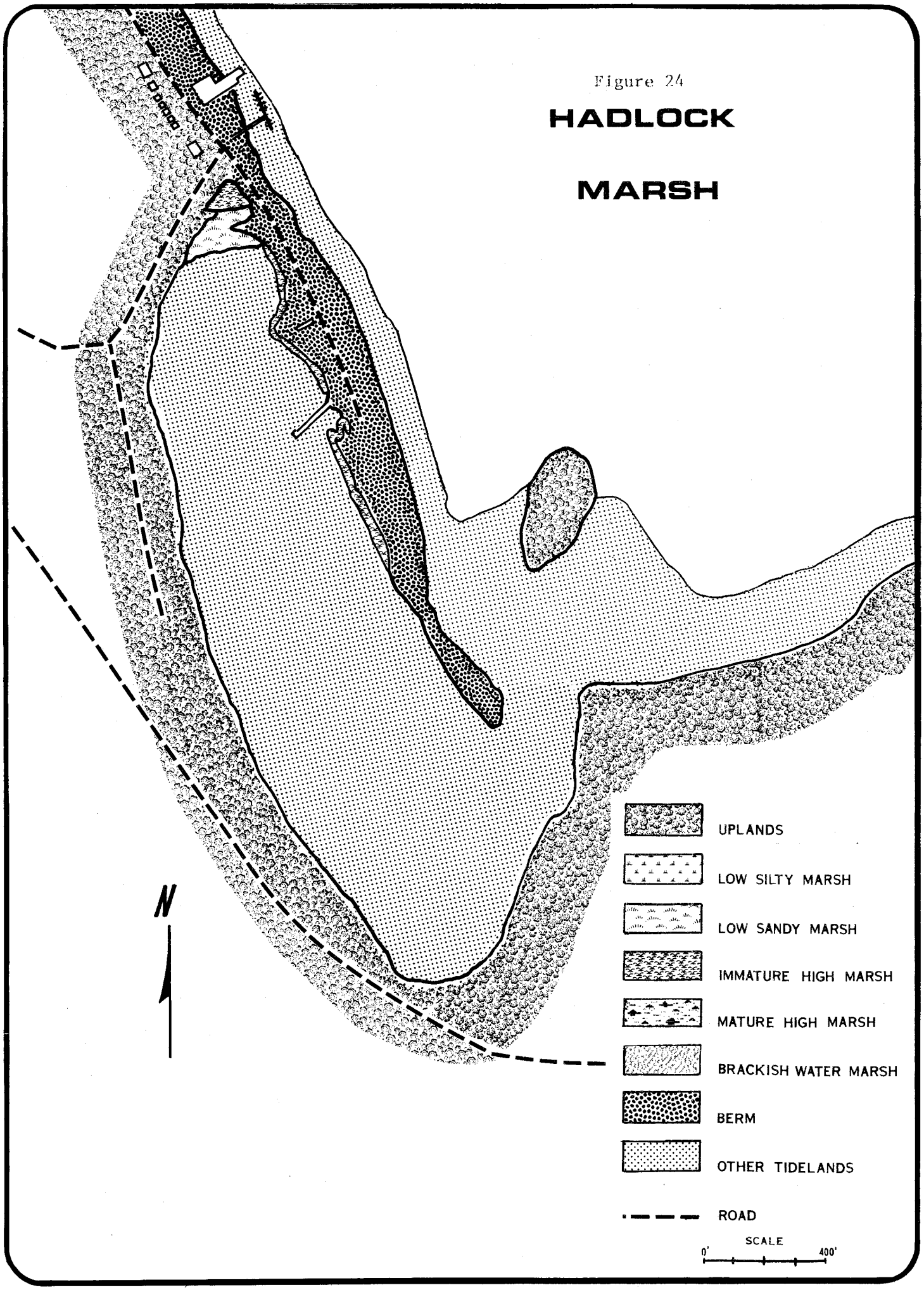


Figure 24
HADLOCK
MARSH
N
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
SCALE
0'
400'

Lat. 48° 1' 0" N.
Long. 122° 43' 30" W.

OAK BAY MARSH

OWNERSHIP: Jefferson County

PHYSICAL CHARACTERISTICS

Low sandy marsh borders the eastern side of a large lagoon. Channel dredging and jetty construction by the U. S. Army Corps of Engineers in 1916 removed the intertidal mudflat which formerly connected Indian Island with the mainland, and probably influenced the formation of the marsh. The lagoon inside the marsh remains open to tidal action through the channel, keeping the marsh integrated with the marine environment.

VEGETATIONAL MARSH TYPES

Low Sandy Marsh	10.3 acres

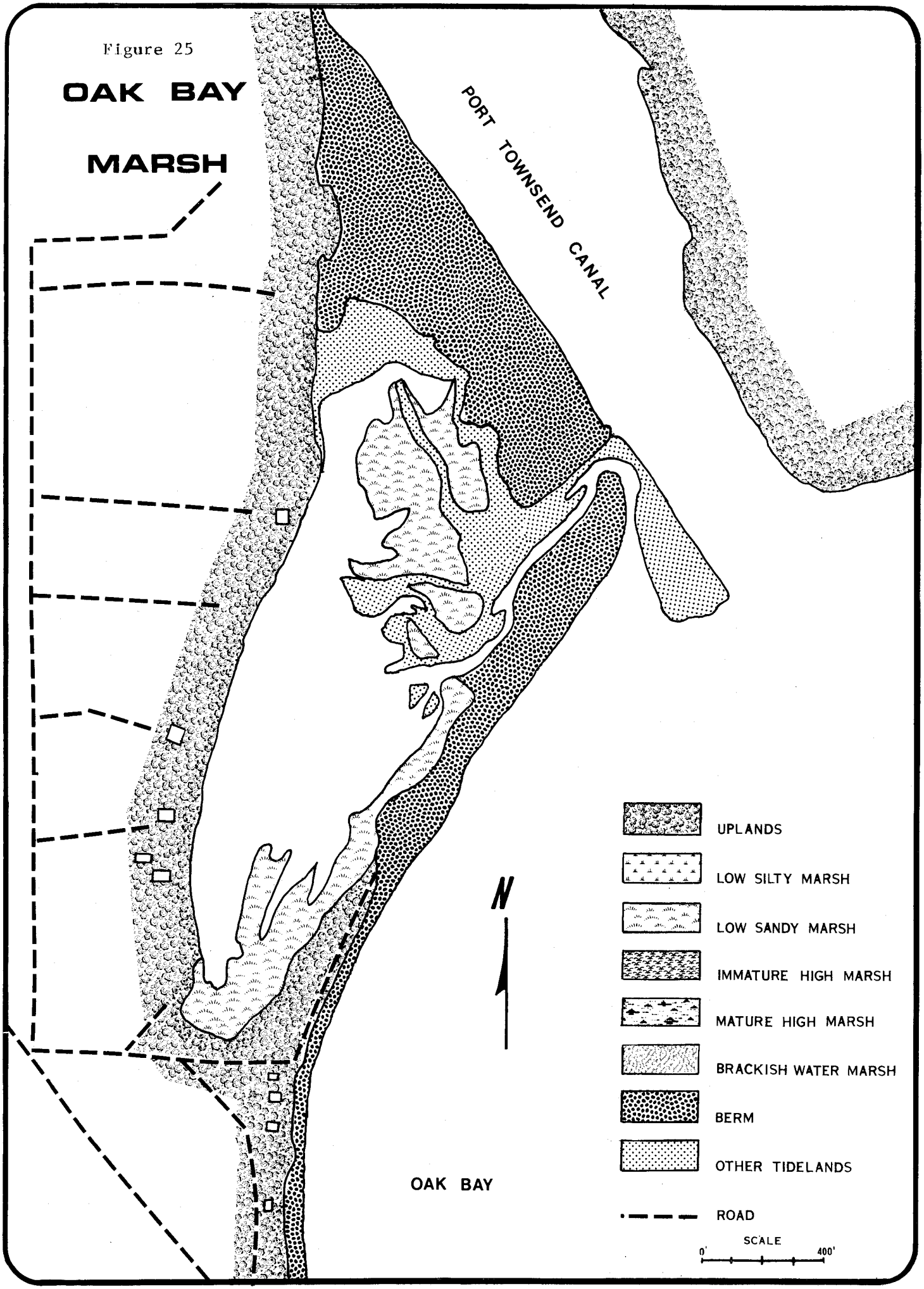
UPLAND USE: Residential

MARSH LAND USE: Recreational, Open Space

NEARBY MARINE RESOURCES

Mixed hardshell clams and geoducks occur in Oak Bay outside the marsh. Concentrated sport salmon fishing, commercial gillnetting and otter trawling also occur in Oak Bay. Herring spawn in Port Townsend Canal to the north. The lagoon is heavily used by migrating brant in the spring, as well as by other waterfowl.

Figure 25


OAK BAY
MARSH
PORT TOWNSEND CANAL
OAK BAY
N
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
SCALE
0'
400'

Lat. 48° 1' 15" N.
Long. 122° 43' 0" W.

SOUTH INDIAN ISLAND MARSH

OWNERSHIP: United States (Upland leased to County for park purposes)

PHYSICAL CHARACTERISTICS

This is a large marsh in two main sections running along three-quarters of a mile of shoreline. The western section is an open point, with both low and high marshes growing around a relatively deep lagoon, approximately five feet deep. A channel connects the lagoon to the Port Townsend Canal so tidal flushing is probably excellent.

The eastern section is a bay protected by a barrier beach. The lagoon and tidal channels in this formation are also fairly deep relative to other Jefferson County marshes, and empty into Oak Bay. The tidelands outside the berm have been used for disposal of dredged materials by the U. S. Army Corps of Engineers (see below).

VEGETATIONAL MARSH TYPES

Low Sandy Marsh	1.7 acres
Immature High Marsh	9.4 acres
Total Marsh Area	11.1 acres

UPLAND USE: Open Space, Recreation

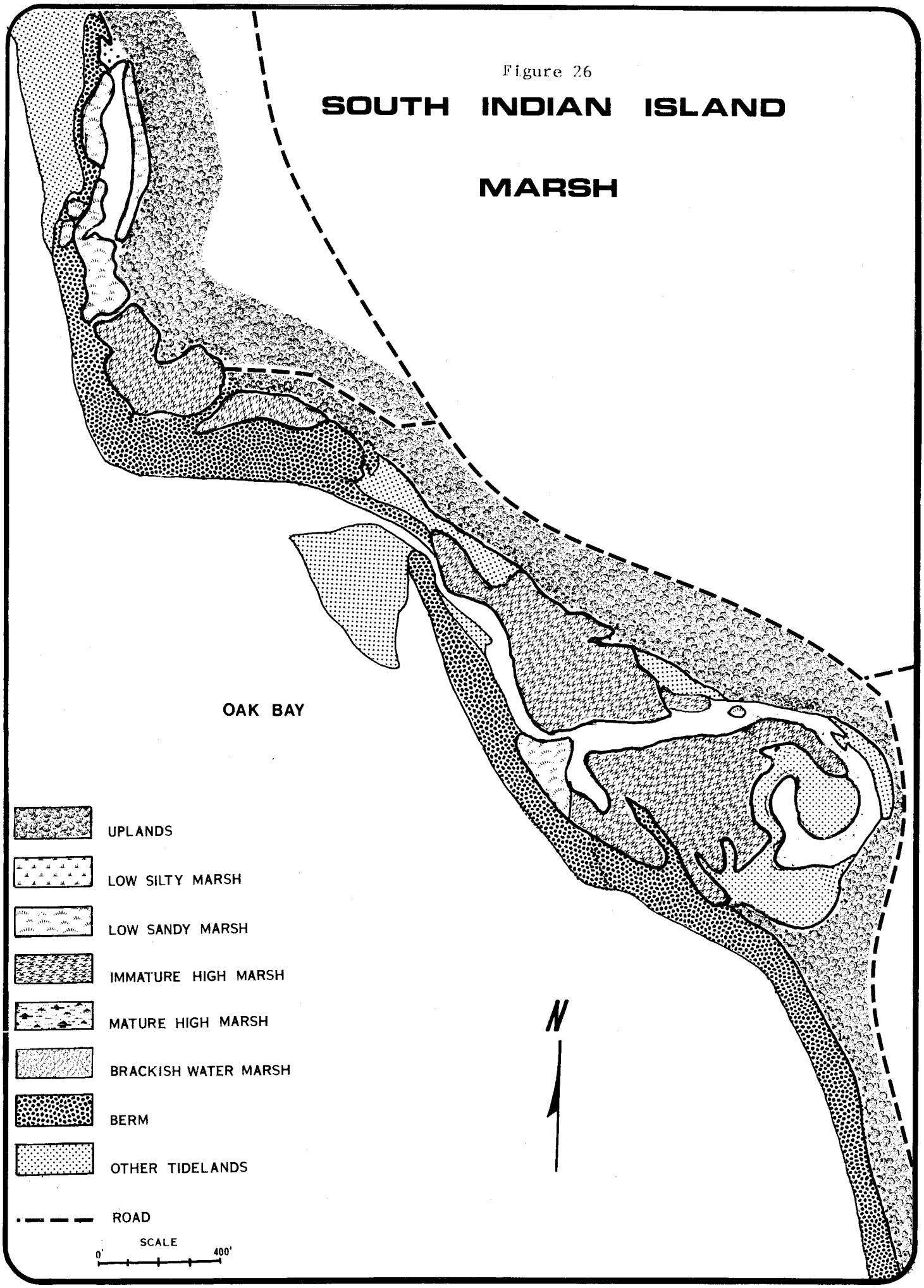
MARSH LAND USE: Open Space, Recreation

NEARBY MARINE RESOURCES

Subtidal geoducks, subtidal and intertidal butter and littleneck clam populations occur offshore. They have been supplemented by littlenecks seeded by the Washington Department of Fisheries into the new tidelands created by disposal of sand and gravel dredged from the Port Townsend Canal by the Corps of Engineers. Nearby Oak Bay is also used by sportsmen for concentrated salmon fishing, as well as by commercial fishermen for gillnetting and otter trawling. This is an area of major waterfowl use also.

Figure 26

SOUTH INDIAN ISLAND MARSH



Lat. 48° 1' 0" N.
Long. 122° 41' 45" W.

SCOW BAY MARSH

OWNERSHIP : United States

PHYSICAL CHARACTERISTICS

Kilisut Harbor, between Indian and Marrowstone Islands, was formerly an open channel through which small boats could navigate. The road between the islands now runs over two large culverts which are placed at a tide level so that the lagoon to the south of the road does not empty at low tide. While this poor flushing has resulted in sediment deposition and marsh expansion, it is not conducive to good water quality and shellfish kills in Scow Bay have been reported.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	6.8 acres
Immature High Marsh	1.0 acres
Total Marsh Area	7.8 acres

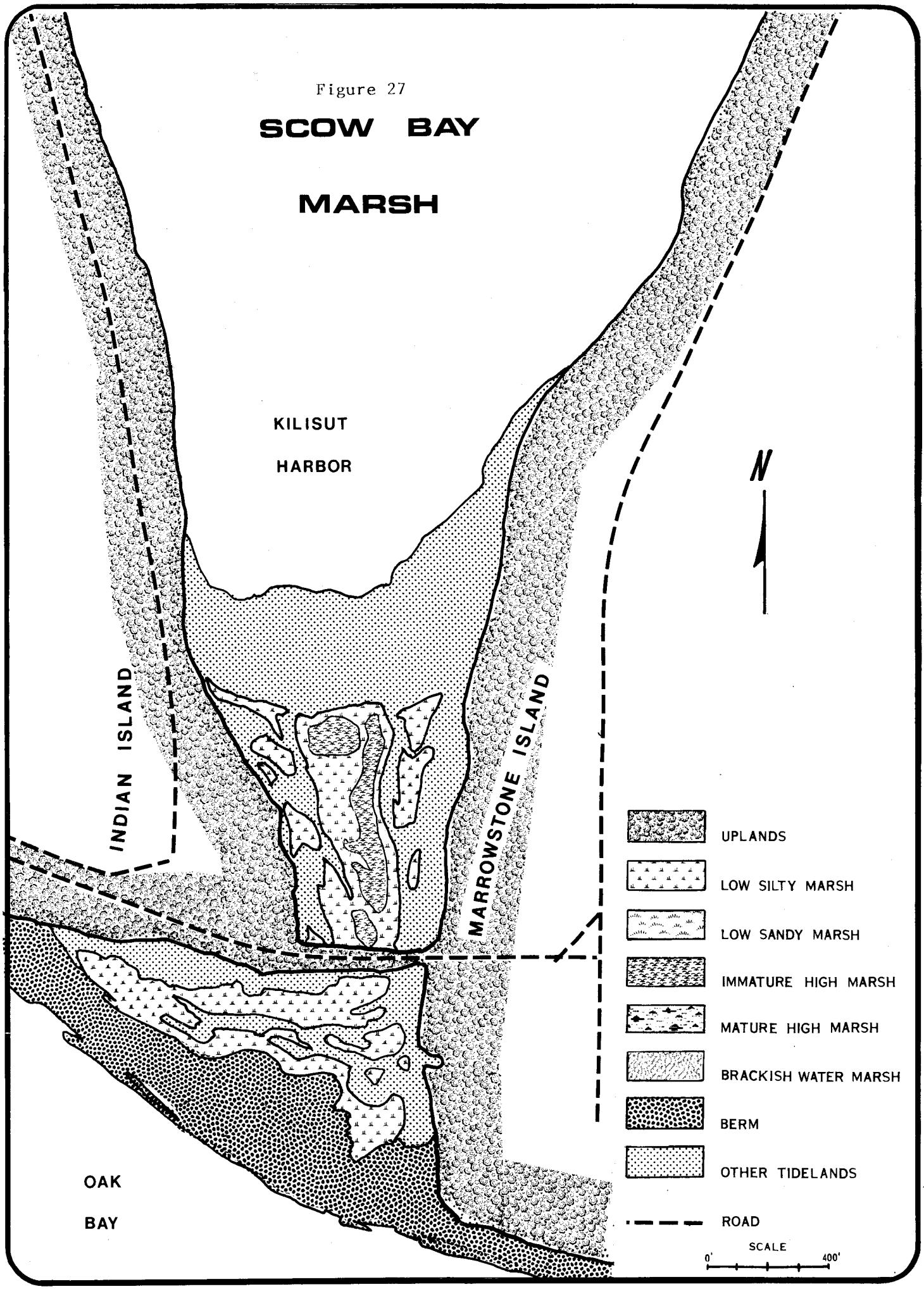
UPLAND USE: Residential, Recreational, Military Reservation (in open space)

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Intertidal butter clams, littleneck clams, and oysters occur in Kilisut Harbor. The harbor is also used for herring spawning and is a major waterfowl area. Commercial otter trawling for bottom fish occurs in Kilisut Harbor.

Figure 27


SCOW BAY
MARSH
KILISUT
HARBOR
INDIAN ISLAND
MARROWSTONE ISLAND
OAK
BAY
N
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
SCALE
0'
400'

Lat. 47° 55' 0" N.
Long. 122° 41' 15" W.

SOUTH LUDLOW BAY MARSH

OWNERSHIP: Pope & Talbot, Inc., Morrison, Holstrom, Rathbone, Timmerman, Dean, Nudley

PHYSICAL CHARACTERISTICS

The marsh is formed on sediment carried from uplands by stream as well as eroded by wave action from Tala Point. Residential development on the outer part of the marsh has involved construction of dikes which now separate most of the marsh from a freshwater stream and separate sections of the marsh from each other.

VEGETATIONAL MARSH TYPES

Immature High Marsh	3.4 acres

Brackish and freshwater vegetation is also present near a freshwater stream and near freshwater seepage.

UPLAND USE: Residential

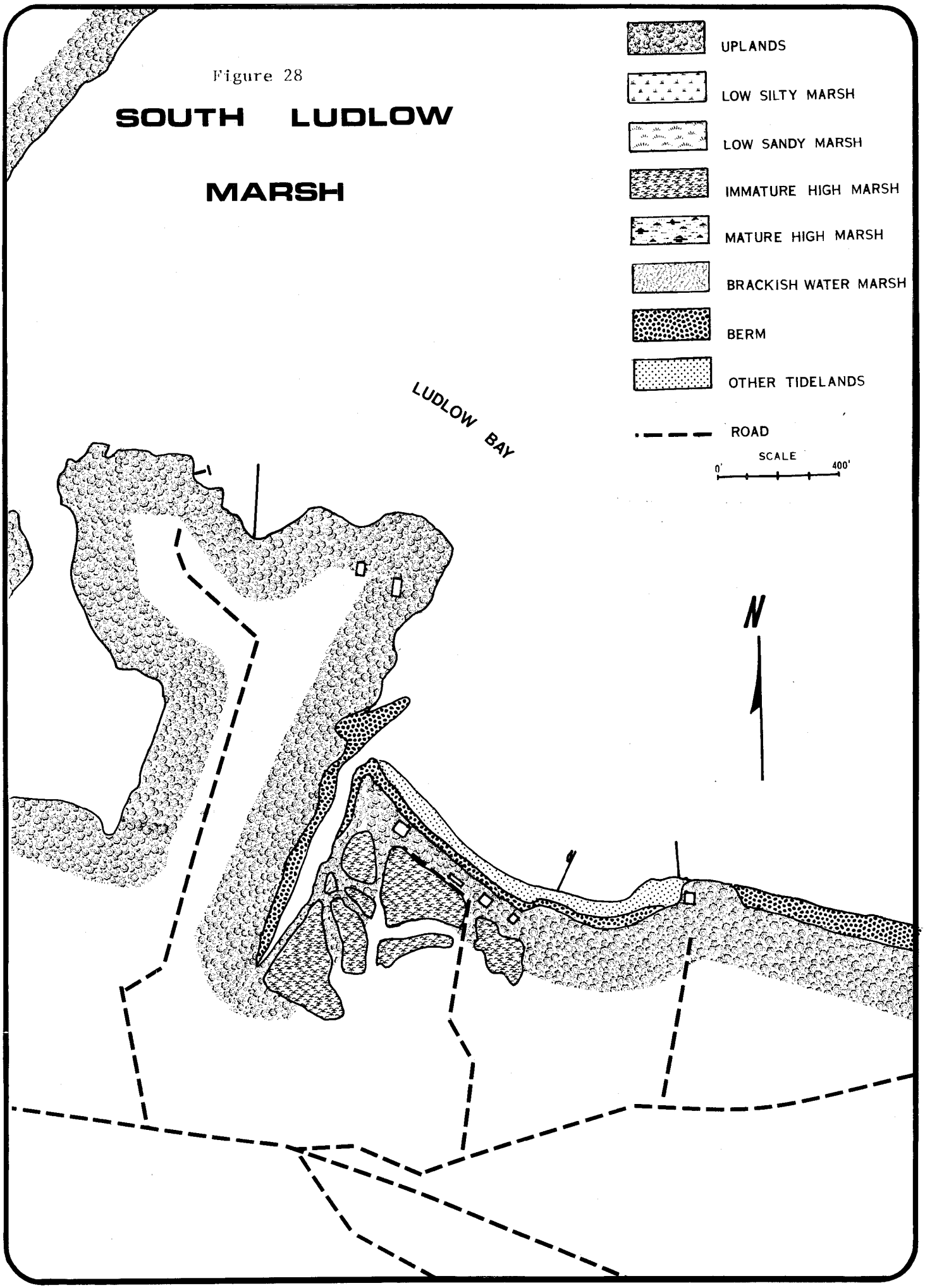
MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

The outer part of Port Ludlow Bay is used by commercial fishermen for gillnetting. The bay is also a major waterfowl area. Mixed hardshell clams and geoducks occur subtidally at the mouth of the bay.

Figure 28

SOUTH LUDLOW MARSH



Lat. 47° 53' 15" N.
Long. 122° 37' 45" W.

BYWATER BAY MARSH

OWNERSHIP: Washington State Parks & Recreation Commission

PHYSICAL CHARACTERISTICS

The east-west oriented tombolo, a causeway-like formation connecting Hood Island with the Olympic Peninsula, and a north-south oriented spit have allowed the deposition of sediment in a lagoon. Marsh has formed around the edge of the lagoon on all sides except the gravelly tombolo.

VEGETATIONAL MARSH TYPES

Low Sandy Marsh	0.9 acres
Immature High Marsh	4.4 acres
Mature High Marsh	0.7 acres
Total Marsh Area	6.0 acres

UPLAND USE: Open Space

MARSH LAND USE: Open Space, Recreation

NEARBY MARINE RESOURCES

Oysters are evident on the tidelands, and the recreational clam digging in Bywater Bay suggests a substantial hardshell clam population. Geoducks occur subtidally just outside the bay in Hood Canal. This area of the canal also supports general sport salmon fishing as well as commercial gillnetting and otter trawling. Herring spawn in Hood Canal just outside Bywater Bay.

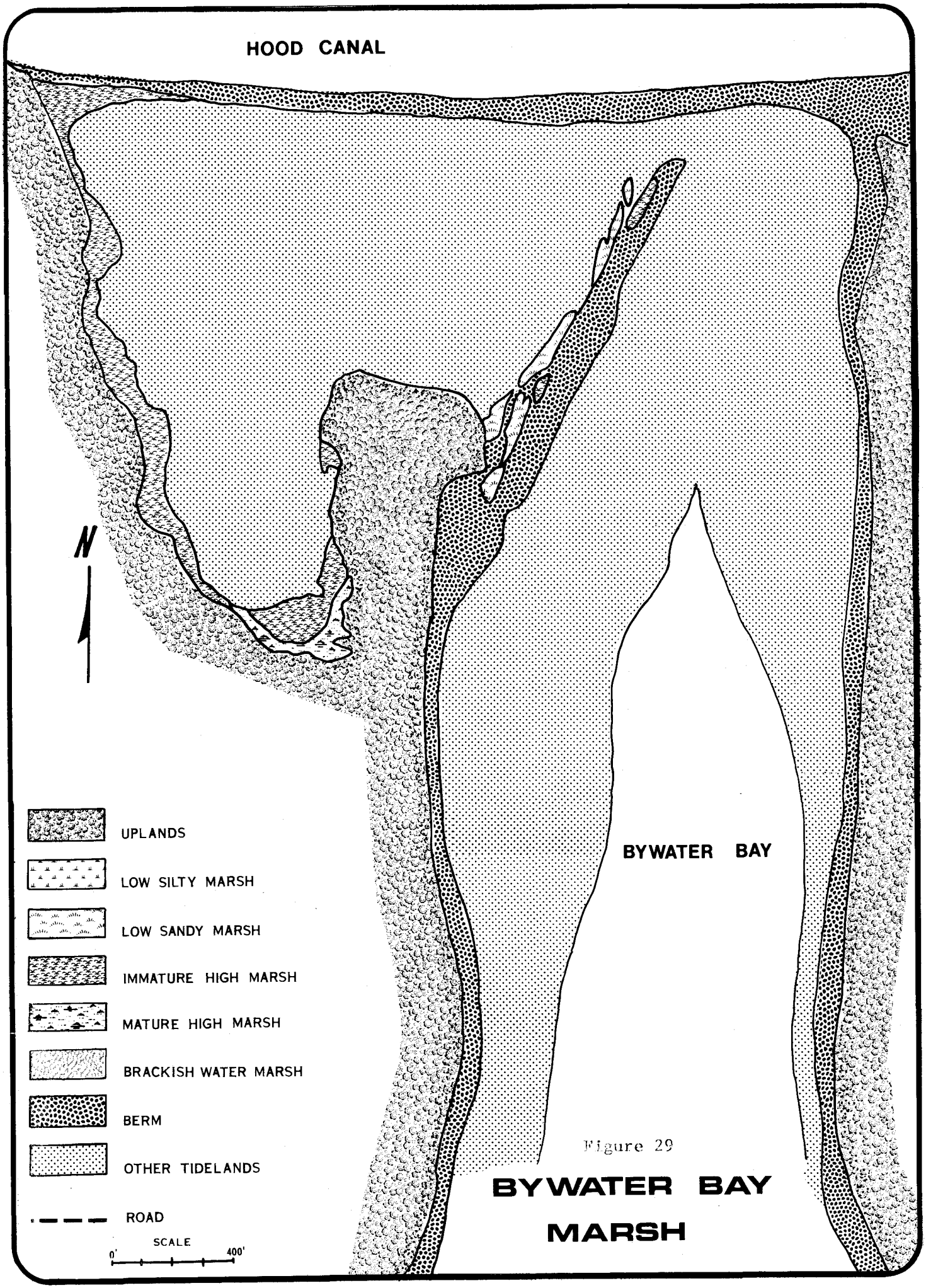


Figure 29

BYWATER BAY MARSH

Lat. 47° 52' 15" N.
Long. 122° 41' 15" W.

SQUAMISH HARBOR MARSH

OWNERSHIP: Pope & Talbot Development, Inc., William B. Criss

PHYSICAL CHARACTERISTICS

This marsh, located in a bay at the extreme northwest corner of Squamish Harbor in Hood Canal, has formed on sediment deposited by an incoming freshwater stream behind a barrier beach. Although the barrier beach extends across most of the mouth of the bay, an open channel to Squamish Harbor is maintained, probably by the continuous flow of freshwater. Water samples taken on the opposite side of the county road reveal a small amount of seawater coming through the culvert; however the influence of that seawater appears minimal in the freshwater marsh.

VEGETATIONAL MARSH TYPES

Immature High Marsh	1.9 acres
Brackish Water Marsh	0.4 acres
Total Marsh Area	2.3 acres

Approximately 1.5 acres of mudflat is presently in the early stages of colonization by arrowgrass, but growth is not yet thick enough to consider it a marsh.

An extensive freshwater marsh occurs on the opposite (west) side of the county road, and is an excellent example of the freshwater vegetation types.

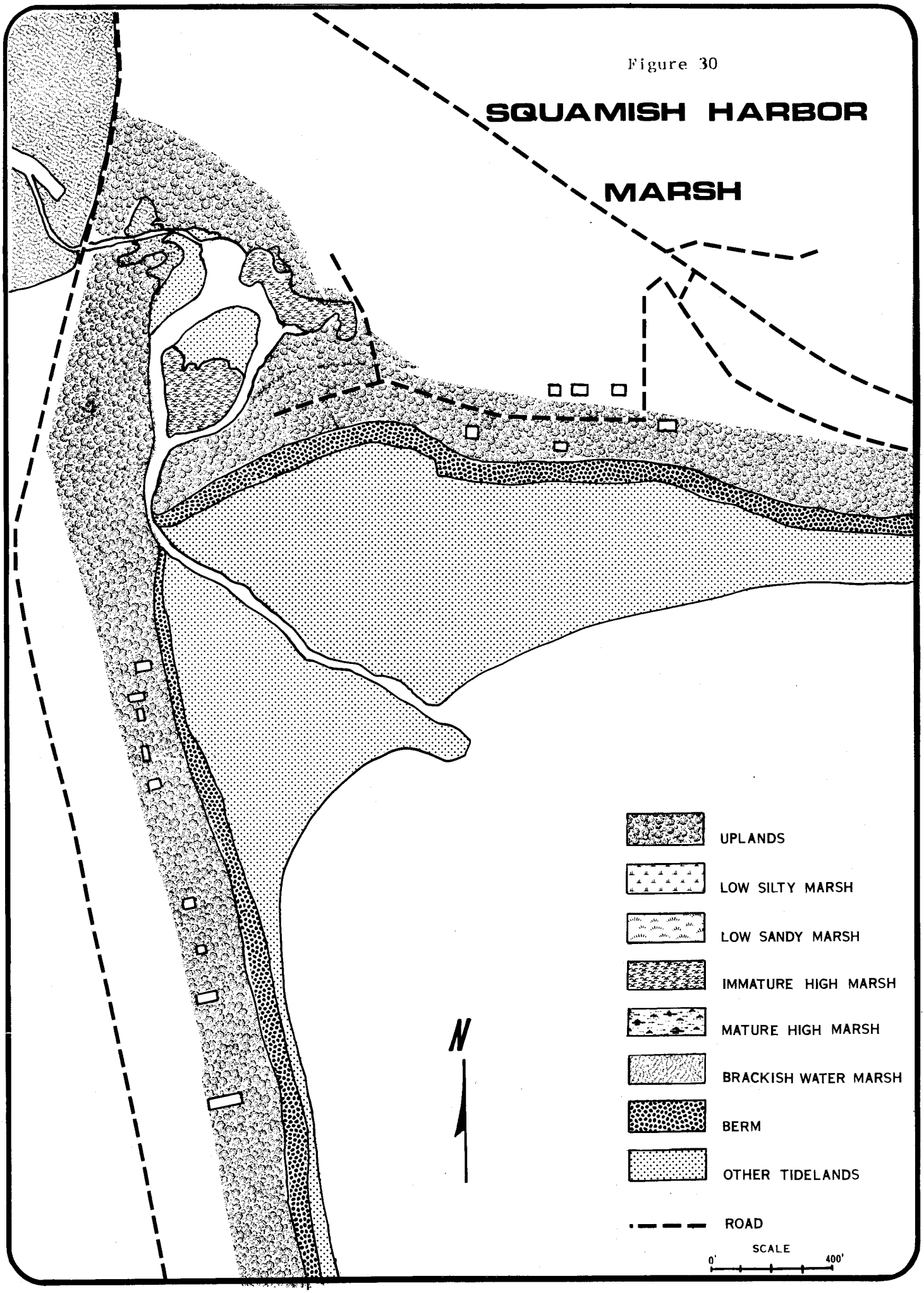
UPLAND USE: Residential, Open Space

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Butter clams and littleneck clams live in the tidelands in Squamish Harbor. These clams, as well as geoducks also live subtidally in the harbor. Both commercial and sport fishermen utilize Squamish Harbor, with commercial gillnetting, and herring fishing in the harbor and otter trawling just outside in Hood Canal. Sport fishing in the harbor includes concentrated salmon fishing and bottom fishing. Squamish Harbor is also a major waterfowl area.

Figure 30


SQUAMISH HARBOR
MARSH
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
N
SCALE
0'
400'

Lat. 47° 50' 15" N.
Long. 122° 41' 0" W.

SOUTH POINT MARSH

OWNERSHIP: See list below*

PHYSICAL CHARACTERISTICS

The marsh grows intermittently in a narrow band on the inland side of a half-mile long open sandspit to the north of the Bridgehaven development on Hood Canal. Eroded remains of marsh peat on tidelands suggest fairly recent shifting or eroding of this spit, possibly caused by interruption of sediment transport related to dredging and/or breakwater construction for Bridgehaven boat basin.

Marsh is also found to the south of Bridgehaven cut off from Hood Canal by roads, except for flow through a culvert.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	0.7 acres
Low Sandy Marsh	1.0 acres
Mature High Marsh	1.4 acres
Brackish Water Marsh	1.4 acres
Total Marsh Area	4.5 acres

UPLAND USE: Open Space, Residential

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Oysters are grown commercially on the tidelands inside the spit. Intertidal butter and littleneck clams, subtidal butter clams, and subtidal geoducks occur offshore. The offshore area is fished commercially for herring and otter trawled for bottomfish. Several hundred brant were observed at this site, although no confirmation of regular use is available.

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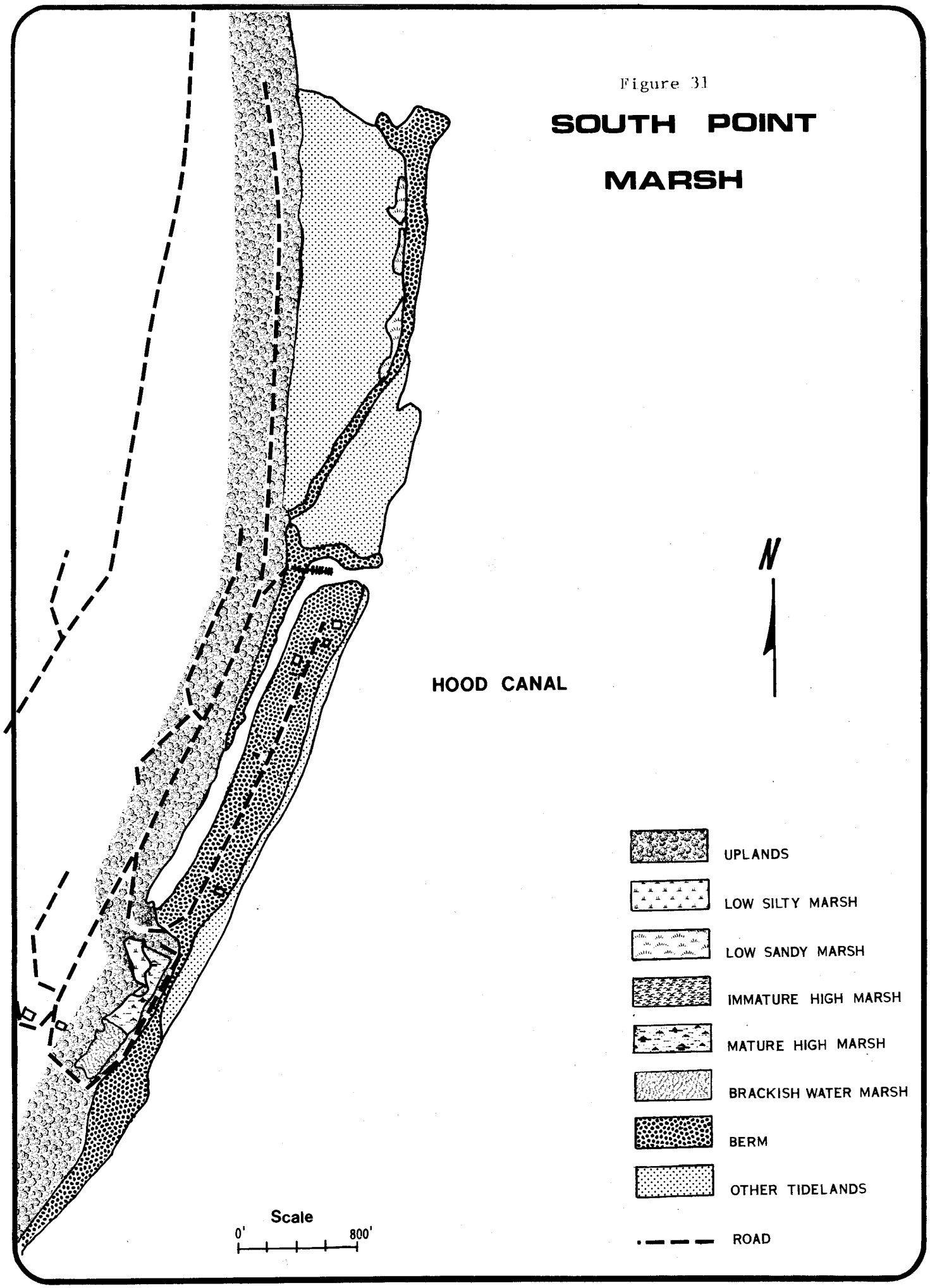
*J. E. Heiber, William L. Henson Co., Inc., Irvin A. Yashimira, Douglas M. Thurston, Puget Sound Exchange Corp., Margot Wyatt (et al.), William S. Howard, Robert Swaffield, James M. Niklos/F. A. Laura, Lloyd Blake/Glenn Beer, Metropolitan Federal Savings & Loan, F. Rober Lee, Robert L. Block, Ralph Enstrom.

Figure 31

SOUTH POINT MARSH



Lat. 47° 48' 45" N.
Long. 122° 44' 30" W.

THORNDYKE BAY MARSH

OWNERSHIP: Pope and Talbot, Inc.

PHYSICAL CHARACTERISTICS

On the northeastern part of the Toandos Peninsula on Hood Canal, this marsh has developed inside a bay with a barrier beach. Thorndyke Creek, running into the head of the bay provides sufficient flow to maintain an open channel through one end of the barrier beach into Hood Canal. Marsh is formed in bands around the edges of the bay and in several large patches.

VEGETATIONAL MARSH TYPES

Low Sandy and Silty Marshes	0.4 acres
Immature High Marsh	14.3 acres
Mature High Marsh	18.1 acres
Total Marsh Area	32.8 acres

Two large stands of cordgrass *(Spartina foliosa)*, a species not commonly found north of California grow on the tideflats in Thorndyke Bay.

Also present is a large amount of brackish and tidally-influenced freshwater vegetation near the head of the bay.

UPLAND USE: Open Space

MARSH LAND USE: Open Space, Recreation (in autumn)

NEARBY MARINE RESOURCES

Thorndyke Bay is a major waterfowl area as recognized by state agencies and as evidenced by the signs of hunting activity. Both migrating and resident waterfowl utilize the bay and the immediate offshore area. Oysters and hardshell clams are found on the tidelands just outside the barrier beach. The subtidal area offshore is leased for commercial harvesting of geoducks. Commercial fishermen use the area for gillnetting, otter trawling, and herring seining, and general sport salmon fishing also occurs in this area of Hood Canal.

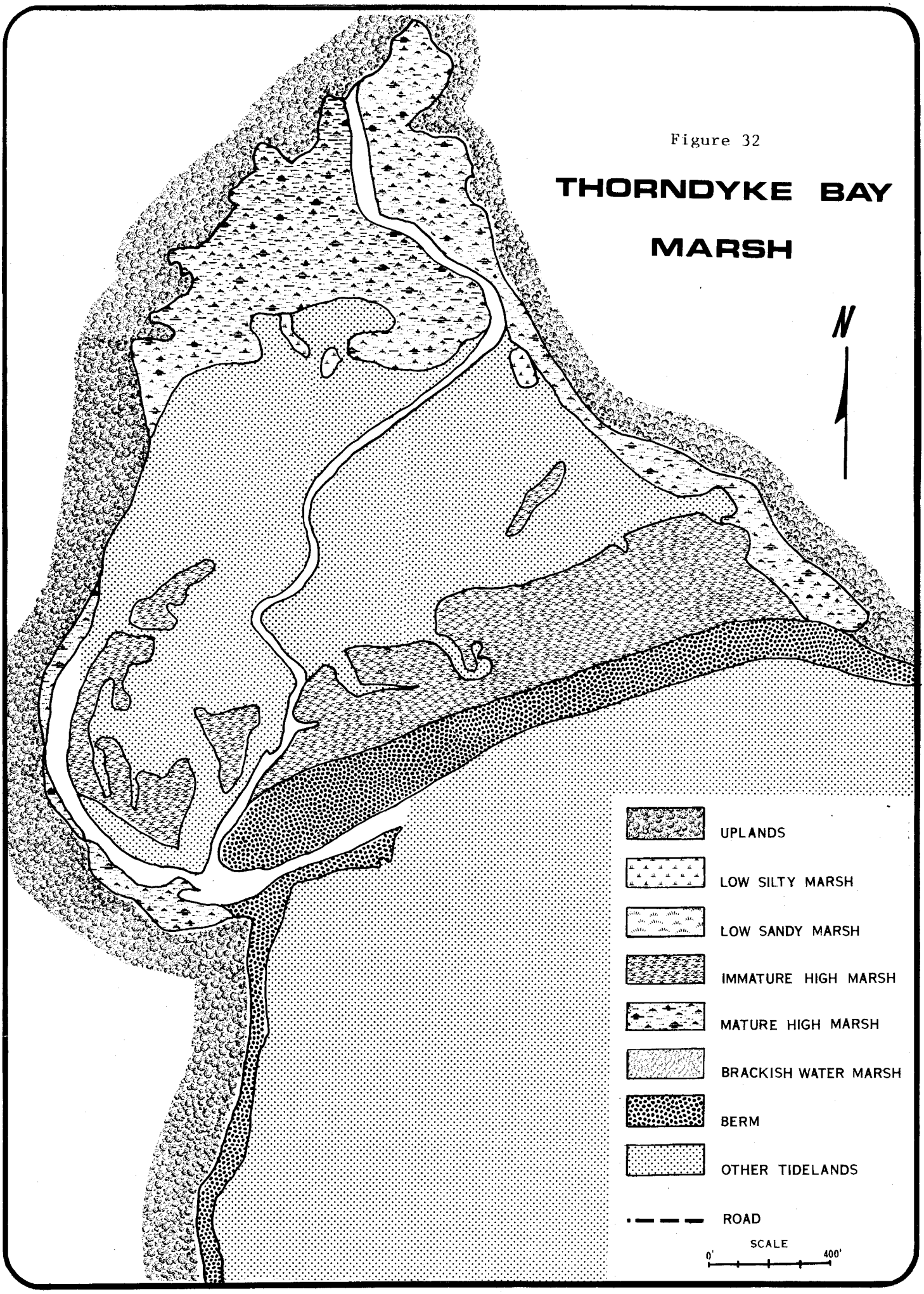


Figure 32
THORNDYKE BAY
MARSH
N
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
SCALE
0'
400'

Lat. 47° 48' 30" N.
Long. 122° 49' 15" W.

BROAD SPIT MARSH

OWNERSHIP: Jefferson County, Coast Oyster Co.

PHYSICAL CHARACTERISTICS

The marsh has developed on a hooked spit, composed of sand and gravel, at the base of a high bank on the west shore of Dabob Bay. A lagoon, open to tidal exchange with Dabob Bay, is inside the spit.

VEGETATIONAL MARSH TYPES

Low Sandy Marsh	2.1 acres

UPLAND USE: Open Space

MARSH LAND USE: Storage of Oyster Seed Rafts

NEARBY MARINE RESOURCES

Oysters are abundant on the tidelands on the spit as well as along the shore of most of Dabob Bay. This bay is one of the few successful spawning grounds for Pacific oysters on the west coast of the United States, and is heavily used by oyster farmers for catching seed. Geoducks, crabs and shrimp are found subtidally, and searun cutthroat trout are caught by sport fishermen in Dabob Bay.

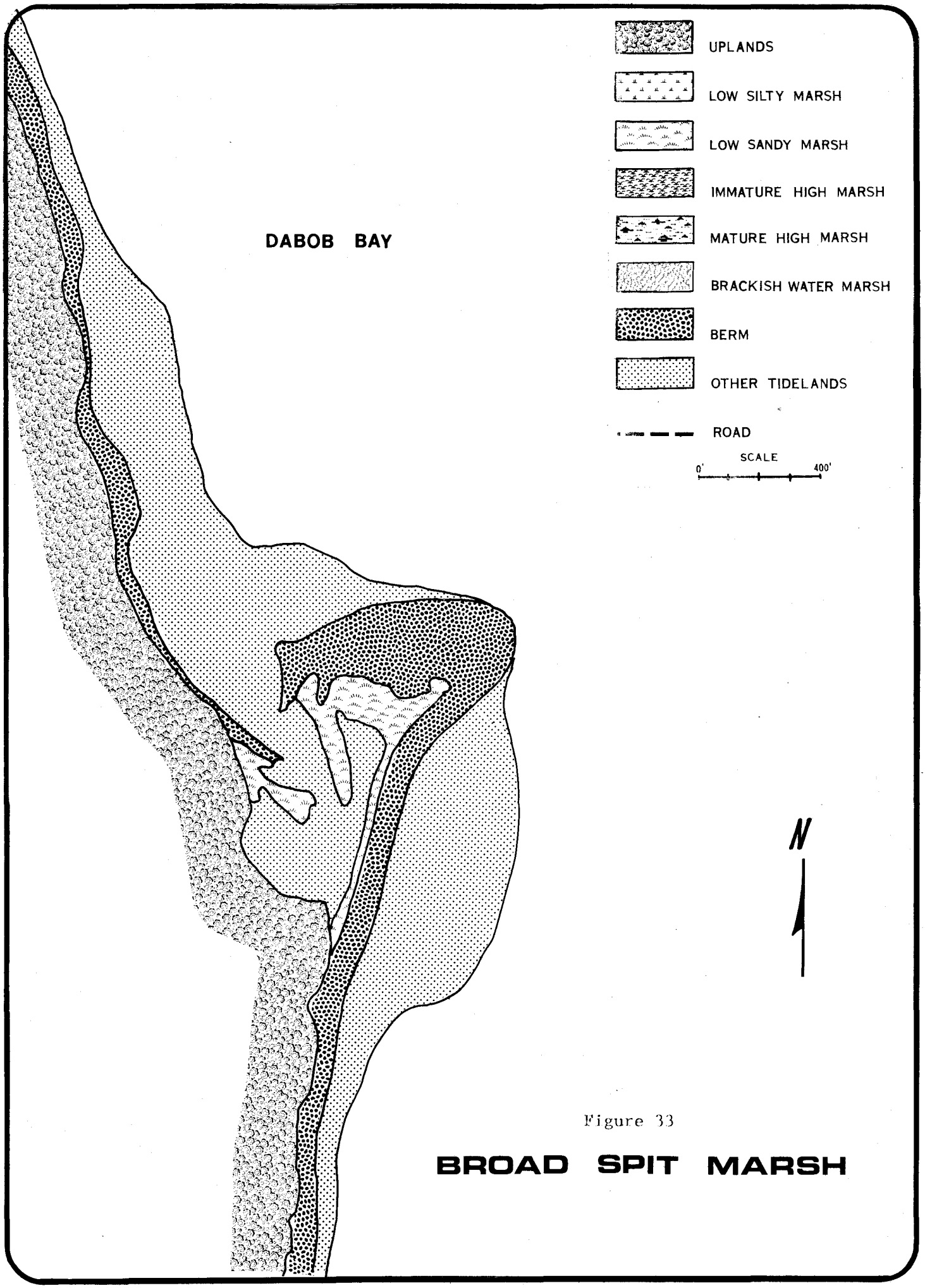


Figure 33

BROAD SPIT MARSH

Lat. 47° 47' 0" North
Long. 122° 51' 15" West

FISHERMANS' POINT MARSH

OWNERSHIP: R. W. Evans (trustee), Ellsworth C. Alvord Jr.

PHYSICAL CHARACTERISTICS

The marsh is located at the base of a steep high bank inside a hooked spit which extends into Quilcene Bay on the southwestern tip of the Bolton Peninsula. A lagoon and mudflat inside have free tidal exchange with open water, allowing marsh to be integrated with the marine environment.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	0.9 acres
Mature High Marsh	1.0 acres
Total Marsh Area	1.9 acres

UPLAND USE: Open Space

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Oysters are found on the tidelands, while the subtidal area offshore supports butter clams, geoducks, crabs and shrimp. The offshore area is also used for concentrated sport salmon fishing.

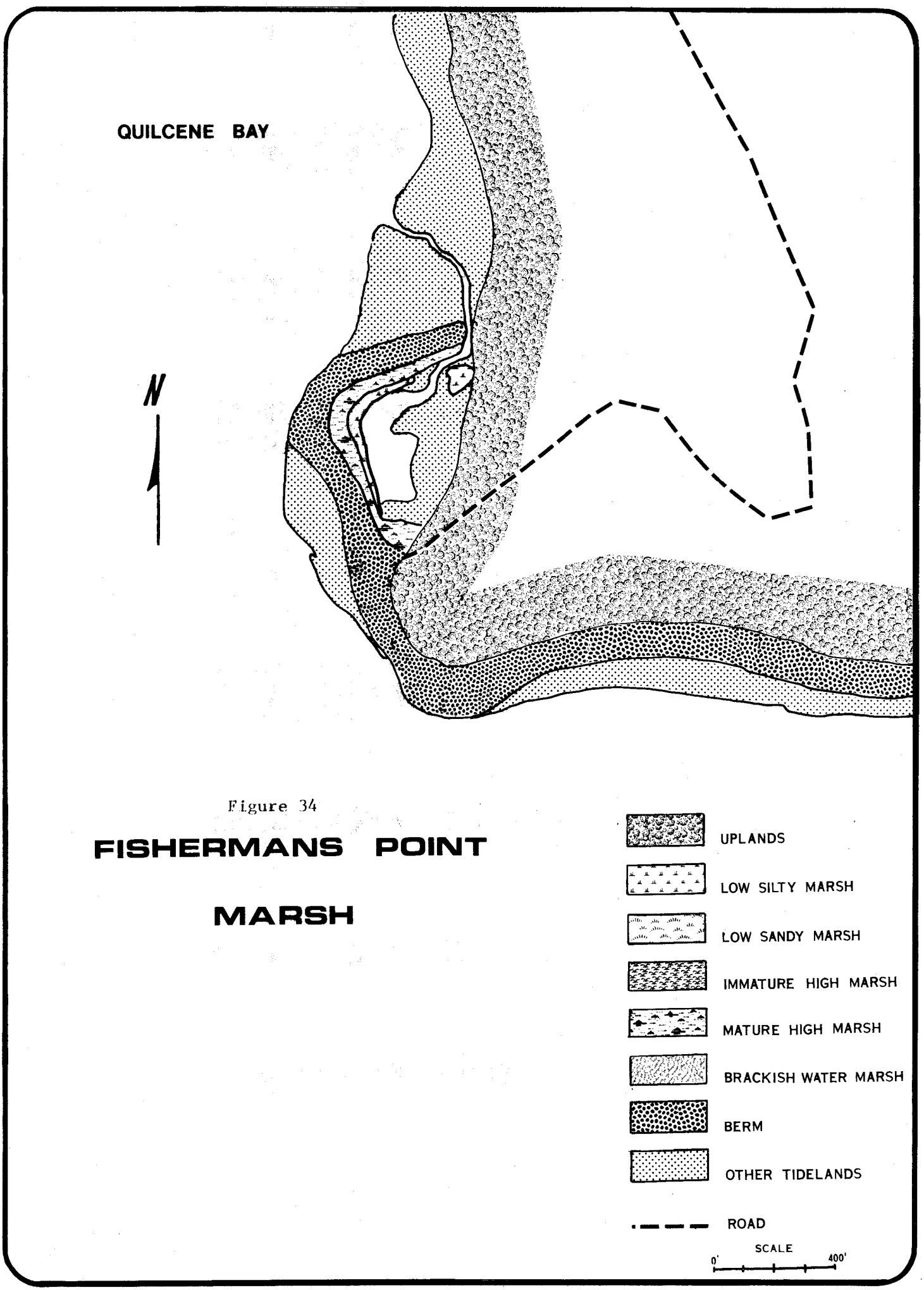


Figure 34

FISHERMANS POINT MARSH

Lat. 47° 49' 15" N.
Long. 122° 52' 0" W.

QUILCENE MARSH

OWNERSHIP: Kenneth Harris, Coast Oyster Co.

PHYSICAL CHARACTERISTICS

Located in Quilcene Bay immediately south of the Big Quilcene River, this marsh appears to have developed on sediment carried from the nearby banks by longshore drift and from the mountains by the river. The development of new low marshes indicates that the marshes are spreading out into the bay as the sediment builds up. Exchange through the tidal creeks to the marsh is complete and the creeks, as well as most of upper Quilcene Bay, are fully exposed at Mean Lower Low Water.

VEGETATIONAL MARSH TYPES

Low Silty Marsh	4.2 acres
Low Sandy Marsh	0.2 acres
Immature High Marsh	10.9 acres
Mature High Marsh	2.3 acres
Brackish Water Marsh	0.4 acres
Total Marsh Area	18.0 acres

Additional large areas of marshland, over 50 acres, are present in the bay north of the Big Quilcene River, but were not mapped for this study. A good deal of brackish and tidally influenced freshwater marsh also occurs to the north of East Quilcene Bay Road at the head of the bay.

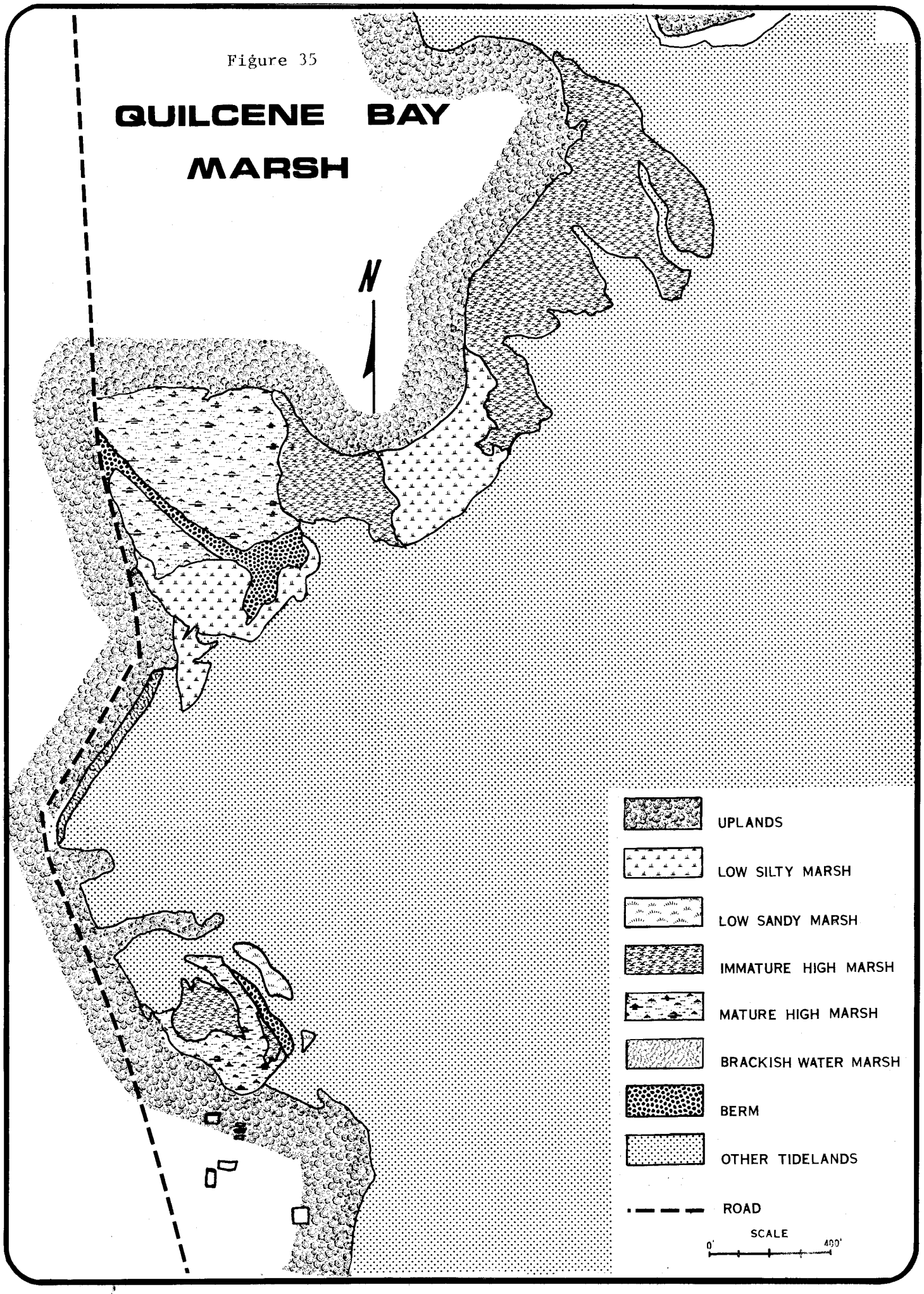
UPLAND USE: Residential

MARSH LAND USE: Open Space, Storage of Oyster Shell (A section of marsh has been proposed for fill for a campground.)

NEARBY MARINE RESOURCES

Oysters, a major commercial fishery in this area, are abundant just offshore of the marsh. Crabs are also found just offshore and shrimp are caught in deeper water nearby in the bay. General sport salmon fishing and searun cutthroat fishing also occur in Quilcene Bay. Herring spawn on the eelgrass to the south of this marsh. Quilcene Bay is a major waterfowl area.

Figure 35


QUILCENE BAY
MARSH
N
UPLANDS
LOW SILTY MARSH
LOW SANDY MARSH
IMMATURE HIGH MARSH
MATURE HIGH MARSH
BRACKISH WATER MARSH
BERM
OTHER TIDELANDS
ROAD
SCALE
0'
400'

Lat. 47° 39' 0" N.
Long. 122° 52' 45" W.

RIGHT SMART COVE MARSH

OWNERSHIP: McCurdy, Griffin, Hedlund, Weed, Hjelvik

PHYSICAL CHARACTERISTICS

The marsh is formed inside a small bay which has barrier berm across most of its mouth. Water in the bay freely exchanges with that in Hood Canal. A cleared area at the head of the bay suggests possible inflow of eroded sediment following logging in the past.

VEGETATIONAL MARSH TYPES

Immature High Marsh	1.8 acres
Mature High Marsh	0.1 acres
Total Marsh Area	1.9 acres

UPLAND USE: Residential, Agricultural

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Oysters are found on the tidelands inside Right Smart Cove as well as out in Hood Canal. Geoducks, crab and shrimp occur nearby in Hood Canal. The offshore area is used for concentrated sport salmon fishing and searun cutthroat trout fishing. Herring utilize both the cove and the nearby canal for spawning.

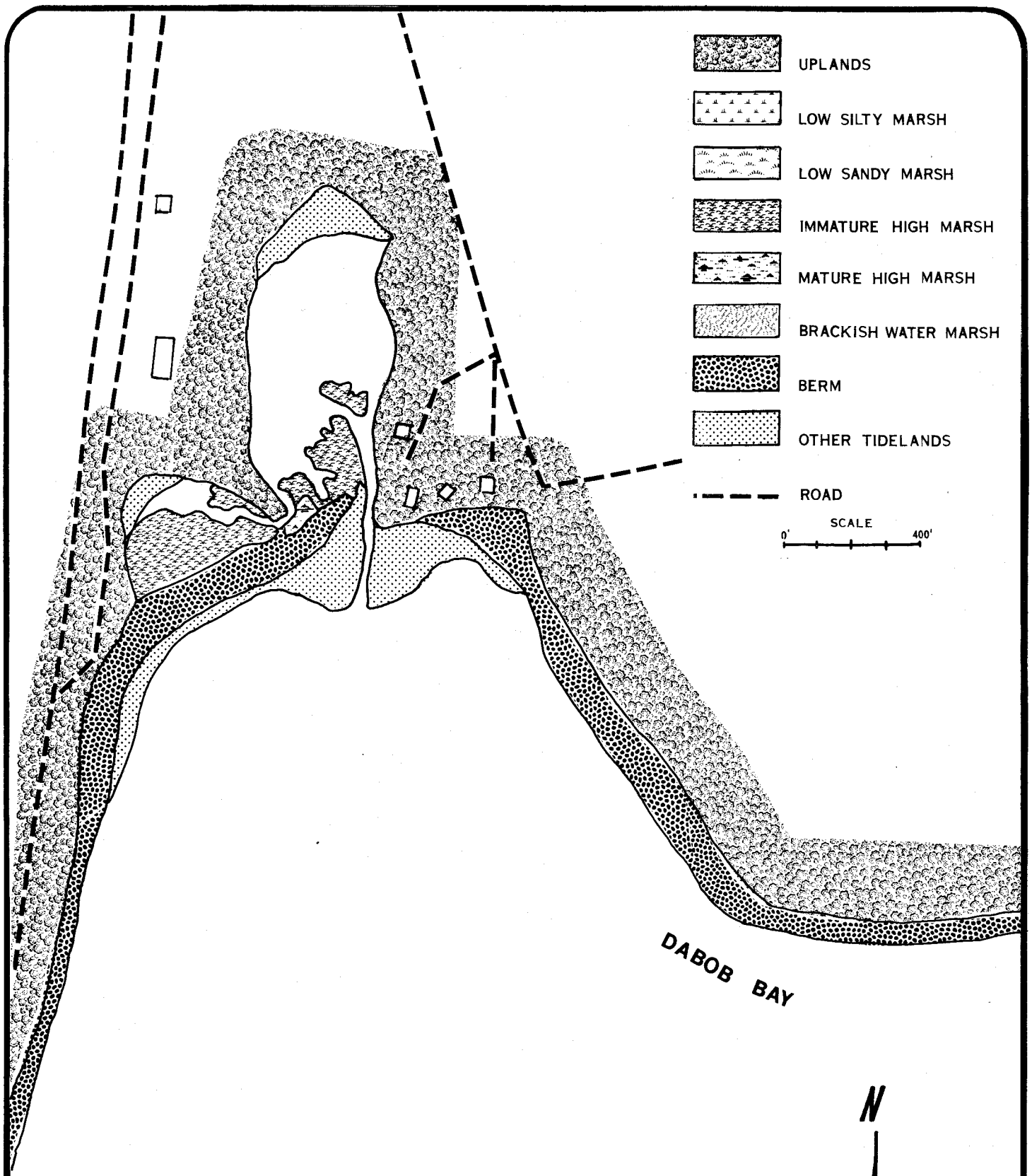


Figure 36

RIGHT SMART COVE

MARSH

Lat. 47° 39' 0" N.
Long. 122° 54' 30" W.

BLACK POINT MARSH

OWNERSHIP: Theodore Pautzke

PHYSICAL CHARACTERISTICS

The marsh is located on the periphery of a large pond connected to Hood Canal by a 216-yard channel which is also bordered by tidal marsh. Tributary marshes extending from the pond suggest freshwater creeks flowing from the uplands, but no creeks are visible. Seawater from Hood Canal enters the pond at high tide, but tidal flushing (and maintenance of water quality) appears to be minimal due to obstructions in the bottom configuration of the channel and to a recently installed culvert under a county road.

VEGETATIONAL MARSH TYPES

Immature High Marsh	9.2 acres
Brackish Water Marsh	0.8 acres
Total Marsh Area	10.0 acres

UPLAND USE: Open Space, Residential

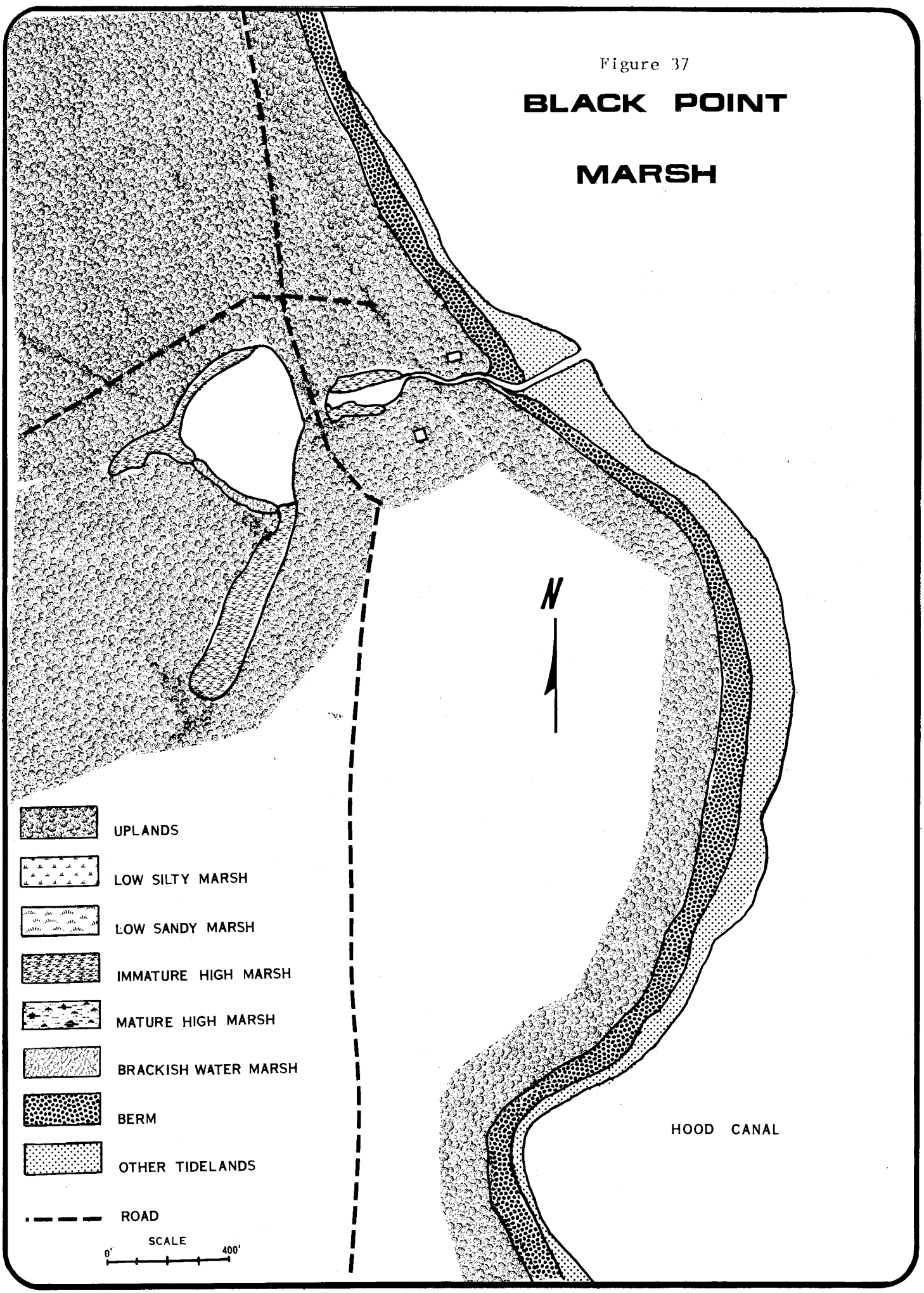
MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

While oysters are present in the brackish pond and channel, they are much more abundant outside in Hood Canal. Butter clams and geoducks are found subtidally offshore. Commercial fishing offshore in Hood Canal includes otter trawling and herring seining. Sport fishermen catch bottomfish and salmon.

Figure 37

BLACK POINT MARSH



Lat. 47° 38' 45" N.
Long. 122° 54' 15" W.

QUATSOP POINT MARSH

OWNERSHIP: Kitsap County Bank, Coast Oyster Co.

PHYSICAL CHARACTERISTICS

Quatsop Point is an open point located at the base of a high bank on the west side of Hood Canal. The channel by which the seawater enters and leaves the lagoon appears to be at an elevation high enough that contact with Hood Canal occurs only during higher high water.

VEGETATIONAL MARSH TYPES

Mature High Marsh	7.3 acres

UPLAND USE: Residential, Open Space

MARSH LAND USE: Open Space

NEARBY MARINE RESOURCES

Oysters are found on the tidelands here as well as along much of the rest of Hood Canal. The subtidal land offshore harbors geoducks and butter clams. The offshore fishery supports commercial herring seining and otter trawling as well as sport salmon and bottom fishing.

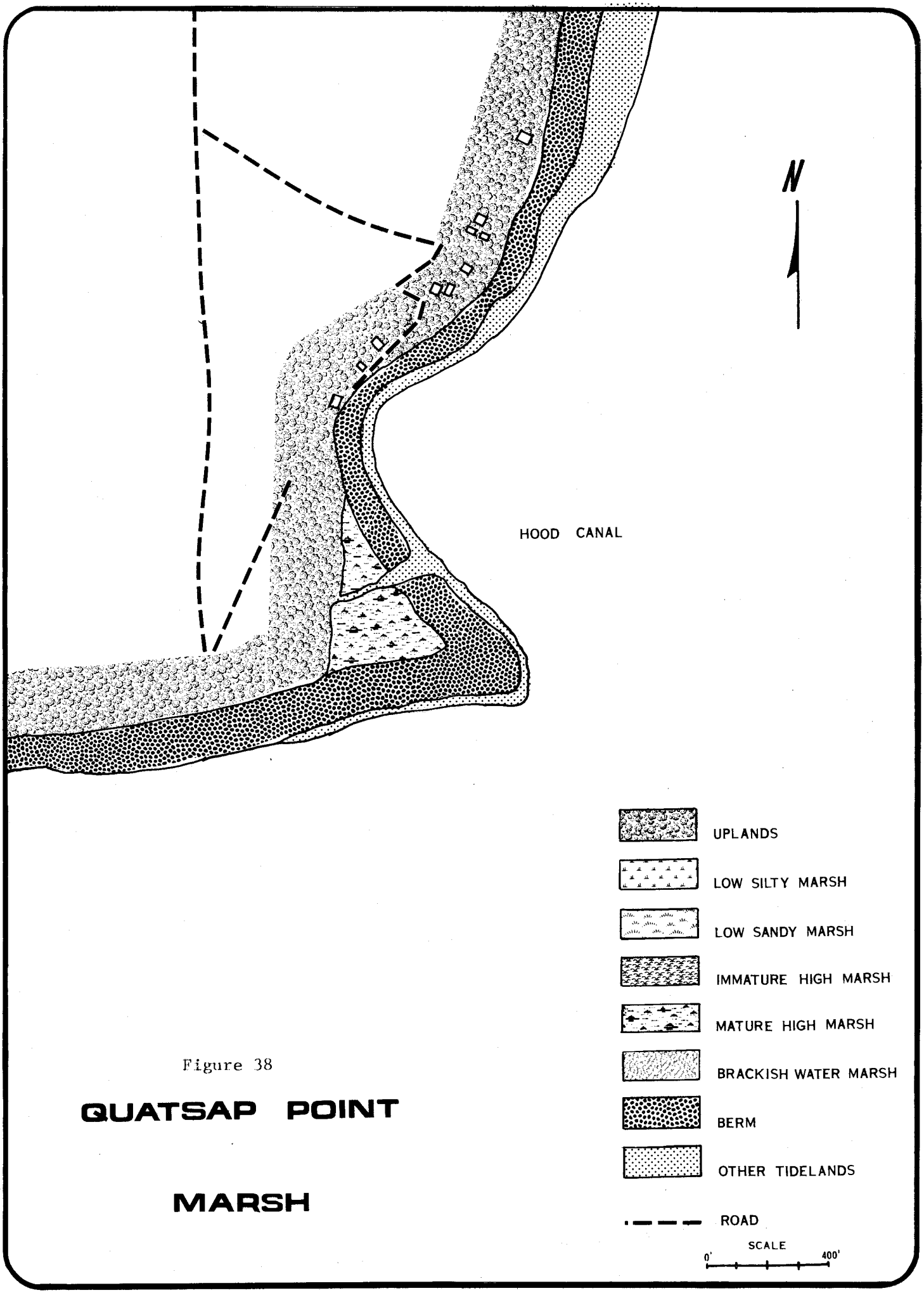


Figure 38

QUATSAP POINT

MARSH

4: Tidal Marshes and Shoreline Management

CHAPTER 4

TIDAL MARSHES AND SHORELINE MANAGEMENT

The significance of the tidal marshes and their value to society are based on the various functions that they perform. As was discussed in the previous section, the functions of Biological Productivity and Export of Productivity, Wildlife Habitat and Buffer Against Erosion are aspects of a marsh that would likely not be performed to their present extent if the marsh were filled, dredged or otherwise altered.

Many of the functions that are performed by the marshes, however, are of benefit not directly to the individual owner, but to society at large or the environment upon which society depends. An example would be the benefit to the seafood industry. The tidal marsh produces abundant organic material which is exported in the form of detritus to the marine environment and consumed directly by oysters, crabs and shrimp which are harvested by the seafood industry, providing food, jobs and tax revenue. The owner of the marsh, however, receives only a small portion of the benefits that society receives from the marsh.

The fact that a tidal marsh is part of a dynamic system indicates that it should be treated as something other than a piece of real estate. Past policies, however, viewed marshes as worthless if they could not be developed. As early as 1849, the Swamp Act authorized Louisiana to levee and drain wetlands in the Mississippi Valley for flood control. Since that time numerous governmental bodies, as well as private concerns, have been diking and filling marshes for the purposes of navigation, flood control and the creation of "reclaimed" land.

In the Puget Sound area tidal marshes have been the object of strong pressures for development. Most of the shoreline is eroding high bank with an estimated ratio of 20:1 of eroding to accreting (building up) shoreline (Bauer, 1975). Accreting shorelines with low banks and often with tidal marshes are, therefore, highly valued for residential or other development.

Although no estimates are available on the extent that Puget Sound area tidal marshes have been destroyed, it can be seen from the larger areas alone that the amount is considerable. The large industrial complexes of the Port of Seattle and the Port of Tacoma were constructed on the dredged and filled sites of the Duwamish and Puyallup River deltas respectively. Industrial facilities and log storage have encroached on the Snohomish estuarine marshes in Everett. Much of the rich agricultural land in the Lower Skagit Valley has been diked and "reclaimed" from tidal marshes. While these uses are necessary in our society they do remove large areas of tidal marsh from contact with the marine environment.

The smaller marshes also have been the object of encroachment in the Puget Sound area. In Jefferson County the development of port facilities in Port Townsend involved disposal of dredged material on tidal marshland. Residential development in the county has altered marshes at Beckett's Point, South Ludlow Bay and South Point, with pending proposals or projects involving Kala Point, Thorndyke Bay, Quilcene Bay and Right Smart Cove. While each project may involve only a small area the cumulative effect is that of reducing the amount of tidal marsh and the contributions of the marshes in an area where tidal marshes are already scarce.

Such reduction brings with it secondary effects. Where fish and wildlife habitat is reduced the abundance of fish and wildlife will also reduced since any nearby habitat is likely utilized to its carrying capacity and cannot support additional populations. The reduction in biological productivity that occurs when a tidal marsh is destroyed will be reflected at many levels in the marine food chains and may reduce the harvest of commercial seafood species.

The problem of filling marshes was recognized by the Jefferson County Shoreline Management Citizens Advisory Committee in the development of its Shoreline Management Master Program. In the Master Program's guidelines, Section 5.2103 (b) states, "landfill is not permitted in estuaries, tidelands, marshes, swamps or similar water retention areas."

Where bulkheading or diking of marshes reduces or eliminates the connection of the marsh with the marine environment, the guidelines under Section 5.1902(1) set forth the policy that dikes "should be placed landward of the streamway, including associated swamps and marshes and other wetlands directly associated and interdependent with the stream proper." Two performance

standards regarding shore defense works directly relate to tidal marshes. Section 5.1903 (b) requires that "shore defense works shall be designed and constructed so as to minimize interruption of fish movements as well as marine and wildlife habitats." Because most of the marshes are located on or behind an accretion shoreform, Section 5.1903 (d), specifying "shore defense works shall not be constructed on spits, hooks, bars or similar accretion terminals or accretion shoreforms," also applies directly to the marshes.

A number of federal laws are in effect which protect tidal marshes. Although the County does not enforce these laws they apply to a number of situations in which the County also has jurisdiction. One of the laws most applicable to the marsh alterations that have occurred and are proposed in Jefferson County is the River and Harbor Appropriation Act of 1899 (33U.S.C.401 et seq.). Section 10 of the Act gives the U. S. Army Corps of Engineers jurisdiction over construction, excavation, fill or other alteration of any navigable waters. The definition of "navigable waters" has changed since the passage of the Act, and presently extends to mean higher high water (MHHW). This definition includes much of the tidal marshland in the county, particularly the low marshes. A property owner proposing an alteration of a marsh below the MHHW line must, besides applying to the County for a permit under the Shoreline Management Act, apply to the Corps of Engineers for a permit under the River and Harbor Act.

More recent legislation, Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (33U.S.C. 1344) authorizes the Corps to issue permits for disposal of dredged or fill material in navigable waters and specifies that the decision to issue the permit should take into consideration such aspects as the effect on fishery areas, wildlife, spawning and breeding areas and recreation areas.

A 1975 Federal Court Decision (U. S. District Court of the District of Columbia, Civil Action No. 74-1292, NRDC v. Callaway, et al.) has resulted in the Corps and the Environmental Protection Agency redefining the term "navigable waters" as used in the FWPCA. Four alternative definitions have been developed and were published in the Federal Register (Vol. 40, No. 88, May 6, 1975). As stated in the Register, some of those alternatives, if adopted, would extend the jurisdiction for disposal of dredged or fill material to "...virtually every natural and artifical water in the United States. This would include low-lying areas such as marshes, swamps, bogs and inland and

coastal shallows contiguous to these waters, regardless of whether these areas are regularly or only periodically inundated by water." Adoption of such a definition would include all tidal marshes in Jefferson County, and would involve the Corps of Engineers in the decision-making process whether or not a marsh falls under County jurisdiction.

As of the printing of this report, no decision has been made on the alternatives, but the first two would clearly extend the Corps' jurisdiction to include all tidal marshes. The decision-making process of the Corps now considers not only obstruction to navigation, but also environmental aspects of a proposal.

Depending on the outcome of the Corps decision, some county-federal coordination will probably be helpful in the future to expedite decisions.

The policies and performance standards mentioned in this chapter would appear to rule out the most common methods by which tidal marshes are altered or destroyed. A number of actions are proposed or pending which would further reduce the acreage of tidal marshes in Jefferson County. The following chapter includes recommendations to assist the County in managing its remaining tidal marshes.

5: Recommendations

CHAPTER 5
RECOMMENDATIONS

The significance of tidal marshes has been recognized by government resource agencies and scientific sources, and has further been documented in this report. Jefferson County has benefited from the contribution of the tidal marshes to biological productivity, fish and wildlife habitat, recreational and aesthetic uses, prevention of erosion and flooding and water quality maintenance. These contributions, however, have been and continue to be diminished by actions which destroy or alter tidal marshes. In order to prevent further destruction of this unique resource, it is recommended that Jefferson County take the following actions:

1. Adopt an ordinance specifically prohibiting filling or dredging in, or construction on, estuaries, marshes or tidelands, and requiring violators to restore such areas to their condition prior to the filling, dredging or construction. Such an ordinance would have the effect of reaffirming the County's commitment to its Shoreline Management Master Program which it adopted in 1974. If adoption of such an ordinance is not politically possible, the following measures can discourage or reduce further destruction of tidal marshes.
2. Use the data sheets on the marshes in this report as well as on-site inspections to make management decisions. If it is determined that some marshes will be altered, the County should establish a critical level, or level of tidal marshes, that must be retained in the County. Such a level should be determined in advance and made County policy, rather than decided upon in the context of a specific project or proposal. A decision to establish a critical level should take into account that further loss of tidal marshes will have the effect of reducing the productivity of the marine environment to some extent.

3. Offer property tax incentives for owners of tidal marshes who agree to maintain their marshes in an unaltered state. The Open Space Tax Act (RCW 84.34) specifies in its definition of open space (84.34.020 (i), (b), iii) "...any land area, the preservation of which in its present use would...promote conservation of soils, wetlands, beaches or tidal marshes...." The Act also recognizes that the benefits from a tidal marsh do not always accrue to the owner, and recommends that the granting authority (the County) may "...take cognizance of benefits to the general welfare by preserving the current use of the property."

4. Purchase development rights or outright ownership of tidal marshes, of both the estuarine and non-estuarine types. The County already owns several of the marshes, in the Oak Bay and South Indian Island Parks. Others, such as Kala Point and Snow Creek are privately owned but evidence of recreational use indicates that public ownership would be more appropriate. If marshes are acquired for county parks, priority should probably be given to those with access to roads. Funding for marsh acquisition could come from a one-eighth mill property tax levy provided for in the Open Space Tax Act. This amount can possibly be matched by Federal Coastal Zone Management Act funds, administered through the Washington Department of Ecology

5. Because of the sensitivity of the marshes, recreational use should be confined to those uses of low intensity such as wildlife observation and fishing. High intensity recreational uses which incur long-term, detrimental and/or irreversible impacts such as motorized trail or cross-country travel and vehicle camping should be prohibited. The following is a list of recreational uses which are evaluated for suitability. It includes a range of activities that could possibly occur in a marsh setting. This ranking does not consider season or type of marsh and assumes the usual environmental activities (such as dredging, grading, etc.) will occur as is common to each use.

<u>Low Intensity</u>

Site appreciation experience	Hunting
Wildlife Observation	Canoeing
Shellfish collecting	Beach activity, sunbathing
Fishing	Swimming, Wading

Moderate Intensity

Trail-foot	Picnic-Day Use
Self-directed interpretive activities	Camping-Tent
Trail-horseback	

High Intensity

Camping-Camper, Cabin Shelters	Directed interpretive activities
Trail-Motorized	Facilities Oriented activities
Organized sports and activities	

6. Public compliance to use restrictions in county park marshes should be encouraged by placing simple interpretive information about the marshes on signboards erected at the parks.

REFERENCES CITED

Akins, Glenn J., and Carol A. Jefferson. 1973. Coastal Wetlands of Oregon. A Natural Resources Inventory Report to the Oregon Coastal Conservation and Development Commission.

Bauer, Wolf. 1975. Accretion Beach Inventory, Puget Sound, Hood Canal, San Juan Islands, Strait of Juan de Fuca. Interagency Committee for Outdoor Recreation, Olympia, Washington.

Day, John W., William G. Smith, Paul R. Wagner, and William C. Stowe. 1973. Community Structure and Carbon Budget of a Salt Marsh and Shallow Bay Estuarine System in Louisiana. Publication No. LSU-SG-72-04. Louisiana State University Center for Wetland Resources, Baton Rouge, Louisiana.

Galtsoff, Paul S. 1964. The American Oyster: *Crassostrea virginica* (Gmelin). Fishery Bulletin of the U. S. Fish and Wildlife Service: Vol. 64. U. S. Department of the Interior, Washington, D. C.

Gerke, Robert J., and Victor W. Kaczynski. 1972. Food of Juvenile Pink and Chum Salmon in Puget Sound, Washington. Washington Department of Fisheries Tech. Report No. 10. Olympia, Washington.

Gosselink, James G., Eugene P. Odum, and R. M. Pope. 1973. The Value of the Tidal Marsh. University of Florida Urban and Regional Development Center, Work Paper no. 3. Gainesville, Florida.

Green, J. 1973. The Biology of Estuarine Animals. University of Washington Press, Seattle and London.

Hart, J. L. 1973. Pacific Fishes of Canada. Bulletin 180 Fisheries Research Board of Canada, Ottawa.

Jefferson, Carol. 1975. Plant Communities and Succession in Oregon Coastal Salt Marshes. Ph.D. Thesis, Oregon State University, Corvallis.

Jefferson County, Shoreline Management Citizens Advisory Committee. 1974. Shoreline Management Master Program for Jefferson County and Port Townsend, Washington. In cooperation with Jefferson County Board of Commissioners, City of Port Townsend and Jefferson County Planning Department.

Odum, Eugene P. 1961. "The Role of Tidal Marshes in Estuarine Production," in The Conservationist. New York State Conservation Department.

_____. 1971. Fundamentals of Ecology. W. B. Saunders Company, Philadelphia, London, Toronto.

Phillips, Ronald C. 1969. "Temperate Grass Flats," in Coastal Ecological Systems of the United States. Editors, Odum, H.T., B. J. Copeland, and E. A. McMahan. A Report to the Federal Water Pollution Control Administration, pp. 737-773.

Pomeroy, L. R., R. J. Reimold, L. R. Shenton and R. D. H. Jones. 1972. "Nutrient Flux in Estuaries," in Nutrients and Eutrophication. G. E. Likem (ed.) American Society of Limnology and Oceanography. Special Symposia Vol. 1:274-296.

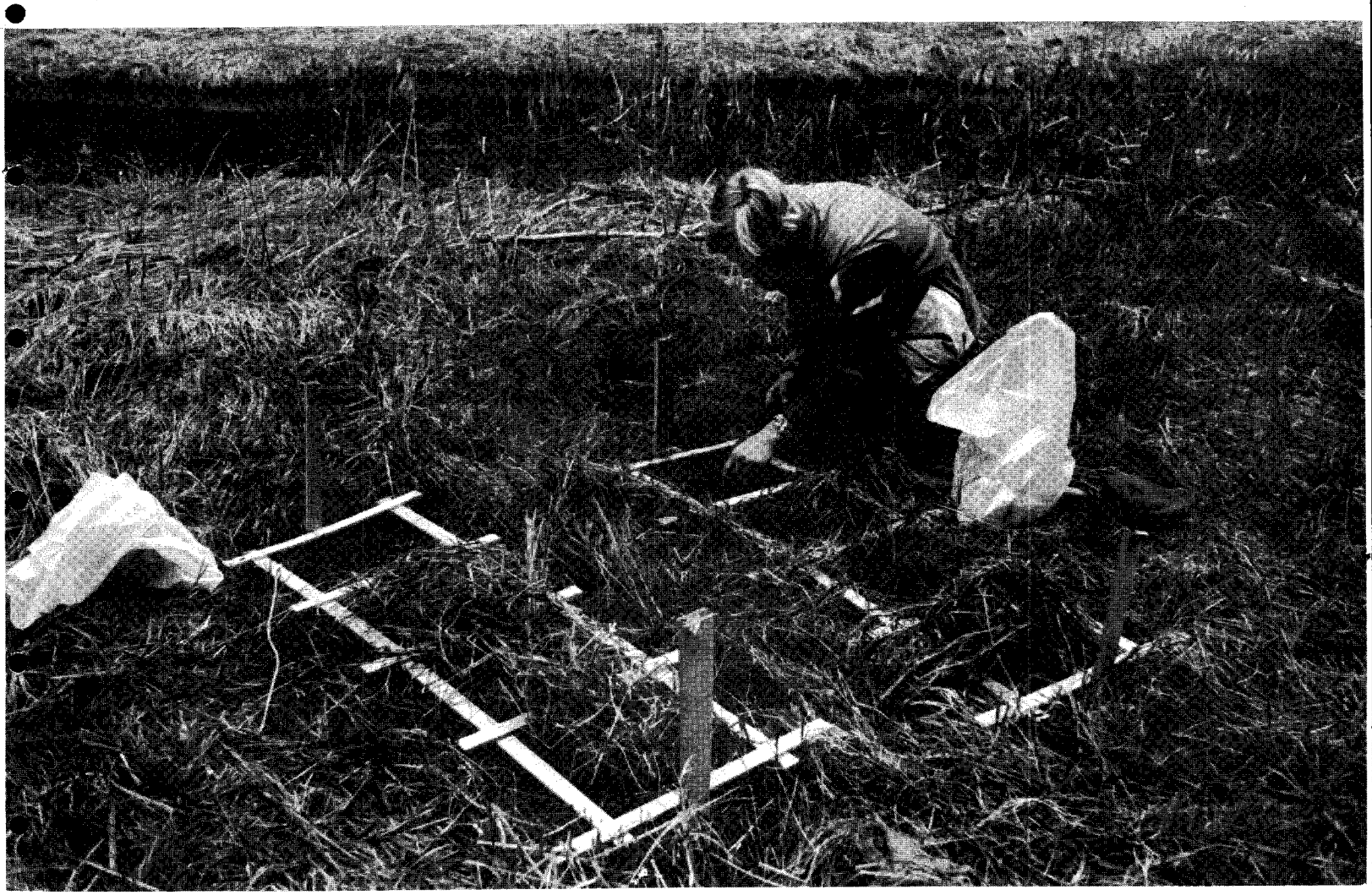
Tripp, Donald and Eric Rosenberg. 1974. "A Vegetation-Elevation Profile of the Nisqually Delta," in The Nisqually Delta, pp. 67-110, Evergreen State College, Olympia, Washington.

U. S. Dept. of the Army, Corps of Engineers. 1973. Help Yourself: A Discussion of the Critical Erosion Problems on the Great Lakes and Alternative Methods of Shore Protection. North Central Division.

Washington, State of., Department of Natural Resources. 1974. Washington Marine Atlas, Vol. I and II. Division of Surveys and Marine Land Management, Aquatic Land Management. Olympia, Washington.

Washington State University Cooperative Extension Service, 1972. Washington Climate for these Counties: Clallam, Grays Harbor, Jefferson, Pacific, Wahkiakum. Pullman, Washington.

Wass, Marvin L., and Thomas P. Wright. 1969. Coastal Wetlands of Virginia. Interim Report of the Governor and General Assembly Virginia Institute of Marine Science Special Report in Applied Marine Science and Ocean Engineering no. 10. Gloucester Point, Virginia.



APPENDIX

APPENDIX A

TABLE A-1

JEFFERSON COUNTY TIDAL MARSHES

PLANT SPECIES LIST

Flowering Plants

	Common Name
Agrostis alba	Creeping Bentgrass
Ammophila sp.	Dunegrass
Atriplex patula	Saltbush
Carex lyngbyei	Sedge
Deschampsia sp.	Tufted Hairgrass
Distichlis spicata	Salt Grass
Eleocharis sp.	Spike Rush
Glaux maritima	Saltwort
Grindelia stricta	Gumweed
Jaumea sp.	Jaumea
Juncus spp.	Rush
Plantago maritima	Water Plantain
Potentilla pacifica	Silverweed
Puccinellia sp.	Alkali Grass
Salicornia virginica	Pickleweed
Scirpus spp.	Bulrush
Spartina foliosa	Cordgrass
Spergularia sp.	Sand Spurry
Triglochin sp.	Arrowgrass
Typha sp.	Cattail

Algae

Cladophora sp.	
Cyanophyta	Blue-Green Algae
Fucus distichus	Rockweed

TABLE A-2

TIDAL MARSH VEGETATION TYPES*

LOW SANDY MARSH

Usually sand or sand-silt substrate, inland side of sand spits or islands on sandy bays, slightly elevated above mudflat, upward slope towards land, flooded by nearly all high tides, drainage diffuse.

Cyanophyta - *Puccinellia* - *Spergularia macrotheca*
Distichlis - *Cladophora* - *Salicornia*
Jaumea - *Salicornia* - *Distichlis*
Jaumea - *Salicornia* - *Triglochin maritimum* - *Distichlis*
Jaumea - *Salicornia* - *Triglochin concinnum* - *Triglochin maritimum* - *Distichlis*
Scirpus americanus
Ruppia

LOW SILTY MARSHES

Silt or mud substrate with rapid sedimentation, surface relatively flat with elevated islands of *Triglochin*, flooded by nearly all high tides, runoff diffuse but channeled around plant tussocks.

Cladophora
Salicornia - *Triglochin maritimum*
Spergularia marina - *Salicornia*
Salicornia - *Cotula*
Eleocharis - *Salicornia*
Carex - *Triglochin maritimum*
Deschampsia - *Carex* - *Triglochin maritimum*
Salicornia - *Cotula* - *Scirpus validus* - *Triglochin maritimum*
Scirpus maritimus

SEDGE MARSH

Silt substrate between Low Silty Marshes and Immature High Marsh or the edges of islands, deltas or dikes, relatively level or abruptly above tidal flats, flooded by most high tides, diffuse runoff on lower but ditched in more mature.

Carex

BULRUSH AND SEDGE MARSH

Same as Sedge Marsh with the addition of *Scirpus*.

Scirpus validus
Scirpus validus - *Carex*

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*After C. Jefferson, 1975.

TIDAL MARSH VEGETATION TYPES
(Continued)

IMMATURE HIGH MARSH

Substrate high in organics or silts, occurs on the inland side of Low Sandy Marsh or Sedge Marsh, surface relatively level with depressions and drainage ditches, abrupt rise above tidal flat--two feet or more or several inches above lower surrounding marsh, flooded by many higher-high tides, runoff in ditches, vegetation cover continuous.

Salicornia - Distichlis - Plantago - Scirpus americanus - Glaux - Spergularia canadensis
Deschampsia - Potentilla - Trifolium - Juncus
Distichlis
Distichlis - Salicornia
Carex - Salicornia - Triglochin maritimum
Salicornia - Distichlis - Triglochin maritimum
Distichlis - Deschampsia - Carex

MATURE HIGH MARSH

Highly organic substrate often overlaying clays, relatively level with well-defined ditches and potholes, abrupt rise above tidal flat three feet or more, higher-high tides just cover, runoff ditched, cover continuous, fresh water may seep through soil.

Potentilla - Deschampsia
Salicornia - Distichlis - Juncus
Juncus gerardii - Deschampsia - Juncus lesueurii

TABLE A-3

INVERTEBRATE SPECIES INHABITING TIDAL MARSHES IN PUGET SOUND*

POLYCHAETAS (Bristleworms)

- *Abarenicola pacifica*
- *Manayunkia aestuarina*
- *Amphicteis glabra*
- *Eteone longa*
- Capitellidae

OLIGOCHAETA

- Four or more species

MOLLUSCA

- Pelecypoda (Clams)
  - *Macoma balthica*
  - *Macoma secta* (White Sand Clam)
  - *Mya arenaria* (Softshell Clam)
  - *Mytilus edulis* (Blue Mussel)
- Gastropoda (Snails)
  - *Littorina sitkana* (Periwinkle)
  - *L. scutulata* (Periwinkle)
  - *Phytia myosotis*
  - *Assiminea californica*
  - *Haminoea virescens* (Bubble Snail)
  - *Notoacmaea scutum* (Limpet)

CRUSTACEANS

- Amphipoda (Beach Hoppers)
  - *Corophium spinicorne*
  - *C. salmonis*
  - *Anisogammarus confervicolus*
- Isopoda (Pill Bugs)
  - *Gnorimosphaeroma lutea*
  - *G. oregonensis*
- Decapoda (Crabs)
  - *Hemigrapsus oregonensis* (Hairy Short Crab)
  - *Pagurus* spp. (Hermit Crabs)
- Tanaidae
  - *Pancolus californiensis*

INSECTA (Insects)

- Chironomidae larva
- Ceratopogaridae larva
- Hemiptera
- Coleoptera

ARACHNIDAE

- Several species of spiders and mites present

*List compiled from samples collected in the field during this study and from unpublished data from James Smith, College of Fisheries, University of Washington.

TABLE A-4

FISH USING TIDAL MARSHES AT HIGH TIDE

OBSERVED OR COLLECTED

Oncorhynchus spp.	Juvenile Salmon (one species collected, other probable)
Thaleicthys pacificus	Candlefish
Gasterosteus aculeatus	Three-Spined Stickleback
Ammodytes hexapterus	Sand Lance
Leptocottus armatus	Staghorn Sculpin
Oligocottus maculosus	Tidepool Sculpin
Platicthys stellatus	Starry Flounder

APPENDIX B

PROPOSED RANKING OF TIDAL MARSHES

With a total areal extent of less than 150 acres, non-estuarine tidal marshes cannot be considered a common environment in Jefferson County and should be considered to have an absolute value by virtue of their scarcity. Other applications of absolute value are discussed elsewhere in this report. This section will deal with the value of these marshes relative to each other.

In order to compare the marshes with each other on a quantitative basis, a ranking system may be established based on the functions performed by a tidal marsh. Each marsh function is defined by a number of factors which, for purposes of this study, will be limited to those factors which may be readily measured. The marsh functions and their associated measurable factors are discussed briefly below.

FUNCTION: BIOLOGICAL PRODUCTIVITY AND EXPORT

This refers to the conversion of solar energy into organic material to the marine environment where it becomes food for marine animals. The following measurable factors influence this function:

Net Yield of Organic Material: This factor is determined most simply by field measurements in selected representatives of each physical/vegetational type. Measurements are conducted by clipping plants in established plots then drying and weighing the material produced within the production period.

Elevation of Marsh: Because of the positive influence of the tides on both productivity and export of that productivity, those marshes with the the lowest evelation and hence the greatest exposure to the tides are of greater value.

Shoreline Length/Marsh Area: This ratio, which may be measured from aerial photographs of the marshes, is important in determining the integration of the marsh with the marine environment. A marsh with a high ratio of shoreline

length to area will be relatively more integrated with the marine environment than will one with a lower ratio. Essentially, this is a measurement of the drainage ditches and shoreline in the marsh, which gives the marsh contact with the marine environment.

Exposure to Wind and Waves: Another indication of integration with the marine environment is the exposure to wind waves. When these waves strike the marsh at high tide, they assist in the export of organic material to the marine environment. The exposure factor may be calculated by measuring the effective fetch, wind frequency and wind velocity as noted in the Washington Marine Atlas (Department of Natural Resources, 1974).

FUNCTION: POTENTIAL FOR UTILIZATION AS HABITAT FOR FISH AND WILDLIFE

If, because of the time frame and scope of this study, it is not possible to station researchers in each marsh full time to record the actual utilization as habitat by fish and wildlife, the following factors may be used as indicators that the habitat is a healthy and valuable one, for use by birds and mammals.

Number of Invertebrates: Sampling should be conducted both in the vegetated portion of the marsh and in the mud of the drainage sloughs, and the results presented in the context of the areal extent of the physical/vegetational type sampled. Because the small invertebrates are used as food by the fish and wildlife, their abundance is considered favorable in promoting the abundance of fish and wildlife.

Diversity of Invertebrates: The diversity of species is an indication of the health of the environment. A high diversity of species indicates that the environment is not limited by any physical factors (i.e., the environment is healthier if it can support a high diversity of species and unhealthy if it can only support a few species).

Wildlife Abundance: This is a factor which might be observed and incorporated into a ranking system; however, as stated above, such observations will be time consuming and probably expensive. Quantifying the results to put in matrix will also be difficult.

Surrounding Land Use: Although many wildlife species are tolerant of the presence of humans, there are also many that are not. It may be assumed that land uses involving open space are more conducive to wildlife utilization than are those involving the presence of many humans, vehicles and buildings.

In descending order of compatibility with wildlife, the uses are conservancy, recreational, residential, commercial, and industrial.

FUNCTION: BUFFER AGAINST EROSION

Action by wind-driven waves can erode banks and cause loss of property. While the marsh vegetation itself is usually behind a berm, the shoreform that includes the marsh can absorb the force of the waves and prevent erosion of the uplands. The value of those shoreforms in performing this function may be quantified by the following factors:

Length of Erodable Bank of Uplands: This factor should be observed in the field and then measured on an aerial photograph. A marsh shoreform protecting a great deal of upland bank should receive a higher score than one protecting only a short length of bank.

Exposure to Wind Waves: This is a measurement of the potential for erosion that would exist if the bank were exposed. Measurement and quantification are performed as noted above in "Productivity."

Once a measurement is obtained for each factor, a matrix is constructed (Table B-1) to combine all the values of the factors in each marsh. Rather than applying the actual measurements to the matrix, the ranking system groups them on a scale of 1 to 5, with the top 20 per cent receiving a score of 5 in any one factor, the next 20 per cent receiving a 4 and so on. This method eliminates the bias that would be involved in comparing unlike quantities (net yield of organic material might be in thousands of grams, while measurements of erodable bank are in feet). The method does, however, apply a bias of equal importance of a number of factors which the reader might not consider to be of equal importance. For this reason, a subtotal is included for each major function, so that the reader may weigh the functions performed by each marsh according to her or his particular interest.

Before using the proposed matrix, the reader should be aware of the strengths and limitations of the system. The data included in the report will always be limited to that available in background literature and that obtainable during a given study period. Information on human uses, particularly recreational uses, requires a good deal of study but is difficult to quantify. Thus, the matrix should be viewed in the context of the beginnings of a decision-making tool, rather than as the final word.

It should also be used in the context of a policy of the County (or other jurisdiction) on alteration of tidal marshes. A ranking of tidal marshes

has little value if used to set the timetable for destruction of those marshes. A decision must be made that the County will retain all, or 90 per cent or some other limit, of their marsh area.

TABLE B-1

MATRIX FOR RANKING JEFFERSON COUNTY TIDAL MARSHES

FUNCTIONS	*S/T												
BIOLOGICAL PRODUCTIVITY AND EXPORT													
Net Yield of Organic Material													
Elevation of Marsh													
Shoreline Length/Marsh Area													
Exposure to Wind Waves													
Subtotal													
POTENTIAL FOR UTILIZATION AS HABITAT FOR FISH AND WILDLIFE													
Abundance of Invertebrates/Sample													
Species Diversity of Invertebrates in Samples													
Wildlife Abundance													
Surrounding Land Use													
Subtotal													
BUFFER AGAINST EROSION													
Value of Erosion Prevention													
OTHER													
Scarcity in Reach													
TOTALS													

NOTES: Maximum possible score in all categories is 5; minimum score is 1.

*S/T Indicates whether measurements were taken in each marsh separately (S) or extrapolated from marsh types (T).

APPENDIX C

METHODS AND SUPPORTING DATA

PRIMARY PRODUCTIVITY

Because no measurements were available on the primary productivity of tidal marshes in the Northwest, and the high rate of production is often used in discussing the value of Atlantic Coast tidal marshes, the study team determined fairly early in this study that some measurements of primary productivity should be conducted in this area. Making a statement about Northwest tidal marshes on the basis of data from Georgia or Louisiana seemed of little validity.

The harvest method, repeated clipping of measured plots, was used, but modified in order to hot only obtain measurements of the productivity but also test whether the clipping has any effect, stimulating or inhibiting, on those measurements. Rather than taking clippings in one plot (or replicate plots) repeatedly, the team used plots (one-tenth square meter in size) in groups of three. The plots were coded with:

Location	
Marsh Type	(LSiM, LSaM, IHM, MHM, SM)*
Replicate Group	(A or B)
Plot No.	(I, II, or III)

At the beginning of the production period, Plot I in each group was clipped, and all shoot material, live and dead, was removed, dried (at 100° C. for 48 hours) and weighed.

After a 30-day interval, another plot in each group was clipped and the harvested material was dried and weighed. In addition, the preceding plots were re-harvested at each sampling time, with the weights coded IHM-A-I_2 for second harvest of Plot I, IHM-A-I_3 for third harvest of Plot I and so on.

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*Abbreviations used for Low Silty Marsh, Low Sandy Marsh, Immature High Marsh, Mature High Marsh and Sedge Marsh.

Time was a major limiting factor in this study, because the final report was due at the end of the fiscal year rather than the end of the growing season. Thus, the final measurements were taken June 6, 1975, and the measured production is valid only for the 52-day production period. Later measurements are planned, however, even though they will not be included in this report.

The harvest pattern, then, was as follows:

	Plot I	Plot II	Plot III	
Clipping #1 April 16, 1975	I_1			Beginning of production period
Clipping #2 May 16, 1975	I_2	II_1		Beginning + 30 days
Clipping #3 June 6, 1975	I_3	II_2	III_1	Beginning + 52 days

This method does not account for loss of organic material by grazing or tidal action. Other methods do consider these factors but require separating live from dead material in several plots. This was attempted but proved exceedingly difficult and time-consuming with *Salicornia* and *Distichlis* which in early spring have live material growing inside dead material

RESULTS AND DISCUSSION

The net yield, expressed in grams dry weight of shoot material from the marsh plants is presented in Table C-1. The data for Plots II and III is calculated on the assumption that those plots began with the same weight as did Plot I, within each group.

One aspect of the results that can be seen from the Table is that the clipping may have an inhibiting effect on the growth of the vegetation in the plots. Of the nine groups of plots with sufficient data to be usable, six had a higher rate of productivity in the plot that was not clipped until the end of the period. It is also significant that of the three groups in which the reverse was true, the average difference between the weight of Plot I and that of Plot III was 3.1 grams, while in the six groups in which the weight of Plot III exceeded that of Plots I or II the difference averaged 37.3 grams. Thus, the following discussion and Table 1, page 12, are based on the figures for Plot III in each group, the plot which had the least disturbance. During the 52-day production period, the highest yield was measured in the Sedge Marsh, a minor marsh type in terms of areal extent in Jefferson County.

TABLE C-1

NET YIELD OF DRY SHOOT MATERIAL

Marsh Type and Location	Group A			Group B		
	Plot I	Plot II	Plot III	Plot I	Plot II	Plot III
Low Silty Marsh Scow Bay	18	X	30.9	16.6	X	13.9
Low Sandy Marsh Kala Point	X	X	R	73.7	0.1	R
Immature High Marsh Kala Point	X	X	89.7	13.7	X	51.2
Immature High Marsh Thorndyke Bay	17	27.4	14.4	18.3	51.3	52.8
Mature High Marsh Thorndyke Bay	20	14.1	20.1	12.2	25.7	8.2
Sedge Marsh Black Point	25.2	32.2	136.6	X	36.2	63.4

X = Insufficient clippings available.

R = Third plot had less material on its first clipping than did the first plot on its first clipping 52 days earlier. While net yield was probably not zero, results if used, would suggest a regression. Data, therefore, is not used.

Of the four major marsh types, the Immature High Marsh was the highest producer, with the four replicates (at two locations) averaging 52.0 grams. It is noteworthy that the Immature High Marsh is also the most widespread studied in the County covering 44.3 per cent of the tidal marsh area.

Extrapolations over a full year of the figures in Table C-1 are presented in Table 1 on page 12 in the text. As explained in that Table, the extrapolations are tentative but were derived conservatively, and the actual production is probably higher.