CLAM-ABALONE STOCK SUPPLEMENTATION FEASIBILITY STUDY

ANNUAL REPORT
July 1, 1973 to June 30, 1974

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Commercial Fisheries Research and Development Act
Project 1-86-R
Contract No. 04-4-208-15
Segment No. 1

June 1974

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CLAM-ABALONE STOCK SUPPLEMENTATION FEASIBILITY STUDY

INTRODUCTION

The objectives of this study were to locate suitable intertidal and subtidal clam planting sites and to determine the feasibility of planting laboratory-spawned clams. Criteria used to determine the suitability of potential clam planting sites included: an evaluation of species of clams indigenous to the survey area and the type of substrate and vegetation within the survey area.

Major emphasis was in Yaquina Bay to evaluate the distribution of bay clams and potential for planting laboratory-spawned clams. In addition, intertidal surveys were initiated on Alsea and Netarts bays.

Work continued during the year to improve our techniques to mass culture Manila littleneck clams *Venerupis philippinarium*. Laboratory-spawned clams were planted in test plots in several areas of Coos, Coquille, and Netarts bays.

INTERTIDAL AND SUBTIDAL CLAM PLANTING SURVEYS

METHODS

Location of Suitable Intertidal and Subtidal Clam Planting Sites

Techniques developed during the 1973 fiscal year (Osis and Gaumer, 1973) were used to locate intertidal and subtidal areas having potential for planting laboratory-produced juvenile clams. We used the presence of clams (both intertidal and subtidal), substrate type, and depth of water as criteria for determining areas having potential for planting clams.

Location of clam beds on intertidal tideflats was accomplished by establishing transect lines across each of the tideflats. Observations made at established stations along the transect line included species of clams in the area, relative density of each species of clam, substrate type, and vegetation type. Similar observations were made subtidally with the use of scuba gear.

RESULTS

Yaquina Bay

Figure 1 shows the distribution of bay clams (butter, *Saxidomus giganteus;* cockle, *Clinocardium nuttallii,* gaper, *Tresus capax;* native littleneck, *Venerupis staminea;* and piddock, *Zirfaea pilsbryi*) in the lower Yaquina Bay. Softshell clam (*Mya arenaria*) beds of the upper bay are not shown although this species is found along both shores upstream of King Slough and Sally's Bend to Toledo.

Cockle and gaper clams were the principal species of clams found in the lower bay (Figures 2 and 3). In the intertidal areas, both species of these clams were generally at densities of less than 1 per square foot. Subtidally gaper clams were considerably more abundant with extensive areas containing clams in excess of 5 per square foot and with several areas having concentrations in excess of 10 per square foot. Few subtidal areas contained cockle clams in excess of 1 per square foot.

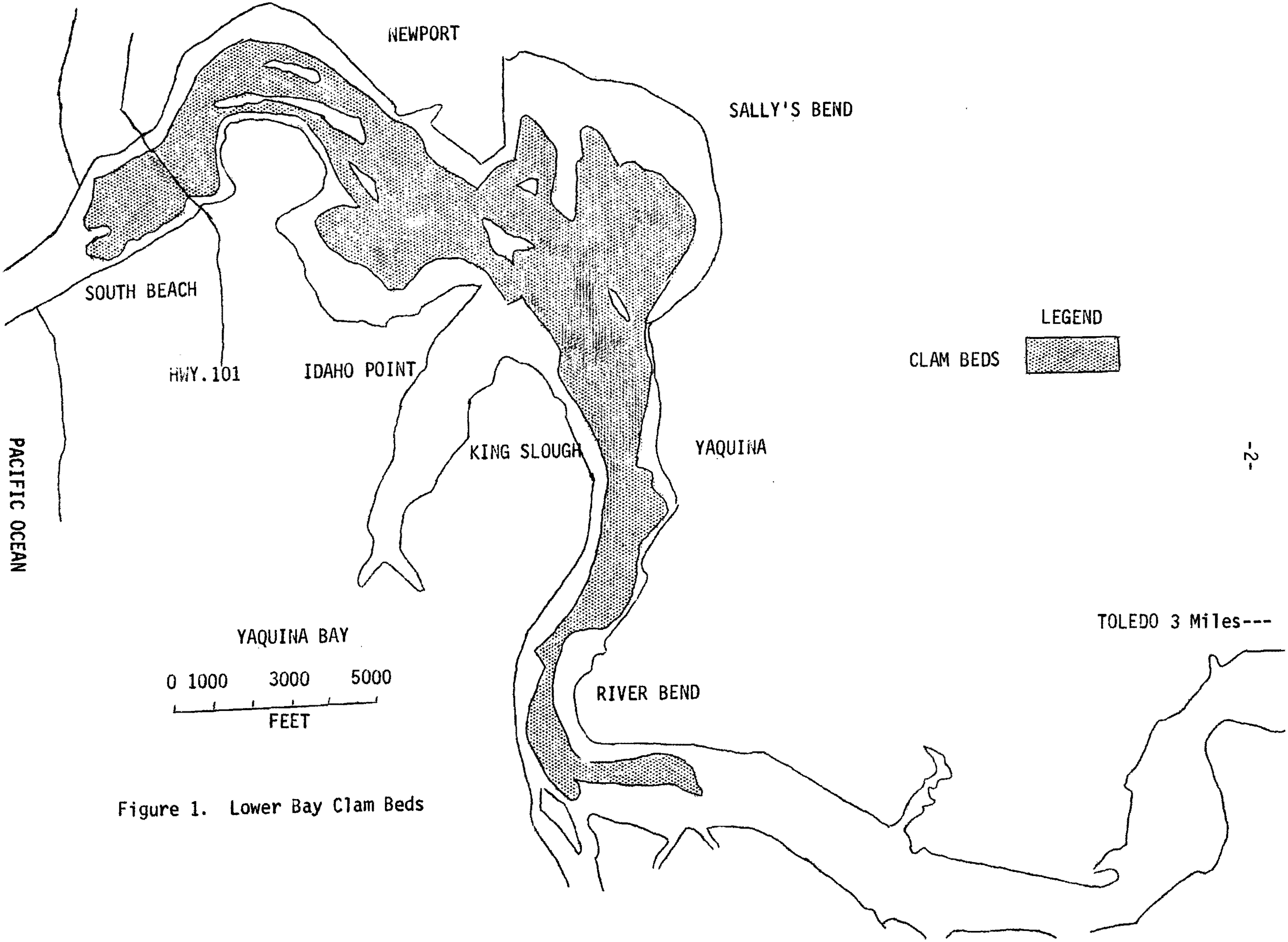

Figure 1. Lower Bay Clam Beds

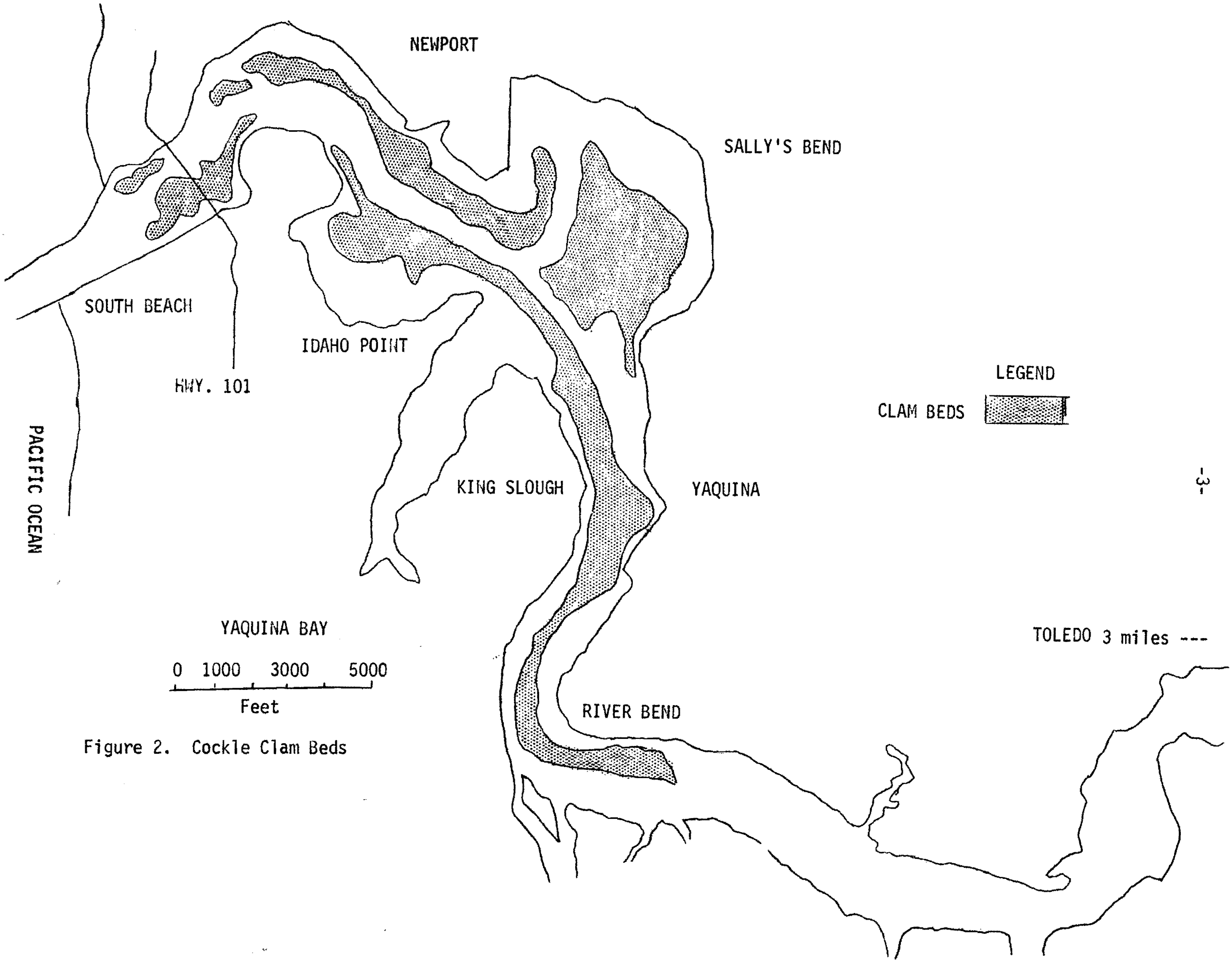

Figure 2. Cockle Clam Beds

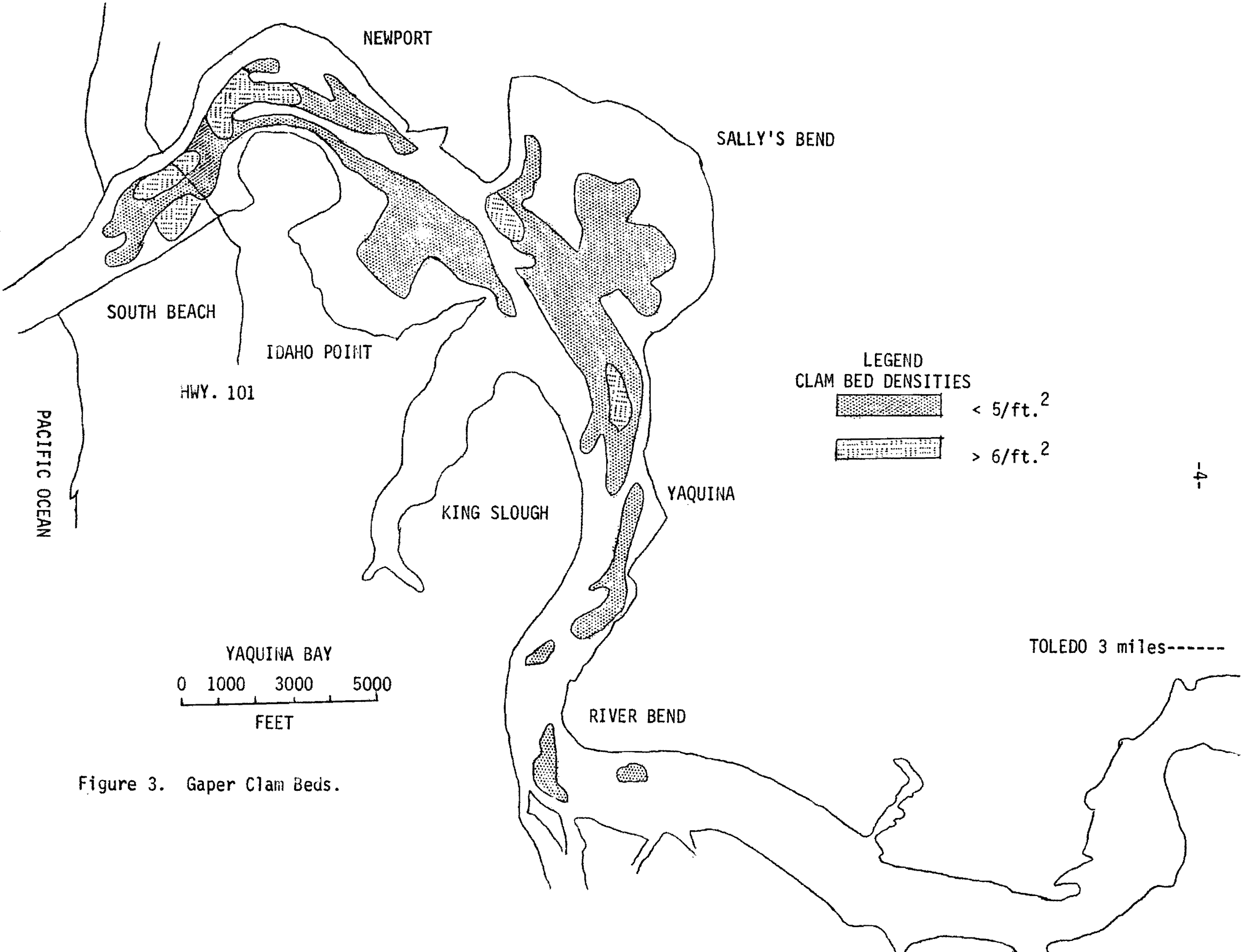

Figure 3. Gaper Clam Beds.

Figure 4 shows the four principal substrate types found in the survey area. Several substrate types were observed at many of the sample stations. The principal material at each station is shown. Only when two or more different substrate types, in nearly equal quantities, were encountered did we show them overlapping on the map.

A preference for sand, gravel, or shell substrate, or a combination of these was found for cockle and gaper clams both intertidally and subtidally whereas mud substrates contained few of these clams.

The distribution of aquatic vegetation in Yaquina Bay is shown in Figure 5. Eel grass *(Zostera marina)* was the principal species found followed by rockweed *(Fucus furcatus)*, and the green alga *(Enteromorpha sp.)*. The importance of these aquatic plants, especially eel grass, for the successful setting and rearing of juvenile clams can be seen when the distribution of bay clams and plants are compared. This applies especially to the intertidal and shallow subtidal areas since depth of water controls the growth of these plants.

Netarts Bay

Clam surveys on Netarts Bay are incomplete. Survey of the intertidal tideflat west of the main channel was nearly completed during the year (Figure 6). Many species of clams including butter, cockle, gaper, and native and Manila littleneck clams were observed and locations mapped for the tideflat. Densities of clams were generally less than 1 per square foot for each species. Of particular interest was the discovery of two areas containing Manila littleneck clams (Figure 7). This discovery was timely since we were looking for an area to evaluate mass planting of laboratory-produced Manila clams in an area already containing Manila clams.

Substrate types for the tideflat are shown in Figure 8. Sand was the principal material observed with mud mixed with sand being abundant in the upper bay. Generally the major concentrations of clams were located in areas containing a sand-mud substrate. Cockle clams were especially abundant in areas composed of a sand-shell substrate. Manila clams were found in a substrate of compacted sand and mud.

Vegetation on the tideflat is confined primarily to the upper estuary where extensive areas of dense eel grass cover the tideflat from the shore to the channel (Figure 9). A major part of this area contained few clams but ghost (*Callianassa californiensis*) and mud (*Upogebia pugettensis*) shrimp were abundant.

Alsea Bay

Figure 10 shows the only area surveyed on Alsea Bay during the year. The tideflat contains a small number of cockle clams and a dense population of ghost shrimp. Sand is the predominant substrate type in the area (Figure 11). *Enteromorpha sp.* was the only vegetation observed on the tideflat.

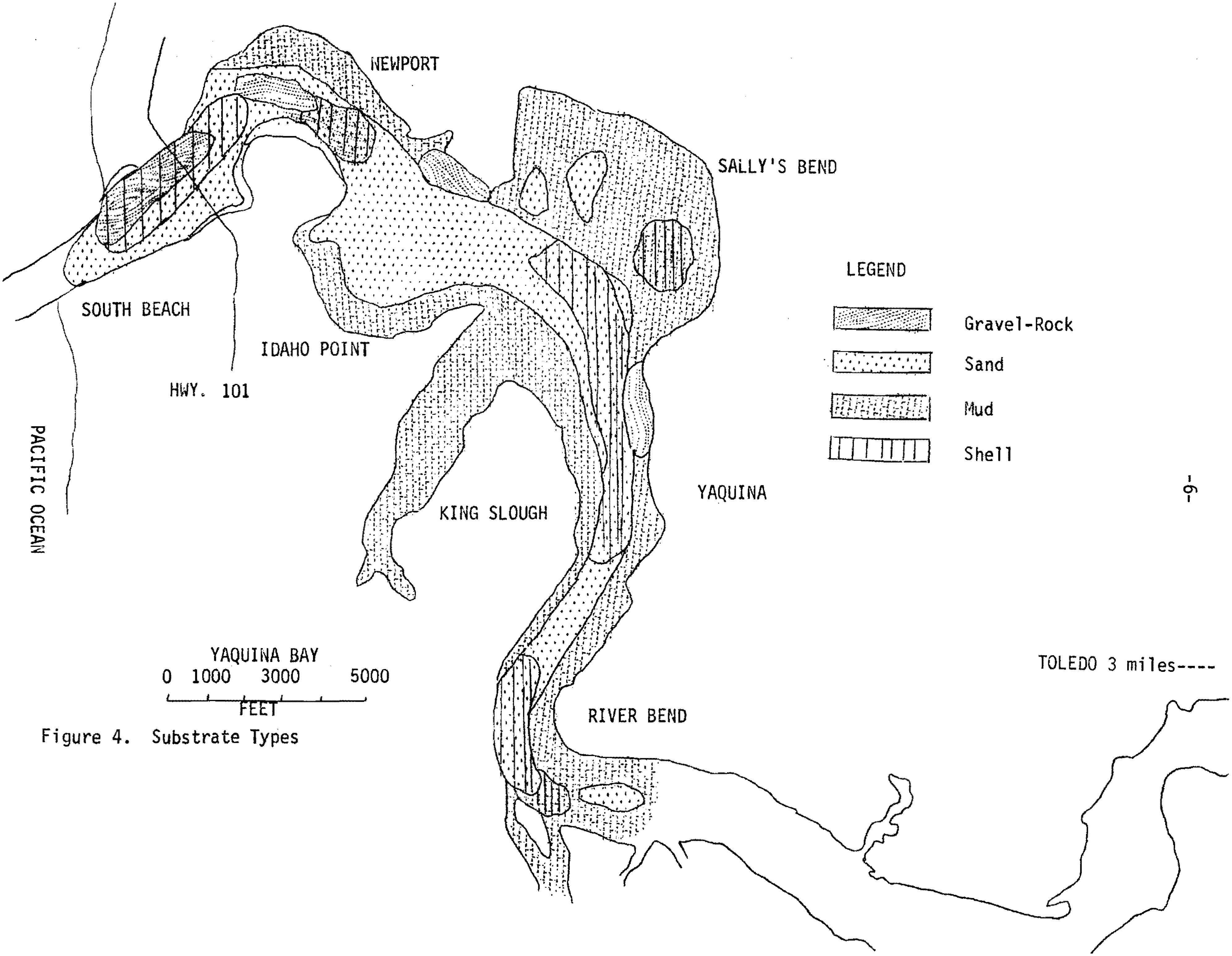

Figure 4. Substrate Types

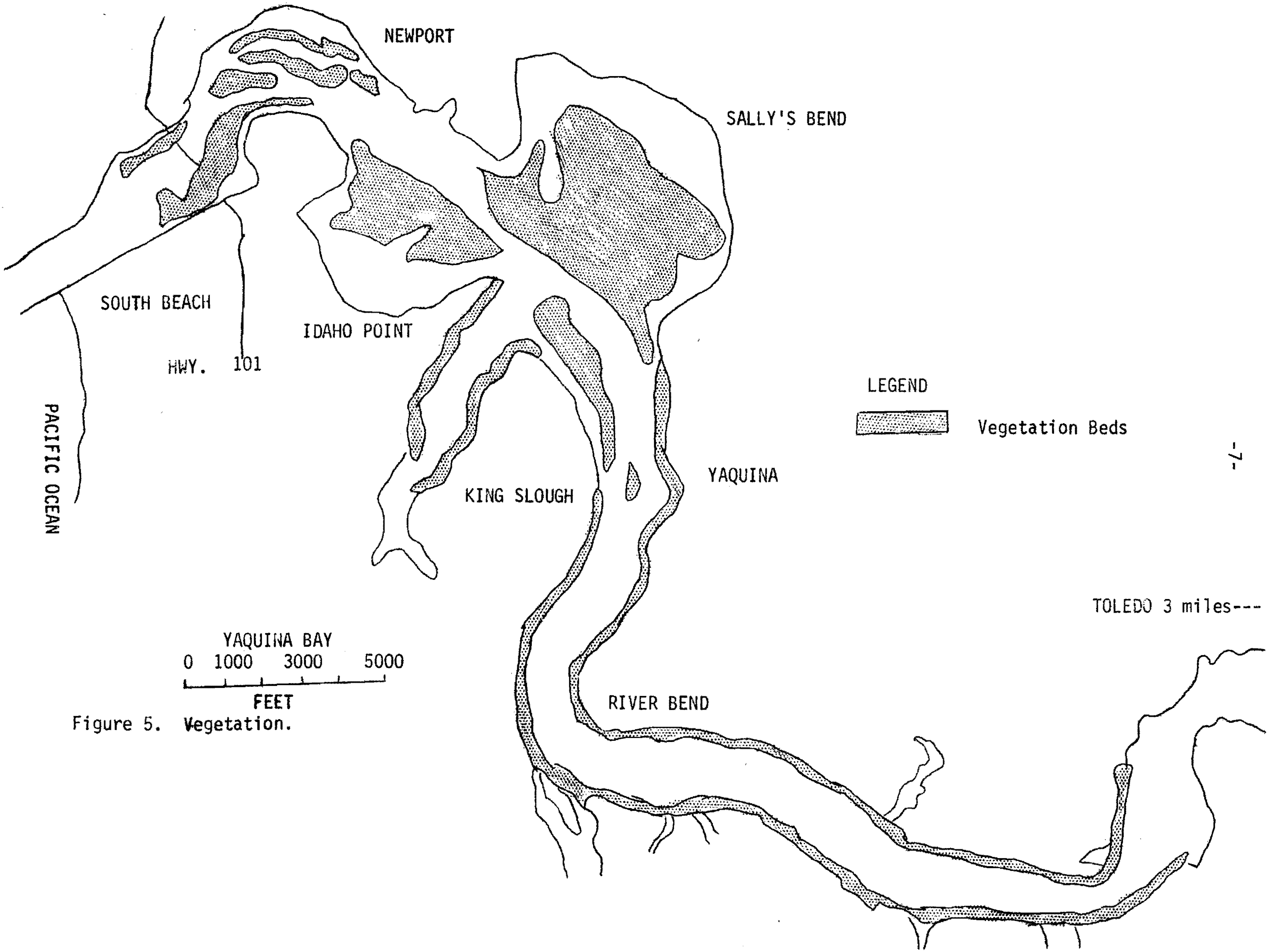

Figure 5. Vegetation.

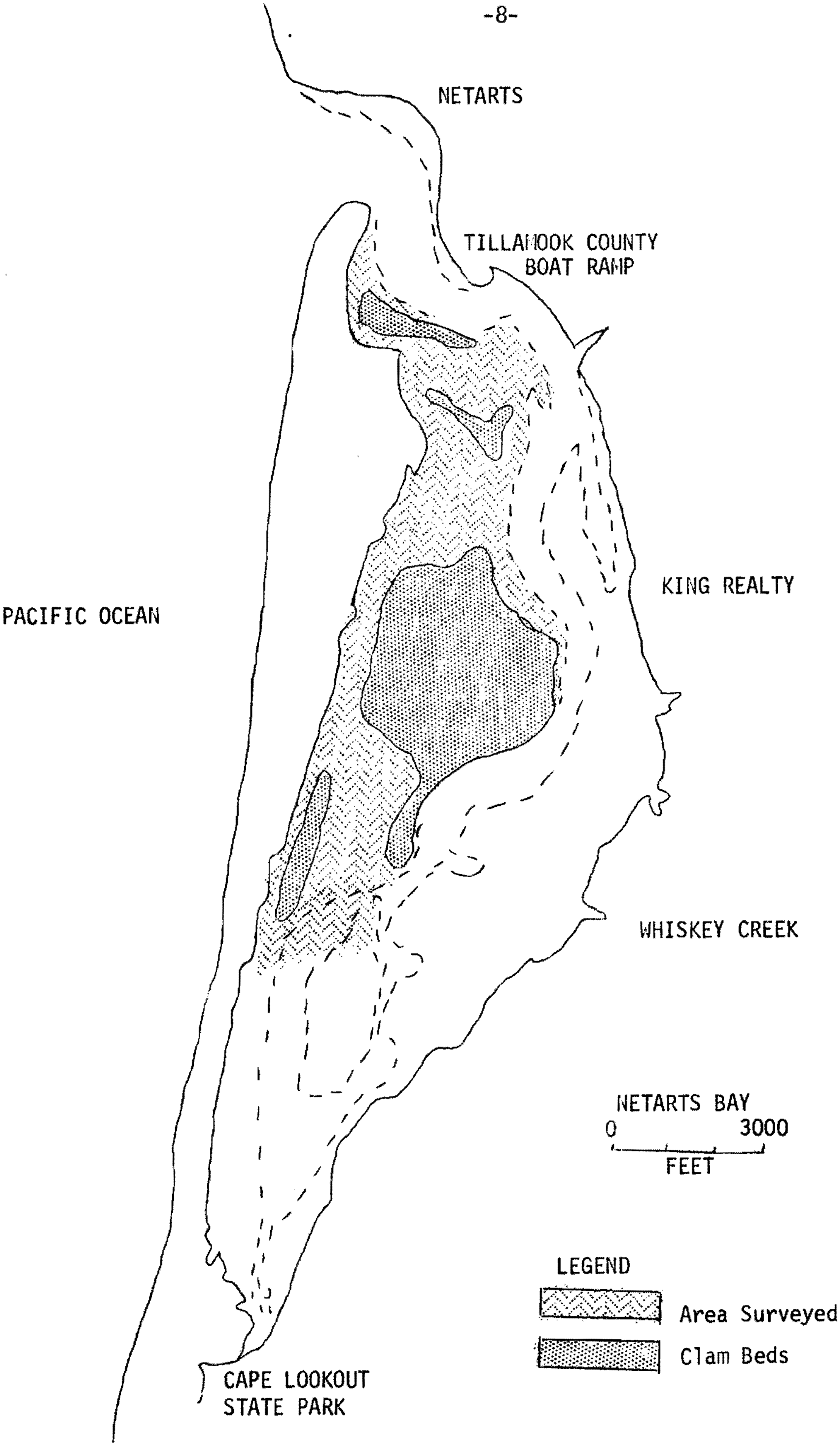

Figure 6. Area and Clam Beds Surveyed.

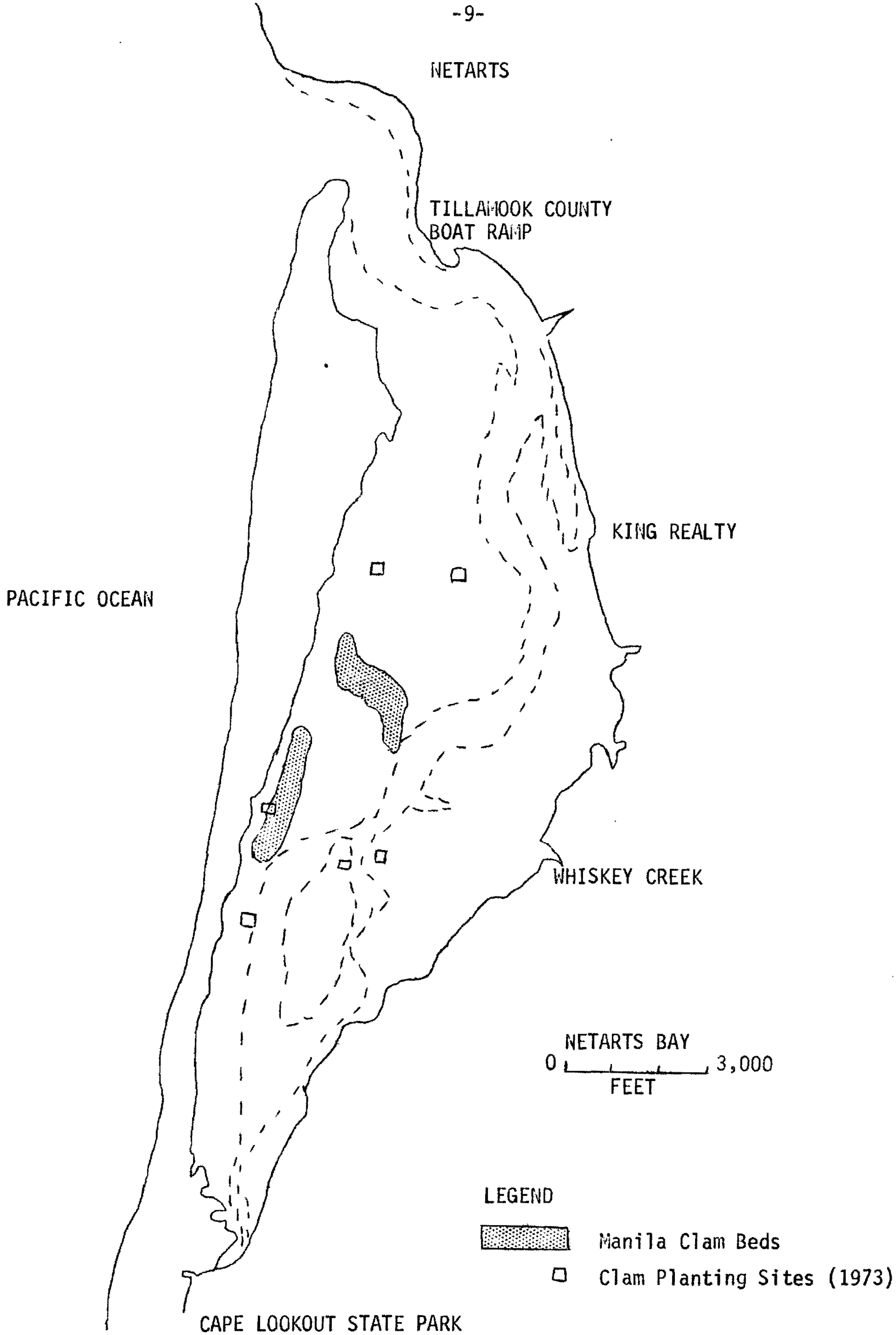

Figure 7. Manila Littleneck Clam Beds.

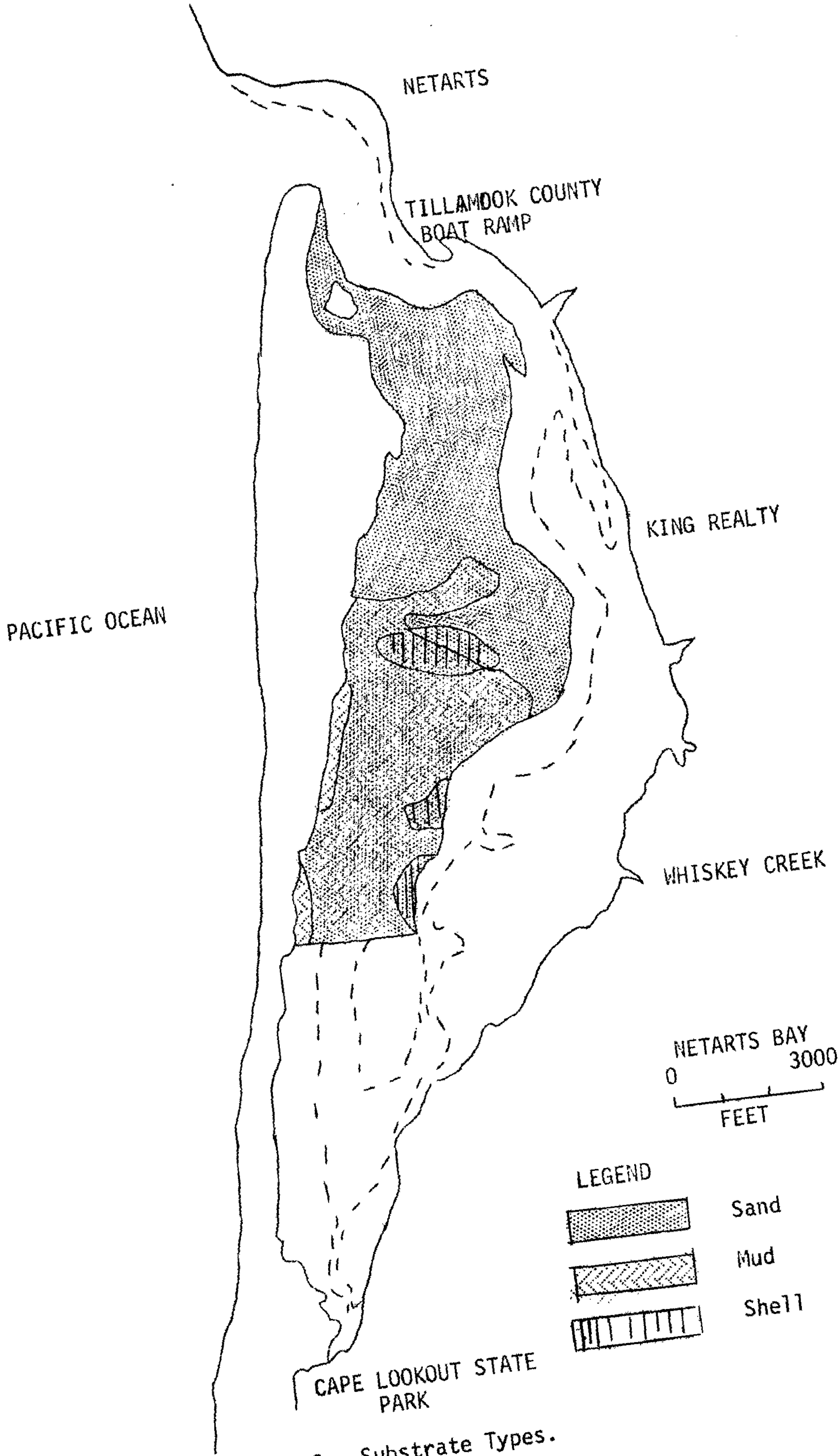

Figure 8. Substrate Types.

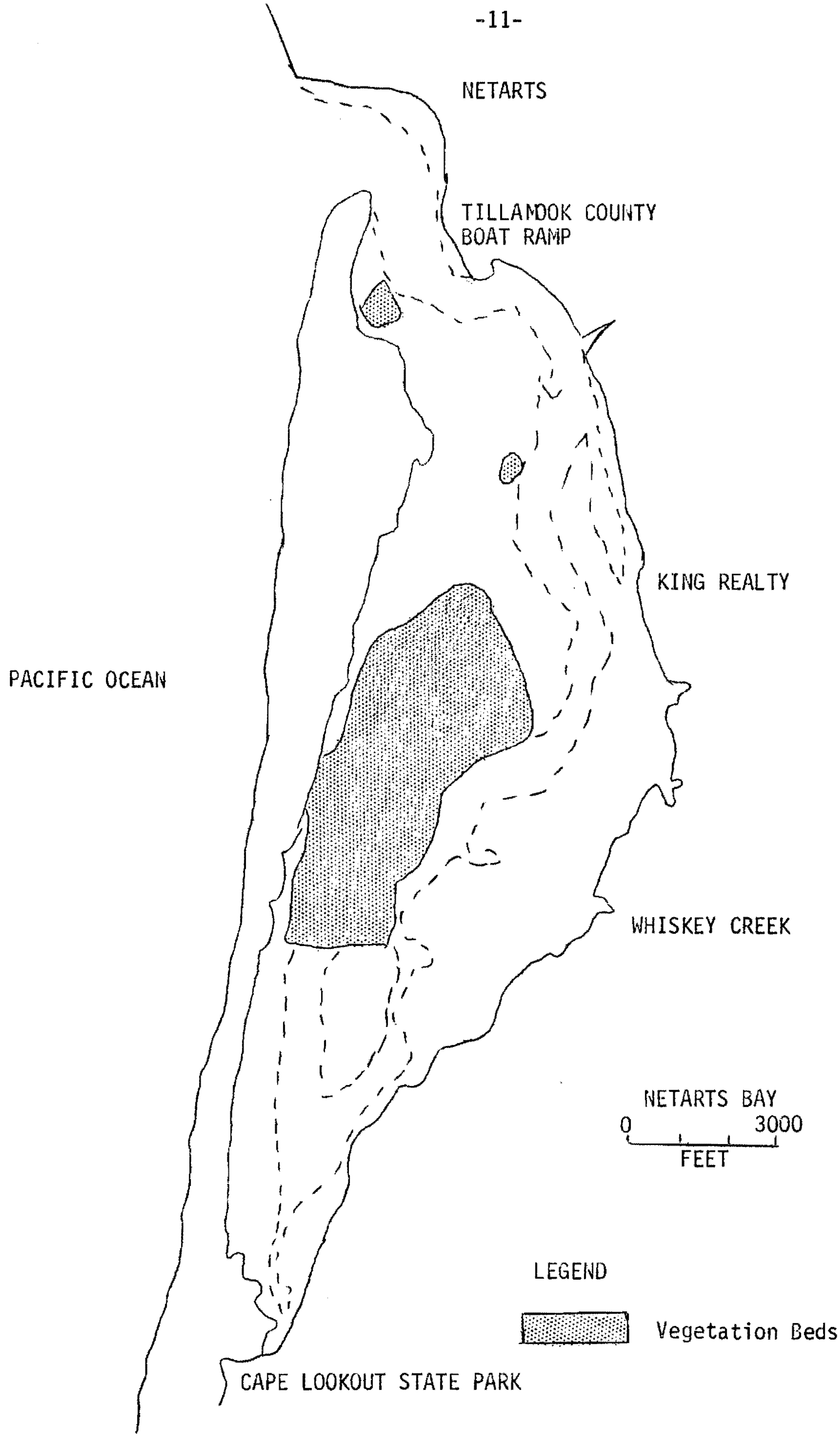

Figure 9. Vegetation.

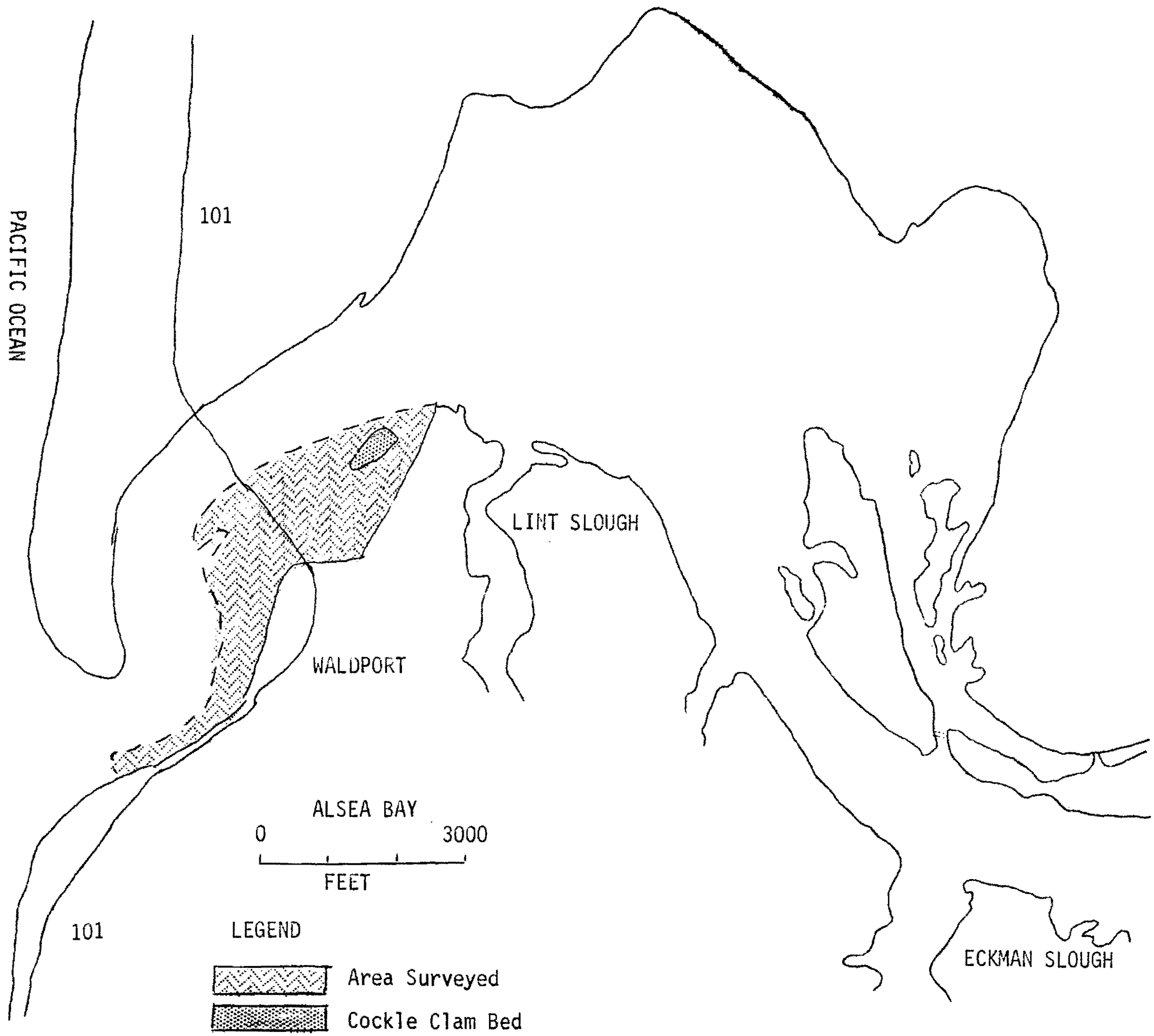

Figure 10. Area and Clam Bed Surveyed.

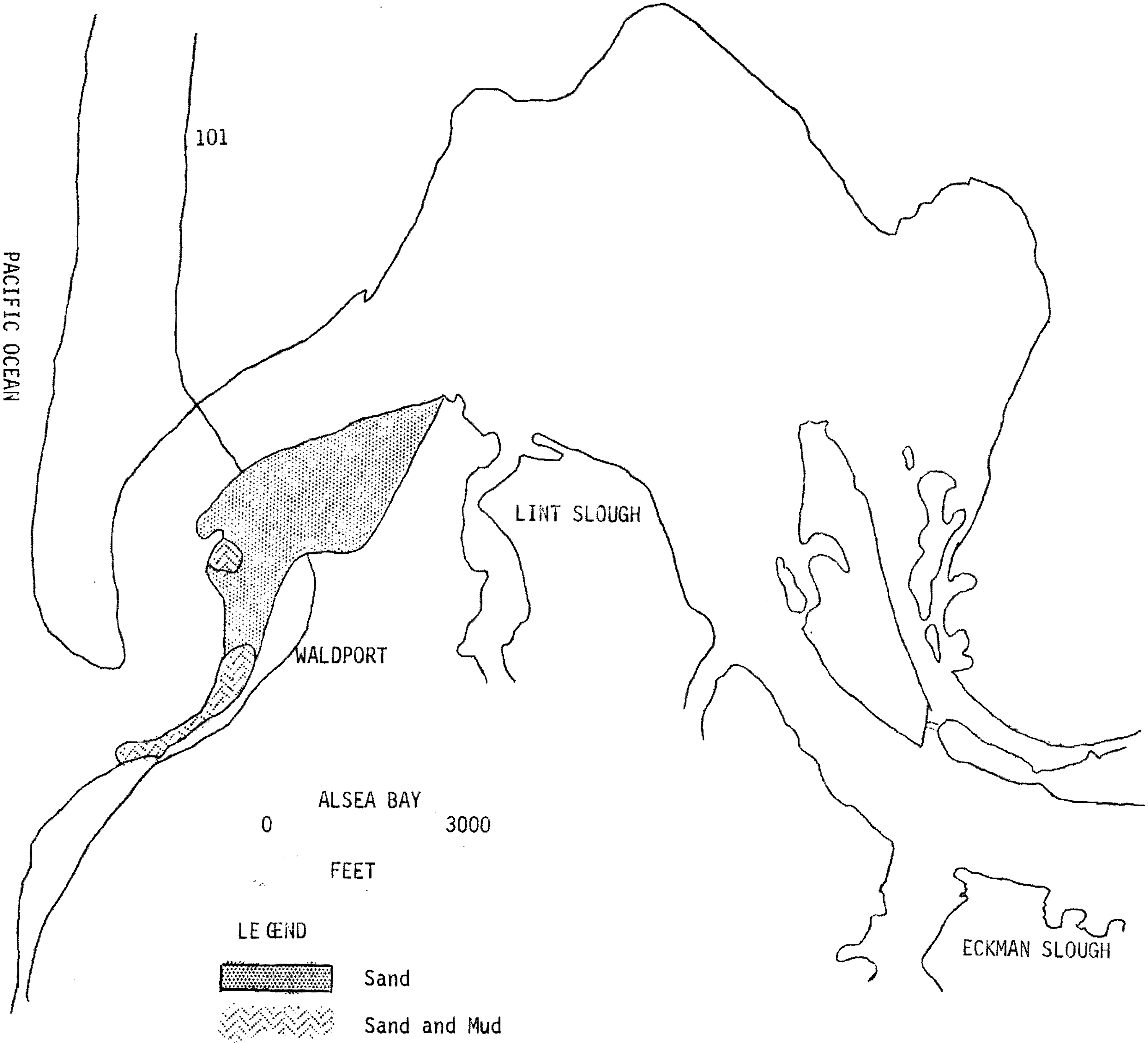

Figure 11. Substrate Types.

DISCUSSION

Results of our surveys indicates that substrate type is important for the establishment of different species of bay clams. Intertidally, cockle clams were more common in a sand, sand-mud, or sand-shell substrate. Gaper clams had a similar preference although fewer were found in a pure sand substrate than the cockle. Subtidally, both species were more abundant in a substrate of sand and gravel mixed with shell. Butter and Manila littleneck clams were found mainly in a substrate of compacted mud and sand.

Vegetation appeared to be a less significant factor than substrate type for governing the distribution of clams. In several areas, gaper and cockle clams were located in eel grass beds although it was not determined whether the substrate type or the eel grass was the principal factor for the clams setting in these areas.

CLAM STUDIES

METHODS

Laboratory Clam Rearing

Basic techniques and procedures for spawning and rearing clams were not altered from those used in previous years (Lukas 1972, 1973). A new rearing device was constructed and tested to determine if clams grew as well or better than those in our standard rearing tray. This device consisted of a 15.1 cm diameter plexiglass tube, 72 cm long. Two screened partitions (1.4 mm nylon mesh) placed at each end of the tubed created a compartment to hold juvenile clams. The rearing tube was placed upright and water pumped in at the bottom at a rate of 7-8 liters/minute. Four thousand Manila clams were held in the rearing tube.

Field Studies

Manila Littleneck Clams. Spot samples were made on the breakwater plot in Yaquina Estuary. This area was planted with 390,000 clams in the summer of 1972. Several subplots were planted with clams of various ages and mean shell lengths. This area, resulting from dredge spoil deposition, consists predominantly of walnut size river-run gravel (ranging from pea to baseball size) mixed with sand. Approximately two-thirds of the area slopes 7-8^{o} from the horizontal and the rest is level.

Experimental plots of laboratory-reared Manilas were established in three estuaries; Netarts, Coos, and Coquille.

In July and August 1973, we established plots in six different areas in Netarts Estuary after the intertidal sampling revealed the existence of a small population of natural-set Manilas. We planted 10,625 juvenile Manila clams in these test plots. One plot was established in one of the two areas where Manila adults were found. Five other areas, north and south of the natural Manila populations, were selected for experimental plantings to evaluate their potential for future Manila introductions. Five of the areas had substrate material consisting of firm sand and mud with a thin layer of silt on top. The sixth area was covered with a dense growth of eel grass. The plots were planted with clams averaging 7.3 mm (range 3.6-11.3 mm) and at a density of 50 clams/square foot.

Two Manila clam plots were established in Coos Estuary in August 1973. The site selected for the two plots was on a dredge-spoil island on the west side of the bay and approximately 1.3 miles upstream from the mouth of the estuary. The substrate consisted of a gravel-sand mix with broken gravel predominating. The two 10 by 20-foot plots were planted with juvenile Manilas, averaging 7.1 mm at a density of 50 clams/square foot.

A 10 by 20-foot plot was established in Coquille Estuary in August 1973 in a small intertidal area near the mouth. The substrate in the area consisted of a coarse sand-fine gravel mix. The Manila clams averaged 7.1 mm and were planted at a density of 50/square foot.

Butter Clams. In September 1970, 600 juvenile laboratory-reared butter clams (*Saxidomus giganteus*) were planted in Yaquina Estuary. The 3 by 10-foot plot was near the base of a breakwater in the lower estuary. The substrate consisted of a gravel-mud mix. The clams were 22 months old when planted and mean shell length was 20 mm. They were marked with an enamel paint to distinguish them from natural set butter clams also found in the area.

RESULTS

Laboratory Clam Rearing

Manila littleneck clams reared in the plexiglass tube had a slightly faster growth rate than the control group held in a partitioned tray (Table 1). For the first few weeks of the test, the screen used to seal the ends of the tube had a mesh size of 0.75 mm (side to side). This mesh was easily clogged with detritus occurring in the seawater. Changing to a screen with 1.4 mm mesh size reduced the problem.

Table 1. Comparison of Mean Shell Length Increase of Manila Littleneck Clams Held in Rearing Tube and Partitioned Tray.

	Mean Shell Length (mm)	
Date	Rearing Tube	Partitioned Tray
6-28-73	3.4	3.4
7-12	4.1	4.0
7-26	5.3	4.6
8-9	6.3	5.7
8-23	7.4	6.0
9-6	8.0	6.7
9-18	8.3	7.3
10-11	8.7	7.6
10-18	8.5	7.6

Field Studies

Manila Littleneck Clams. Sampling of the experimental plot on the breakwater in Yaquina Estuary revealed that survival of the juvenile Manilas was dependent upon whether the substrate was level or sloped (Table 2). However, one group of clams (lot number 69-sm) in one area did not demonstrate this and other factors may have influenced survival. With the exception of group 69-sm, survival of clams on the level area ranged from 20.9 - 30.4% while survival on the sloped area ranged from 3.8 - 4.1%. Survival of juvenile Manilas of group 69-sm located on the level area ranged from 3.3 - 3.8%, slightly better than those of the slope which ranged from 0.6 - 2.9%.

Table 2. Growth and Survival of Manila Littleneck Clams in Experimental Plots on Breakwater, Yaquina Estuary.

Experimental Clam Group	Substrate Gradient	Percentage Survival	Mean Shell Length (mm) When Planted	When Sampled	Increase	Approximate Tidal Height	Months in the Plot
#11	Level	20.9	5.3	10.4	5.1	4.0	8.0
#11	Slope	3.8	5.3	11.7	6.4	3.2	8.0
71-12B	Level	21.4	6.1	12.0	5.9	3.8	11.0
71-11A	Slope	4.1	4.1	11.8	7.7	3.3	11.0
71-9(lg)	Level	24.6	10.6	20.8	10.2	4.0	12.5
71-9(sm)	Level	30.4	6.7	16.1	9.4	4.0	12.5
69 sm-6	Level	3.8	6.6	13.0	6.4	3.6	12.5
5	Level	3.3	6.6	14.6	8.0	3.8	12.5
4	Slope	2.1	6.6	14.7	8.1	3.8	12.5
3	Slope	2.9	6.6	15.4	8.8	3.7	12.5
2	Slope	1.2	6.6	16.2	9.6	3.3	12.5
1	Slope	0.6	6.6	23.0	18.4	2.9	12.5

One group of clams (group 71.9) were screen-sorted into two size groups before planting and averaged 10.6 and 6.7 mm shell length. After 12.5 months in the plot, the average shell length of the "large" group increased 10.2 mm and the "small" group 9.4 mm.

Butter Clams. The experimental butter clam plot established near the base of the Yaquina Bay breakwater in September 1970 has been sampled twice (Table 3).

Table 3. Growth and Survival of Butter Clams Planted on the Breakwater September 1970.

Date Sampled	Mean Shell Length (mm)	Percentage Survival	Age of Clams (Months)	Months in Plot
7-13-72	37.0	31.7	44.5	22
7-30-73	46.7	46.7	57	34.5

The growth of the clams in this plot has been less than that of a comparable group planted on the breakwater in an artificial substrate plot located about 100 yards away (Lukas 1972) (Figure 12).

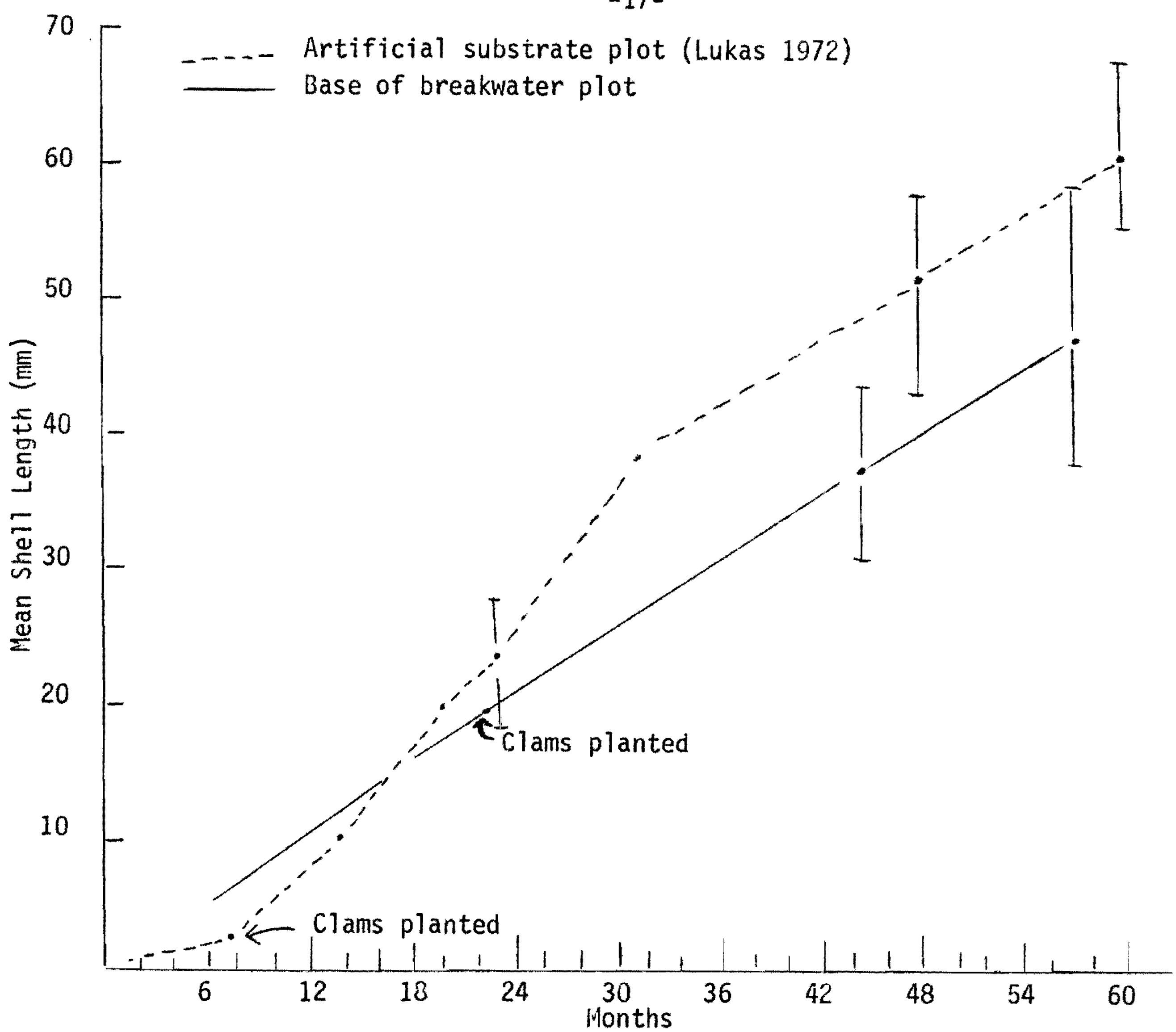

Figure 12. Growth Curve of Butter Clams Planted on the Breakwater, Yaquina Bay. Vertical lines indicate range in mm.

DISCUSSION

Laboratory Clam Rearing

The plexiglass rearing tube, in which juvenile clams grew at a slightly faster rate than controls, offers the advantage of being able to hold and rear a large number of clams in a smaller space than the currently-used trays. The maximum numbers of clams which could be held in this tube and the optimum water flow rates were not determined. Only 4,000 clams were used in the initial test.

Field Studies

Manila Littleneck Clams. Survival differences of clams planted on a slope and level area has been discussed in a previous progress report (Lukas 1972). The observation in 1972 was related also to substrate type. Higher survival occurred on a level area with a gravel substrate while poorer survival occurred on a slope area which had a sparse amount of gravel. The substrate composition of the areas sampled in 1973 on the breakwater in Yaquina Estuary was consistent on both the slope and level. Yet in 2 of 3 plots, there was a notable difference in survival between the two gradients. This area has a southern exposure and apparently wave action during winter stroms on a sloped surface is disruptive enough to scour clams out of the substrate, even if it has a protective layer of gravel on it.

Another observation from this plot was the comparison of growth of two groups of clams of the same age but of different mean lengths when planted. The increase in shell length of the two groups was similar.

Butter Clams. There is no data available on butter clam growth rates in Oregon to compare with the data on the clams planted near the breakwater. Growth rates of butters in these two experimental plots are comparable to growth rates of butter clams in British Columbia (Fraser and Smith, 1928; Quayle and Bourne 1972). From the results obtained so far, these laboratory-reared clams seem to be doing well in field plots.

ABALONE STUDIES

METHODS

Abalone Spawning

Adult abalone, to be used as spawning stock, were obtained from three areas; Fort Bragg, California, near Brookings, Oregon, and at Whale Cove near Newport, Oregon. Fifty adult abalone were collected at Fort Bragg in April 1973 and successfully transported with 100% survival to the Newport Laboratory in wooden fish boxes, lined and covered with damp burlap sacks. The abalone were held in the laboratory in two 550-liter tanks at a water temperature of 7-8 C for two months. The water was renewed every two weeks. We began conditioning the abalone in June. Filtered and sterilized seawater was run through the tanks at a rate of 3-5 l/min. The water was heated with a water immersion heater to 14 C (± 1 C). Lights in the room were adjusted to a period equaling the longest possible photoperiod occurring during the summer (5:30 AM - 9:00 PM). Bull kelp (*Nereocystis luetkeana*) blades were fed daily to the abalone.

Fourteen adult red abalone were collected from the southern Oregon coast in June 1973 and conditioned in the same way as the Fort Bragg animals. Abalone were collected from Whale Cove in September.

Attempts to spawn the abalone began in August 1973. Methods used were similar to those used in previous years (Lukas 1972, 1973). In addition we tried electrical shocking as a method to initiate spawning. Electrical current ranging from 5 - 15 volts for 5 seconds duration were tried.

Whale Cove Abalone

In June 1973 the intertidal area of Whale Cove was searched for red abalone planted as juveniles in May and June 1967. Sampling was conducted on days with low tides of -2.7 and -2.8 feet. Animals recovered were measured, tagged, and replaced.

RESULTS

Abalone Spawning

Spawning attempts with the red abalone were unsuccessful, at least under controlled conditions. Part of the problem may be our conditioning technique. There was a gain in gonad size during the conditioning period. We selected only those animals with the largest gonads for spawning purposes. However, since none of these animals spawned they may not have had fully developed gonads. Abalone obtained from the Brookings area had full gonads when collected but did not respond to spawning inducements. Several spawned in the conditioning tank one week after arrival at the laboratory. The spawning was at night and not induced. The majority of the larvae did not develop normally because of the possible excess sperm in the water. We did salvage several thousand viable larvae and held them in 2 liter beakers at a water temperature of 14 C. Some of the larvae developed to the setting stage but none settled on diatom-coated glass slides provided as a food source, and eventually died.

Whale Cove Abalone

Eighty-eight red abalone were located and tagged at Whale Cove. Average length of the abalone was 118.5 mm (range, 87-162 mm) and average width was 84.2 mm (range 60-117 mm). In six years these animals have grown 99.7 mm in average shell length.

Of the 88 abalone recovered, 15 had been tagged in June 1972. Of these 15, only 3 still retained the Peterson disc tag. The remaining 12 retained the stainless attachment wire. Growth of these three in one year was 2, 14, and 22 mm.

Six of the abalone were cut on the foot when they were retrieved. The animals were placed in the laboratory for observation. The most serious cut was approximately ½-inch into the side of the foot. All injuries healed in 2 - 3 months with no mortality. This survival after injury is contrary to what many workers have stated.

DISCUSSION

Abalone Spawning

During the past three years, we have attempted to spawn several groups of red abalone and thus far have been unsuccessful. We do not know specifically why the animals have not responded to spawning inducements. The methods used have been similar to those used by other investigators for other species of abalone. In addition we have tried innovations of our own. The occasional and unexpected spawnings which have occurred in the laboratory have indicated to us that the gonads of some of the animals were developed. Apparently we were not applying the right inducements at the right time, or there may be other factors such as poor water quality or water chemistry which has influenced the abalone.

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