Charleston

METHODS OF SUPPLEMENTING CLAM AND ABALONE PRODUCTION

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by
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METHODS OF SUPPLEMENTING CLAM AND ABALONE PRODUCTION

INTRODUCTION

The principal objectives of this study were: (1) to locate suitable intertidal and subtidal clam planting sites and to determine the feasibility of planting laboratory spawned clams; (2) to map locations of bay clams having commercial harvesting potential; (3) to develop techniques for spawning and rearing native species of clams and determine if fast growth is a heritable characteristic of the Manila littleneck clam *Venerupis philippinarium*; and, (4) to determine the feasibility of purchasing and planting juvenile red abalone *Haliotis rufescens* along the Oregon coast.

CLAM PLANTING SITES

During the year, clam surveys were conducted on Alsea and Tillamook bays and the South Slough portion of Coos Bay. Clam distribution surveys were completed on Yaquina Bay in 1973 (Lukas and Gaumer 1974).

Methods

Location of Suitable Intertidal and Subtidal Clam Planting Sites

We continued to evaluate the distribution of intertidal and subtidal clams using techniques developed during the 1973 fiscal year (Osis and Gaumer, 1973). Criteria used for determining areas having potential for planting clams included the presence of native clams (both intertidal and subtidal), substrate type, and water depth.

Results

Alsea Bay

Intertidal and subtidal clam distribution surveys were completed on Alsea Bay. We covered 152,600 feet of transect line during our survey and made 827 observations (Figures 1 and 2).

Figures 3 and 4 shows the distribution of the four main species of clams in Alsea Bay; gaper *Tresus capax*, cockle *Clinocardium nuttallii*, littleneck *Venerupis staminea*, and softshell *Mya arenaria*.

The softshell clam was the principal species found in the bay. In the intertidal areas densities of small clams (less than 1" long) were greater than $10/ft^2$ in many of the samples whereas densities were generally less than $2/ft^2$ for the larger clams.

Figures 5 and 6 show the substrate material of Alsea Bay. Much of the substrate of the lower bay consist of unstable, shifting sand. Sand with scattered shell was common in the mid-bay subtidal area while mud and sand was predominate in the up-bay intertidal area.

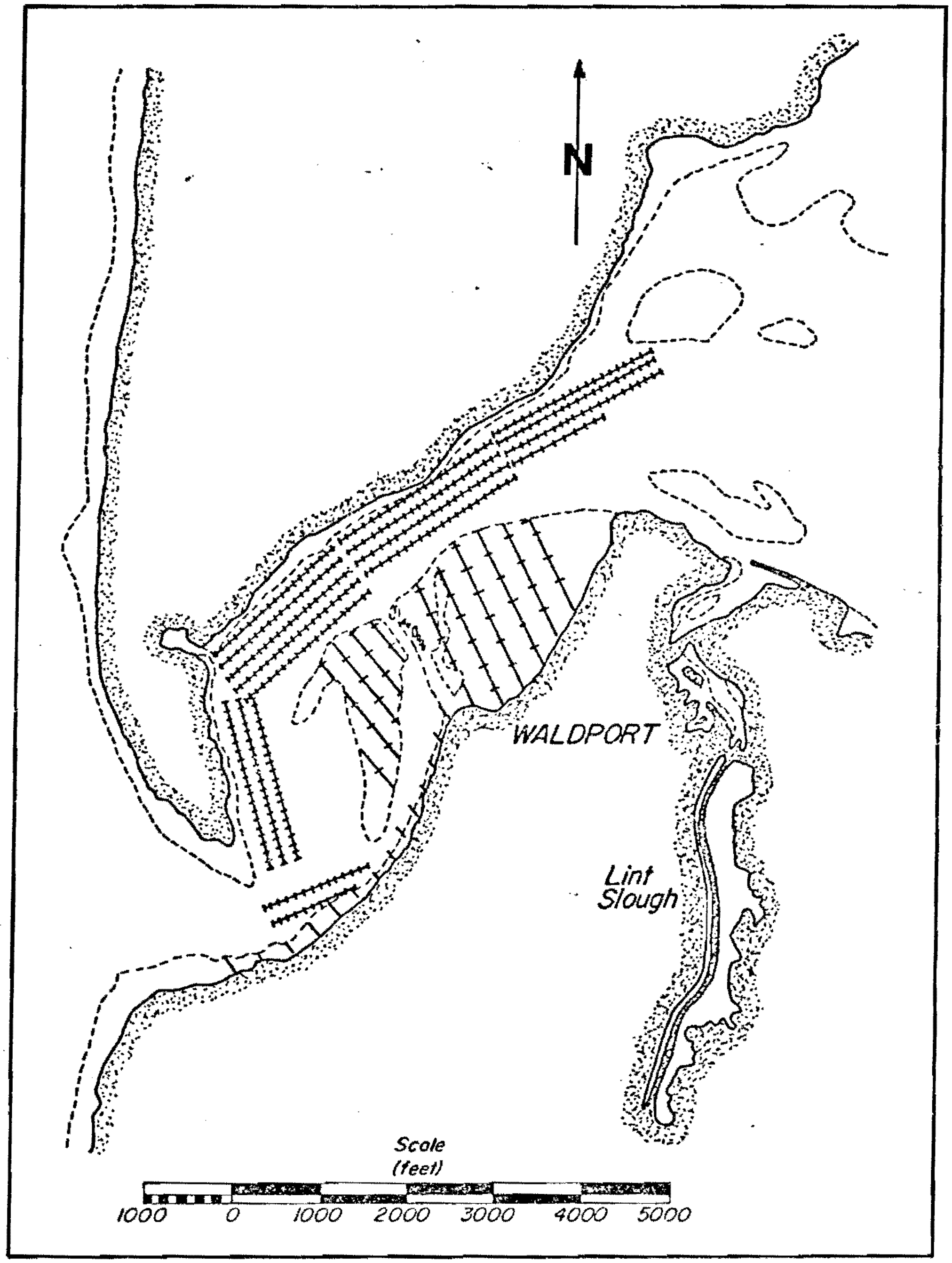

Figure 1. Intertidal and Subtidal Clam Survey Transect Lines and Sample Stations, Lower Alsea Bay, 1974

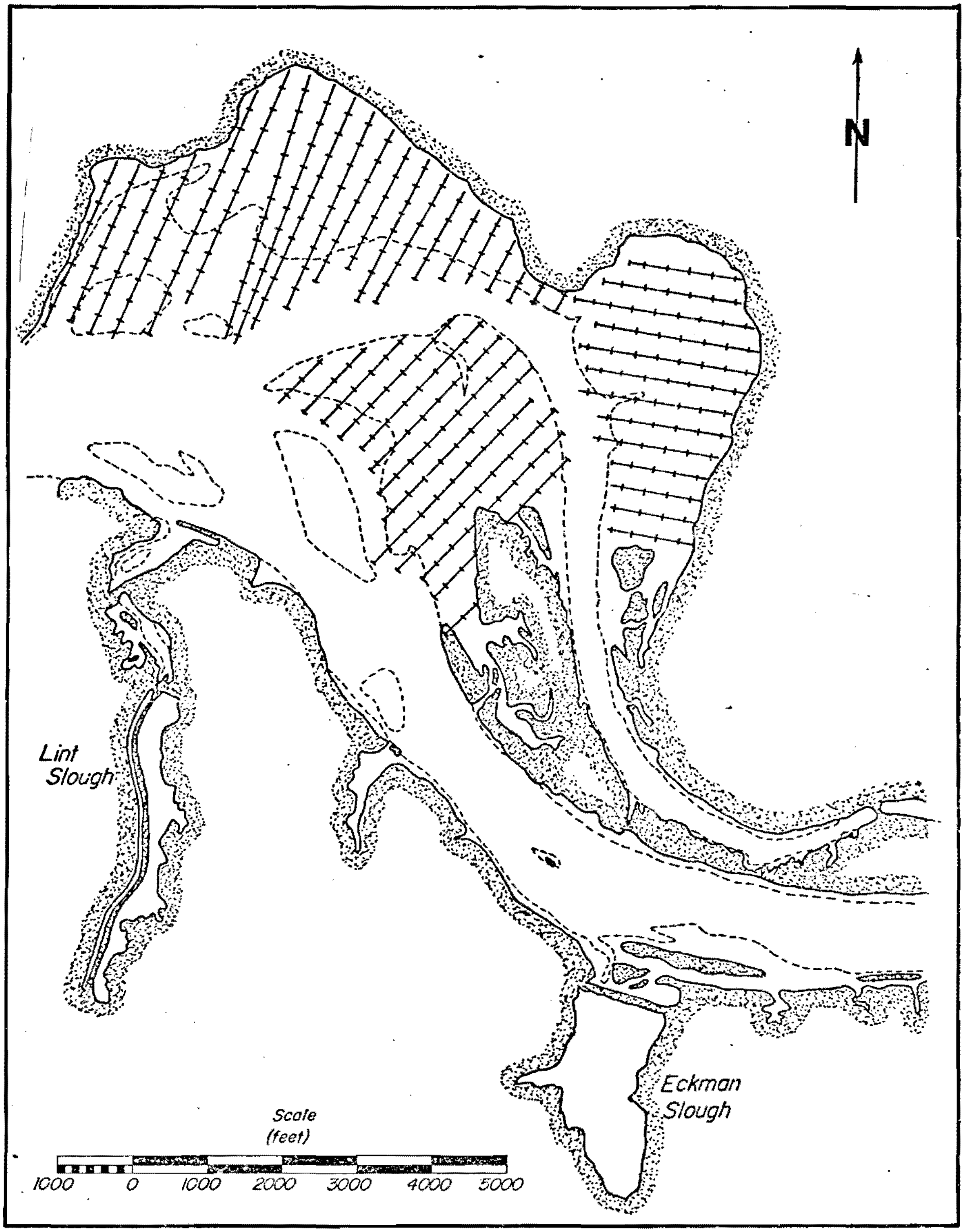

Figure 2. Intertidal Clam Survey Transect Lines and Sample Stations, Upper Alsea Bay, 1974

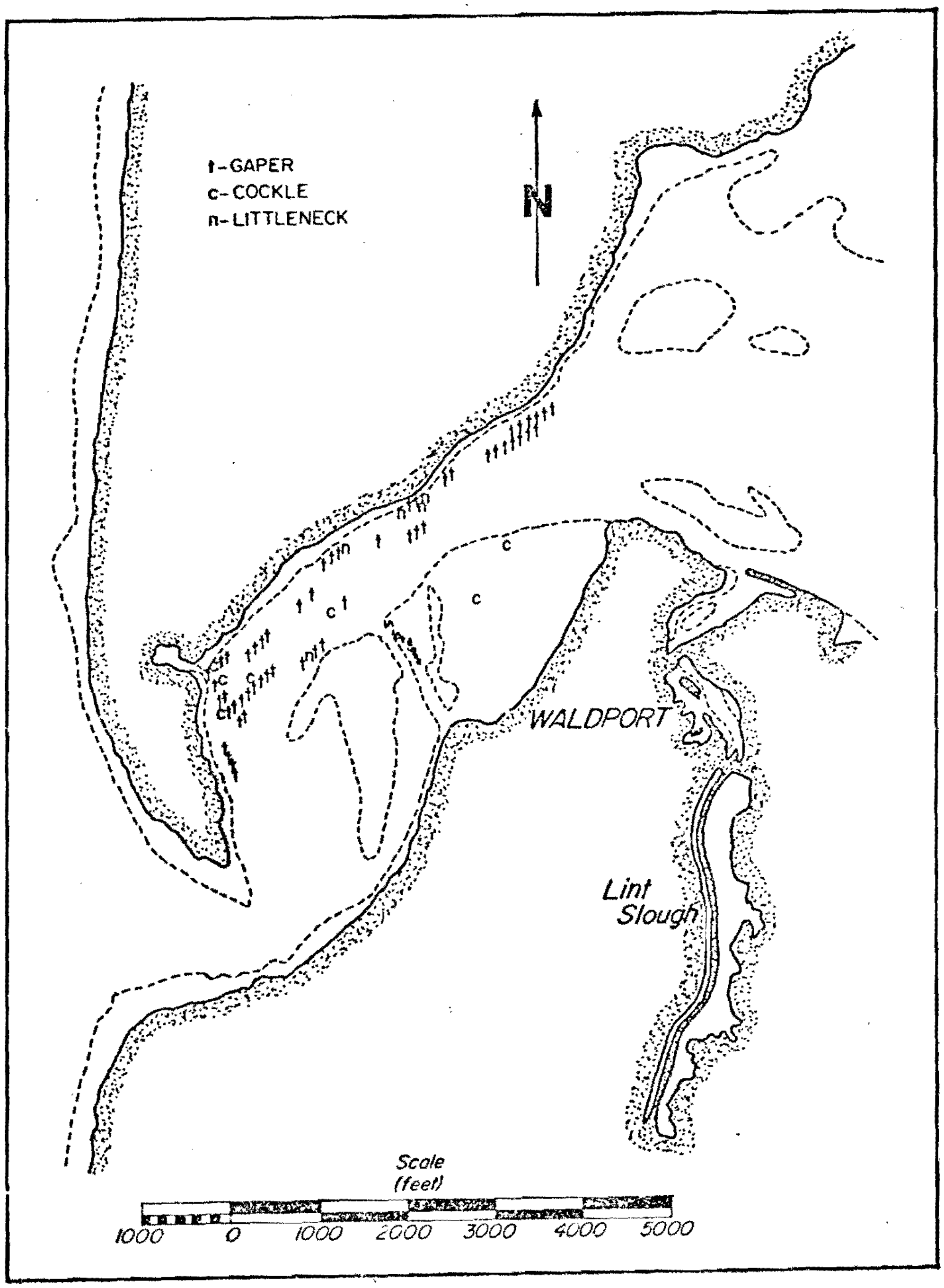

Figure 3. Distribution of Clams, Lower Alsea Bay, 1974

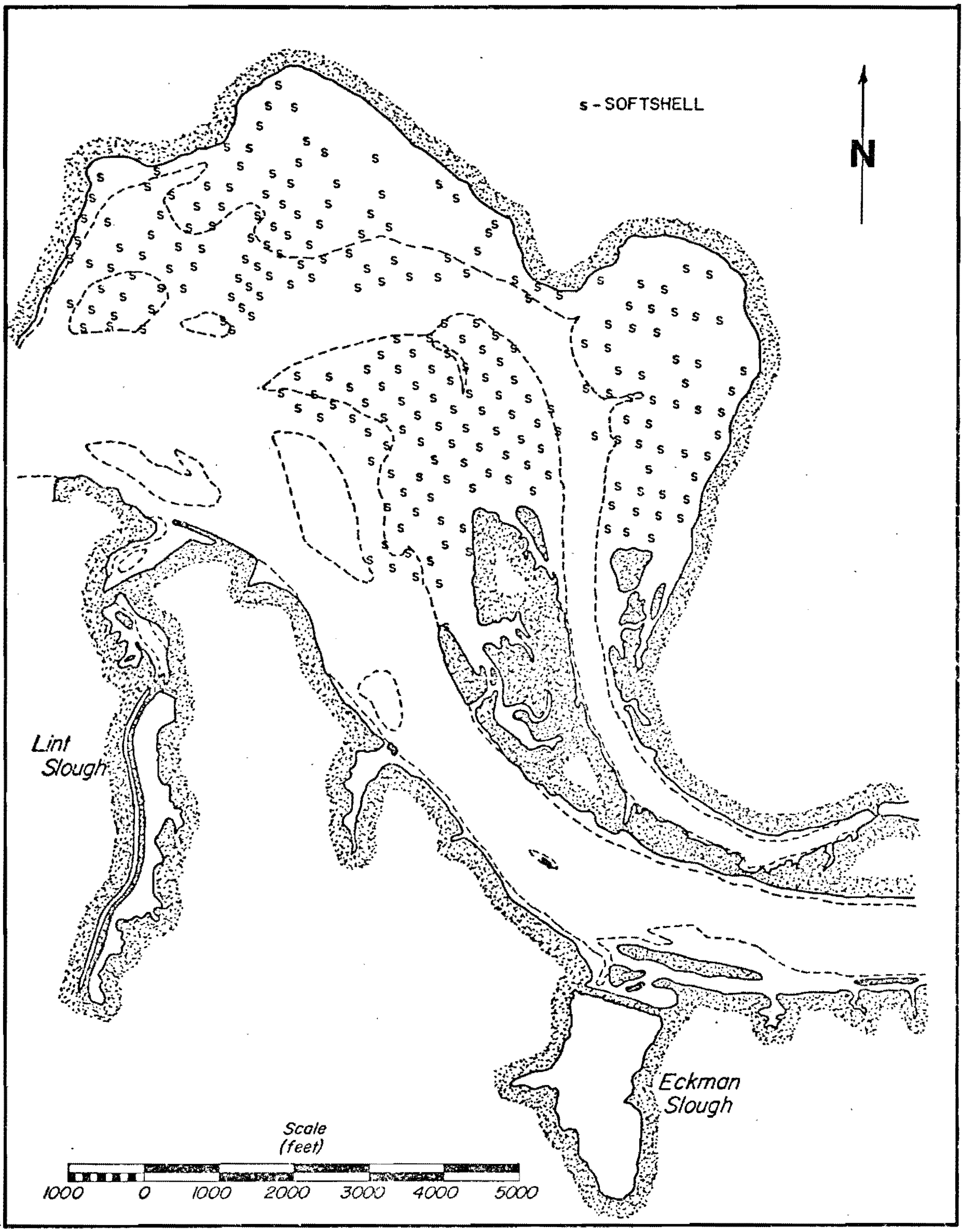

Figure 4. Distribution of Clams, Upper Alsea Bay, 1974

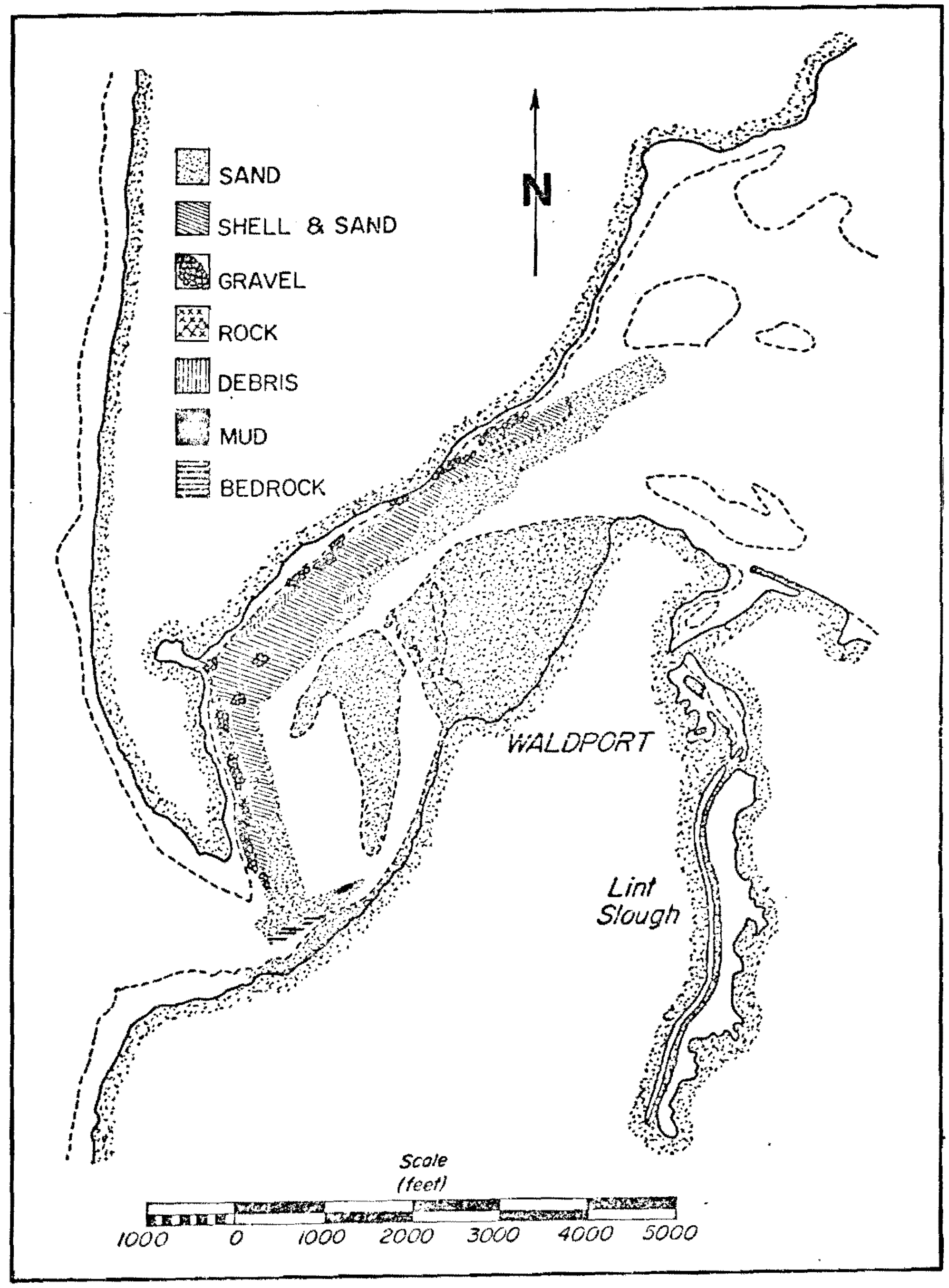

Figure 5. Substrate Material of the Lower Alsea Bay, 1974

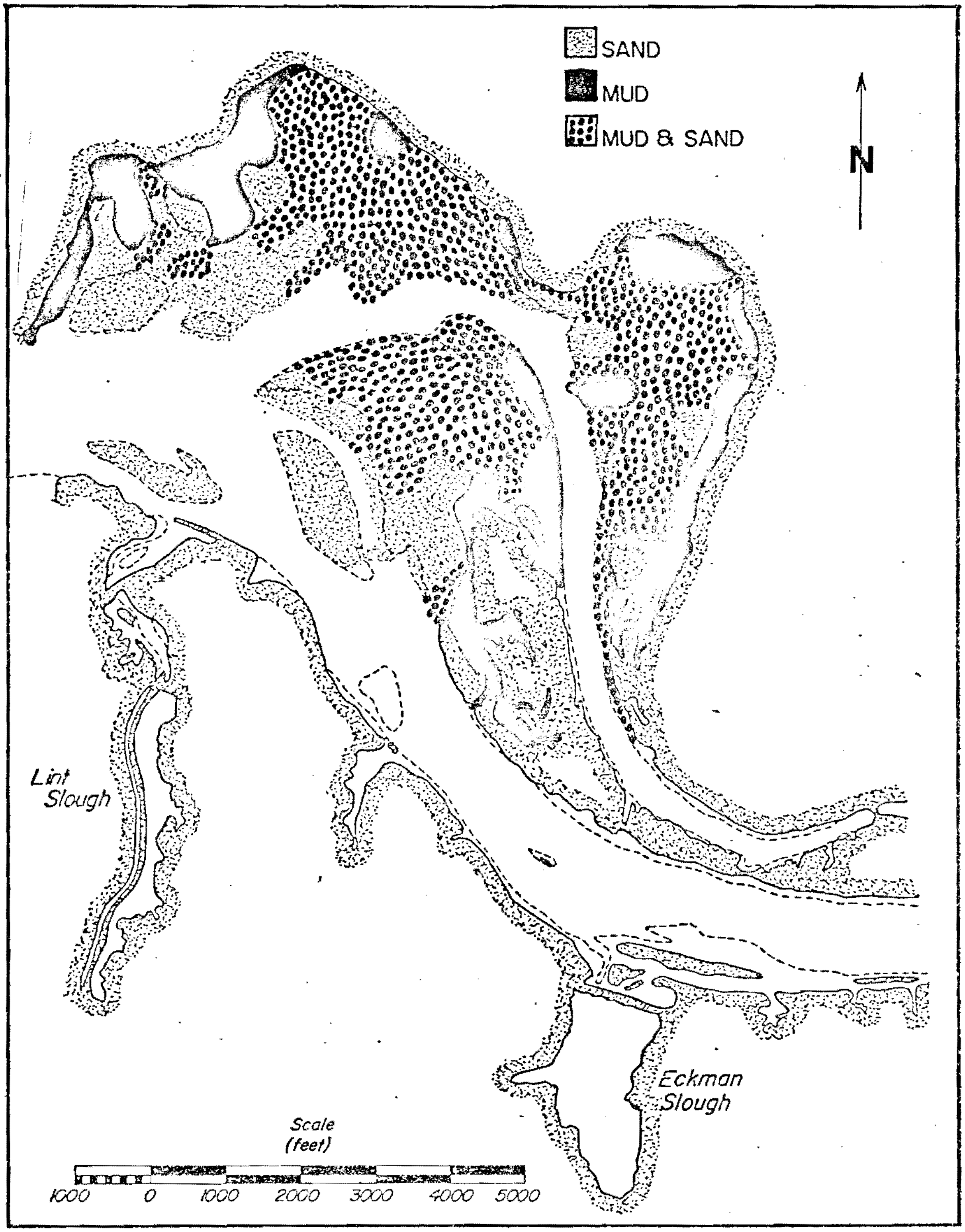

Figure 6. Substrate Material of the Upper Alsea Bay, 1974

Tillamook Bay

Approximately 80% of the Tillamook Bay subtidal area was surveyed. This re presents 840 observations along 84,000 feet of transect line. Figure 7 shows the transect lines and sample stations. To date, none of the intertidal tideflats have been surveyed.

The subtidal distribution of cockle, gaper and littleneck clams are shown in Figure 8. The 100 acre clam bed adjacent to Hobsonville Point and Larson Cove proved to be the most substantial clam bed yet mapped.

Much of the substrate was sand with varying amounts of other material (primarily shell and gravel) mixed with the sand (Figure 9). Rock and bedrock was common in the main channel areas whereas mud mixed with sand was prevalent in areas of lesser current.

South Slough of Coos Bay

Much of the subtidal area of South Slough was surveyed during 1974 when we covered 31,600 feet of transect and made 316 observations (Figure 10).

Figure 11 shows the subtidal distribution of cockle, piddock, softshell, gaper, and littleneck clams. Of particular interest was the scattered concentrations of cockle and gaper clams throughout the Charleston ship channel.

Sand and a combination of shell mixed with sand was the predominate substrate material throughout the channel areas (Figure 12). An extensive rock shelf covered much of the bottom across and down bay from the Charleston boat basin.

SURVEYS OF POTENTIAL COMMERCIAL CLAM BEDS

As a result of our clam distribution studies, four commercial fishermen have requested permits to harvest clams in Yaquina Bay and two have applied for Tillamook Bay permits. (A special permit is required to commercially harvest subtidal clams in Oregon by any means other than hand or hand powered tool). Because of the commercial harvest potential, additional quantitative data were collected on subtidal clam stocks of Yaquina and Tillamook bays.

Methods

Yaquina Bay

We located and mapped 18 definable subtidal clam beds in Yaquina Bay during the distribution phase of our survey (Figure 13). These beds covered 560 acres of which 260 were classified as having dense concentrations (greater than one clam per square foot) of clams. The remaining 300 acres, although containing a large number of clams, were considered too sparsely populated to support a commercial fishery. Approximately 160 acres of the 260 acres are in an area closed to the commercial harvest of shellfish by the Oregon State Board of Health. The remaining 100 acres of "open area" occur between McLean Point and Coquille Point, about 2½ miles upbay from the mouth of Yaquina Bay.

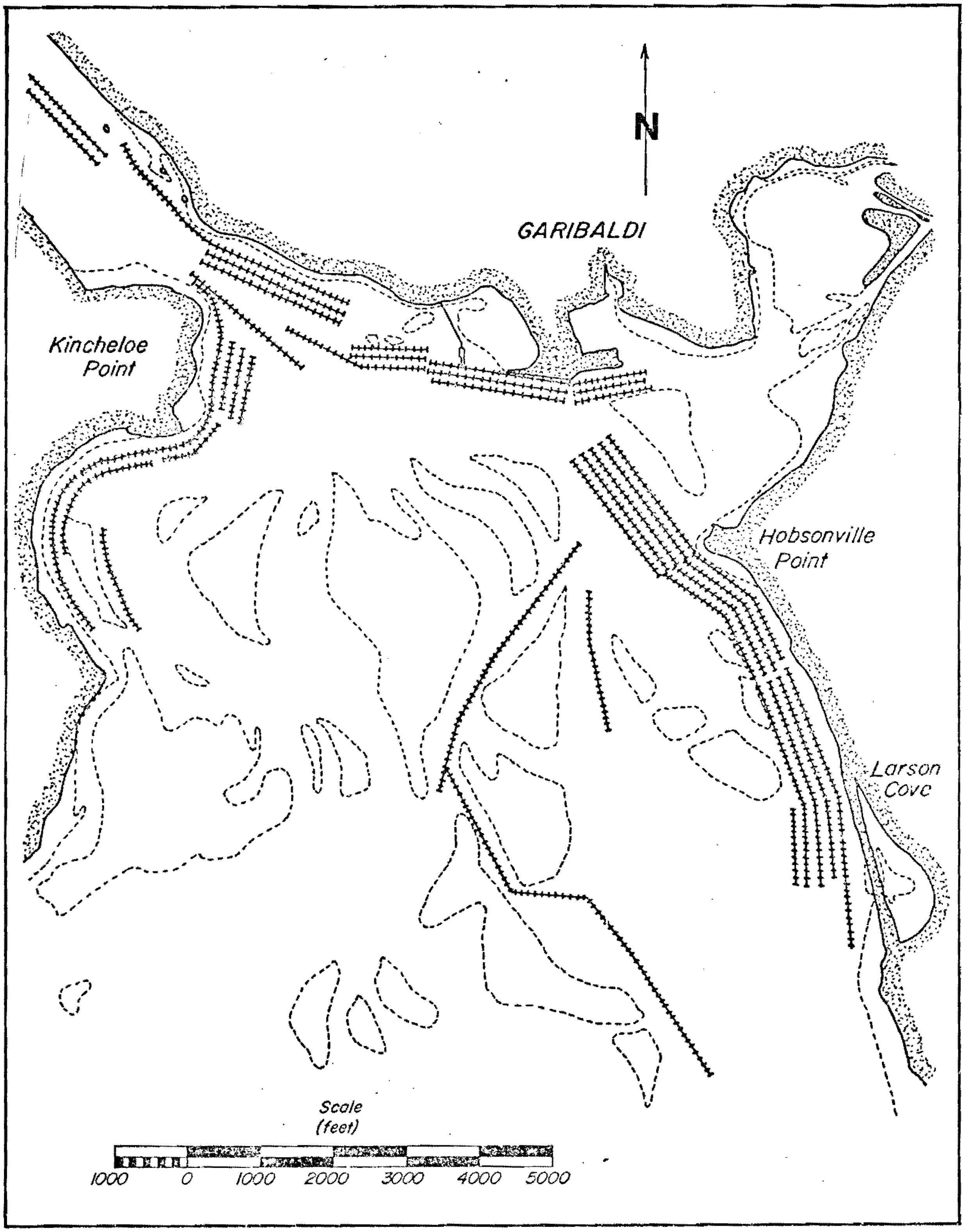

Figure 7. Subtidal Clam Survey Transect Lines and Sample Stations, Tillamook Bay, 1974

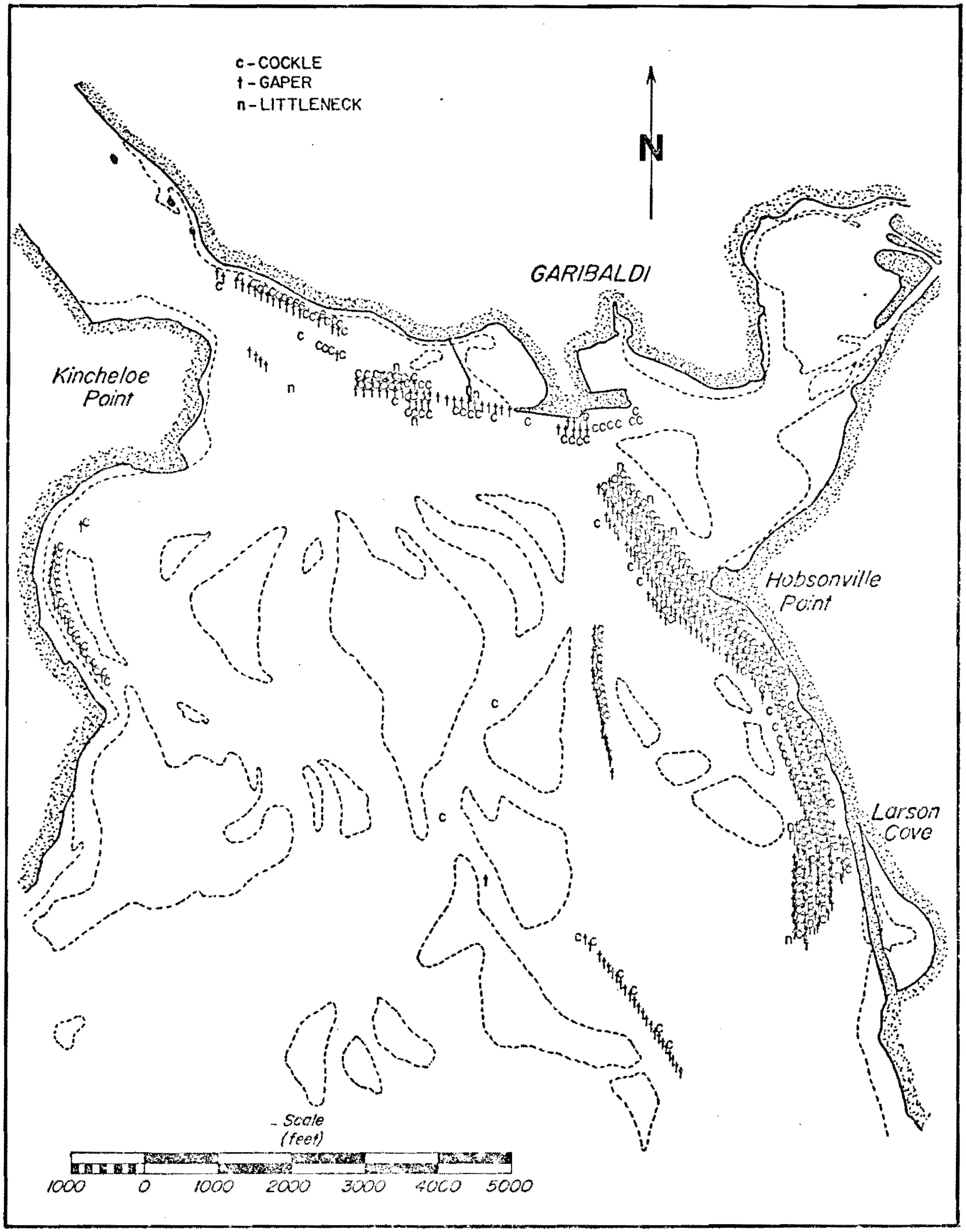

Figure 8. Distribution of Subtidal Clams, Tillamook Bay, 1974

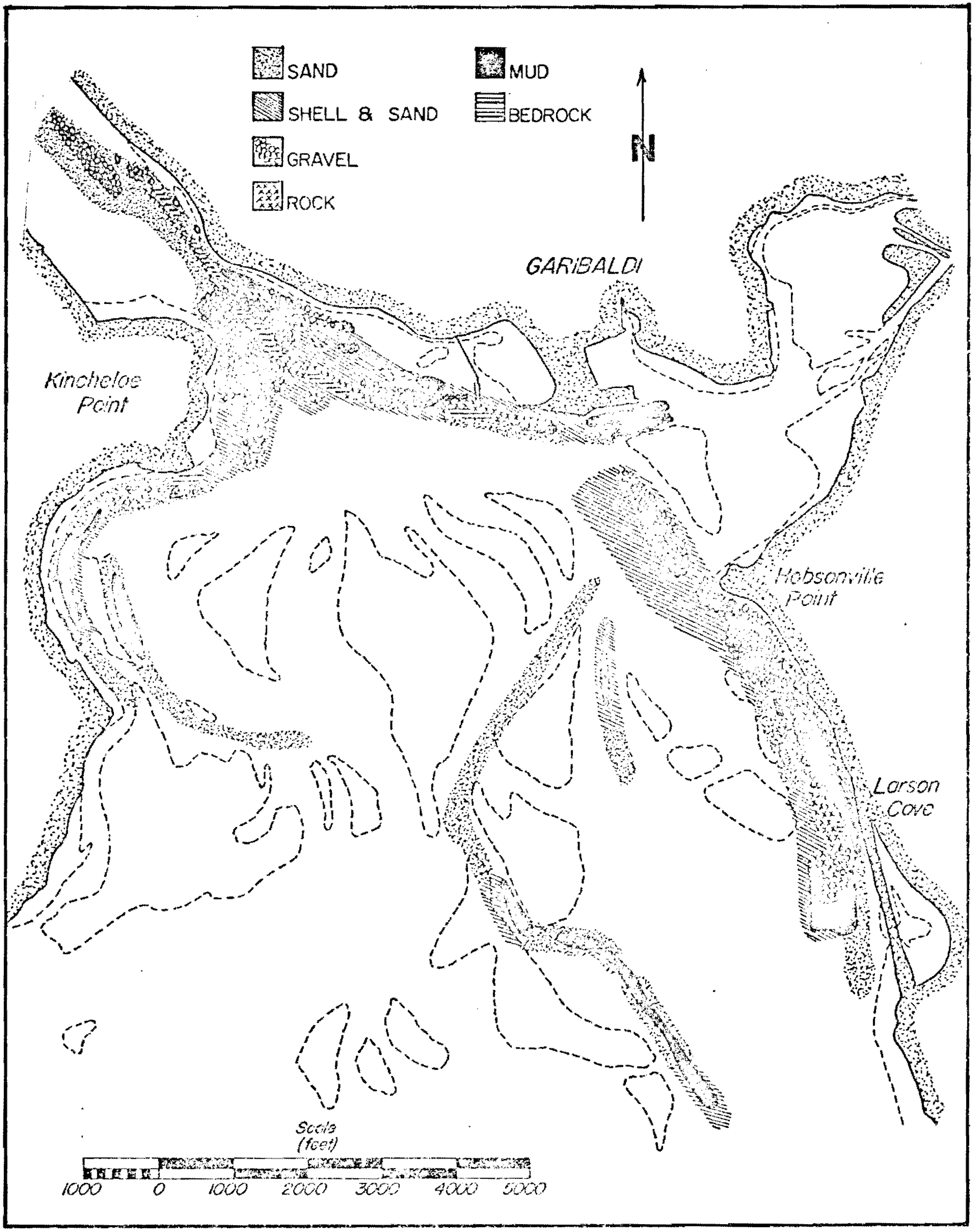

Figure 9. Subtidal Substrate Material of Tillamook Bay, 1974

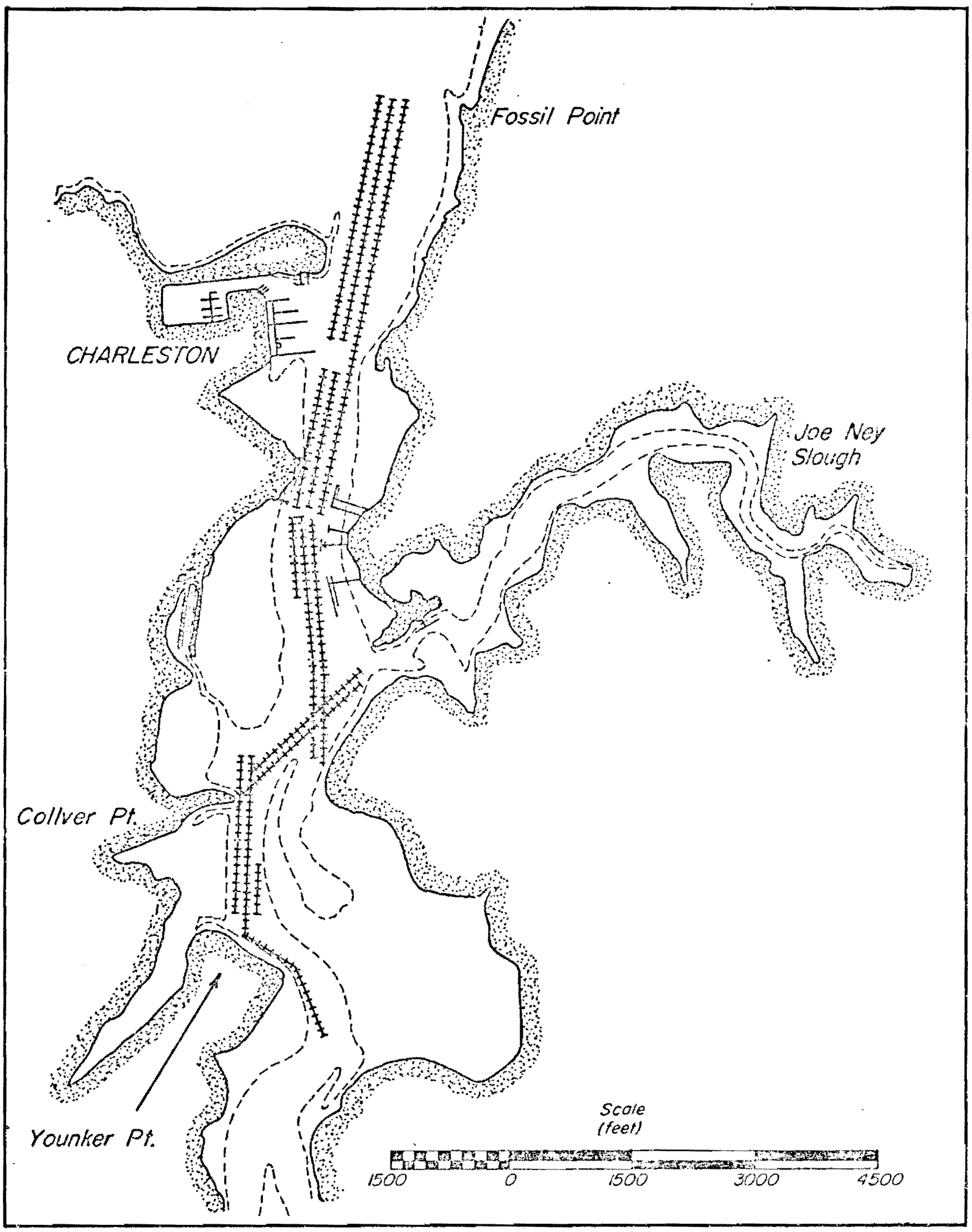

Figure 10. Subtidal Clam Survey Transect Lines and Sample Stations, South Slough of Coos Bay, 1974

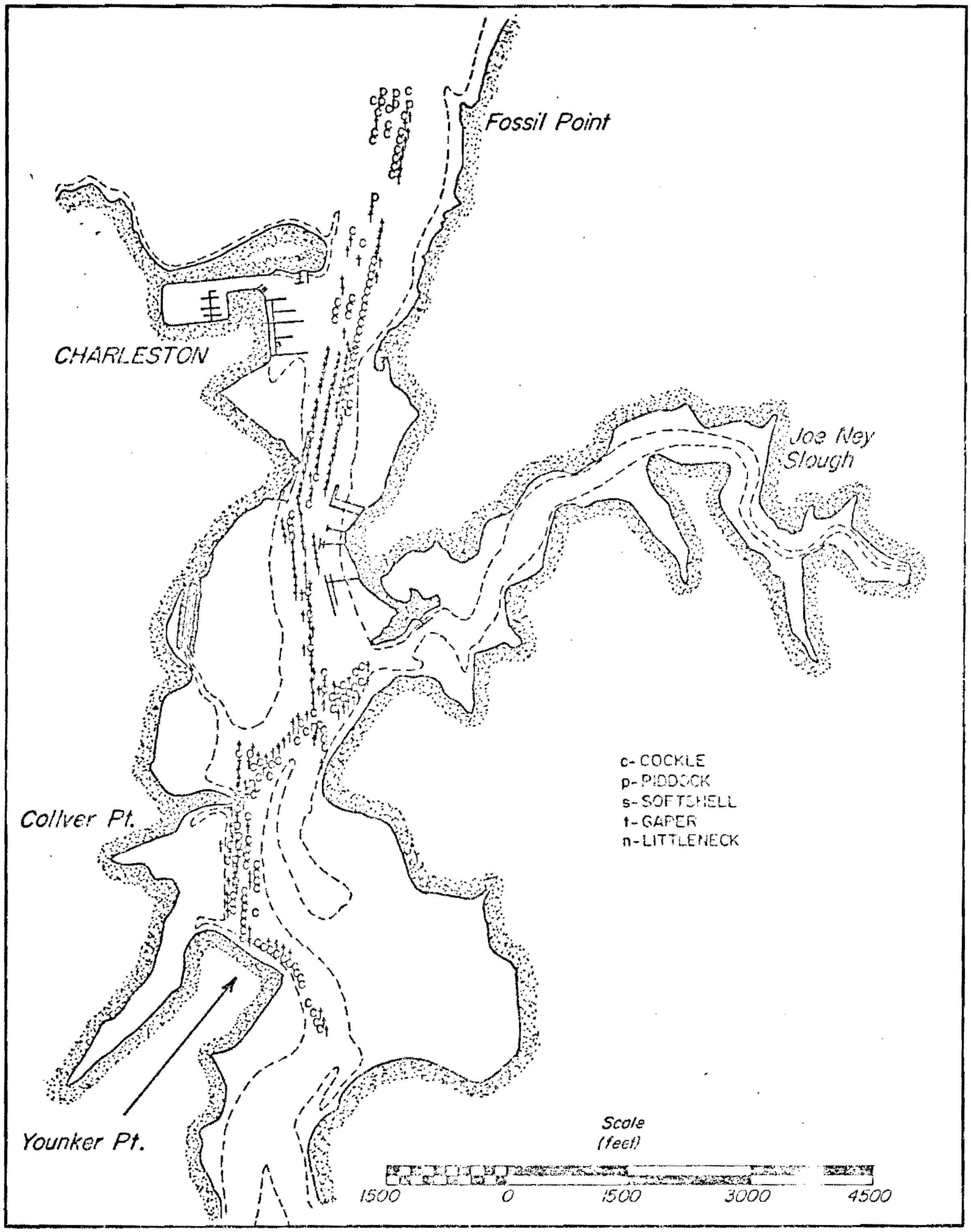

Figure 11. Distribution of Subtidal Clams, South Slough of Coos Bay, 1974

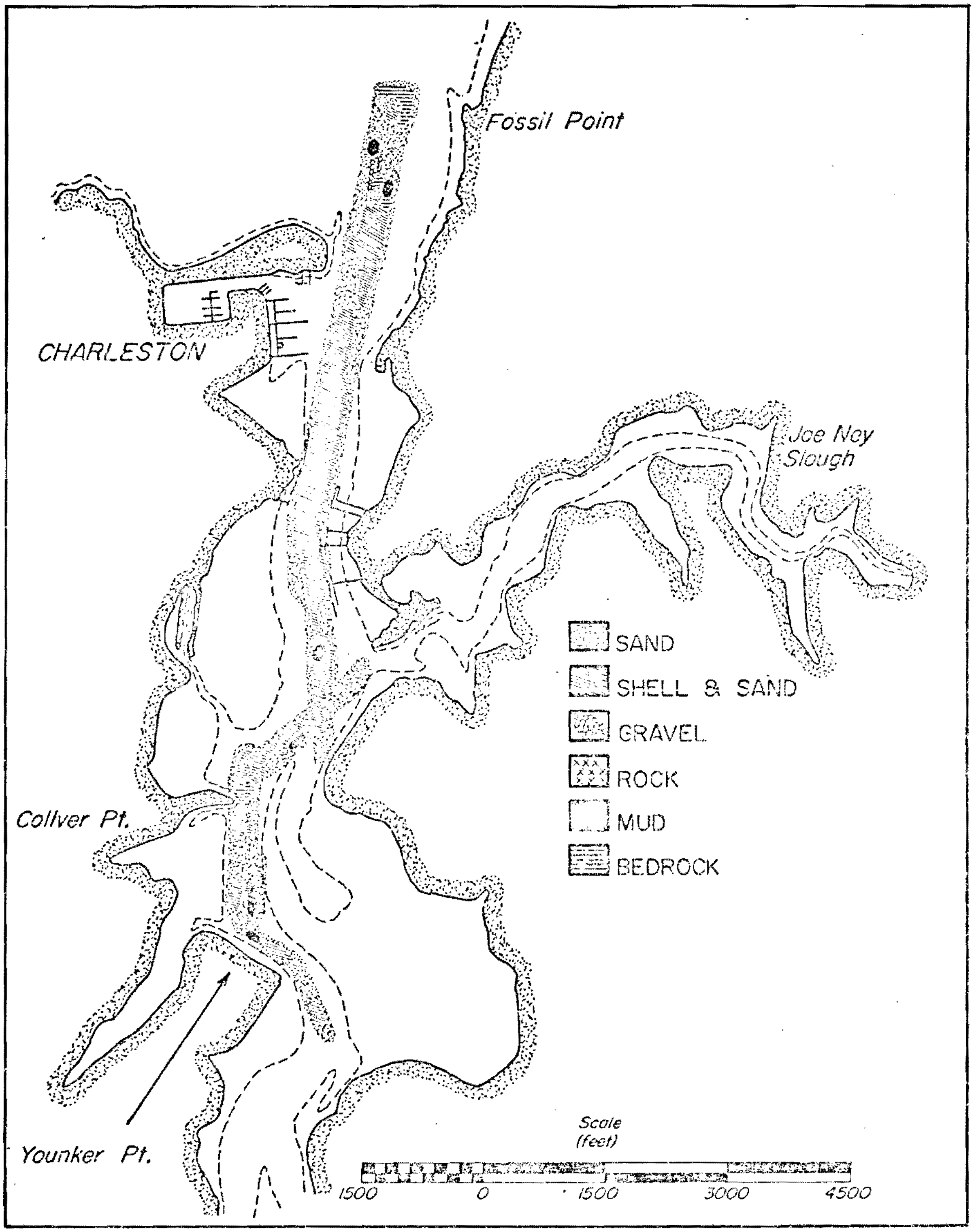

Figure 12. Substrate Material of South Slough of Coos Bay, 1974

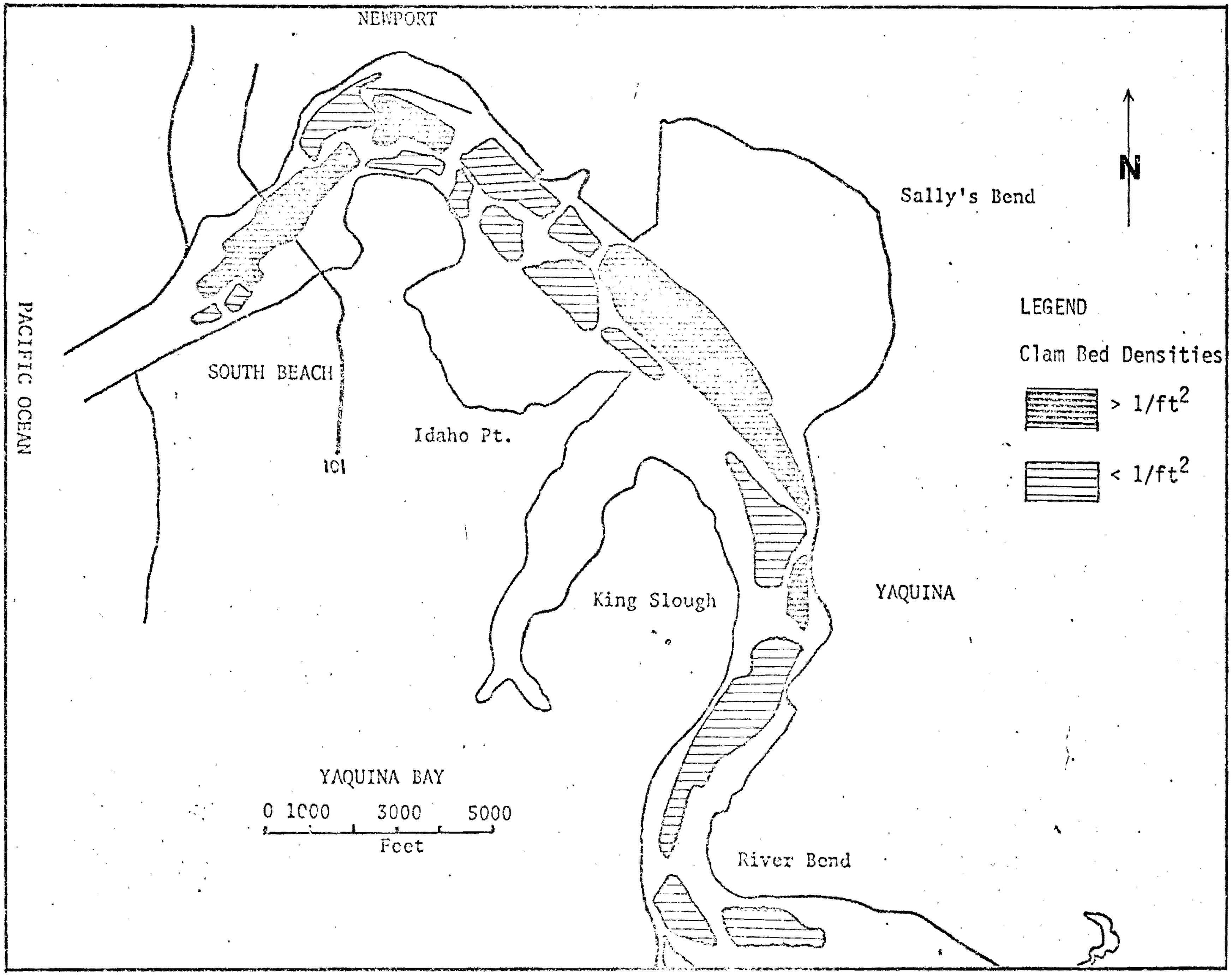

Figure 13. Subtidal Clam Beds in Yaquina Bay, 1974

The "open" subtidal clam bed in Yaquina Bay was subdivided into three sections (13-A, 13-B and 13-C). Areas 13-A and 13-B (38 and 27 acres respectively) contained dense concentrations of clams and area 13-C (75 acres) was sparsely populated (Figure 14). A sampling grid was designed for each area with sampling intensity being proportionate to the number of clams observed in the areas during the distribution study. We collected 301 samples; 134 in area 13-A, 93 in 13-B, and 74 in 13-C. Samples were collected by scuba divers using a suction dredge as described by Gaumer (1972). Sample size was 2-square feet of surface area. Each sample was excavated to a depth of approximately 12 to 18 inches or until the dredge operator was confident all clams had been removed. The dredge was fitted with a collection basket covered with ½-inch mesh vinyl covered hardware cloth that retained all clams 10 mm and larger. The retained dredge material was emptied from the basket and sorted in the boat. All clams were saved and placed in plastic sacks, labeled, and brought to the laboratory. Length measurements (in mm) were taken from all clams except the cockle where height (rib length) was used. All clams were weighed to the nearest lower gram. Gaper clams were cut open, washed and drained prior to weighing. All other clams were weighed alive. All cockle, gaper and littleneck clams and young butter clams *Saxidomus giganteus* were aged. Annual growth rings were counted on the butter, cockle and littleneck clams, while annual rings in the ligament scar were used to age gaper clams. Indistinct growth rings on the older butter clams precluded aging them beyond their 5th or 6th year.

Tillamook Bay

To date seven subtidal clam beds have been mapped in Tillamook Bay (Figure 15). Only one of these beds appeared to contain commercial quantities of clams. This 100-acre bed follows the channel from just below Hobsonville Point to Larson Cove. A major portion of this bed is located in the unrestricted shellfish harvesting or "open" area.

Using the same techniques as used on Yaquina Bay, we started an evaluation of the clam resources in the Hobsonville Point clam bed. Time constraints only allowed us to complete abundance and age composition estimates on one half of the 100-acre clam bed. Estimates for the other half will be completed in 1975.

Results

Yaquina Bay

Figure 16 shows the occurrence of butter, cockle, gaper and littleneck clams in our dredge samples. Two different observed concentrations of clams per sample are illustrated; those samples having less than 2 clams/square foot and those samples having more than 2 clams/square foot.

From our dredged samples we estimated that 7.1 million clams inhabit area 13 in Yaquina Bay (Table 1). Of this total, 1.9 million were found in area 13-A, 4.2 million in 13-B, and 885,000 in 13-C. Four of the 8 species dredged (butters, cockles, gapers and littlenecks) were considered commercially desirable. Clams of the remaining species were too small in size or few in number. Of the "desirable" clams, only gapers appeared in numbers (2.3 million) large enough to sustain a commercial fishery. An incidental fishery might utilize some of the other three species of clams but probably only in conjunction with a gaper fishery.

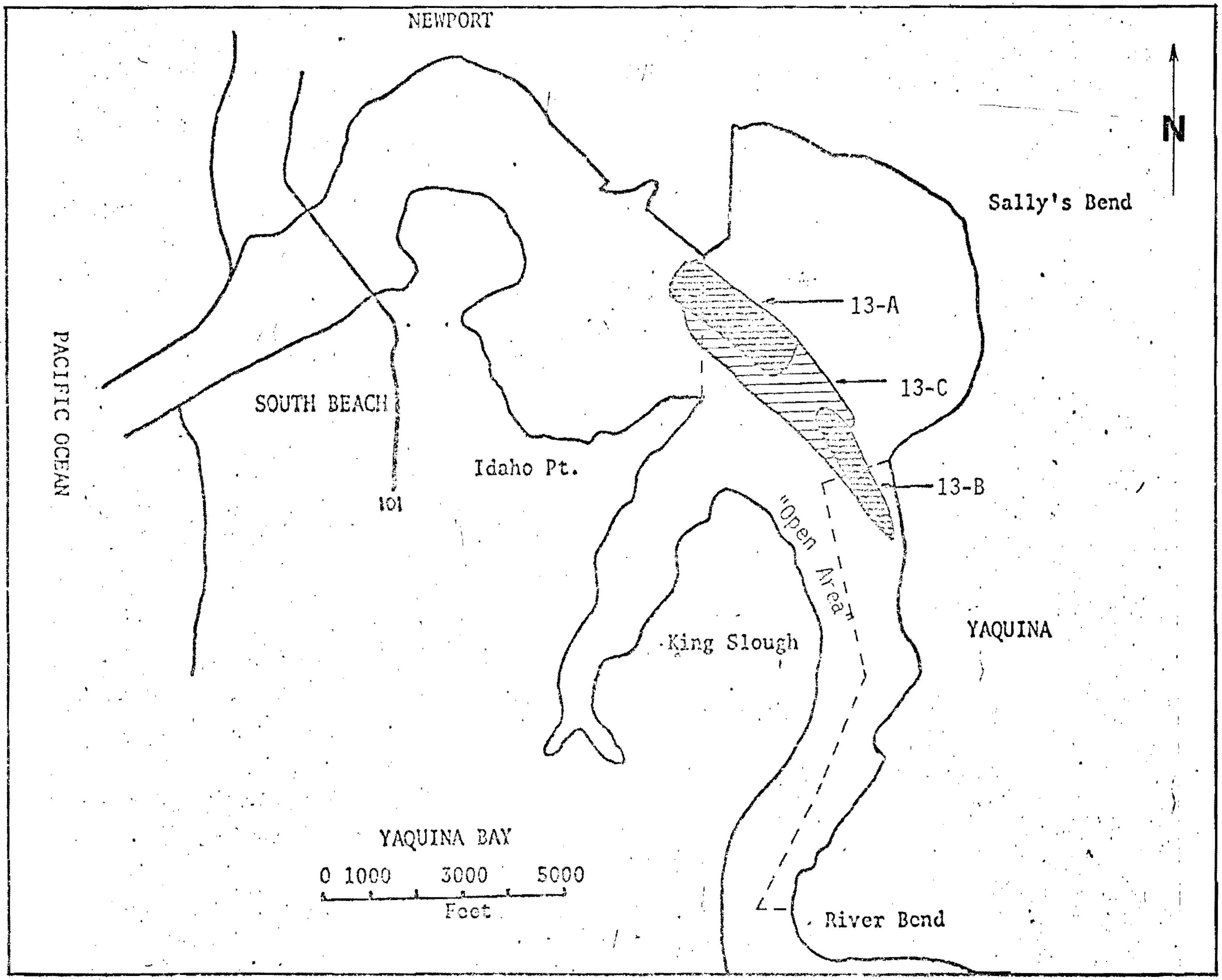

Figure 14. Subtidal Clam Bed (Area 13) in Yaquina Bay, 1974

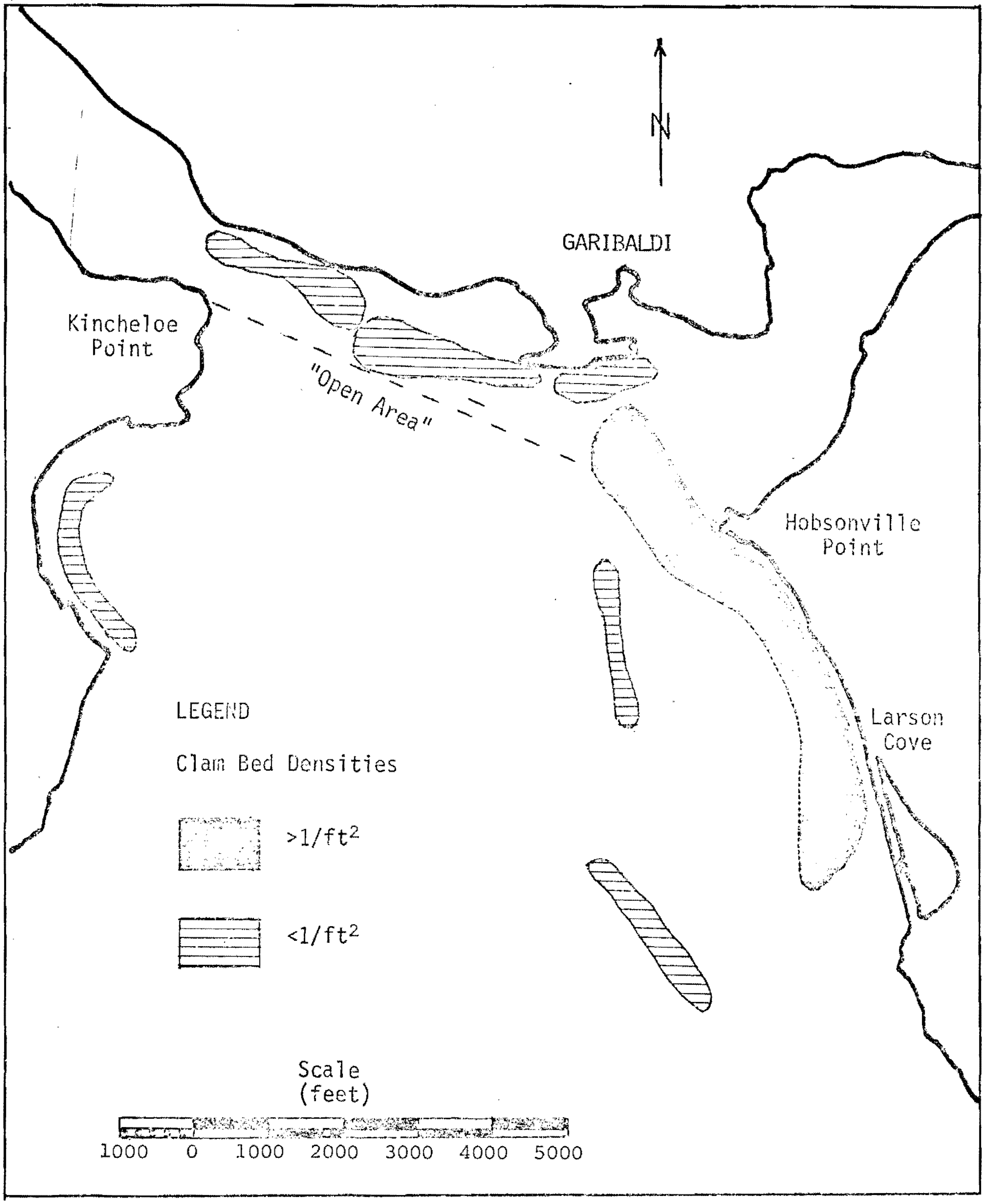

Figure 15. Subtidal Clam Beds in Tillamook Bay, 1974

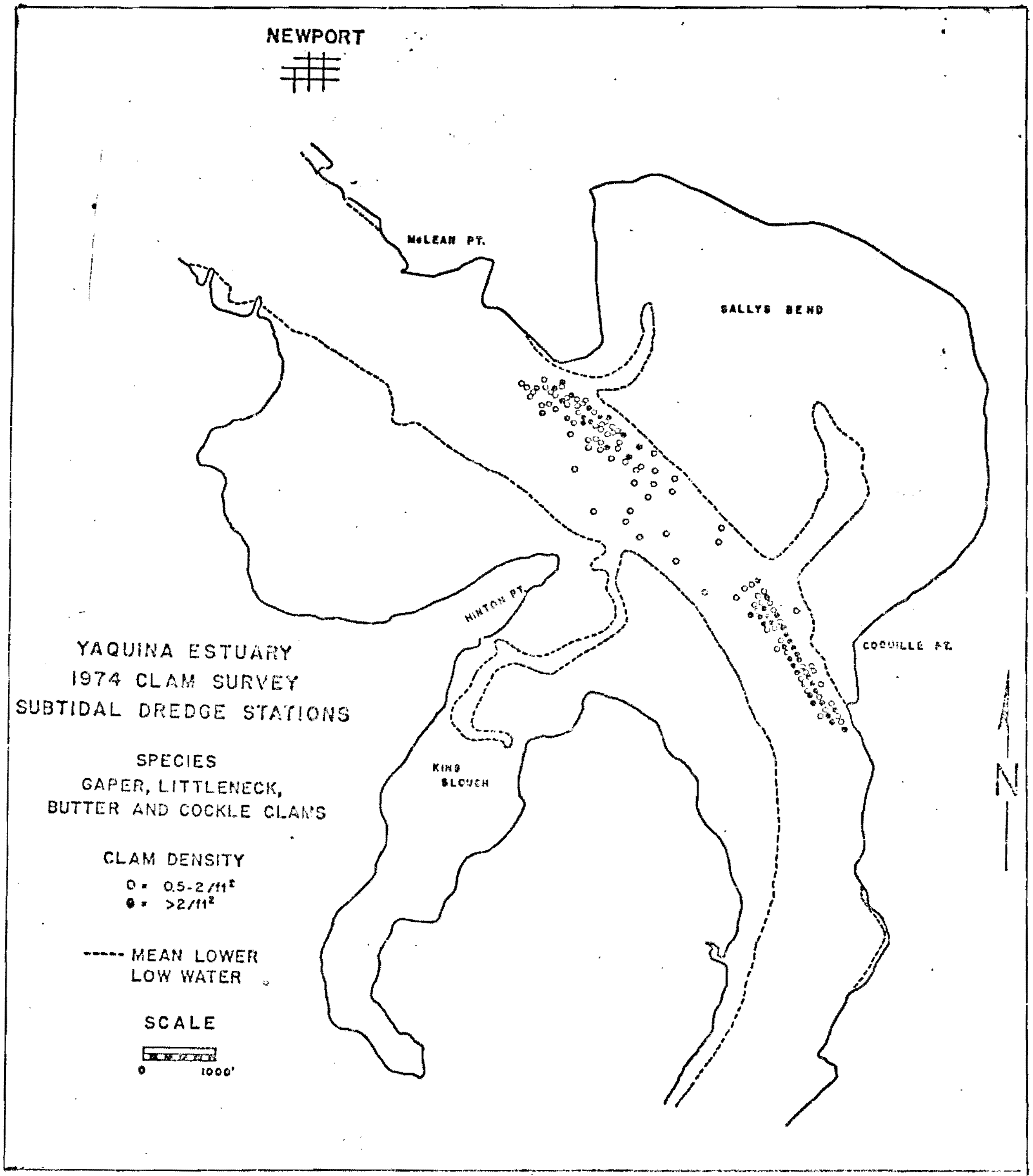

Figure 16. Occurrence of Gaper, Littleneck, Butter and Cockle Clams in Dredge Samples, Area 13 of Yaquina Bay, 1974

Table 1. Summary of Numbers of Subtidal Clams in Area 13, Yaquina Bay, 1974

Species	Areas 13-A	13-B	13-C	Total Area 13
Butter	12,100	620,200	22,000	654,300
Cockle	128,200	25,600	221,400	375,200
Gaper	831,000	1,278,400	154,800	2,264,200
Littleneck	91,600	415,500	21,000	529,100
Softshell	103,800	89,400	22,000	215,200
Bentnose	109,900	0	376,600	486,500
Irus	617,100	1,841,200	22,000	2,480,300
Jackknife	61,100	6,300	44,300	111,700
Total	1,954,800	4,276,600	885,110	7,116,500

Length frequency of butter, cockle, littleneck and gaper clams dredged from area 13 is shown in Figure 17. The lack of small butter and gaper clams in our samples causes concern about the condition of the stocks of clams in this area.

Age composition of cockle, gaper and littleneck clams is shown in Figure 18. This figure illustrates the scarcity of younger gaper clams in area 13. As mentioned earlier, we were unable to age the older butter clams in our sample.

During our preparation of gaper clams for weighing we examined body tissue. During this examination we noted the occurrence of a haplosporidian infestation on many of the clams. Armstrong and Armstrong (1974) observed this parasite in 43% of the gaper clams they collected from intertidal clam beds adjacent to area 13. Our observations showed this parasite to occur in 26% of the gapers in area 13-A, 3% in 13-B and none in 13-C.

Tillamook Bay

To date we have evaluated the distribution and abundance of subtidal clams in only one area of Tillamook Bay (Figure 19). As with Yaquina Bay, two concentrations of clams are shown. Analysis of our data showed this area to contain 12.3 million clams (Table 2).

Table 2. Summary of Numbers of Subtidal Clams in Hobsonville Point Clam Bed, Tillamook Bay, 1974

Species	Number
Butter	1,824,800
Cockle	2,841,700
Gaper	1,767,800
Littleneck	3,126,900
Softshell	1,026,500
Bentnose	9,400
Irus	1,682,200
Total	12,279,300

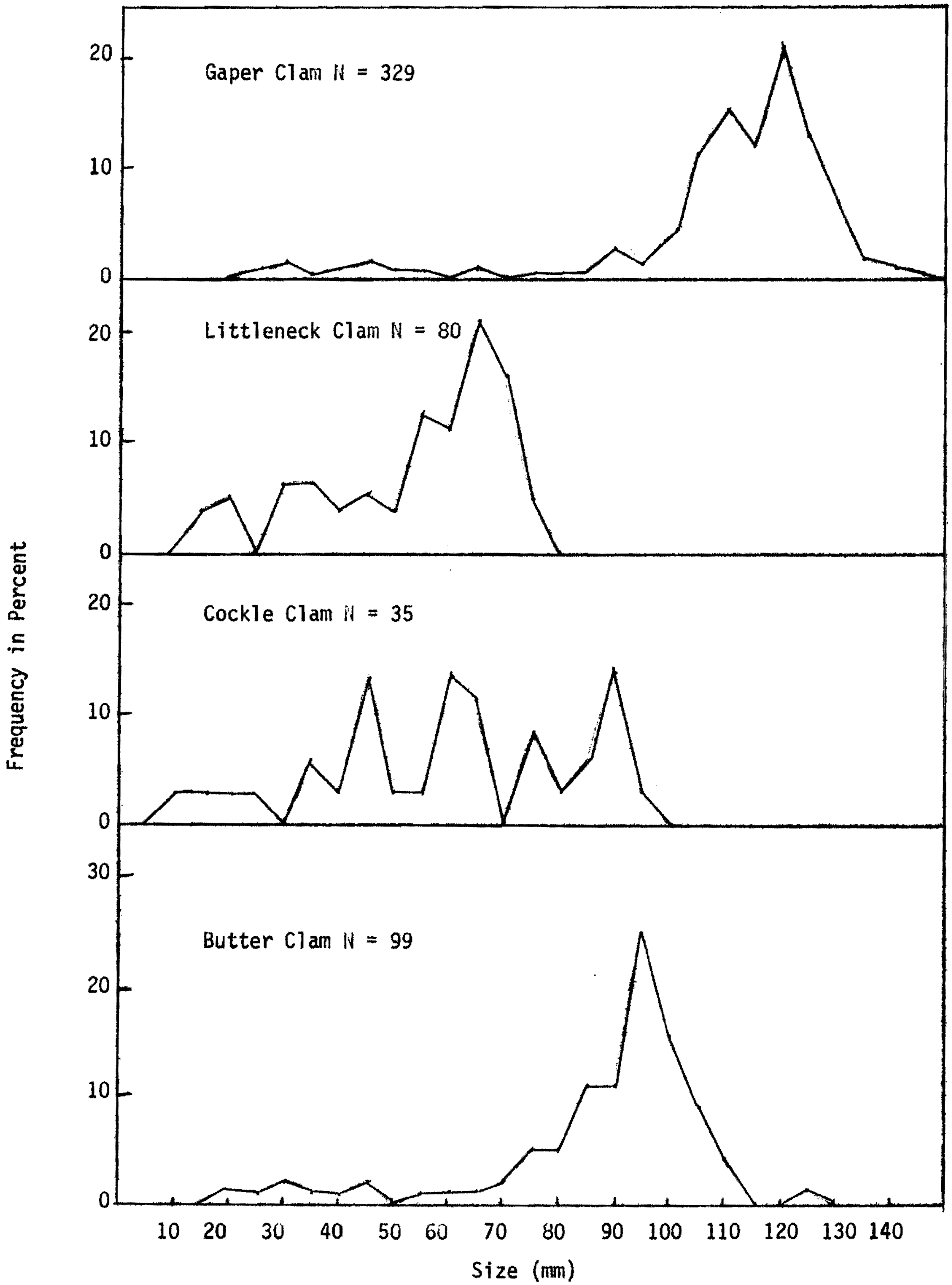

Figure 17. Length Frequency of Dredged Clams, Area 13 of Yaquina Bay, 1974

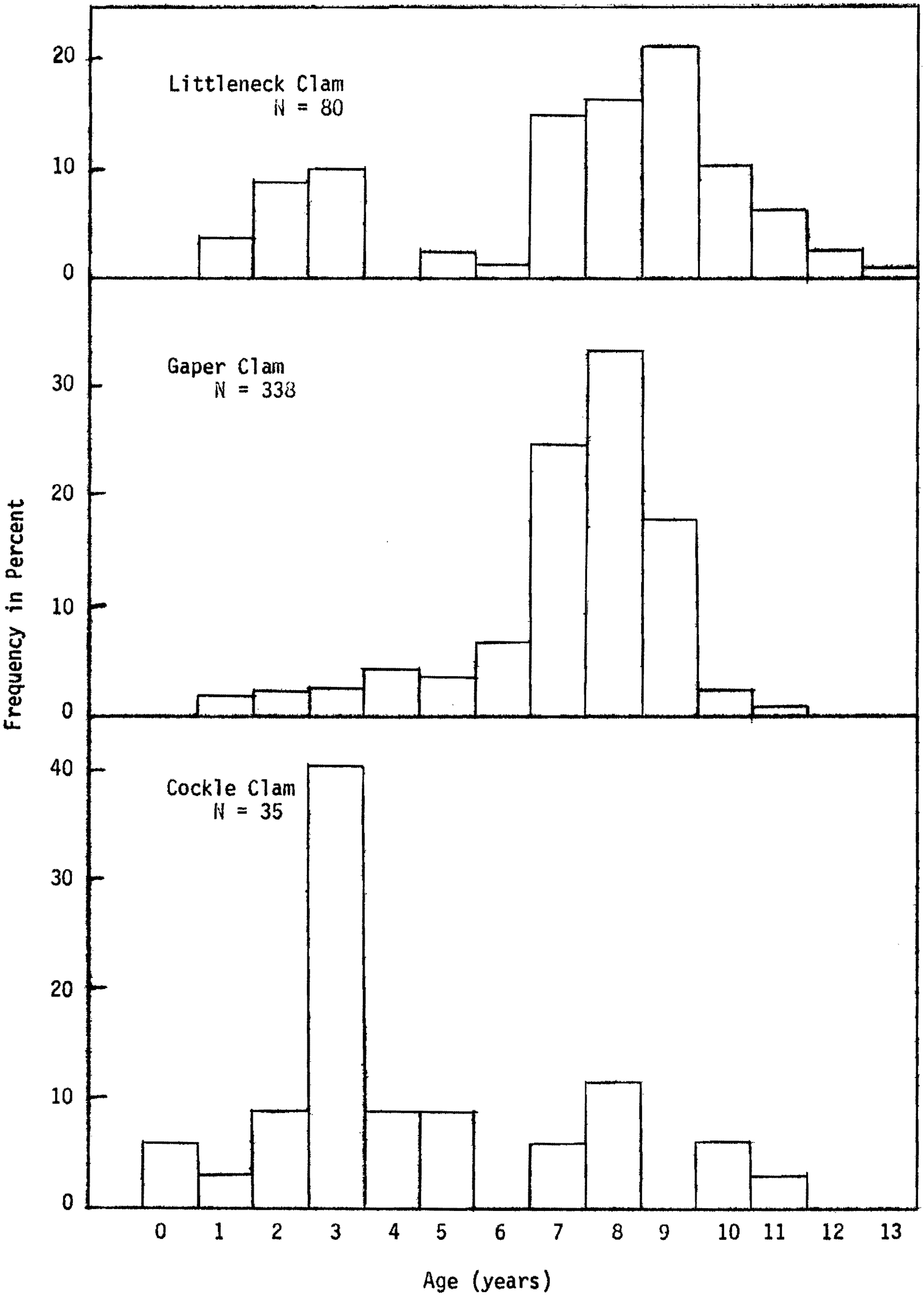

Figure 18. Age Composition of Dredged Clams, Area 13 of Yaquina Bay, 1974

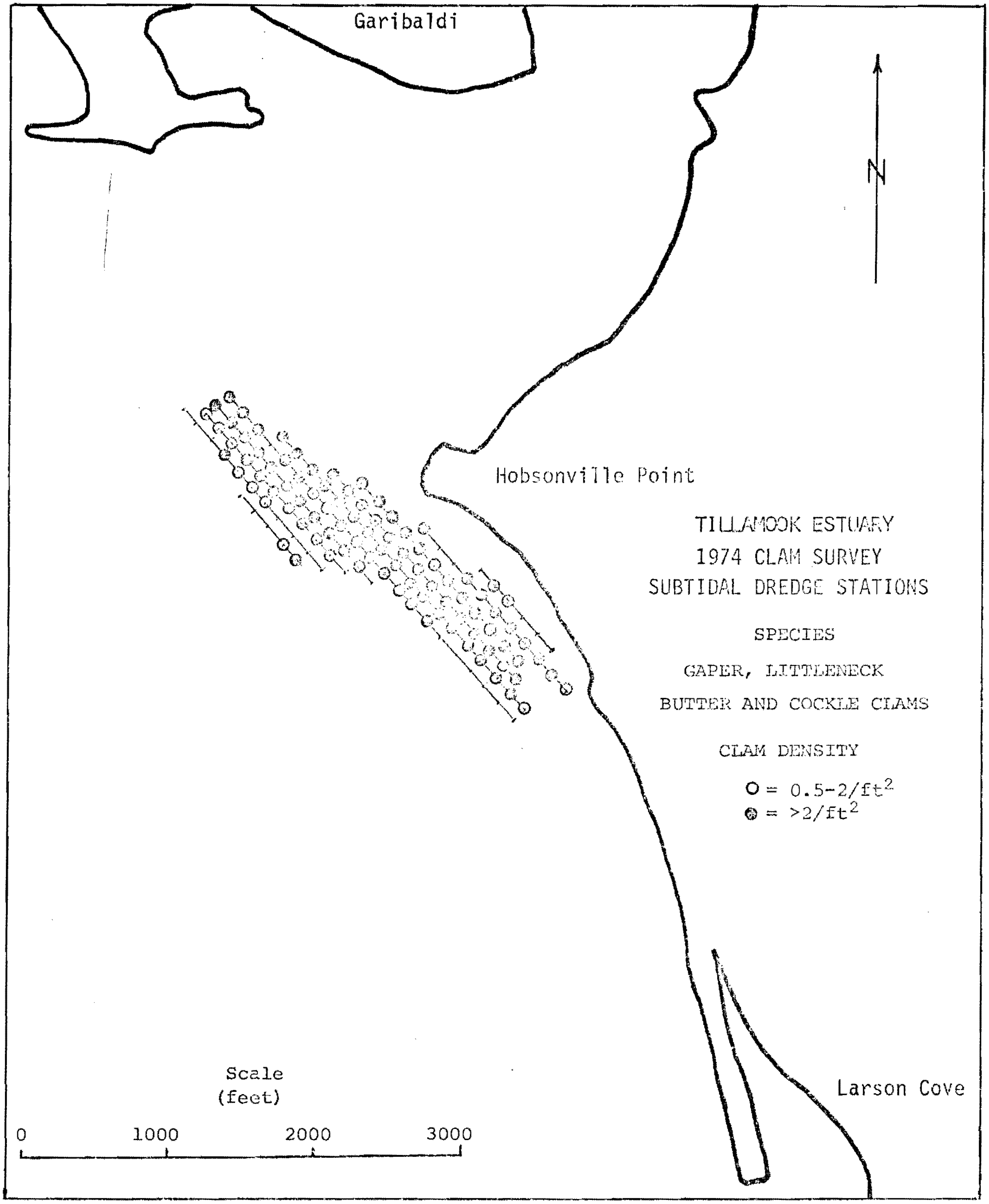

Figure 19. Occurrence of Gaper, Littleneck, Butter and Cockle Clams in Dredge Samples, Hobsonville Point Clam Bed, Tillamook Bay, 1974

Length frequency of butter, cockle, littleneck and gaper clams dredged from the Hobsonville Point clam bed is shown in Figure 20. As in Yaquina Bay most clams for each species were of the older age groups.

Age composition of cockle, gaper and littleneck clams is shown in Figure 21. In contrast to Yaquina Bay, a significant number of the gaper and littleneck clams were of the younger age groups.

Of the 186 gaper clams dredged, only one was infected with the haplosporidian reported for Yaquina Bay. This is the first reported occurrence of this parasite in Tillamook Bay.

Discussion

Since 1973 we have surveyed 391,900 feet of intertidal and 345,000 feet of subtidal transect line looking for areas to plant hatchery reared clams. Observations of species of clams, relative density of clams, bottom type, and vegetation type were made at 5,085 sample stations. During this survey we have located eight subtidal clam beds having commercial clam harvest potential. As a result, six commercial fishermen have requested permits to harvest these clams. One permit has been issued on an experimental basis for Yaquina Bay. A subtidal commercial clam fishery has existed in Coos Bay since 1962. Other permits will be issued upon completion of our survey.

Several biologically significant factors have been revealed during our study. The age composition of gaper clams in Yaquina Bay shows primarily 7, 8, and 9 year-old clams. Survival of set appears to be sporadic. In addition, the absence of older clams in the "untouched" population can probably be attributed to damage caused by the 1964 earthquake in Alaska. Extremely strong tidal currents entered the bay and numerous reports by divers described windrows of dislodged gaper clams covering the bottom of the bay and many clams were picked up on the ocean beaches. Adult gaper clams lack the ability to reestablish themselves.

Another factor causing us concern is the high incidence of the haplosporidian infestation of the gaper clam. Implications to the commercial fishery are obvious because the infected clams are unsightly. Also, the effects on clam mortality and condition are unknown. A recent proposal has been submitted by Oregon State University for Sea Grant funding to study this problem.

CLAM STUDIES

Methods

Laboratory Clam Rearing

We explored the feasibility of improving the growth rate of laboratory reared. Manila littleneck clams. Groups of fast growing clams were selected from juveniles spawned in 1969 and 1972 and held in laboratory aquaria until needed for spawning. Two groups were successfully spawned using procedures and techniques developed in past years (Lukas 1972-73).

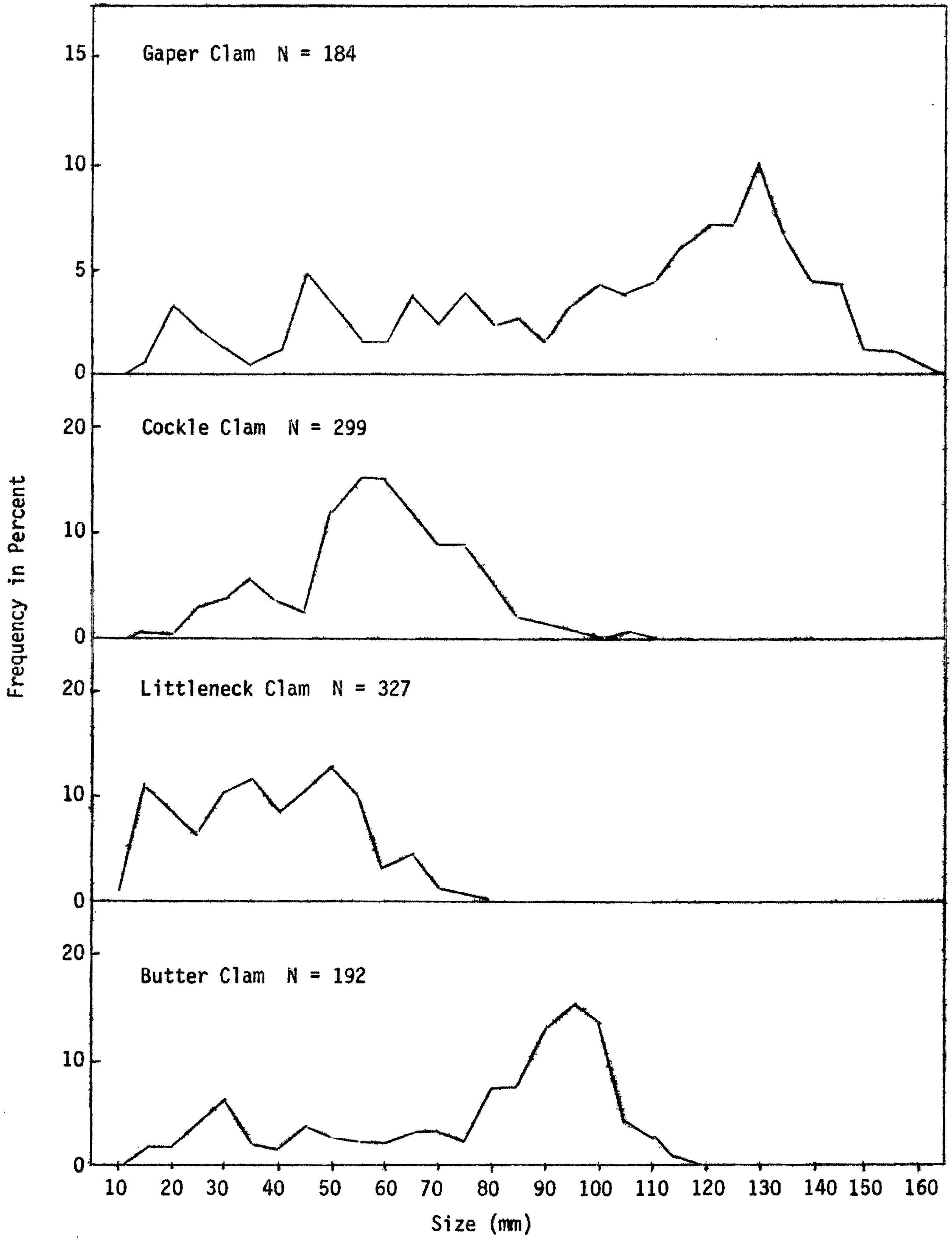

Figure 20. Length Frequency of Dredged Clams, Hobsonville Point Clam Bed, Tillamook Bay, 1974

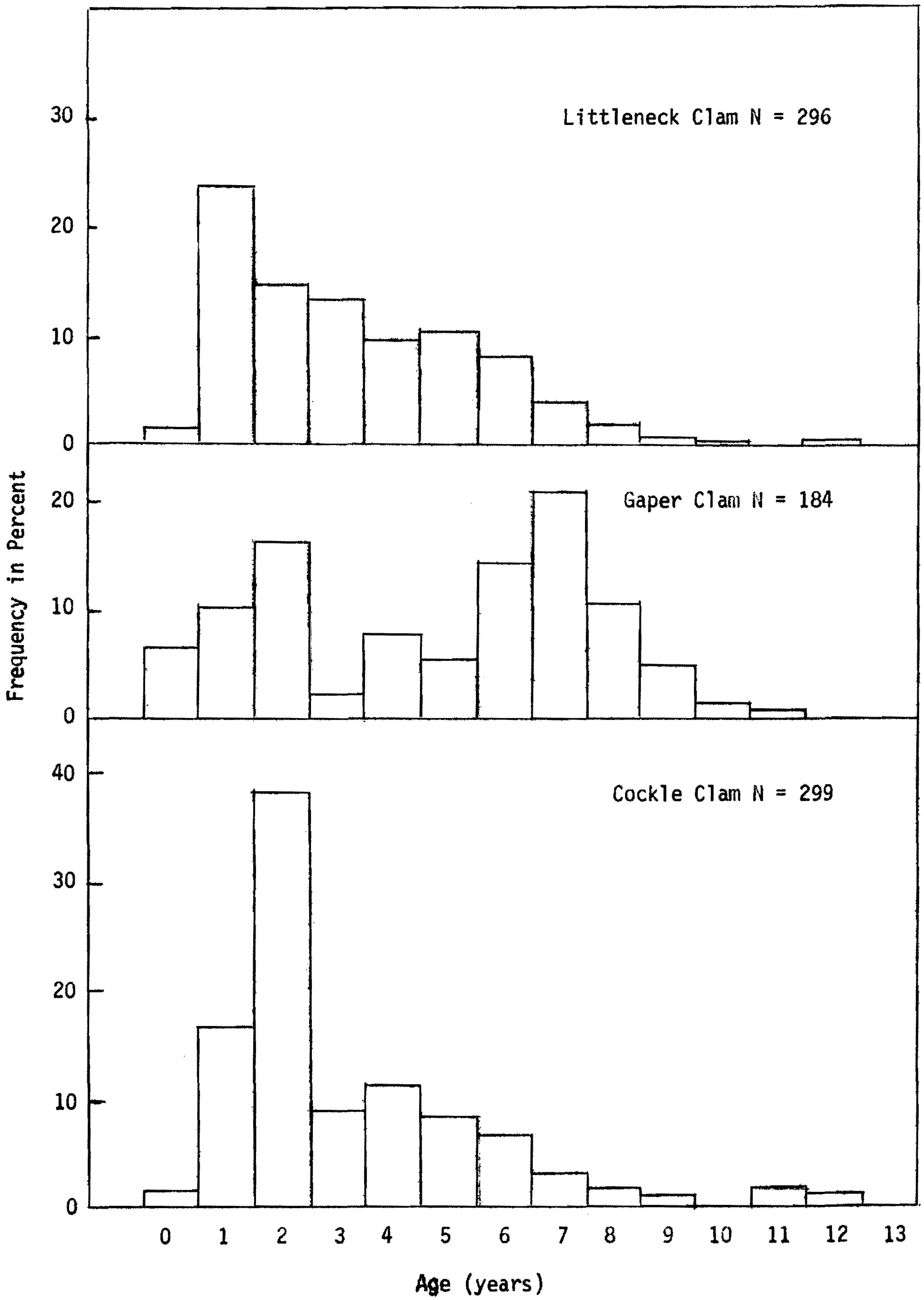

Figure 21. Age Composition of Dredged Clams, Hobsonville Point Clam Beds, Tillamook Bay, 1974

Field Studies

Manila Littleneck Clams. Manila littleneck clams planted in experimental plots were sampled to obtain survival and growth data. These plots were established in Netarts, Yaquina, Coos and Coquille bays to assess their potential as future sites for introductions of laboratory reared Manila juveniles (Lukas and Gaumer, 1974).

In June 1974, two plots were established in Netarts to evaluate movement of clams. Both plots measured 5 by 10 feet. One plot was fenced with ¼-inch mesh wire cloth and the other was unfenced. The fence extended 3-4 inches above the substrate. Both plots were planted with 2,500 juvenile Manila clams, averaging 13.1 mm, at a density of $50/ft^2$. The substrate where the clams were planted consists of firm sand with a thin layer of mud on the surface. The area has a scattering of eelgrass plants. A third plot was established 250 feet towards the channel and near a dense eelgrass bed. We wished to determine two things with this plot: (1) Since the area had a slightly lower elevation, would the clams exhibit a significantly different growth than those in higher elevation plots? (2) We suspected that the eelgrass harbored predators (crabs) and we wished to determine if there was a difference in survival between a plot near the eelgrass and one relatively far away. The plots were sampled twice.

Approximately 515,000 laboratory-reared Manila littlenecks were planted in Netarts in June, August, and October 1974. Nineteen plots of Manilas of different ages and size groups were planted in an area measuring 135 by 190 feet. It was hoped that with a concentration of clams, natural spawning might result in successful fertilization.

Butter Clams. Two plots of butter clams were established on the breakwater in Yaquina Bay in 1968 and 1970 to evaluate growth and survival. These plots, planted with laboratory reared clams, have been monitored annually.

Native Littleneck Clams. A plot of laboratory reared native littleneck clams was established in 1970 on the breakwater in Yaquina Bay. This plot has been sampled annually to assess growth.

Results

Laboratory Clam Rearing

The two groups of laboratory reared Manila littlenecks, selected for their fast growing ability, were successfully spawned. These clams were 2 and 4 years old. No difficulties were encountered in spawning these clams. Of 82 two-year old clams, 54 spawned, which compares favorably with other groups of Manilas that we have spawned. Average egg diameter was not significantly different from those reported in the literature. Growth (average lengths) of larvae and juveniles, in the laboratory aquaria, did not differ greatly from that of juveniles resulting from spawnings of randomly selected adults.

In August and October 1974, 173,165 of these juveniles were planted in Netarts Bay. The clams will be periodically sampled to determine growth characteristics in the field.

Field Studies

Manila Littleneck Clams. Sampling of the experimental plots in Yaquina, Coos and Coquille bays produced discouraging results. The plot on the breakwater in Yaquina Bay had shown good survival through two winters (1971-73). The 1974 sample indicated a survival of less than 0.1%. Erosion of the plot appeared to be 4-5 inches based on stake exposure.

Three small Manila plots located in the upper Yaquina Bay above Riverbend showed zero survival through the winter of 1973-74.

Two 10 by 20-foot plots set up in Coos Bay in August 1973 were sampled in May 1974. These plots were located on the west side and 1.3 miles upstream from the mouth of the estuary. No clams, dead or alive, were recovered. Both plots had erosion of approximately 2-3 inches on the lower tidal portion and a deposition of sand on the upper portion.

A 10 by 20-foot plot established near the mouth of Coquille Bay in August 1973 also showed no survival when sampled in May 1974.

Results of sampling plots in five different areas in Netarts Bay showed almost the same results. In four plots there was little or no survival. In the one remaining plot survival was 8.3% after 10 months. Average size was 16.4 mm, an increase of 9.1 mm since planting. In addition to sampling within the plots several samples were also taken outside the plot boundaries. Two square feet were sampled at distances of 4 and 6 feet from each side of the 6x6-foot plot. Four juveniles were found in the sample taken 4 feet from the northern boundary of the plot. These clams were assumed to have originated from the plot as their lengths were similar to lengths of clams planted within the plot. A small natural population of Manilas is present in the area, but since they are so thinly distributed it was felt that the chances were poor of finding four "natural set" Manila juveniles in a small sample. Because of these results, we established a fenced and unfenced plot to assess the extent of movement of clams.

The results of sampling the fenced and unfenced plots showed that survival was greater in the fenced plot than in either of the unfenced plots and that the percentage of dead clams with broken shells was much higher in the plot nearest the dense eelgrass bed (Table 3). Broken shells are indicative of crab predation. The fenced plot, though not totally immune from predation, did offer some protection from predation. The results also showed that a significant number of clams in the unfenced plots were unaccounted for (Table 4). The differences between the number of clams recovered alive in the fenced and unfenced plots are 78 clams/5 ft^2 on August 22 and 44 clams/5 ft^2 on October 15 (Table 4). These figures indicate that between 17 and 31% of the clams moved from the experimental plots.

Table 3. Summary of Survival, Dead with Broken Shells, and Average Lengths of Manila Clams in Three Plots in Netarts Bay, 1974

Plot	Date	Percentage Survival	Percentage of Dead with Broken Shells	Average Length (mm)
Fenced	8-22	80.4	11.7	16.3
	10-15	68.4	6.7	18.5
Unfenced	8-22	49.2	17.8	16.0
(Control)	10-15	50.8	16.4	-
Unfenced	8-22	15.7	63.2	16.3
Near Eelgrass Bed	10-15	12.0	57.4	18.6

Table 4. Summary of Total Number of Dead and Alive Manila Littleneck Clams Recovered During Sampling of Three Plots in Netarts Bay, 1974

Plot	Date	Clams Recovered/5 ft² Dead	Alive	Total	Total Clams Expected/5 ft²	Number Unaccountable
Fenced	8-22	101	201	302	250	-
	10-15	90	171	261	250	-
Unfenced (Control)	8-22	45	123	168	250	82
	10-15	55	127	182	250	68
Unfenced Near Eelgrass Bed	8-22	87	85	162	250	88
	10-15	63	30	93	250	157

The average length of the clams in the plot near the eelgrass bed did not differ from the two plots 250 feet away and at a slightly higher tidal elevation. In nearly four months, clams in both areas increased over 5 mm from the 13.1 mm when planted.

Butter Clams. Six square feet of a 30 ft^2 experimental butter clam plot was sampled. This portion of the plot had not been sampled since the clams were planted as 22-month-old clams in September 1970. Therefore, clam shell lengths were not affected by handling. Mean shell length of recovered clams did not increase significantly when compared with the average length of clams sampled in 1973 (Table 5).

Table 5. Growth and Survival of Butter Clams Planted on the Yaquina Bay Breakwater, 1970 1/

Date Sampled	Mean Shell Length (mm)	Percentage Survival	Age of Clams (Months)	Months in Plot
7-13-72	37.0	31.7	44.5	22.0
7-30-73	46.7	46.7	57.0	34.5
7-19-74	48.4	59.2	68.0	46.0

1/ Butter Clams averaged 20 mm when planted.

Figure 22 shows the growth of these clams lags behind a comparable group planted in an artificial substrate plot located about 100 yards away (Lukas, 1972). The average length of butter clams in the artificial substrate plot increased only 3.2 mm in one year, from 60.1 mm to 63.3 mm, indicating a reduction in growth of both groups at about five years of age.

The reason for the differences in survival of butter clams during the three sampling periods is not known (Table 5). Either the clams were not randomly distributed when planted or there are subtle environmental differences from one end of the plot to the other which have affected survival.

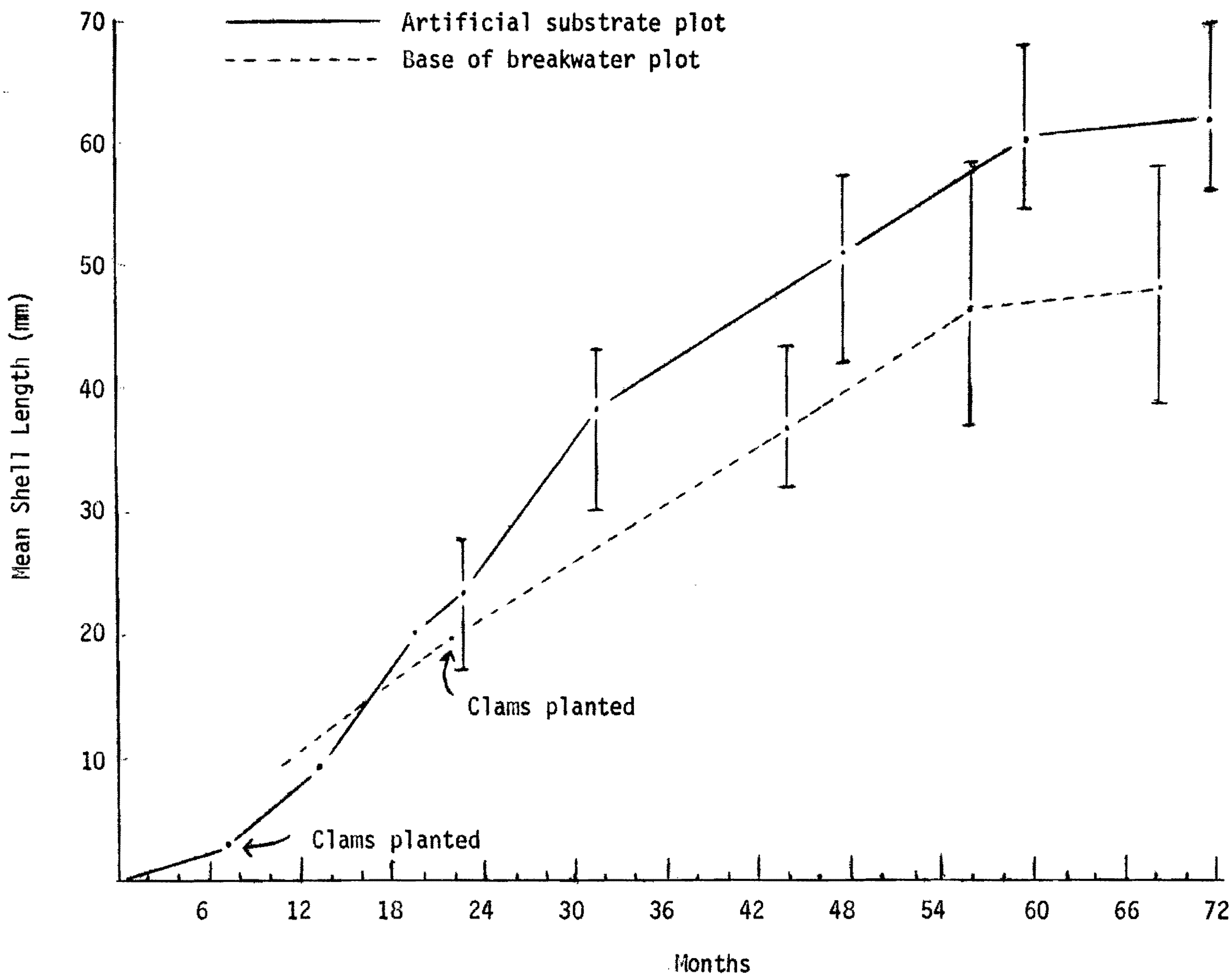

Figure 22. Growth Curve of Butter Clams Planted on the Breakwater, Yaquina Bay (Vertical Lines Indicate Range in mm), 1974

Native Littleneck Clams. We continued sampling a plot of native littleneck clams which were established in September 1970. Since 1972, all clams in the plot have been sampled. Subsequent sampling has necessitated digging up the entire plot because of the small numbers of clams remaining. Consequently, growth of the clams may be somewhat retarded due to handling. The sampling in April 1974 showed that the clams averaged 41.5 mm, an increase of 5.4 mm since 1973 (Figure 23).

Discussion

The probable explanation for the failure of the experimental plots in Yaquina, Coos and Coquille bays would be weather. Storms and heavy rainfall during the winter of 1973-74 were relatively frequent. All three bays were subject to heavy runoff of freshwater and consequently low salinities. Intertidal areas were subjected to heavy wave action generated by strong winds from accompanying storms. The plot on the breakwater in Yaquina Bay has a southern exposure and was subjected to erosion by wave action. The plot appeared to have eroded 4-5 inches based on stake exposure. Because these clams are located near the surface they are more vulnerable to being washed out of the substrate and subjected to predation or carried away by currents. Prolonged periods of low salinity probably added another stress factor which resulted in clam mortality.

The plots in Coos Bay were also subjected to the scouring effects of wave action as evidenced by changes in the lower portions of the two plots. The deposition of sand on the upper portions of the plot forced the clams to move up into this unstable medium and thus more susceptible to being washed out of the plot.

The plot in Coquille Bay was not situated where wave action would have been a factor in affecting clam survival. The cause of clam mortality in this area was probably related to prolonged low salinities. A preliminary survey of the small intertidal area indicated that softshell clams were the only live species of clams present. Only a few cockle and native littleneck shells were found. The presence of only softshell clams indicated that the area is subjected to low salinities during certain periods of the year. We decided to establish a small Manila test plot to resolve the question of whether or not Manila's could survive in areas of good substrate type but low salinities. The zero survival rate offered conclusive proof that this is not the case.

Even though Netarts Bay is subjected to the same winter weather as other estuaries, it differs in that it does not have any large rivers entering the estuary which would greatly affect salinities. The areas where the plots are located are flat and the effect of wave action is lessened. Nevertheless, only one area of the five different areas where plots were established supported clams through the winter indicating that other environmental factors played a role in affecting clam survival. Unfortunately we were unable to closely monitor conditions in each of these areas and thereby cannot reach a conclusion as to why a clam will survive in one area and not another.

The results of test plots in other estuaries indicates that they are probably unsuitable for Manila introductions, either because of effects of environmental conditions or because of unsuitable substrates in the areas available. One exception might be Coos Bay. In the lower estuary there is a clam bed created by deposition of dredge spoils. The substrate consists primarily of river-run gravel which should be suitable for Manila littleneck clams. However, the area already has an extensive

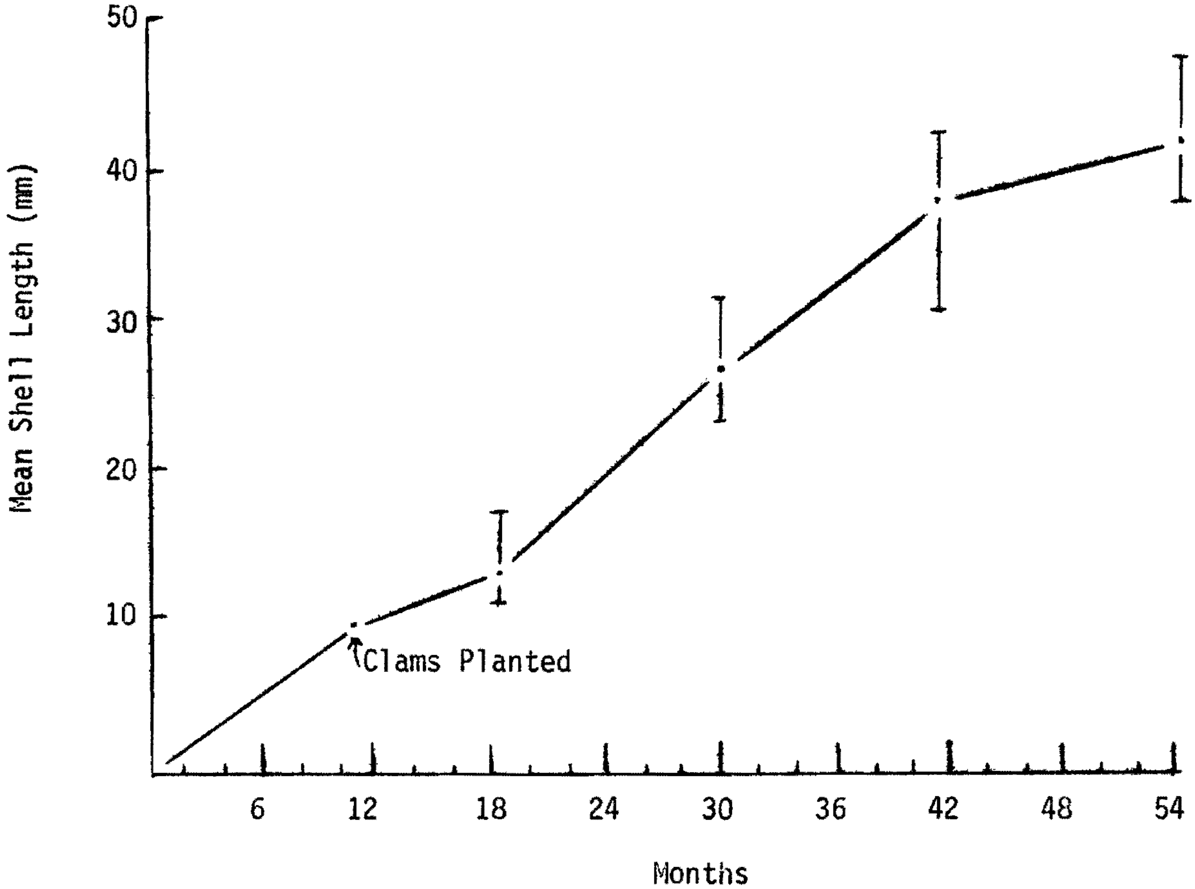

Figure 23. Growth Curve of Native Littleneck Clams Planted in Artificial Substrate Plot, Yaquina Bay (Vertical Lines Indicate Range in mm), 1974

population of native littleneck, butter and gaper clams. Since our original intent was to establish Manila littlenecks only in areas where native littlenecks are not found in substantial numbers, it was decided therefore not to establish a test plot in this area.

We believe the results of the sampling of the fenced and unfenced plots confirm the assumption that clams do move when planted in sand substrates. In both unfenced plots a significant number of the clams were unaccounted for. However, the fence apparently prevented dead clams (broken and unbroken) from being removed from the plot by wave action and/or water currents. Some of the unaccounted clams may have died and their shells swept or scoured from the plot. In spite of this we still feel that a significant number of the unaccounted for clams did move from the plot. Because the fenced and nearby unfenced plot are so close it is assumed that they are both subject to the same environmental conditions and therefore the survival rates should be similar.

Future sampling of all plots in Netarts (except the fenced plots) will only yield growth data. It will be impossible to obtain an accurate estimate of survival because of the clams ability to move across the sand substrate.

The results of growth and survival of butter clams in the experimental plots are encouraging. Growth has been comparable to growth rates of butter clams in British Columbia, and though there is no comparable survival data, rates seem to be good. A mariculture program involving planting of laboratory reared juvenile butter clams would probably be feasible. These clams should be planted only in areas where butter clams are known to inhabit but have been subjected to heavy sport digging pressure.

WHALE COVE ABALONE

Methods

The yearly sampling of red abalone planted in Whale Cove as juveniles in 1967 was conducted in June 1974. Both the intertidal and subtidal areas were searched. The intertidal search was conducted in two days during a period of extremely low tide (-2.7 and -2.8 ft.). The area where the abalone are located is characterized by the presence of large basalt boulders. The abalone are located by searching between and under these boulders.

The subtidal area was searched by two divers using Scuba gear and an underwater light.

Results

Sixty abalone, having an average length of 139.9 mm with a range of 98-186 mm, were recovered (Figure 24). These animals ranged from 5-20 mm when planted seven years ago. Twenty-five of the animals had been tagged and measured in the previous year. The average increase in length in one year was 15.2 mm with a range of 4-55 mm.

All the animals recovered came from the intertidal zone (0 to -2.8 feet). Only one abalone was observed in the subtidal region but because of its placement, it could not be recovered.

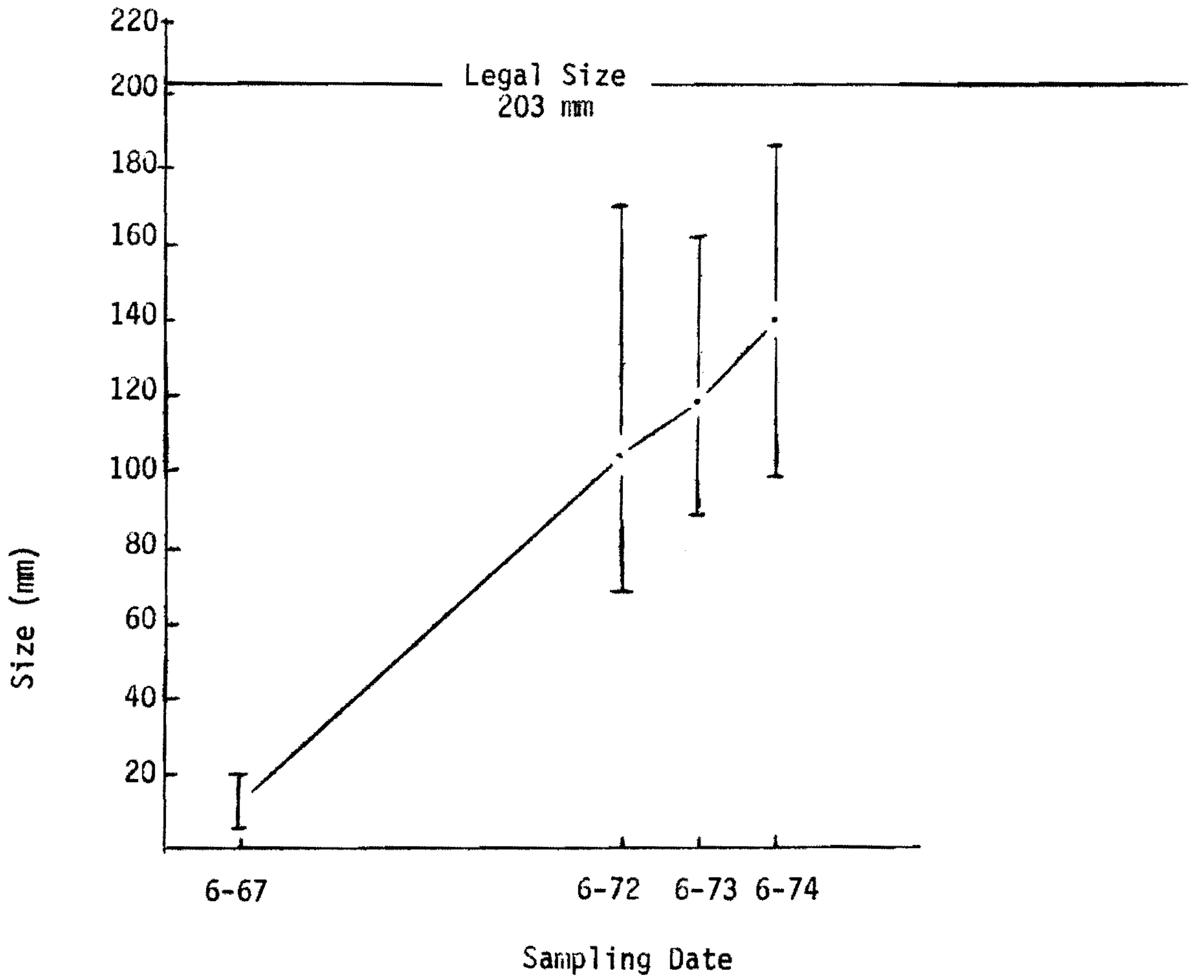

Figure 24. Growth Curve of Whale Cove Abalone (Vertical Line Indicates Range), 1974

Discussion

Using the mark-recovery data collected in the past 3 years it was possible to make an estimate of the total population of abalone in Whale Cove. The population in 1972 was estimated to be 295 animals and 173 in 1973. Survival rate in 1973 was 3.5%.

Observations made on gonad size during the past two years indicated that they were full and similar in size and appearance to those observed on adults collected from other areas. This is not meant to imply that the animals can or will spawn, but that they have the potential. Thus far we have not observed any juvenile abalone in the area resulting from spawning of abalone in Whale Cove.

JUVENILE ABALONE PROCUREMENT

Inquiries were made to two commercial mariculture hatcheries about the current price for hatchery reared juvenile red abalone. Our interest was derived from the success of the Whale Cove transplant.

Only one mariculture firm responded; California Marine Associates of Cayucos, California. Their offer was based on a sliding scale depending on number of animals ordered. They charge 3¢/mm on orders less than 1,000, 2.5¢/mm on orders of 1,000 to 10,000 and 2¢/mm on orders greater than 10,000 abalone.

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LITERATURE CITED

Armstrong, David A. and Janel L. Armstrong. 1974. A Haplosporidian Infection in Gaper Clams, *Tresus capax* (Gould), from Yaquina Bay, Oregon. Proc. Nat. Shellfish. Assoc: 64: 68-72

Gaumer, Thomas F. 1972. Estuary Resource Study. Comm. Fish. Res. and Devel. Act. Ann. Rept., July 1, 1971 to June 30, 1972. Fish Comm. of Ore. Proc. Dept. 6 p.

Lukas, Gerald. 1972. Clam-Abalone Spawning and Rearing. Comm. Fish. Res. and Devel. Act. July 1, 1971 to June 30, 1972. Fish Comm. of Ore. Proc. Rept. 16 p.

Lukas, Gerald. 1973. Clam-Abalone Spawning and Rearing. Comm. Fish. Res. and Devel. Act. Completion Rept. July 1, 1970 to June 30, 1973. Fish Comm. of Ore. Proc. Rept. 19 p.

Lukas, Gerald and Thomas F. Gaumer. 1974. Clam-Abalone Stock Supplementation Feasibility Study. Comm. Fish. Res. and Devel. Act. July 1, 1973 to June 30, 1974. Fish Comm. of Ore. Proc. Rept. 20 p.

Osis, Laimons and Thomas F. Gaumer. 1973. Estuary Resource Survey, Subtitle: Clam Inventory Techniques Study. Comm. Fish. Res. and Devel. Act. Completion Rept. July 1, 1971 to June 30, 1973. Fish Comm. of Ore. Proc. Rept. 11 p.