METHODS OF SUPPLEMENTING CLAM AND ABALONE PRODUCTION

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by

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CONTENTS

CONTENTS (Continued)

FIGURES

Figure No. Page No.

FIGURES (Continued)

TABLES

Table No. Page No.

SUBTIDAL CLAM DISTRIBUTION, ABUNDANCE AND PLANTING SITES

ABSTRACT

Studies on the distribution of clams in Oregon's estuaries continued. Maps showing survey areas, the distribution of clams, substrate type, and vegetation type are presented.

Population estimates, age and size of clams were calculated for three areas of Yaquina Bay and for single areas of Tillamook and Coos bays. Age data showed an exceptionally strong survival of 1975 year class gaper clams. Commercial quantities of clams were located in each of the above bays.

An aging study showed that the gaper clam could most reliably be aged by counting annuli in the chondrophore. Butter, cockle and littleneck clams were aged by counting the annuli on the exterior surface of the shell.

Permits were issued for the commercial harvest of subtidal clams in Yaquina and Coos bays. Due to poor marketing conditions, the Yaquina fishery produced only 1,505 pounds (683 kg) of gaper clams. The Coos Bay fishery produced 55,482 pounds (25,166 kg) of gaper clams. The 1969 year class was prevalent in the Yaquina Bay harvest while the 1966 year class was the principal age group taken in Coos Bay.

We continued to monitor growth of laboratory produced clams planted in Netarts and Yaquina bays.

Population estimates showed 241 (4.3%) of the abalone planted in Whale Cove in 1967 still survive. They averaged (137.3 mm) in size.

INTRODUCTION

During the year we continued our studies on the clam resources in Oregon's estuaries. Principal objectives of this study were: (1) to refine techniques of determining subtidal clam distribution, abundance and potential clam planting sites for mariculture projects; (2) to determine the potential for a subtidal clam fishery in Oregon; (3) to develop appropriate subtidal clam management schemes applicable on a coastwide basis; (4) to refine techniques for aging clams; and (5) to monitor growth of laboratory planted clams. In addition, we monitored the growth and survival of abalone planted in Whale Cove.

CLAM DISTRIBUTION AND PLANTING SITES

During the year, clam surveys were conducted in Nehalem, Tillamook, Netarts, Nestucca, Salmon River and Siletz bays. Clam distribution surveys were completed in Yaquina Bay in 1973 (Lukas and Gaumer, 1974) and Alsea Bay in 1974 (Gaumer and Lukas, 1975).

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. Subtidal surveys started at the mouths of each estuary and extended up-bay until we were confident all major clam beds had been examined.

Results and Discussion

Nehalem Bay

Subtidal clam distribution surveys were completed for the lower Nehalem Bay. We examined 16,000 feet of transect line during our survey and made 160 observations (Figure 1).

Gaper and littleneck clams were the principal species observed. The distribution of gaper (*Tresus capax*), cockle (*Clinocardium nuttallii*), littleneck *Venerupis staminea*), and butter clams (*Saxidomus giganteus*) in the bay were charted (Figure 2).

Much of the substrate in the channel of the lower bay consisted of rock, gravel, and sand with some shell. Extensive areas of unstable sand bordered the west side of the channel (Figure 3).

Vegetation covered parts of the channel bottom (Figure 4). Eel grass *Zostera marina* was common along the up-bay portion of the survey area.

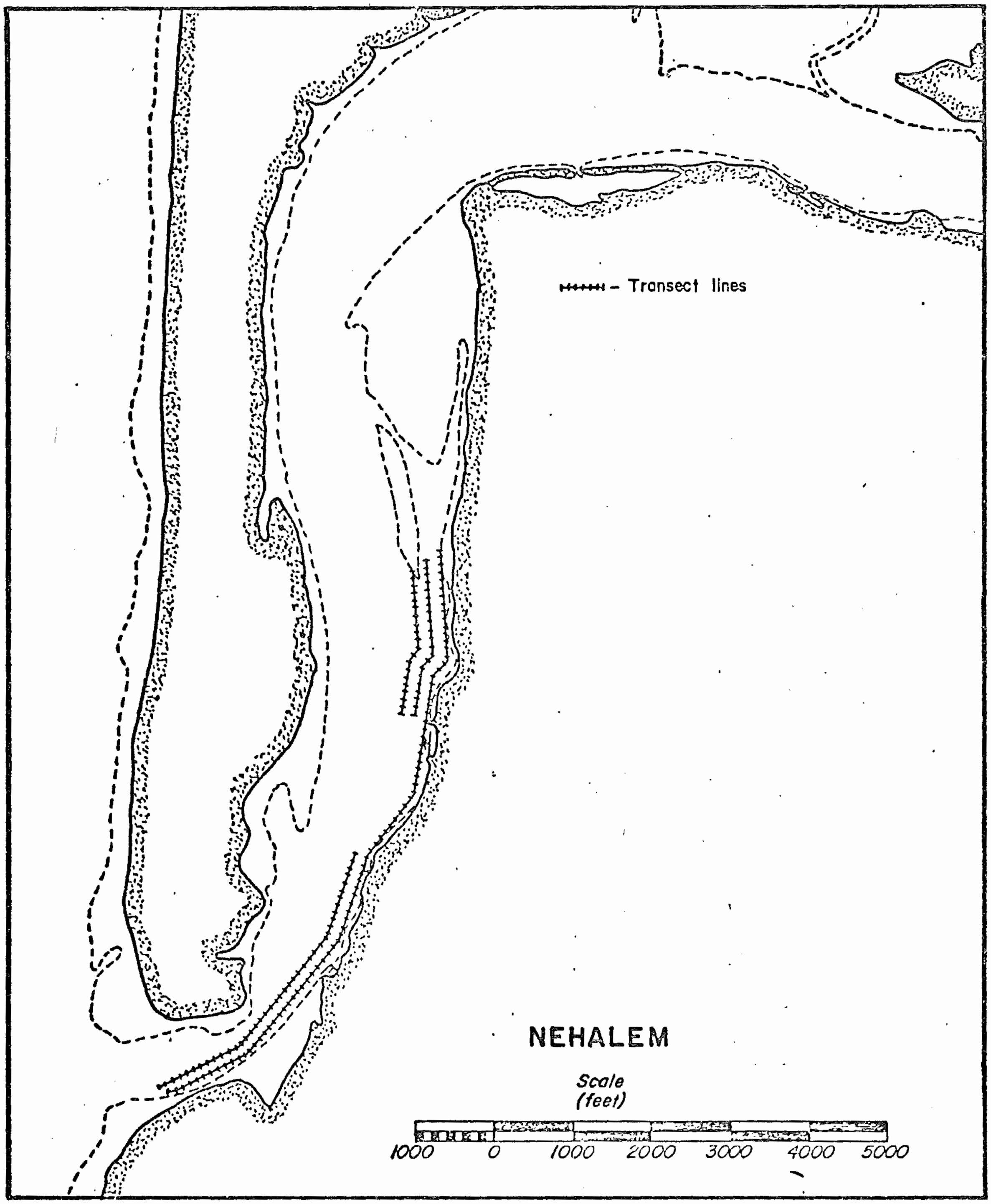


Figure 1. Clam Survey Transect Lines and Sample Stations, Nehalem Bay, 1975

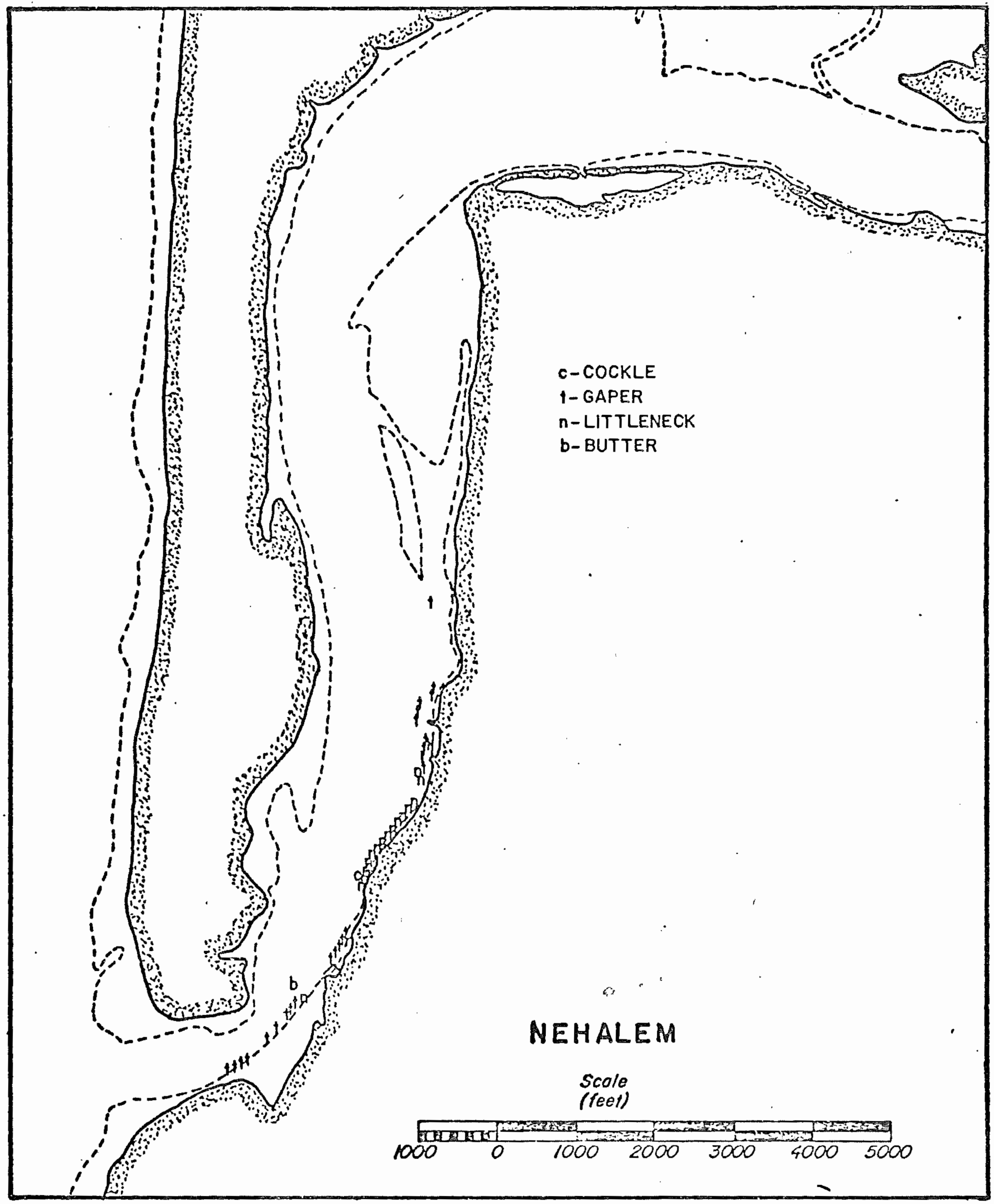


Figure 2. Distribution of Subtidal Clams, Nehalem Bay, 1975

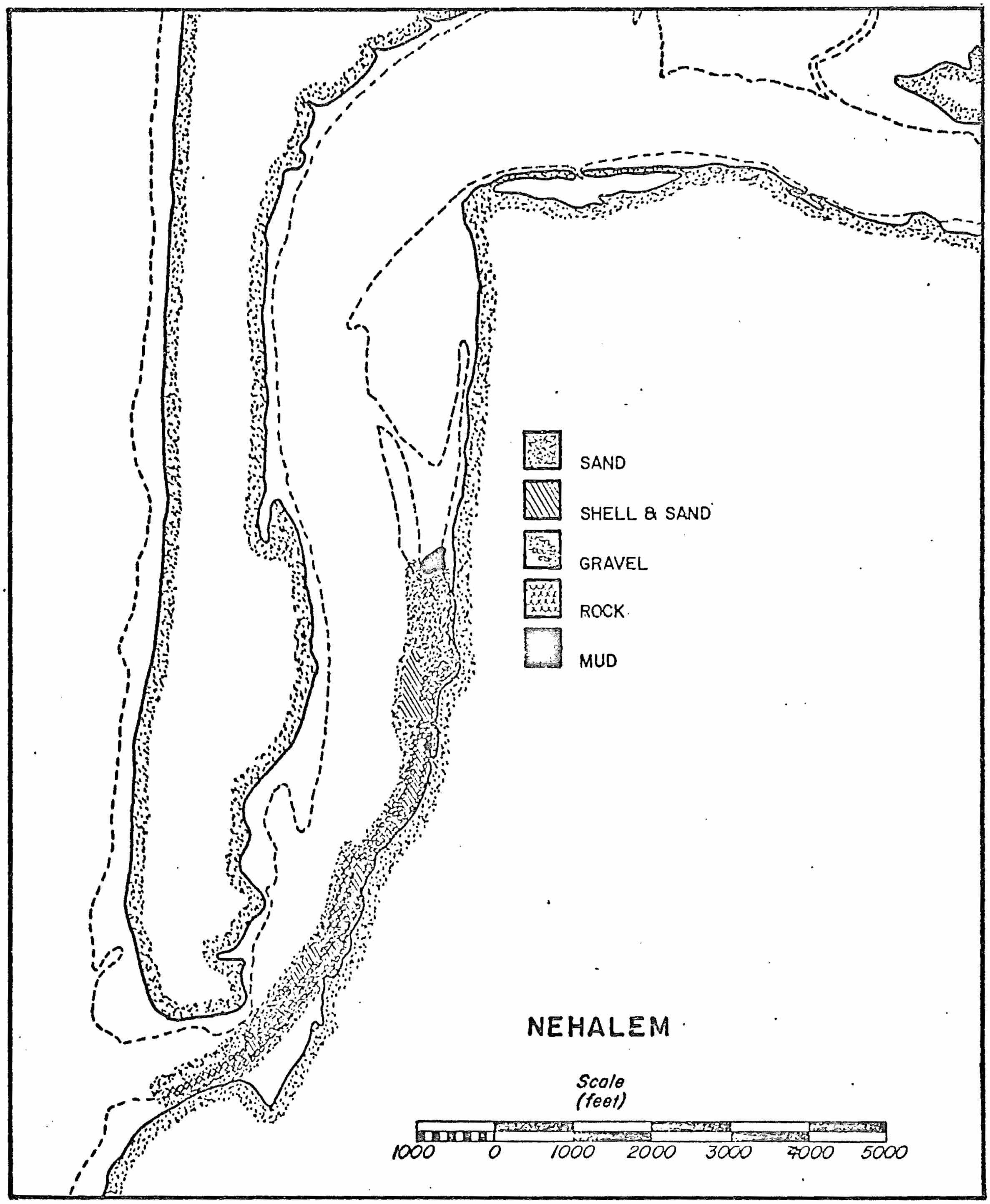


Figure 3. Substrate Material, Nehalem Bay, 1975

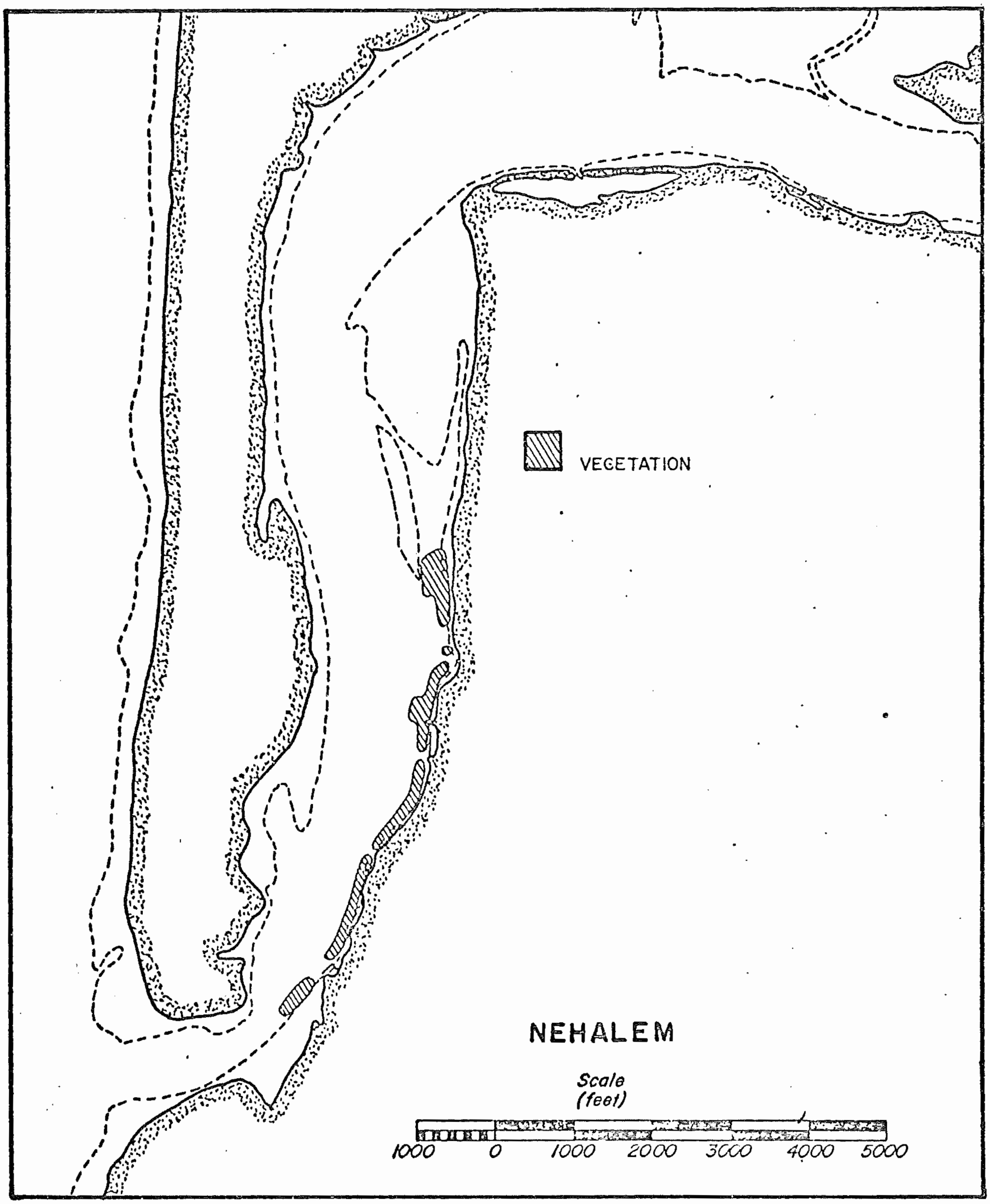


Figure 4. Vegetation, Nehalem Bay, 1975

Tillamook Bay

We completed subtidal clam distribution surveys in Tillamook Bay. Intertidal surveys were started and most of the tideflat on the Bay Ocean sand spit was completed during the year (Figure 5). These surveys represent 358 observations along approximately 93,000 feet of transect line.

The distribution of intertidal bay clams was charted (Figure 6). Of the recreationally important clams, gapers and cockles were the principal species seen.

Sand and sand mixed with mud were the predominant substrate materials on the intertidal tideflat (Figure 7).

Extensive patches of eelgrass cover parts of the surveyed Bay Ocean tideflat (Figure 8). The major gaper clam beds occurred in several of these patches of eelgrass.

Netarts Bay

Subtidal clam distribution surveys were completed on Netarts Bay. Most of the tideflats have also been surveyed. To date, over 1,000 observations have been made along 175,000 feet of transect line. Figures 9 and 10 show the areas surveyed in 1975.

The distribution of clams in the subtidal clam beds surveyed in 1975 were mapped (Figures 11 and 12). Clams were generally scattered throughout the long and narrow channel. Gaper and cockle clams were the principal species observed.

Sand and sand mixed with shell were the principal substrate materials in the channel although rock and gravel occurred in pockets, especially in the lower bay (Figure 13 and 14). Sand and sand mixed with mud covered most of the tideflats.

Vegetation covered extensive areas of the channels (Figures 15 and 16). Few clams were observed in the vegetation due, at least partially, to the denseness of the plants and the difficulty of locating clams in this type of environment.

Nestucca Bay

We completed the subtidal and intertidal surveys in Nestucca Bay. This represented 225 observations made along 51,500 feet of transect (Figure 17).

Figure 18 shows the distribution of intertidal clams in the bay. The softshell clam *Mya arenaria*, was the principal species observed. No clams were seen in the subtidal survey although there appeared to be suitable habitat in the channel near the mouth of the bay.

The tideflats consisted primarily of sand and sand mixed with mud (Figure 19). Subtidally, massive boulders and rock outcroppings predominated at the mouth of the bay, grading into a substrate of gravel and sand up-bay.

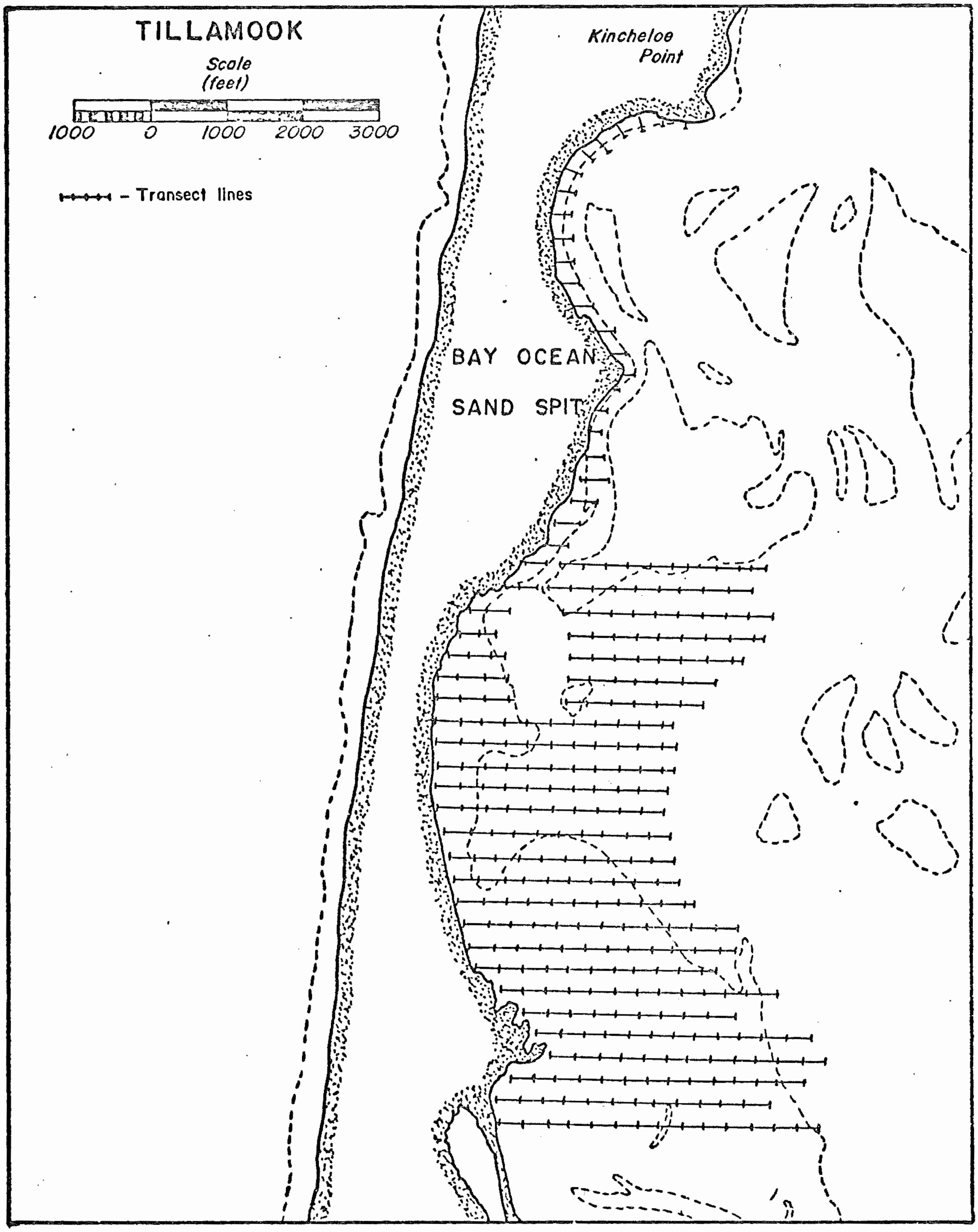


Figure 5. Intertidal Clam Survey Transect Lines and Sample Stations, Tillamook Bay, 1975

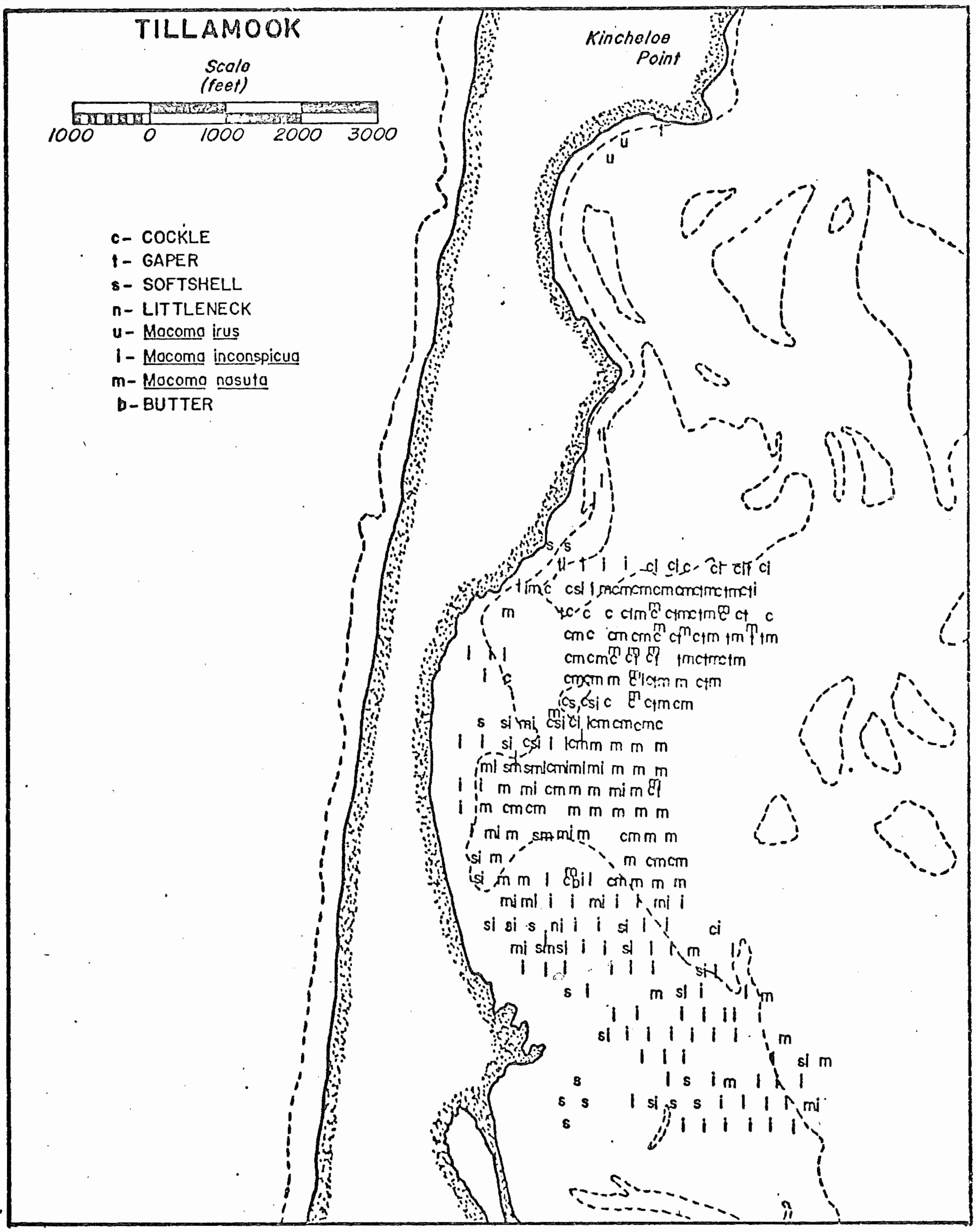


Figure 6. Distribution of Intertidal Clams, Tillamook Bay, 1975

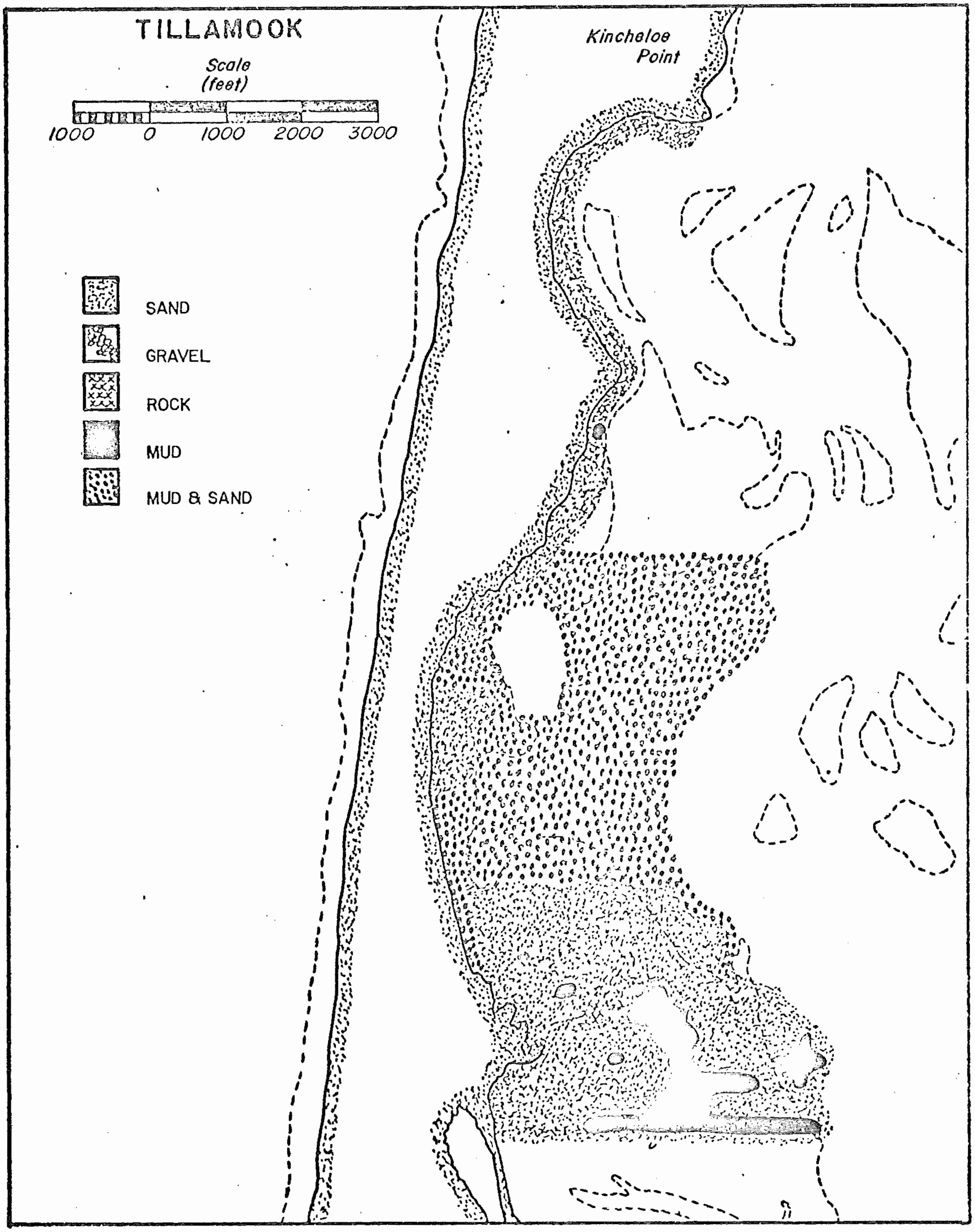


Figure 7. Substrate Material, Tillamook Bay, 1975

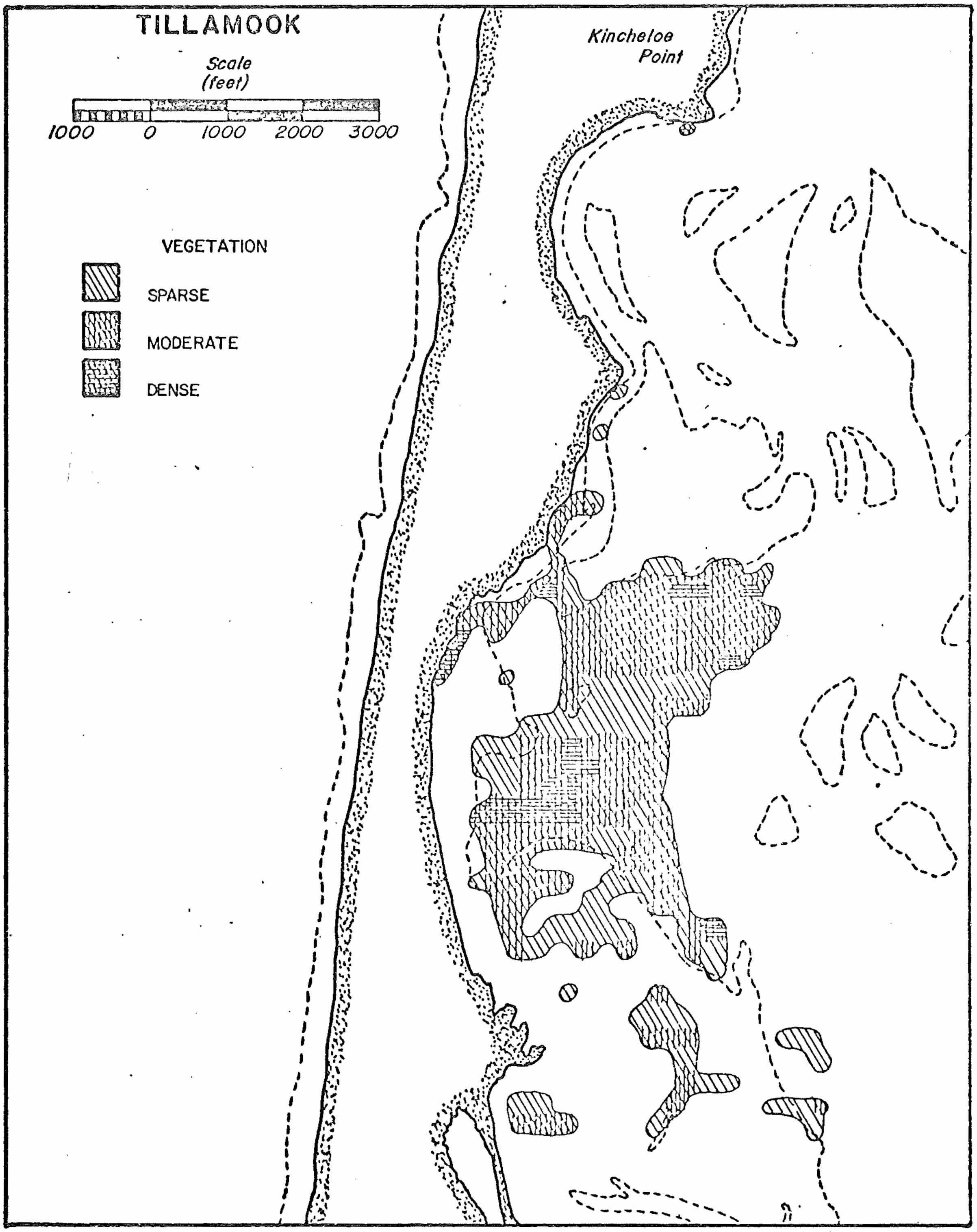


Figure 8. Vegetation, Tillamook Bay, 1975

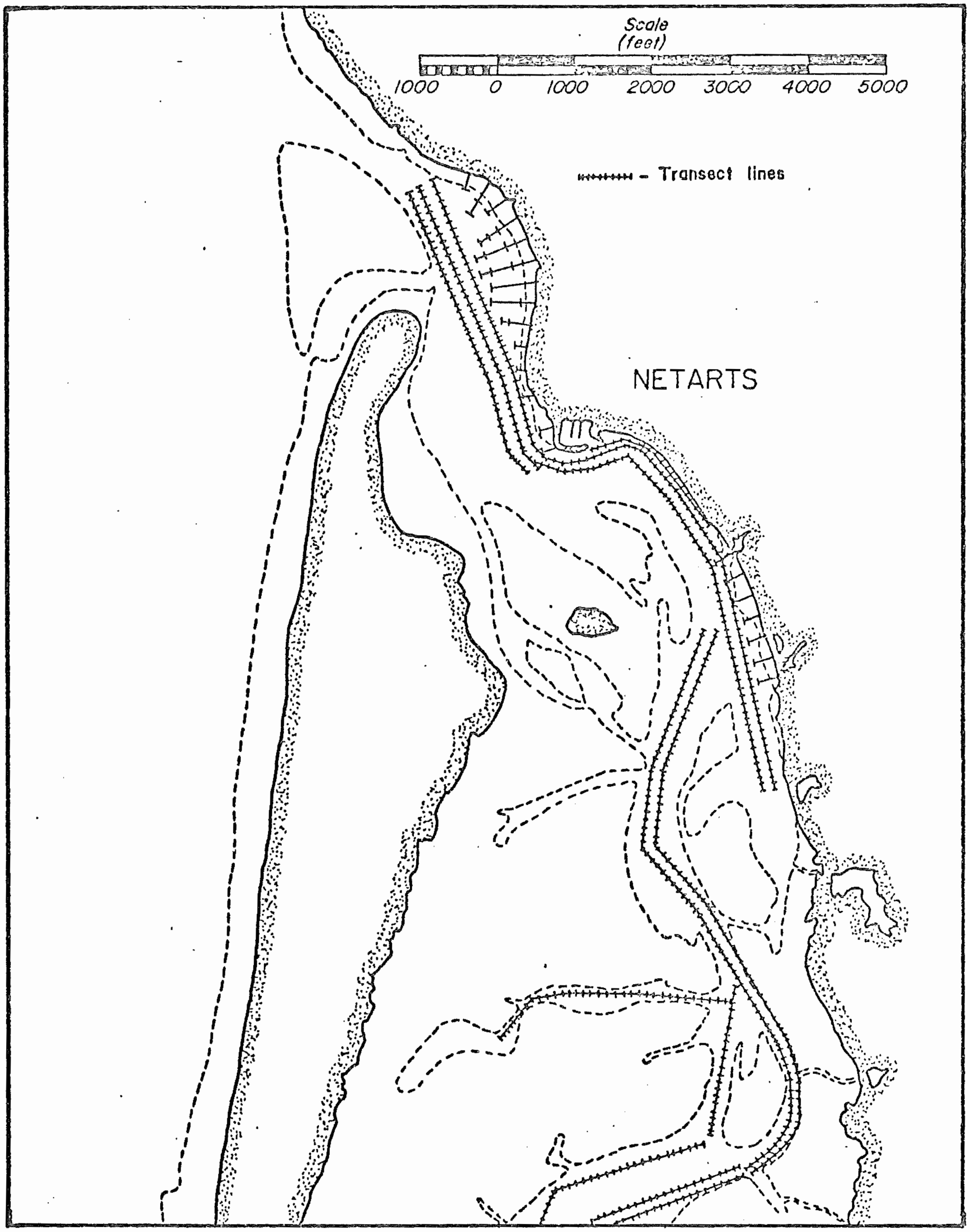


Figure 9. Clam Survey Transect Lines and Sample Stations, Lower Netarts Bay, 1975

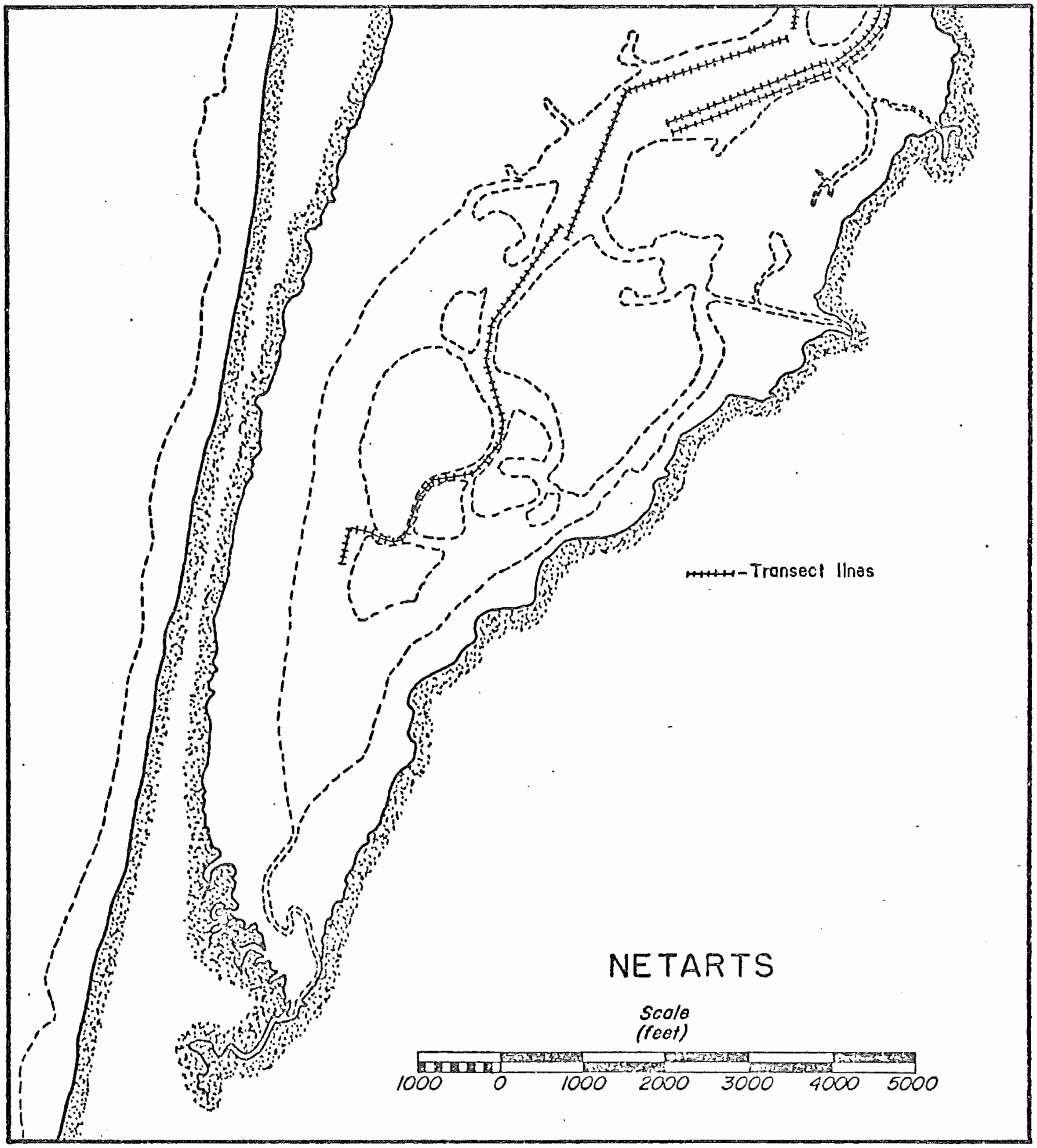


Figure 10. Clam Survey Transect Lines and Sample Stations, Upper Netarts Bay, 1975

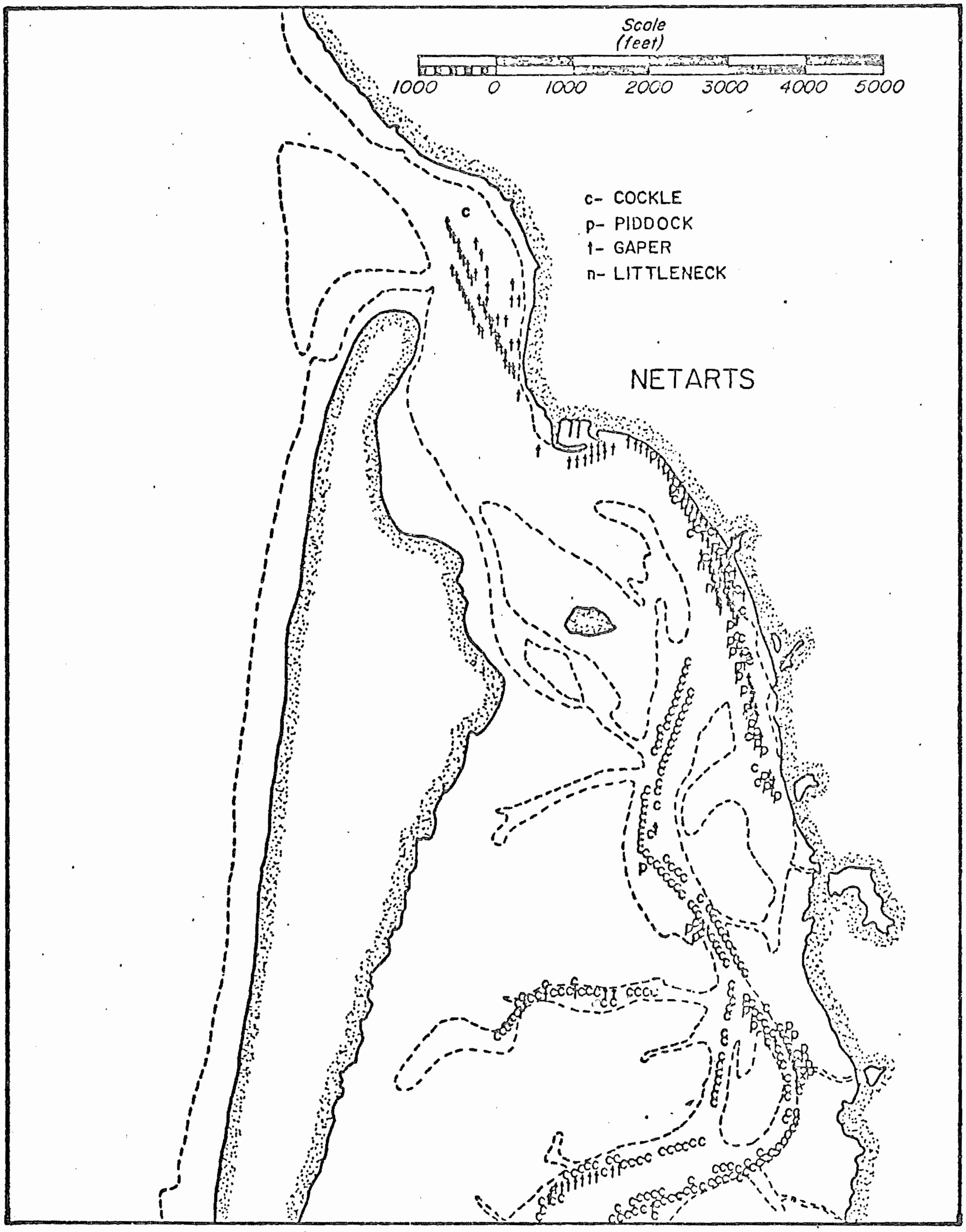


Figure 11. Distribution of Subtidal Clams, Lower Netarts Bay, 1975

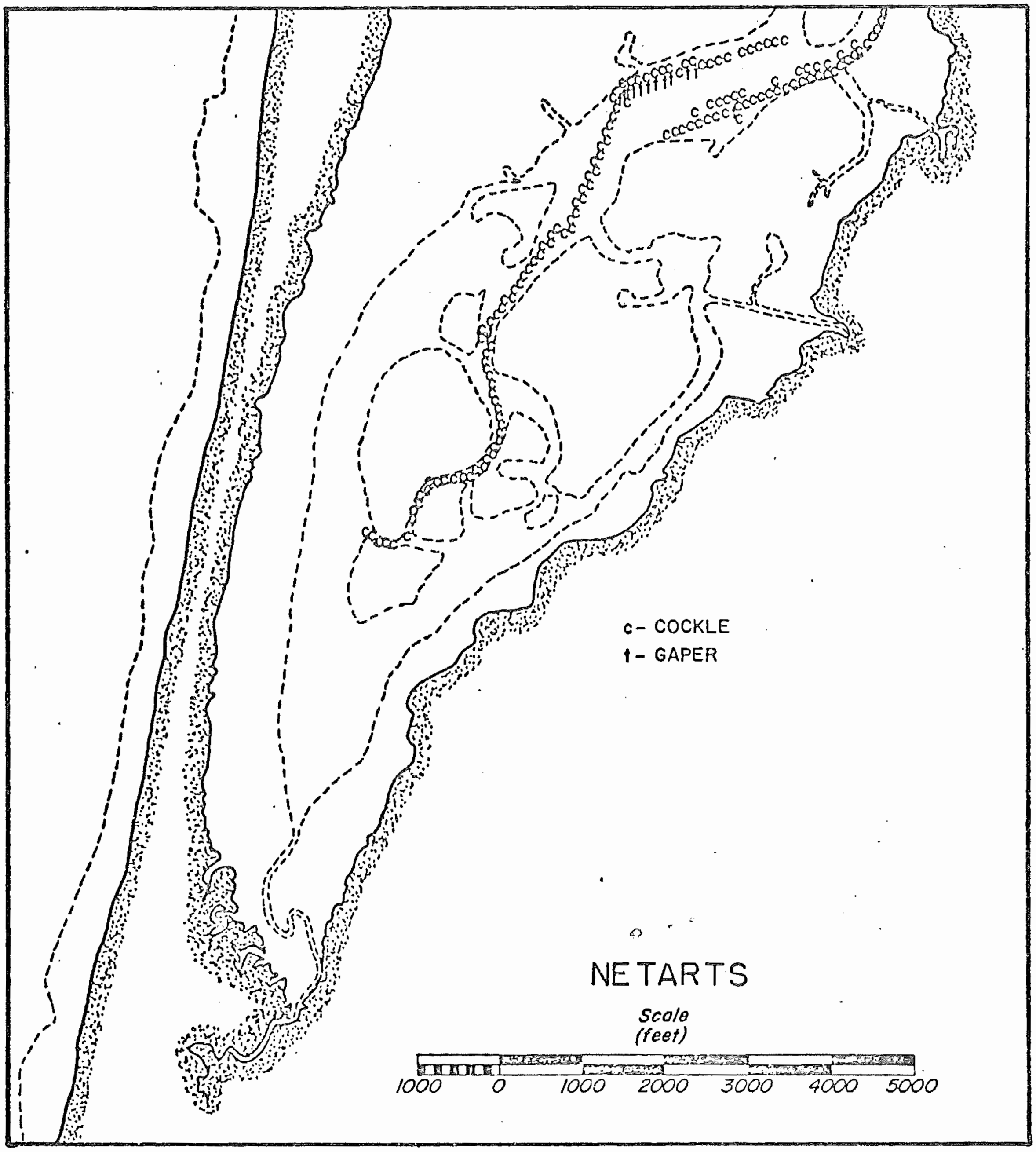


Figure 12. Distribution of Subtidal Clams, Upper Netarts Bay, 1975

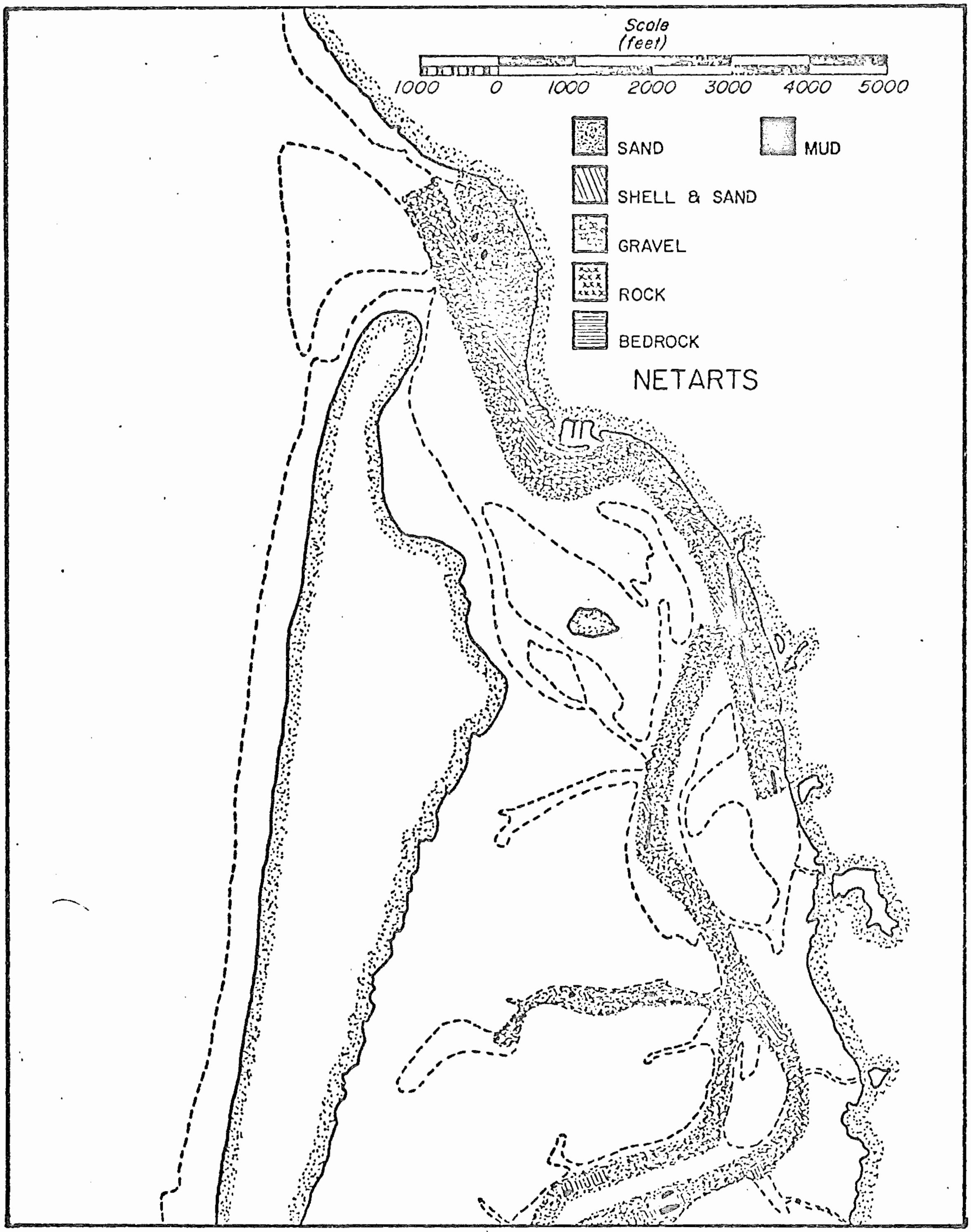


Figure 13. Substrate Material, Lower Netarts Bay, 1975

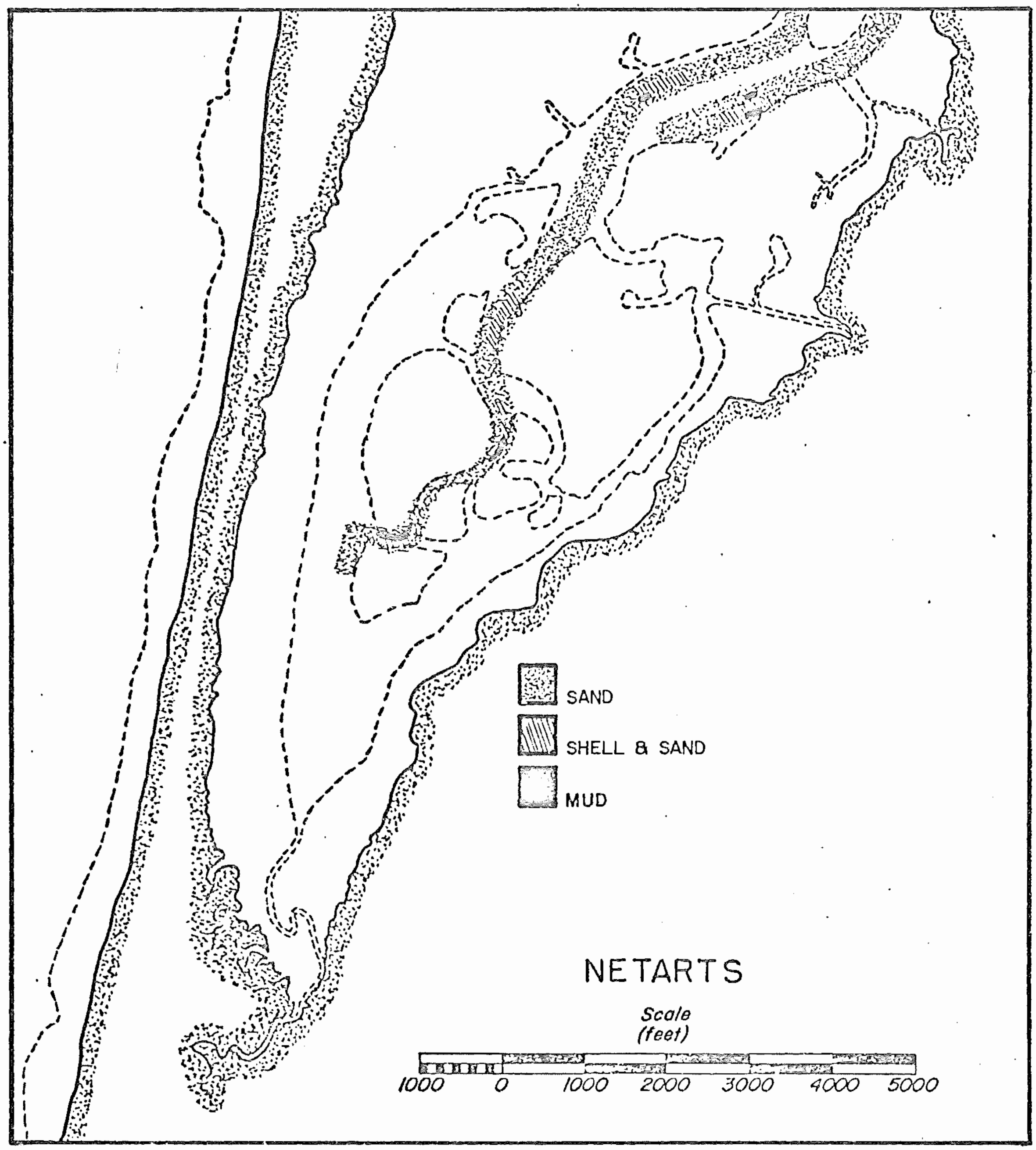


Figure 14. Substrate Material, Upper Netarts Bay, 1975

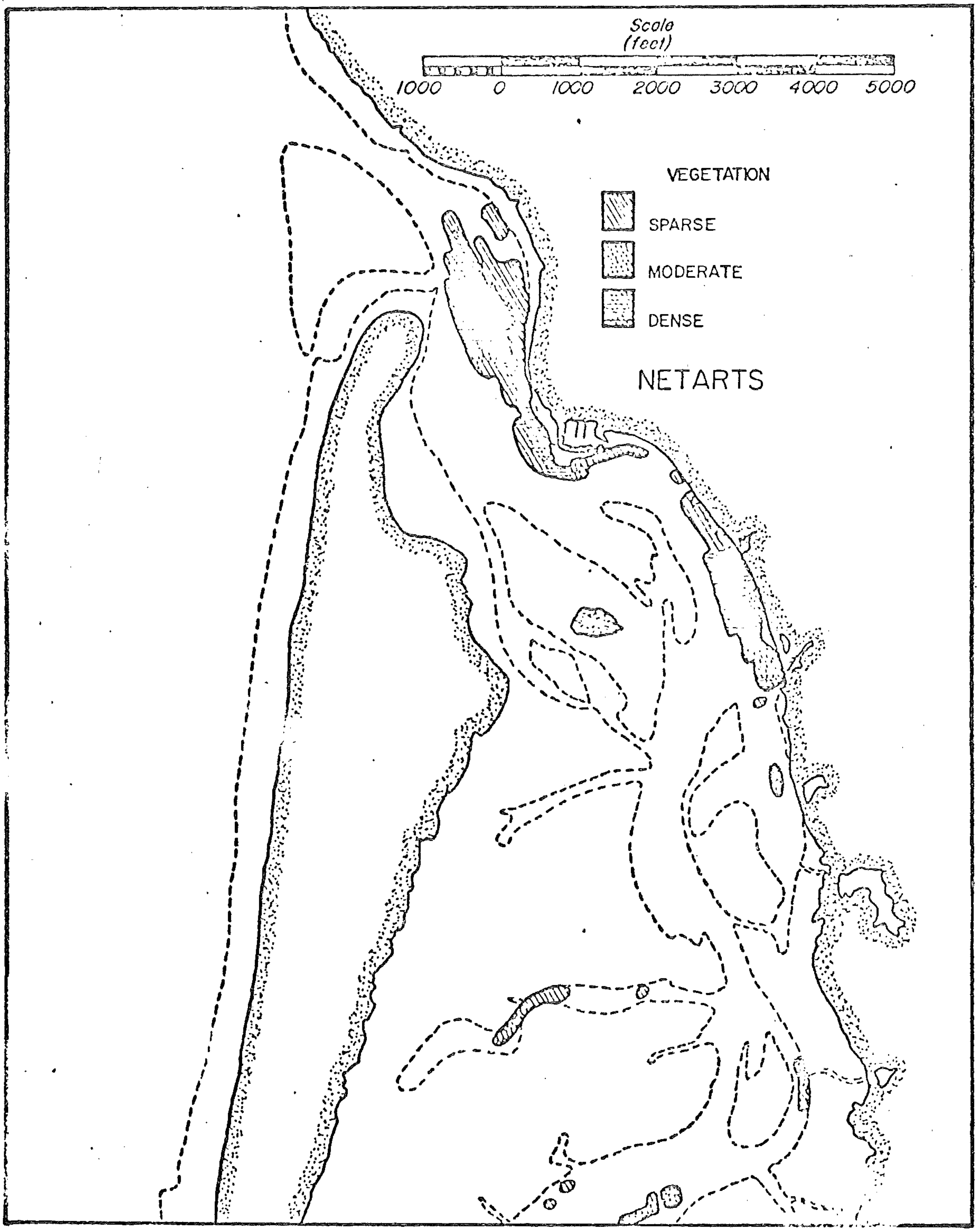


Figure 15. Vegetation, Lower Netarts Bay, 1975

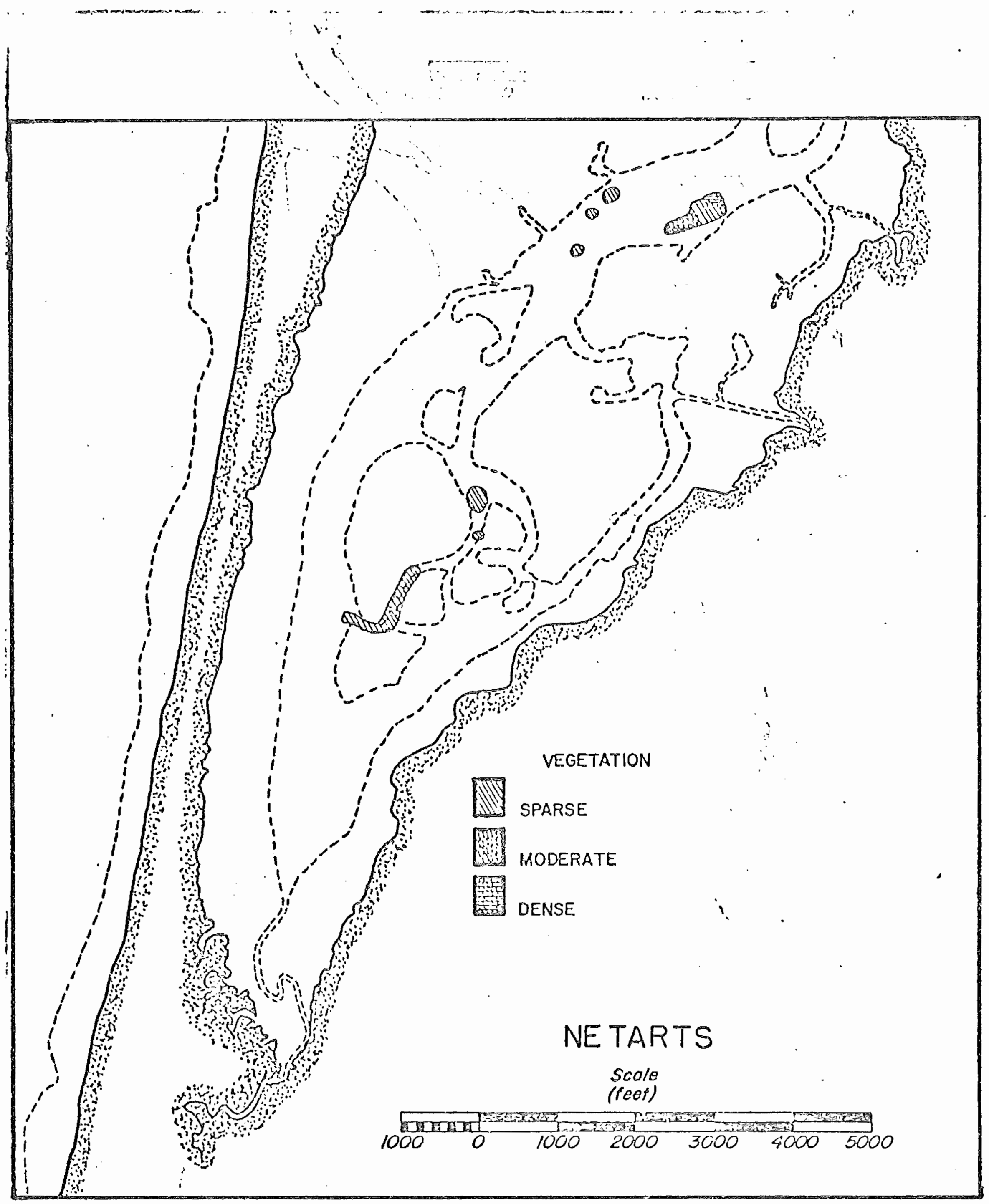


Figure 16. Vegetation, Upper Netarts Bay, 1975

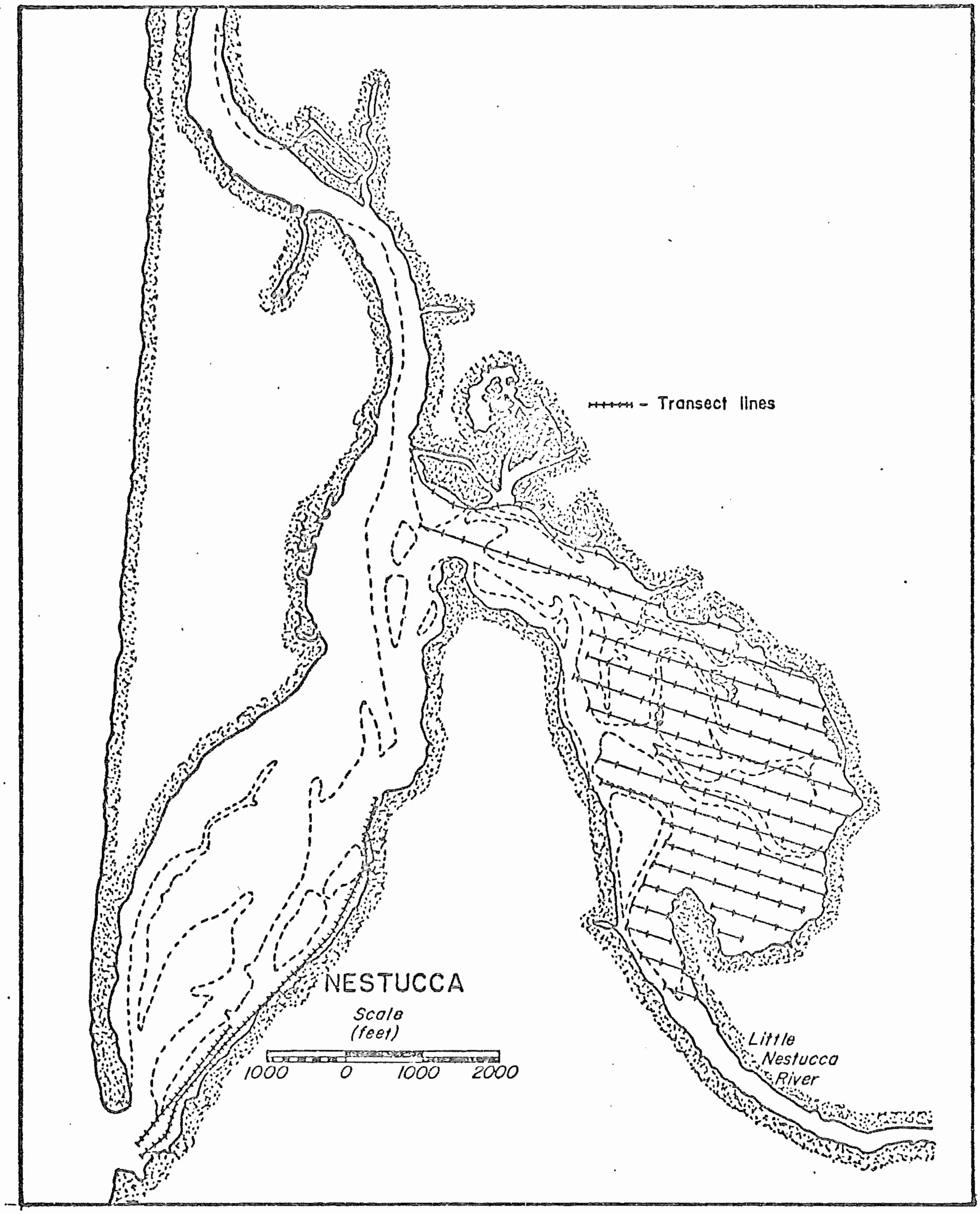


Figure 17. Clam Survey Transect Lines and Sample Stations, Nestucca Bay, 1975

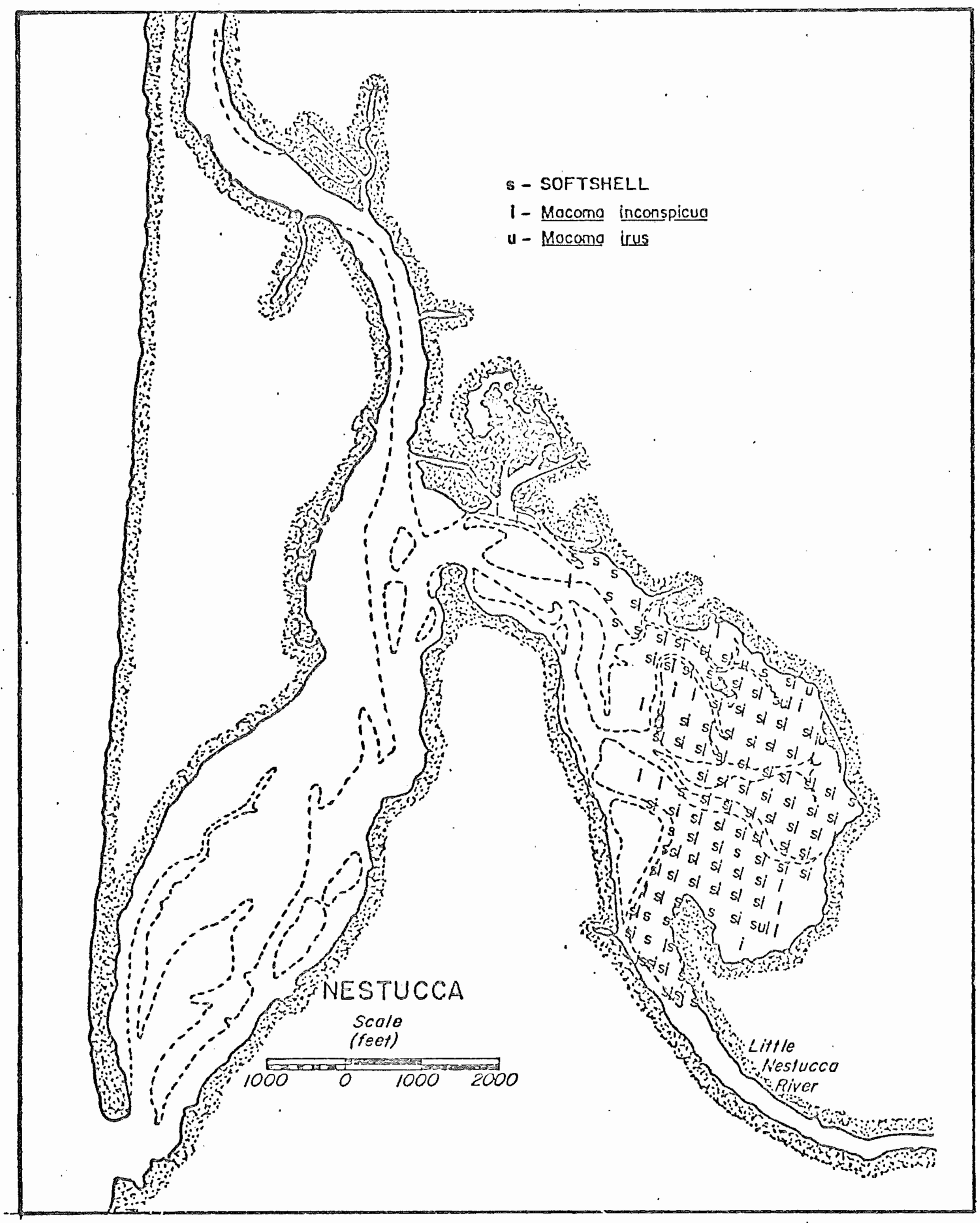


Figure 18. Distribution of Clams, Nestucca Bay, 1975

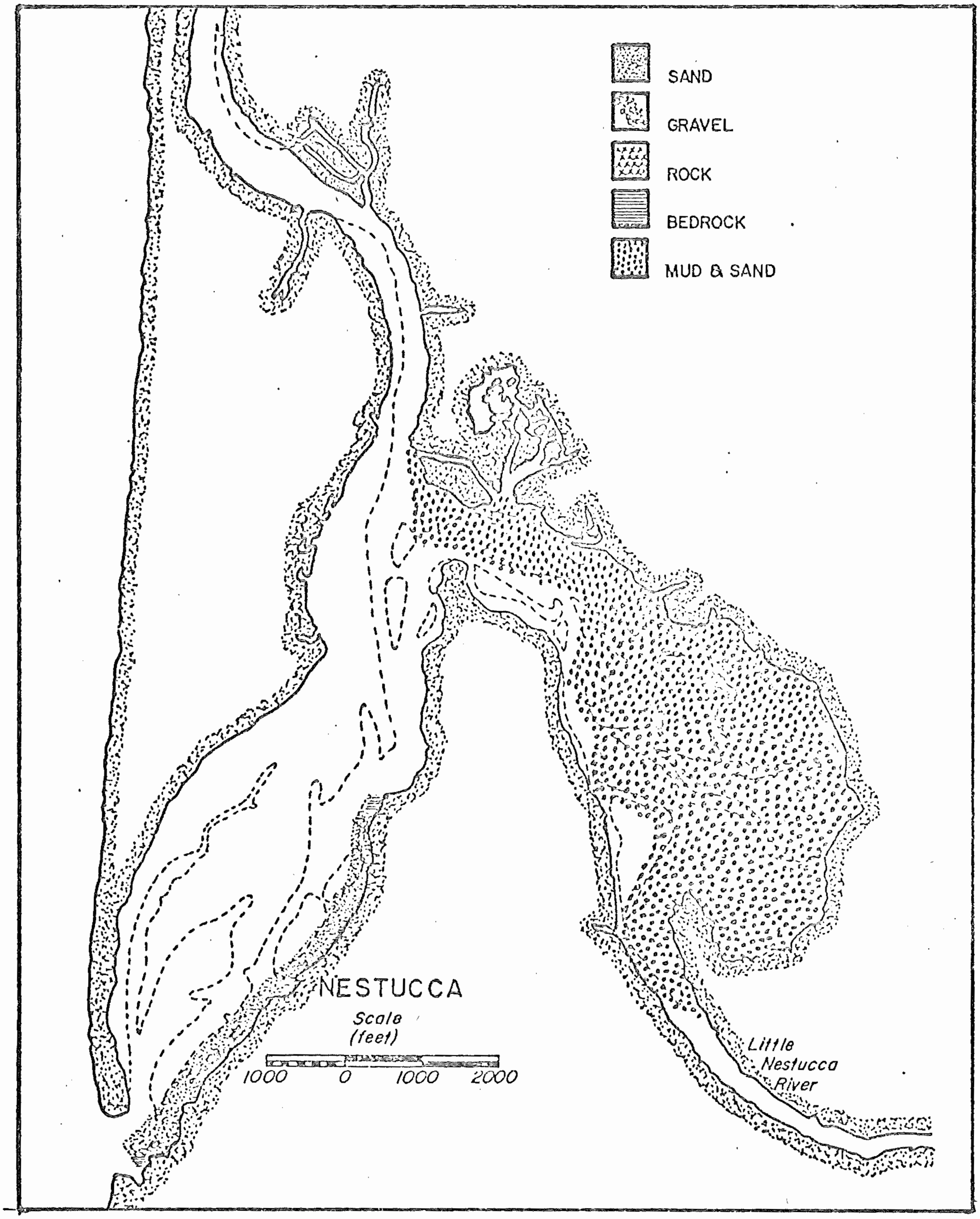


Figure 19. Substrate Material, Nestucca Bay, 1975

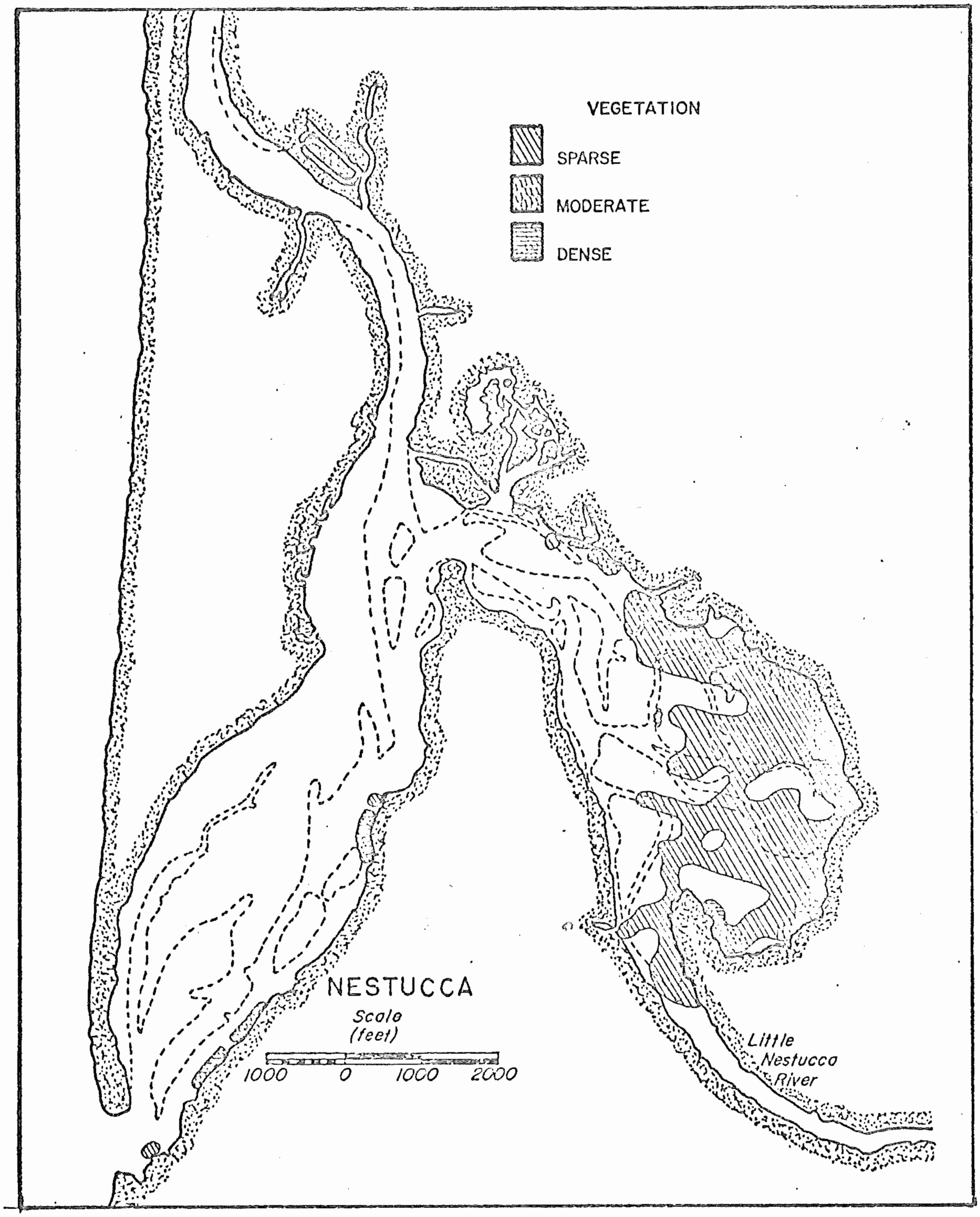


Figure 20. Vegetation, Nestucca Bay, 1975

Eelgrass was the most common vegetation observed and occurred over much of the tideflat of the Little Nestucca Estuary (Figure 20). Patches of eelgrass and sea lettuce, *Ulva sp.*, occurred in the subtidal channels.

Salmon River Estuary

Intertidal surveys were completed on approximately 50% of the estuary (Figure 21). Fifty-five observations were made along 7,200 feet of transect.

Sparse populations of softshell clams and *Macoma inconspicua* were observed scattered throughout the survey area (Figure 22).

Most of the substrate consisted of mud or mud mixed with sand (Figure 23). Rock and gravel covered much of the tideflat near the mouth of the bay.

Sparse vegetation was scattered throughout most of the survey area (Figure 24).

Siletz Bay

Intertidal and subtidal clam surveys were completed for the Siletz Estuary (Figure 25). We made 372 observations along 93,600 feet of transect.

The softshell clam was one of the main species observed (Figure 26). *Macoma inconspicua*, and the bentnose clam, *Macoma nasuta*, also inhabited the intertidal tideflats. Ghost (sand) shrimp, *Callianassa californiensis*, and mud shrimp, *Upogebia pugettensis*, populations were extremely dense throughout the area. No clams were observed in the subtidal survey.

Tideflats of the upper bay consisted mainly of soft mud and mud mixed with sand. The lower-bay tideflats consisted primarily of sand (Figure 27). The channel consisted of rock, gravel and sand. This material appeared to be suitable clam habitat but strong currents might preclude clam larvae from settling on or surviving in this area.

The up-bay tideflats were sparsely covered with a variety of aquatic vegetation (Figure 28). Sea lettuce and rockweed, *Fucus sp.*, covered much of the rocky area of the subtidal channel.

SURVEYS OF POTENTIAL COMMERCIAL CLAM BEDS

We continued our assessment of clam stocks in several of the major clam producing estuaries using a hydraulic dredge and techniques previously described (Gaumer and Lukas, 1975). Data collected included abundance of clams by species, size and age composition, bottom composition, vegetation type, and water depth. A haplosporidian infection in gaper clams was also studied. Data were collected from subtidal clam beds in Tillamook, Netarts, Yaquina, Siuslaw and Coos bays.

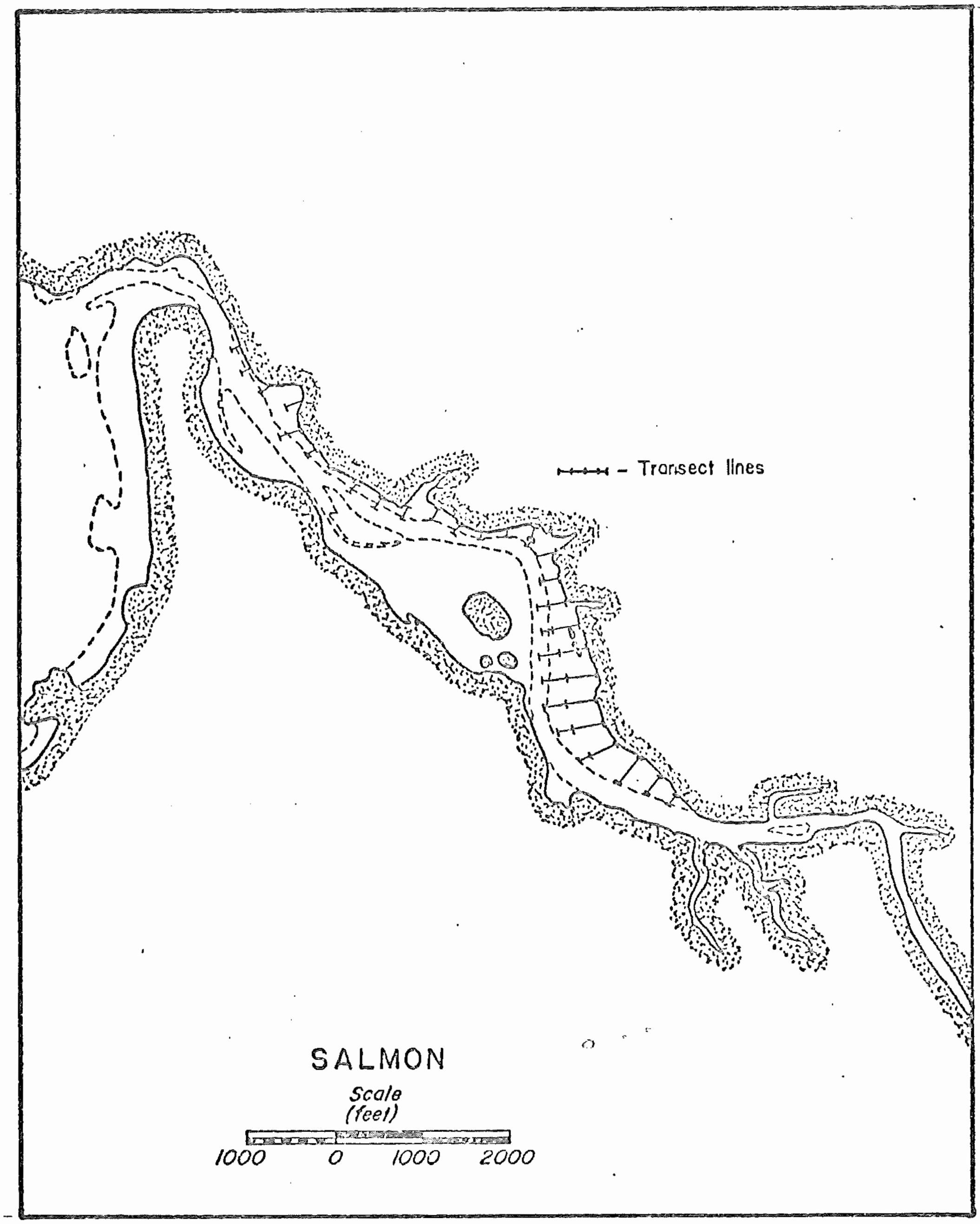


Figure 21. Clam Survey Transect Lines and Sample Stations, Salmon River, 1975

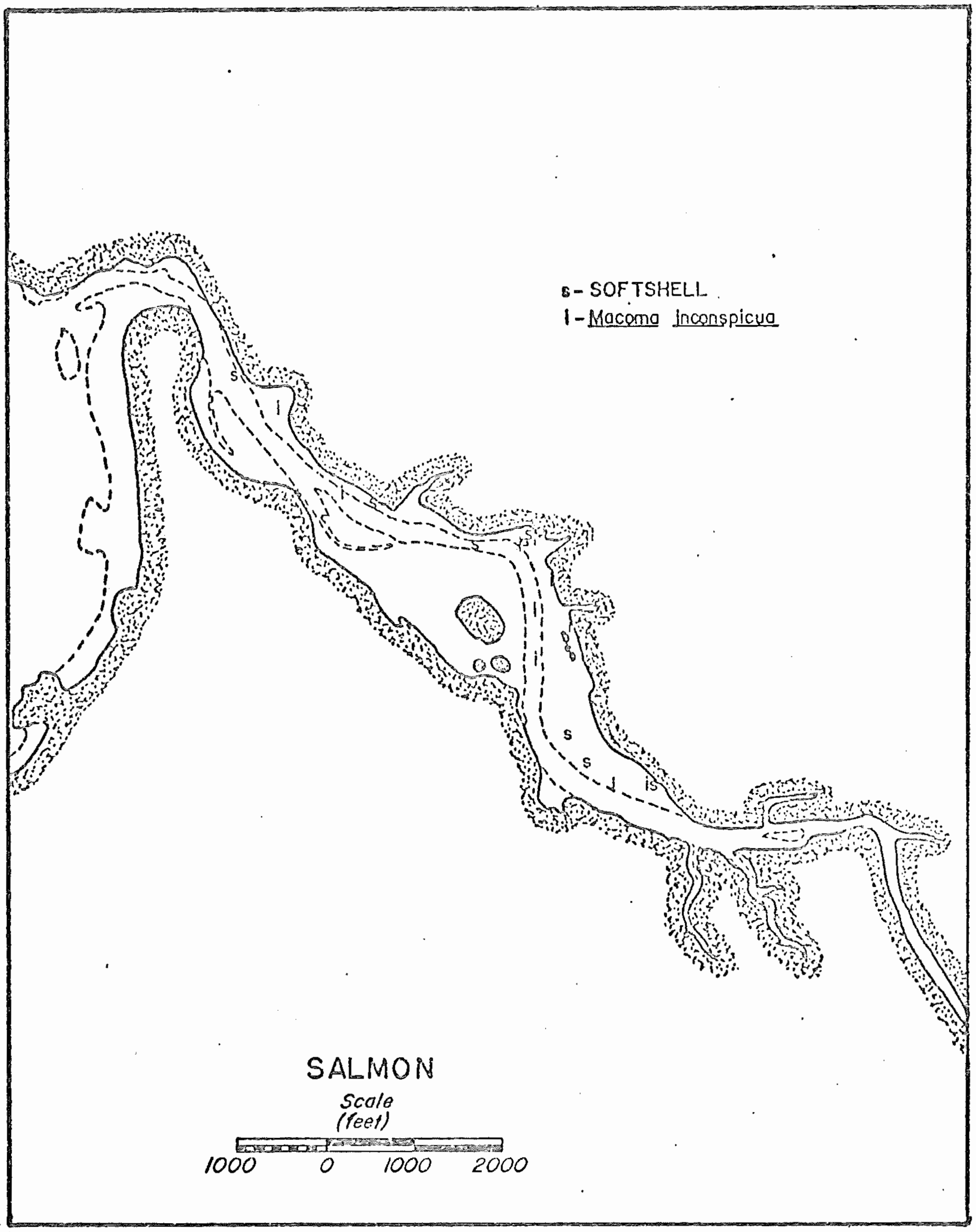


Figure 22. Distribution of Clams, Salmon River, 1975

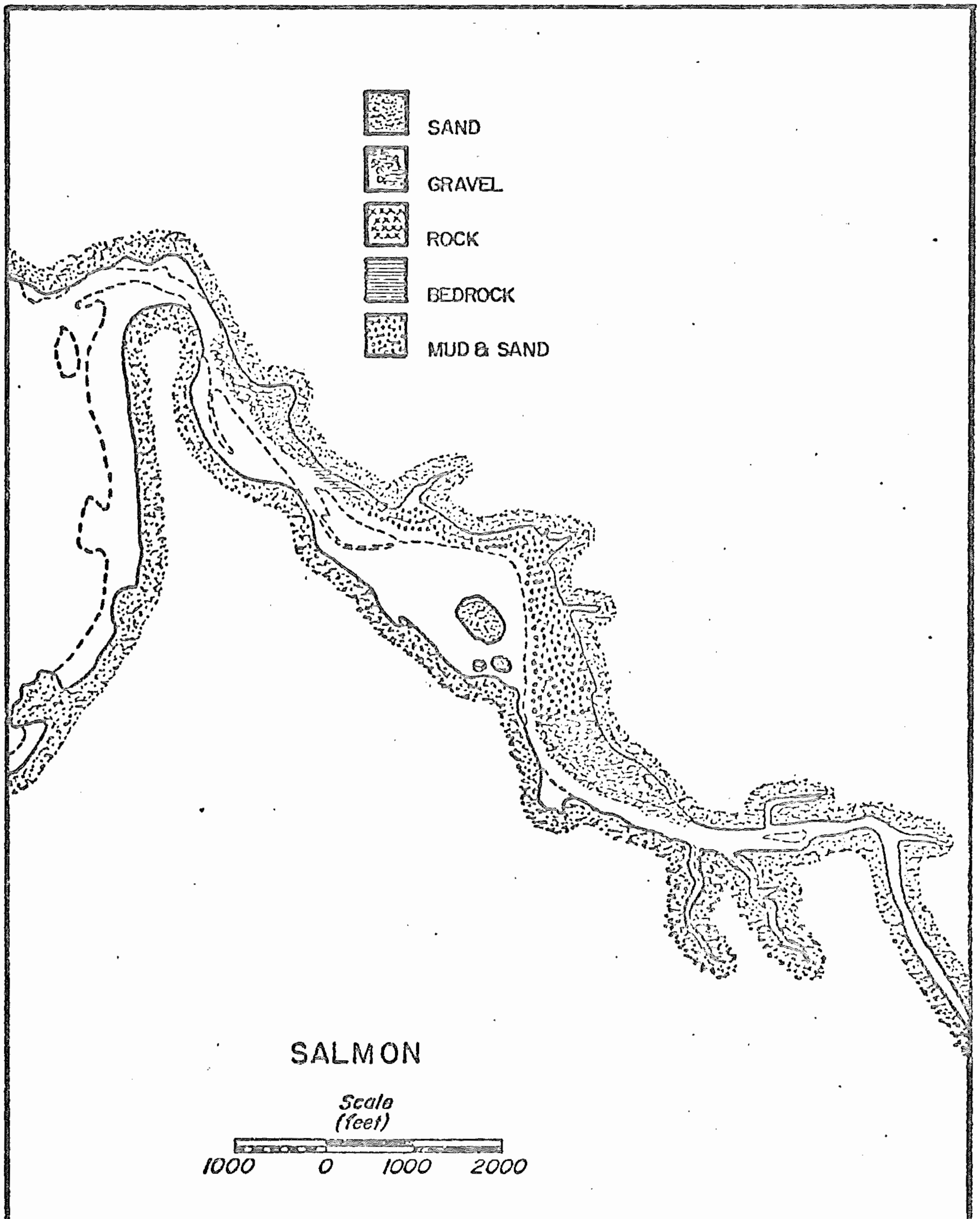


Figure 23. Substrate Material, Salmon River, 1975

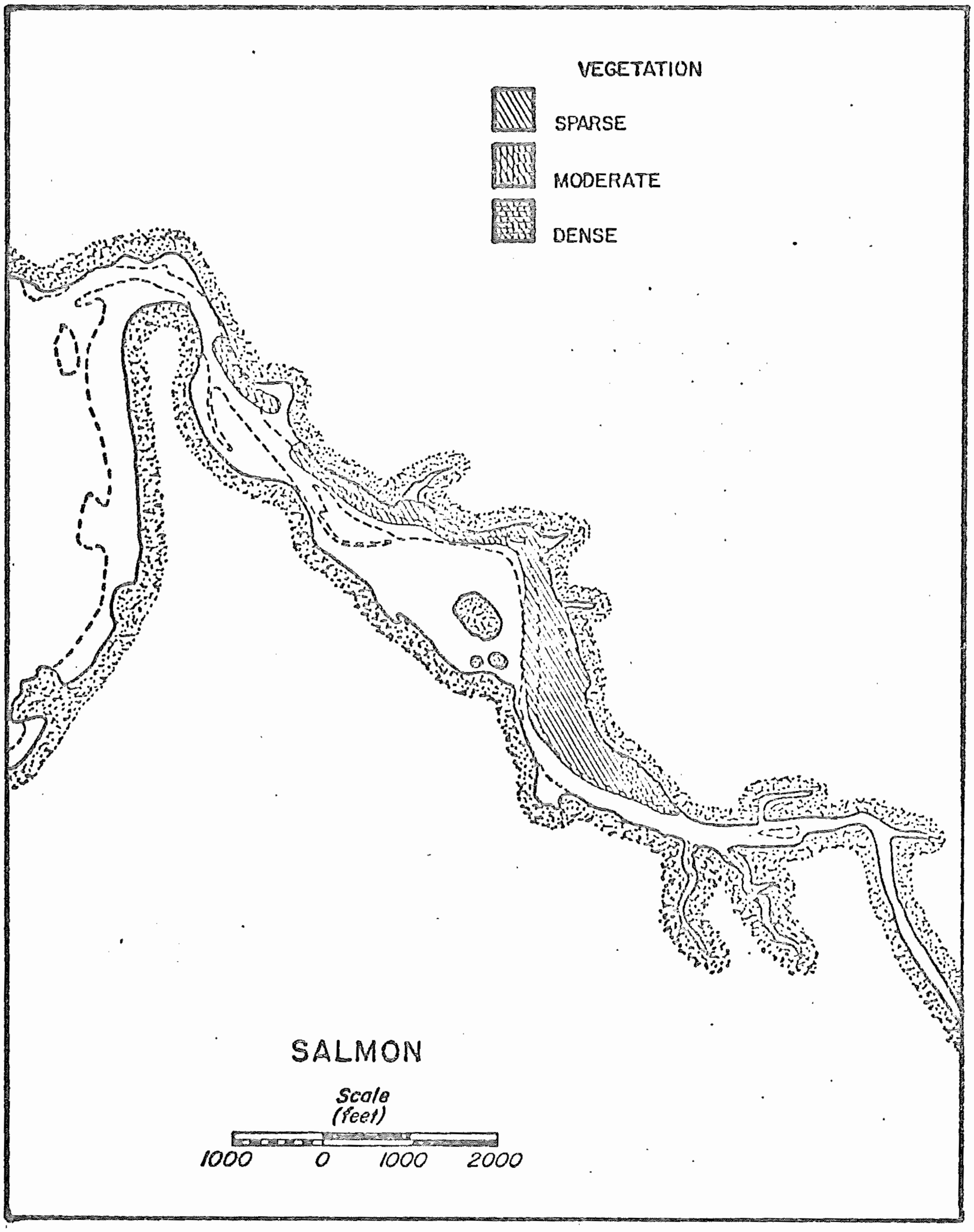


Figure 24. Vegetation, Salmon River, 1975

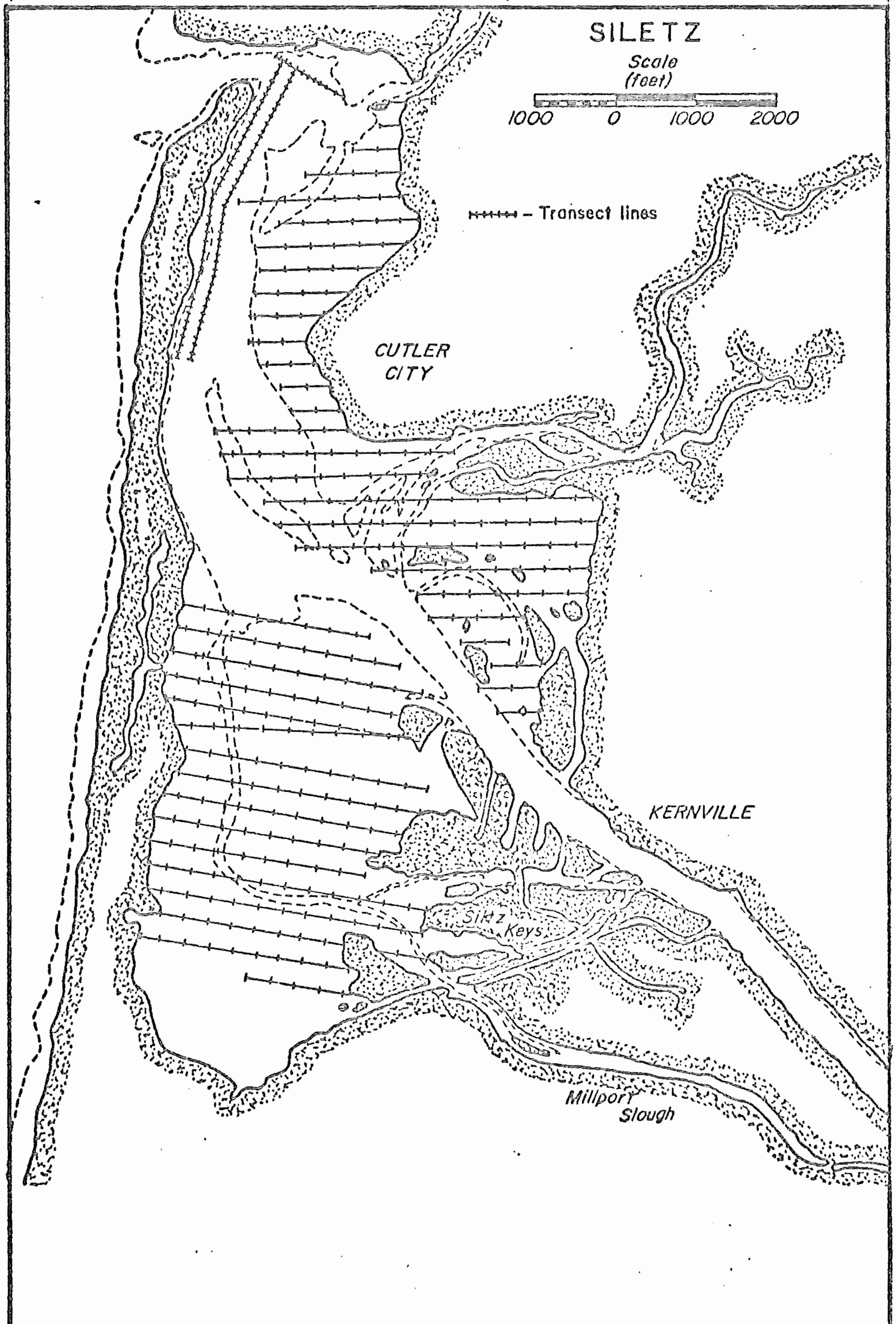


Figure 25. Clam Survey Transect Lines and Sample Stations,
Siletz Bay, 1975

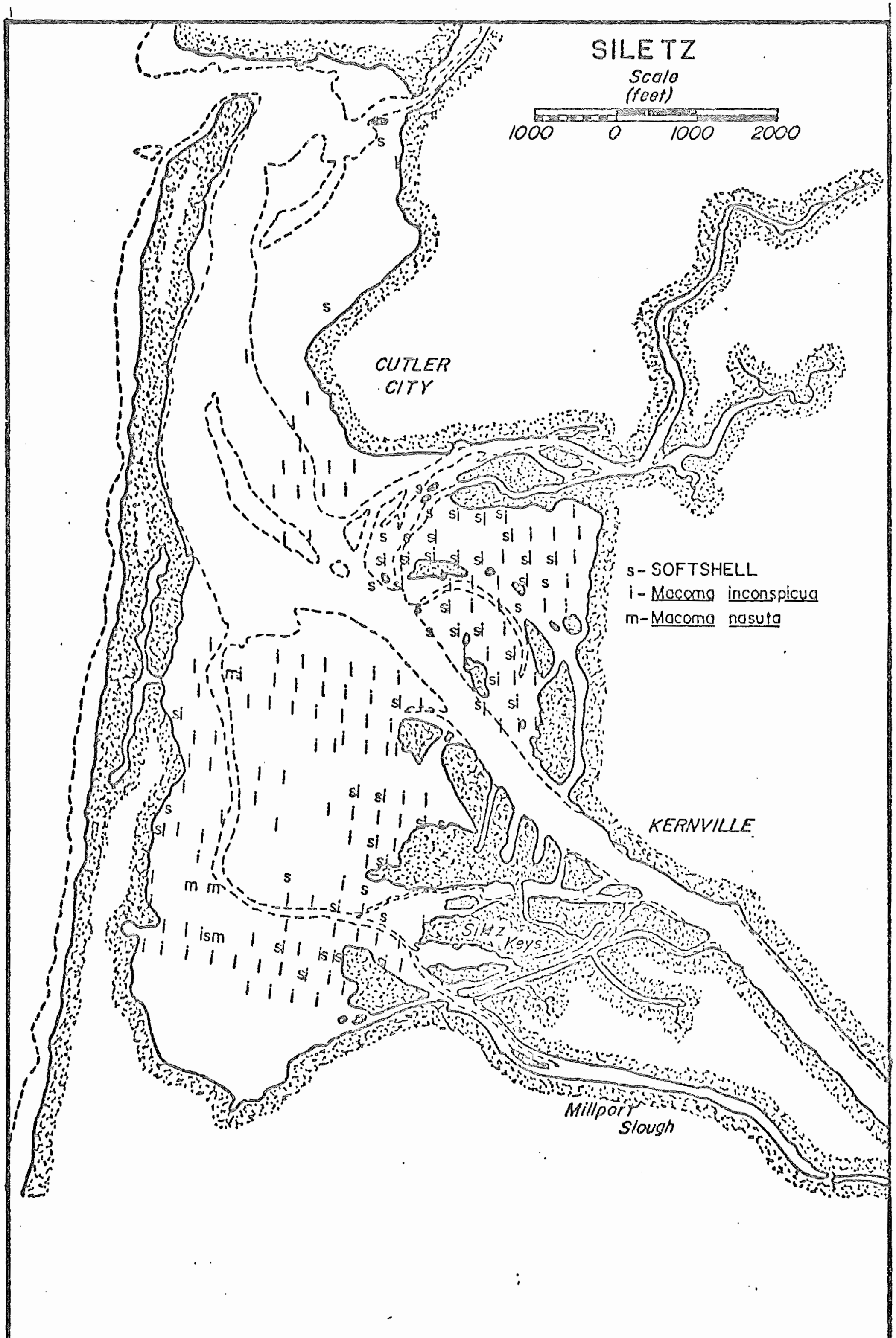


Figure 26. Distribution of Clams, Siletz Bay, 1975

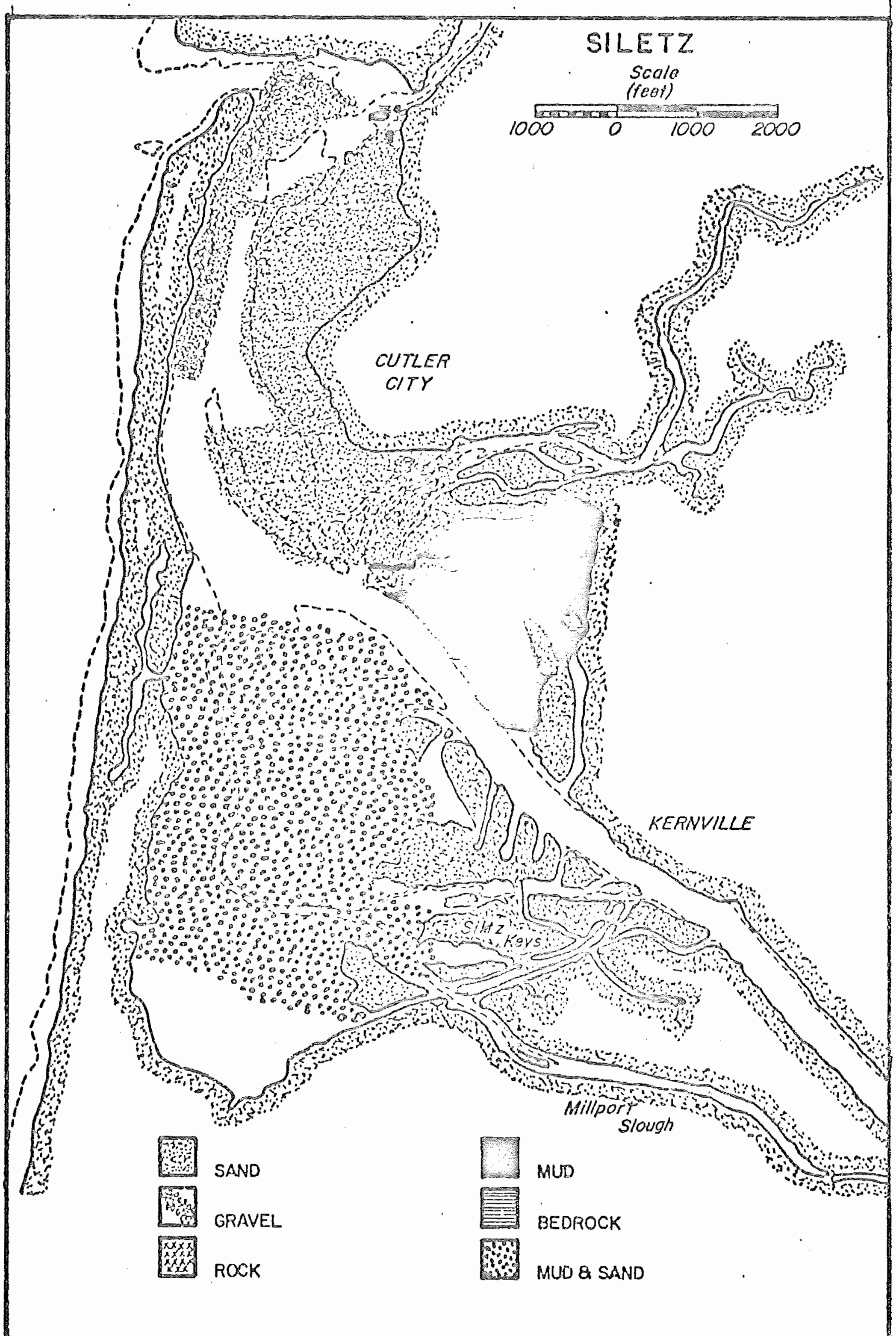


Figure 27. Substrate Material, Siletz Bay, 1975

Methods

Population Estimates

Yaquina Bay. Three clam beds were extensively surveyed in Yaquina Bay during the year. Area 1 is mostly in the ship channel below the U.S. highway 101 bridge and contains 20.2 acres (8.2 hectares). Twenty-seven dredge samples were taken from the area. Area 2 is a 35.4 acre (14.3 ha) clam bed and extends immediately up-bay from the highway 101 bridge. This bed is also primarily in the channel and 38 samples were taken for analysis. Area 3 contains 35.6 acres (14.4 ha) and is located adjacent to the main ship channel and just south of the breakwater. Forty dredge samples were excavated from this clam bed. In addition to the extensive surveys completed in areas 1, 2, and 3, we dredged a sample of gaper clams adjacent to Sally's Bend (Area 4) and Sawyer's Marina (Area 5) in April and again in July to provide a comparison of differences in size and age, through time, over the major range of gapers in the bay.

Coos Bay. We surveyed a 48-acre (19.4 ha) site between Pigeon Point and Empire that the U.S. Army Corps of Engineers had proposed as a dumping site for dredge spoils. Sixty-two dredge samples were taken.

Tillamook Bay. An additional 26.5 acres (10.7 ha) of the Hobsonville Point-Larson Cove clam bed was surveyed in 1975. Forty-six dredge samples were taken. Estimates for the down-bay portion of this clam bed were reported in 1975 (Gaumer and Lukas, 1975).

Aging Study

Various methods of aging clams have been used by different investigators but a comparison of the methods had not been done. We compared five different methods of aging gaper clams.

A random sample of gaper clams was collected from the subtidal area off Pigeon Point in Coos Bay during October after the clams had just finished their rapid summer growth. A total of 135 clams were used to test five methods of determining the ages of gaper clams. The right and left valves were also measured separately to determine if any difference in size existed.

After all clams were aged, statistical analysis was performed to determine if there were significant differences between the aging techniques. From this, the most consistent and accurate method of aging clams was selected.

Aging Technique 1: Shell Annuli

This technique involves identifying and counting the annular rings on the exterior surface of the valves.

Aging Technique 2: Cartilage Annuli

This technique requires that the valves be separated and the cartilage removed from the chondrophore, or ligament pit. Caution must be used when removing the cartilage because often the tip at the oldest portion breaks off during removal. After successful removal, annular rings can be counted on the cartilage at either of two places: where the cartilage attaches to the chondrophore, or where the left and right sections of the cartilage separate. For the smaller clams, it is necessary to use a 10x magnifying glass to accurately count the annuli. No attempt was made to age the left and right components of the cartilage separately, as generally only one section of the cartilage showed distinct annuli.

Aging Technique 3: Chondrophore Annuli

This technique necessitates that the valves be separated and the cartilage removed and discarded from the chondrophore. The annular rings in the chondrophore appear as light purplish bands interspaced between the cream colored background of the chondrophore.

Aging Technique 4: Chondrophore Annuli with High Intensity Light

This technique consists of separating the valves, removing the cartilage from the chondrophore and removing the chondrophore intact from the remainder of the valve. The chondrophore is easily separated from the valve by snipping it apart with a pair of wire cutters or tin snips. Once removed, a high intensity light is held or mounted behind the chondrophore and the annular rings appear as bright white lines against a darker background.

Aging Technique 5: Chondrophore Cross Section

This technique comprises separating the valves, removing the cartilage from the chondrophore, and cross sectioning the valve from the umbo to the outer margin of the shell. This can be accomplished with either a hacksaw or a pair of wire cutters or tin snips. Either the annular rings of the chondrophore or of the valve can then be counted.

Haplosporidian Study

A haplosporidian infection in intertidal gaper clams was first reported from Yaquina Bay by Armstrong and Armstrong (1974). Gaumer and Lukas (1975) reported on observations in subtidal gaper clams. To increase our knowledge of the incidence and distribution of this infection, subsamples of gaper clams collected during our surveys from Yaquina, Coos and Tillamook bays were examined by Dr. Robert Olson, Oregon State University, Department of Zoology. Clams were also collected from Netarts and Siuslaw bays for examination. Clams were collected quarterly from Yaquina Bay from five different major subtidal clam beds. Single samples were taken from each of the other bays.

Results and Discussion

Population Estimates

Yaquina Bay. Figure 29 shows the occurrence of butter, cockle, gaper and littleneck clams in three subtidal clam beds of lower Yaquina Bay. Two different observed concentrations of clams per sample are illustrated; those with less than two clams/square foot (.092 m^2) and those with more than two clams/square foot.

From our dredged samples we estimated that 141.4 million clams inhabited the

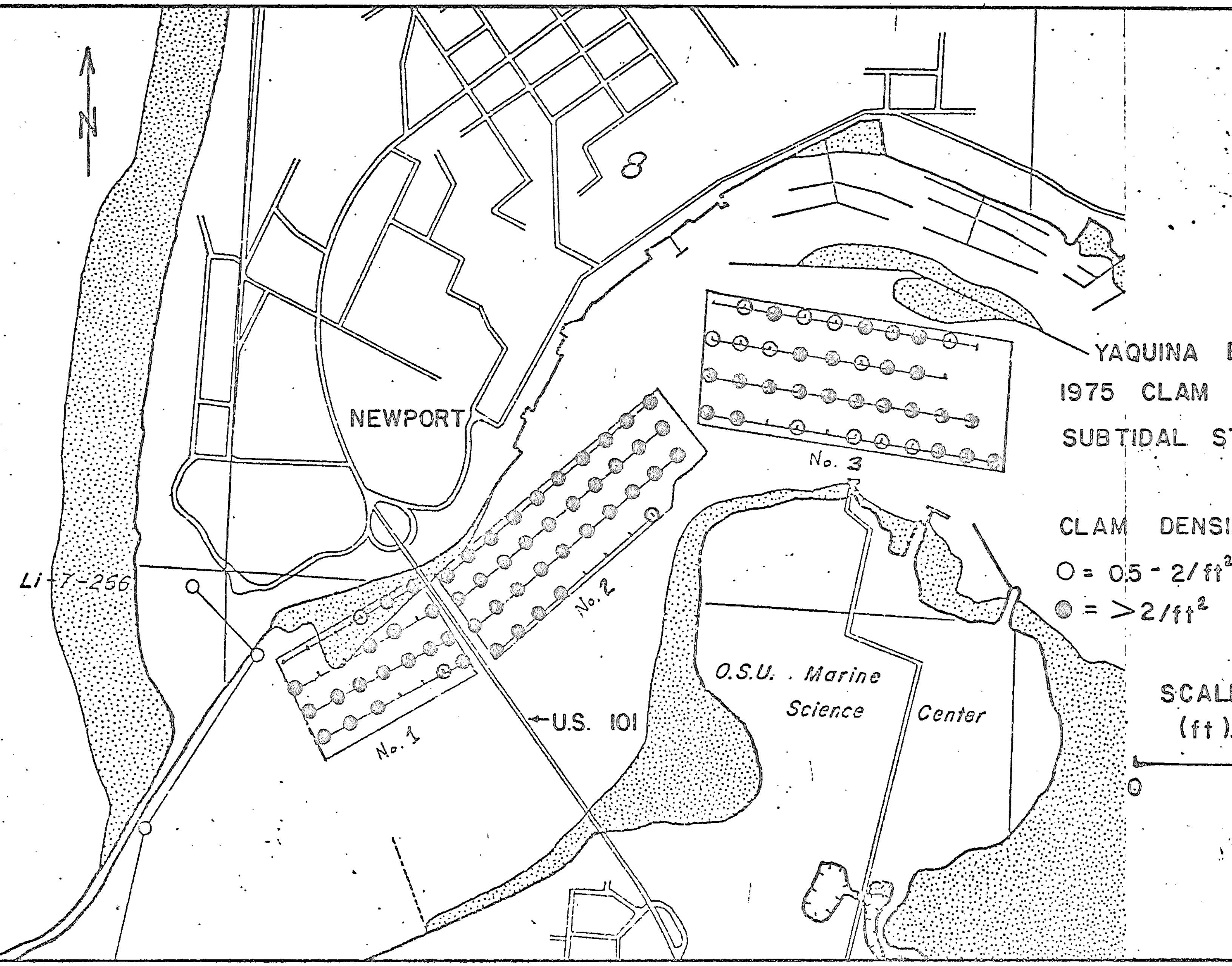


Figure 29. Occurrence of Butter, Cockle, Gaper and Littleneck Clams in Dredge Samples, Areas 1, 2 and Yaquina Bay, 1975

three areas (Table 1). Of this total, 25 million were found in area 1, 93.2 million in area 2, and 23.1 million in area 3. The gaper clam was the principal species dug from each of the areas, with a population estimate of over 101 million. Of this total, 82.3 million (81.4%) were zero-age clams of the 1975 year class. Zero-age gapers were found in large numbers in each area (Figure 30). Clams progressed in age as we moved up-bay with the mean age in areas 1, 2, and 3 being 0.9, 0.7, and 1.7, years, respectively. Excluding the zero-age clams from the sample gave a mean age of 3.1, 4.9, and 6.4 years for areas 1, 2, and 3, respectively.

Table 1. Summary of Numbers of Subtidal Clams in Areas 1, 2 and 3, Yaquina Bay, 1975

Species	Areas 1	Areas 2	Areas 3	Total
Gaper	19,262,100	68,252,500	13,608,000	101,122,600
Cockle	81,400	315,700	462,000	859,100
Littleneck	146,600	568,300	168,000	882,900
Butter	260,700	989,400	567,000	1,817,100
Irus clam (*Macoma irus*)	4,611,800	20,863,000	7,854,000	33,328,800
Bentnose	0	0	168,000	168,000
Piddock (*Zirfaea pilsbryi*)	635,500	2,147,400	0	2,782,900
Bodega tellen (*Tellina bodegensis*)	16,300	105,100	273,000	394,400
Jack knife (*Solen sicarius*)	0	0	42,000	42,000
Total	25,014,500	93, 241,400	23,142,000	141,397,800

The length frequency for the dredged gaper clams is shown in Figure 31. Mean size of gaper clams in areas 1, 2, and 3 was 41.1, 36.9, and 47.6 mm, respectively.

Mean size of gaper clams for each area was nearly the same through the first four age groups (Figure 32) whereas older clams were slightly larger in the up-bay area. Clam size ranged from 10 to 155 mm and was generally similar for all three areas.

Figure 33 shows the age composition of butter, cockle, gaper, and littleneck clams in Yaquina Bay. Clams were combined for all three areas. Age composition for each species, other than the gaper clam, showed that the 1974 and 1975 year classes were especially strong, with excellent survival of new clam set.

The lack of large numbers of clams for certain year classes suggests that spawning or survival of set is sporadic or that occasional dredging of the channel is removing the older clams. The small percentage of adult gaper clams (Figure 33) was the result of the exceptionally large number of 1975 set. Excluding the zero-age clams, these areas contained an estimated 18.8 million gaper clams.

Clams of each species showed the expected range in size as observed for clams in other areas and bays. Mean sizes for the butters, cockles, gapers, and littlenecks

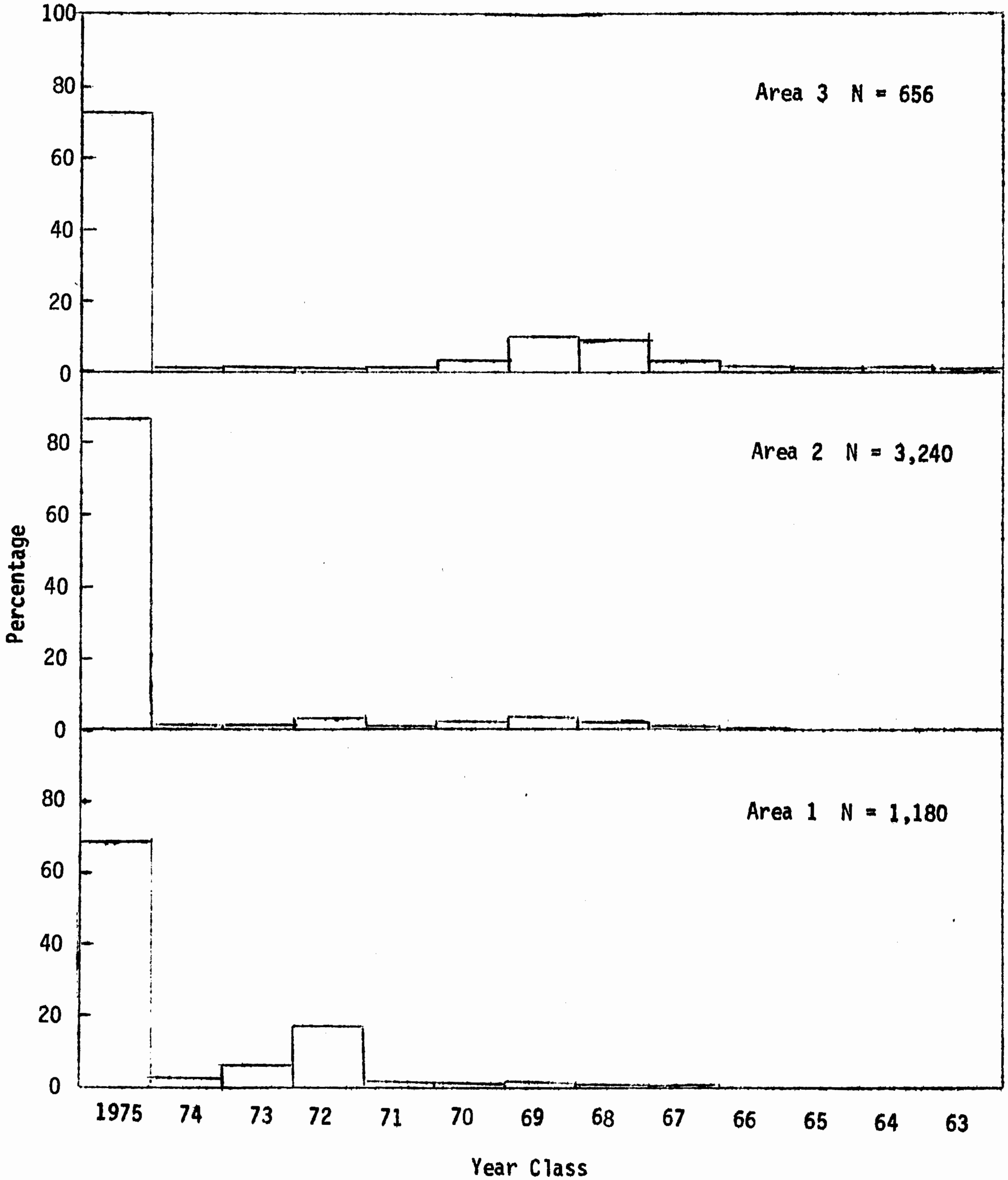


Figure 30. Age Composition of Dredged Gaper Clams, Areas 1, 2 and 3 of Yaquina Bay, 1975

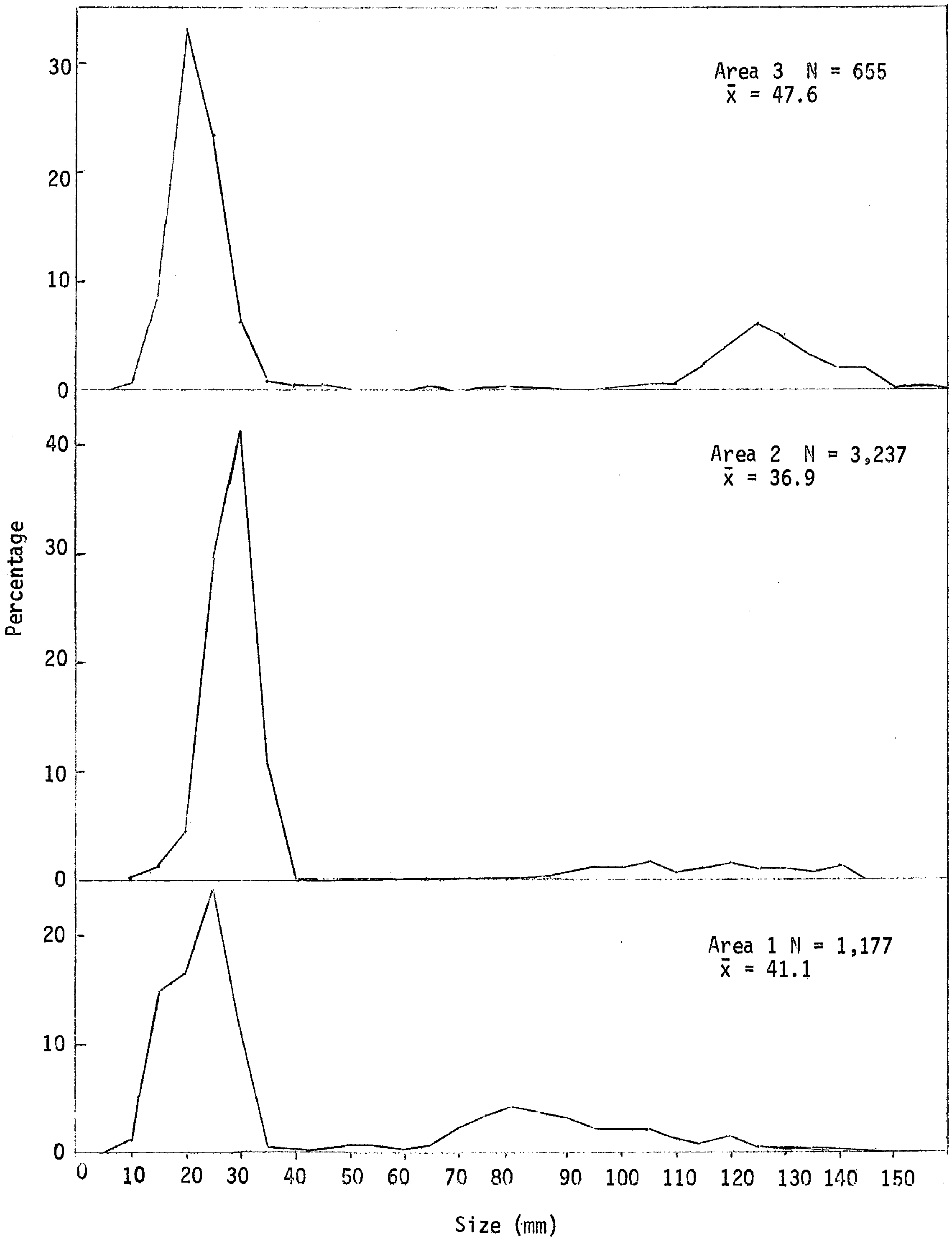


Figure 31. Length Frequency of Dredged Gaper Clams, Areas 1, 2 and 3 of Yaquina Bay, 1975

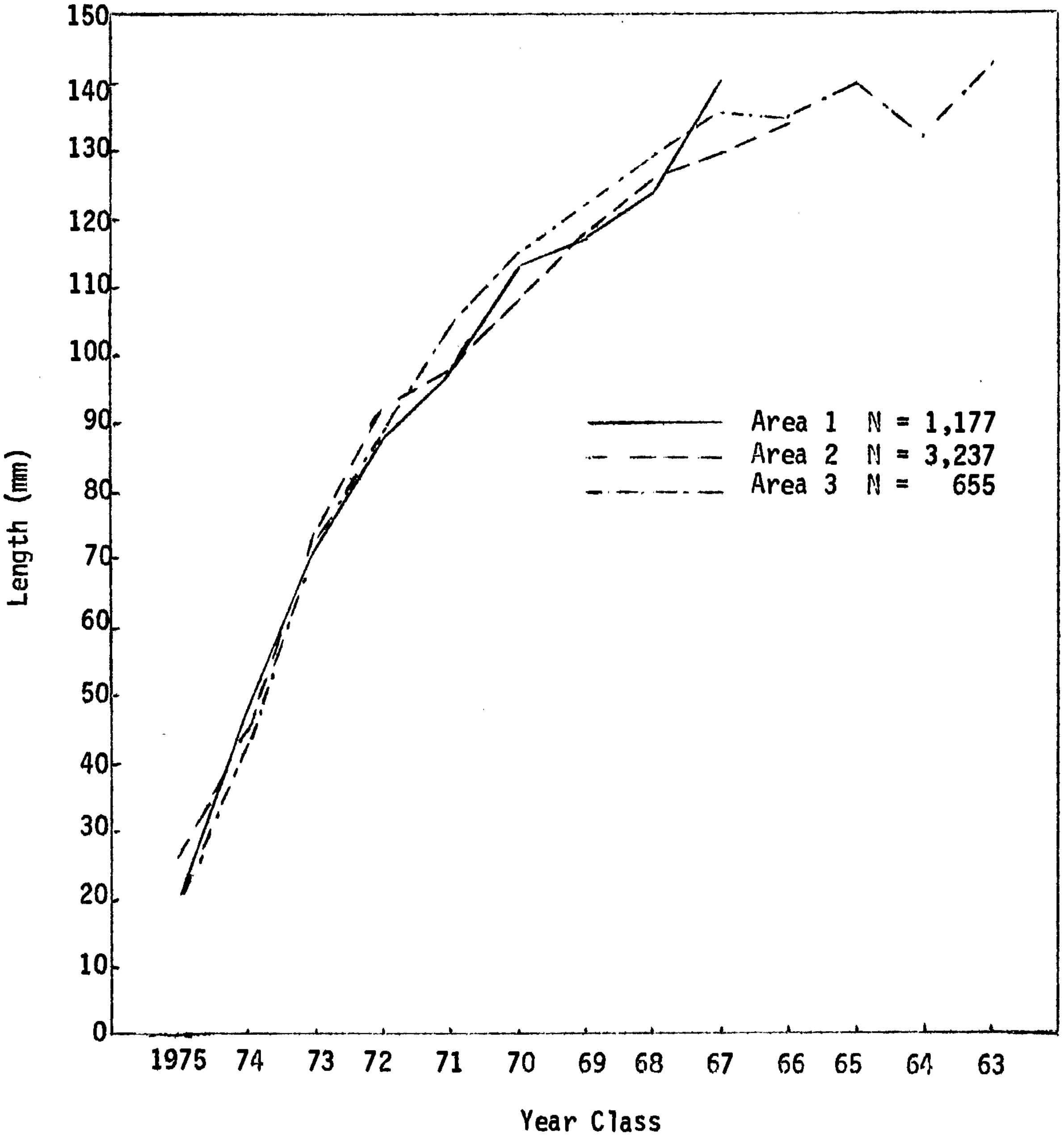


Figure 32. Mean Size of Gaper Clams, by Age, for Areas 1, 2 and 3 of Yaquina Bay, 1975

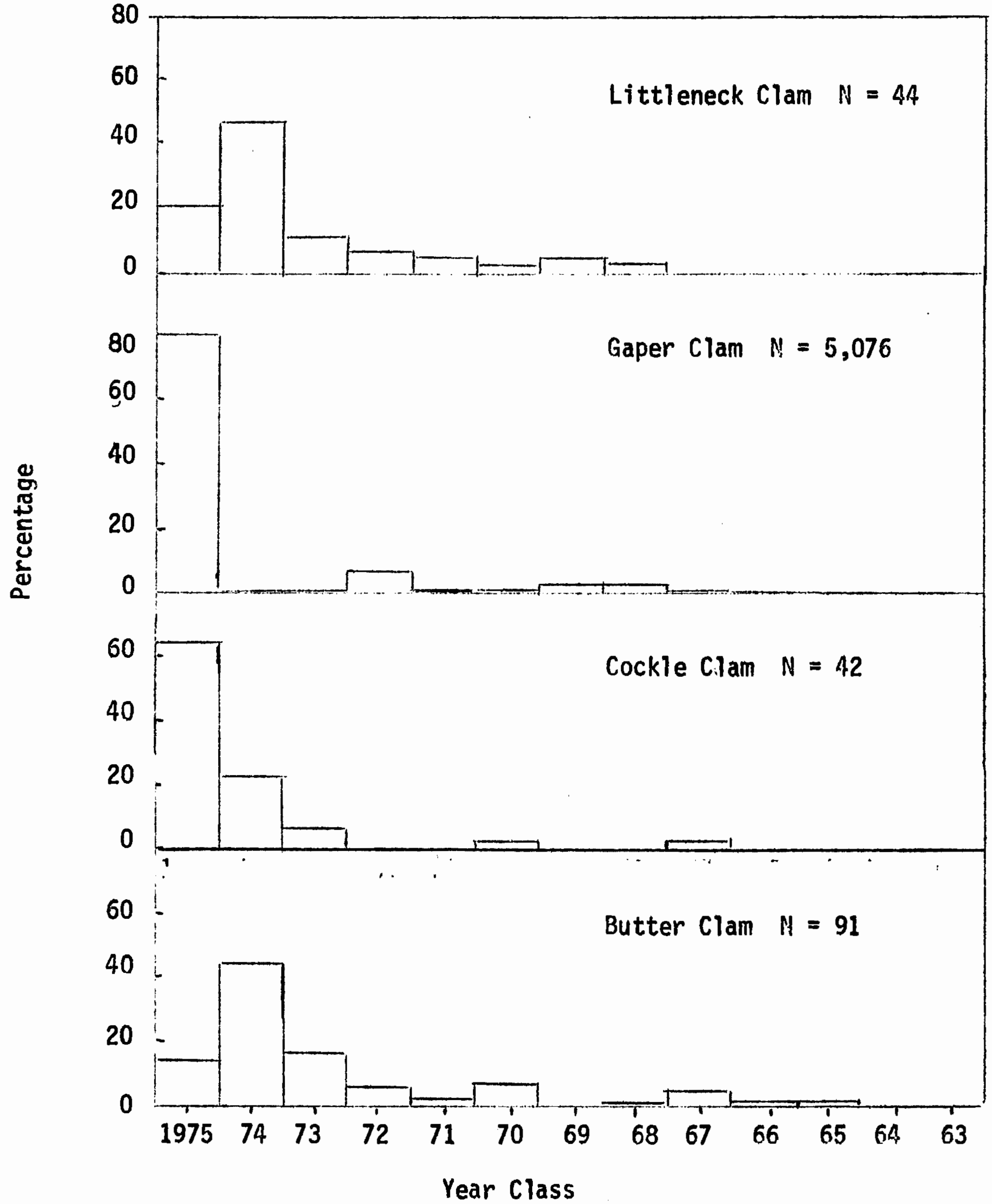


Figure 33. Age Composition of Dredged Clams, Areas 1, 2 and 3 Combined, Yaquina Bay, 1975

were 28.5, 19.6, 39.2, and 24.7 mm respectively, again illustrating the predomin[illegible] of younger clams in the bay (Figure 34).

The age composition of gaper clams in five different areas of Yaquina Bay w[illegible] compared during April and July (Figure 35). Two major differences were seen in [illegible] stocks of clams. The gapers generally increased in age as we moved up-bay and [illegible] age composition changed in July with the first recovery of zero-age set. No 19[illegible] set were dredged in April nor were any taken from area 5 in the July sample. I[illegible] general, there was only fair to poor recruitment from the 1974 and 1973 year cl[illegible] This was especially true for areas 2 and 3. Other differences in age compositi[illegible] between April and July can be attributed to sampling procedures. Our July samp[illegible] were not taken in exactly the same spot as those taken in April.

Length frequency of gaper clams from each of the five areas is shown in Fig[illegible] The range in size of clams for each area was generally the same except for area [illegible] which lacked the zero-age set.

Coos Bay. Figure 37 shows the distribution and abundance of the commerciall[illegible] important subtidal clams adjacent to Pigeon Point in Coos Bay. As in Yaquina Ba[illegible] two concentrations of clams were apparent. Analysis of our data showed this are[illegible] contain 26.4 million clams (Table 2). Of this total, 2.2 million were adult gap[illegible] clams and 3.4 million were 1975 gaper clam set.

Age composition of butter, cockle, gaper, and littleneck clams is shown in Figure 38. As in Yaquina Bay, gaper clam set was the principal year class colle[illegible] indicating excellent recruitment was wide-spread in 1975. Unlike Yaquina Bay, l[illegible] neck and butter clams were primarily of the older age groups.

Length distribution of butter, cockle, gaper, and littleneck clams is sh[illegible] Figure 39. Mean size was nearly twice as large for each species as those found [illegible] Yaquina Bay clams.

Table 2. Summary of Numbers of Subtidal Clams off Pigeon Point, Coos Bay, 1975

Species	Number
Gaper	5,648,700
Cockle	202,200
Littleneck	843,000
Butter	809,200
Irus clam	16,018,600
Bentnose	2,647,300
Bodega tellen	101,000
Rock clam (*Petricola carditoides*)	101,000
False mya (*Cryptomya californica*)	67,300
Total	26,438,300

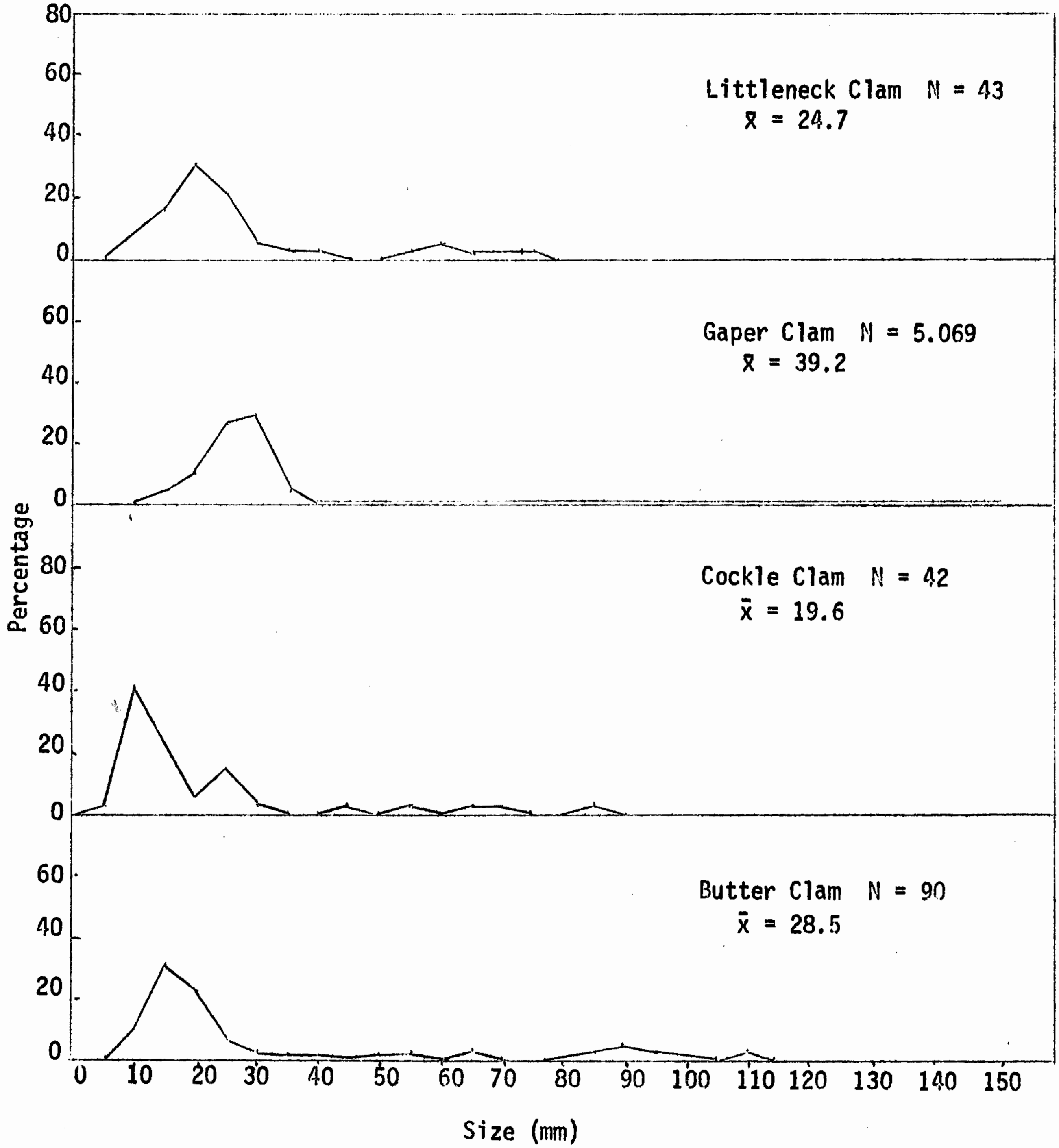


Figure 34. Length Frequency of Dredged Clams, Areas 1, 2 and 3 of Yaquina Bay, 1975

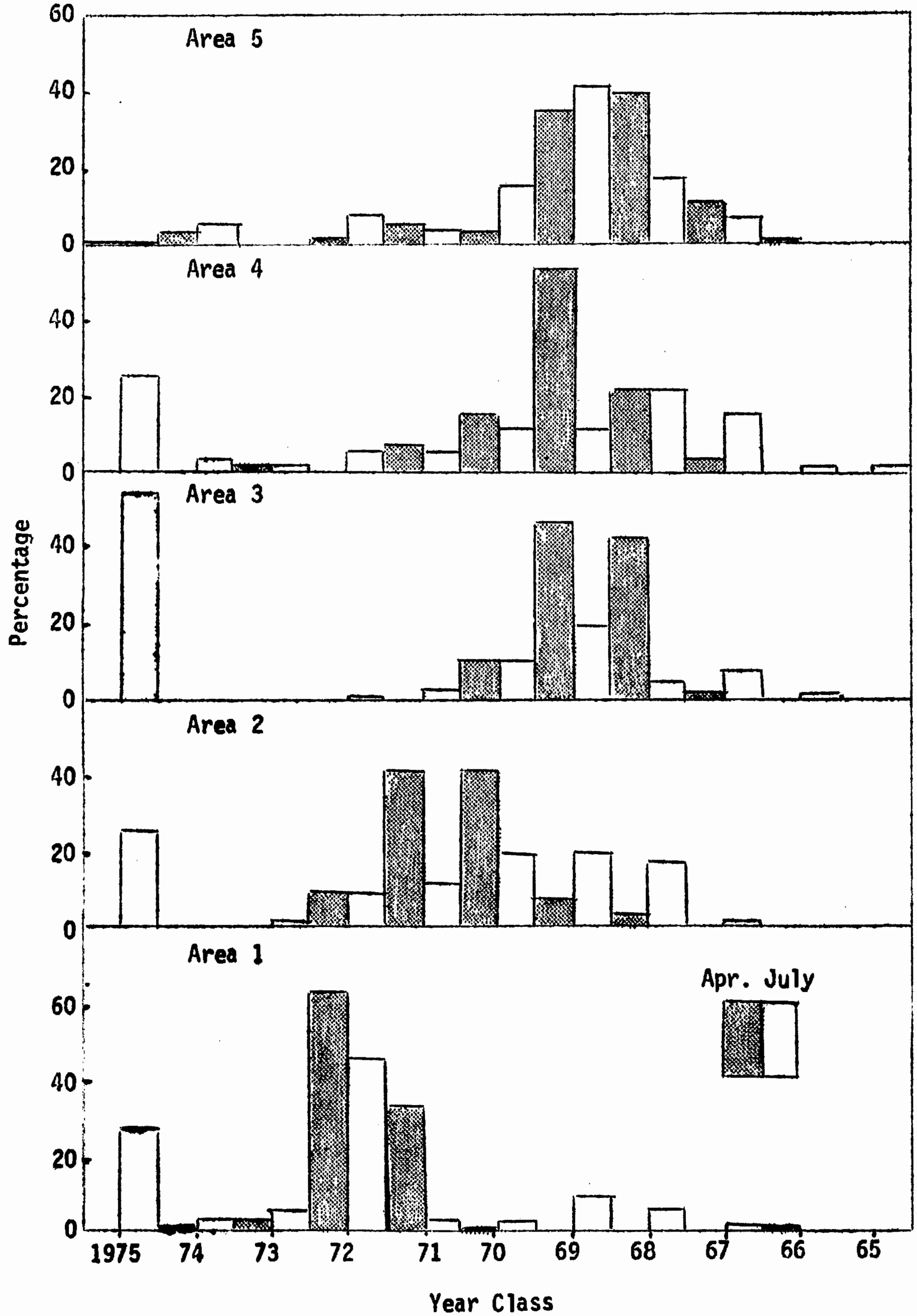


Figure 35. Age Composition of Dredged Gaper Clams, Yaquina Bay, 1975

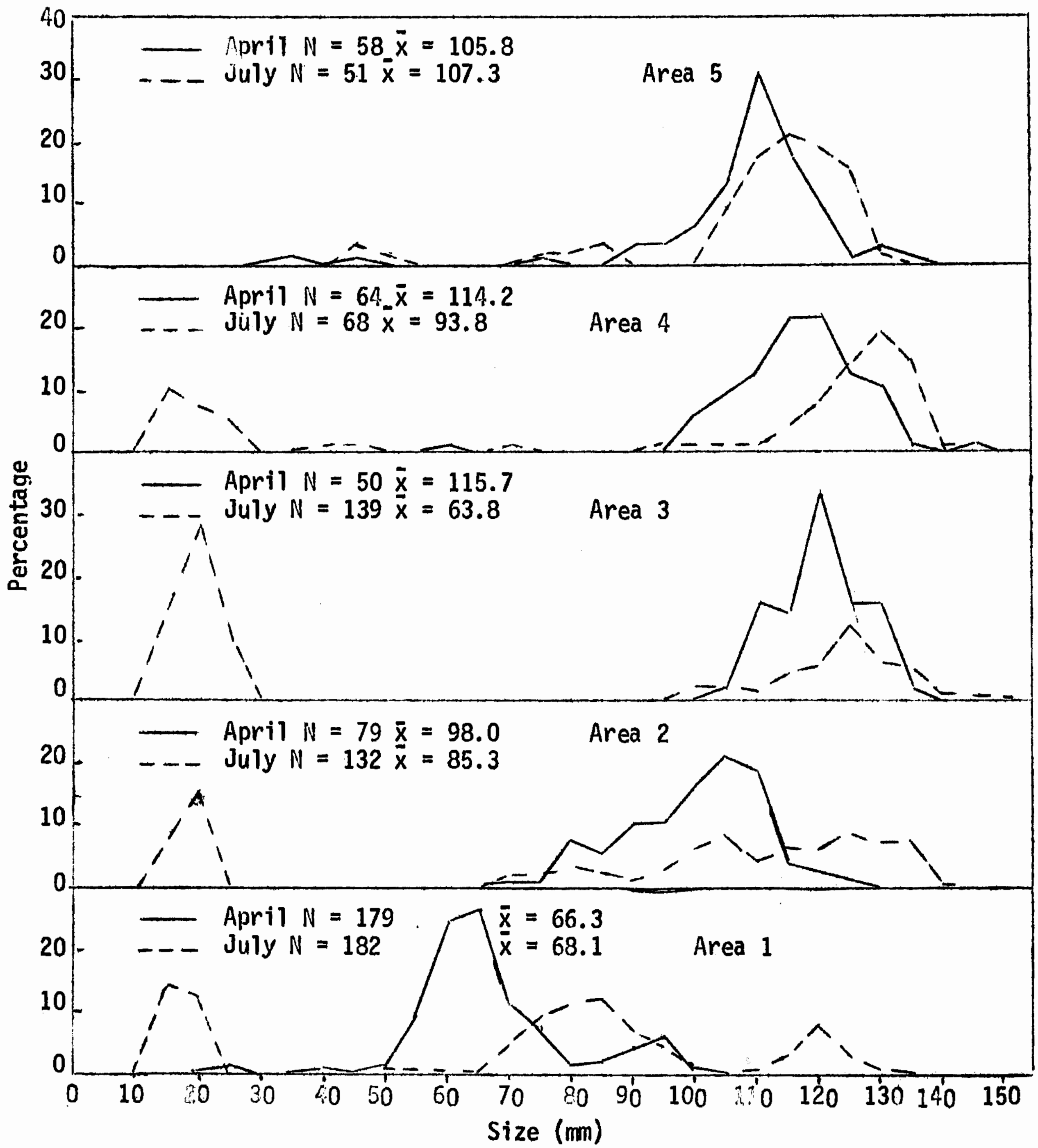


Figure 36. Length Frequency of Dredged Gaper Clams from Areas 1, 2, 3, 4 and 5, Yaquina Bay, 1975

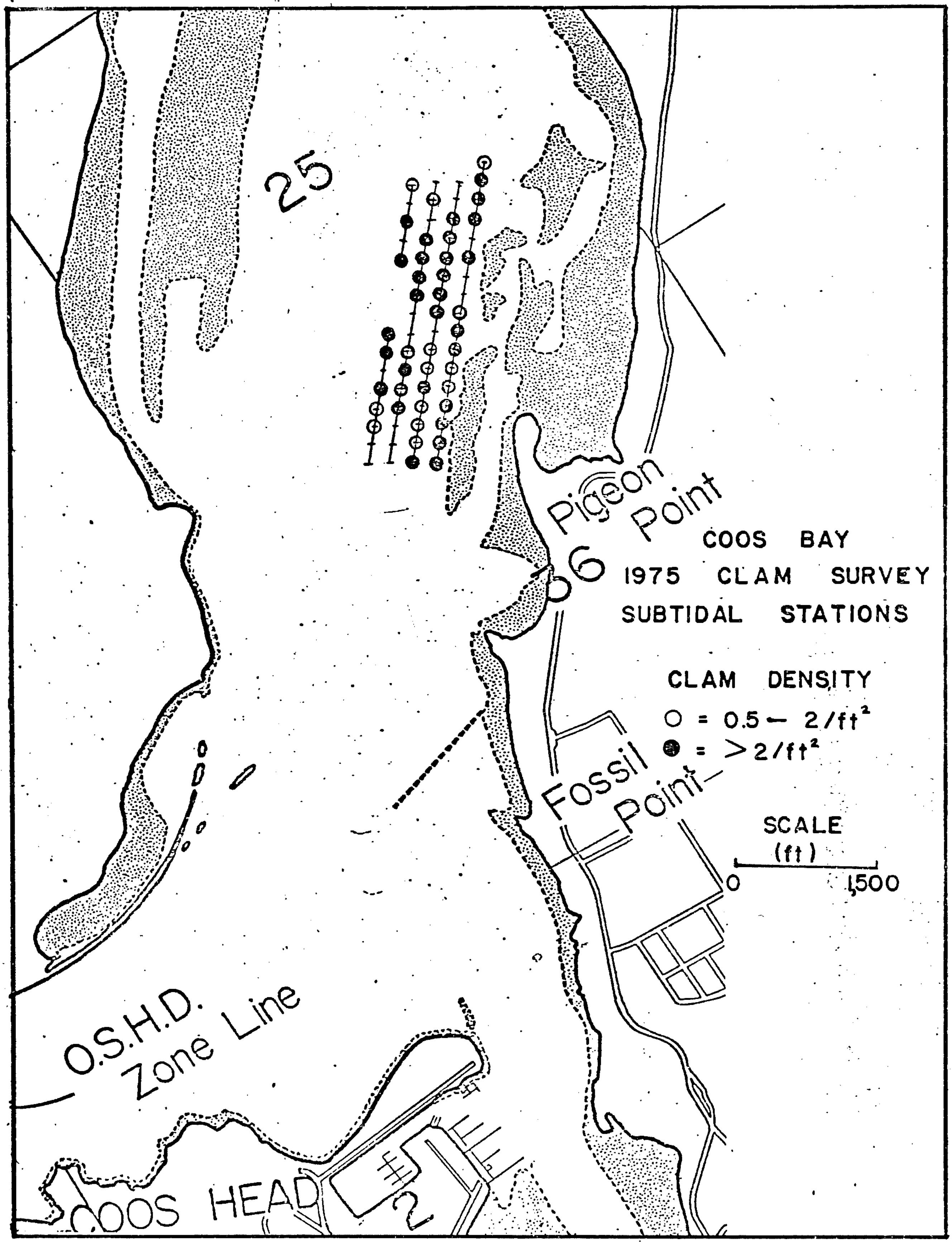


Figure 37 Occurrence of Butter, Cockle, Gaper and Littleneck Clams in Dredge Samples, Pigeon Point Area of Coos Bay, 1975

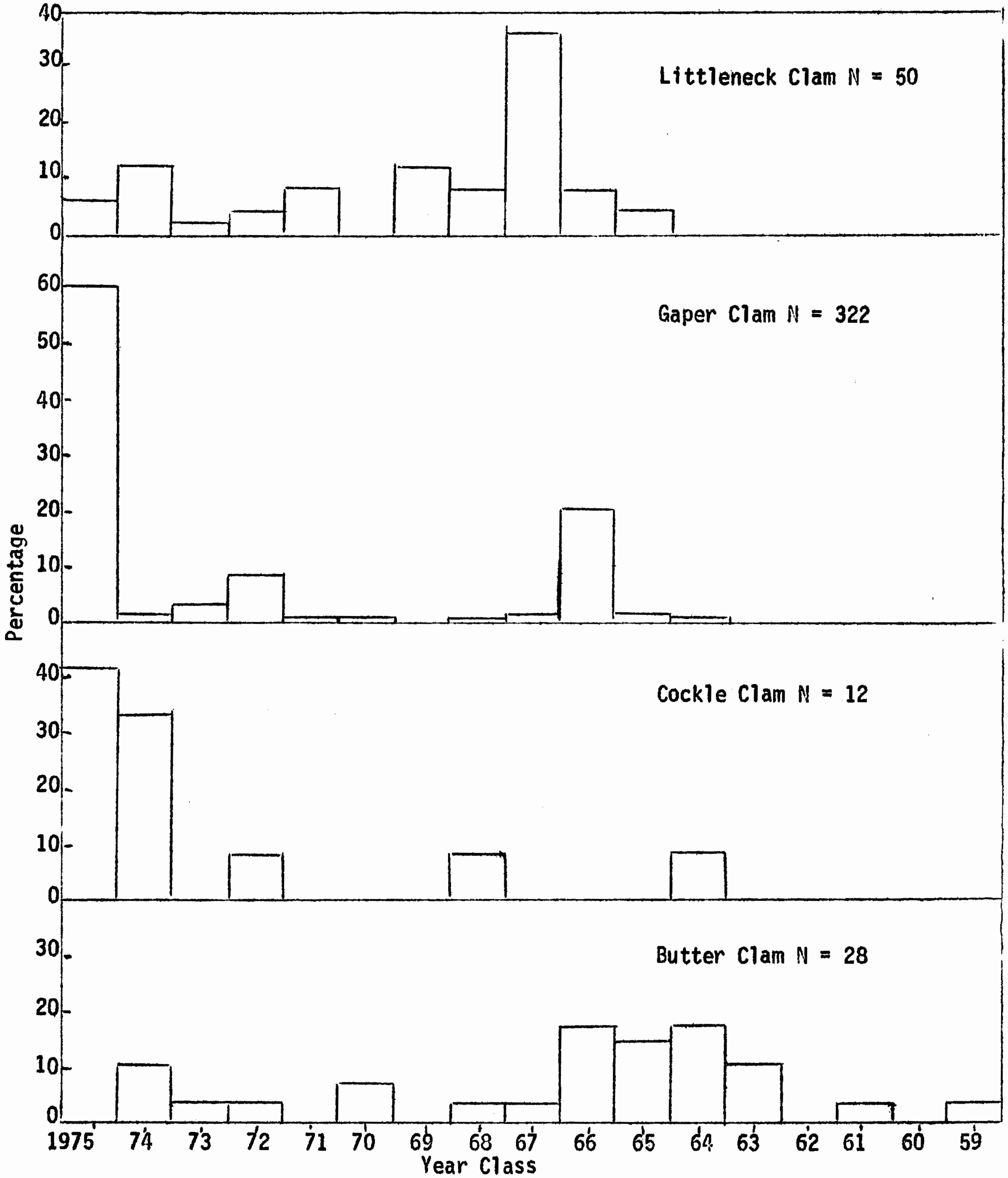


Figure 38. Age Composition of Dredged Clams, Pigeon Point, Coos Bay, 1975

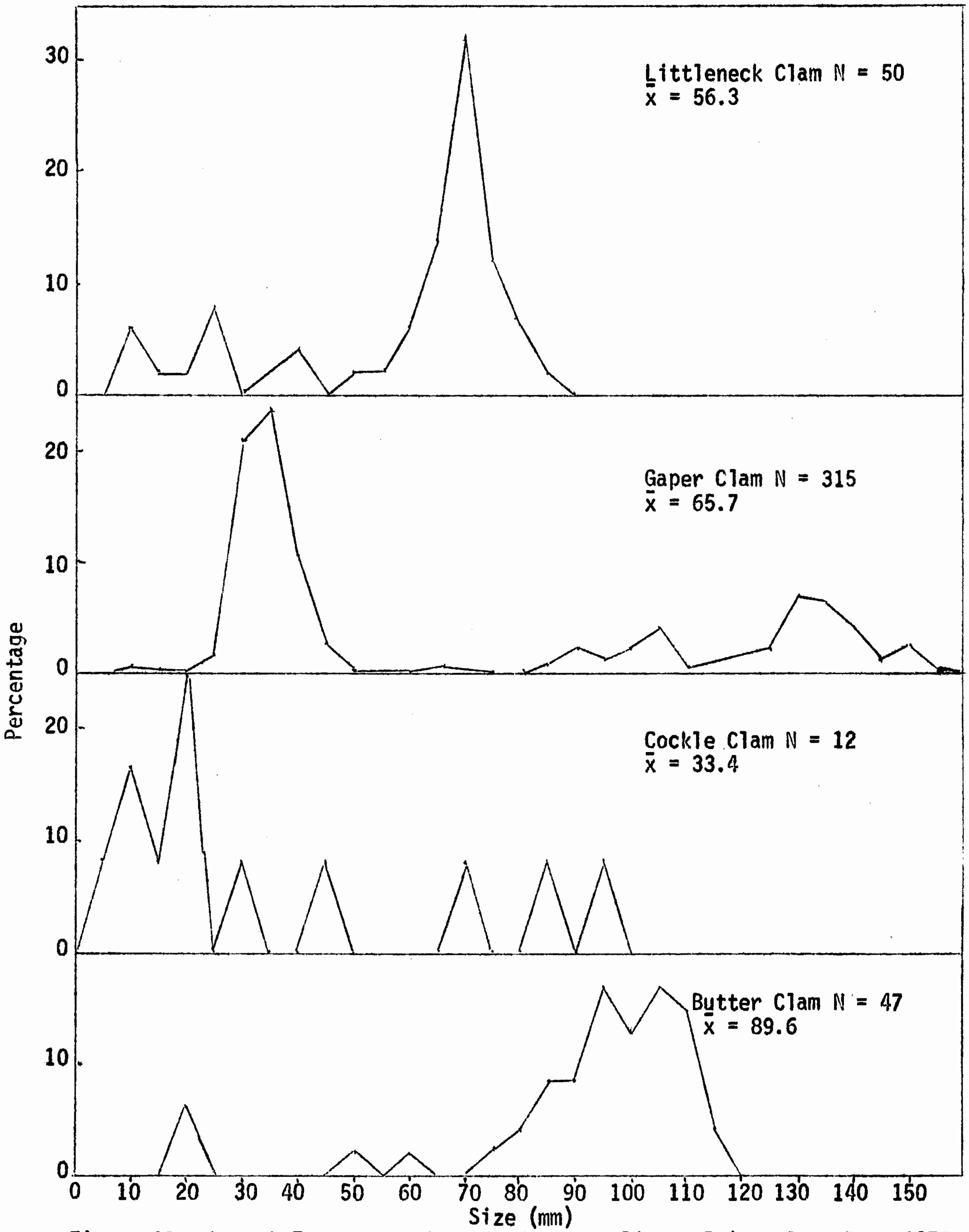


Figure 39. Length Frequency of Dredged Clams, Pigeon Point, Coos Bay, 1975

Tillamook Bay. The distribution and abundance of butter, cockle, gaper and littleneck clams in the Larson Cove area of Tillamook Bay is shown in Figure 40. This clam bed is the up-bay portion of the clam bed surveyed and reported on in 1975 (Gaumer and Lukas, 1975). We estimated that 8.4 million clams inhabited this clam bed (Table 3). Of all the areas surveyed, this clam bed had the most uniform species composition.

Age composition of cockle, gaper and littleneck clams is shown in Figure 41. No attempt was made to age butter clams from this area. In contrast to Yaquina and Coos bays, the strongest recruitment, for each species, occurred from the 1969-73 year classes. Recruitment was not nearly as sporadic as seen for the other two bays. Recruitment from the 1975 year class was only fair for each species although our sampling in August probably precluded our collecting a total index of 1975 year class strength for cockle and littleneck clams.

Length distribution for cockle, gaper, and littleneck clams is shown in Figure 42. Mean sizes for cockle, gaper, and littleneck clams were 59.1, 98.5, and 38.4 mm, respectively. Cockle and gaper clams were larger than those in Yaquina and Coos bays.

Table 3. Summary of Numbers of Subtidal Clams in Larson Cove Area of Tillamook Bay, 1975

Species	Number
Gaper	912,400
Cockle	1,637,500
Littleneck	1,462,500
Butter	1,012,500
Irus clam	2,599,900
Bentnose	49,900
Softshell	762,500
Total	8,437,200

Aging Study

One of the basic requirements for managing clam resources is an understanding of the age structure for each species. All aging methods depend on the fact that growth is usually greatly reduced during winter months and an annular ring is formed during this period. Since the clams were collected just before the appearance of the next annular ring, aging was somewhat simplified and possibly more accurate. The results of various aging techniques were not identical and the null hypothesis of identical results was rejected at the 5% significance level (Table 4).

The aging technique that involved counting the annular rings on the exterior of the valve accounted for the greatest variance, 29%; followed by the cartilage annuli method, 26%; chondrophore method, 18%; cross section technique, 16%; while the chondrophore held in front of a high intensity light accounted for the least variance, 11%.

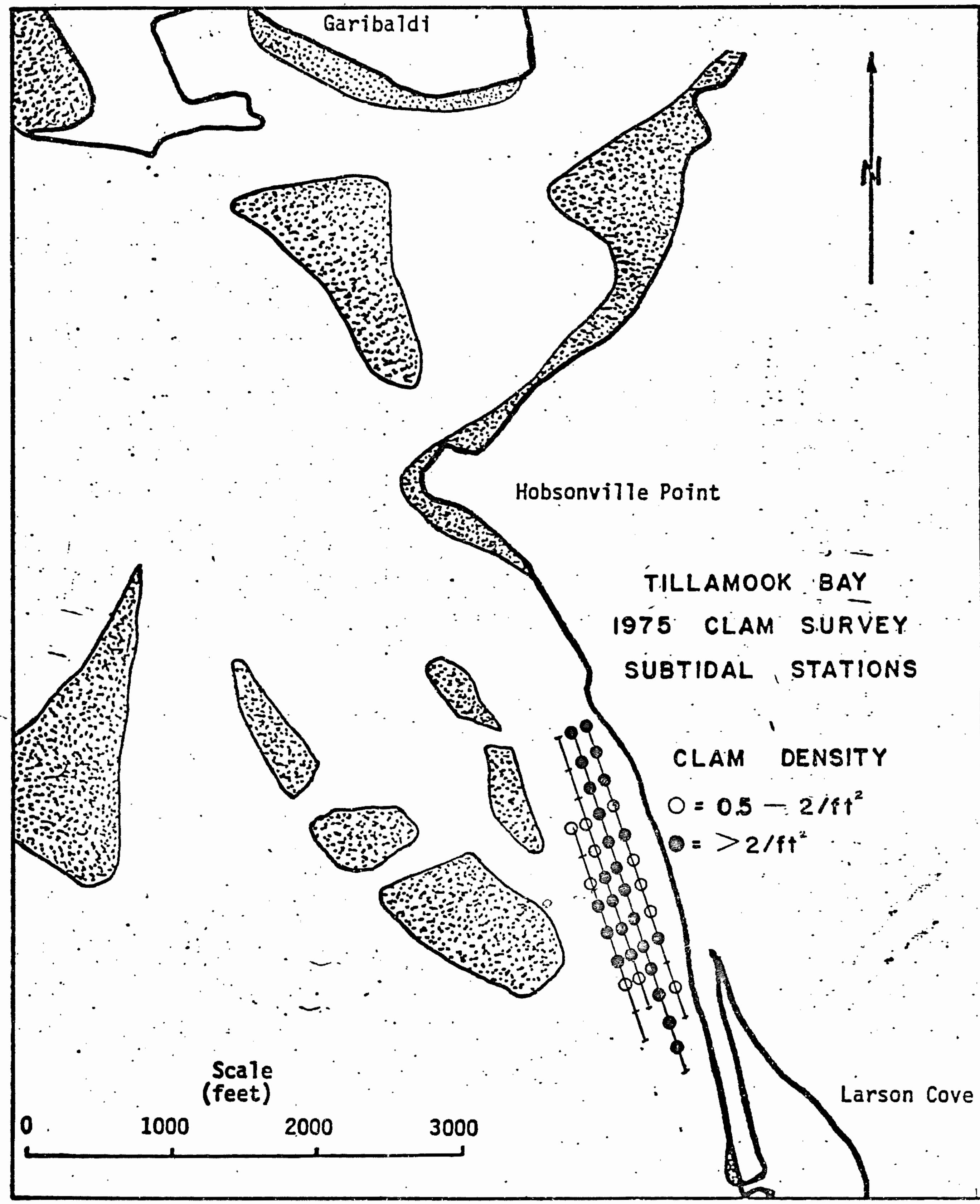


Figure 40. Occurrence of Butter, Cockle, Gaper and Littleneck Clams in Dredge Samples, Near Larson Cove of Tillamook Bay, 1975

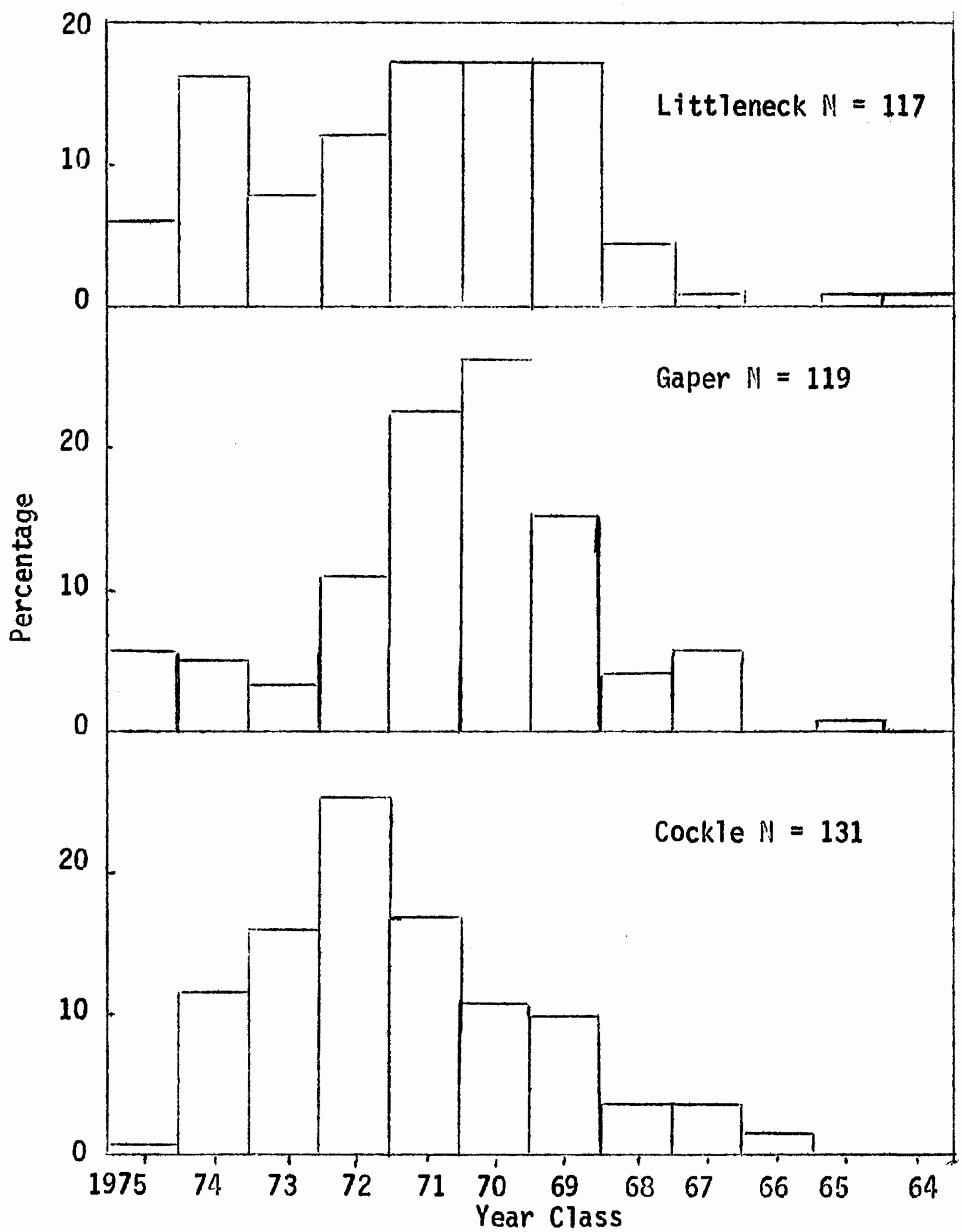


Figure 41. Age Composition of Dredged Clams, Larson Cove Area of Tillamook Bay, 1975

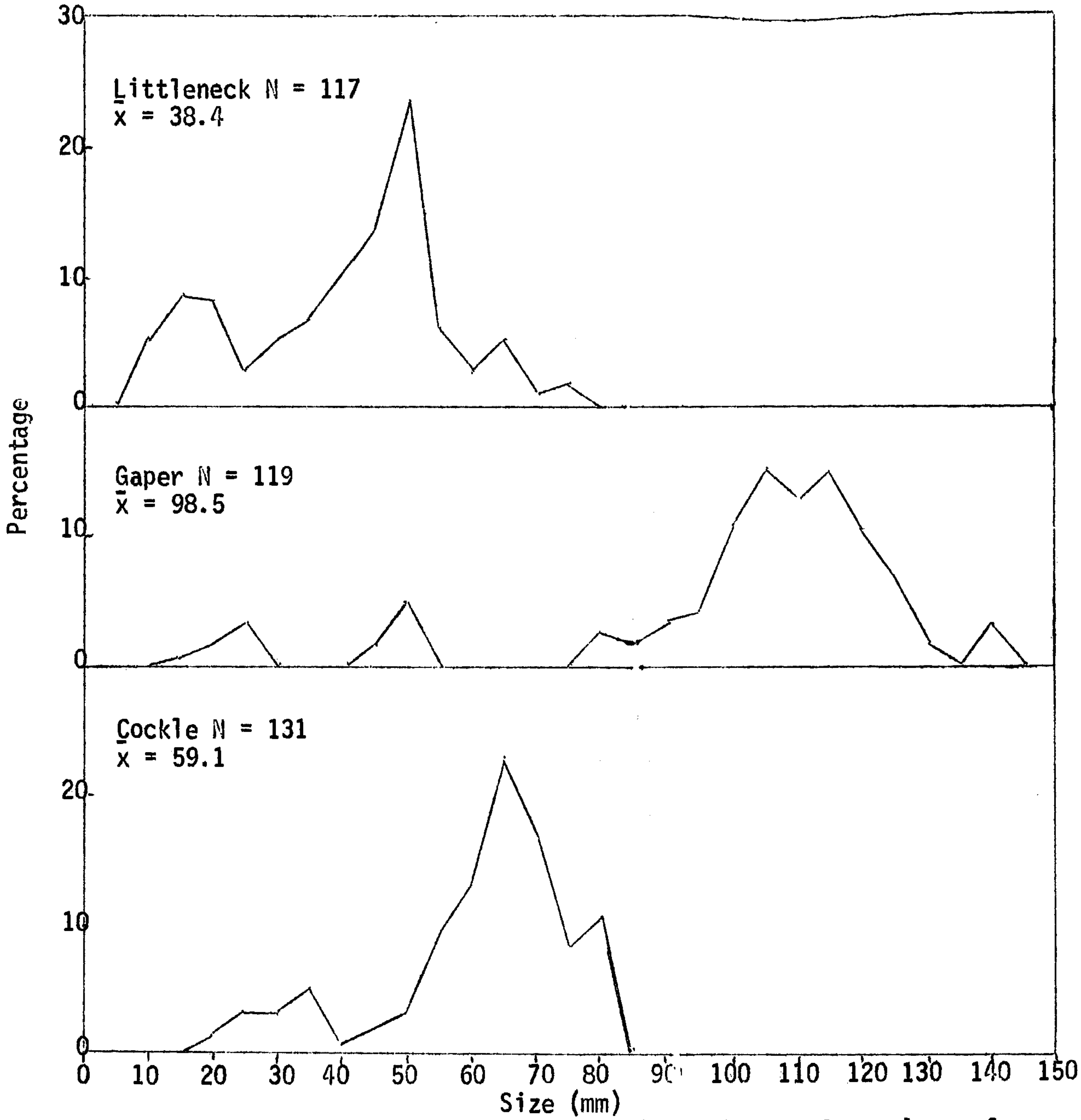


Figure 42. Length Frequency of Dredged Clams, Larson Cove Area of Tillamook Bay, 1975

Table 4. Two-Way ANOVA of Clam Aging Techniques

Source	SS	df	MSS	F	$F_{.05}$
Between clam ages	13465.35	134	100.49	904.5	1.00
Between aging techniques	5.20	8	0.65	5.85	1.94
Residual	119.10	1072	0.11		

$0 \leq [Pr\ (F \geq 5.85)/H_o\ true] \leq .001$

When the results were analyzed for differences in apparent age between the left and right valves the cross section technique showed the greatest variance at 34%. This was due to the necessity of sectioning the valve exactly at the umbo. The first annular ring is missed and the age is underestimated by one year if the separation does not begin exactly at the umbo. Aging the annular rings on the exterior of the valves had almost the same amount of variance, 33%, as the cross-sectioning technique. This was due primarily to the difficulty of determining if a ring on the valve is an annular ring or a disturbance check. The aging technique utilizing the chondrophore and high intensity light varied 8% between right and left valves. There was only 2% variance between the left and right chondrophore aging technique without the high intensity back-up light. The left and right valves of a clam differed in length by more than 1 mm only 14% of the time, and never by more than 3 mm.

Each technique has certain advantages and disadvantages:

<u>Aging Technique 1: Shell Annuli</u>. The annular rings on the exterior of the valves were more pronounced along the posterior edge and easier to identify. The annular rings in the middle portion of the valve showed better on the more recently formed part of the valve. It was often necessary to scrape off the periostracum that covers the shell in order to locate the annular ring. Two distinct advantages of this method over the others were that examination for age was rapid, and the clams did not have to be sacrificed to make the age determinations. This method is complicated by the occasional presence of false checks which resemble annular rings but are caused by circumstances other than the reduced growth period of winter. Further complications are caused by the erosion of the older part of the shell which erases the first few annular rings. It was often necessary to compare known zero-age shells to the shell in question to help determine where the first annuli occurred. Reduced growth in older clams made it difficult to separate the later annuli because they are spaced close together.

<u>Aging Technique 2: Cartilage Annuli</u>. It was very difficult to remove the cartilage intact, especially in the larger clams. It was also difficult to determine where the first annuli was, as the older portion of the cartilage was always compressed and folded over. On a few occasions it was possible to count the annular rings on the cartilage at the separation between the left and right sections. Generally, the

cartilage was cracked and had an irregular surface which damaged the annular rings.

Aging Technique 3: Chondrophore Annuli. The first annular ring of the chondrophore was usually difficult to locate. This was especially true for the older clams, as often the first ring had been over grown by later portions of the shell. The disturbance checks on the chondrophore annuli were much easier to recognize than the disturbance checks on the exterior of the valves. This technique was much more accurate using dry samples rather than fresh, wet samples.

Aging Technique 4: Chondrophore Annuli with High Intensity Light. This method seemed to be the most accurate of the five methods analyzed. There was very little doubt as to whether a ring was an annular ring or a disturbance check. The main disadvantage was the animals had to be sacrificed for aging.

Aging Technique 5: Chondrophore Cross Section. The greatest problem with this method was obtaining a uniform, smooth break along the valve. Therefore, it was easier to count the annuli in the chondrophore than those in the valve itself. The annular rings in the cross section of the valve were very indistinct and not nearly as identifiable as those in the chondrophore. Cross-sectioning did not work well for smaller or younger clams which have less distinct annular rings than older clams.

Haplosporidian Study

The incidence of a haplosporidian infection of gaper clams from five different areas of Yaquina Bay and from single areas of Tillamook, Netarts, Coos, and Siuslaw bays was documented (Table 5). In Yaquina Bay, incidence increased as we progressed up-bay. Area 5, approximately three miles, (4.8 km) above area 1, generally had the largest proportion of infected clams. Incidence also appeared to increase with time although detection might have improved with experience. The high incidence in clams from area 1 in November of 84.0% and the relatively low rate observed in area 5 are inexplainable. Particularly distressing was the consistently high rate of incidence seen in gapers from area 4 since this area is the only one of the five sample areas presently open to the commercial harvest of shellfish.

Gaper clams in Tillamook, Netarts, Coos, and Siuslaw bays also hosted the haplosporidian infection. Clams for these samples were collected from areas having known dense concentrations of adult gapers. Haplosporidian cysts were not observed in any of the zero-age gapers. Gapers appeared to be more heavily infected with increasing age. The disease was not observed in any other clam species.

Table 5. Percentage Incidence of Haplosporidian in Gaper Clams, 1975-76

		Period						
Bay	Area	Apr. 75	July 75	Aug. 75	Oct. 75	Nov. 75	Jan. 76	Feb. 76
Yaquina	Area 1	5.4	12.1	-	-	84.0	-	71.6
	Area 2	7.6	25.8	-	-	21.0	-	45.8
	Area 3	32.0	47.3	-	-	50.0	-	50.0
	Area 4	51.6	63.2	-	-	82.3	-	89.0
	Area 5	70.2	65.4	-	-	40.6	-	60.6
Tillamook	Hobsonville Point	-	-	38.5	-	-	-	-
Netarts	Wilson Beach	-	-	19.8	-	-	-	-
Coos	Pigeon Point	-	-	-	45.8	-	-	-
Siuslaw	South Jetty	-	-	-	-	-	46.2	-

COMMERCIAL BAY CLAM FISHERY

Two commercial clam diggers received special permits to harvest clams subtidally in 1975. One permit was issued for a 15-acre (6.1 ha) site adjacent to Sally's Bend in Yaquina Bay. This permit limited the harvest to 100,000 pounds (35.4 metric tons) of clams in 1975. The other permit was issued for the 48-acre (19.4 ha) site, mentioned earlier in this report, in Coos Bay. This permit was non-restrictive for numbers or weight harvested since our intent was to salvage as many clams from this area as possible before the Corps of Engineers filled the area with dredge spoils.

Methods

The two permit holders were allowed to use a high pressure water jet and SCUBA to harvest clams. Each was required to file weekly harvest reports listing areas worked, numbers and pounds harvested by species, and diving time. We periodically sampled the catch to obtain age and size composition.

Results and Discussion

Yaquina Bay

The commercial fishery for clams in Yaquina Bay produced only 1,505 pounds (683 kg) of gaper clams. The main problem was caused by poor market conditions. Figure 43 shows the age composition of clams harvested. The 1969 year class was prevalent in the catch of clams, although the 1968 and 1970 year classes were nearly as strong.

Length distribution of the clams taken in the commercial harvest is shown in Figure 44. Range and mean size of clams were generally the same for the two sample periods. Clams harvested on July 14 had a mean length of 123.4 mm while those taken on July 24 averaged 117.8 mm.

Coos Bay

The commercial fishery for clams in Coos Bay produced 55,482 pounds (25,166 kg) through March 1976. Age composition of gaper clams for four sample periods is shown in Figure 45. The data suggests that clams harvested were generally composed of the same year classes for each period. The 1966 year class was the principal age harvested. The 1972 year class was especially strong in the January 19 sample suggesting possibly a slightly different harvest site. Of interest was the total lack of 1969 year class clams in any of the samples. Our assessment survey of the area also showed a total lack of these clams (Figure 38).

Length frequency of the commercially harvested clams is shown in Figure 46. Mean sizes ranged from 126.3 mm for the January 19 sample to 133.8 mm for the February 9 sample.

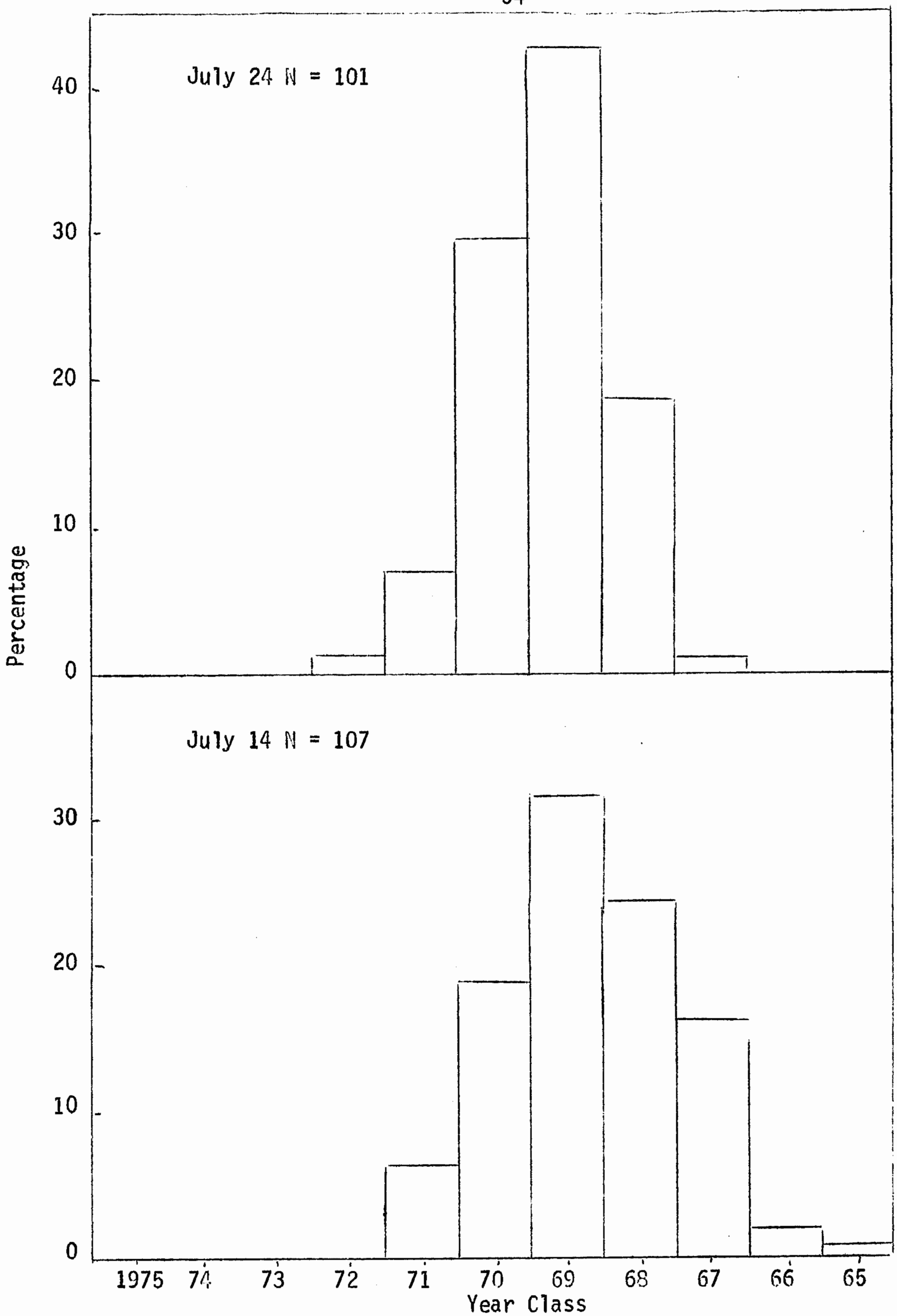


Figure 43. Age Composition of Commercially Harvested Gaper Clams, Area 4, Yaquina Bay, 1975

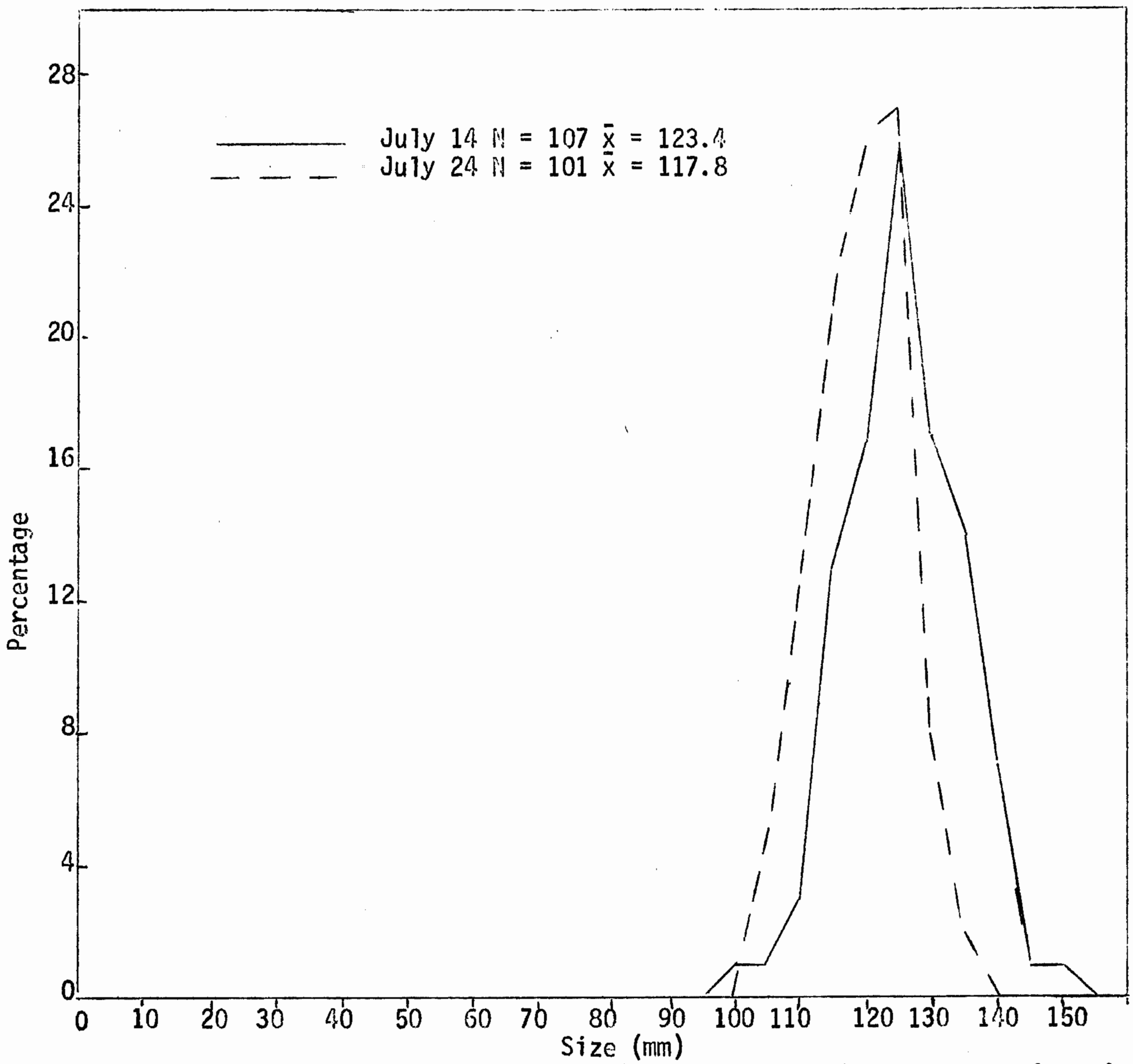


Figure 44. Length Frequency of Commercially Harvested Gaper Clams, Area 4, Yaquina Bay, 1975

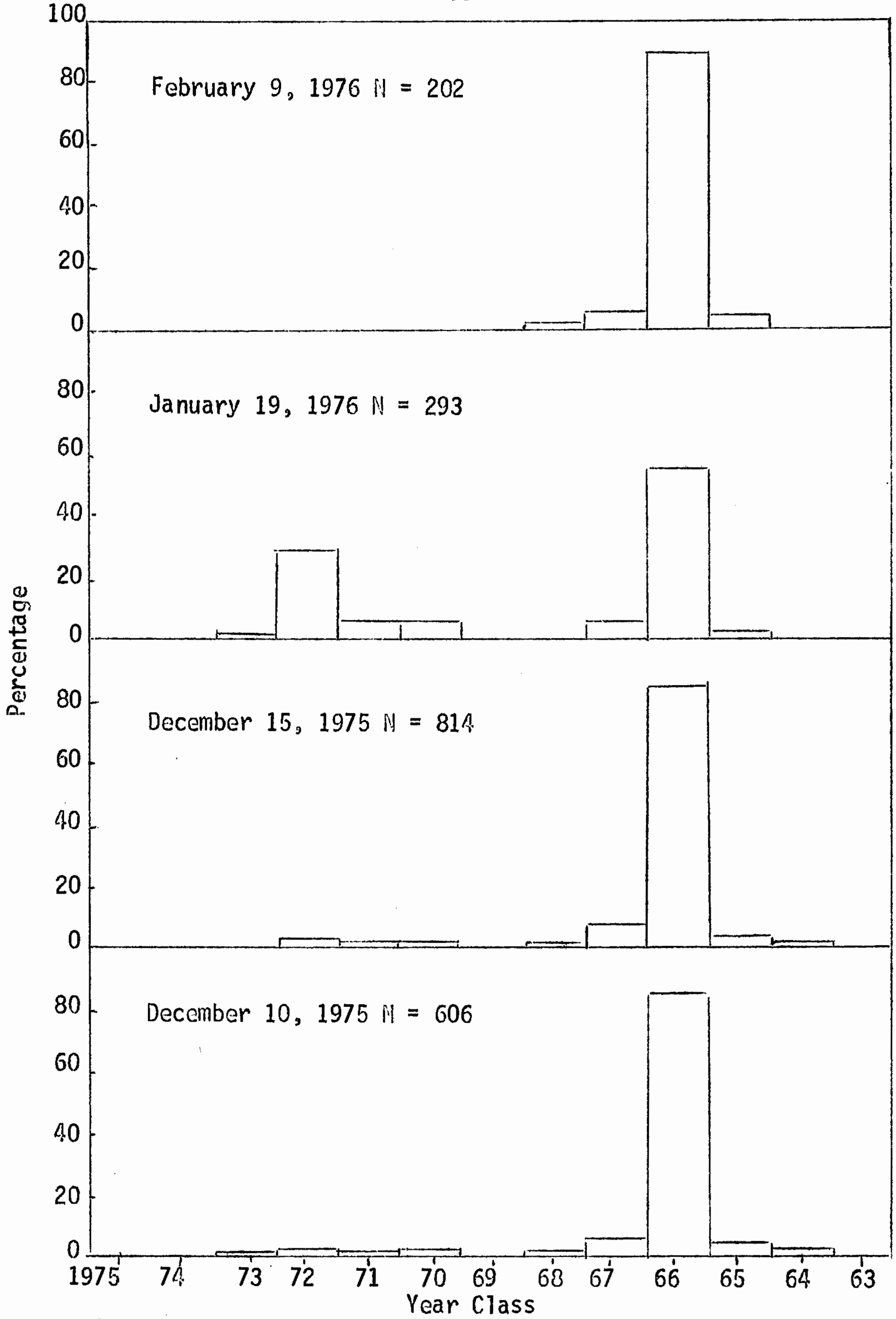


Figure 45. Age Composition of Commercially Harvested Gaper Clams, Pigeon Point of Coos Bay, 1975-76

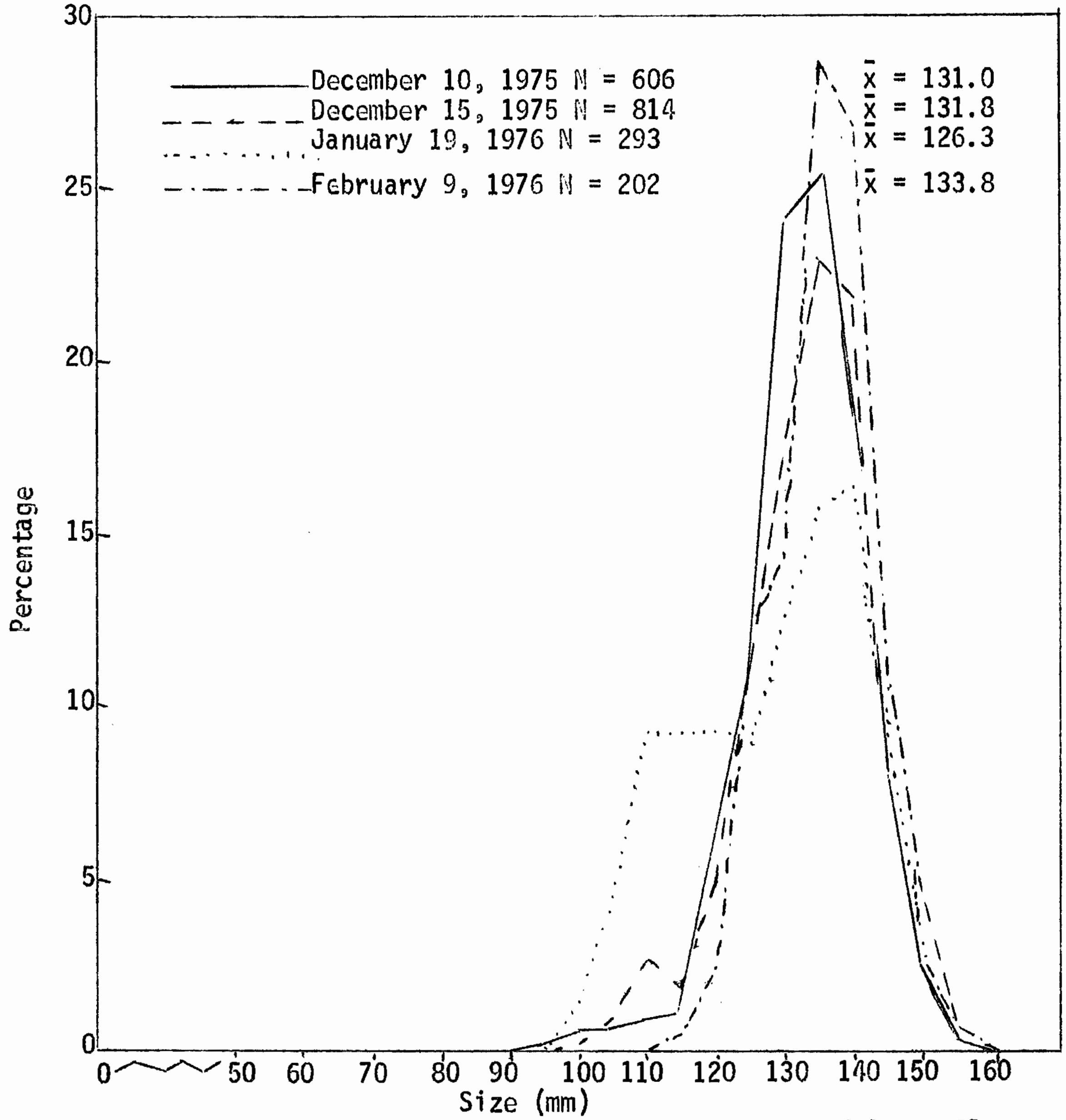


Figure 46. Length Frequency of Commercially Harvested Gaper Clams, Pigeon Point of Coos Bay, 1975-76

LABORATORY CLAM FIELD STUDIES

Our laboratory clam studies were phased out during the year and our activities consisted only of monitoring growth and survival of clams planted in previous years in Netarts and Yaquina bays.

Methods

Our studies in Netarts Bay were limited to measuring growth characteristics of clams selected for their fast growing ability vs. normal growing clams (Gaumer and Lukas, 1974). Growth of clams in a screened enclosure vs. unscreened area was also measured. Survival was not determined because studies in 1974 showed that Manila littleneck clams readily moved from the area of release.

Our Yaquina Bay studies included an evaluation of the growth and survival of butter and native littleneck clams planted in 1970 in a natural substrate vs. an artificial substrate experiment (Lukas, 1972).

Results and Discussion

Netarts Bay

Manila Littleneck Clams. Manila littleneck clams, spawned from fast-growing parent stock, after nine months had grown 5.7 mm and averaged 11.0 mm whereas progeny from the "normal" clams grew 4.7 mm and averaged 10.4 mm.

Manila clams planted in the screened enclosure in June 1974 and measured in May 1975, averaged 21.5 mm, whereas, clams in the unscreened test plot averaged 20.3 mm. Clams planted in an unscreened test plot adjacent to an eelgrass bed and at a slightly lower elevation were 23.8 mm. Clams for all three releases averaged 13.1 mm when planted.

Yaquina Bay

Butter Clams. From a natural substrate test plot we screened a 3-square foot (2.5 m^2) section that had never been sampled. This eliminated any adverse affects due to handling. Mean shell length of recovered clams increased 5.3 mm to 53.7 mm (Table 6). The reason for the differences in survival of butter clams during the four sampling periods is unknown. Either the clams were not randomly distributed when planted or there were subtle environmental differences from one end of the plot to the other which affected survival.

Table 6. Growth and Survival of Butter Clams Planted on the Yaquina Bay Breakwater, 1975[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
7-9-75	53.7	65.0	80.0	58.0

1/ Butter clams averaged 20 mm when planted.

Figure 47 shows the growth of butter clams in the natural substrate lagged behind a comparable group planted in an artificial substrate plot located about 100 yards (91.4 m) away although the average length of butter clams in the artificial substrate plot increased only 2.3 mm in the past year as compared to an increase of 5.3 mm in the natural substrate.

Native Littleneck Clams. Small numbers of littleneck clams remaining in our test plot necessitated measuring all clams to obtain reliable growth and survival data. This has been done since 1972; consequently, growth of the clams may have been retarded due to handling. In 1975 the clams averaged 42.2 mm, an increase of 0.7 mm since 1974 (Figure 48).

WHALE COVE ABALONE

In 1967 5,500 juvenile red abalone (*Haliotis rufescens*) were purchased from a commercial hatchery in California and placed in Whale Cove, Oregon. Since 1972 we have annually counted and tagged the abalone to monitor growth and survival.

Methods

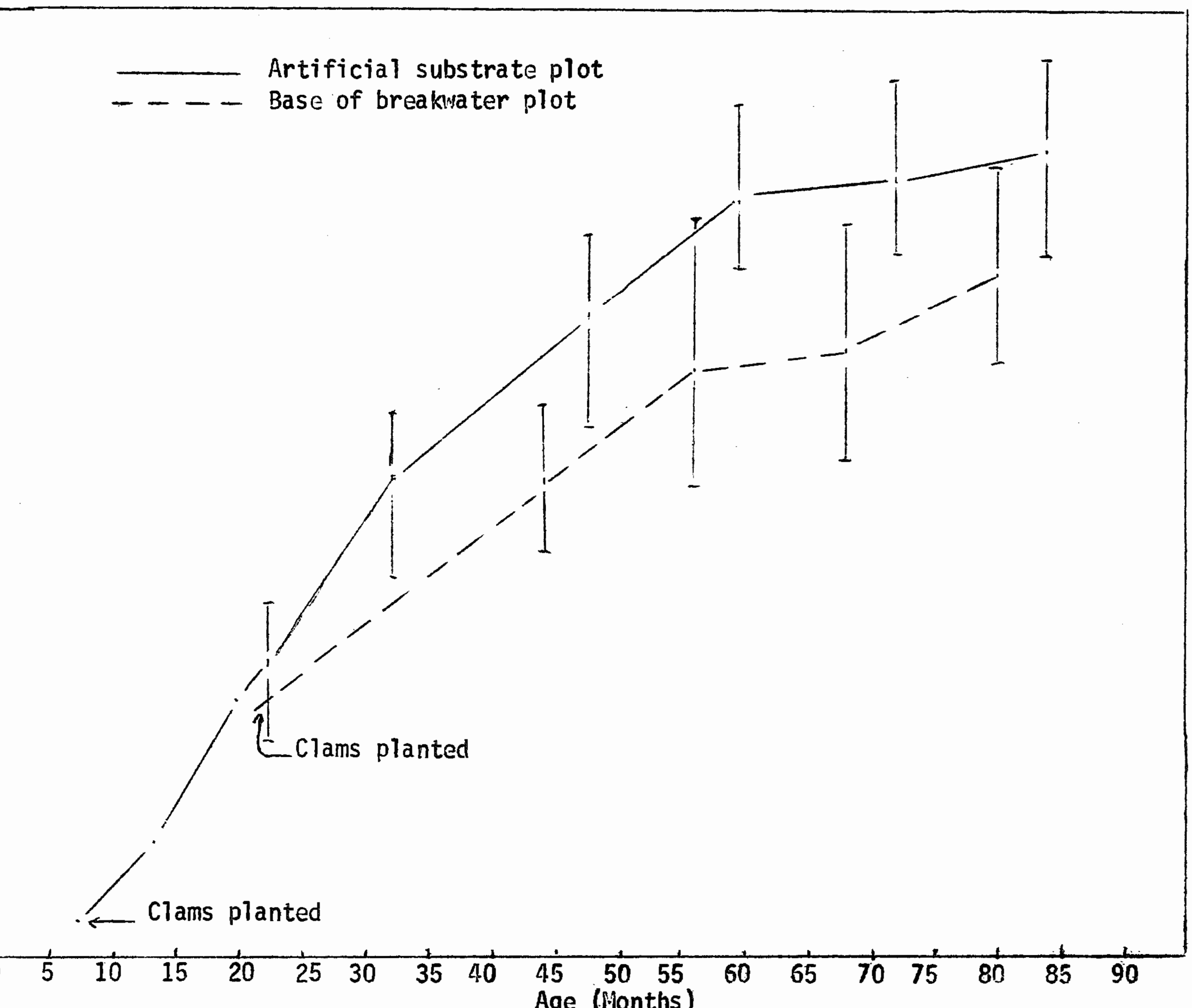
The yearly sampling of red abalone planted in Whale Cove was conducted in June 1975. Both the intertidal and subtidal areas were searched. The intertidal search was conducted in two days during a low tide of -1.3 and -1.2 feet (-0.4m). The subtidal area was searched by two divers using scuba.

Results and Discussion

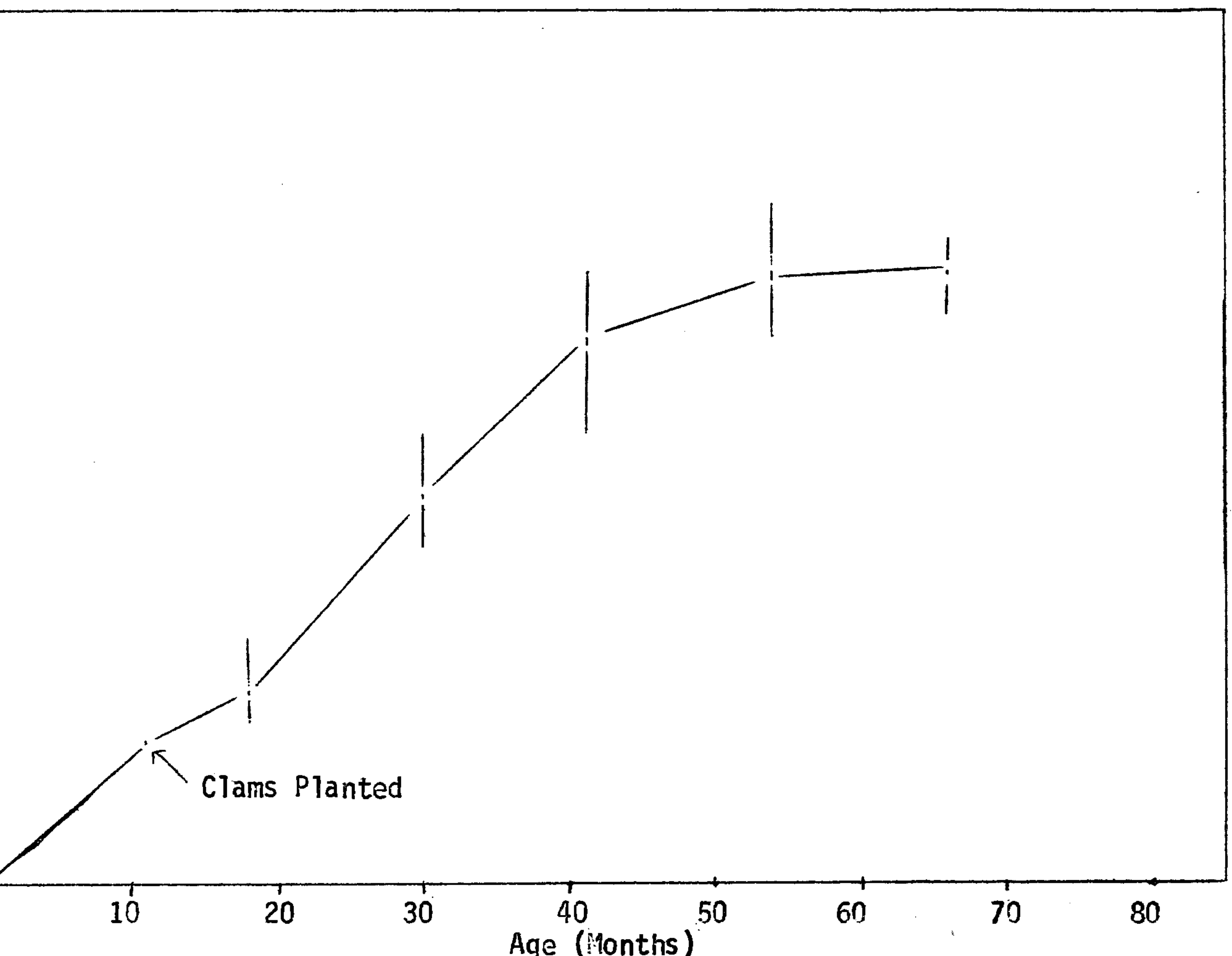
Thirty-two abalone, having an average length of 137.3 mm with a range of 102-168 mm, were captured (Figure 49). Of the 20 tagged abalone recovered, 14 had been tagged in 1973 and 6 in 1974. The average increase in length for one year was 11.3 mm with a range of 1-17 mm. Eight abalone tagged in 1973 and not recovered in 1974 were recaptured in 1975. These animals had grown an average of 19.6 mm with a range of 6-31 mm.

Available red abalone growth data from Whale Cove, Oregon were summarized (Figure 50) by Laimons Osis (unpublished MS, Abalone Research and Management Activities, 1958-75). It includes three years of growth data from tag recoveries of animals planted as juveniles in 1967 and from transplants of adults in 1968 and 1969. This growth curve is generally similar to that found by Burge for red abalone in Northern California (personal communication, March 14, 1975, with Richard T. Burge, California Department of Fish and Game, Morro Bay, California 93442). Using this data, one can extrapolate that it will take (on the average) 22 years for the abalone to reach the 8-inch (20.3 cm) minimum legal size in Oregon.

Mark-recovery data showed that 241 (4.3%) of the original 5,500 juvenile red abalone planted in 1967 still survive in Whale Cove. No juvenile abalone were observed from natural spawning although adult abalone with mature gonads have been seen in the cove since 1972.



igure 47. Growth Curve of Butter Clams Planted on the Breakwater, Yaquina Bay (Vertical Lines Indicate Range in mm), 1975



igure 48. Growth Curve of Native Littleneck Clams Planted in Artificial Sgbstrate Plot, Yaquina Bay (Vertical Lines Indicate Range in mm), 1975

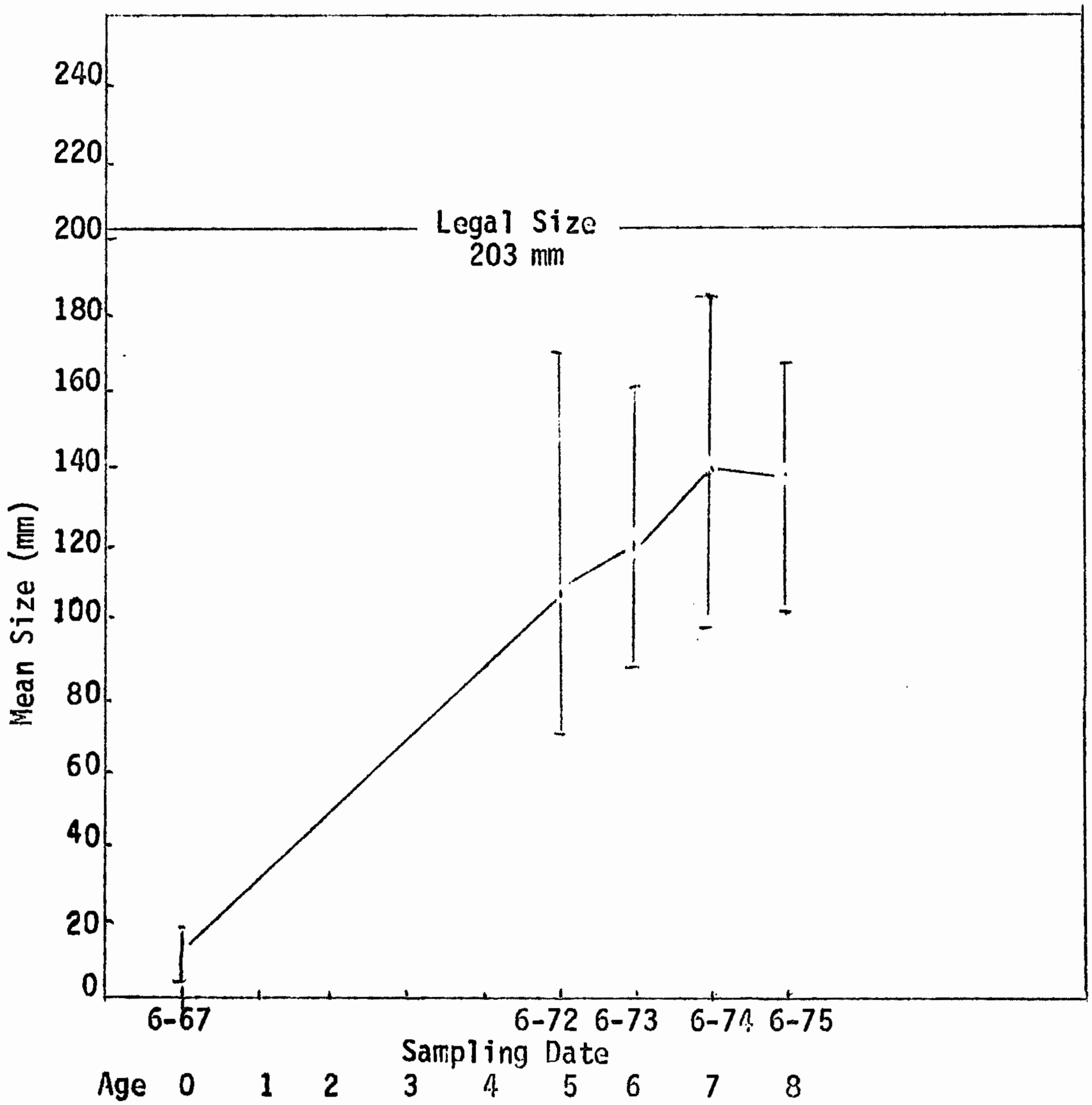


Figure 49. Growth Curve of Whale Cove Abalone (Vertical Line Indicates Range), 1975

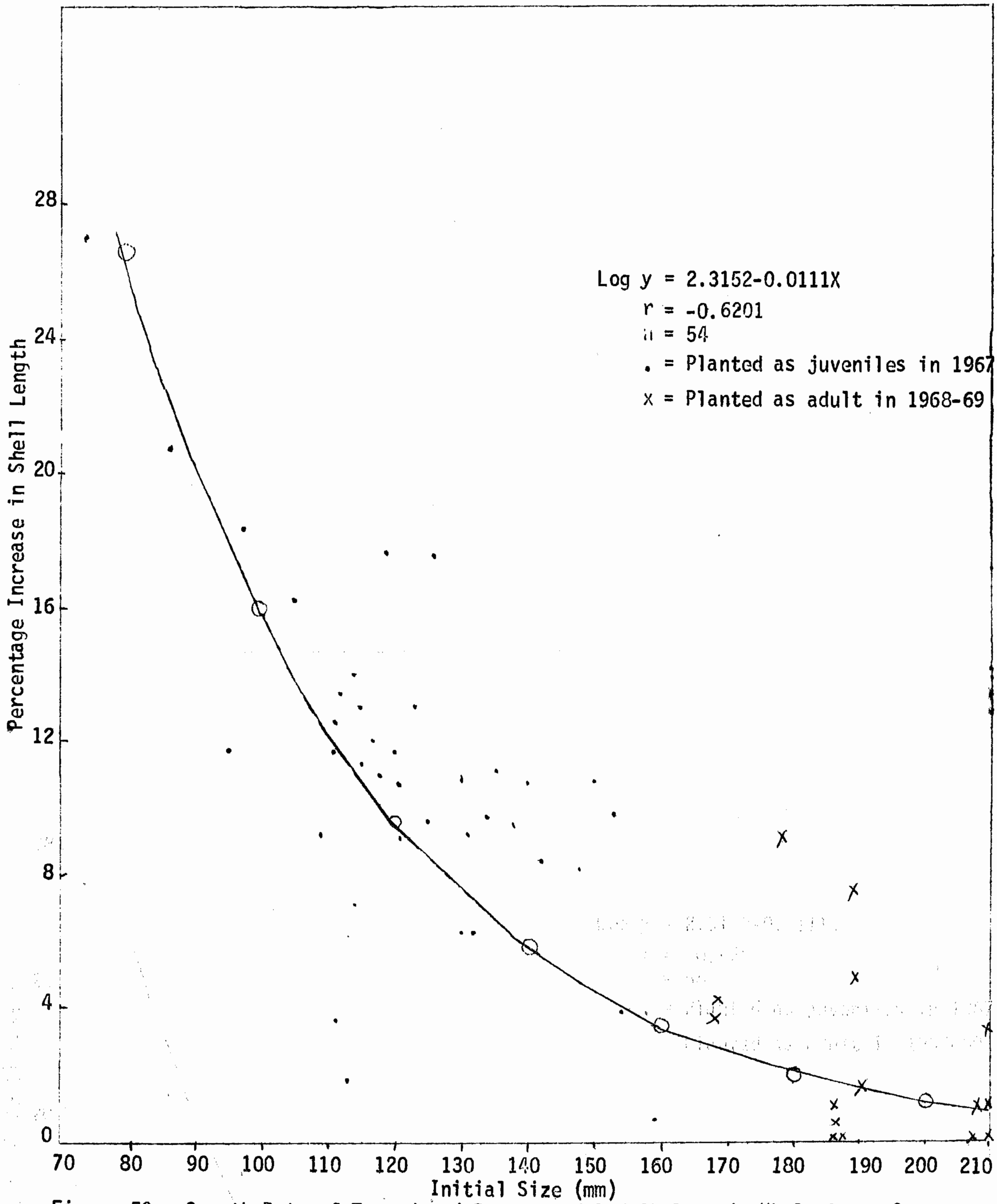


Figure 50. Growth Rate of Tagged and Recaptured Red Abalone in Whale Cove, Oregon, 1973-1975

SUMMARY

Since 1973, we have surveyed along 628,000 feet of intertidal and 483,600 feet of subtidal transect line to determine the distribution of bay clams. Observations on species of clams, relative density, bottom type, and vegetation type were made at 7,250 sample stations.

Five subtidal clam beds were extensively surveyed during the year. Three of the beds, located in Yaquina Bay, had a combined total of an estimated 141.4 million clams, of which 101 million were gaper clams. Clam beds surveyed in Tillamook and Coos bays contained an estimated 8.4 and 26.4 million clams, respectively.

Several biologically significant factors have been revealed during our study. The 1975 year class of gaper clams was exceptionally strong for each of the estuaries surveyed. Several areas had more than 200 gaper set per square foot (2,174/m^2). Spawning or survival of set also appears to be sporadic in each of the bays, with some beds dominated by certain year classes. The 1966 year class apparently was exceptionally strong in Coos Bay. Wendell et al. (1976) reported the same strong year class for gapers in Humboldt Bay. The apparent lack of the strong 1966 year class in Yaquina and Tillamook bays might be attributed to our aging techniques since these clams were aged by shell annuli instead of the chondrophore.

Studies on the distribution and degree of infestation of gaper clams by a haplosporidian parasite showed it to be wide-spread in each of our estuaries. Parasite incidence is correlated with age, with older clams more heavily infected. No infected zero-age clams were observed.

Aging technique studies showed there were statistically significant differences between five different aging techniques. There were also statistically significant differences between the apparent age of the left and right valves, but not of the left and right chondrophore. For these reasons, the past practice of aging by the annular rings on the exterior of the valves was abandoned, and all aging, whenever possible, will be done using the chondrophore. Since the clam is destroyed with this method for aging recreationally dug clams, we will continue to use the annular rings on the exterior of the right valve.

Length measurements can be taken from either the left or right valve of a clam as there is not a significant difference between the size of the two valves.

As a result of our surveys, two commercial clam harvesting permits were issued. One for Yaquina Bay resulted in a harvest of 1,505 pounds of gaper clams. Poor marketing conditions were primarily responsible for the failure of this fishery to develop. The second permit was issued for a 48-acre section of Coos Bay, between Pigeon Point and Empire, where the Corps of Engineers had proposed dumping dredge spoils. Surveys in the area showed most of the substrate to be solid bedrock with several dense pockets of gaper clams. In issuing the permit, we hoped many of the clams in these pockets would be salvaged. As a result, 55,482 pounds were harvested which averaged nearly 1,000 pounds of gapers taken per day of work.

Manila littleneck clams, planted in Netarts Bay, showed clams spawned from fast-growing brood stock grew slightly faster than those from "normal" clams. Butter clams planted in an artificial substrate plot in Yaquina Bay grew 2.3 mm while those planted in natural substrate grew 5.3 mm. Total growth, after 80 months, remained better for clams planted in the artificial substrate plot. Native littleneck clams planted in Yaquina Bay grew only 0.7 mm.

Red abalone planted as juveniles in 1967 in Whale Cove averaged 137.3 mm. Mark-recovery data showed 241 (4.3%) of the original 5,500 still survived.

ACKNOWLEDGMENTS

We wish to thank Darrell Demory, Laimons Osis, and Gerald Lukas of the Oregon Department of Fish and Wildlife for the many hours of diving assistance in the project. Appreciation is also extended to Norma Smallbone, Oregon State University School of Oceanography, for the work she did on preparing many of the maps for this report and to Dr. Robert Olson, Oregon State University Department of Zoology, for his assistance in determining the incidence of haplosporidian infection of gaper clams in several of Oregon's estuaries.

LITERATURE CITED

Armstrong, David A. and Janet 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. and Gerald Lukas. 1975. Methods of Supplementing Clam and Abalone Production. Comm. Fish. Res. and Devel. Act. July 1974 to June 30, 1975. Fish Comm. of Ore. Proc. Rept. 34 pp.

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 pp.

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 pp.

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 pp.

Wendell, Fred, John D. DeMartini, Paul Dinnel, and John Siecke. 1976. The Ecology of the Gaper or Horse Clam, *Tresus capax* (Gould 1850) (Bivalvia: Mactridae), in Humboldt Bay, California. Cal. Fish and Game, 62: 41-64.