METHODS OF SUPPLEMENTING CLAM AND ABALONE PRODUCTION

COMPLETION REPORT

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ABSTRACT

Studies on the clam and abalone resources of Oregon were conducted to determine if these resources could be supplemented by artificial means to increase production.

Clam surveys consisted of mapping the distribution of clams in each of our estuaries using a system of transects across the tideflat. Similar transects, using scuba, were made in the channel areas.

Population estimates, ages and sizes of clams were determined for areas containing dense clam populations in Tillamook, Yaquina and Coos bays. The surveys showed commercial quantities of clams in each of these bays. As a result, special commercial clam harvesting permits were issued for Yaquina and Coos bays to evaluate the effects of a commercial fishery on the habitat and clam resources.

A haplosporidian infection of the gaper clam, *Tresus capax*, was documented subtidally from a number of Oregon's estuaries. A joint study with Oregon State University was initiated to study this problem.

The release of laboratory produced clams in selected areas of several estuaries produced discouraging results. Scouring of the substrate material at most of the release sites appeared to be the main problem.

Statistical tests showed the gaper clam could most reliably be aged by counting annuli in the chondrophore. Butter, *Saxidomus giganteus*, cockle, *Clinocardium nuttallii*, and littleneck, *Venerupis staminea*, clams were aged by counting the annuli on the exterior surface of the shell.

An estimated 241 (4.3%) of the red abalone, *Haliotis rufescens*, planted (at 5-20 mm) in Whale Cove in 1967 still survive. They averaged 137.3 mm in size by 1975.

INTRODUCTION

Clam surveys have been conducted in Oregon's estuaries since 1973. During this project period primary objectives were: (1) to locate suitable intertidal and subtidal clam planting sites and to determine the feasibility of planting laboratory spawned clams; (2) to determine the potential for a subtidal clam fishery in Oregon; (3) to develop techniques for spawning and rearing clams; (4) to refine techniques for aging clams; (5) to develop appropriate subtidal clam management schemes applicable on a coastwide basis; and (6) to determine the feasibility of purchasing and planting juvenile red abalone along the Oregon coast.

INTERTIDAL AND SUBTIDAL CLAM PLANTING SITES

Criteria used to determine the suitability of potential clam planting sites included: an evaluation of species of clams indigenous to the survey area, the type of substrate and vegetation within the survey area, and water depth.

Methods

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. Intertidal clam beds were located by establishing transect lines across each of the tideflats. Subtidally, transects were placed parallel with the current and surveyed with the use of scuba. Observations made at each station along the transect line included species of clams in the area, relative density of each species of clams, substrate type, vegetation type, and water depth. Similar observations were made subtidally.

Results and Discussion

Intertidal and subtidal clam distribution surveys were made on ten Oregon estuaries (Table 1). Surveys were completed on Siletz, Yaquina and Alsea bays. During these surveys we examined more than 1.1 million feet (325,280 m) of transect line and made 7,250 observations.

All of the estuaries surveyed contained intertidal clam populations. Tillamook, Netarts and Yaquina bays contained the most clam beds. Species of clams observed included the butter, cockle, gaper, native littleneck, softshell, *Mya arenaria*, irus clam, *Macoma irus*, bentnose, *Macoma nasuta*, pink clam, *Macoma inconspicua*, and false mya, *Cryptomya californica*. The Nestucca, Salmon, Siletz and Alsea bays, being less saline, contained mainly softshells and one or more species of *Macoma*. To date, we have not surveyed any of the tideflats in Nehalem, Siuslaw or Coos bays. Maps showing the transect lines, clam distribution, substrate materials and vegetation were included in our previous progress reports (Lukas and Gaumer, 1974, Gaumer and Lukas, 1975, and Gaumer and Halstead, 1976).

Subtidal concentrations of clams were located in all estuaries surveyed except the Nestucca and Siletz bays. Tillamook, Netarts, Yaquina and Coos bays contained extensive areas of cockle and gaper clams. Butter and littleneck clams along with numerous species of other clams also inhabit these bays but were difficult to document by our survey techniques.

We did not survey the subtidal area of the Salmon River estuary. As with the intertidal surveys, distribution maps were presented in our 1974, 1975 and 1976 annual progress reports.

Table 1. Feet of Transect Surveyed and Number of Observations Made, by Estuary, 1973-75.

Estuary	Total Area Surveyed (feet of transect)	Number of Observations
Nehalem	16,000	160
Tillamook	190,000	1,423
Netarts	175,800	1,000
Nestucca	51,500	225
Salmon	7,200	55
Siletz*	93,600	372
Yaquina*	391,300	2,851
Alsea*	152,600	827
Siuslaw	2,000	21
Coos	31,600	316
Total	1,111,600	7,250

* Surveys completed

SURVEYS OF POTENTIAL COMMERCIAL CLAM BEDS

As a result of our clam distribution studies, six commercial fishermen have requested permits to harvest clams subtidally in Yaquina Bay. Two permits each were also requested for Tillamook and Coos bays. (A special permit is required to commercially harvest subtidal clams in Oregon by any means other than hand or hand power tools).

Because of the commercial harvest potential, and the lack of existing information, additional quantitative data were collected on subtidal clam stocks in Tillamook, Yaquina and Coos bays.

Methods

Clam samples were collected with a suction dredge patterned after one used by the Washington Department of Fisheries to inventory hard clams in Puget Sound (Gaumer, 1972). Data collected included species composition, distribution, abundance, age and size of clams and substrate material. Single areas were selected for study in Tillamook and Coos bays and four areas were inventoried in Yaquina Bay (Figures 1, 2 and 3). Sampling schemes were generally similar for each area (Gaumer and Lukas, 1975, Gaumer and Halstead, 1976). A sampling grid was designed for each area with sampling intensity being proportional to the number of clams observed in the areas during the distribution study. Samples were collected by scuba divers using the suction dredge. Sample size was 2 square feet (0.6 m^2) of surface area. Each sample was excavated to a depth of approximately 12 to 18 inches (30.5 to 45.7 cm) or until the dredge operator was confident all clams had been removed. The dredge was fitted with a collection basket covered with 1/2-inch (12.7 mm) mesh vinyl covered hardware cloth that retained all clams 10 mm and larger. The retained dredge material was sorted in the boat. All clams were saved and placed in plastic bags, 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 butter, cockle, gaper and littleneck clams that could be aged, were aged. Annual growth rings were counted on the butter, cockle and littleneck clams, while annual rings in the chondrophore were used to age gaper clams.

Substrate materials were recorded at each sample station to provide information on the sediment preference for each species of clams. Sediment composition was subjectively estimated at each sample station by the dredge operator. Sediment material was classified as bedrock, rock, gravel, sand, mud, shell or debris.

The clam bed in Tillamook Bay was partly surveyed (off Hobsonville Point) in 1974 and the remainder (off Larson Cove) was surveyed in 1975. Area 4 in Yaquina Bay was surveyed in 1974 and areas 1, 2 and 3 in 1975. Coos Bay was surveyed in 1975.

In a cooperative study on a haplosporidian infection of gaper clams, we supplied OSU researchers with clams from five areas of Yaquina Bay four times a year. Single samples of gapers were supplied from Tillamook, Netarts, Siuslaw and Coos bays.

Results and Discussion

Our surveys showed that extensive numbers as well as numerous species of clams inhabited the subtidal areas of Oregon's estuaries. Species observed included the

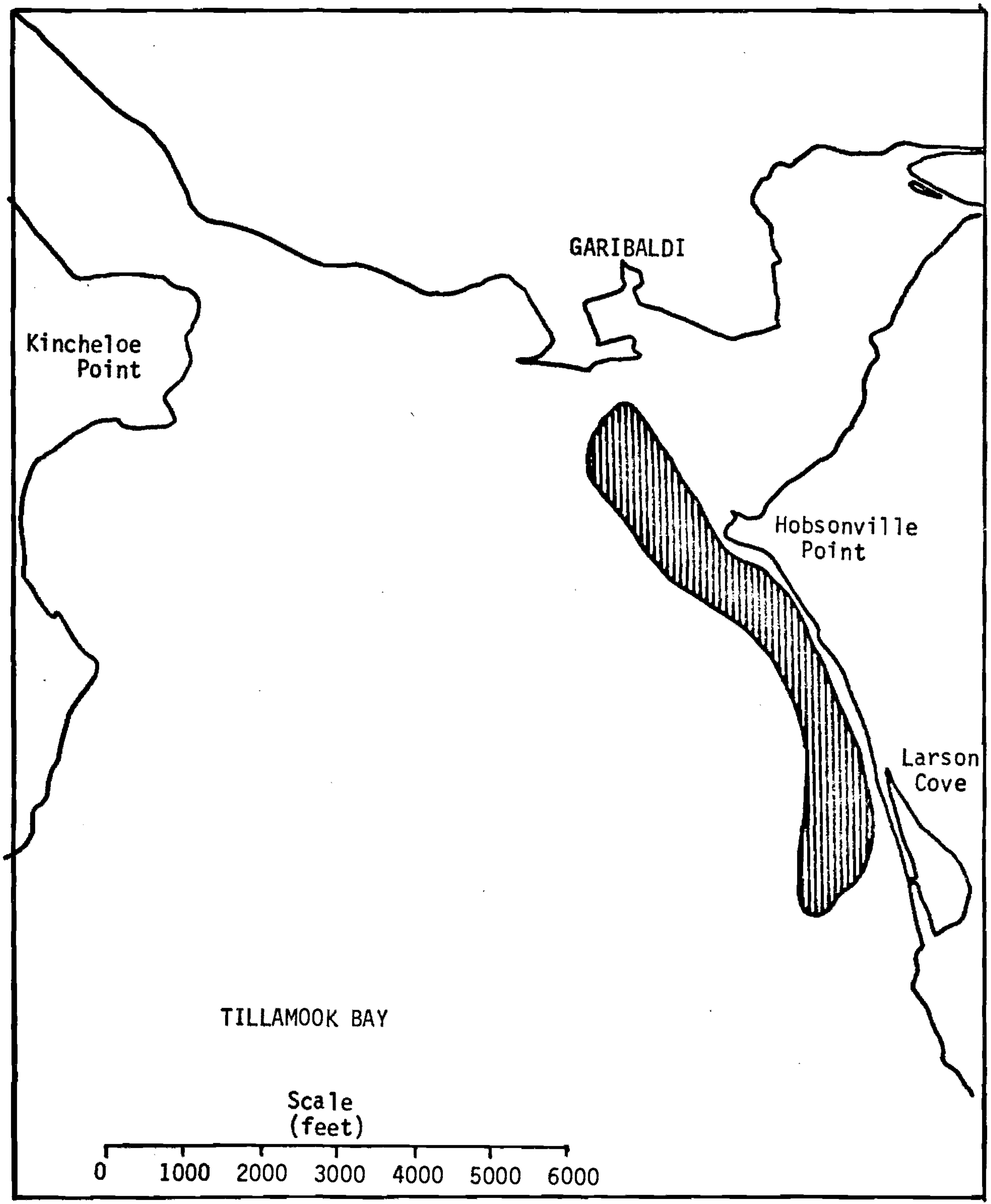

Figure 1. Subtidal Clam Bed in Tillamook Bay, 1976

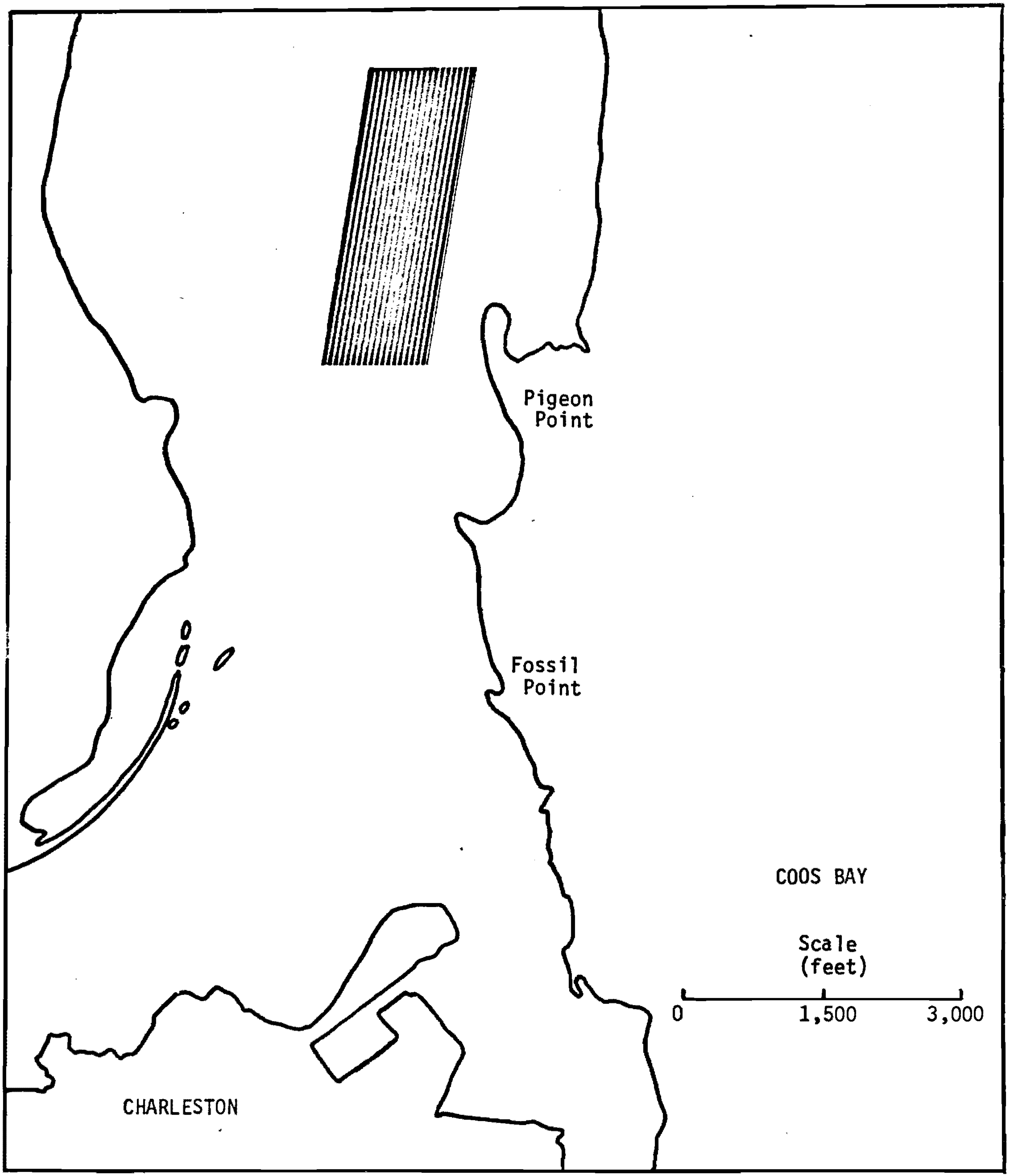

Figure 2. Subtidal Clam Bed in Coos Bay, 1976

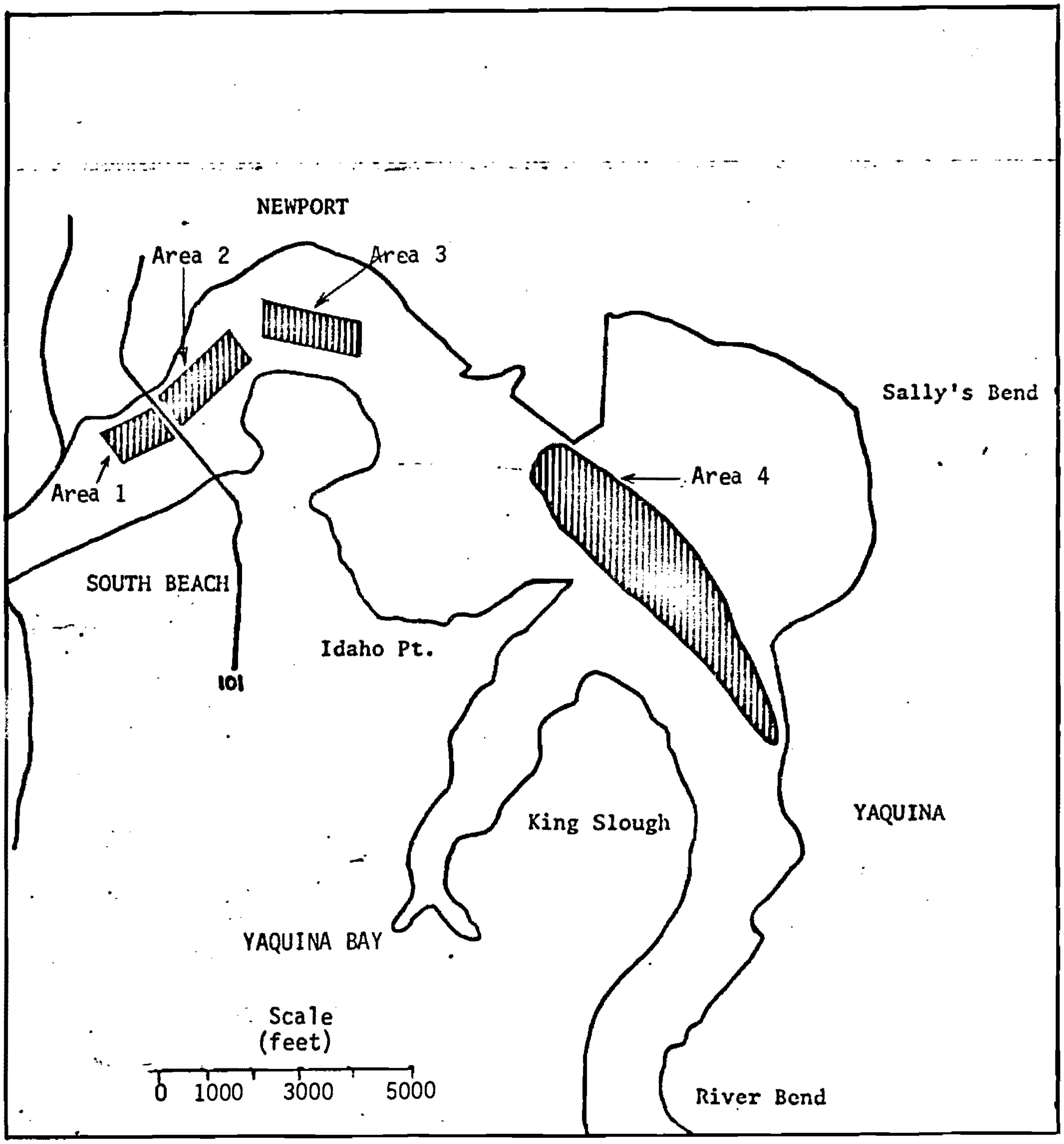

Figure 3. Subtidal Clam Beds in Yaquina Bay, 1976

butter, cockle, gaper, littleneck, softshell, bentnose, irus, jackknife, *Solen sicarius*, bodega tellen, *Tellina bodegensis*, rock piddock, *Zirfaea pilsbryi*, and rock clam, *Petricola carditoides*.

Tillamook Bay

Our surveys showed that the subtidal clam resources in Tillamook Bay have a definite potential for the development of a commercial clam fishery. Population estimates revealed that approximately 21 million clams inhabited the 80-acre (32.4 hectares) area adjacent to U.S. Highway 101 between Hobsonville Point and Larson Cove (Table 2). Littleneck, irus and cockle clams were the principal species recorded although large numbers of butter and gaper clams also inhabited the area.

Age composition data revealed that gaper clams, adjacent to Hobsonville Point, were primarily of the 1967 year class, whereas clams upstream and adjacent to Larson Cove were mainly of the 1970 and 1971 year classes. Several 12-year-old clams were dredged from the area. Cockle and littleneck clams exhibited strong recruitment from the 1969 through 1973 year classes. Maximum age observed for both of these species was 13. Indistinct annular growth rings on the butter clams from Tillamook Bay precluded our aging these clams.

Mean sizes for the butter, cockle, gaper and littleneck clams collected off Hobsonville Point were 73.7, 56.3, 96.7 and 36.5 mm, respectively, whereas these same species averaged 90.1, 59.1, 98.5 and 38.4 mm, respectively, off Larson Cove.

Statistical analysis of the sediment materials and their significance to the presence of clams is not yet available. Preliminary observations indicate that butter, gaper and littleneck clams preferred a substrate material containing a mixture of gravel, sand, shell and mud. Cockles exhibited a preference for a sand substrate.

Yaquina Bay

From our dredge samples we made population estimates of 25.0 million, 93.2 million, 23.1 million and 7.1 million clams for areas 1, 2, 3 and 4, respectively (Table 2). Areas 1, 2, 3 and 4 contained 20.2 acres (8.2 ha), 35.4 acres (14.3 ha), 35.6 acres (14.4 ha) and 142 acres (57.5 ha), respectively. Gaper and irus clams were the main species observed for the four areas. Gaper clams predominate in our population estimates because of an exceptionally strong 1975 year class. Several areas had more than 200 gaper set per square foot (2,174/m^2).

Age composition of the gaper clam showed that clams increased in age as we moved up-bay with the mean age in areas, 1, 2, 3 and 4 being 0.9, 0.7, 1.7 and 7.2 years, respectively. Excluding the zero-age clams from the sample gave a mean age of 3.1, 4.9, 6.4 and 7.2 years, respectively. The same mean age seen for area 4 reflects the lack of 1975 year class set in the sample for that area. Due to the scarcity of cockle and littleneck clams sampled in areas 1, 2 and 3, we combined these clams and compared their age to those clams collected from area 4. Results showed, as with gapers, that clams were older in the up-bay area 4. Butter clams from area 4 were not aged. In areas 1, 2 and 3, butter clams were primarily of the 1973 and 1974 year classes.

Table 2. Population Estimates for Dredged Clams in Tillamook, Yaquina and Coos Bays, 1974-75

Clam Species	Tillamook Area Hobsonville-Larson Cove	Yaquina Areas 1	Yaquina Areas 2	Yaquina Areas 3	Yaquina Areas 4	Coos Area Pigeon Point-Empire
Butter	2,837,300	260,700	989,400	567,000	654,300	809,200
Cockle	4,479,200	81,400	315,700	462,000	375,200	202,200
Gaper	2,680,200	19,262,100	68,252,500	13,608,000	2,264,200	5,648,700
Littleneck	4,589,400	146,600	568,300	168,000	529,100	843,000
Softshell	1,789,000	0	0	0	215,200	0
Bentnose	59,300	0	0	168,000	486,500	2,647,300
Irus	4,282,100	4,611,800	20,863,000	7,854,000	2,480,300	16,018,600
Jackknife	0	0	0	42,000	111,700	0
Bodega tellen	0	16,300	105,100	273,000	0	101,000
Piddock	0	635,500	2,147,400	0	0	0
Rock	0	0	0	0	0	101,000
False mya	0	0	0	0	0	67,300
Total	20,716,500	25,014,500	93,241,400	23,142,000	7,116,500	26,438,300

Length frequency data showed that gaper clams in areas 1, 2, 3 and 4 had a mean size of 41.1, 36.9, 47.6 and 109.2 mm, respectively. The high value for area 4 reflects the lack of set in that area. Length frequencies for butter, cockle and littleneck clams from areas 1, 2 and 3 were combined and compared to those from area 4. Mean sizes for these three species from the down-bay area (areas 1, 2 and 3) were 28.5, 19.6 and 24.7 mm, respectively, whereas these same species averaged 86.8, 59.7 and 53.8 mm, respectively, in area 4.

The sediments in Yaquina Bay were primarily a combination of sand, shell and gravel. The up-bay portion of area 4 contained some bedrock and mud in addition to the sand, shell and gravel. As with Tillamook Bay, data on sediment preference by clams has not been fully analyzed. However, sediment preference appeared to be similar in each bay.

Coos Bay

Analysis of our data showed the 48-acre (19.4 ha) clam bed in Coos Bay contained an estimated 26.4 million clams (Table 2). Gaper and irus clams were the principal species observed.

Age composition data for gaper clams showed that the 1975 year class experienced extremely high survival. The 1966 year class was also very abundant. Butter, cockle, and littleneck clams were more uniform in year class strength and did not exhibit the sporadic spawning success of the gaper clam.

Mean sizes of butter, cockle, gaper and littleneck clams were 89.6, 33.4, 65.7 and 56.3 mm, respectively. These clams were nearly twice as large as those found in Yaquina Bay.

Sediment material in Coos Bay was primarily bedrock with pockets of sand, shell and gravel interspersed throughout the area. Clams were found concentrated in these pockets.

Haplosporidian Study

Observations on the distribution and degree of infection 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. Implications to the commercial fishery are obvious because the infected clams are unsightly. Also, the effects on clam survival and condition are unknown. Since 1975 we have provided clams to personnel at Oregon State University who are studying this parasite using Sea Grant funds.

LABORATORY CLAM REARING STUDIES

Work during the project period was directed primarily towards mass rearing of the Manila littleneck clam, *Venerupis philippinarium*. In addition, butter and littleneck clams, planted in natural and artificial substrate plots, were monitored for growth and survival.

Methods

Basic spawning and rearing methods used were similar to those developed prior to the project period (Lukas 1972, 1973). One innovation was the rearing of juvenile clams in a vertical plexiglass tube (Lukas and Gaumer, 1974). We also compared growth characteristics of clams selected for their fast growing ability vs. normal growing clams (Gaumer and Lukas, 1975). Growth and survival of clams placed in a screened vs. unscreened area were also measured (Gaumer and Lukas, 1975). Most of these tests were carried out in Netarts Bay where over 1/2 million juvenile Manila littleneck clams were planted. Test plots of lesser numbers of clams were also established in Coos and Coquille estuaries.

Results and Discussion

After 112 days Manila littleneck clams reared in the plexiglass tube had a slightly faster growth rate (8.5 mm average size) than those reared in a horizontal partitioned tray (7.6 mm average size). This offered the advantage of being able to hold and rear a large number of clams in a smaller space than the normally used trays. Due to lack of funds, our Manila clam studies were discontinued prior to a complete evaluation of the rearing capabilities of the tube.

With the exception of our work in Netarts Estuary, all Manila clam planting experiments produced discouraging results. The plots in Coos and Coquille estuaries showed zero survival one winter after release. Both of these plots were exposed and sloped to the bays' wave action. Evidence of scouring by wave action suggested the newly planted clams might have been washed out. Results of studies in Yaquina Bay showed that Manila clam survival, approximately one year after release, was higher (20.9-30.4%) when planted on a level substrate than for those planted on a 7° to 8° slope (3.8-4.1%) and exposed to the waves.

The most encouraging results occurred for Manila clams planted in Netarts Bay in a screened enclosure vs. an adjacent unscreened plot. Survival after 59 days was 80.4% in the fenced plot vs. 49.2% in the unfenced plot (Gaumer and Lukas, 1975). This suggested that many of the clams were leaving the area of release. Tracks observed made by these clams across the surface of the tideflat substantiated this movement characteristic. Because of this nomadic feature, survival data is misleading. Growth data for clams in the enclosure vs. open area were similar (21.5 mm vs. 20.3 mm, respectively) (Gaumer and Halstead, 1976).

Manila clams spawned from fast-growing parent stock grew faster (11.0 mm) than progeny from "normal" size clams (10.4 mm) (Gaumer and Halstead, 1976).

After 80 months, butter clams, planted in a natural substrate averaged 53.7 mm compared to 63.7 mm for those reared in an introduced rock substrate (Gaumer and Halstead, 1976).

CLAM AGING STUDY

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

Methods

A random sample of 135 gaper clams was collected from the subtidal area off Pigeon Point in Coos Bay (Gaumer and Halstead, 1976). Aging methods tried were (1) counting the annuli on the external surface of the shell; (2) counting the annuli on the cartilage after removal from the chondrophore pit; (3) counting the annuli in the chondrophore pit; (4) separating the chondrophore pit from the shell and counting the annuli in the pit using a high intensity light; and (5) counting the annuli in the chondrophore or shell after cross sectioning the valve from the umbo to the outer margin of the shell.

Results and Discussion

Statistical analysis of our aging techniques showed that aging clams using the annuli on the surface of the shell accounted for the greatest variance, 29%; followed by the cartilage annuli method, 26%; chondrophore method, 18%; cross section technique, 16%. The chondrophore held in front of a high intensity light accounted for the least variance, 11%. Based on these tests, all gaper clams in the dredge samples were aged by using the chondrophore.

Length measurements of the left and right valve showed no significant difference in size.

SUBTIDAL COMMERCIAL CLAM FISHERY

As a result of our subtidal clam studies, two commercial clam harvesting permits were granted to harvest clams on an experimental basis. One permit was issued for a 15-acre (6.1 ha) site in Yaquina Bay and the other for a 48-acre (19.4 ha) site in Coos Bay. The Coos Bay permit was issued for an area between Pigeon Point and Empire where the U.S. Army Corps of Engineers had proposed dumping dredge spoils. In issuing the permit, we hoped many of the clams in the area would be salvaged.

Methods

Both permits were issued on an experimental basis and provided us an opportunity to implement specific restrictions on the harvest. These restrictions were necessary to evaluate the effects of a commercial harvest on the environment and clam resources. The restrictions attached to the Yaquina Bay permit included:

1. The mechanically powered equipment was limited to a jet of water.

2. Harvesting activities were limited to a 15-acre (6.1 ha) site adjacent to Sally's Bend and at a depth in excess of minus six feet (1.8 m) as measured from mean lower low water.

3. Not more than 100,000 pounds (45.4 metric tons) of all clam species were to be harvested per year.

4. A monthly report on the approximate weight, in pounds, of each species of clams harvested shall be submitted.

The Coos Bay permit was less restrictive because our primary purpose was to salvage as many clams from this area as possible before the U.S. Army Corps of Engineers filled the area with dredge spoils. The restrictions imposed included the following:

1. The harvest was confined to a 48-acre (19.4 ha) area off Pigeon Point and extended from the minus 5-foot (1.5 m) depth to the minus 20-foot (6.1 m) depth.

2. The number of clams, pounds, date of harvest, and down time was to be submitted monthly to the Department.

Results and Discussion

The commercial clam fishery in Yaquina Bay produced only 1,505 pounds (683 kg) of gapers. Poor marketing conditions were primarily responsible for the failure of this fishery to develop. The 1968, 1969 and 1970 year classes were dominent in the catch.

The commercial clam fishery in Coos Bay produced 55,482 pounds (25,166 kg). The harvest was dominated by the 1966 year class. Wendell, et al., (1976) reported the same strong year class for gapers in Humboldt Bay.

RED ABALONE STUDY

During the project period we continued our annual monitoring of the growth and survival of red abalone, planted in 1967 as juveniles in Whale Cove, Oregon. In addition, we investigated the possibility of buying more juvenile abalone from commercial mariculture hatcheries in California.

Results and Discussion

The abalone in Whale Cove, planted as 5-20 mm individuals in 1967, averaged 137.3 mm in 1975. This rate of growth is similar to what was observed for red abalone in California (personal communication, March 14, 1975, with Richard T. Burge, California Department of Fish and Game, Morro Bay, California). Using our growth data, we estimated 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 in 1975 showed that 241 (4.3%) of the original 5,500 juvenile red abalone still survived 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.

Our inquiries into the cost and availability of juvenile abalone brought only one response; California Marine Associates of Cayucos, California offered abalone with price depending on number 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. Lack of funds precluded us from purchasing additional abalone during the project period.

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