SUMMARY REPORT ON RELEASES OF LABORATORY PRODUCED CLAMS

BY

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Table of Contents

List of Figures

List of Tables

List of Appendix Figures

Summary Report on Releases of Laboratory Produced Clams

INTRODUCTION

In 1968 the Oregon Fish Commission (now Oregon Department of Fish and Wildlife) initiated P.L. 88-309 funded studies to develop techniques to spawn and rear several species of bay clams. After our successful spawning and rearing studies, we planted the laboratory-produced juvenile clams on various tideflats of several estuaries to evaluate their growth and survival (Figures A-F in Appendix).

This report summarizes the results of our field work on Yaquina, Netarts, Tillamook, Alsea, Coos and Coquille estuaries.

METHODS

Yaquina Bay

Four species of clams were spawned and juveniles reared for planting experiments in Yaquina Bay.

Butter Clam. Butter clams *Saxidomus giganteus* were successfully spawned and reared in the laboratory (Phibbs, 1968 and 1969). Approximately 30,000 of the juvenile clams were marked with sodium alizarin monosulfonate using techniques described by Hidu and Hanks (1968). These marked clams were then used in a habitat preference study in Yaquina Bay where we attempted to evaluate the effects of various substrate types upon growth and survival. The test plots were located on the north side of the breakwater in the Department's shellfish preserve (Figure 1).

The experiment was designed to evaluate the following substrate types: Plot 1 was the control consisting primarily of a mud-sand substrate; plot 2 contained crushed rock 19 mm-38 mm; plot 3 contained river run rock 19 mm; plot 4 contained crushed rock 19 mm; plot 5 contained river rock 19 mm-38 mm; and plot 6 contained crushed rock 38 mm-76 mm.

After allowing the plots to settle for one week, juvenile butter clams were placed in a 1.2 x 1.2 m portion of each plot at a density of 100 clams/0.09 m^2. The clams were planted in December 1968. The clams were eight months old and

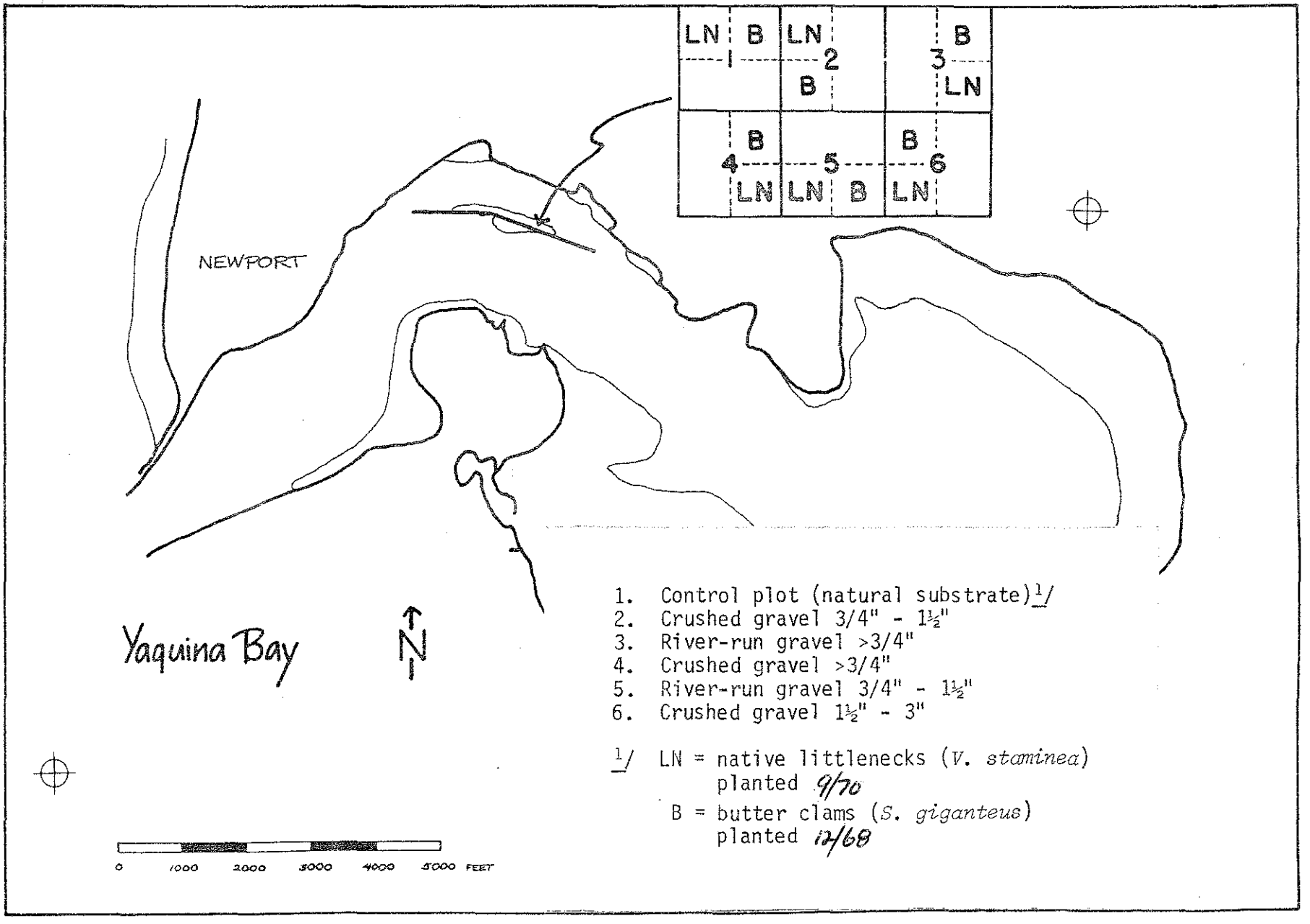

Figure 1. Location and Substrate Composition of Artificial Substrate Test Plots, Yaquina Bay.

averaged 2.9 mm in shell length when planted. Survival and growth was monitored by annually sampling randomly selected 0.09 m^2 portions of each test plot.

In 1970, 600 juvenile butter clams were planted in a 0.9 x 3.0 m plot in natural substrate near the base of the Yaquina Bay breakwater. The clams were 22 months old when planted and averaged 20 mm. They were marked with enamel paint to distinguish them from natural set.

Manila Littleneck Clams. Manila littleneck clams *Venerupis philipinarium* were successfully spawned in the laboratory (Phibbs, 1970). The resultant 4,000 juveniles were planted in upper Yaquina Bay near the mouth of McCaffery's Slough. The 2.4 x 7.6 m test plot was placed at the 0 to 0.45 m tide level. The clams were planted at a density of 20/0.09 m^2 and averaged 3.0 mm in shell length.

In October 1971, an additional experimental planting of 5,340 Manila clams was made on McCaffery's Island to evaluate optimum size and density of Manila juveniles at time of planting. Three groups of 10-month-old clams averaging 3.7, 7.0 and 11.4 mm were planted at four different densities (50, 80, 125 and 200/0.09 m^2).

In 1972 we planted Manila clams in four additional areas of Yaquina Bay. One plant of 12,950 Manilas occurred in April across from the Riverbend Marina and was also designed to evaluate optimum size and density for planting Manilas. Nine test plots were established and separated into three groups of three plots each. Group one clams were planted at densities of 200/0.09 m^2; group two at 125/0.09 m^2; and group three at 80/0.09 m^2. The small clams averaged 3.7 mm, the medium-size clams averaged 6.5 mm and the large clams were 11.0 mm.

A second planting was made in a 4.6 m^2 plot on the west side of Sally's Bend. The plot was planted with 2,500 juveniles (50 clams/0.09 m^2) in October 1972 and averaged 6.2 mm. The planting was made to determine suitability of the area for future plants.

The third release of Manilas occurred in July 1972 near Oregon Oyster Company. Three 3.3 m^2 plots were established at the 0.97 to 1.5 m tide level. Each plot

received 1,800 Manilas (at 50/0.09 m^2) of an average length of 6.7 mm.

The fourth plant involved placing 426,000 Manilas enmass in a 353 m^2 plot on the south side of the Yaquina Bay breakwater. These clams were released in July, September and October of 1972.

Native Littleneck Clams. In September 1970, 600 juvenile littleneck clams *Venerupis staminea* were planted in specially prepared plots containing the several types of substrate described in the butter clam section. The clams were 11 months old and averaged 9.9 mm when planted. They were planted at a rate of 6.3/0.09 m^2.

In 1972 we planted 4,000 native littlenecks on the breakwater of Yaquina Bay. The clams were planted at a density of 100/0.09 m^2 and averaged 9.8 mm.

Gaper Clams. Three thousand laboratory-reared gaper clams *Tresus capax* were planted in Yaquina Bay in 1970. The clams averaged 13.6 mm and were planted at 25/0.09 m^2. The clams were planted on the breakwater in an area containing a natural population of adult gaper clams.

Netarts Bay

Our clam plants in Netarts Bay started in 1971 and extended through 1974. The Manila littleneck was the only clam species released.

In 1971 20,000 juvenile Manilas were planted near Wilson Beach in Netarts Bay at a density of 50 clams/0.09 m^2. The clams ranged from 3.2 to 11.6 mm in length. Our primary goal was to determine the suitability of the area for future releases.

In 1973 five test plots were established in scattered locations of Netarts Bay. A total of 10,625 juvenile Manilas were planted in an attempt to locate areas that might be suitable for additional plants. Each plot was planted with clams at 50/0.09 m^2 and the clams averaged 7.3 mm in length.

In 1974 two plots were established in Netarts to evaluate movement, survival and growth of Manila clams. One 1.5 x 3.0 m plot was fenced with 6.3 mm mesh wire cloth that extended 10.1 cm above the substrate and the other area was unfenced. Both plots were planted at a density of 50/0.09 m^2 with 2,500 juvenile Manilas

averaging 13.1 mm. At the same time an additional test plot was established about 75 m closer to the main channel in an area covered with dense eelgrass *Zostera marina*. This area was at a slightly lower elevation than the other two plots and planted at a density of 54 clams/0.09 m^2. This release was made to (1) evaluate the difference in growth rate at a lower tidal height as compared to the fenced and unfenced areas and (2) to determine if eelgrass harbored predators (crabs) which might effect clam survival.

Also in 1974 two test plots were established to evaluate the growth and survival of progeny from selected fast growing adult clams and from "normal" growing adults. A total of 39,114 juveniles averaging 5.7 mm were planted from fast growing adults and 11,375 clams averaging 5.3 mm were released from "normal" growing adults.

An additional 430,200 laboratory reared Manilas were planted in adjacent areas to attempt to supplement the existing spawning stocks in the bay.

Tillamook Bay

In 1971 we planted a total of 20,000 juvenile Manila littleneck clams in Tillamook Bay adjacent to Hobsonville Point. Our primary objective was to determine the suitability of the area for future releases.

Alsea Bay

In 1971 we planted 20,000 juvenile Manila littleneck clams in Alsea Bay on the north shore above the U.S. highway 101 bridge. In 1972 two additional releases were made upbay of the 1971 plant. A total of 19,800 clams were released. Suitability of the area for future clam releases was our primary objective.

Coos Bay

Two areas of the north spit of Coos Bay, across from the town of Empire, were planted with a total of 20,000 Manila clams in August 1973. Suitability of the area for future releases was our primary concern.

Coquille Bay

We planted 10,000 juvenile Manila clams across from the abandoned light houses in Coquille Bay in August 1973. Primary objective was to evaluate suitability of the area for future Manila clam plants.

RESULTS

Yaquina Bay

Butter Clams. Survival of butter clams in the artificial substrate test plots has been low. After 15 months, survival ranged from 0.5 to 4.5% (Table 1). Clams planted in the control plot failed to survive. Our sampling in April 1978, 112 months after the clams were released, showed a total survival rate ranging from 0% (for clams planted in natural substrate and 19 mm minus river rock) to 0.8% for clams planted in 19 mm minus crushed rock.

Growth of the butter clams after 15 months, for all substrates combined, averaged 20.6 mm; the butters averaged 2.9 mm when planted. In the artificial substrate plots, growth ranged from 19.3 mm in 38 mm to 76 mm crushed rock to 21.5 mm in 19 to 38 mm crushed rock. Twenty-four months after release, growth ranged from 33.6 mm for clams released in 19 to 38 mm minus river rock to 38.1 mm for clams planted in 19 mm minus river rock. Figure 2 shows the average growth curve of butter clams. After 119 months the butter clams averaged 71.8 mm in length.

One parameter that was not measured was the effect of digging and handling on survival and growth; both probably were important.

Survival of butter clams, planted in 1970 in a natural substrate environment at the base of the Yaquina Bay breakwater, was 51.7% after 83 months in the test plot (Table 2). Each year a 2.5 m^2 section, never previously sampled, was removed to eliminate adverse effects of handling. The reason for the annual increases in survival is unknown. Either the clams were not randomly distributed when planted or there was subtle environmental differences from one end of the plot to

Table 1. Growth and Survival of Butter Clams Planted in Artificial Substrate Plots, Yaquina Bay Breakwater, 1968-78

Substrate type	Date sampled	Months after release	Survival (%)	Mean size (mm)
Control	12/15/68	0	100.0	2.9
	6/8/69	6	1.5	11.1
	12/26/69	12	0.0	-
Crushed rock 19mm to 38mm	12/15/68	0	100.0	2.9
	6/8/69	6	3.3	10.3
	12/26/69	12	0.0	-
	3/25/70	15	2.0	24.4
	12/9/70	24	0.8	38.6
	4/12/73	52	0.1	56.1
	4/25/74	64	0.1	59.1
	4/28/75	76	0.1	63.0
	4/16/76	88	0.1	64.9
	4/6/77	100	0.1	71.4
	4/25/78	112	0.1	72.1
River Run 19mm -	12/15/68	0	100.0	2.9
	6/8/69	6	1.0	7.9
	12/26/69	12	0.0	-
	3/25/70	15	0.5	23.8
	12/9/70	24	0.2	41.0
	4/12/73	52	0.0	-
Crushed 19mm -	12/15/68	0	100.0	2.9
	6/8/69	6	4.5	10.5
	12/26/69	12	1.0	20.8
	3/25/70	15	4.5	23.8
	12/9/70	24	3.4	38.8
	4/12/73	52	2.4	61.2
	4/25/74	64	1.7	62.2
	4/28/75	76	1.6	64.7
	4/16/76	88	1.1	65.6
	4/6/77	100	0.9	69.1
	4/25/78	112	0.8	72.7
River Run 19mm to 38mm	12/15/68	0	100.0	2.9
	6/8/69	6	0.8	7.4
	12/26/69	12	1.8	20.7
	3/25/70	15	0.9	23.3
	12/9/70	24	0.7	36.5
	4/12/73	52	0.2	61.0
	4/25/74	64	0.3	63.2
	4/28/75	76	0.3	65.3
	4/16/76	88	0.3	-
	4/6/77	100	0.3	67.0
	4/25/78	112	0.3	71.8
Crushed 38mm to 76mm	12/15/68	0	100.0	2.9
	6/8/69	6	7.3	9.2
	12/26/69	12	1.5	19.6
	3/25/70	15	2.4	22.2
	12/9/70	24	2.5	38.2
	1972	-	-	49.9
	4/12/73	52	1.7	58.5
	4/25/74	64	1.4	60.3
	4/28/75	76	1.3	62.3
	4/16/76	88	0.9	63.6
	4/6/77	100	0.9	69.1
	4/25/78	112	0.4	70.9

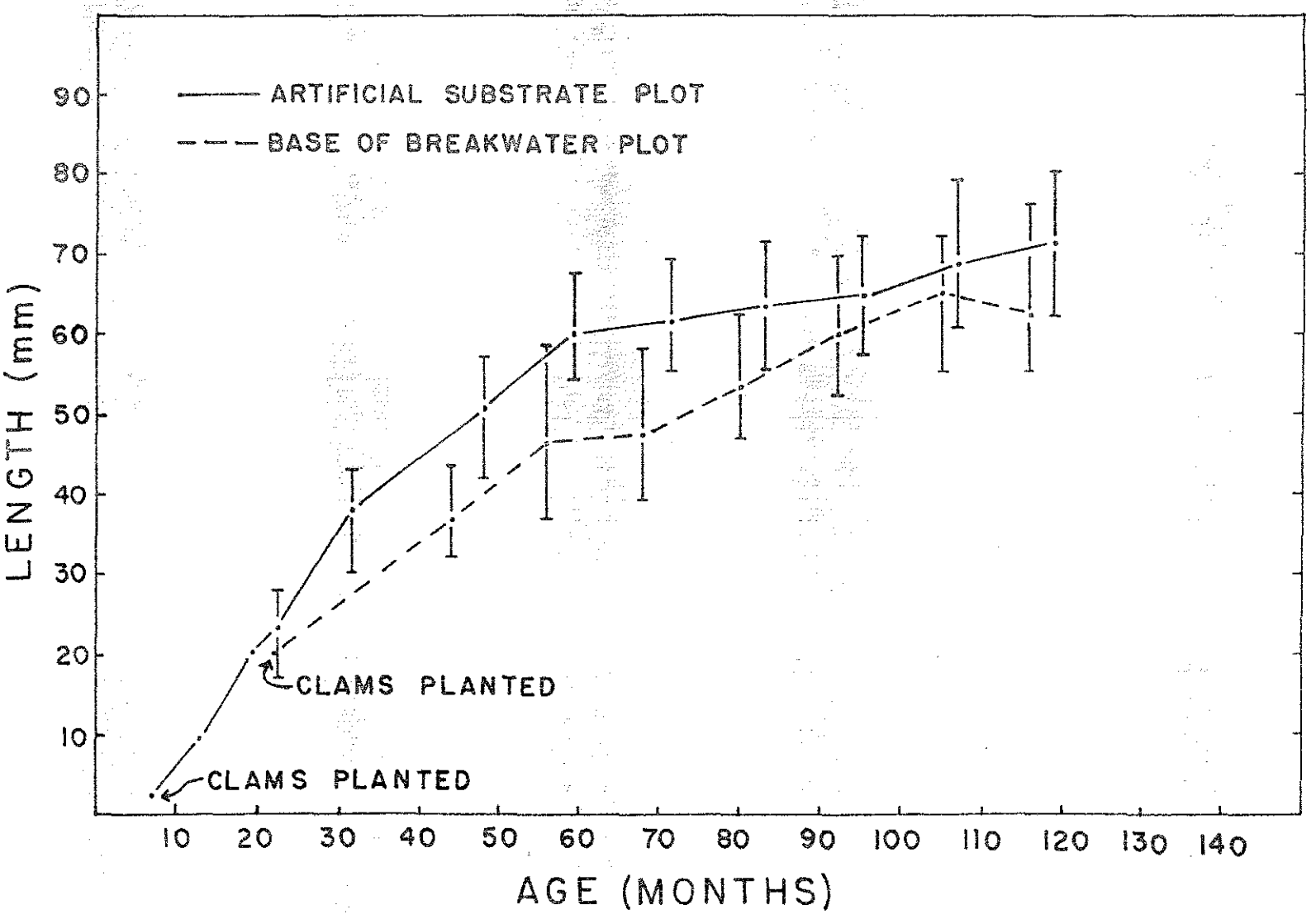

Figure 2. Growth Curve of Butter Clams Planted on the Breakwater, Yaquina Bay (Vertical Lines Indicate Range in mm), 1978.

the other which affected survival.

Table 2. Growth and Survival of Butter Clams Planted on the Yaquina Bay Breakwater, 1977[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
7-27-76	60.0	68.3	92.0	70.0
8-2-77	65.4	51.7	105.0	83.0

1/ Butter clams averaged 20 mm when planted.

Growth of butter clams in the natural substrate lagged behind a comparable group planted in the artificial substrate plot located 91 m away (Figure 2). Clams in the natural substrate, after 105 months, averaged 65 mm whereas those in the artificial substrate averaged 68 mm.

Manila Littleneck Clams. Twelve months after planting 4,000 juvenile Manila littleneck clams on McCaffery's Island we found that 4.6% had survived. After 24 months <1.0% survived. Evidence of severe winter flooding and silt deposition was seen on the tideflat.

In 1971 we repeated planting Manila clams on McCaffery's Island in a size-density experiment. Eight months after release we failed to find any surviving clams.

Manila clams planted in a size-density experiment, across from Riverbend Marina on Yaquina Bay, experienced good growth but poor survival after one year (Table 3). Growth was fastest for Manilas planted at 6.5 mm and at densities of 200/0.09 m^2 whereas survival was highest for clams planted when 11.0 mm in size and at a density of 80/0.09 m^2. After 13 months the clams averaged 30.8 mm and survival was 1.5%.

A planting of 2,500 Manila clams on Sally's Bend was checked 6 months later and we found no surviving clams.

Table 3. Summary of Size-Density Manila Clam Plants at Riverbend Marina, Yaquina Bay, 1972.

Plot No.	Planting density/(0.09m^2)	Planting size (mm) (4/19/72)	Recovery size (mm) (5/4/73)	Number Recovered (5/4/73)	Percent Recovery
1	80	3.7	29.2	3	3.8
2	80	6.5	30.7	1	1.3
3	80	11.0	31.7	6	7.5
4	125	3.7	29.6	1	1.3
5	125	6.5	-	0	0.0
6	125	11.0	32.2	2	2.5
7	200	3.7	28.9	2	2.5
8	200	6.5	33.6	3	3.8
9	200	11.0	-	0	0.0
Total	1,215	7.1	30.8	18	1.5

The release of 5,400 Manila clams in three test plots near Oregon Oyster Company initially produced encouraging results with survivals ranging from 12.8 to 34.4% after nine months. Twenty-one months after release all planted clams had died.

A release of 426,000 Manila s on the south side of the Yaquina Bay breakwater, to evaluate the suitability of that area for rearing clams, produced less than 1% survival after 20 months. Poor stability of the substrate and exposure of the area to strong wave action during southwest winds probably contributed to the massive mortality in that area.

Native Littleneck Clams. Native littleneck clams planted in September 1970 in an artificial substrate plot were sampled annually to assess growth. The study was discontinued in 1977 due to the small number of clams remaining. The clams were 10 mm when planted and averaged 48.9 mm, 79 months later (Figure 3). Due to the small numbers of clams in the intial experiment and poor survival, all clams were remeasured annually since 1972; consequently, growth of the clams may have been retarded due to handling.

None of the 4,000 native littleneck clams planted on the Yaquina Bay breakwater in 1972 were found alive in July 1973. These clams were planted in a natural

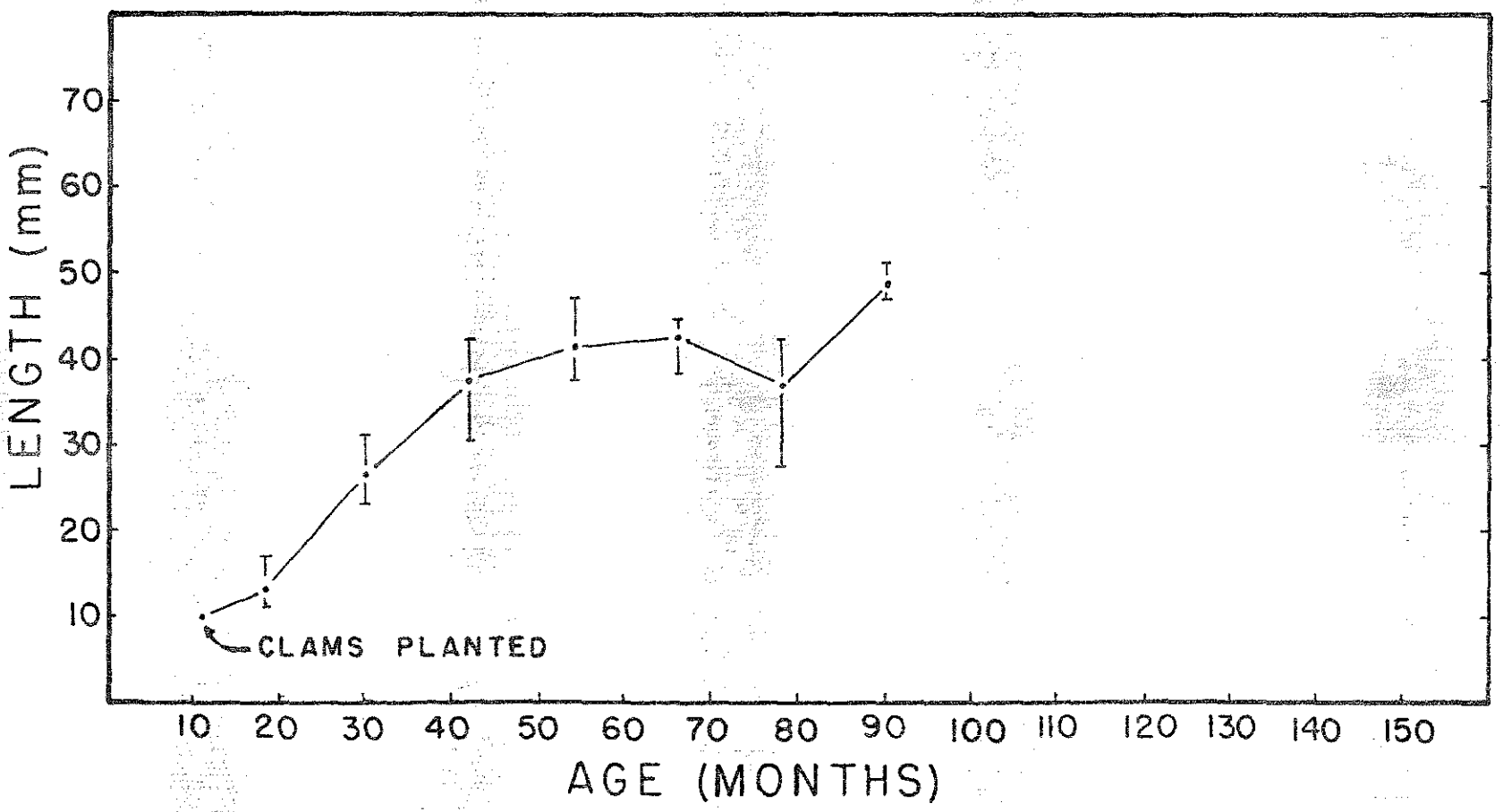

Figure 3. Growth Curve of Native Littleneck Clams Planted in Artificial Substrate Plot, Yaquina Bay (Vertical Lines Indicate Range in mm), 1977.

substrate area where wild native littleneck clams already existed.

Gaper Clams. None of the three thousand juvenile gaper clams planted on the Yaquina Bay breakwater survived. No additional plants of laboratory reared juvenile gaper clams were attempted.

Netarts Bay

We have had various degrees of success with our releases of hatchery produced juvenile clams in Netarts Bay.

Manila Littleneck Clams. An initial release in 1971 of 20,000 Manilas near Wilson Beach was nearly a total failure. Eight months after planting, less than 1% of the young clams survived. The area of release contained native littleneck, gaper and cockle clams suggesting something incompatible with juvenile Manila clams existed in the area during and/or following time of release.

The release of Manila clams in five different test plots in 1973 to attempt to locate suitable release sites produced discouraging results. Ten months after release, 8.3% of the clams released in one test plot remained alive. None of the clams in the remaining test plots were alive.

Our experimental plantings of Manila clams in 1974 to determine survival, growth and movement of clams showed that Manilas were quite mobile. Two months after release 80% of the clams in the fenced area were alive whereas 49% of the clams released in the unfenced plot were recovered; 15.7% were recovered from the eelgrass covered test plot. Because of the movement of clams from the unfenced areas, comparison of survival between the three areas was inconclusive. Clams remaining in each of the test plots is shown in Table 4. Although the eelgrass plot was planted at a slightly denser concentration than the other two plots (54.0.09 m^2 vs 50/0.09 m^2), fewer clams remained in the area. Part of this might be attributed to predation from crabs that inhabited the eelgrass beds since many of the remaining valves of dead clams showed evidence of breakage.

Manila clams planted in the eelgrass plot averaged 40.0 mm 36 months after

release. This was considerably larger than clams planted in the fenced and unfenced plots which averaged 37.8 and 33.8 mm, respectively (Figure 4).

Table 4. Summary of Clams Remaining in Fenced, Unfenced, and Eelgrass Covered Test Plots, Netarts Bay, 1974-77[1]/.

Test Plot	Date 8/74	10/74	5/75	5/76	6/77
Fenced	3.7	3.2	2.0	1.8	0.8
Unfenced	2.3	2.4	0.8	0.1	0.2
Eelgrass	1.3	0.6	0.2	0.1	0.1

1/ Values are clams/m^2 remaining in test plots.

Results of our studies on growth and survival of clams spawned from "fast" and "normal" growing brood stock showed that after 34 months, progeny from fast growing clams averaged 31.5 mm as compared to 29.2 mm for normal growing clams (Figure 5).

The "normal" size clams were planted at a density of 98/0.09 m^2 whereas "fast" growing clams averaged 113 clams/0.09 m^2.

Tillamook Bay

We realized no survival from the 20,000 juvenile Manila littleneck clams planted adjacent to Hobsonville Point in Tillamook Bay. Excessive wave action and beach exposure appeared to be the major factors effecting survival.

Alsea Bay

None of the 20,000 juvenile Manila littleneck clams planted in 1971 in Alsea Bay appeared to survive. Beach erosion during heavy winter runoff appeared to be a factor.

Results of the 1972 release of 19,800 Manila clams upbay of the 1971 plant in Alsea Bay produced similar results to the 1971 plant with only 1 clam recovered from 7.3 m^2 of sample area.

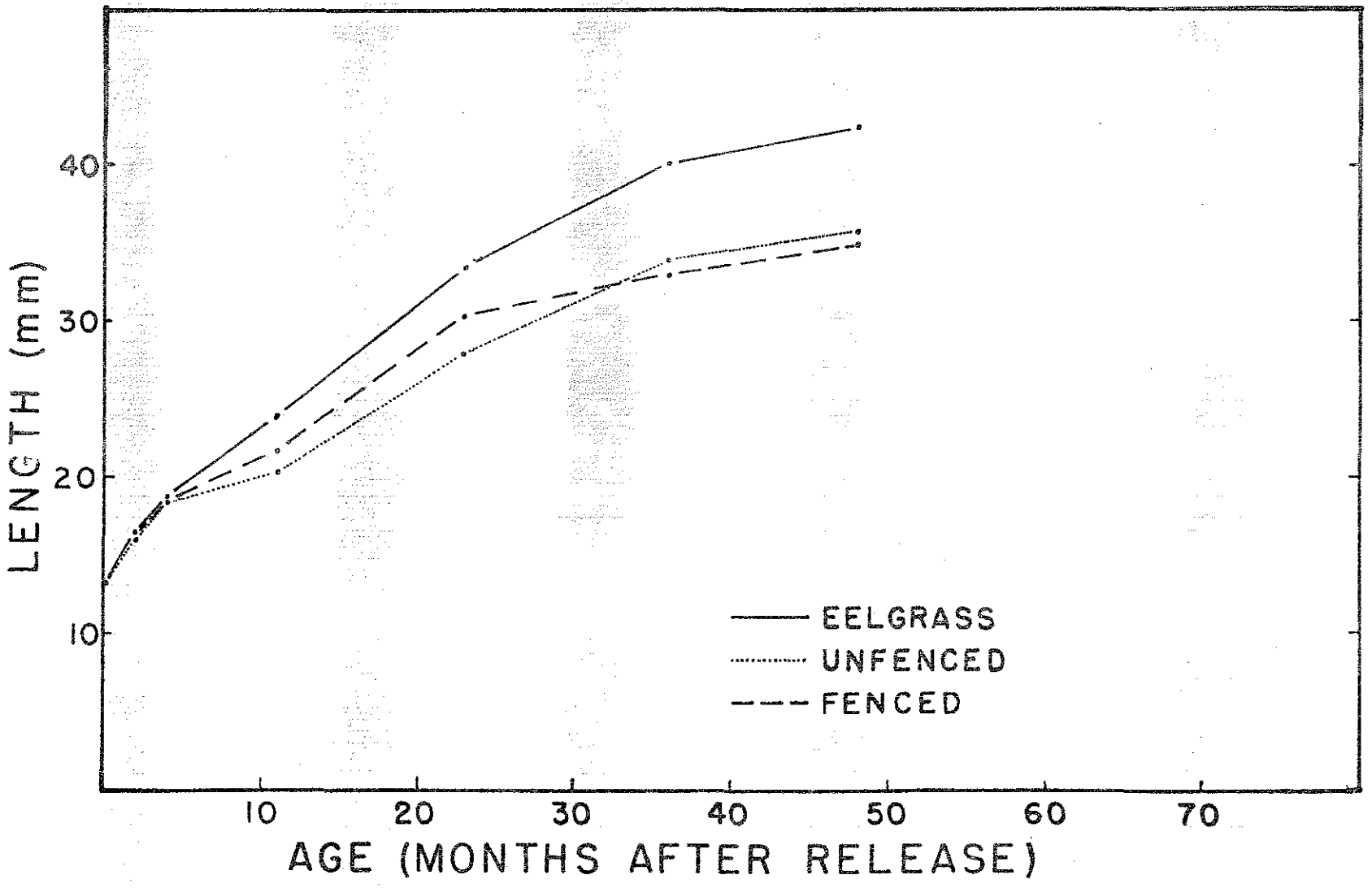

Figure 4. Growth Curve of Manila Littleneck Clams Planted in Fenced, Unfenced and Eelgrass Covered Areas of Netarts Bay, 1978.

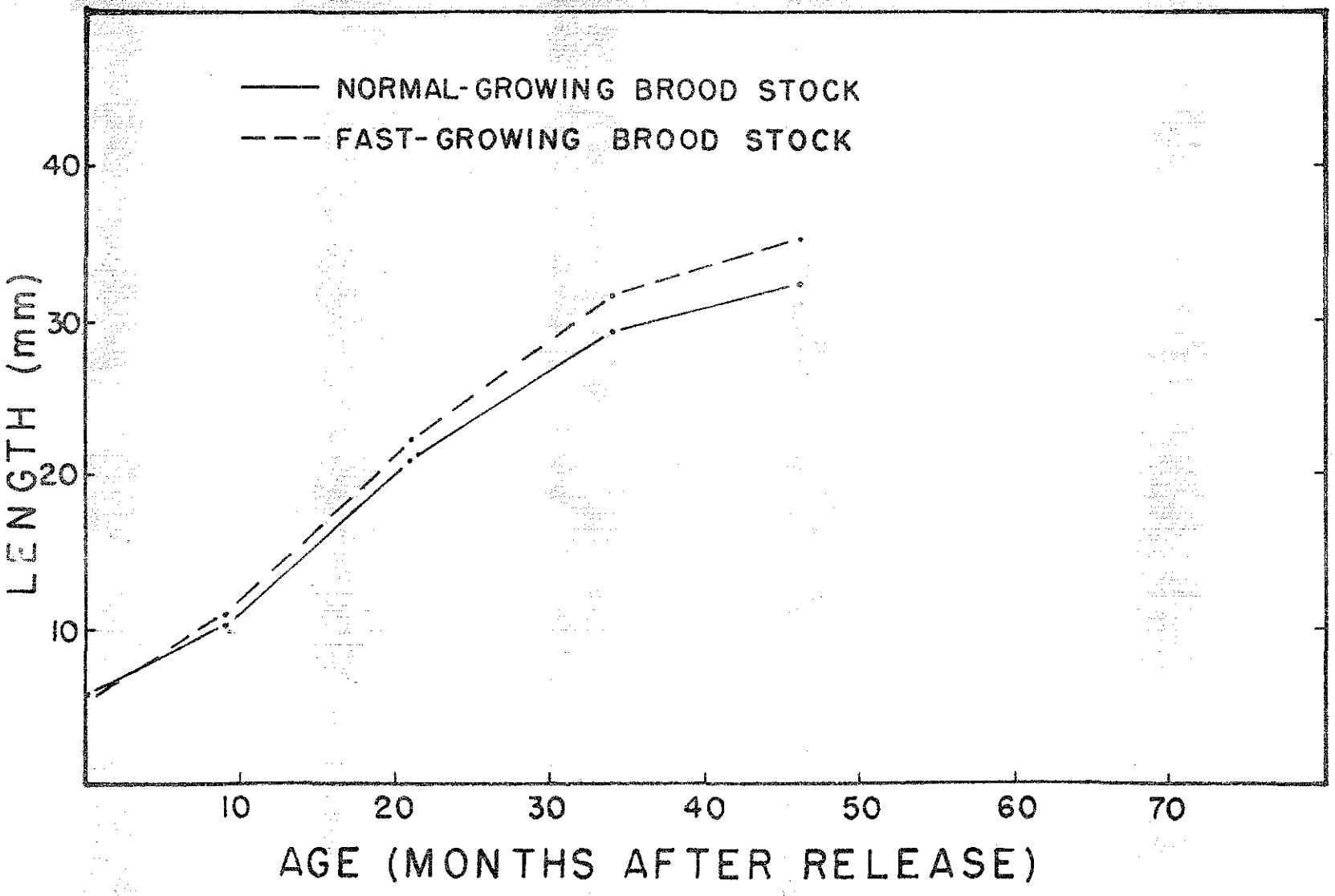

Figure 5. Growth Curve of Manila Littleneck Clams Spawned and Planted from Normal and Fast Growing Brood Stock in Netarts Bay, 1978.

Coos Bay

The two areas on the north spit of Coos Bay, planted in 1973 with 20,000 Manila littleneck clams, were resurveyed nine months later. No evidence of live clams was seen. Strong wave action from passing ships and winter storms might have destroyed the newly planted set.

Coquille Bay

None of the 10,000 Manila littleneck clams, planted in August 1973, were alive nine months later. Inadequate substrate and low winter salinities probably attributed to the total mortality.

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SUMMARY

Ten years of studies on the spawning, rearing and planting of juvenile clams has produced the following results:

1. We were successful in spawning and rearing the butter, Manila littleneck, native littleneck and gaper clam. Clams of each of these species were raised in sufficient numbers to release in field experiments.
2. Survival of butter clams planted in artificial substrate plots was low, ranging from 0.5 to 4.5%, 15 months after release. One hundred twelve months after release, clams planted in 19 mm minus crushed rock produced the highest survival (0.8%).

3. Growth of butter clams planted in artificial substrate plots, after 24 months, ranged from 33.6 mm for clams released in 19 to 38 mm minus river rock to 38.1 mm for clams planted in 19 mm minus river rock.
4. Survival of butter clams planted in a natural substrate near the base of the breakwater was 51.7%, 83 months after release.
5. Survival of Manila littleneck clams, planted in various locations of Yaquina Bay, was extremely low. Lack of suitable substrate material was suspected to be a leading factor in the poor survival.
6. Few of the native littleneck clams planted in Yaquina Bay survived.
7. None of the gaper clams planted in Yaquina Bay survived.
8. Plants of Manila littleneck clams in Netarts Bay produced encouraging results. We concluded that juvenile Manilas are quite mobile which makes evaluating survival difficult. Manilas grew faster when planted in eelgrass beds at a slightly lower tidal height than for clams planted on non-vegetated areas higher on the tideflat. And progeny from "fast" growing adults grew faster than clams spawned from "normal" size adults.
9. Manila clams planted in Tillamook, Alsea, Coos and Coquille bays failed to survive. Inadequate substrate material and instability of the release sites are thought to have been the major causes of the loss of clams.

APPENDIX

(Figures A through F)

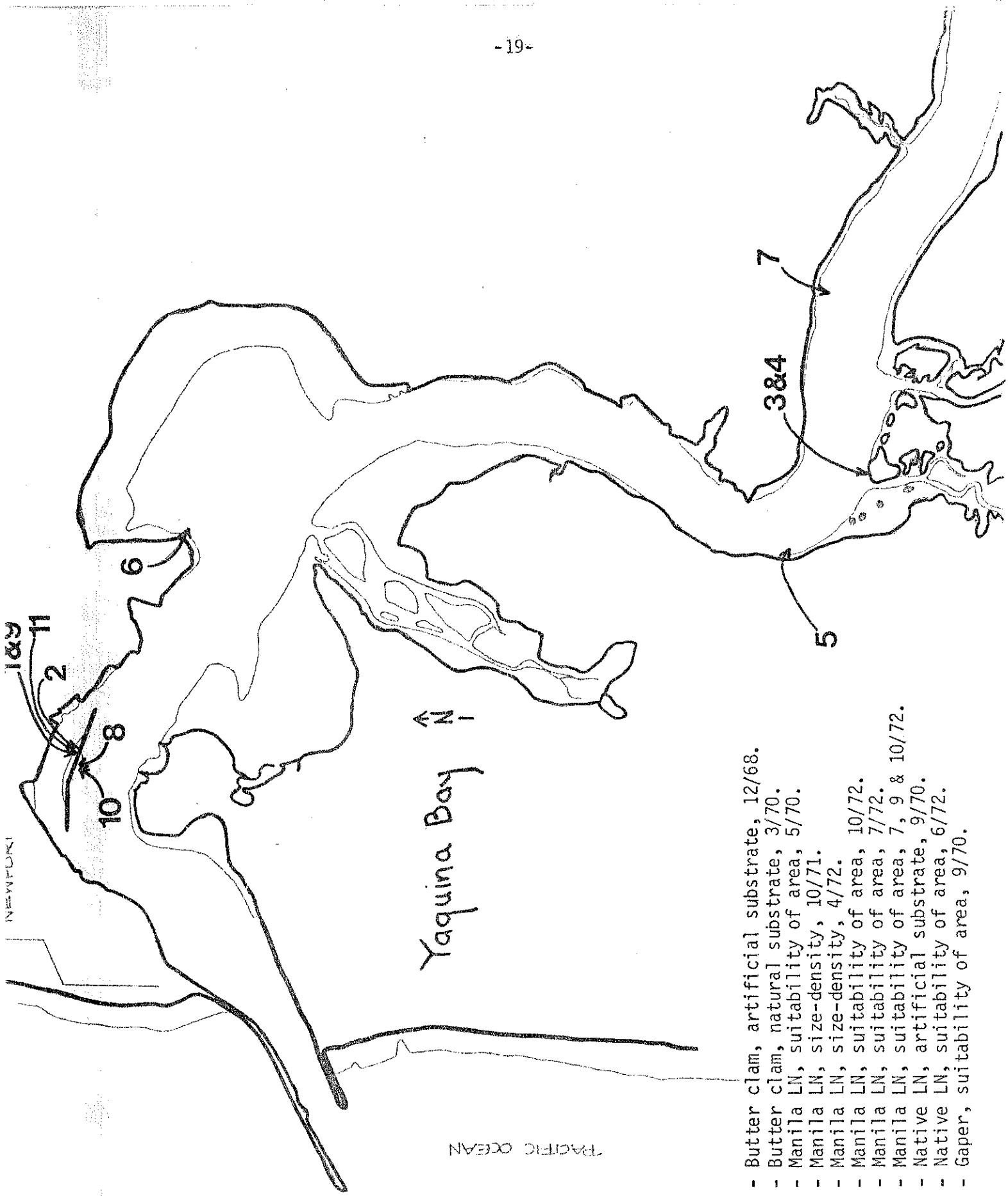

Figure A. Location of Experimental Clam Plants, Yaquina Bay, 1968-72.

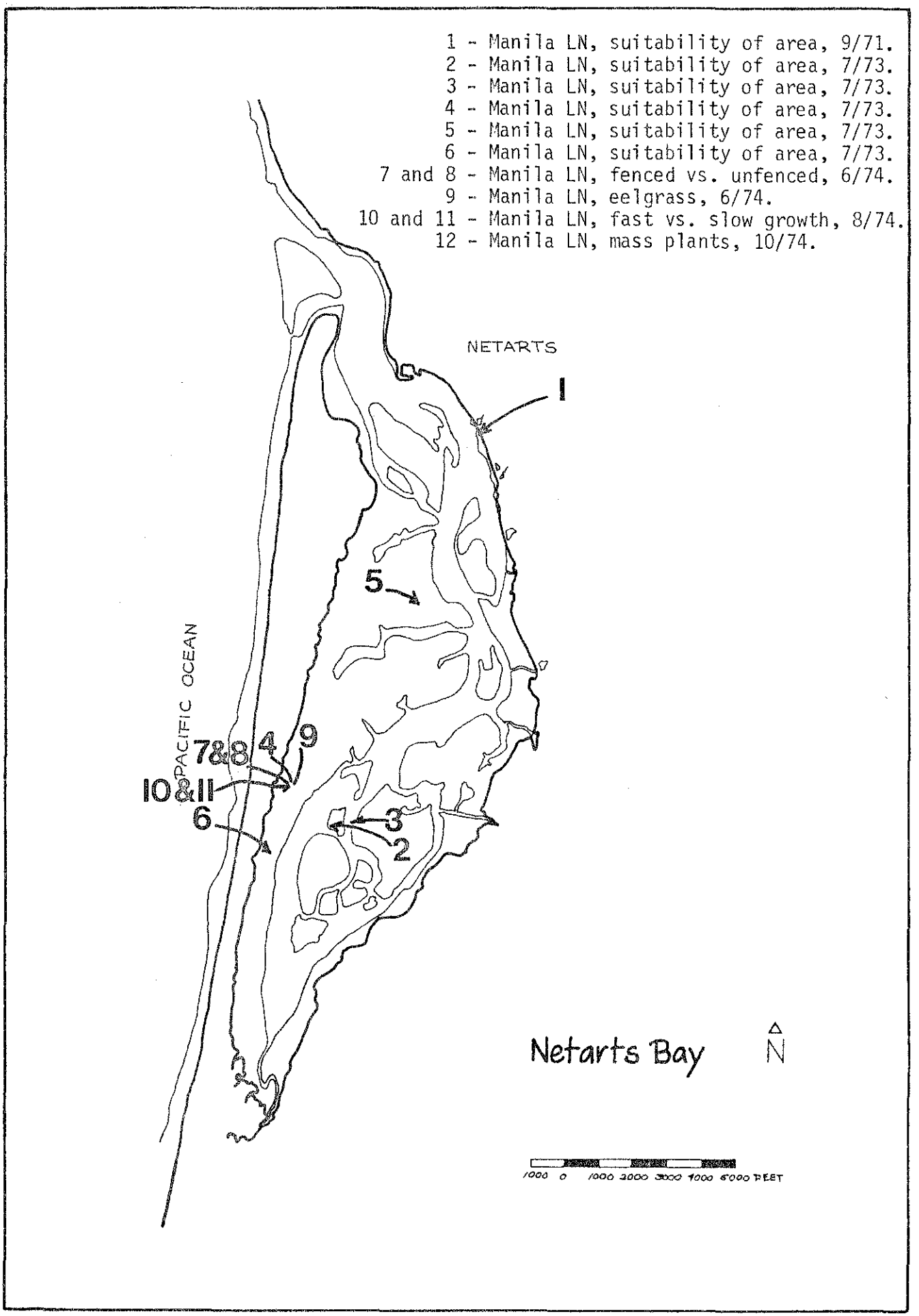

Figure B. Location of Experimental Clam Plants, Netarts Bay, 1971-74.

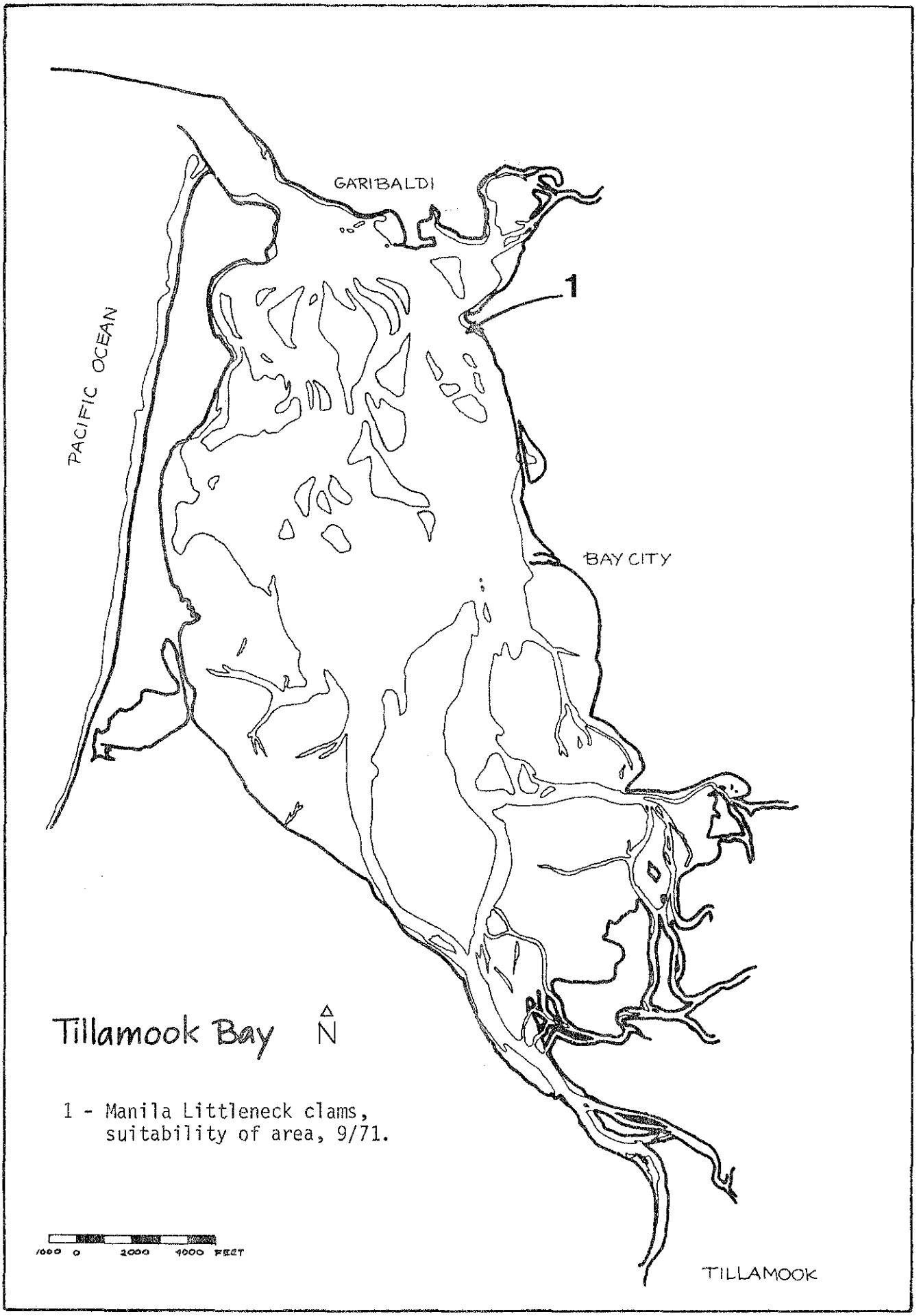

Figure C. Location of Experimental Clam Plant, Tillamook Bay, 1971.

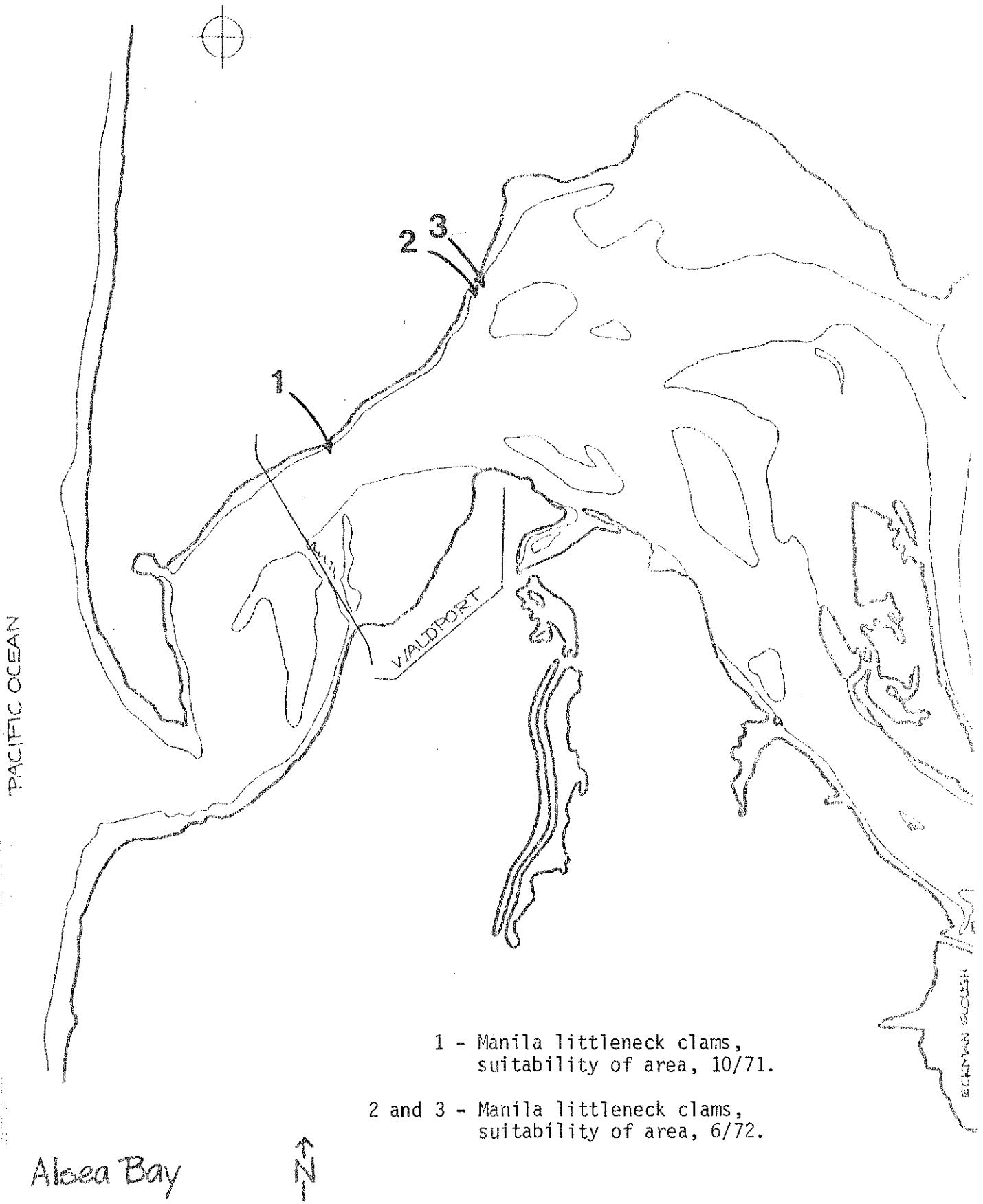

Figure D. Location of Experimental Clam Plants, Alsea Bay, 1971-72.

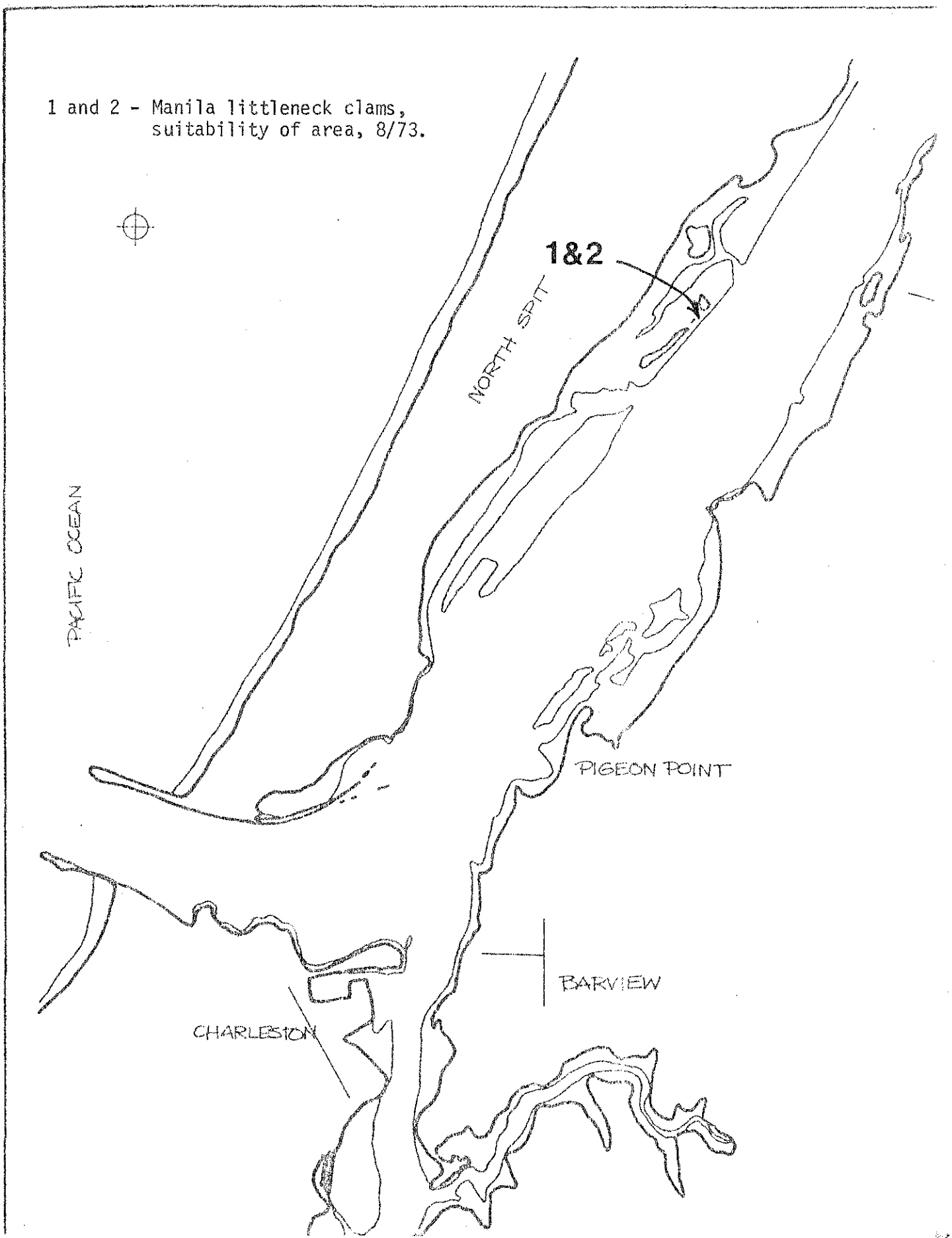

Figure E. Location of Experimental Clam Plants, Coos Bay, 1973.

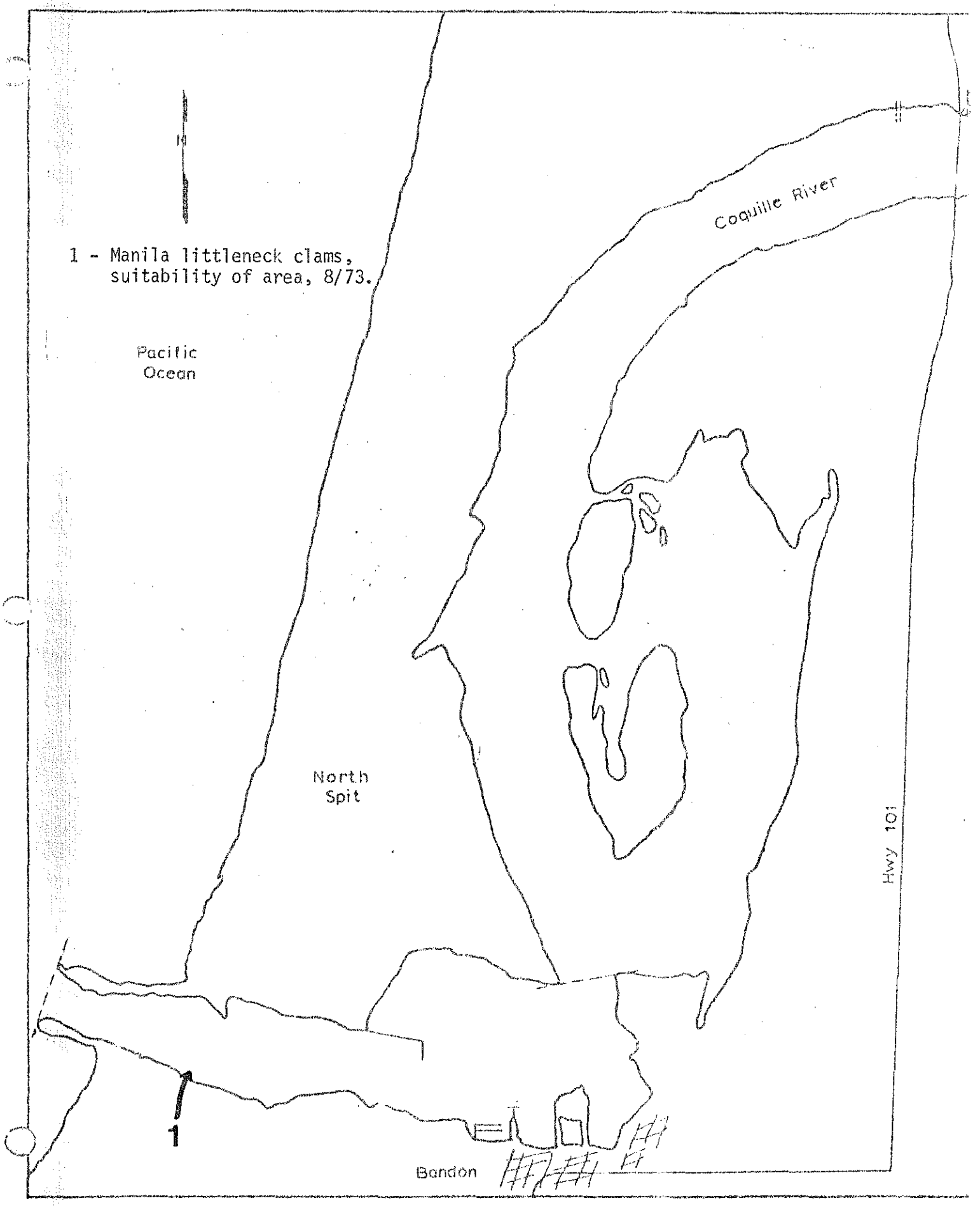

Figure F. Location of Experimental Clam Plant, Coquille Bay, 1973.