COMMERCIAL CLAM DEVELOPMENT

ANNUAL REPORT

October 1, 1979 to September 30, 1980

by

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National Marine Fisheries Service
National Oceanic and Atmospheric Administration
United States Department of Commerce
Commercial Fisheries Research and Development Act
Project Number 1-150-R Segment 1
Contract Number 80-ABD-ORAB

December, 1980

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ABSTRACT

Population and biomass estimates and age and size of clams were calculated for an area in Yaquina Bay having commercial harvest potential. The data revealed that the 1975 year class remained strong for gaper clams. Approximately 4.3 million pounds (1,934.5 mt) of gapers were estimated for the area and a harvest quota of 200,000 pounds (90.7 mt) was established.

Estimates of natural mortality was calculated for six year classes of gaper clams in Yaquina Bay and ranged from 0.12 to 0.89.

Due to difficulties clam harvesters had in getting U.S. Army Corp of Engineers and Division of State Lands permits for Yaquina Bay, no clams were harvested in 1980. This compares to a harvest of 74,565 pounds (33.8 mt) in 1979.

In Coos Bay 60,741 pounds (27.5 mt) of clams were harvested. Production figures showed that 273 pounds (0.1 mt) were taken/hour.

Post harvest surveys showed no significant difference, at the 95% confidence level, in numbers of clam set settling out in the treatment areas and control sites. The same was true for 17 other taxa of benthic invertebrates sampled. Analysis of variance also showed no significant difference in taxonomic diversity in the treatment and control plots.

INTRODUCTION

We continued our studies on the clam resources in Oregon's estuaries. Our objectives were: (1) to monitor the commercial harvest of subtidal clams in Yaquina and Coos bays and evaluate the effects of mechanical harvest on subtidal clam populations and habitat; (2) to calculate natural mortality of gaper clams in Yaquina Bay and; (3) to monitor growth of laboratory reared Manila littleneck clams released in Netarts Bay.

ASSESSMENT OF HARVEST POTENTIAL

Two areas were resurveyed in 1980 to determine the commercial harvest potential for gaper clams. Area 2 in Yaquina Bay (Figure 1) has been surveyed every year since 1975 and the Pigeon Point area of Coos Bay was previously surveyed in 1975 (Figure 2).

Methods

Yaquina Bay

Using techniques developed by the Washington Department of Fisheries (Goodwin, 1973) and the Oregon Department of Fish and Wildlife (Gaumer and Halstead, 1976) we collected data on the subtidal clam populations in Yaquina Bay. Twenty-four samples were taken from the 18.4 acre (7.4 ha) site. Data

collected provided estimates on numbers and biomass, size, weight, age and species composition, recruitment and natural mortality.

Following our assessment of clam stocks in Area 2, we selected a 0.9 acre (0.4 ha) portion of the area for the 1980 commercial clam fishery (Plot E, Figure 1). Data similar to that collected for Area 2 was obtained from Plot E.

Coos Bay

The same 48 acre (19.4 ha) site, that was approved in 1975 for the commercial harvest of clams in Coos Bay was resurveyed in 1980 using the same techniques developed for Yaquina Bay. Sixty two samples were collected.

Results and Discussion

Yaquina Bay

Population and Biomass Estimates, Area 2. From our samples we estimated that 21.6 million clams inhabited Area 2 (Table 1) which is nearly the same number estimated in 1979. Gaper clam, the target species in the commercial fishery, represented over 11 million of this total with a biomass estimated at 4.3 million pounds (1,934.5 mt).

Table 1. Population and Biomass Estimates of Subtidal Clams in Area 2, Yaquina Bay, 1975-80.

	Numbers					
Species	1975	1976	1977	1978	1979	1980
Gaper	36,300,000	25,566,400	29,316,000	10,560,000	11,116,700	11,050,000
Cockle	183,200	16,800	0	32,000	16,700	0
Littleneck	366,400	216,800	116,000	48,000	133,300	66,700
Butter	416,000	333,600	200,000	240,000	200,000	366,700
Irus	13,532,800	20,566,400	12,049,600	11,200,000	10,100,000	10,100,000
Piddock	1,700,000	0	0	0	0	0
Total	52,498,400	46,700,000	41,681,600	22,080,000	21,566,700	21,583,400
	Biomass (lbs)					
Species	1975	1976	1977	1978	1979	1980
Gaper	5,084,200	5,217,200	4,968,991	4,136,800	3,461,100	4,265,600

Figure 3 shows the year class composition of gaper clams in Area 2. The 1975 year class continues to represent a majority of the clams (85.2%) in the population. Mean age of the clams was 5.3 years, an increase of 0.9 years since 1979, illustrating the lack of recruitment. Our gaper set sampling has shown no significant survival

of set since 1976. Samples in 1980 were taken too early to expect that year class to show in the samples. Age composition data for butter, cockle and littleneck clams is not presented due to the few clams collected.

The length distribution of gaper clams from Area 2 is shown in Figure 4. Mean size was 88.7 mm an increase of 5.5 mm since 1979.

Application of an iterative numerical fitting routine involving least squares techniques (Steele and Torrey, 1960) to gaper clam population estimates provided regression lines with variable rates of natural mortality (Figure 5). Table 2 shows computer generated cohort abundance over time with corresponding values of m. Estimates of natural mortality for individual cohorts range from 0.12 to 0.89. This range in estimates reflects possible differences in environmental influences and survival of individual year classes of gaper clams. Another source of variation could be difficulties in assigning accurate ages especially to older year classes. Neal Bourne (Pers. Comm.) has suggested that clams in excess of five years of age frequently exhibit false checks making accurate age determination for most species of bay clams extremely difficult.

Table 2. Computer Generated Abundance of Various Cohorts of Gaper Clams, Area 2, Yaquina Bay.

Year Class	Sept 1975	Oct 1976	May 1977	Feb 1978	Mar 1979	Mar 1980	M
1967	3,958,000	1,512,000	893,790	458,150	175,020		0.89
1968	11,932,000	2,957,500	1,380,400	530,800	129,880		0.12
1969	16,277,000	6,171,500	3,666,100	185,280	702,490		0.89
1970	10,894,000	4,666,900	2,936,900	1,630,100	698,300	318,520	0.78
1972	21,371,000	12,036,000	8,795,300	5,903,200	3,324,500	1,953,600	0.53
1975	34,767,000	27,806,000	24,611,000	21,074,000	16,850,500	13,705,000	0.20

Population and Biomass Estimates, Area 2, Plot E. We estimated that 3.8 million clams inhabited the 0.9 acre (0.4 ha) Plot E of Area 2 (Table 3). Of this total, 576,700 were gaper clams weighing an estimated 226,900 pounds (102.9 mt). Figure 6 shows the year class composition of gaper clams in Plot E. Sampling in Plot E revealed the first evidence of 1980 year class gaper set. Plot E was inventoried in April two months after Area 2. The strong showing of the 1970, 71 and 72 year classes in Plot E also suggests an irregular survival of gaper clam set. This test plot was one of the few sampled where the 1975 year class was not dominant. Mean age of the gapers was 3.1 years.

Length frequency of gaper clams in Plot E is shown in Figure 7. Mean size of the clams in the preharvest sample was 51.6 mm which is 37.1 mm smaller than for clams found in the overall Area 2 sample. This again reflects the impact of the strong showing of the incoming 1980 year class.

Table 3. Population and Biomass Estimates of Subtidal Clams in Area 2, Plot E, Yaquina Bay, Oregon, 1980.

Species	Number	Biomass (lbs)
Gaper	576,700	226,900
Cockle	30,000	Not calculated
Littleneck	30,000	Not calculated
Butter	103,300	Not calculated
Irus	3,096,700	49,900
Bentnose	3,300	Not calculated
Total	3,840,000	276,800

Coos Bay

Population and Biomass Estimates. We estimated that 3.7 million clams inhabited the 48 acre (19.4 ha) experimental clam harvesting area in Coos Bay (Table 4). Of this total, 606,400 were gaper clams weighing 464,400 pounds (210.6 mt). The 3.7 million total clams in this area represents a reduction of 22.7 million clams since our 1975 survey of the same area. Each species experienced a similar reduction in numbers with several species not even appearing in the 1980 sample (Table 4). Although there has been a commercial fishery in the same area since 1975, less than 200,000 clams have been reported taken. It should also be emphasized that the fishery has occurred in a small portion of the entire unit and our sampling showed a uniform lack of clams over the entire area. One possible explanation for the reduction in numbers of clams is the recent deepening and widening of the main ship channel which is adjacent to the commercial plot. Visual observations at each sample station revealed what appeared to be more fluid sand over much of the area. Although these observations were subjective, previous observations in the area showed less sand and more gravel and rock.

Table 4. Population and Biomass Estimates of Subtidal Clams in Pigeon Point Area, Coos Bay, 1975 and 1980.

	1975		1980	
Species	Number	Biomass	Number	Biomass
Gaper	5,648,700	1,530,800	606,400	464,400
Cockle	202,200	23,000	16,900	Not Calculated
Littleneck	843,000	71,600	151,800	" "
Butter	809,200	248,200	236,100	" "
Irus	16,018,600	Not Calculated	2,428,100	" "
Piddock	0	" "	252,900	" "
Petricola	101,000	" "	0	" "
Bentnose	2,647,300	" "	0	" "
Cryptomya	67,300	" "	0	" "
Bodega	101,000	" "	0	" "
Total	26,438,300	1,873,600	3,692,200	464,400

The year class composition of gaper clams sampled in Coos Bay is shown in Figure 8. As in Plot E of Yaquina Bay, the 1980 incoming year class was dominant. The 1969-74 year classes were also well represented. Of particular interest was the total lack of the 1975 year class, which, since 1975, has been the dominant year class in all gaper populations sampled in Yaquina, Tillamook and Netarts bays. The near absence of 1976-79 year classes of gapers in Coos Bay was similar to that found in Yaquina Bay. Gaper clam age averaged 5.7 years.

Figure 9 shows the length-class composition of gaper clams in Coos Bay. Mean size of the gapers was 102.8 mm.

COMMERCIAL HARVEST OF CLAMS

In 1980 we issued six permits to commercial clam fishermen to mechanically harvest subtidal clams/in experimental test plots. Permits were required since the use of mechanical means to harvest clams is unlawful. The permits specified the pounds of clams that could be harvested, season, harvest area and harvest equipment. In addition, monthly reports giving pounds and numbers of clams harvested and hours of effort were required of each operator. The season started July 1, 1980, and ended December 31, 1980.

Methods

Yaquina Bay

Two commercial clam harvesting permits were issued for the 1980 season. Plot E of Area 2 in Yaquina Bay was designated the harvest area (Figure 1). A quota of 200,000 pounds (90.7 mt) was set for the area.

Due to difficulties the two clam harvestors had in obtaining appropriate permits from the U.S. Army Corp of Engineers and the Oregon Division of State Lands, no commercial harvest of clams occurred in 1980. Although the fill and removal laws have been "on the books" during previous harvest years, the USACE and DSL only began enforcing these laws as they apply to subtidal clam harvesting in 1980.

Coos Bay

Four commercial clam harvesting permits were issued for Coos Bay. Three of the permits allowed the use of a hand held water jet and the fourth permit allowed the use of a subsurface suction pump. As with Yaquina Bay, difficulties in obtaining fill and removal permits delayed the harvest of clams until October.

We sampled the commercially harvested clams for size, age and species composition.

Results and Discussion

Yaquina Bay

As mentioned earlier, no clams were commercially harvested in the experimental fishery in Yaquina Bay. This was the first year since 1975 that clams were not harvested (Table 5). Of the clams harvested in the fishery since 1975, 305,862 pounds (138.7 mt) or 99.5% were gaper clams.

Table 5. Pounds of Clams Mechanically Harvested in Experimental Fishery, Yaquina Bay, Oregon, 1975-80.

Species	Year						Total
	1975	1976	1977	1978	1979	1980	
Gaper	1,478	0	68,074	162,351	73,959	0	305,862
Cockle	24	0	10	0	0	0	34
Littleneck	0	0	49	1	0	0	50
Butter	0	0	590	22	606	0	1,218
Irus	0	0	334	44	0	0	378
Total	1,502	0	69,057	162,418	74,565	0	307,542

Coos Bay

The commercial harvest in Coos Bay produced 60,741 pounds (27.5 mt) of which 60,616 pounds (27.5 mt) or 99.8% were gaper clams (Table 6). The remainder were butter clams. The fishery extended from September through November (Table 7). Each trip averaged 4.3 hours of dive time. Harvest figures revealed that 273 pounds/hour (124 kg/hr) or 1,168 pounds/trip (531 kg/trip) were taken.

Table 6. Summary of Pounds of Clams Mechanically Harvested in Experimental Fishery, Coos Bay, Oregon, 1975-80.

Species	Year						Total
	1975	1976	1977	1978	1979	1980	
Gaper	14,467	102,442	11,931	36,744	13,351	60,616	239,551
Butter	735	1,142	0	0	39	125	2,041
Littleneck	0	0	0	0	511	0	511
Total	15,202	103,584	11,931	36,744	13,901	60,741	242,103

Gaper clams averaged 8.9 years of age with the 1972 year class being prevalent in the harvest (Figure 10). The clams averaged 133.7 mm (Figure 11). In 1979 the clams harvested from the same area averaged 126.4 mm in shell length.

Table 7. Pounds of Subtidal Clams Harvested in Coos Bay Commercial Fishery, 1980.

Month	Species		Total	Dive Time (hrs)
	Gaper	Butter		
September	9,926	0	9,926	37.0
October	28,577	0	28,577	103.0
November	22,113	125	22,238	82.5
Total	60,616	125	60,741	222.5

ASSESSMENT OF EFFECTS OF COMMERCIAL CLAM HARVEST ON RECRUITMENT

Methods

In 1980 we continued to evaluate the effects of commercial harvest on recruitment of clams in Yaquina Bay. Sampling procedures were somewhat modified from previous sampling (Gaumer et. al, 1979). We reduced the size of individual samples to 1 ft^2 (0.09 m^2) but increased sampling intensity to 12 samples each per treatment and control plots.

Benthic samples were returned to the laboratory and all invertebrates were sorted into taxonomic groups. Invertebrates easily identified were separated to species. All others were grouped by family, order or phyla. A two way analysis of variance was applied to test for possible variation due to temporal separation of sampling periods. Since our data showed no variation due to sampling in different time periods, a one way analysis of variance was utilized as the most powerful test for evaluating differences in number of taxonomic groups between treatment and control.

Results and Discussion

The macrobenthic data collected from treatment and control plots of Area 2, Plot C of Yaquina Bay is shown in Table 8. Analysis of variance failed to show significant differences at the 95% confidence level in any of the five species of clams or in any of 17 other taxa of benthic invertebrates sampled. Accordingly, there is no evidence that the commercial harvest of subtidal gaper clams has any immediate detrimental effect on benthic fauna. Yet to be understood is the near total mortality of newly recruited gaper clams in both the treatment and control areas of Yaquina Bay (Figure 12).

Analysis of variance also showed that in the treatment and control plots, taxonomic diversity did not differ significantly either in numbers of taxa represented nor in numbers of individuals (Figures 13 and 14). The opportunistic *Macoma inquinata* (Macoma clam) increased following harvest in 1978 (Figure 15) and by May 1979 had reached 102.5/0.09 m^2 in the control. Similar recruitment of *Macoma inquinata* was reported by Swartz, et. al, 1980. By November of 1979 the numbers of *Macoma inquinata* had decreased to levels similar to that of the

Table 8. Summary of Number of Marine Organisms Occurring in Commercially Harvested Plot C of Area, Yaquina Bay, Oregon.

	10-25-78[1]/ Plot C	10-25-78[1]/ Control	3-13-79 Plot C	3-13-79 Control	5-24-79 Plot C	5-24-79 Control	8-03-79 Plot C	8-03-79 Control	11-06-79 Plot C	11-06-79 Control	5-01-80 Plot C	5-01-80 Control	9-17-80 Plot C	9-17-80 Control	F Oneway Anova	Degrees of Freedom
MOLLUSCA																
Macoma inquinata	48.0	0.5	56.6	4.3	102.5	3.3	8.0	-	3.8	4.6	60.3	5.4	10.9	9.3	8.24	(1,10)
Venerupis staminea	0	0.1	0.8	1.2	0.5	0.8	1.0	-	0.3	1.3	0.4	4.1	0.2	1.7	4.22	(1,10)
Saxidomus giganteus	0	0	1.9	2.8	0.9	1.0	2.4	-	4.4	2.5	0.9	1.8	1.0	3.1	0.80	(1,10)
Tresus capax	0	0	0	0	6.0	12.3	7.5	-	0.5	0	1.3	42.0	0.3	5.1	1.59	(1,10)
Clinocardium nuttallii	0	0.1	0	0.4	0.5	0.3	0.7	-	0.8	0	0.3	1.8	0	0.3	0.47	(1,10)
Nudibranchia	-	-	0.1	0.3	0.1	0	0.3	-	0.1	0.1	0	0.1	0	0	0.44	(1,8)
ANNELIDA																
Ophellidae	-	-	0	0	0	0	0		0.3	0	4.2	0	0.8	1.7	0.72	(1,8)
Lumbrineridae	-	-	0	0	0.3	0	2.2	-	0	0	5.0	0	11.8	1.3	1.87	(1,8)
Capitellidae	-	-	0	0	>10.0	>10.0	3.2	-	0	0	0	1.4	1.3	1.0	0.86	(1,6)
Orbinidae	-	-	0	0	0	4.5	4.9	-	4.9	0	15.6	3.0	1.8	5.4	0.36	(1,8)
Polynoidae	-	-	0	0	>10.0	0	2.7	-	0.1	5.1	0	0.4	0	0	0.17	(1,8)
Phyllodocidae	-	-	0	0	>10.0	>10.0	2.0	-	1.7	0.2	1.4	0.4	1.0	1.2	4.69	(1,4)
Ceratulidae	-	-	0	0	0.5	0	1.2	-	1.2	0	3.0	0	2.0	0	9.71	(1,6)
Glyceridae	-	-	0	0	0	0	0	-	0.7	0	0.3	0.1	2.0	0.2	3.12	(1,4)
ARTHROPODA																
Pagurus sp.	-	-	0.1	0	1.9	2.0	1.0	-	0.2	0.3	0.1	0.4	0.3	0.8	0.03	(1,8)
Hemigrapsus oregonensis	-	-	0	0.1	0.3	0	0.5	-	0.5	0.2	0.2	4.2	0.2	0.7	0.99	(1,8)
Cancer magister	-	-	0	0	0	0	2.9	-	2.9	2.5	1.0	0.1	0.3	0	0.18	(1,8)
Cancer productus	-	-	1.5	2.2	1.8	0.5	0.5	-	0	0	0.2	1.9	0.5	1.8	0.73	(1,8)
Grammeridean amphipods	-	-	0	0	0	>10.0	1.3	-	1.3	1.9	0.9	5.4	1.0	3.5	6.18	(1,4)
Caridean shrimp	-	-	0	2.4	0.5	0	0	-	0.1	0	0.1	0.7	0.4	0.5	1.03	(1,8)
ECHINODERMATA																
Ophiuroidea	-	-	0.8	0.7	1.6	3.0	-	-	2.3	2.8	2.1	5.1	8.6	13.2	0.53	(1,8)
Pycnopodia helianthoides	-	-	0	0.8	0	0.5	0.3	-	0	0.2	0.3	0.4	0.2	0.3	8.88	(1,8)
Anthozoa	-	-	0.5	0	0.3	0	1.8	-	1.8	0	0.4	0.3	0.4	0.1	4.50	(1,8)
Total taxonomic groups	1	3	8	10	17	13	19	-	19	12	20	20	20	19	0.11	(1,10)
Total numbers/.09 m^2	48.1	0.90	62.3	15.2	147.7	48.2	44.4	-	27.9	21.7	98.0	79.0	45.0	50.3	2.75	(1,10)

[1]/ Only clam species were collected and identified in the October 25, 1978 sample.

control. A similar pattern in recruitment for this species was observed for the incoming 1980 year-class followed by another decline to control levels by the fall of 1980.

Figure 14 shows the total number of benthic invertebrates in the treatment and control plots. Recruitment and mortality throughout the sampling period was similar for both treatment and control. The fluctuations in total numbers of benthic invertebrates reflects the recruitment and mortality of the *Macoma* clam.

LABORATORY CLAM STUDIES

Our laboratory clam studies were terminated in 1975. Since then we have annually monitored the growth of clams planted in Netarts Bay.

Methods

Two studies were continued in Netarts Bay. One compared the growth characteristics of Manila littleneck clams that were selected for their fast growing ability vs. normal growing clams (Gaumer and Lukas, 1975); the other compared growth of clams in a screened enclosure vs. unscreened areas.

Results and Discussion

Manila littleneck clams spawned in August 1974 from fast growing parent stock grew 2.3 mm since June 1979 and averaged 39.2 mm in length, whereas progeny from the "normal" clams grew 3.2 mm and averaged 37.3 mm (Figure 16). We have been unable to determine survival of the Manila clams due to their movement outside of the study plot.

Evidence of natural spawning was found with the recovery of one 1977 year-class clam that averaged 23.8 mm.

Manila clams planted in the screened test plot averaged 38.6 mm, an increase of 2.6 mm since 1979, whereas clams planted in an adjacent unscreened test plot averaged 40.0 mm, an increase of 2.5 mm since 1979. Manilas planted adjacent to an eelgrass bed and at a slightly lower elevation were 44.9 mm, an increase of 2.0 mm since 1979 (Figure 17). Clams in all three test plots averaged 13.1 mm when released.

ACKNOWLEDGMENTS

We wish to thank Laimons Osis, Jean McCrae, and Bruce Williams of the Oregon Department of Fish and Wildlife, Dave Bernard of Oregon State University and Marian Asche for their assistance in the study.

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Appendix 1

(Figures 1-17)

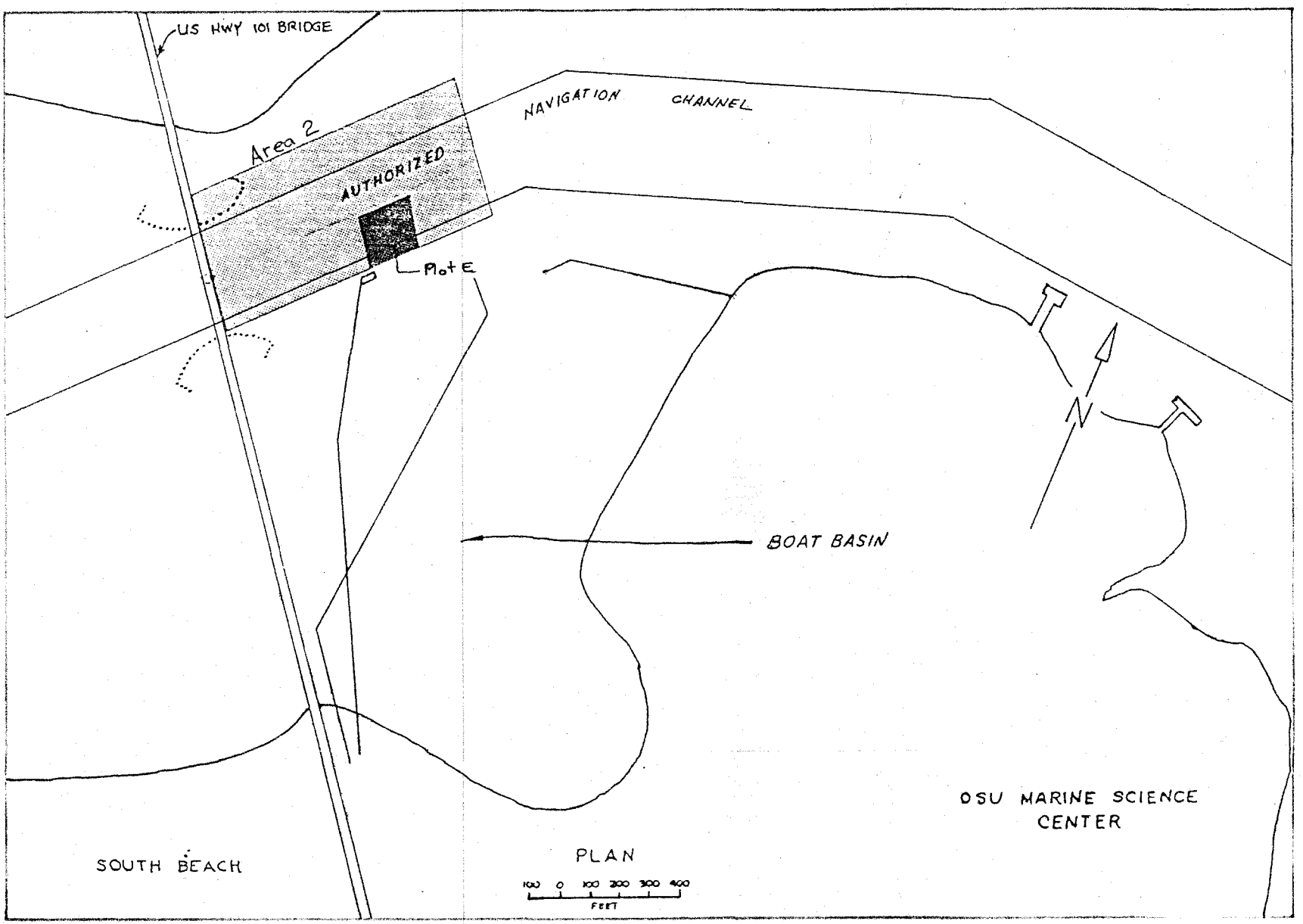

Figure 1. Map of Yaquina Bay, Showing Area Approved for Commercial Clam Harvest.

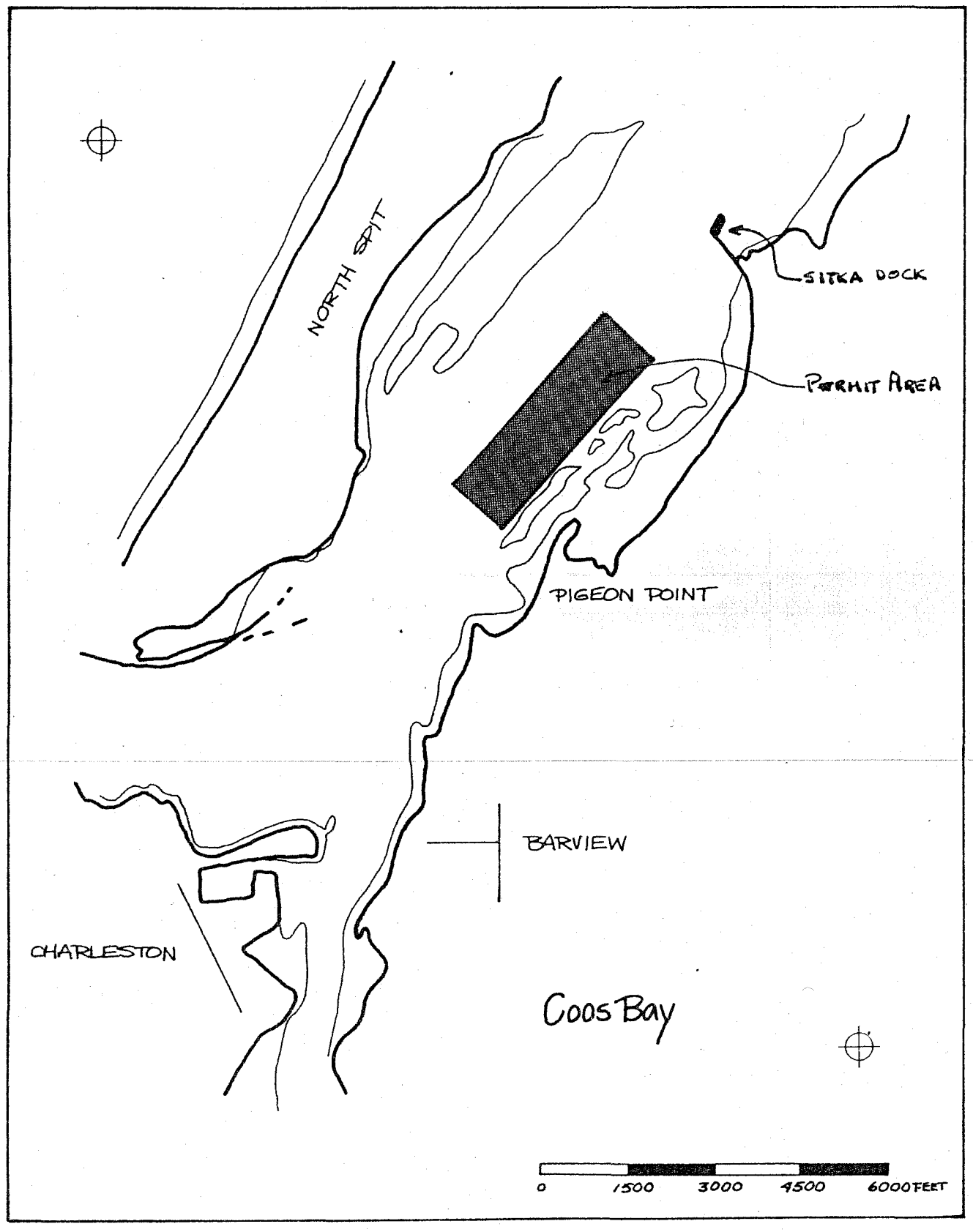

Figure 2. Map of Lower Coos Bay, Showing Area Approved for Commercial Clam Harvest.

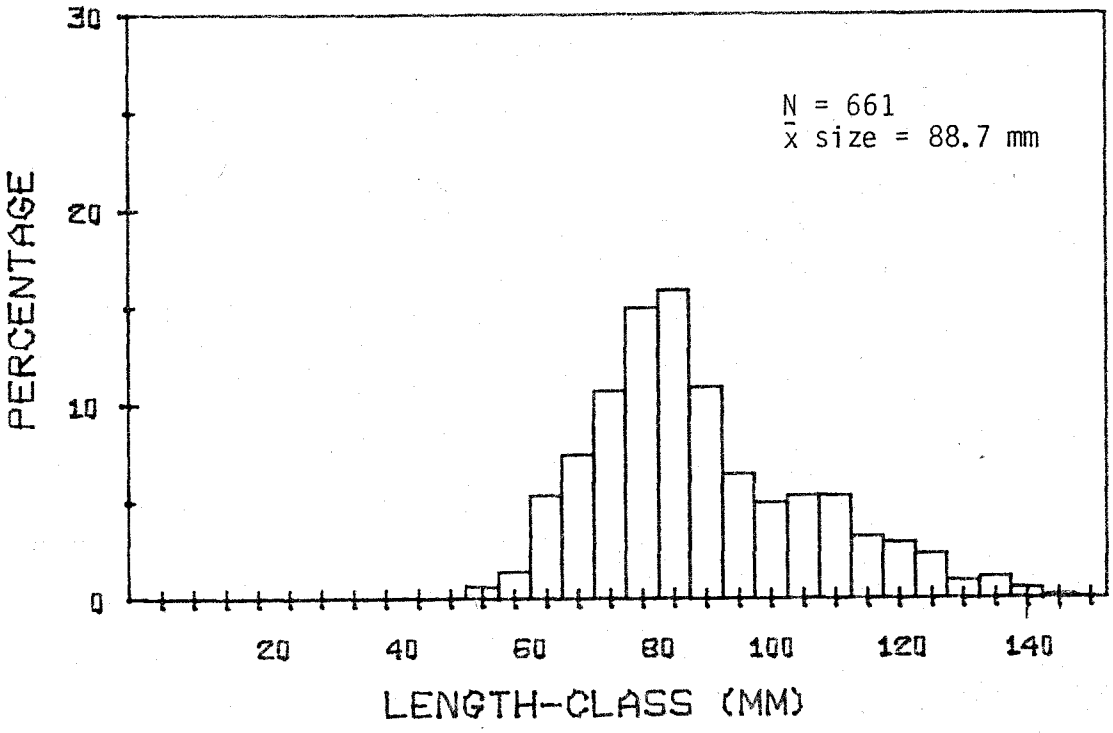

Figure 4. Length-Class Composition of Subtidal Gaper Clams Collected from Area 2, Yaquina Bay, Oregon, 1980.

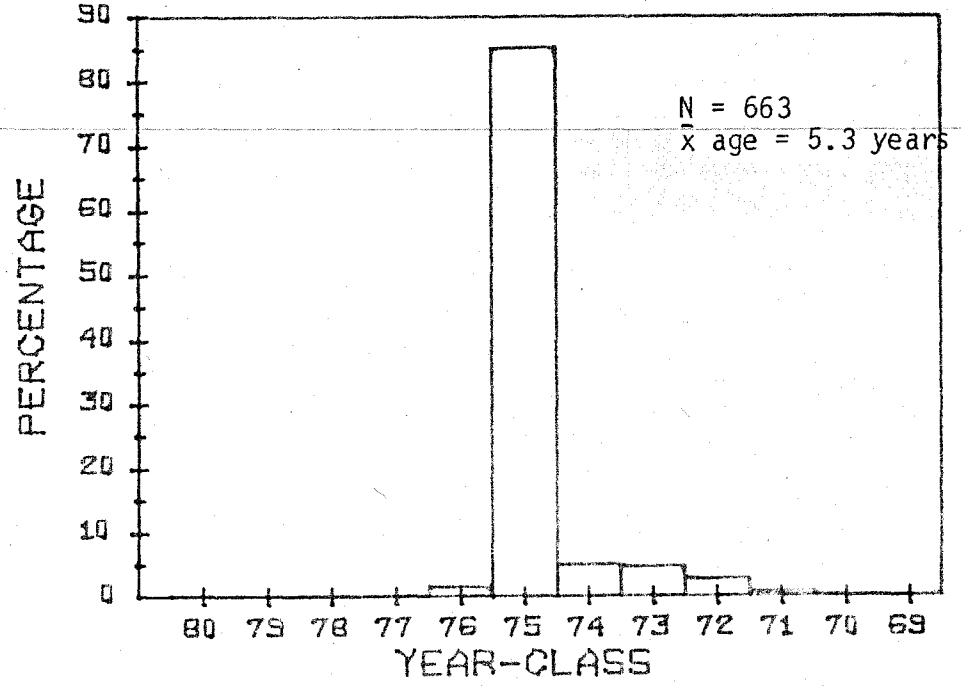

Figure 3. Year-Class Composition of Subtidal Gaper Clams Collected from Area 2, Yaquina Bay, Oregon, 1980.

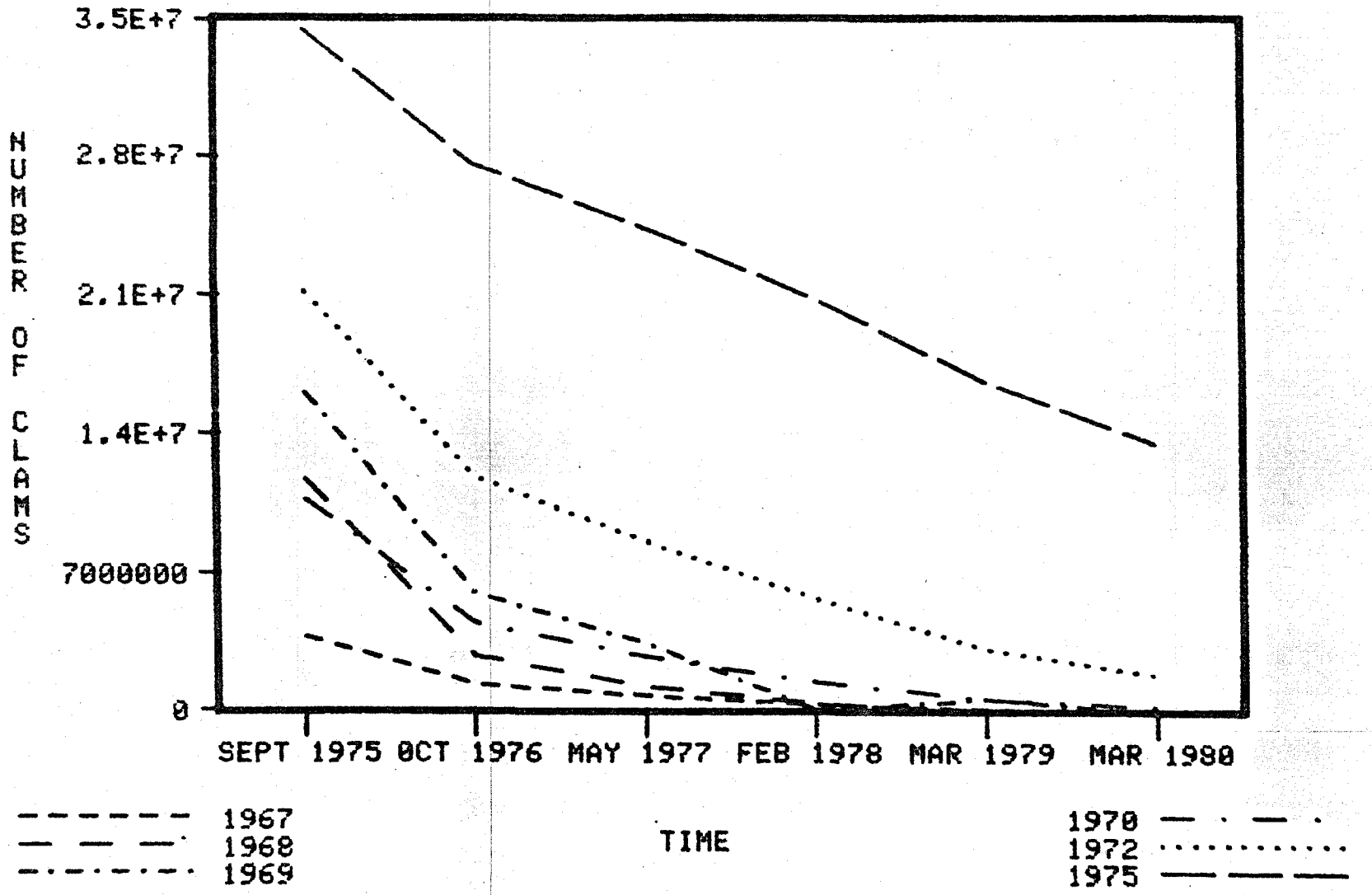

Figure 5. Calculated Estimates of Natural Mortality for Gaper Clams by Year-Class, Area 2, Yaquina Bay, Oregon.

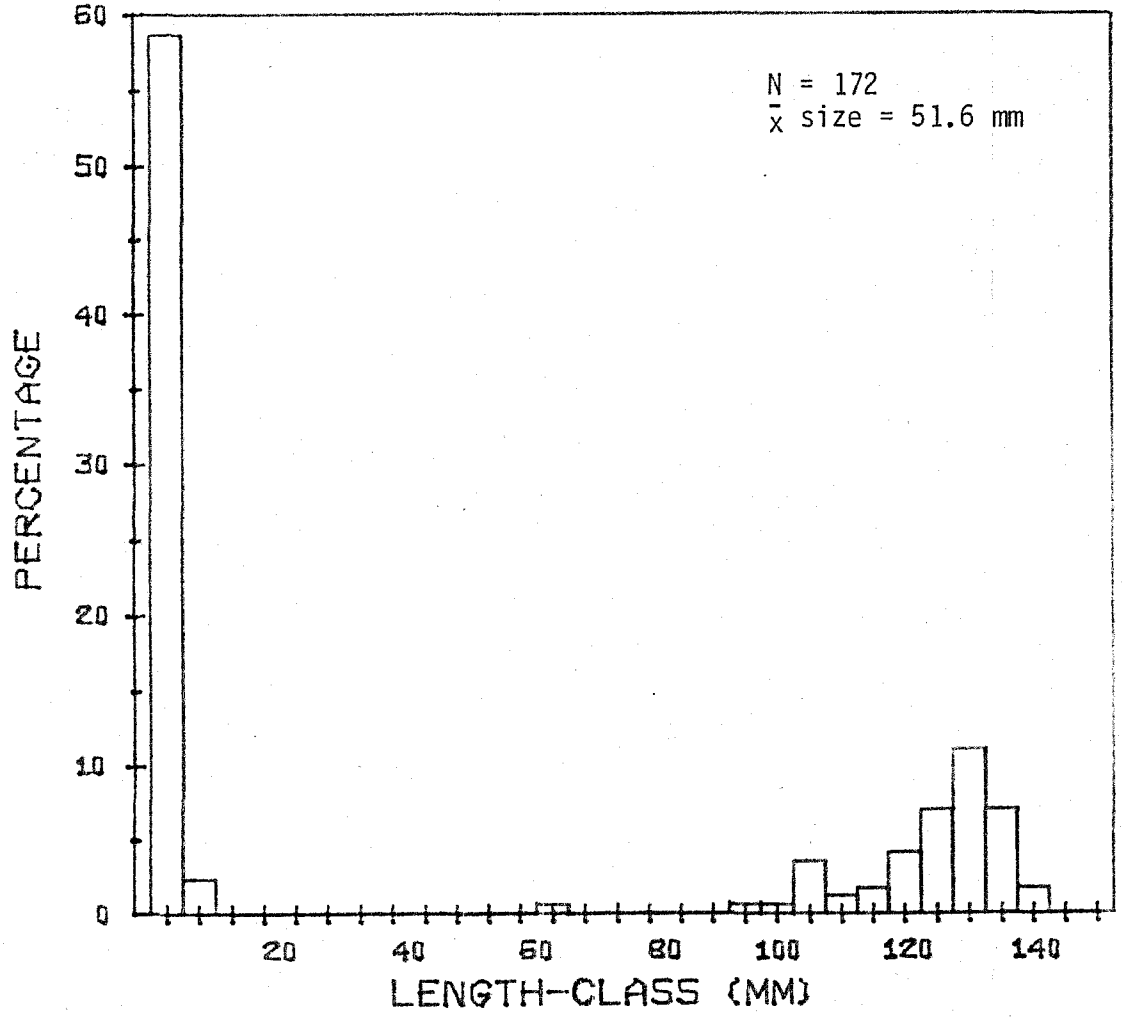

Figure 7. Length-Class Composition of Subtidal Gaper Clams from Plot E of Area 2, Yaquina Bay, Oregon, 1980.

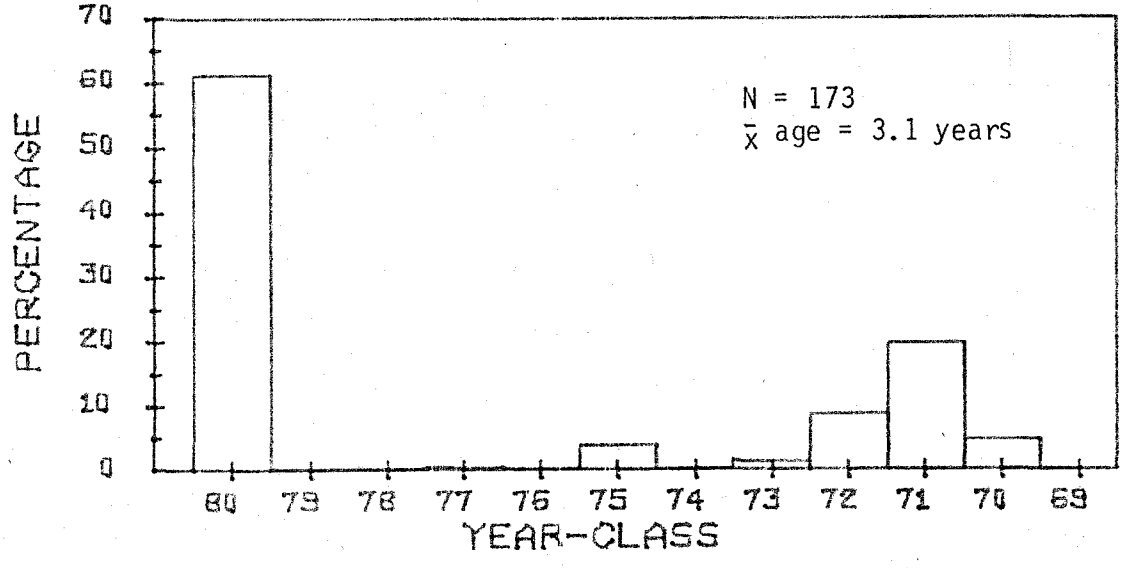

Figure 6. Year-Class Composition of Subtidal Gaper Clams Collected from Plot E of Area 2, Yaquina Bay, Oregon, 1980.

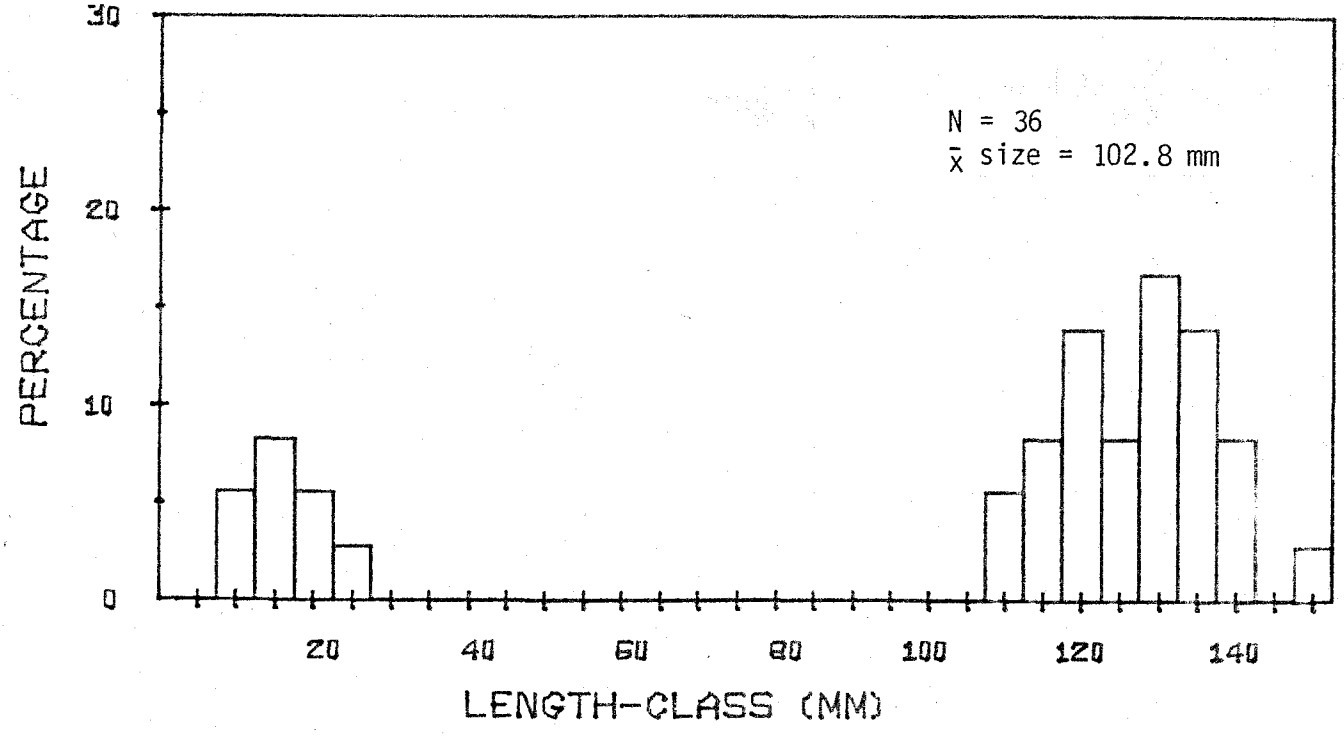

Figure 9. Length-Class Composition of Subtidal Gaper Clams Collected from Pigeon Point Area of Coos Bay, Oregon, 1980.

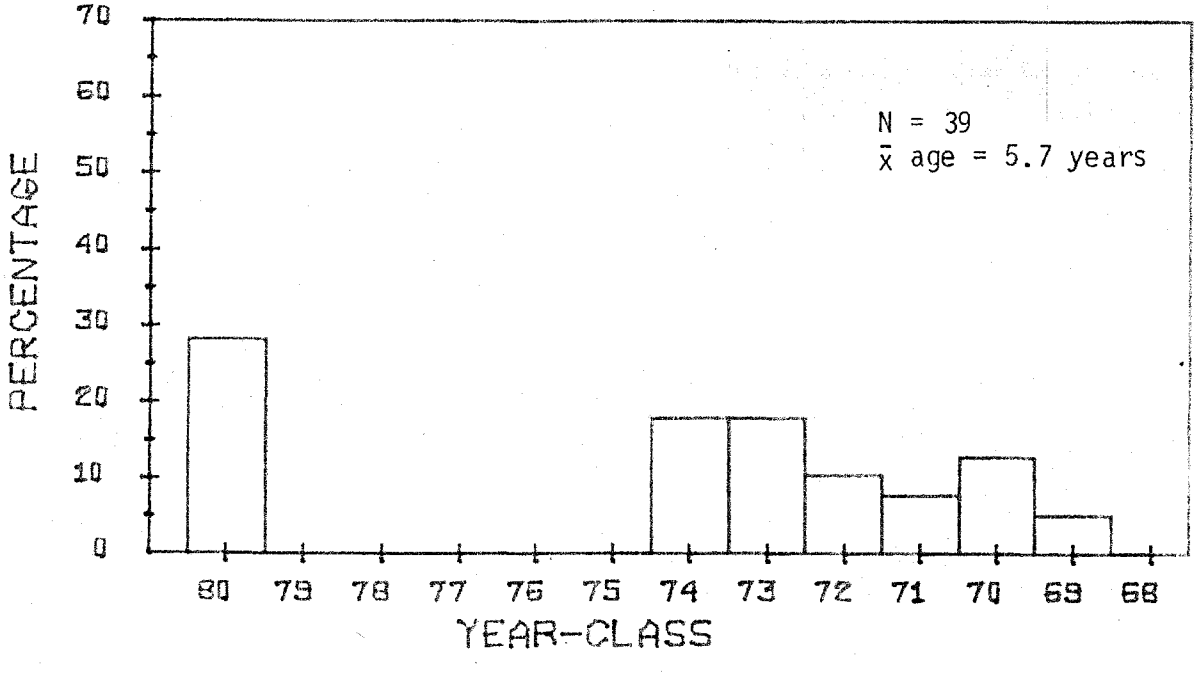

Figure 8. Year-Class Composition of Subtidal Gaper Clams Collected from Pigeon Point Area of Coos Bay, Oregon, 1980.

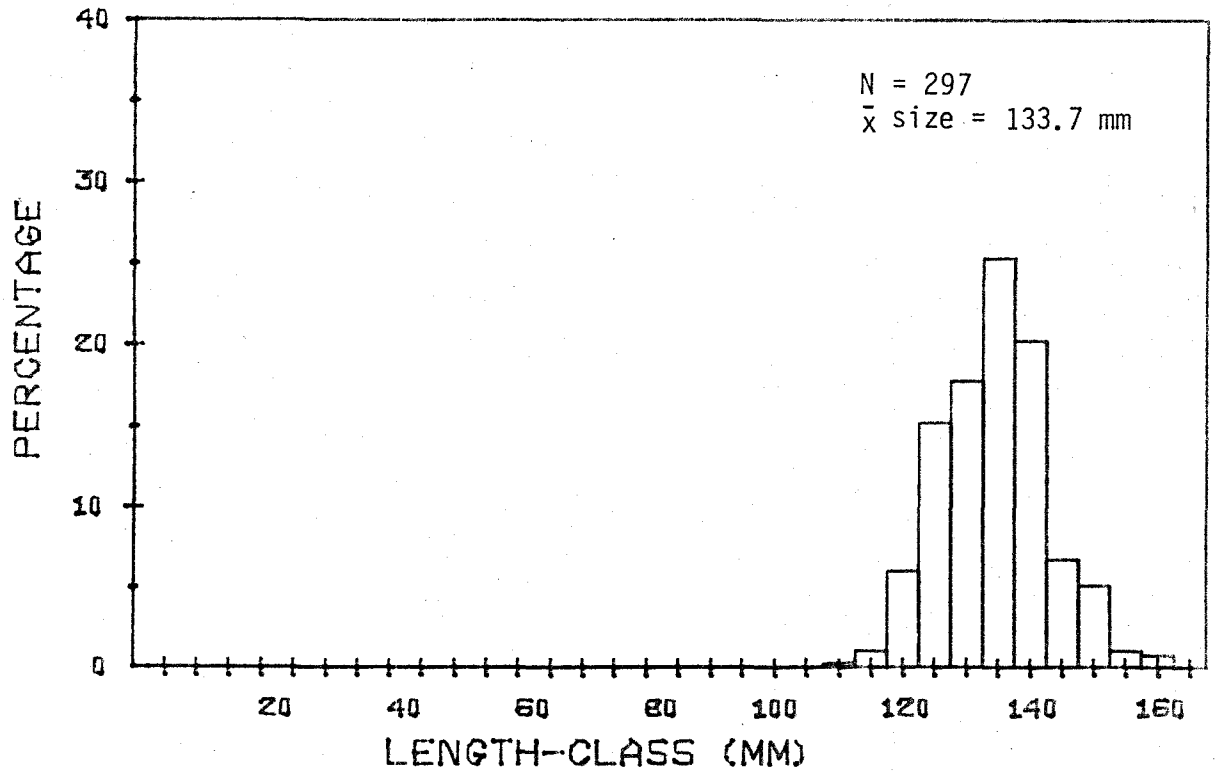

Figure 11. Length-Class Composition of Subtidal Gaper Clams Commercially Harvested from Pigeon Point Area of Coos Bay, Oregon, 1980.

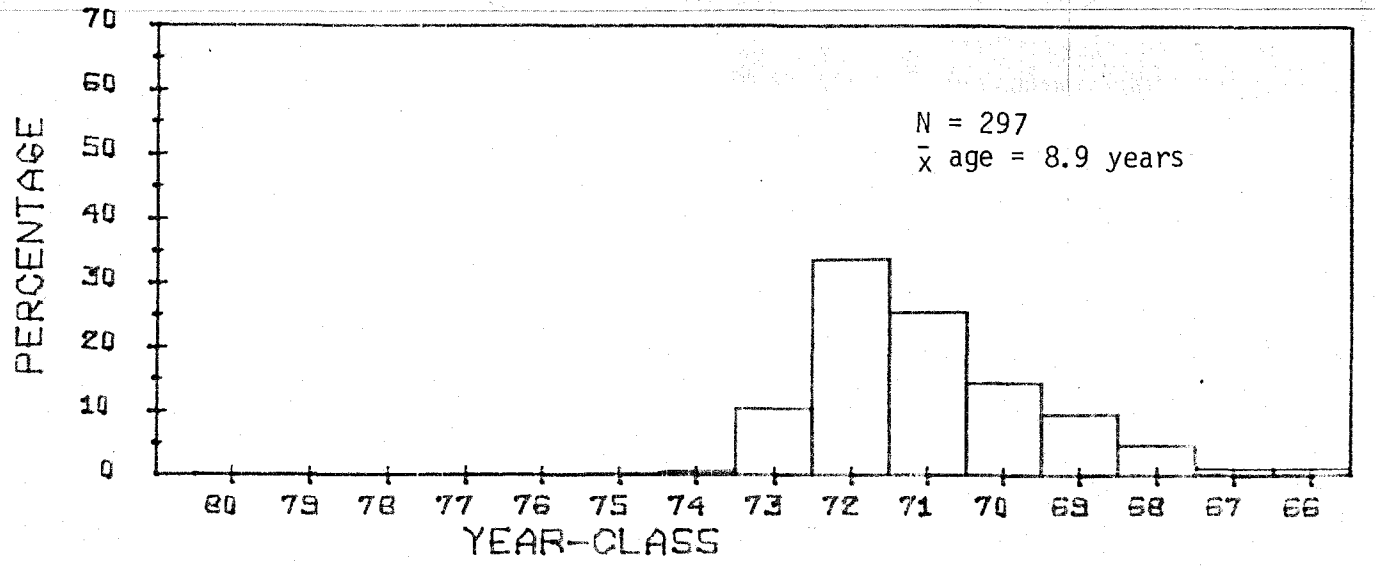

Figure 10. Year-Class Composition of Subtidal Gaper Clams Commercially Harvested from Pigeon Point Area of Coos Bay, Oregon, 1980.

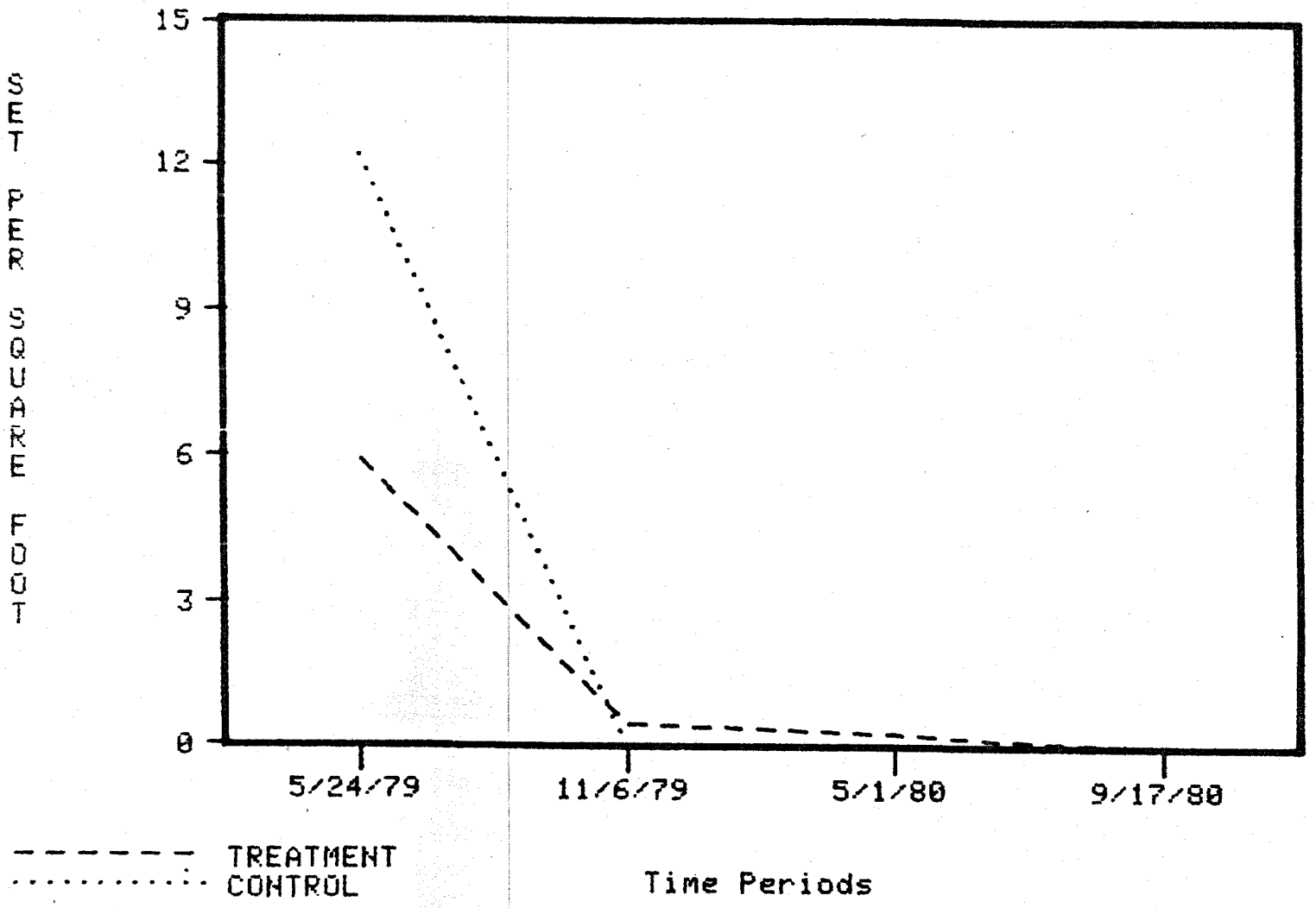

Figure 12. Survival of Gaper Clam Set, 1979 Year Class, Area 2, Plot C, Yaquina Bay.

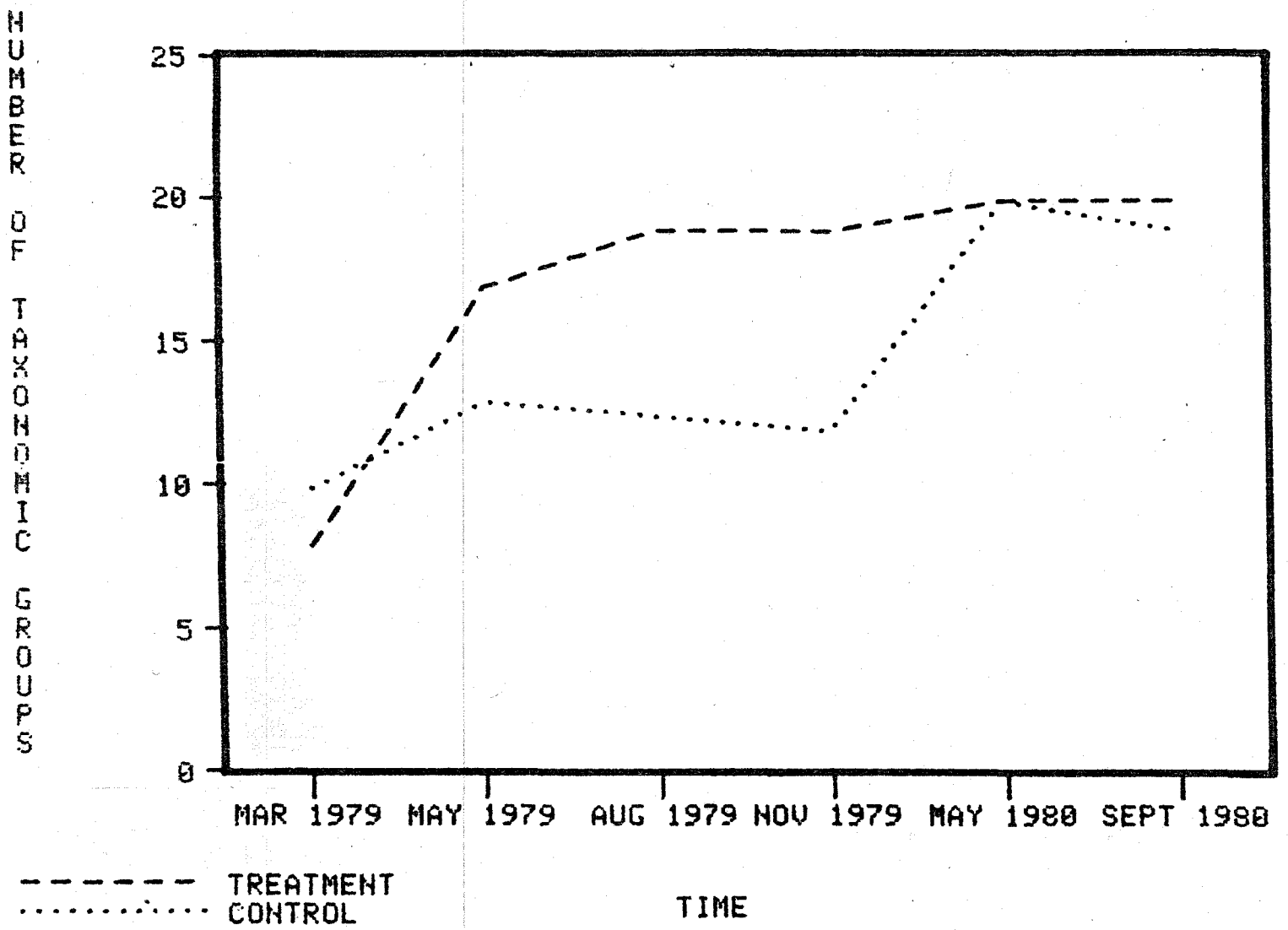

Figure 13. Number of Taxonomic Groups of Macrofaunal Benthos in Area 2, Plot C, Yaquina Bay.

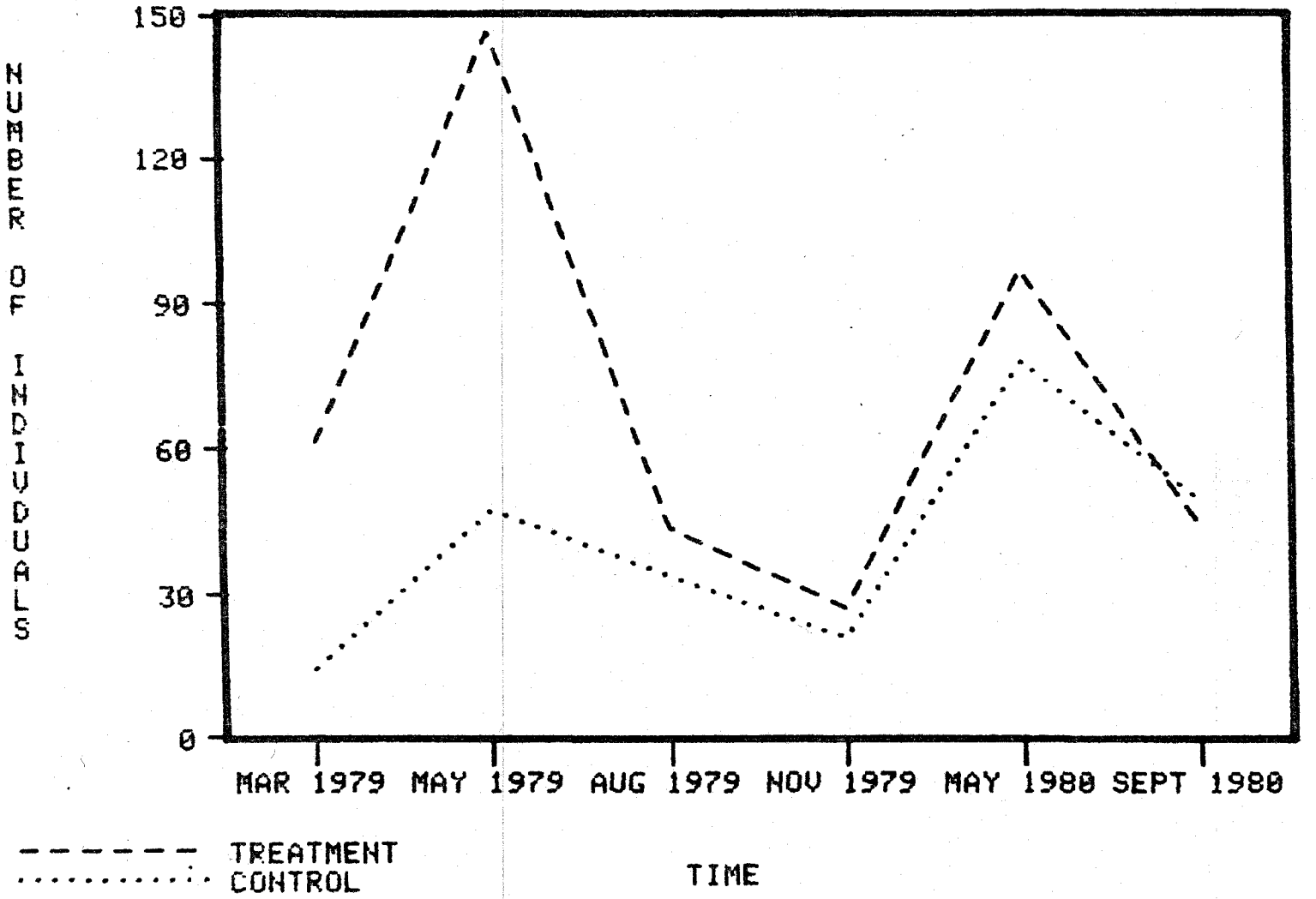

Figure 14. Total Number of Benthic Invertebrates, Area 2, Plot C, Yaquina Bay.

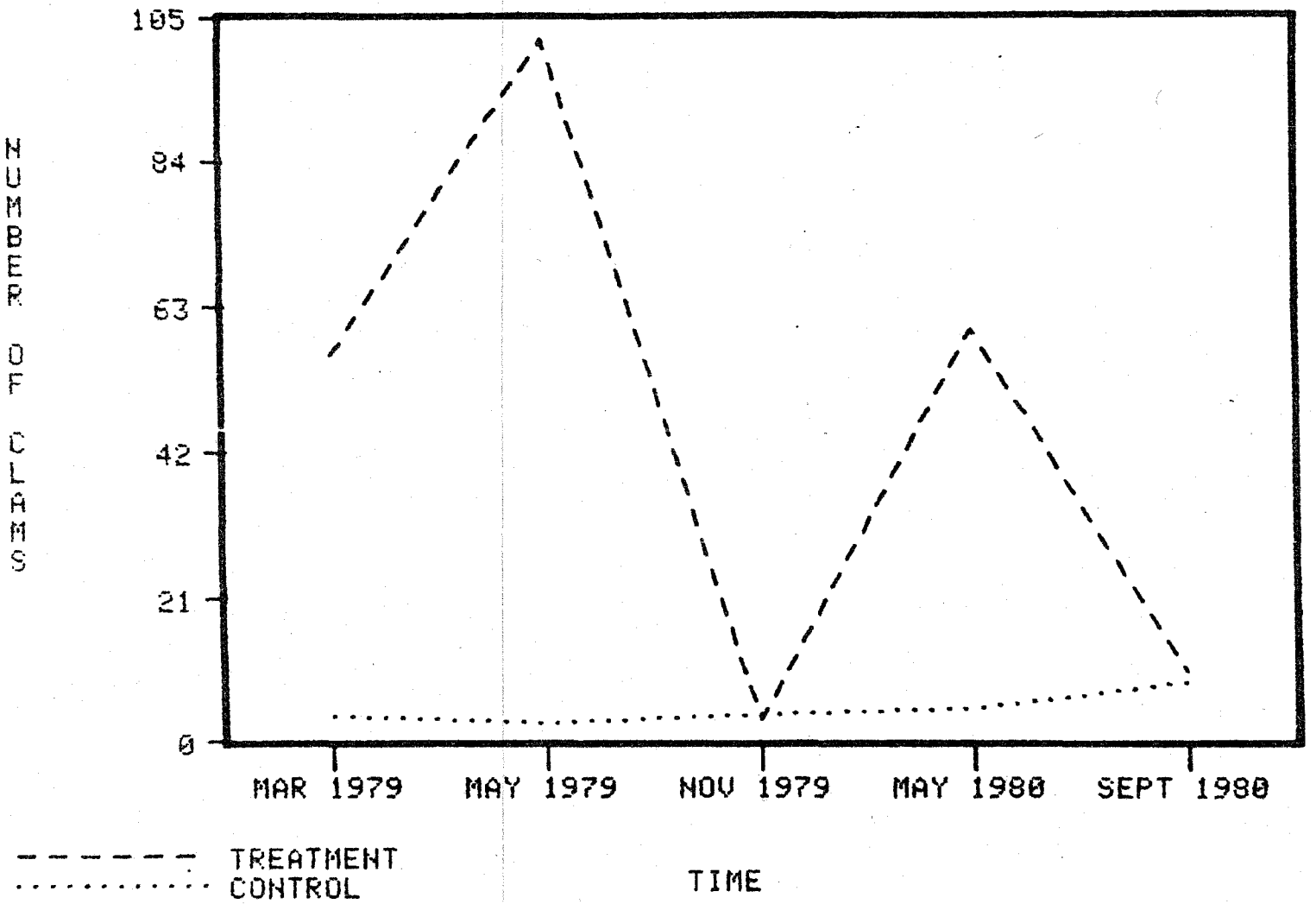

Figure 15. Temporal Distribution of *Macoma inquinata* in Area 2, Plot C, Yaquina Bay.

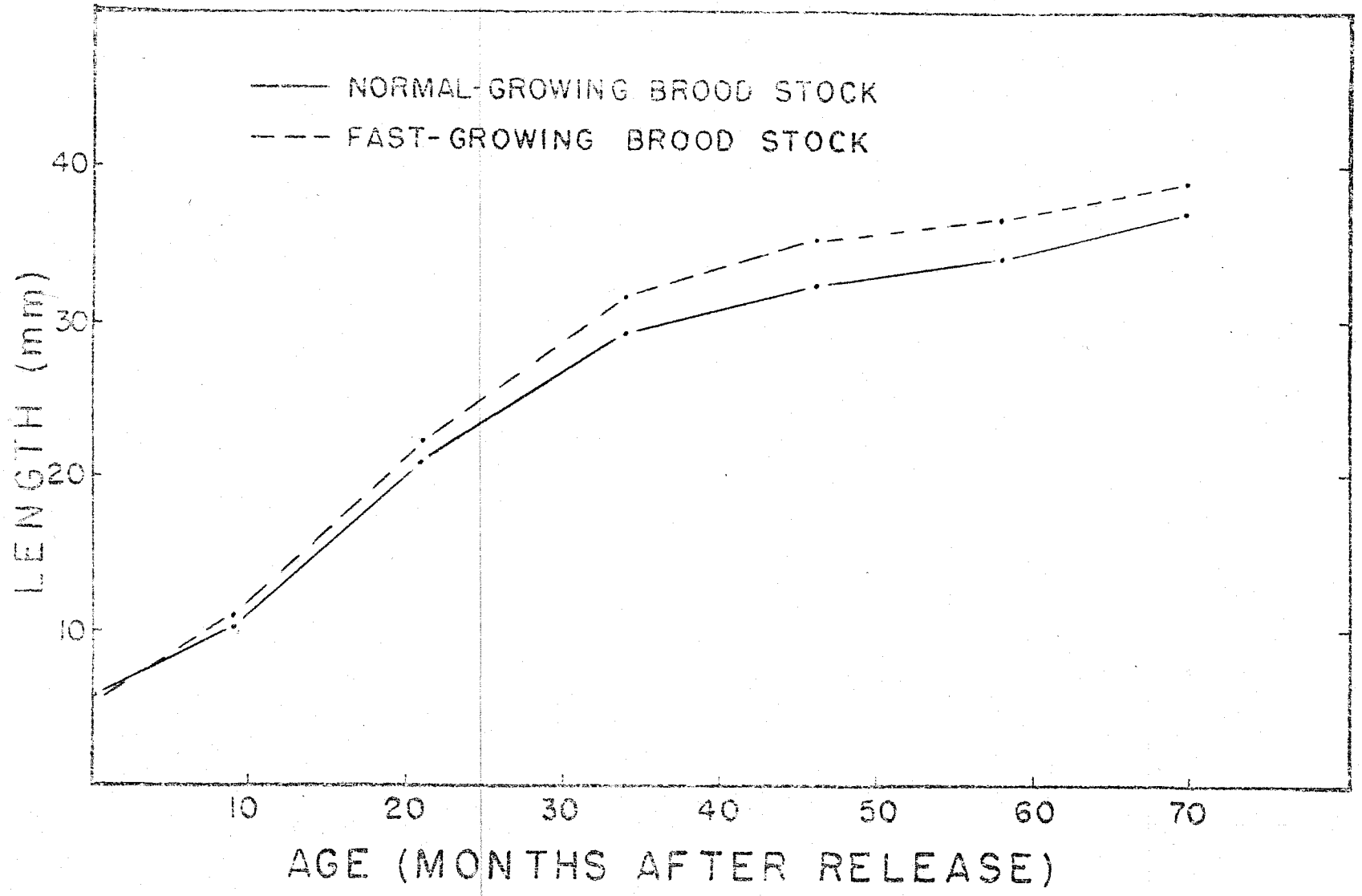

Figure 16. Growth Curve of Manila Littleneck Clams Spawned and Planted from Normal and Fast Growing Brood Stock in Netarts Bay, 1980.

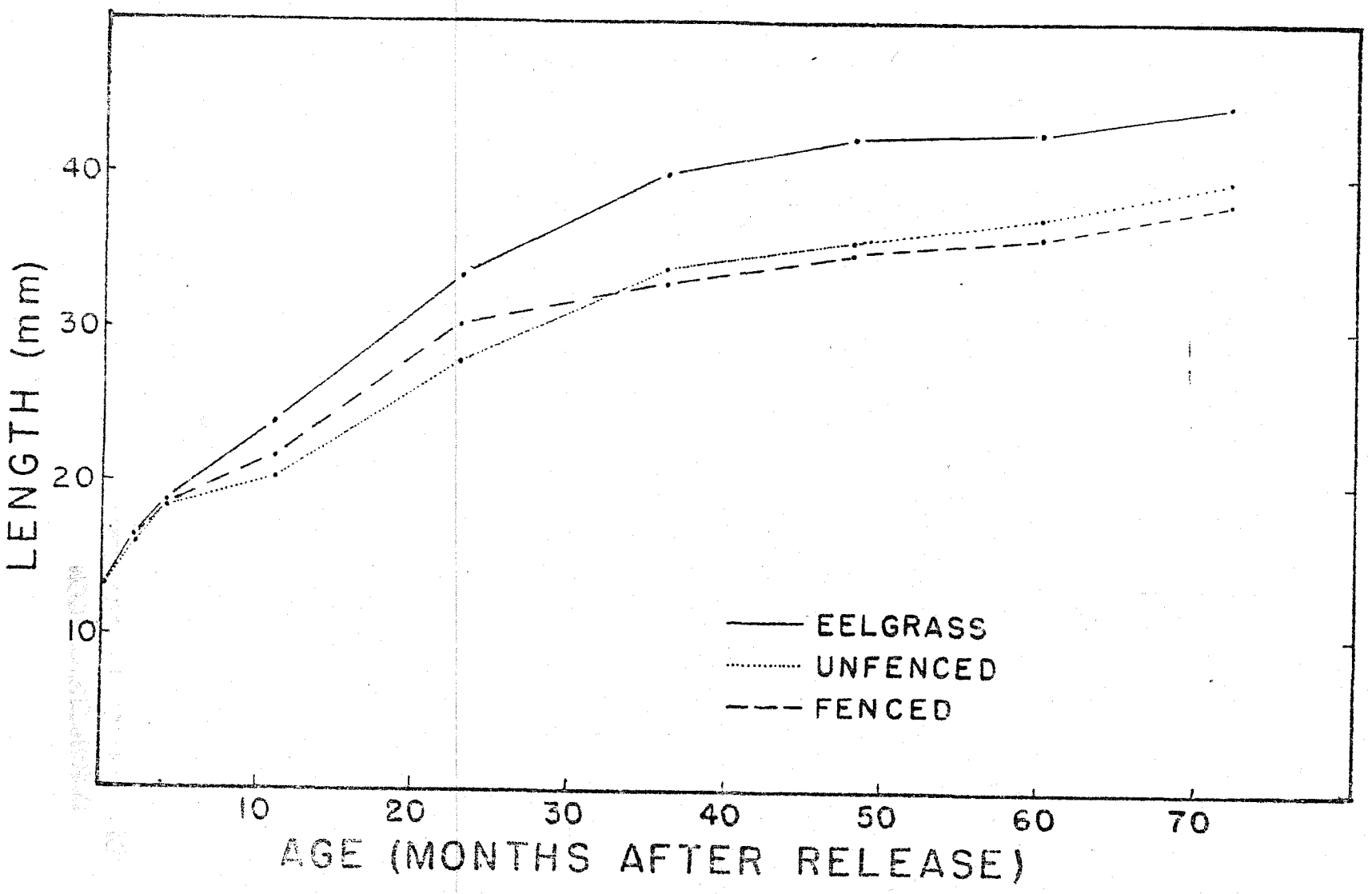

Figure 17. Growth Curve of Manila Littleneck Clams Planted in Fenced, Unfenced and Eelgrass Covered Areas of Netarts Bay, 1980.