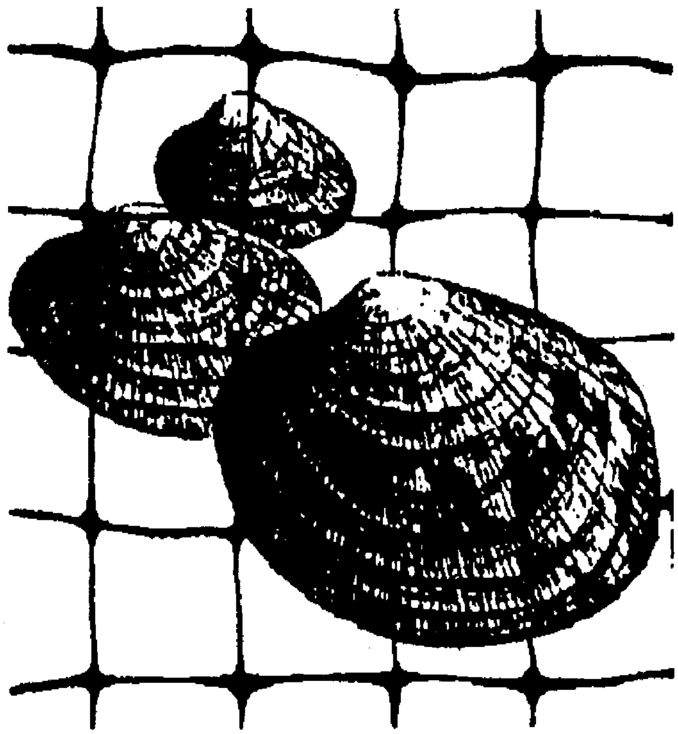
CLAM SURVEY
KOSCIUSKO BAY CLAM CULTURE PLOTS
SOUTHEAST ALASKA
1994



Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division
Juneau, Alaska

Regional Information Report No. 5J94-21

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CLAM SURVEY, KOSCIUSKO BAY CLAM CULTURE PLOTS SOUTHEAST ALASKA - 1994

by

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INTRODUCTION

Kosciusko Bay is located on the southeast side of Kosciusko Island, approximately 51.5 km north-northwest of the City of Klawock (Commercial Fish Statistical Area A, District 103, Southeast Alaska). Waters of the bay are well protected with wooded slopes generally coming to the water's edge. The intertidal beaches are small disperse areas located between steep rocky cliffs and exposed bedrock points. The only permanent habitation around the bay consists of a caretaker's floathouse and upland facilities (tent platform and storage shed) associated with the operation of a commercial shellfish farm.

Harvest and processing of shellfish are governed by regulations established in Article II of the State of Alaska Fish Inspection Regulations, 18 AAC 34. These regulations require an annual permit be obtained in order to harvest, process, pack, repack, sell, or possess shellfish for sale. Before a permit is issued, shellfish growing/harvest areas must be certified by the Department of Environmental Conservation (DEC). At the request of the oyster farmer, the bay was certified by DEC as a commercial shellfish growing area in 1989; the farm began oyster growout operations the following year. Littleneck clams *Protothaca staminea* within a DEC certified shellfish growing area may be harvested for commercial sale. Commercial harvest of littlenecks in Kosciusko Bay started on a small scale in 1990 and has since been managed conservatively with a maximum harvest of about 227.3 kg per permit per month with an annual total of 2358 kg per year. The remote location of the bay limits the amount of recreational clam harvesting pressure.

In 1993 the oyster farm operators applied for an amendment to their aquatic farm permits requesting use of 2222 m^2 (0.2 hectare) of beach area within the bay for littleneck clam farming. The operational and technical feasibility of littleneck clam farming is untested in Alaska, therefore the amendment proposal was considered experimental. To date, permitted areas for experimental species farming have been limited to 0.4 hectare or less. Following a comprehensive review process, the amendment authorizing commercial clam farming on 0.2 hectare of beach in Kosciusko Bay was approved by the department in July of 1994.

Currently no hatchery seed source for littleneck clams exists. The farm operational plan for culture plot reseeding initially relied on natural recruitment. Farm production was based on the husbandry of the existing standing crop of wild littleneck clams contained in the culture plots and clam set that occured naturally. Several practices were proposed for use in the Kosciusko Bay culture plots to test the advantages of clam culture over simply harvesting wild populations.

Controlling Density. Stocking density (number of clams per unit of area) information for farmed littleneck clams does not exist. A species with similar biophysical requirements, the Manila clam

Tapes phillippinarum, is cultured extensively in Washington State and British Columbia. Recommended Manila clam planting densities from published literature warn of the possibility of stunting and increased mortality at high densities (Toba et al 1992). As a starting point, Kosciusko Bay farm plots will be maintained at densities reported successful for Manila clam culture, in the range of 324 to 648 clams per m^2.

Predator Control. Clam culture plots will be covered with predator exclusion netting to control mortality associated with crab, fish, bird, and starfish predation.

Culling Non-target Bivalves. All species of larval bivalves may experience improved post set survival under the predator netting. The interspecific competition for food is expected to reduce the growth potential of the littlenecks. Removal of non-target bivalves from culture plots will be conducted every two to three years. Incidental species removed will be distributed on similar beach areas within Kosciusko Bay.

Vertical Plot Location Strategy. Clams growing higher intertidally are reported to grow slower than those grown lower in the intertidal zone (Glock and Chew 1979). Culture plots were located at tidal levels that offered the best balance between harvest access and maximal submergence periods between tidal cycles.

Selecting Plots Based on Preferred Substrate Characteristics. Littlenecks are seldom encountered in muddy or sandy areas, they prefer loosely packed substrate consisting of gravel, mud, sand, and shell (Nickerson 1977). Plots were selected on the basis of these habitat characteristics. Beach areas containing large rocks or irregular surfaces that prevents the use of predator netting were avoided.

Sustaining Natural Recruitment. The plots selected on the basis of the preferred substrate mentioned above should continue to attract larvae to settle. Predator exclusion netting can provide additional beneficial influences useful in stabilizing clam populations (Glock and Chew 1979). The netting slows water currents and creates eddies that concentrate larvae and creates a setting stimulus. Substrate stability is improved under the netting. Firm interstitial space created for newly settled clams allows the small clams to expend energy on growth rather than maintaining their position in the substrate.

Rotational Digging. Harvest per unit of effort should be more efficient if beaches are dug on a schedule that reflects plot growth characteristics. Less frequent handling of subharvestable clams will minimize feeding interruptions associated with handling stress and siphon reorientation. Reduced physical damage to the delicate shells of small clams is expected.

The purpose of the Kosciusko Bay clam survey was to document bivalve species composition and abundance, and determine size distribution and age of the littleneck clams within permitted beach sites prior to the commencement of farming activities. The data collected for this project will facilitate farm production forecasting and provide a basis to evaluate the effects of the proposed farming practices. This background information will assist in determining if active cultivation of wild littleneck clams increases yield and shortens the interval between harvests.

METHODS

Ten separate beach areas were selected by the farm operators for littleneck clam culture plots (Figures 1-2). The culture plots were clustered in three regions of the bay. One representative culture plot within each region was sampled during the series of morning low (minus) tides on April 26, 27, and 28, 1994.

Each of the three areas sampled was formed by a 6.1 x 30.5 m rectangle (185.2 m^2). The sample plots were divided into four equal-sized subareas (1.5 x 30.5 m rectangles-46.3 m^2). The size of the area sampled was influenced by available labor and the time period of plot exposure that allowed complete collection of core samples during a single tidal cycle (about four hours). The sample area of two plots (2b and 3b) encompassed the entire area of the selected culture plot, the third sample area (in plot 5b) comprised about 45% of the selected culture plot. Notes on the physical characteristics of each sample plot are included under the comments section of the Sample Area Standing Crop Tables (Tables 1-3). Substrate size and composition was estimated following the visual analysis of sediment from washed core samples. Plot tidal height was established by consulting tide tables and estimating vertical plot location by comparing the tide level associated with maximum low water during the sample period.

Sampling was conducted according to the systematic stratified sampling method for estimation of bivalve standing crop described by Toba et al. (1992). Four horizontal transects parallel to the water's edge were established for each sample plot. Each line bisected equal subareas (strata) of the plot resulting in four parallel transects 1.5 m apart. The standard selected for defining the core sample area (0.0188 m^2) was a hollowed 1.4 kg coffee can 15 cm in diameter. The sediment in each core was sampled to a depth of 25 cm. Beginning at a randomly selected point, core samples were collected at equal 3.8 m intervals over the length of the transect. Eight cores were taken for each transect producing an equal number of cores from each stratum. A total of 32 cores were dug in each sample area. Cores were excavated with a garden trowel and placed in marked fine mesh nylon bags for later analysis. The samples were processed in a floating work area of the oyster farm the afternoon of the same day they were collected. Each core sample was washed through a series of three screens constructed of 12.5, 6.2, and 3.1 mm mesh. The bivalves retained by the screens were identified by species and counted, additionally all the littleneck clams were measured to the nearest millimeter (greatest shell length). A minimum of 250 littleneck clams per sample plot were randomly selected from pooled core samples and returned to the laboratory (and frozen) for age and growth analysis.

At a later date, the clams selected for age and growth analysis were thawed and the measurement for greatest shell length was made at each annulus with electronic digital calipers for each clam. Annuli were identified with the aid of a x10 binocular dissecting scope. (Paul and Feder 1973 and Fraser and Smith 1928, offer details for recognizing true annuli in littleneck clam shells.) Since identification of early annuli was impossible, shells with badly abraded surfaces near the umbo region (about a third of the clams collected) were discarded. Age was determined by counting the number of annuli to the edge of the new seasonal shell growth. No adjustment was made for the season in which the clam was dug. The term 0 age group is a reference to clams of the setting year class that have formed their first winter annulus at the end of one growing season. Individuals referred to as one year of age have actually lived through two growing seasons.

The standing crop for each stratum was calculated (stratum clam density x 46.3 m^2) and then summed for the entire plot to yield total standing crop.

RESULTS

Clam Distribution and Density

Clams were found in all three sample plots (Tables 1-3). Ninety six per cent (92 of 96) of the core samples contained some clams. Four samples collected below a freshwater runoff stream in plot 2b produced no clams.

The most common clam species encountered on the three beaches was the littleneck clam. Large quantities of dead littleneck clam shell was found mixed with the live littlenecks indicating a sizable historical population. Moderate quantities of *Macoma* sp. clams were found uniformly distributed within the sample areas. A few butter clams *Saxidomus gigantus*, cockles

Clinocardium nuttalli, and Arctic hiatella *Hiatella arctica*, were collected from each sample plot. Species nominally present were softshells (*Mya* sp.) and nut clams (*Nuculana* sp.); one specimen of each species was found in the core samples. Two other clams known to exist on the intertidal beaches of Kosciusko Bay (Elzada Henderson, personal communication), horse clams *Tresus capex* and Greenland cockles *Serripes groenlandicus*, did not appear in the core samples.

The maximum depth the littleneck clams were found was 15 cm. *Macoma* sp., cockles, and hiatellas were encountered at depths of less than 10 cm. The butter clams were found at the greatest depth of all species sampled at 25 cm.

Clams were evenly distributed within the sample plots with the exception of the upper stratum of plot 2b and 3b. These strata contained 20 to 40% more clams than each of the three lower strata within the plot.

Densities of various clam species during the sampling period are shown in Tables 1-3. The highest number of individual clams per unit area occurred in plot 5b (1275.5 clams/m^2): nearly double the number found in plot 2b (556.7 clams/m^2) and plot 3b (666.4 clams/m^2). Densities of littleneck clams were divided into two size categories: legal commercial harvest size clams greater or equal to 38 mm and sublegal clams less than 38 mm. Roughly a third of the littleneck clams (32.4%) sampled in plot 3b were legal harvest size, only 13.6% were 38 mm or greater in plot 5b, and just 8.7% of the littleneck clams in 2b during the sampling period were commercial size.

Size Frequency Distribution

Graphs showing the length-frequency distribution of the littleneck clams found in each sample plot are shown in Figures 3-5. The length-frequency distribution of the littleneck clams found in each sample plot are compared in Figure 6.

There was a general wide distribution of littleneck clam sizes within each plot that ranged from 3-48 mm shell length during the period of sampling. Mean shell length was similar in plot 3b (30.2 mm) and plot 5b (29.3 mm). The average shell length of littleneck clams in plot 2b was 22.5 mm. The initial peak of size distribution at 5 and 6 mm for plot 3b and 5b was probably the age 1 year class: clams that have lived through two growing seasons. The frequency distribution for plot 2b exhibited an initial peak of 6 to 9 mm which is probably a combination of age 1 and age 2 year classes. Other peaks in size that were common to all three sample plots occurred at 10-12, 15-18, 24-25, 28, 30-31, 34, and 39-40 mm. The major peak of abundance for plot 2b was 30-32 mm; plot 3b was 40mm, and plot 5b was 34 mm.

Growth

Winter annuli of littleneck clams were generally distinct and could be measured readily. The range of sizes of littleneck clams in Kosciusko Bay at a given age is recorded in Table 4. Growth rates of littleneck clams from the three sample plots are compared in Figure 7. The annual increase in shell length for the various size classes of littlenecks in Kosciusko Bay was typically 2-5 mm. The most abundant size class reported for each plot and the corresponding age group was the age 7-8 year class (30-32 mm) for 2b, the 11-12 year class (40 mm) for 3b, and the 8-9 year class (34 mm) for 5b. The littleneck clams need an average of seven to eight growing seasons to achieve a 30 mm shell length. An additional three to five years are required for Kosciusko Bay littleneck clams to reach the minimum commercial harvest shell length of 38 mm. (Approximately 2% of the clams sampled reached 38 mm in 7 to 9 years.) The oldest clam examined was 13 years old and 46.1 mm long.

Bourne and Adkins (1985) characterize evidence of stunting in Manila and littleneck clam shells from British Columbia as a convolution and thickening of the ventral margin of the shell. They also reported some distortion of shell shape. A portion of the littleneck clams from the Kosciusko Bay sample plots displayed these features. Initial growth of these clams was normal; beyond 25-30 mm shell length growth slowed significantly. Increase in shell length at the older ages (8-12) practically stopped before clams reached the minimum commercial harvest size of 38 mm.

Standing Crop

The standing crop estimate of the number of clams (all species) within the three Kosciusko Bay sample plots is shown in Tables 1-3. Littlenecks comprised 75% of the total number of clams sampled. *Macoma* sp. clams contributed about 18% to the total bivalve population estimate. The other species of clams found within the sample plots collectively accounted for less than 7% of the standing crop. The estimated number of littlenecks 38 mm or greater was similar for plot 3b and 5b (about 26,000). Plot 2b was projected to have 7,000 littlenecks of commercial harvest size. The total number of sublegal littlenecks (all sizes) contained in the three plots during the sampling period was estimated to be approximately 300,000 clams. Plot 5b contained over half (167,000) the projected standing crop 38 mm or less.

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Table 1. Number of clams sampled, density, and standing crop of plot 2b, Kosciusko Bay, (4/28/94).

Number of clams sampled	stratum 1	stratum 2	stratum 3	stratum 4	TOTAL
littleneck >,=38mm	7	2	2	12	23
littleneck <38mm	95	64	42	42	243
butter	2	1	0	2	5
macoma	19	9	9	8	45
cockle	0	0	0	1	1
softshell	0	0	0	0	0
nestler	0	2	1	3	6
other	0	0	0	0	0
TOTAL	123	78	54	68	323
Density of clams in sample plot (clams per sq m)					**PLOT MEAN**
littleneck >,=38mm	48.6	14.0	14.0	85.3	40.0
littleneck <38mm	655.6	440.6	288.4	289.4	419.0
butter	14.0	6.5	0.0	14.0	8.6
macoma	130.7	61.6	61.6	55.1	77.8
cockle	0.0	0.0	0.0	6.5	1.6
softshell	0.0	0.0	0.0	0.0	0.0
nestler	0.0	13.0	6.5	20.5	9.7
other	0.0	0.0	0.0	0.0	0.0
TOTAL	861.8	543.2	378.0	467.6	556.7
Estimated number of clams in sample plot					**TOTAL**
littleneck >,=38mm	2250	650	650	3800	7350
littleneck <38mm	30350	20420	13350	13400	77520
butter	650	300	0	650	1600
macoma	6050	2850	2850	2550	14300
cockle	0	0	0	300	300
softshell	0	0	0	0	0
nestler	0	600	300	950	1850
other	0	0	0	0	0
TOTAL	39300	24820	17150	21650	102920

Comments: Plot estimated tide level: +0.15 to -0.15 m. Substrate type: a combination of fine, medium and course angular gravel(40-60%); mud/sand(30-50%); shell(15% or less). Four cores collected below a freshwater runoff area yielded no clams.Minimum sieve size: 3 mm. Plot sampling transects were parallel to the tideline. Strata numbering started at the upper tide level. Strata were equal 1.5x 30.5 m rectangles. Plot has sustained prior harvest. The minimum legal commercial harvest length is 38mm.

Table 2. Number of clams sampled, density, and standing crop of plot 3b, Kosciusko Bay (4/26/94).

Number of clams sampled	stratum 1	stratum 2	stratum 3	stratum 4	TOTAL
littleneck >,=38mm	16	19	28	19	82
littleneck <38mm	66	42	30	33	171
butter	0	4	2	2	8
macoma	26	29	28	33	116
cockle	1	2	1	0	4
softshell	0	0	0	0	0
nestler	3	2	0	0	5
other	0	0	0	1	1
TOTAL	112	98	89	88	387
Density of clams in sample plot (clams per sq m)					**PLOT MEAN**
littleneck >,=38mm	110.2	130.7	193.3	130.7	141.2
littleneck <38mm	454.7	289.4	206.3	226.8	294.3
butter	0.0	28.1	14.0	14.0	14.0
macoma	179.3	199.8	193.3	226.8	199.8
cockle	6.5	14.0	6.5	0.0	6.8
softshell	0.0	0.0	0.0	0.0	0.0
nestler	20.5	14.0	0.0	0.0	8.6
other	0.0	0.0	0.0	6.5	1.6
TOTAL	771.2	676.0	613.4	604.8	666.4
Estimated number of clams in sample plot					**TOTAL**
littleneck >,=38mm	5102	6051	8950	6051	26155
littleneck <38mm	21053	13399	9552	10501	54504
butter	0	1301	648	648	2597
macoma	8302	9251	8950	10501	37003
cockle	301	648	301	0	1250
softshell	0	0	0	0	0
nestler	949	648	0	0	1597
other	0	0	0	301	301
TOTAL	35707	31299	28400	28002	123408

Comments: Plot estimated tide level: 0.0 to -0.3 m. Substrate type: medium and course angular gravel(50-70%), mud/sand(20-40%), shell(10% or less). Large substrate hampered digging. Minimum sieve size: 3 mm. Plot sampling transects were parallel to the tideline. Strata numbering started at the upper tide level. Strata were equal 1.5x 30.5 m rectangles. Plot has sustained prior harvest. The minimum legal commercial harvest length is 38mm.

Table 3. Number of clams sampled, density, and standing crop of plot 5b, Kosciusko Bay, (4/27/94).

Number of clams sampled	stratum 1	stratum 2	stratum 3	stratum 4	TOTAL
littleneck >,=38mm	15	27	14	27	83
littleneck <38mm	136	125	124	140	525
butter	16	6	11	8	41
macoma	21	20	25	21	87
cockle	0	0	1	1	2
softshell	0	0	1	0	1
nestler	0	0	0	2	2
other	0	0	0	0	0
TOTAL	188	178	176	199	741
Density of clams in sample plot (clams per sq m)					**PLOT MEAN**
littleneck >,=38mm	103.7	185.8	96.1	185.8	142.9
littleneck <38mm	936.4	860.8	854.3	964.4	904.0
butter	110.2	41.0	75.6	55.1	70.5
macoma	144.7	138.2	171.7	144.7	149.8
cockle	0.0	0.0	6.5	6.5	3.3
softshell	0.0	0.0	6.5	0.0	1.6
nestler	0.0	0.0	0.0	14.0	3.5
other	0.0	0.0	0.0	0.0	0.0
TOTAL	1295.0	1225.8	1210.7	1370.5	1275.5
Estimated number of clams in sample plot					**TOTAL**
littleneck >,=38mm	4801	8603	4449	8603	26456
littleneck <38mm	43355	39855	39554	44652	167416
butter	5102	1898	3500	2551	13052
macoma	6700	6399	7950	6700	27748
cockle	0	0	301	301	602
softshell	0	0	301	0	301
nestler	0	0	0	648	648
other	0	0	0	0	0
TOTAL	59959	56755	56055	63454	236223

Comments: Plot estimated tide level: +0.15 to -0.15 m. Substrate type: fine and medium angular gravel(50-60%) mud/sand(30-40%), shell(15% or less). Gravel depth: 10 - 17.5 cm. Minimum sieve size: 3 mm. Plot sampling transects were parallel to the tideline. Strata numbering started at the upper tide level. Strata were equal 1.5x 30.5 m rectangles. The minimum legal commercial harvest length is 38 mm.

ML= mean length of clams. N= number of clams. SD= standard deviation.

Age	PLOT 2b (N=182)			PLOT 3b (N=118)			PLOT 5b (N=185)		
	ML(mm)	SD(mm)	Ranges	ML(mm)	SD(mm)	Ranges	ML(mm)	SD(mm)	Ranges
0*	2.0	0.56	1.0- 3.7	3.0	0.56	2.0- 4.1	2.7	0.59	1.5- 4.0
1	4.3	1.08	2.1- 7.2	6.0	1.29	3.8- 10.3	5.4	1.14	2.6- 9.0
2	7.3	1.88	3.7- 13.6	9.6	2.25	6.2- 17.1	8.8	2.15	4.5- 15.4
3	10.6	2.69	5.2- 19.6	14.2	3.39	9.1- 23.6	13.5	2.70	8.1- 21.1
4	14.6	3.56	7.3- 21.9	19.4	4.47	10.3- 32.5	18.6	3.25	10.1- 27.4
5	19.1	4.85	9.3- 30.0	23.9	4.24	15.4- 37.3	23.2	3.41	16.5- 32.4
6	22.9	4.20	12.3- 34.5	27.5	3.79	17.4- 37.0	27.1	3.74	18.1- 37.3
7	25.9	3.64	18.1- 32.5	31.0	3.61	21.9- 38.5	30.7	3.49	21.2- 39.3
8	29.1	3.97	20.5- 37.6	33.5	3.12	27.0- 41.2	33.0	3.61	28.1- 41.8
9	32.0	3.86	21.9- 39.0	35.6	3.13	30.5- 44.5	35.0	3.25	29.1- 41.1
10	34.7	2.60	24.1- 39.3	37.6	3.41	32.2- 47.5	36.3	3.58	31.4- 41.9
11	35.5	4.27	27.6- 41.2	38.5	2.70	35.7- 43.6	37.3	3.63	33.8- 42.4
12	37.8	3.53	34.3- 42.7	41.1	2.75	38.3- 46.1	43.9	none	none
13							46.1	none	none

* The term 0 age group is a reference to clams of the settling year class that have formed their first winter annulus at the end of one growing season. Individuals referred to as one year of age have actually lived through two growing seasons.

Table 4. Average size at age of littleneck clams collected from Kosciusko Bay culture plots, April 1994.

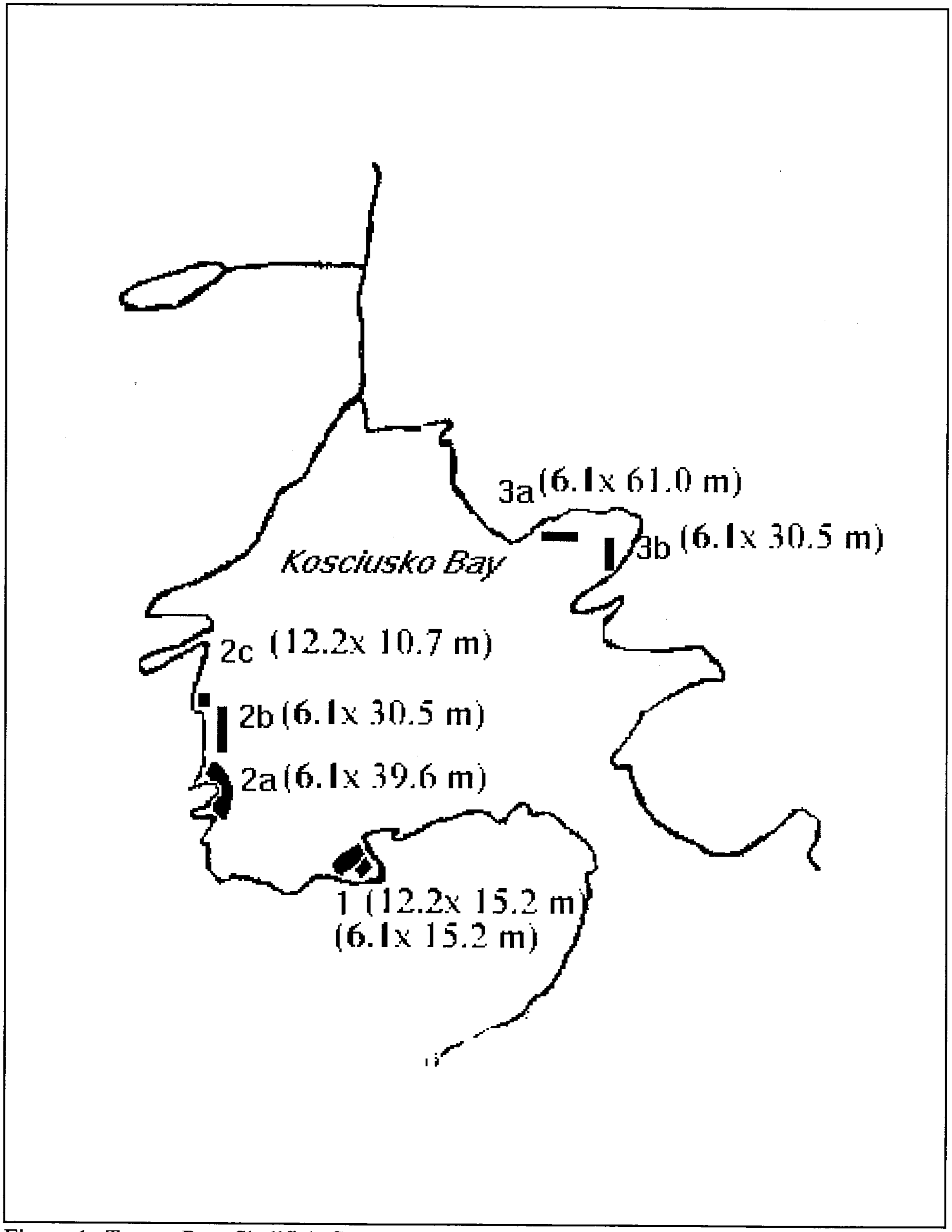

Figure 1. Tenass Pass Shellfish Co. approved clam farming beds, Kosciusko Bay, 5/2/94

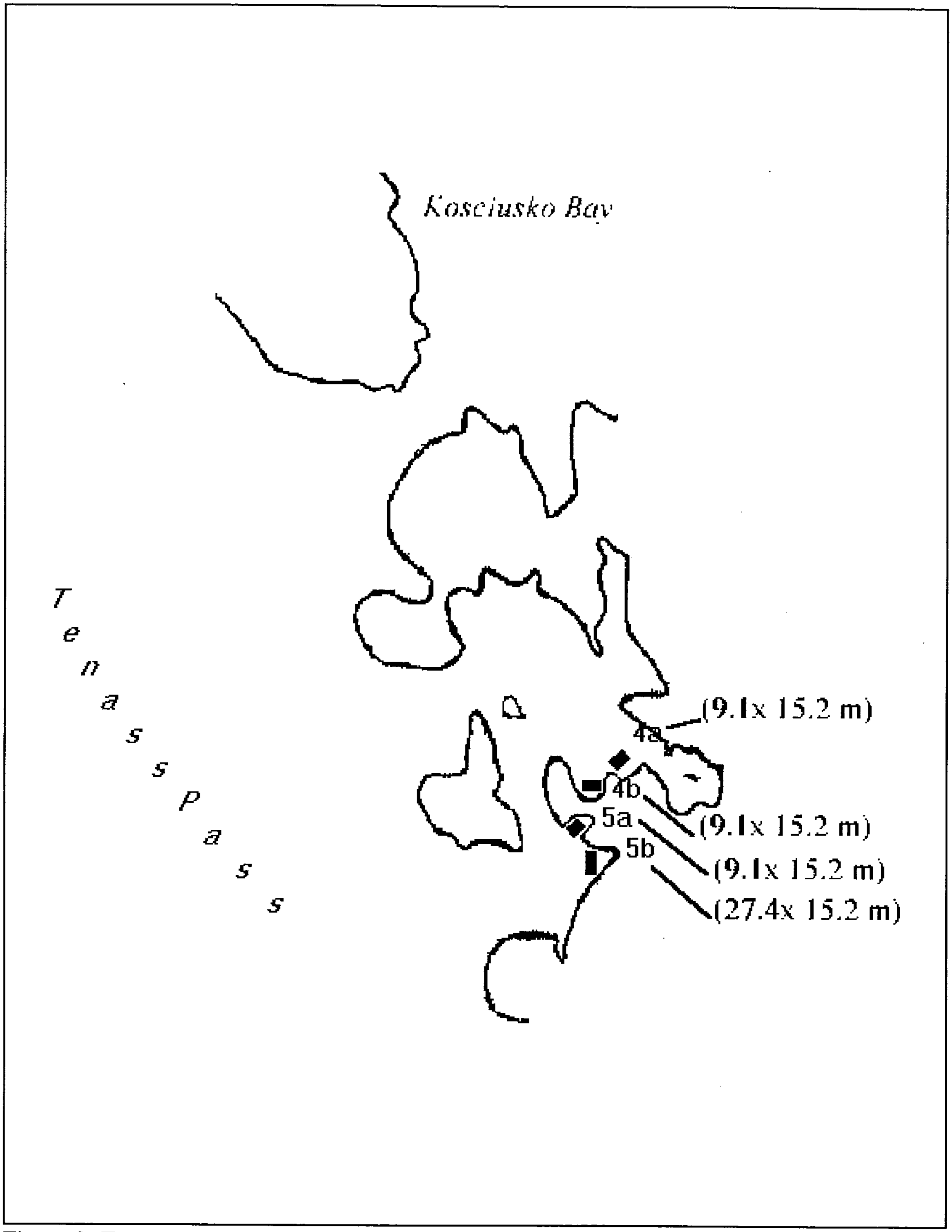

Figure 2. Tenass Pass Shellfish Co. approved clam farming beds, outer Kosciusko Bay, 5/2/94

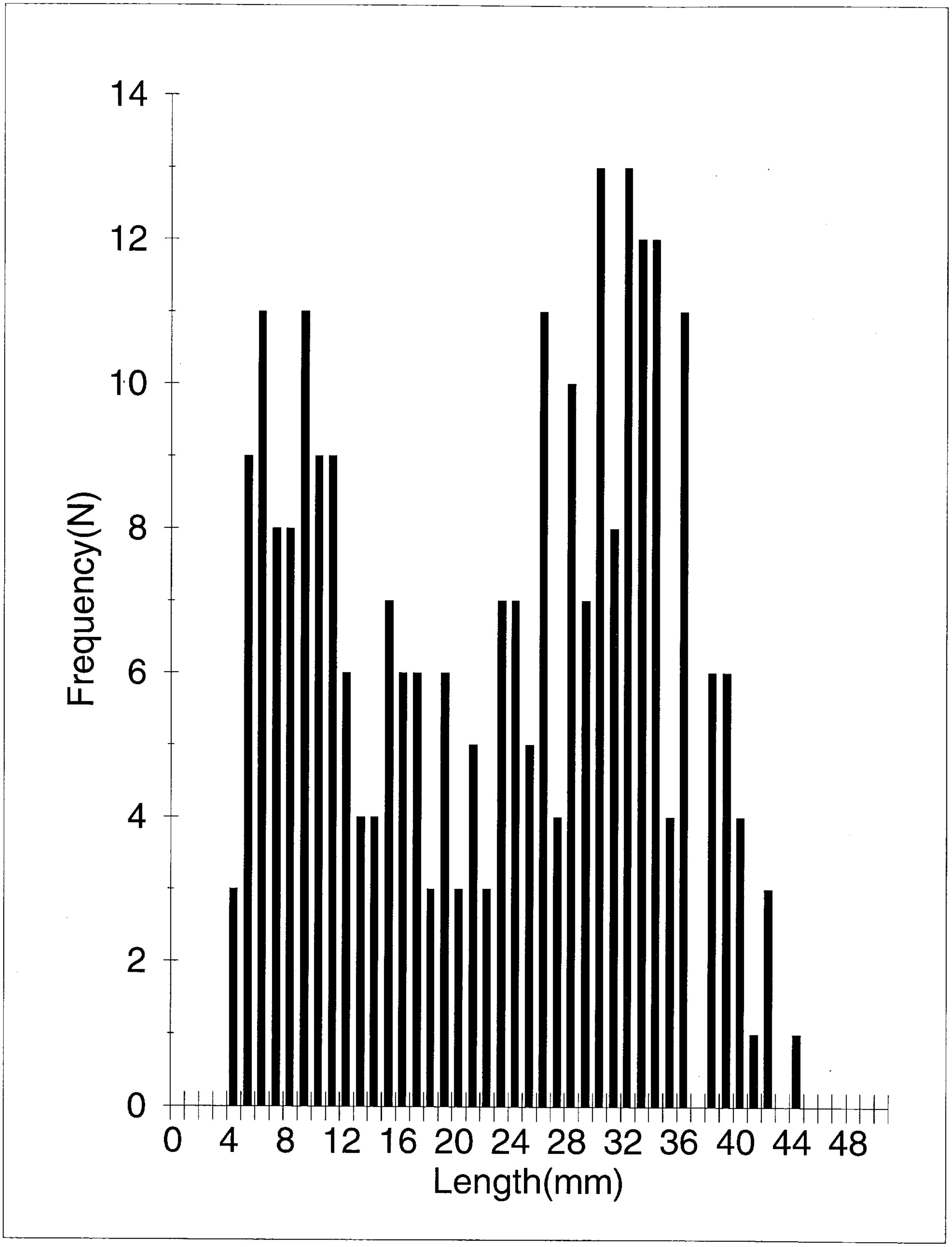

Figure 3. Littleneck clam length-frequency distribution of plot 2b in Kosciusko Bay, 4/28/94, N=266

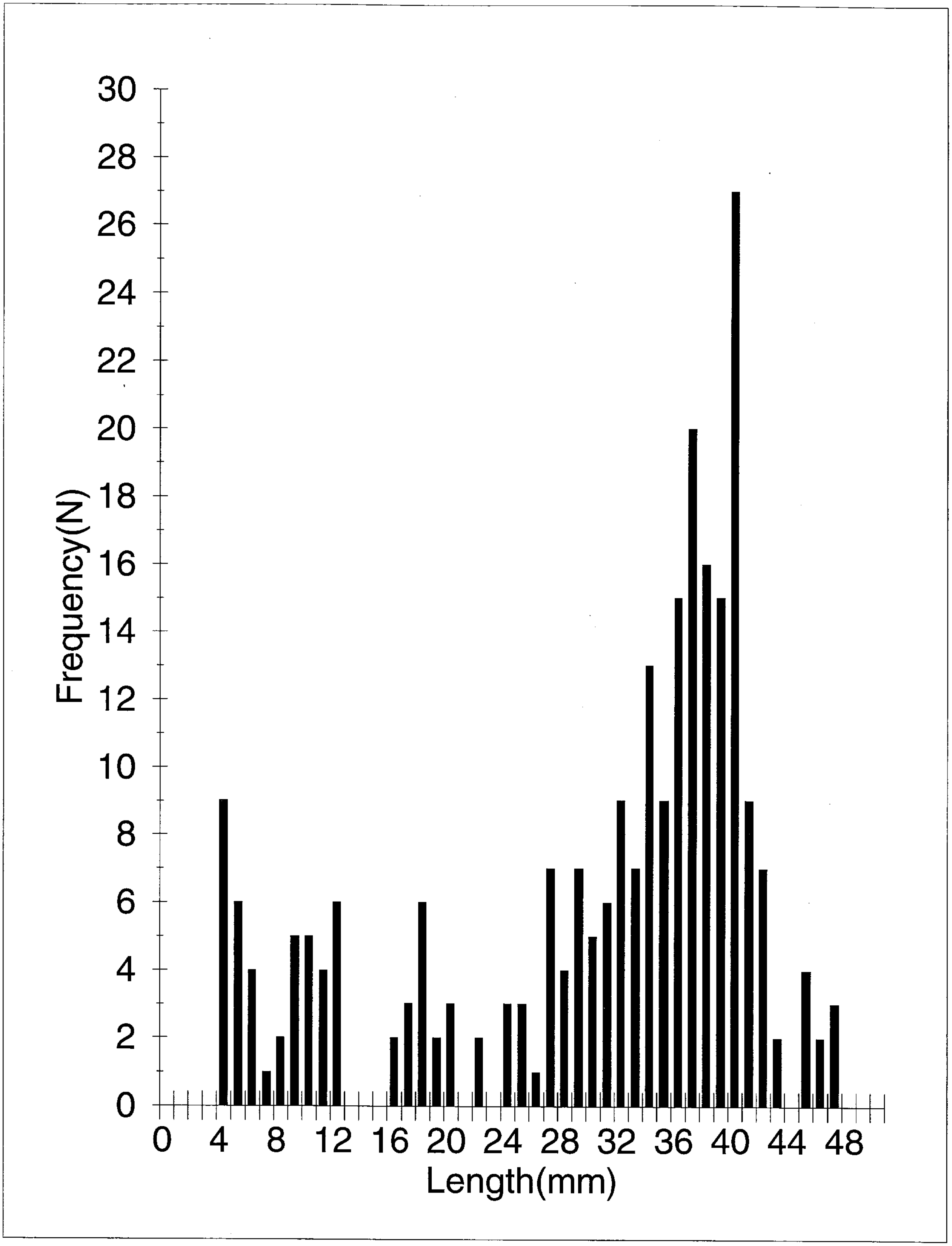

Figure 4. Littleneck clam length-frequency distribution of plot 3b in Kosciusko Bay, 4/26/94, N=253

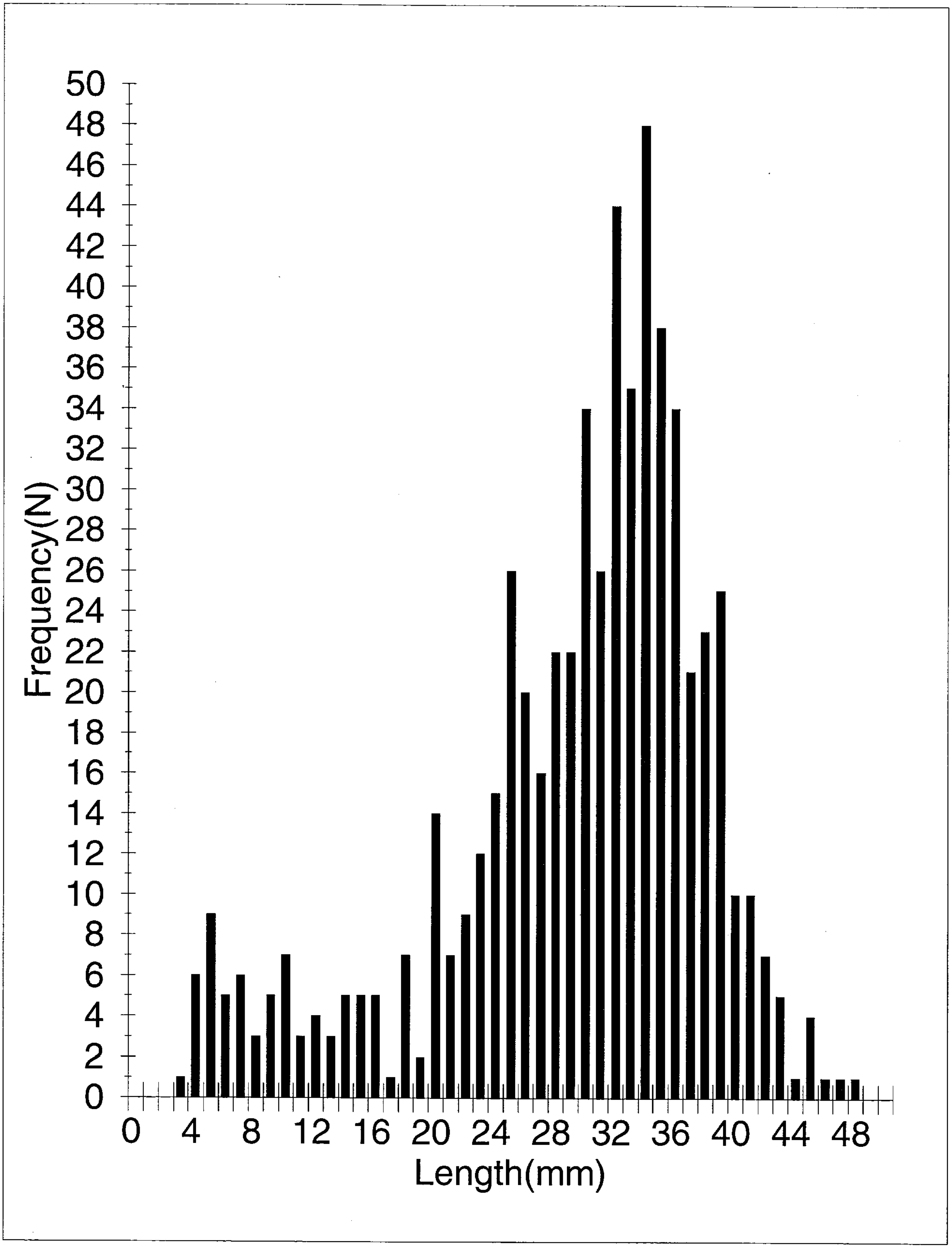

Figure 5. Littleneck clam length-frequency distribution of plot 5b in Kosciusko Bay, 4/27/94, N=608

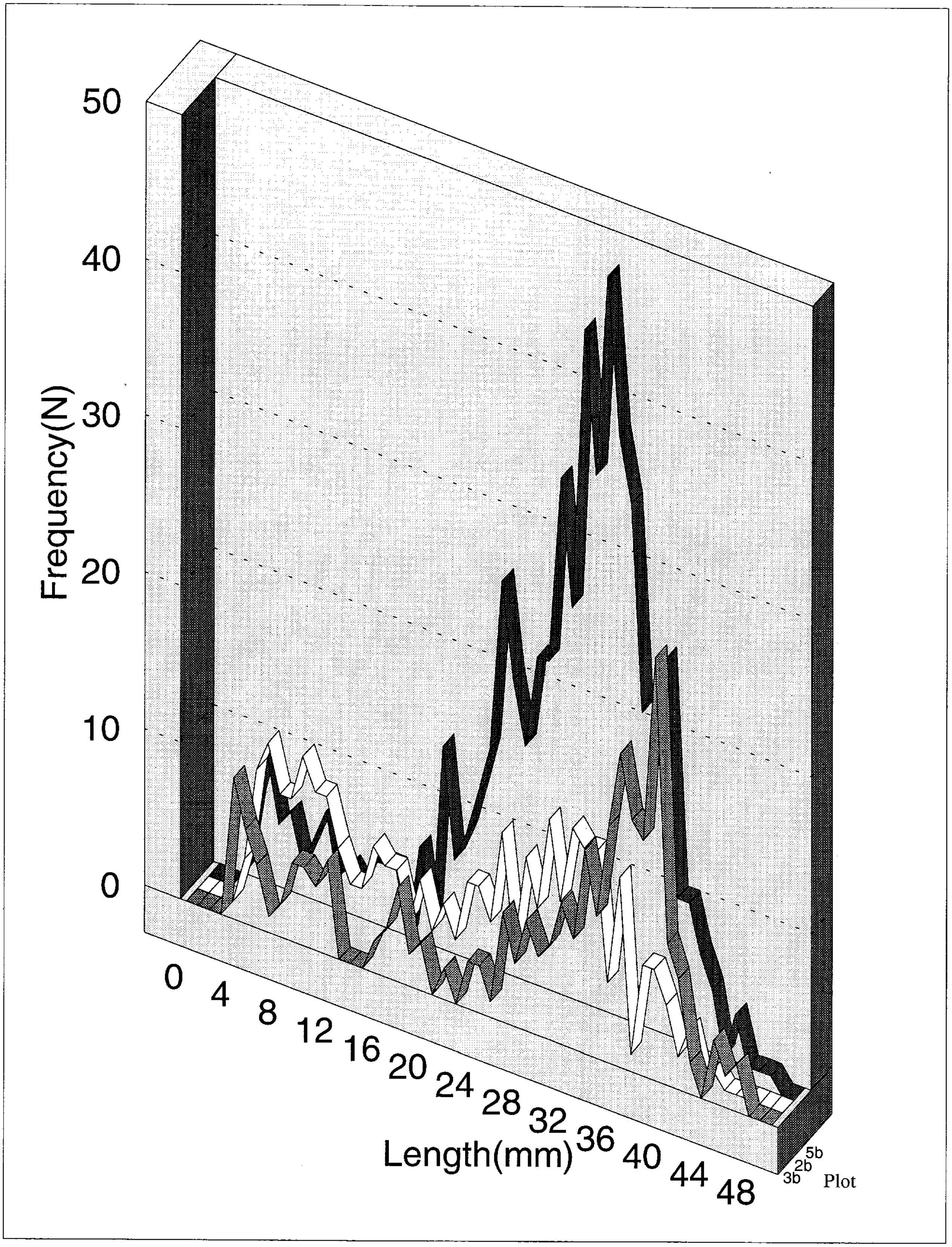

Figure 6. Littleneck clam length-frequency distribution of sampled plots in Kosciusko Bay, April 1994

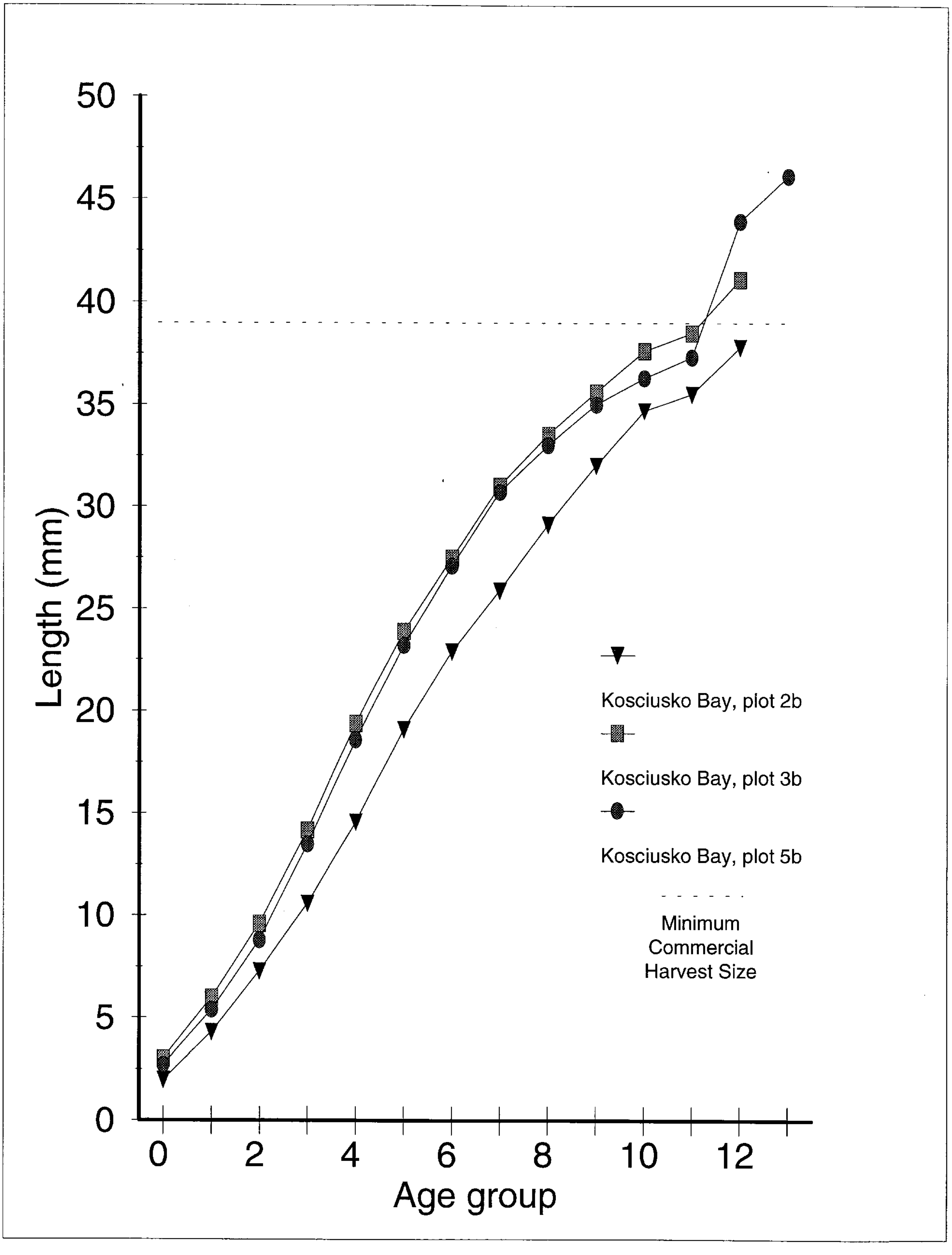

Figure 7. Littleneck clam shell length at age from Kosciusko Bay, Southeast Alaska