Ohiwa Harbour Mussel Survey

Summer 1978/79

by
A.R. Kilner and J.M. Akroyd

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Abstract

The distribution, abundance and size of the green lipped mussel Perna canaliculus Gmelin in Ohiwa Harbour, New Zealand, was investigated by SCUBA diving surveys over the summer 1978/79. The mussels are found in two main beds covering an area of 9.3 ha, and these were surveyed by setting up transects across them. The population was estimated at 20.7 million mussels, and a weight of 1,698 tonnes. The majority of mussels were of a good edible size with mean lengths ranging between 88.7 and 126.9 mm. Analysis of variance showed that there was no significant difference in size of mussels between surveys, but there were significant differences between beds and transects. A number of size classes were distinguished using probability paper methods, but the majority of mussels were found to occur in only one of these size classes.

1. Introduction

Ohiwa Harbour is a shallow estuary in the Eastern Bay of Plenty, North Island, New Zealand (Fig. 1). Ohiwa Harbour is locally renowned for the collection of green-lipped mussels Perna canaliculus Gmelin. Large numbers of shore-pickers, snorkel divers, and people using grabs from boats can be seen collecting mussels from the easily accessible beds, especially at low tide at weekends and over the summer months.

Recent concern that the beds were being over-exploited led to an investigation to assess the present state of the mussel beds. The distribution of the main mussel beds, and the numbers and size of mussels within these beds were studied using SCUBA.

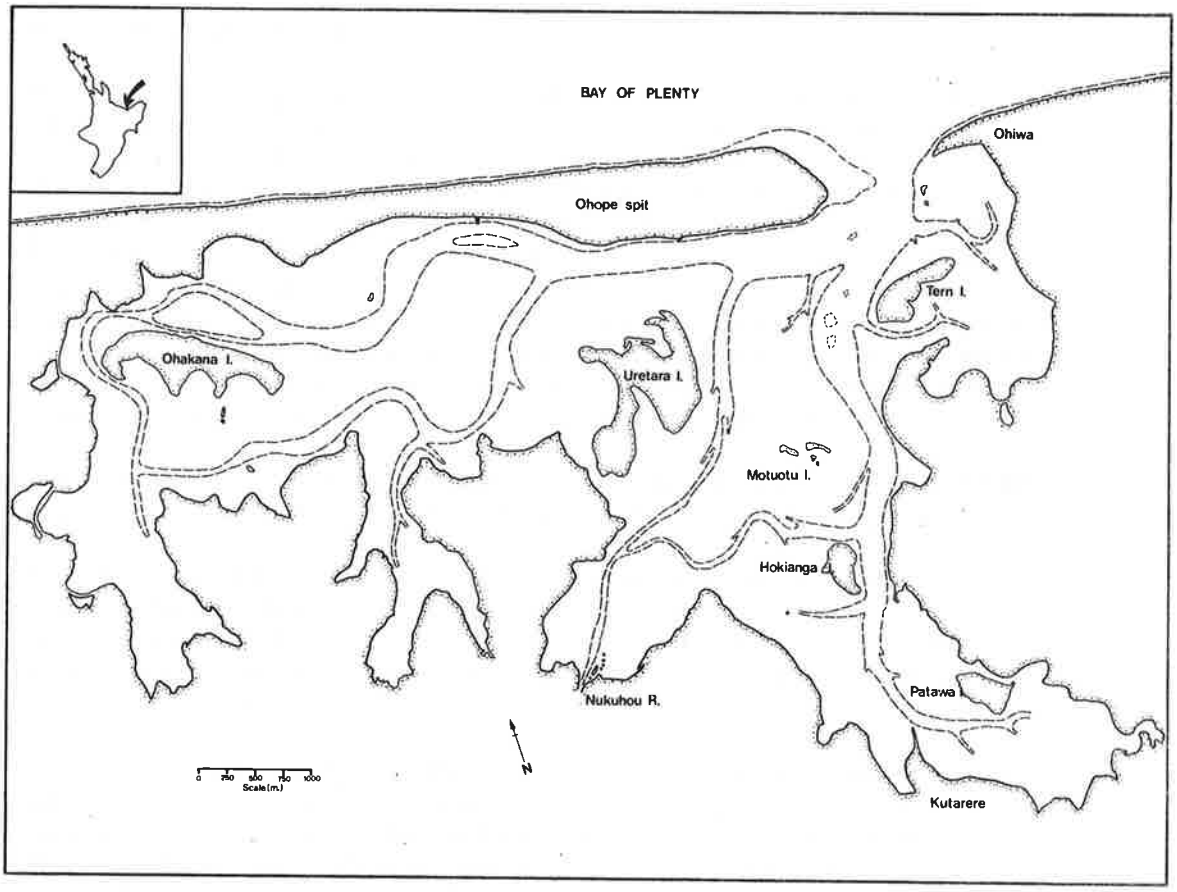

Fig. 1: General map of Ohiwa Harbour

2. Methods

Three surveys of the mussel beds were conducted over the 1978/79 summer.

These surveys were confined to the area where local divers and shorepickers were known to gather mussels. Other beds may be present but were not investigated during our surveys.

The first survey on November 2-3, 1978, a manta board survey by SCUBA divers, established the general area of the mussel beds. Three traverses were made across the low tide channel at approximately 200 metre intervals. Buoyed shotlines were dropped by the divers to mark the edges of the bed. Two tows were then made down the length of the bed marked out by the buoys to determine if the beds were continuous between traverses.

Further surveys were carried out on December 9-11, 1978, and February 17-20, 1979, before and after the summer holidays when mussel gathering was thought to be at its peak. Transect lines were established across the channel at 120 metre intervals. A baseline for transects was surveyed by Lands and Survey Department personnel, Rotorua, so that the same areas can be returned to and investigated in the future. A 300 metre weighted line, marked at 10 metre intervals, was run across the channel following the line of orientation set up by the surveyors.

Each transect began at mean low water mark and distances were recorded across the transect from that point.

Six transects (M to R) were established across the mussel beds during the December survey (Fig. 2). The area covered for the February survey was extended to eight transects (L to S), to ensure full coverage of the mussel beds.

The transects were traversed using SCUBA, the divers carrying a 0.5 m^2 quadrat, and a buoyed numbered sugarbag. At each 10 metre mark along the transect, the quadrat was placed on the mussel bed and all mussels within the quadrat were transferred into the numbered bag. The buoyed bag had a drawstring attached to prevent any loss of mussels. This operation was repeated at each 10 metre mark using a new bag.

For each sample the mussels were counted, and the total live weight of mussels measured to the nearest 100 grams, once all dead shell, algae etc., attached to the mussel shells had been removed. Individual lengths of all mussels from a randomly selected portion of the sample, were recorded in millimetres to the nearest below using vernier calipers.

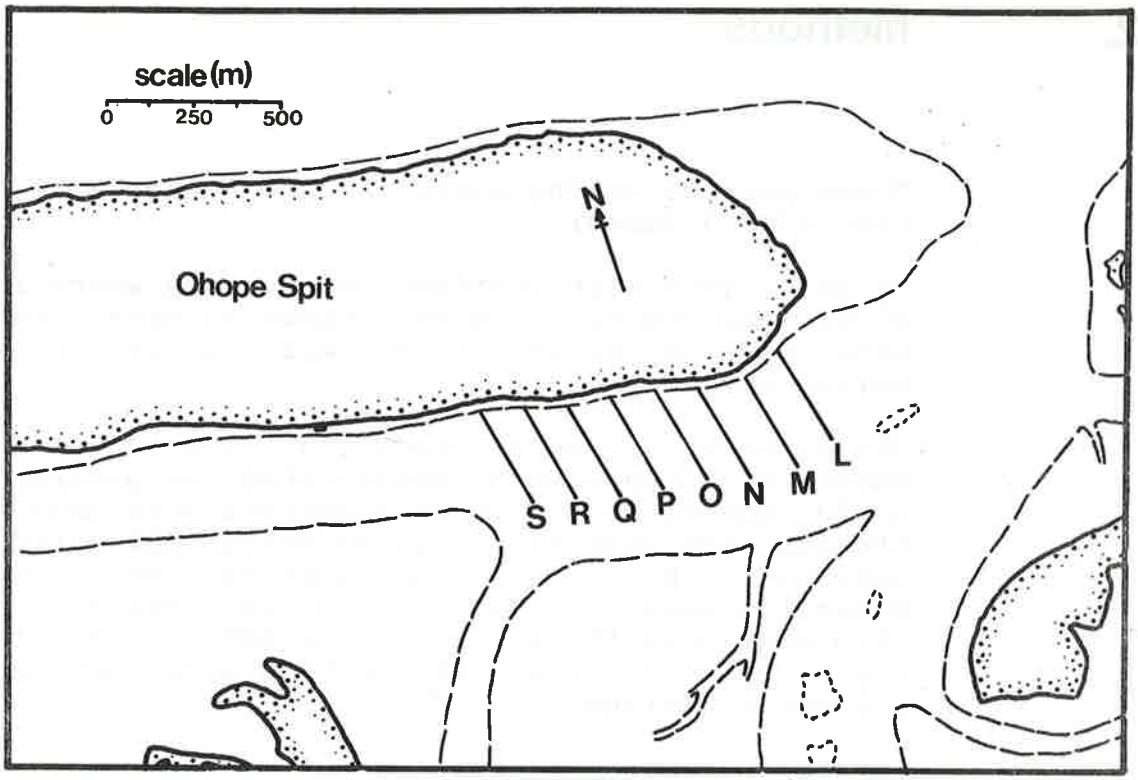

Fig. 2: Location of transect positions for the December 1978 and February 1979 surveys

3. Results and Discussion

3.1 Distribution

The mussel beds investigated during the course of the surveys were found to form two beds running parallel to the channel axis. The bed closest to Ohope Spit shoreline will be referred to as the "inner bed" and the other in the middle of the channel as the "outer bed".

No major difference was observed in the distribution of the beds between surveys. Minor differences in bed positioning between surveys is probably attributable to the difficulty of laying a straight taut line on a specified compass bearing for 300 metres across a channel. To minimise this difficulty a heavily weighted line was used, and laid out during slack tides.

The manta board survey in November 1978 showed that the mussels form an almost continuous cover within the area of the beds, except for occasional bare patches of 0.3 - 2.0 metres diameter, probably caused by mussel gatherers. Distribution of mussels is discontinuous on the outer edges of the main beds.

The inner bed was at least 840 metres in length and 80 metres in width; the outer bed 600 metres and 110 metres respectively. Both beds taper off towards either end (Figures 3 and 4).

The inner bed extends from about mean low water adjacent to the Ohope Spit shoreline into gradually deepening water. This bed is separated from the outer bed by a deep water channel, which is used by the larger fishing boats to gain access to the Ohope Wharf. The outer bed occurs on the other side of this channel where the depth of water decreases again, but the bed is sub-tidal.

The area of beds, estimated from the February survey data, was approximately 4.9 hectares for the inner bed and 4.4 hectares for the outer bed, a total 9.3 hectares.

In 1930, the Inspector of Fisheries at Opotiki estimated that the mussel beds in Ohiwa Harbour were over 20 acres (8.1 ha) in extent and he expressed no fears of depletion. In 1945, A.E. Hefford reported that the beds had by then practically disappeared (Marine Department files). Paul (1966) stated that "mussels are reported by local residents to be still present in some of the main channels but they are no longer gathered".

The mussel beds apparently increased in extent again as Bioresearches Ltd., (1975) reported "the green mussel flourishes in the shallow channels near the entrance to the Harbour".

K.A. Ford investigated the beds between 1975 and 1977, and he reported that "the mussel beds have been drastically depleted" (Ministry of Agriculture and Fisheries files, 1978).

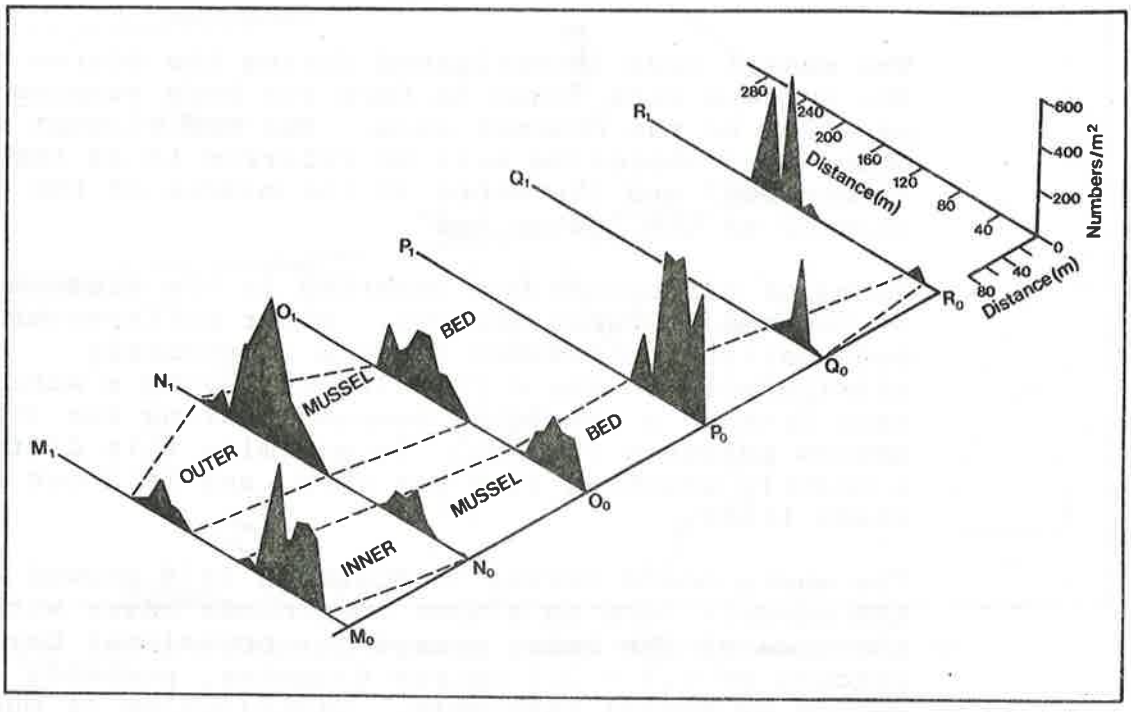

Fig. 3: Distribution of mussels in December 1978. M_o is the low water end of Transect M and M_1 is the mid channel end of Transect M; similarly for Transects N to R

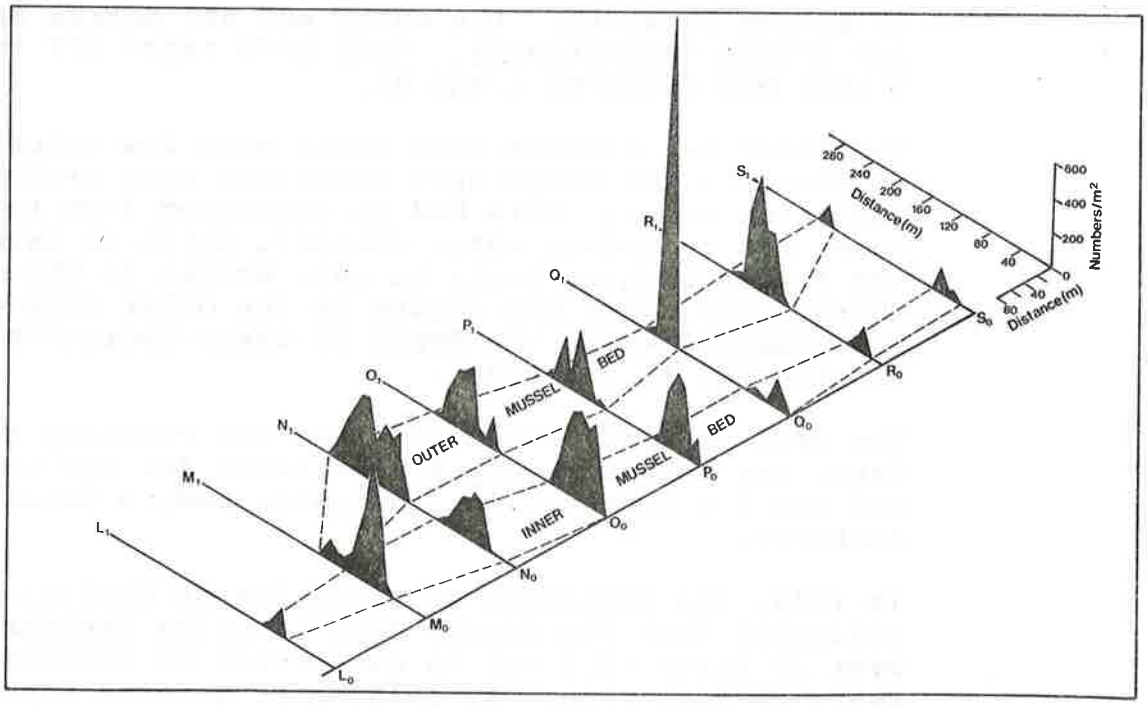

Fig. 4: Distribution of mussels in February 1979

If the 1930 estimate of the extent of the beds is accurate, then the present extent of the beds could be similar to that occurring in 1929, when 100 tons of mussels were reported to have been harvested.

3.2 Abundance

The distribution of abundance of mussels in the two surveys are shown in Figures 3 and 4.

In order to make estimates of the total number of mussels present, it was necessary to assume that the distribution of mussels between transects was similar to that measured on the adjacent transects. The data was treated as "stratified", where each bed/transect combination is a single stratum.

The estimate for total numbers on a transect across a bed is

$$q. \sum_{i=1}^{n} x_i$$

where q is the fraction of the area sampled, i.e. (distance between transects multiplied by distance between samples) divided by sample size;

n is number of samples; and

x_i is the number of mussels in the ith sample.

Bed estimates are the sums of their component bed/transect estimates, and the bed estimates can be summed to give an overall estimate.

The standard formula for sample variance (s^2) was applied separately to each bed/transect combinations. Thus the variance of the number estimate is

$$q^2. n. s^2$$

Variance of bed estimates are the sums of the corresponding $q^2. n. s^2$ variance estimate terms, and the bed variance estimates can be summed to give an overall variance.

In December only Transects M to R were surveyed. As large numbers of mussels were found at both M and R, it was assumed that the mussel beds could be more extensive, therefore the February survey was extended by adding Transects L and S.

As the December survey was incomplete the total numbers of mussels for this survey could not be estimated. However, there is sufficient data to compare population estimates for Transects M to R

of the inner bed. The estimated number of mussels for these transects in December was 8.62 ± 1.61 million, and for February 8.91 ± 1.51 million (Table 1). These estimates are not significantly different. No such comparison can be made for the outer bed as the data is incomplete for December.

For February a complete set of data was obtained so bed population estimates could be made. These estimates were 9.21 ± 1.52 million for the inner bed, and 11.51 ± 2.69 million for the outer. The sum of these bed estimates give a total population estimate of 21.2 million.

By inspection of Table 1 it would seem reasonable to assume that the total number of mussels were similar in each survey.

Table 1: The total number of mussels from all 0.5 m^2 sampling sites on each transect, and the population estimates derived from them

	December		February	
Transect	Inner	Outer	Inner	Outer
L	*	*	122	0
M	956	159	836	92
N	219	1534	604	1349
O	487	723	1263	728
P	1631	*	726	442
Q	267	*	132	1210
R	31	657	104	953
S	*	*	210	57
Transect M to R population estimate x 10^6	8.62	-	8.91	-
Standard error x 10^6	±1.61	-	±1.51	-
Bed population estimate x 10^6	-	-	9.21	11.51
Standard error x 10^6	-	-	±1.52	±2.69

* denotes not sampled

3.3 Weight

The live weight of mussels for all samples was measured for both December (Fig. 5) and February (Fig. 6). In general the distribution of live weight followed the pattern observed for the distribution of numbers.

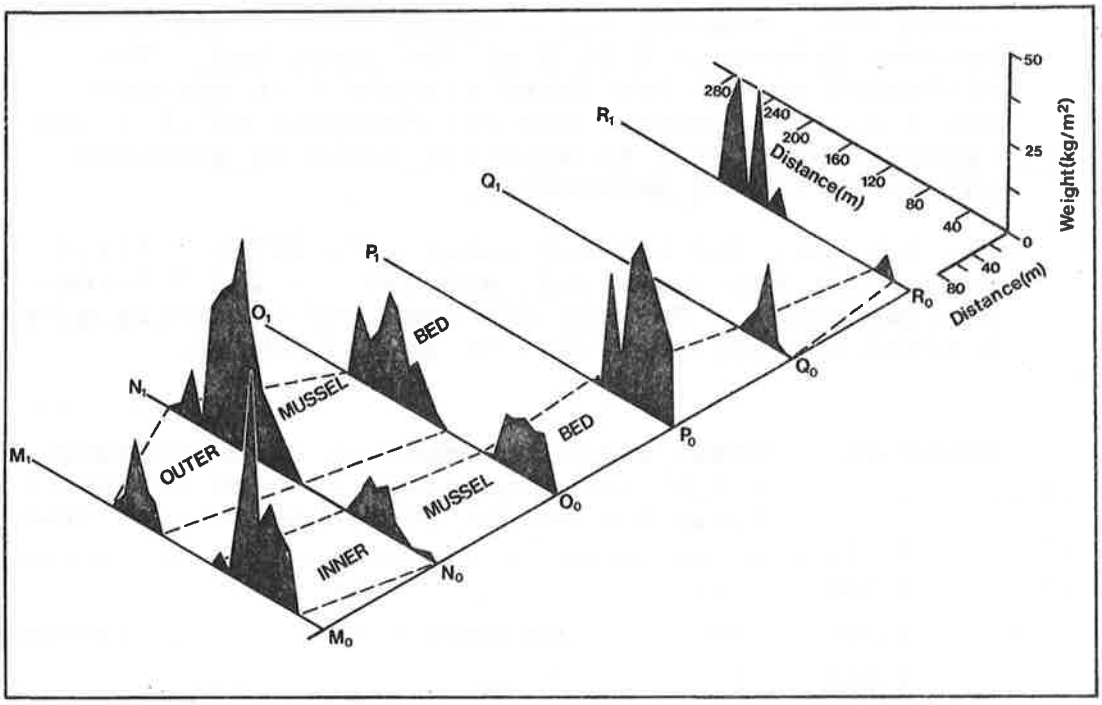

Fig. 5: Distribution of the weight of mussels in December 1978

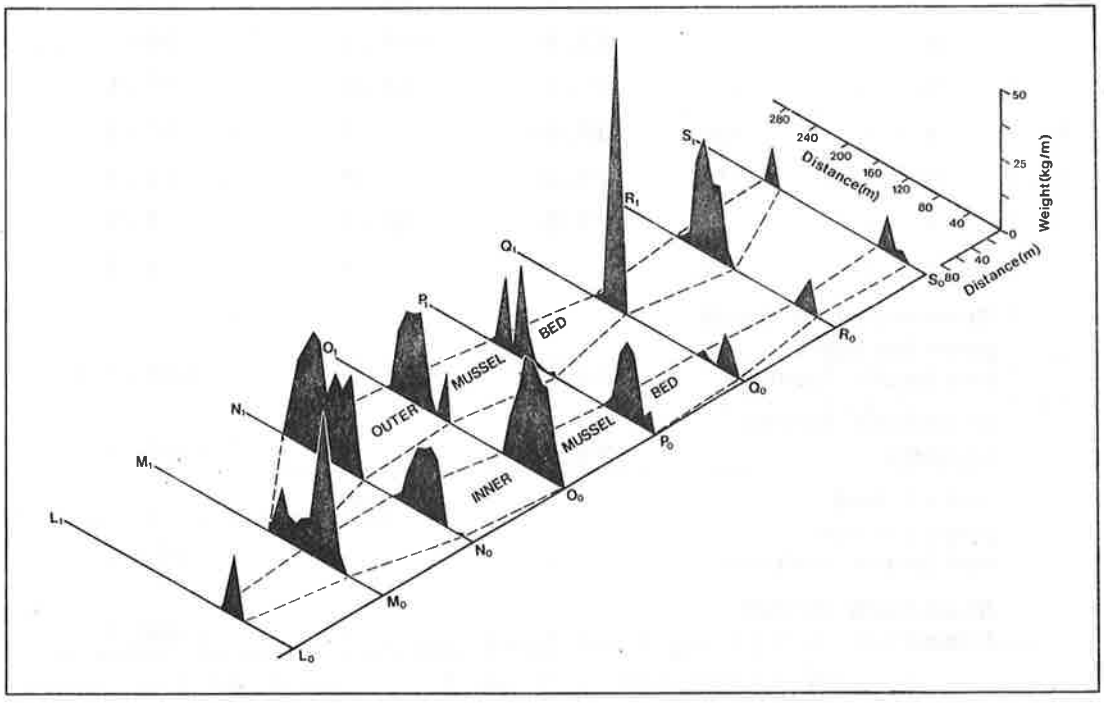

Fig. 6: Distribution of the weight of mussels in February 1979

In order to make estimates of the total weight of mussels present, it was necessary to assume that the distribution of weight of mussels between transects was similar to that measured on the adjacent transects.

The estimates of population weights and their variance were calculated in the same way as for numbers (refer Section 3.2).

As explained in Section 3.2 the December survey was incomplete, however again comparisons could be made between Transects M to R of the inner bed. The estimated weight for these transects in December was 672.2 ± 94 tonnes, and for February 687.6 ± 100 tonnes (Table 2). No estimate could be made for the outer bed in December.

For February the bed estimates were 742.6 ± 104.7 tonnes for the inner bed, and 955.7 ± 161.7 tonnes for the outer. The sum of these bed estimates gives a total population weight of 1698.3 tonnes.

Table 2: Total weight of mussels in kilogrammes from all 0.5 m^2 sampling sites on each transect, and the total bed weight estimates derived from them

	December		February	
Transect	Inner	Outer	Inner	Outer
L	*	*	13.7	0
M	89.4	23.8	66.0	15.2
N	22.8	144.1	55.1	134.3
O	37.0	69.5	97.4	74.6
P	108.7	*	45.3	39.0
Q	19.1	*	12.3	71.3
R	3.1	47.7	9.9	56.5
S	*	*	9.7	7.3
Transects M to R population estimate tonnes	672.2	-	687.6	-
Standard error tonnes	±94.0	-	±100.0	-
Total bed population estimate tonnes	-	-	742.6	955.7
Standard error tonnes	-	-	±104.7	±161.7

* denotes not sampled

3.4 Length Frequency

During the course of the surveys 8734 mussels were measured.

Length frequency distributions are shown for both December (Fig. 7) and February (Fig. 8). Mean lengths and standard deviations were calculated for this data (Table 3).

Table 3: Means ($\bar{x}$) and standard deviations (σ) of the length frequency distributions (n = number measured)

Transect	December			February		
	n	$\bar{x}$	σ	n	$\bar{x}$	σ
Inner Bed						
L	*	-	-	75	118.9	9.77
M	529	102.3	13.69	490	104.2	11.42
N	194	110.9	14.89	280	110.4	19.92
O	320	97.9	14.00	622	102.4	9.53
P	1104	88.7	17.58	396	95.4	12.10
Q	254	99.7	16.15	70	110.9	8.68
R	31	112.6	5.85	49	111.4	7.13
S	*	-	-	79	104.7	16.50
Outer Bed						
L	*	-	-	0	0.0	0.00
M	103	126.9	11.62	44	125.8	6.24
N	786	109.4	10.45	703	112.7	9.64
O	363	111.4	10.37	355	112.5	10.53
P	*	-	-	325	107.4	11.51
Q	*	-	-	632	98.6	9.65
R	424	98.8	13.27	469	101.5	11.94
S	*	-	-	33	119.9	10.05

*denotes not sampled

The mean lengths ranged from 88.7 to 112.6 mm for the inner and 98.8 to 126.9 mm for the outer bed in December. In February the mean length ranged between 95.4 and 118.9 mm for different transects of the inner bed and 98.6 to 119.9 mm for different transects of the outer bed.

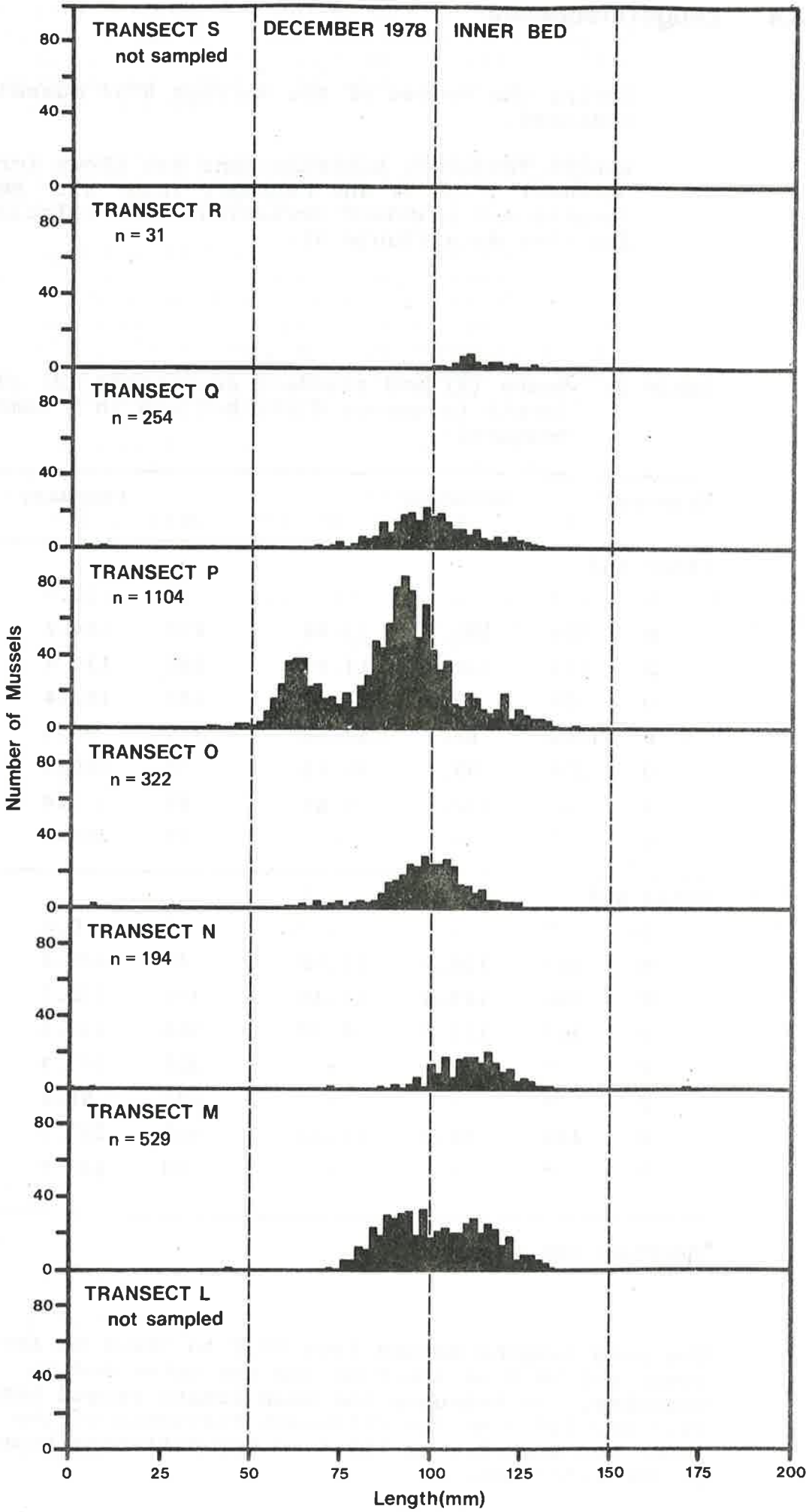

Fig. 7: Length frequency distribution of mussels in December 1978

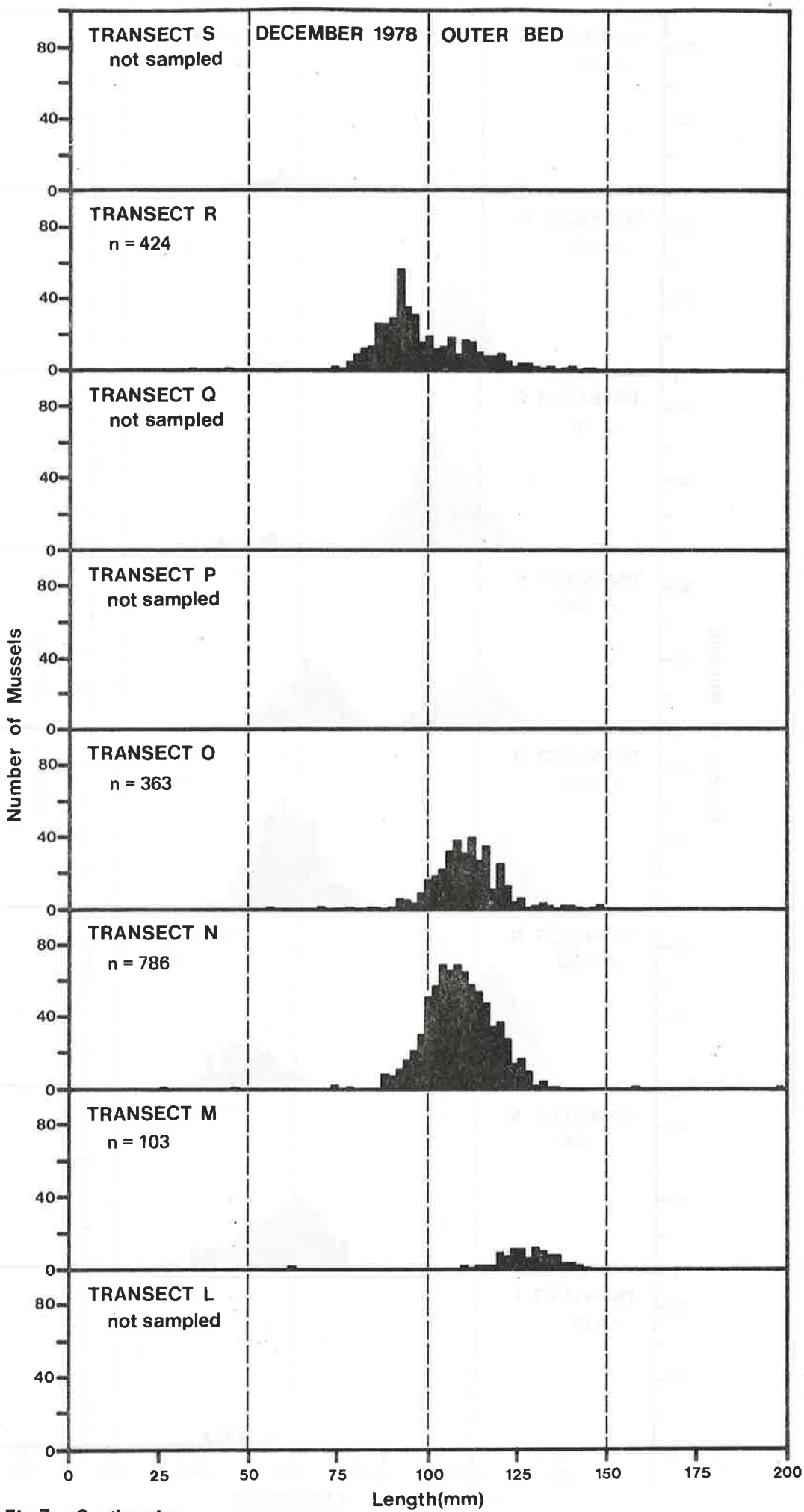

Fig. 7: Continued

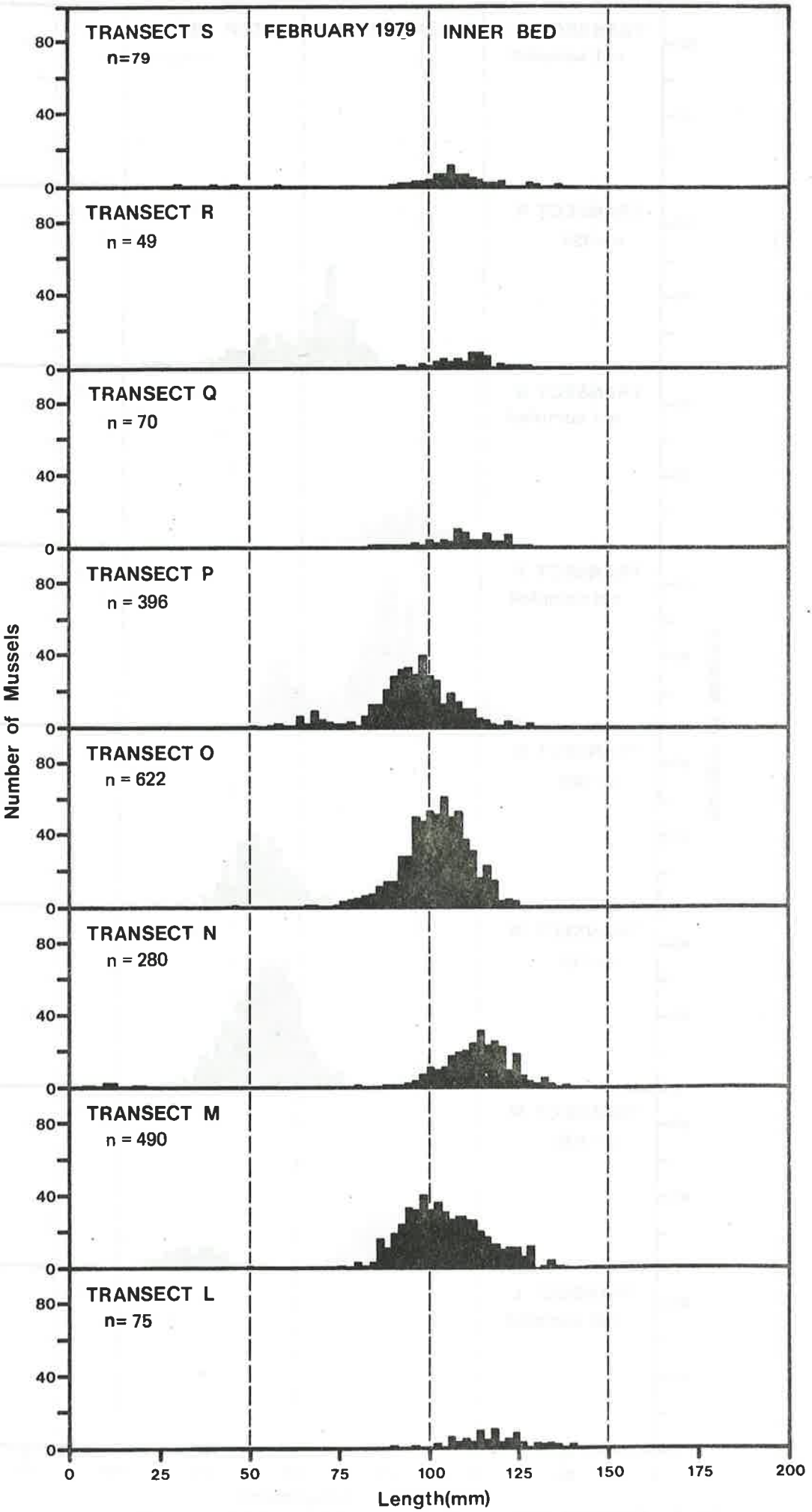

Fig. 8: Length frequency distribution of mussels in February 1979

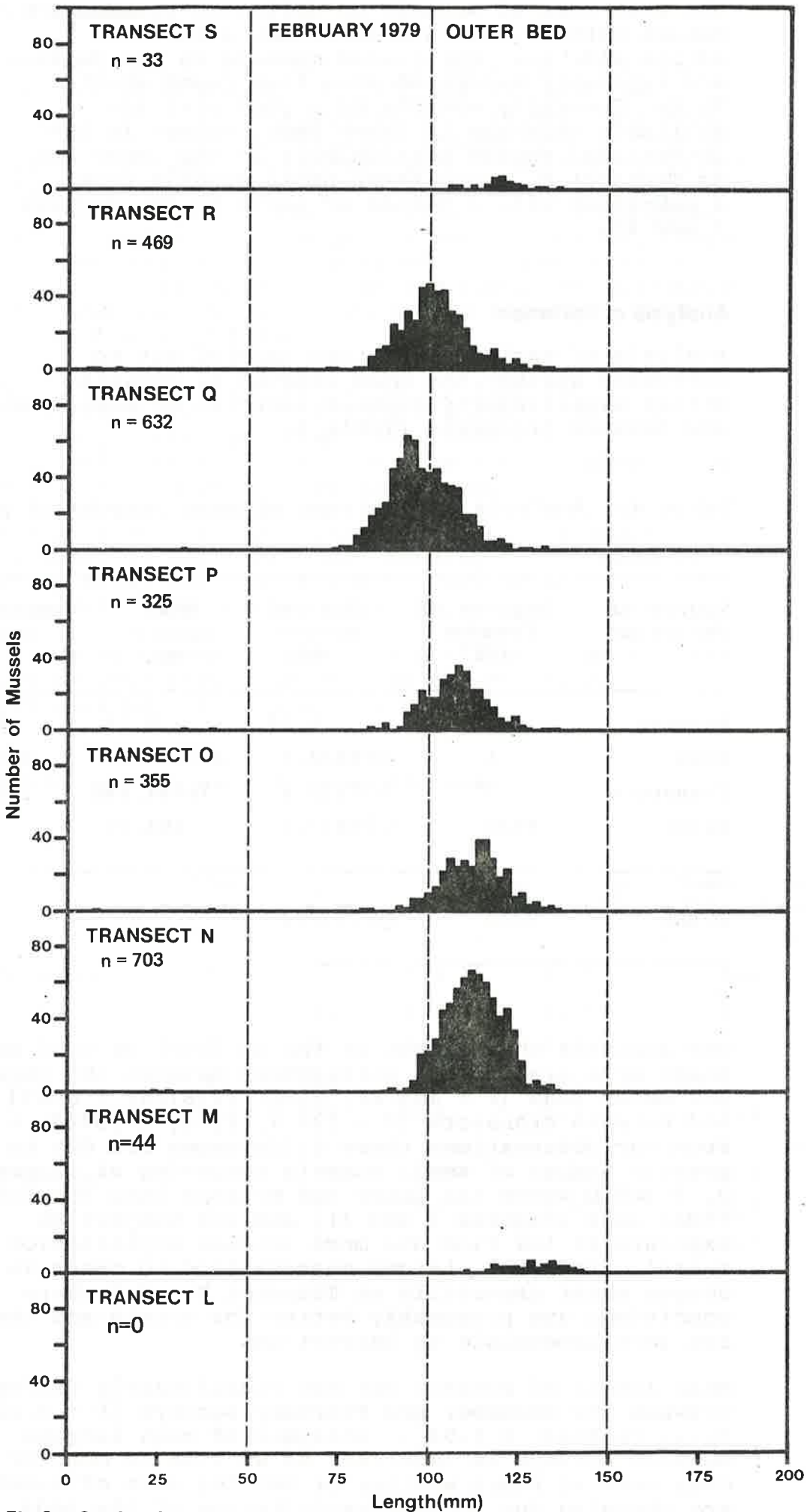

Fig. 8: Continued

The mean size of mussels on different transects ranged between 88.7 and 126.9 mm, a suitable edible size i.e. cultivated mussels in New Zealand are typically harvested when they reach about 90 mm. Generally mussels of a good size are available anywhere in these beds, except in the inter-tidal region particularly in the inner bed of Transect P, where these small mussels form a sub-group with a median of about 65 mm (Figures 7 and 8).

Analysis of Variance:

Analysis of variance was then carried out to determine whether the mean lengths of mussels differ significantly between surveys, between beds, and between transects (Table 4).

Table 4: Analysis of variance of mean lengths of mussels

Source of Variation	Degrees of Freedom (df)	Sum of Squares (SS)	Mean Square (MS)	Computed F Value
Surveys	1	0.24	0.24	0.0004
Beds	1	299842.2	299842.2	495.81
Transects	7	537212.8	76744.686	126.9
Error	8724	5275877.1	604.75	
TOTAL	8733	6112932.3		

The analysis showed that at the 1% level of confidence there were significant differences between the inner and outer beds [$F = 495.81$, $F_{0.01}$ (1,8724) = 6.63] and between transects [$F = 126.9$, $F_{0.01}$ (7,8724) = 2.64]. From our observations these differences are due to a greater number of small mussels occurring at Transects O, P and Q where the inner bed extends into the inter-tidal zone (Figures 3 and 4), and are subject to exposure at low tide and more intense exploitation by mussel gatherers. Larger mussels tend to occur in the deeper water especially at Transect N and O where conditions are presumably better for growth and they are less accessible to harvesting.

Mean length of mussels was not significantly different between the December and February surveys [$F = 0.0004$, $F_{0.01}$ (1,8724) = 6.63]. Analysis of mean lengths between surveys is important as we wish to monitor over several years whether or not the size of mussels are changing due to over-exploitation of the beds.

Size Classes:

Size frequency distribution is analysed to allow monitoring of trends in exploitation rate and stability within the population. If only one size class is present it probably indicates that only a single settlement of mussel larvae has occurred, and that the bed may collapse as the population dies or are fished out and are not replaced. On the other hand, if a number of size classes is present, there is a greater chance of a stable population as it indicates that there has been a number of settlements of young mussels in the past, and hopefully this pattern will continue.

Inspection of the size frequency distribution (Figures 7 and 8) identified few distinct size classes, apart from some exceptions e.g. Transect P of the inner bed from the December survey where three size classes are apparent.

Analysis of size frequency distributions using probability paper methods (Harding, 1949; Cassie, 1950, 1954) was used for both surveys to elucidate size classes (Fig. 9).

Following the method of Cassie (1954) these figures can be interpreted to provide the following analysis of size classes (Table 5).

Table 5: Analysis of size classes

	Size Class	$\bar{x}$	σ	Percentage of Total	Number in Size Class
December	1	6	1.5	0.16	6.6
	2	41	11.5	0.24	9.9
	3	62	5.0	6.1	205.6
	4	104	13.0	93.4	3836.9
	5	173	29.0	0.1	4.1
February	1	9	3.0	0.25	11.6
	2	36	12.5	0.4	18.5
	3	72	7.0	1.35	62.5
	4	105	10.5	98.0	4533.5

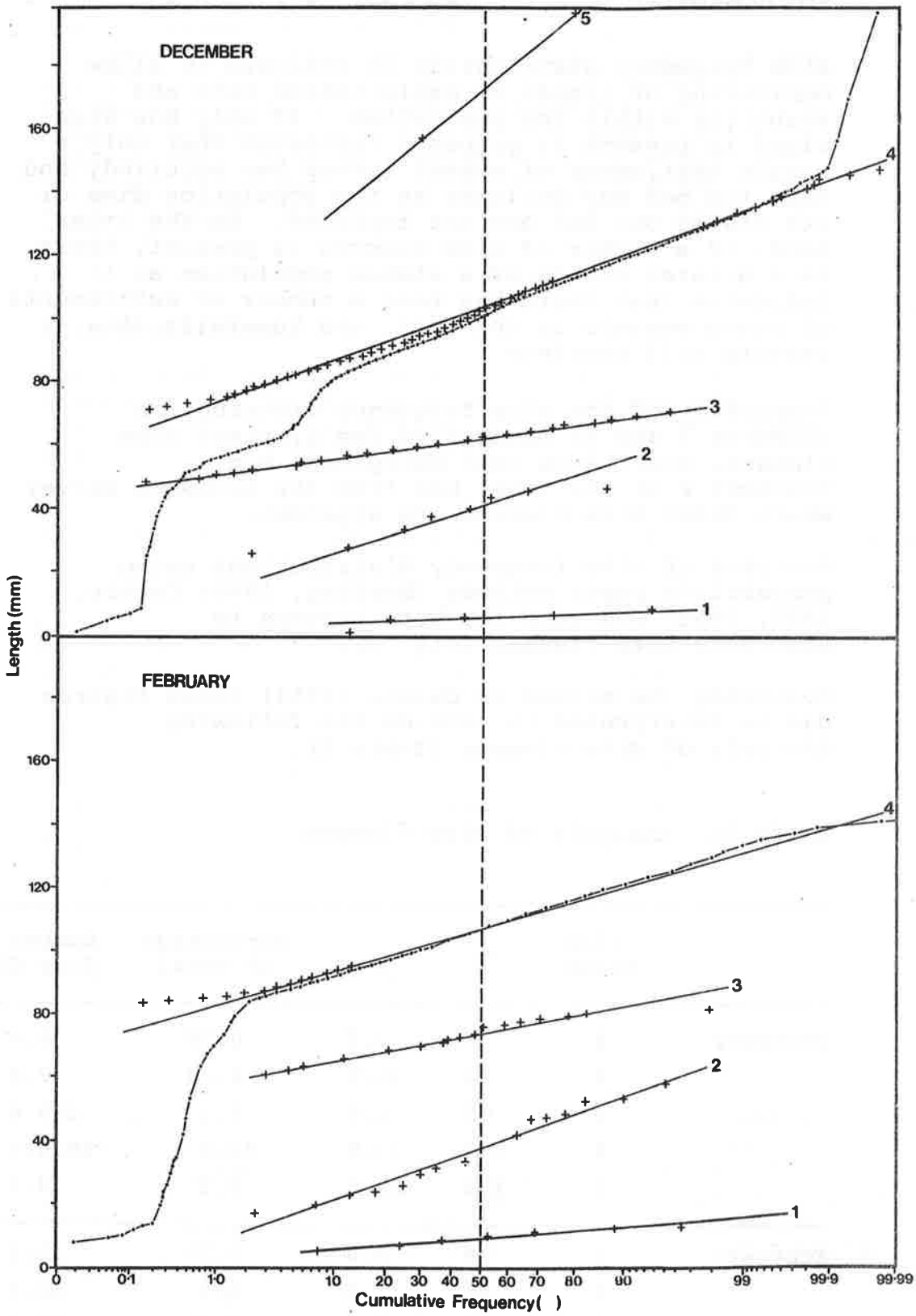

Fig. 9: Cumulative percentage length distribution of mussels

From the December data five size classes were recognised (Table 5). There is a large difference in mean size of mussels between Size Classes 4 and 5 and therefore it is probable that at least one size class of mussels is not represented in our data.

In both surveys the majority of the mussels occur in one size class. In December 93.4 percent of the population of mussels occurred in Size Class 4 with a mean length of 104 mm, and in February 98 percent occurred in Size Class 4 with a mean length of 105 mm. In both surveys the percentage of small mussels was low. This may be due to poor recruitment in the past year. However, this may not be a cause for concern as larval recruitment in New Zealand is known to vary greatly from year to year.

It may also be due to the difficulty of finding very small mussels as they are often hidden amongst the algae, hydroids, and byssus threads of the larger mussels collected in our samples.

Recognition of separate size classes may also be hampered by overlapping of size classes. One factor observed that would cause overlapping of size classes was the stunted growth of the mussels commonly found in the intertidal region. These mussels have growth checks in their shells which tend to show up as marked deformities inferring a greater age than their length indicates.

Growth Rates:

The interpretation of size classes and the size frequency distributions have proved difficult because we do not have any information on growth rates of mussels in Ohiwa Harbour. Growth rate studies are being carried out which should allow interpretation of data from future surveys.

3.5 Future Surveys

The February survey data provides a baseline for future surveys. Many of the sampling problems that occurred in the December survey have been overcome.

Future surveys will be carried out so that the level of exploitation of the beds can be assessed and to evaluate possible management options.

4. Summary

In November 1978, a diving survey established the general area of mussel beds in Ohiwa Harbour. The location, area of beds, numbers and weight of mussels in the two main beds were investigated in December 1978 and February 1979.

The two main beds occur near the distal end of the Ohope Spit. The beds run parallel to the tidal flow in the channel, with the inner bed extending out from about mean low water of Ohope Spit shoreline and the outer bed occurring further out in the middle of the channel. The inner bed is estimated to be 4.9 ha in area and the outer bed 4.4 ha. Mussels form an almost continuous cover within these beds.

The population was estimated at 9.21 million mussels for the inner and 11.51 million for the outer bed in February. The corresponding population weights were estimated to be 742.6 tonnes and 956.7 tonnes. During the surveys the lengths of 8734 mussels were measured. From this data the mean lengths of mussels were calculated for each transect; they ranged from 88.7 to 126.9 mm.

No significant difference in mean length could be demonstrated between the December and February surveys, but there were significant differences between the inner and outer beds, and between transects.

Size classes generally proved difficult to recognise using length frequency histograms but by using probability paper methods five size classes could be distinguished in December and four in February. The majority of mussels however, occurred in one size class in both surveys. Comparatively few small mussels were found.

The two main mussel beds in Ohiwa Harbour cover an extensive area, 9.3 ha, and support a large population estimated to be about 21 million mussels. The majority of these mussels are of a suitable edible size.

Further surveys are required to determine growth rate, recruitment, stability of the mussel beds over a longer period of time and to evaluate possible management options.

5. Acknowledgements

We wish to thank many of our colleagues who assisted with the field work.

Special thanks to M. Jorgenson for computer analysis of the data, and S. Williamson and M. Williams for preparation of the illustrations.

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