Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 89/ 70

CSCPCA Document de recherche 89/ 70

PRELIMINARY SURVEY OF SUBTIDAL MUSSEL RESOURCES IN SOUTHWESTERN NOVA SCOTIA

by

G. J. Sharp[1],T. Amaratunga[2] and D. M. Tremblay[3]

Benthic Fisheries and Aquaculture Division[1,3]
Biological Sciences Branch
Halifax Fisheries Research Laboratory
Department of Fisheries and Oceans
Scotia-Fundy Region
P. O. Box 550
Halifax, N. S.
B3J 2S7

Northwest Atlantic Fisheries Organization[2]
P.O.Box 638
Dartmouth,N.S.
B2Y 3Y9

ABSTRACT

A preliminary survey of subtidal mussel (Mytilus edulis L.) resources in southwestern Nova Scotia, in Lobster Bay and St. Mary's Bay indicates that while there was no such resources in St. Mary's Bay, commercially harvestable beds were found at the lower limit of Laminaria distribution in Lobster Bay. The mussel biomass of the south section of St. Ann's Shoal was conservatively estimated at 2,000 to 3,500 t. There is a large variation in size frequencies despite the relatively small geographical area.

High lobster fishing effort takes place in and around the mussel bed. Mussels play an important role in the lobster diet. The study shows that there is no significant by-catch or direct injury of lobsters in the present mussel fishery.

Between June and October, the exploratory fishery caught 41 t of mussels. Catch-rates fluctuated widely at approximately 45 kg / min (±.41). The optimum fishing depth was 15 - 16 m.

RESUME

Un inventaire préliminaire des ressources infralittorales de moules bleues (Mytilus edulis L.) dans le sud-ouest de la Nouvelle-Ecosse, dans la baie Ste-Marie et Lobster Bay indique qu'une telle ressource n'existe pas dans la baie Ste-Marie mais que des quantités commerciables étaient présentes à la limite inférieure de la distribution des Laminaires dans Lobster Bay. On a estimé d'une façon conservative la biomasse de moules de la section sud du St. Ann's Shoal à 2,000 - 3,500 t. Il y a une grande variation de fréquences de taille malgré une aire géographique relativement petite.

La moulière et ses environs font l'objet d'une pêche au homard intensive. Les moules jouent un rôle important dans la diète des homards. L'étude montre que la pêche aux moules ne cause pas de mortalité induite importante ou de blessures directes chez le homard.

Entre Juin et Octobre, la pêche exploratoire fut de l'ordre de 41 t. Les taux de capture ont fluctué beaucoup, aux alentours de 45 kg / min (± 41). La profondeur de pêche optimale était entre 15 et 16 m.

INTRODUCTION

The exploitation of natural subtidal Mytilus edulis Linn. stocks is an established industry in Europe and the USA. Landings in eastern USA have been mainly from Maine (13,000 t in 1978, Chalfant et al,1980) which borders with southwestern Nova Scotia (SWNS) on a common body of water, the Gulf of Maine. Although there has been a decline in the US landings, several European fisheries have demonstrated that a sustained yield is possible over the long term (Dare, 1973). The mussel beds near Conway, Wales, in western England have yielded 300 - 600 t annually for more than 20 years without enhancement. Limfjord in Denmark has yielded 23,000 to 44,800 t annually over 15 years of harvesting (Munch-Petersen and Kristensen,1987).

Until recently the gathering of wild mussels in Nova Scotia has been largely recreational, while small commercial operations using rakes or tongs produced less than 10 t annually. Recent increases in demand for mussels has stimulated interest in the harvest of wild mussels. Entrepreneurial fishermen now apply for fishing licenses to exploit locally known populations. One exploratory mussel dragging license was issued for areas around Lobster Bay, N.S. and an exploratory commercial operation was underway in the summer and fall of 1988.

Although intertidal and subtidal biological studies have noted the ubiquitous nature of M.edulis, no information is available on the extent or nature of subtidal mussel beds in SWNS. Early studies focused on intertidal populations and their individual rates of growth (Mossop,1921 and 1923).

The purpose of this study was to provide preliminary information on the extent, distribution, biomass, density, population structure and some environmental characteristics of subtidal mussel beds in a selected area in SWNS. The 1988 exploratory fishery is also described with notes on the catch characteristics.

METHODS

A survey was completed consisting of two legs. The first was performed in Lobster Bay, Yarmouth Co., N.S. on the C.F.V. "Lady Danielle" in July 1987, and the second in St. Mary's Bay and Lobster Bay on the R.V. "J.L.Hart" in August 1987 (Figs 1 & 2). Four stations at Ram and Rankin Islands in Lobster Bay were selected in 1988 as sites for recruitment studies (Fig 3).

The first leg was focused on those areas known by observations of the nearshore trawl and lobster fishermen to contain mussel beds. The limits of mussel beds were located by towing an underwater T.V. camera (Lobsiger Assoc. Ltd) mounted on a benthic sled. Due to the poor resolution of the camera and low water clarity, 0.1-m^2 Petersen grab samples were periodically taken and spot dives were made at some stations (Figs 2 & 3). Biomass and density data were derived from grab samples and scuba diving samples. The dive sampling consisted of collecting mussels from 0.25-m^2 quadrats at 2-m intervals along an arbitrarily laid 25-m transect across a known area of mussel concentration.

All samples were cleaned of extraneous material, mussels were counted and total weight recorded. Where possible, shell height, length, width, meat weight and shell weight were taken from all mussels. When samples were large, a random subsample of >200 animals was taken.

At Ram and Rankin Islands, divers subjectively placed quadrats in areas containing mussels to sample for recently settled mussels. These sample areas were suctioned (air lift) prior to hand collecting the mussel clumps to insure removal of the smallest animals. In the laboratory the bagged samples were washed through a sieve series of 20 mm to 0.5 mm mesh. Observations of substrate type, macrophyte cover and lobster density were noted on each transect.

On three sled transects,divers held on to the sled and signaled to the surface via T.V. the number of lobsters observed in the path of the sled and noted the substrate type periodically. Station locations were fixed by radar ranges on land masses, depth soundings and Loran C readings.

In 1988, a survey of Lobster Bay was conducted by the Geological Survey of Canada using a sidescan sonar and profiler. Several parts of the cruise track were directed over or near mussel beds identified in our 1987 survey. Details of substrate type, bottom relief and depth were interpreted in 150-m swaths located by Loran C and radar fixes.

Temperature records were based on Ryan recorder placements near two subtidal mussel beds (Pubnico Harbour entrance and Rankin Island). Current measurements were made with a newly developed rotar vane meter placed in the tidal channel of Rankin Island.

RESULTS

Distribution

No subtidal M. edulis beds were located in St. Mary's Bay. The horse mussel Modiolus modiolus however was distributed throughout the Bay in densities of 3 - 10 individuals m^{-2} in and at the edge of kelp beds from 5 to 20 m depth. The Petersen grab was ineffective in this area due to the low density of animals and the predominating bedrock and boulder substrate.

In Lobster Bay, commercially harvestable beds of M. edulis were located at the lower limit of Laminaria distribution from 10 to 16 m deep on gravel, shell, sand and cobble substrates. The most extensive beds were located on shoals within this depth range having a relatively homogeneous substrate. The largest of these beds was 1 km by 1.6 km at the south end of St. Ann's Shoal (Fig 2). Side scan sonar interpretation identified patchy gravel and scattered boulders in the area of the mussel beds (Fig 4). Mussel beds occur at the edge of most kelp beds in Lobster Bay. These beds rarely exceed 100 m in width. Within the kelp beds of Lobster Bay, M.edulis was the dominant sessile invertebrate. These areas, however, are inaccessible to harvesting gear because of the kelp stands and the substrate usually consisting of exposed bedrock or loose boulders.

Open water sites off the mouth of Pubnico Harbour are areas of vigorous tidal mixing. The temperature at 11 m depth ranges from a low of 0° C in winter to a high of 16° C in summer; maximum degree days are reached in September and total 2,676 for the year (Fig 5A). In the more sheltered and estuarine waters of Rankin Island the pattern of degree days is similar but reaches a higher yearly total of 2,924 (Fig 5A).

Although the area of St. Ann's Shoal and Ram Island can be considered to be exposed to waves, the mussel population is 10 m or deeper and receives very little wave action except in cases of extreme storms. Tidal currents are the principle source of water movement. In the area of St. Ann's Shoal currents at the mussel bed rarely exceed 0.2 m sec^{-1} and is evidenced by mussels requiring very light byssal attachment. At the tidal channel station (Rankin Island), currents reach 0.4 m sec^{-1} on an outgoing tide and are less than 0.1 m sec^{-1} on incoming tides (Fig 5B). Animals in this area of higher currents are partially buried in soft sediments.

Biomass and Density

A comparison of samples taken with the Petersen grab and those sampled by divers showed that the grab recovered proportionately fewer and larger mussels (Table 1). The grab frequently encountered small rocks and cobbles which prevented proper closure of the jaws. This decreased the sampling area to samples with mud and shell substrates The small area the grab sampled also led to an over-estimation of densities when compared to the dive samples. The grand mean mussel density was 290 animals m^{-2} and mean biomass was 2,394 g m^{-2} for all 142 samples (excludes Ram and Rankin Islands). Dive samples from the northwest edge of St. Ann's Shoal had the greatest mean biomass in the survey (Table 1, Fig 2). Although samples were selected subjectively at Ram and Rankin Islands the mean biomass and density fell within the range of maximum values reported from the 1987 survey. Variation was high (± 70-90% of mean values) at most stations indicating patchy distribution on a micro-geographical scale. However,the biomass of the south section of St. Ann's Shoal (1.6 km^2) was conservatively estimated at 2,000 to 3,500 t using stations on the Shoal.

Population Structure

The size frequency distribution (shell length) of M. edulis in most samples was unimodal, the mode being above 40 mm (Fig 6). The exceptions were the south end of St. Ann's Shoal, stations 2 and 3, and inside of the kelp bed, station 10a (Figs 6 & 7). Dive samples tended to have a lower mode than grab samples. Insufficient numbers of animals were available from stations 6,7 and 8 to plot size frequencies.

Dive samples taken from the center, edge and outside of the Ram Island kelp bed show the shift of size modes from the small animal inside the bed to the largest at a distance of 80 m outside (Fig 7). Mussels in the tidal channel of Rankin Island (Station 9) exceeded 60 mm mean shell length.

In addition to being separated geographically, the two stations selected for determination of shell and meat weight relationships were also seasonally separated; station 1 was sampled in May while station 4 was sampled in July. Shell length to shell weight relationships were similar at these two stations (Fig 8A). Shell length to meat weight and shell weight to meat weight were greater in May than in July (Figs 8B & 8C).

Lobsters

Aerial photography of trap buoys indicates that high fishing effort occurs in and around the mussel beds (Fig 9). Trap buoy density ranges between 200 to 600 traps km^{-2} (Sharp,unpublished data). Lobster density on 6x25-m transects in mussel beds averaged 2 individuals per 50 m^2. The animals were most commonly found under the edge of the largest rocks on the transect. Observations from three runs of the camera sled (assuming a swath of 2.5 m) resulted in a count of one lobster over 75 m^2, 80 m^2, and 25 m^2 respectively.

Characteristics of the fishery

Mussels were fished from a 13-m Cape Island style vessel of 14 gross tons powered by a 240 H.P. diesel engine and rigged with a drum winch and davit frame. A Maine-type mussel drag was tested for the first 2 days of the fishery but was found too cumbersome and dangerous to handle. The gear used for the rest of the season was an aluminum box drag, 1.8 m by 0.5 m with sled runners attached to a 2-m bag of 5-cm mesh (Fig 10). Three chains preceded the net bag to lift mussels off the bottom and to dump any boulders in the drag path. The drag was towed for 2 to 6 min at approximately 2 km hr^{-1}. The drag moved on top of the substrate riding over most obstacles and removing mussels in clumps in its path. Divers observed lobsters escaping from the path of the drag and boulders dropping between the chains. No lobsters were captured while observers were aboard the vessel (6 tows) or during direct observations of the drag. Three lobsters were captured in 3 tows near the northern edge of St. Ann's Shoal in an area of boulder bottom.

Although some exploratory towing was done north and south of the mapped mussel bed, the majority of tows (21) was concentrated within a 1.6 km^2 area with a catch of 40.73 t between June and October. Catches averaged 159.0 ± 161.4 kg per tow and 44.8 ± 40.8 kg per minute. Depth was related to the catch rate, 15 -16 m being the optimum (Fig 11a). CPUE fluctuated greatly during the exploratory phase of this fishery as it peaked at 22 t and leveled off after 25 t (Fig 11b). The total area swept by the gear was estimated at 34,320 m^2, 0.2% of the mussel bed. Exploratory tows yielded 181.3 kg in 9 tows.

The size frequency of animals in the catch was consistent during the fishery on the main bed with a mode at market size of 50 mm (Fig 12). The gear was not selective due to the clumping habit of the mussels.

DISCUSSION

Although only one mussel bed has been delimited and biomass estimated, other significant beds exist in Lobster Bay as indicated from our 10 sampling stations. The biomass density of subtidal M. edulis in Lobster Bay is low (2.4 kg m^{-2}) in comparison to the White Sea (USSR) 2.2 - 10.4 kg m^{-2} (Oshurkov and Lukanin, 1982) and the Danish Wadden Sea 9.8 - 19.7 kg m^{-2} (Munch-Petersen and Kristensen, 1987). The lack of homogeneity in substrate type may explain the patchiness of the bed and the lower overall densities in Lobster Bay since in areas of 100% coverage by mussels, biomass reached reported White Sea levels. The only other benthic survey in this area listed filter feeding biomass as dominated (78 - 88%) by M.edulis and M.modiolus (Michaud,1986). M.modiolus appeared only infrequently in our samples but was common in the immediate subtidal (<5m) depth.

The dramatic differences in size frequencies within a relatively small geographical area is not uncommon for M.edulis (Bayne,1976). Mortality, recruitment and growth rates have all been shown to vary greatly with small changes in macro and micro-habitats.

If spat fall is a generally reliable annual event, survival to the second year is low. A first year mortality rate for Danish mussels was 0.68 (Thiesen,1968). Preliminary results of our spat monitoring and recruitment suggest that survival beyond the 5-mm size group is low. Storm induced mortality of adults as described for very wave exposed populations (Witman, 1987) is unlikely to be a factor for all our stations except the kelp bed station 10a. The presence of very large "old" animals in the deeper beds or in sheltered tidal channels and very weak byssus attachment suggest that water movement is not an important factor in mortality. Mussels are the most consistent prey species for lobsters in SWNS based on studies of stomach contents (Elner and Campbell, 1987). Ecological studies in Lobster Bay noted predation on "small" sizes of mussels by lobsters (Michaud, 1986). The landings of lobster in SWNS exceed 2,000 t annually and mussel beds are a part of the active fishing zone suggesting lobster predation is significant. Eight other predators of mussels including crabs, starfish, and gastropods were identified in Lobster Bay (Michaud, 1986).

The fishery did not impose any significant mortality on the major mussel bed. The area swept by the gear was 0.2% of the bed area and the catch was 1.0 to 0.5% of the estimated biomass.

Information on growth rates of M. edulis from the Bay of Fundy is restricted to one study (Mossop, 1923). There was a wide range of growth for the population but unfortunately, no length at age was reported. The growth rates of "subtidal" animals peaked in "age" two at 13 mm and by addition, an age 4+ mussel is 40 mm. However, the range of increments was wide, being 3 - 23 mm for ages 2 and 3. Preliminary aging results from our samples using internal lines show animals 50 - 60 mm being 5 to 6 years old and agree with this study. Application of the von Bertalanffy equation to Mossop's data resulted in L infinity and k values similar to other temperate populations (Table 2). These values are also consistent with the number of annual degree days (2,500 - 3,000) required for animals to reach 50 - 60 mm in 5 years (Bayne, 1976).

CONCLUSIONS

A minimum of 2,000 t of Mytilus edulis biomass exists in Lobster Bay.

The exploratory fishery has been of insufficient duration and scope to conclude what level of fishing effort is sustainable in Lobster Bay.

There is no significant by-catch or direct injury of lobsters in the present mussel fishery.

REFERENCES

Bayne, B.L., 1976. Marine mussels: their ecology and physiology. Cambridge University Press, 506 p.

Chalfant, J. S. Jr., Archambault, T., and A. E. West, 1980. Natural stocks of mussels: growth, recruitement and harvest potential. In: Mussel culture and harvest: a North American perspective (ed. R.A. Lutz) Amsterdam, Elsevier Scientific Publishing Co., 350 p.

Dare, P. J., 1973. Seasonal changes in meat condition of sublittoral mussels (Mytilus edulis L.) in the Conway fishery, North Wales. ICES. C.M. 1973, Shellfish and Benthos Committee, Doc.no. K: 31.

Elner, R. W. and A. Campbell, 1987. Natural diets of lobster Homarus americanus from barren ground and macroalgal habitats off southwestern Nova Scotia, Canada. Mar. Ecol. Prog. Ser. 37: 131-140.

Michaud, B. J., 1986. Composition and production of macrobenthic invertebrate communities and food resources of the American lobster Homarus americanus along the Atlantic coast of Nova Scotia. Ph.D. thesis, Dalhousie University, Halifax, Nova Scotia.

Mossop, B. K. E., 1921. A study of the sea mussel (Mytilus edulis Linn.). Contributions to Canadian Biology : 17-48.

Mossop, B. K. E., 1923. The rate of growth of the sea mussel (Mytilus edulis L.) at St.Andrews, New Brunswick; Digby, Nova Scotia; and in Hudson Bay. Transactions of the Royal Canadian Institute,14: 3-22.

Munch-Petersen, S. and P. S. Kristensen, 1987. Assessment of the stocks of mussels in the Danish Wadden Sea. ICES C. M. 1987, Shellfish Committee, Doc.no. K: 13.

Oshurkov, V. V. and V. V. Lukanin, 1982. Sublittoral mussel settlements in the Kandalaksha Bay of the White Sea. Leningrad University (Biol.),15: 5-11.

Thiesen, B. F., 1968. Growth and mortality of culture mussels in the Danish Wadden Sea. Meddelelser Fra. Danmarks Fiskeri-og Havunder-sogelser, N.S., 6: 47-78.

Witman, J. D., 1987. Subtidal coexistence: storms,grazing,mutualism and the zonation of kelps and mussels. Ecological Monographs, 57(2): 167-187.

Table 1. Mean and standard deviation for mussel (Mytilus edulis) density and biomass (per m^2).

Station	Date	No. of samples	Mean no. of mussels	Mean wet weight of mussels
1	14/05/87	9d	115.6±75.7	2727.7±1937.0
2	01/07/87	11d	53.1±50.6	117.4±111.0
2	01/07/87	8g	662.5±1078.8	4240.4±3154.0
3	01/07/87	10d	601.6±446.6	964.5±613.6
4	02/07/87	33d	222.2±241.2	3074.2±2642.7
4	02/07/87	12g	135.0±143.8	2934.8±2949.4
5	03/07/87	24d	586.7±354.6	4681.2±3304.1
5	03/07/87	13g	483.1±412.0	3753.4±3309.9
6	03/07/87	4g	15.0±30.0	323.6±647.3
7	03/07/87	3g	96.7±167.4	1453.2±2517.0
8	03/07/87	3g	220.0±372.4	2401.4±3902.2
9 *	04 to 1088	24d	221.0±122.3	8278.4±4486.0
10a*	04 to 1088	14d	718.0±396.4	6052.1±2911.7
10b*	04 to 1088	15d	236.8±145.9	4732.9±2542.9
10c*	04 to 1088	15/14d	85.3±35.8	3551.4±1551.8

*Subjective samples
d=dive samples
g=grab samples

Table 2. Values for L infinity and k from von Bertalanffy growth equation for Mytilus edulis lowest intertidal or subtidal populations, modified from Bayne (1976).

Locality	L_{inf}	k	Study
Danish Wadden Sea	77.60	0.5611	Thiesen(1968)
Conway, Wales	74.44	0.3927	Thiesen(1968)
St. Andrews (N.B.)	68.45	0.3100	Mossop(1923)

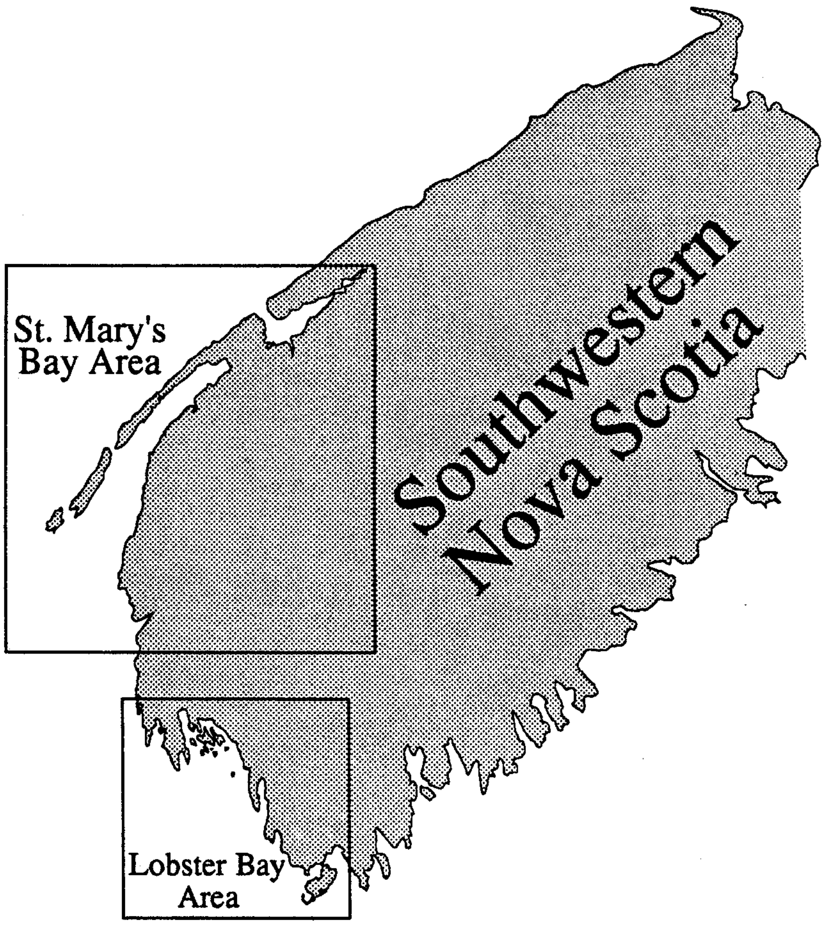

Figure 1. Southwestern Nova Scotia survey areas.

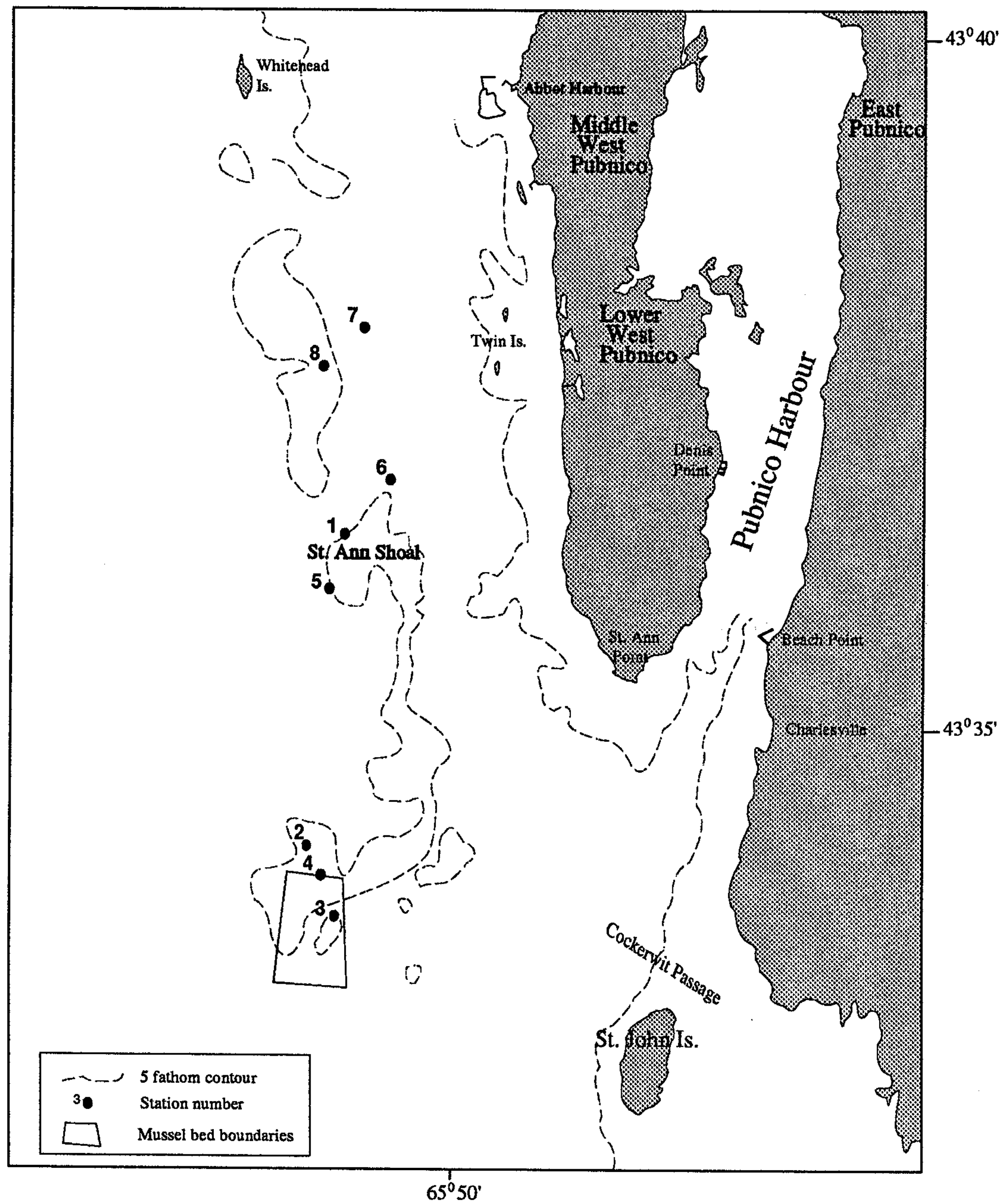

Figure 2. Location of mussel sampling stations, Lobster Bay and the limits of a commercial bed.

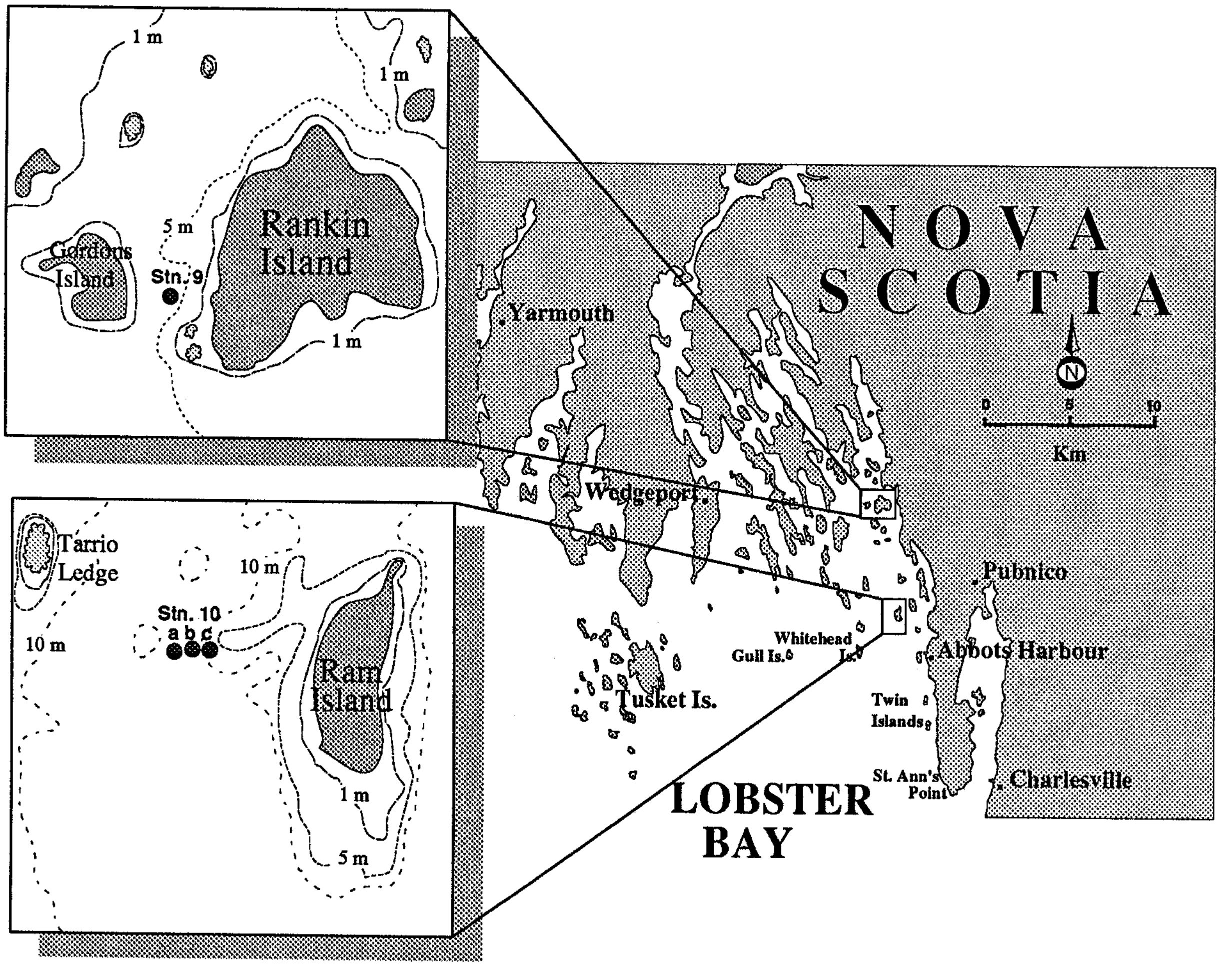

Figure 3. Location of mussel sampling stations at Rankin Island and Ram Island,Lobster Bay, N.S.

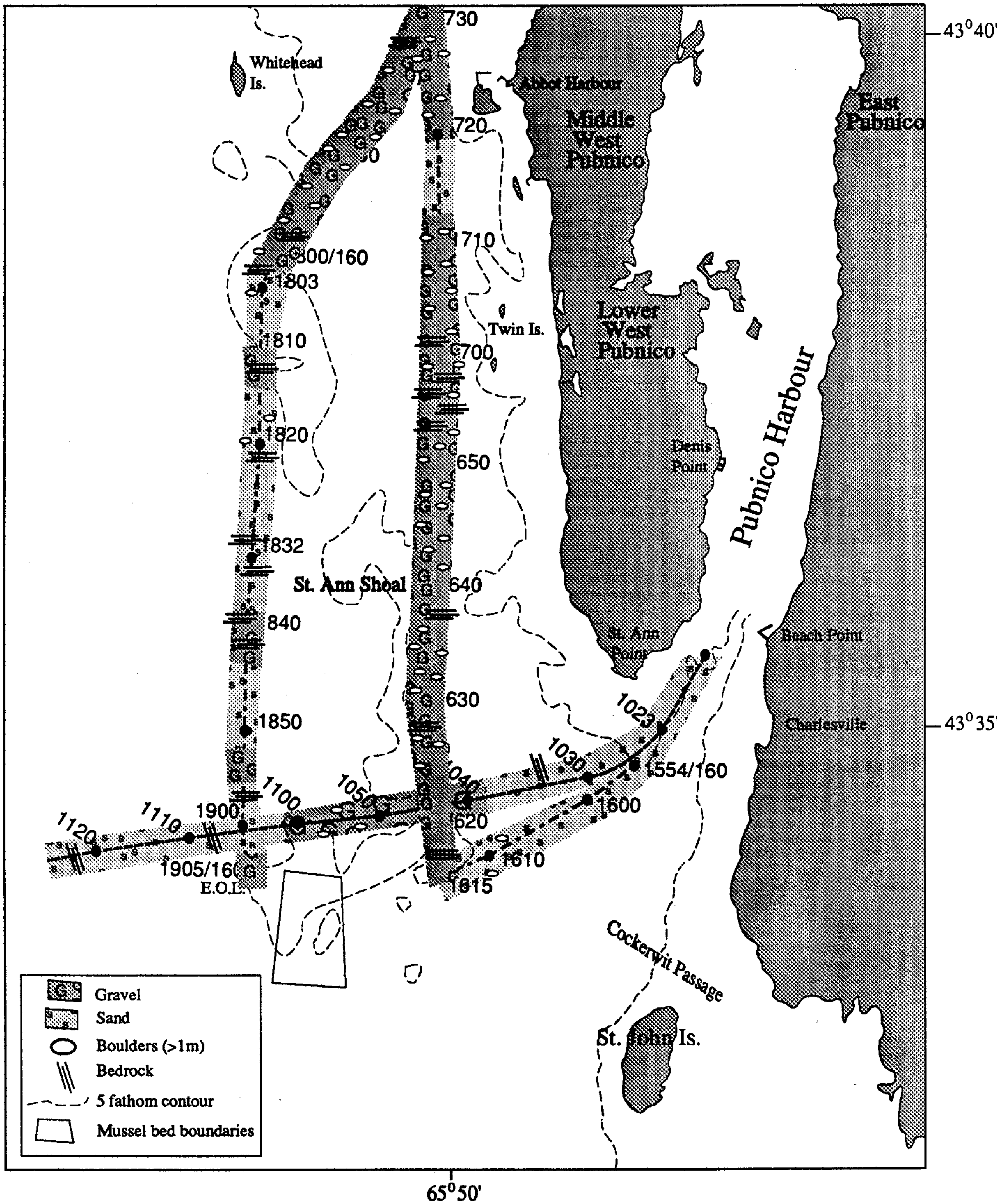

Figure 4. Substrate characteristics of selected areas in Lobster Bay.

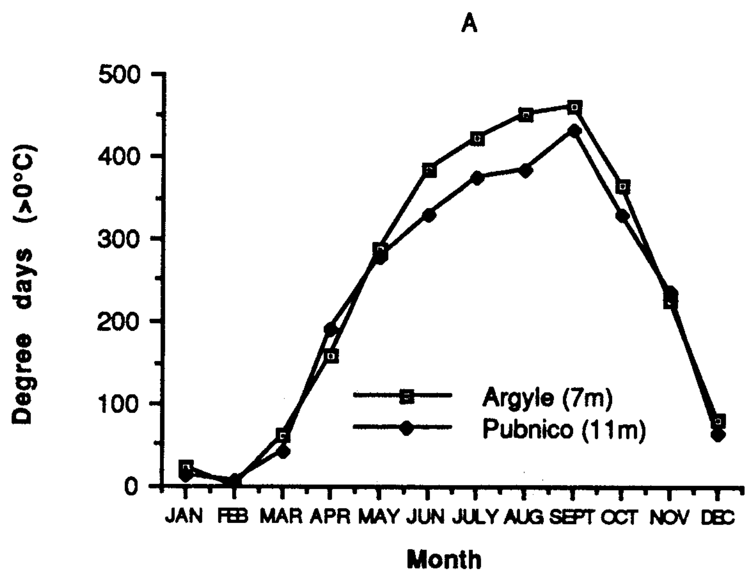

Figure 5a. Degree days (>0°C) at two subtidal mussel beds, Lobster Bay.

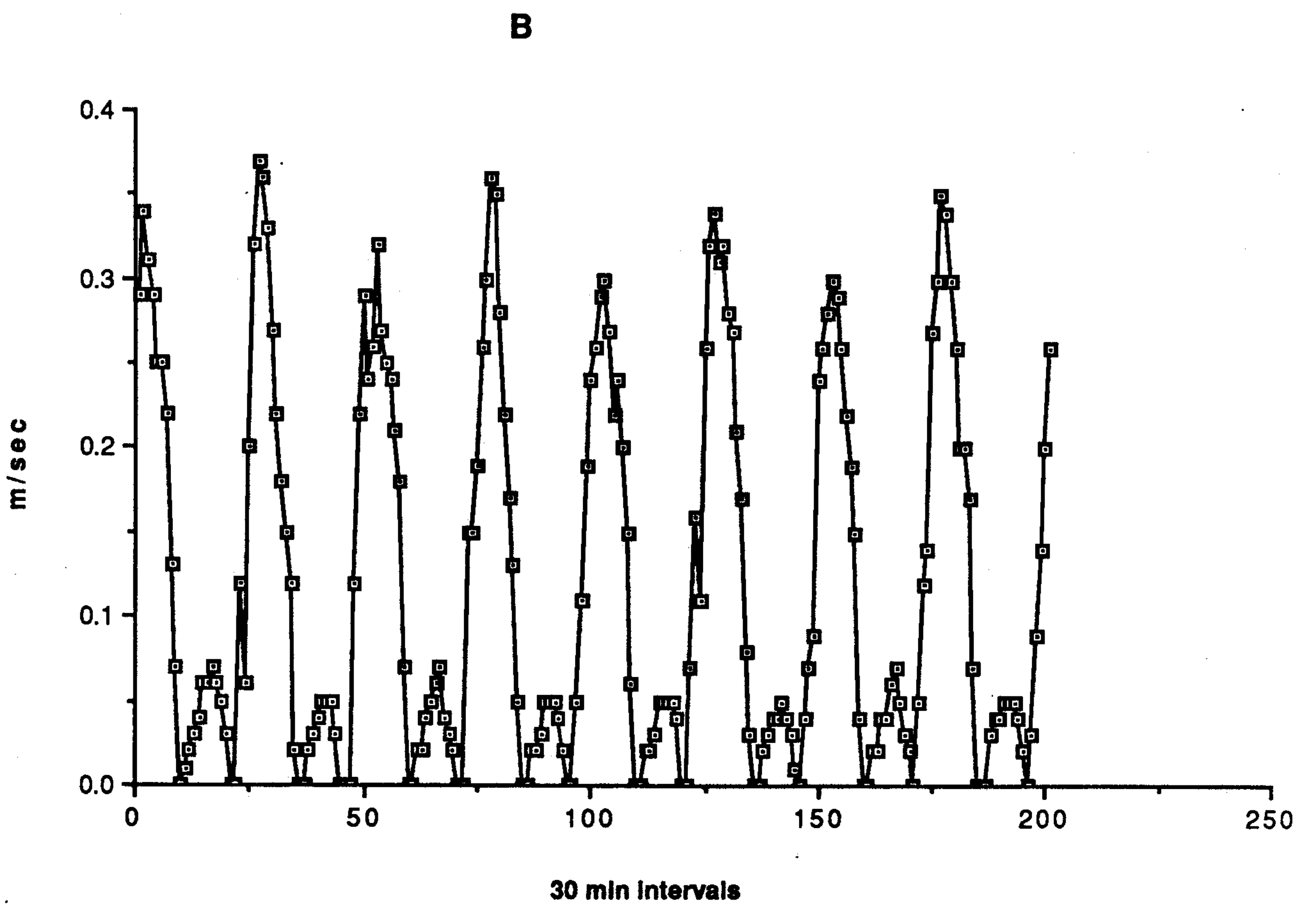

Figure 5b. Cycle and velocity of tidal currents at Rankin Island (7m).

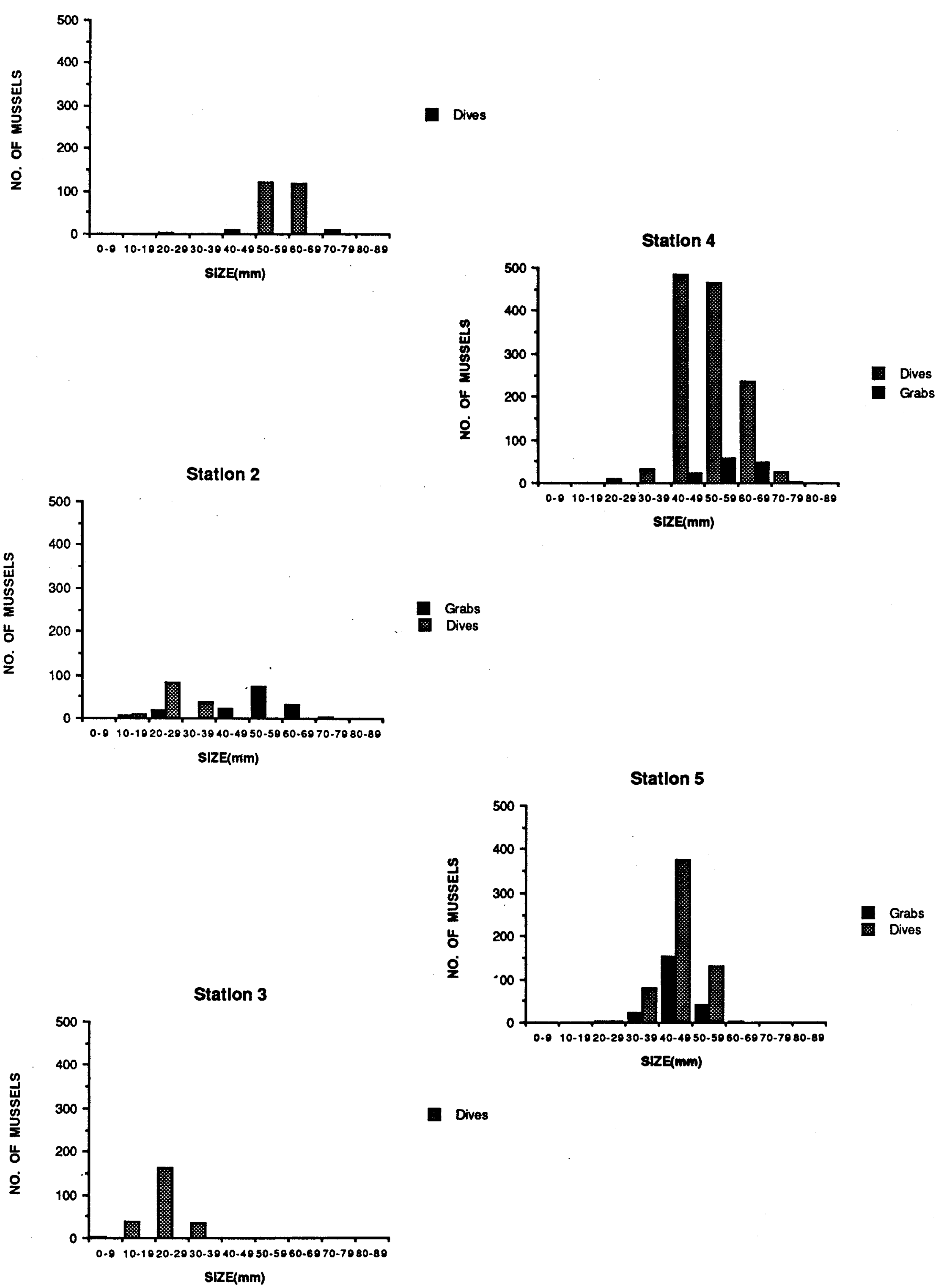

Figure 6. Size frequency (shell length) of Mytilus edulis at survey stations in Lobster Bay, 1987.

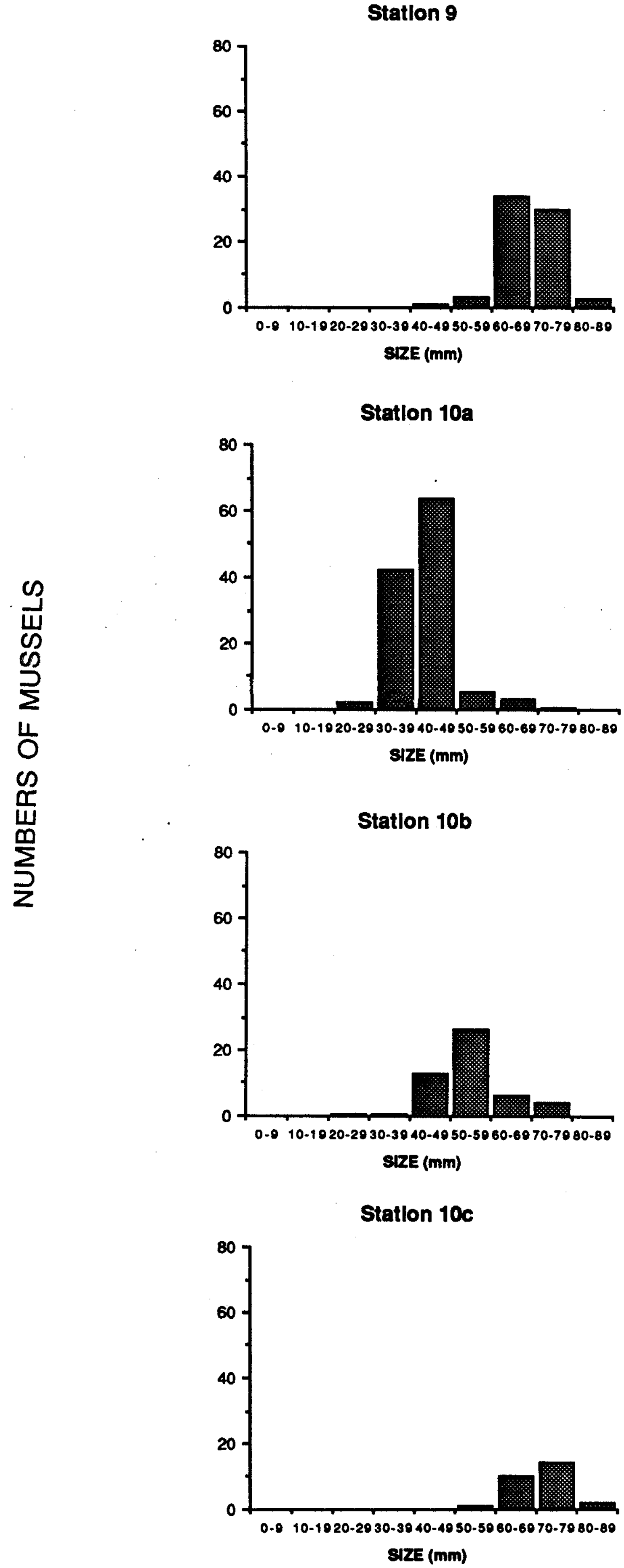

Figure 7. Size frequency (shell length) of Mytilus edulis at survey stations in Lobster Bay, 1988.

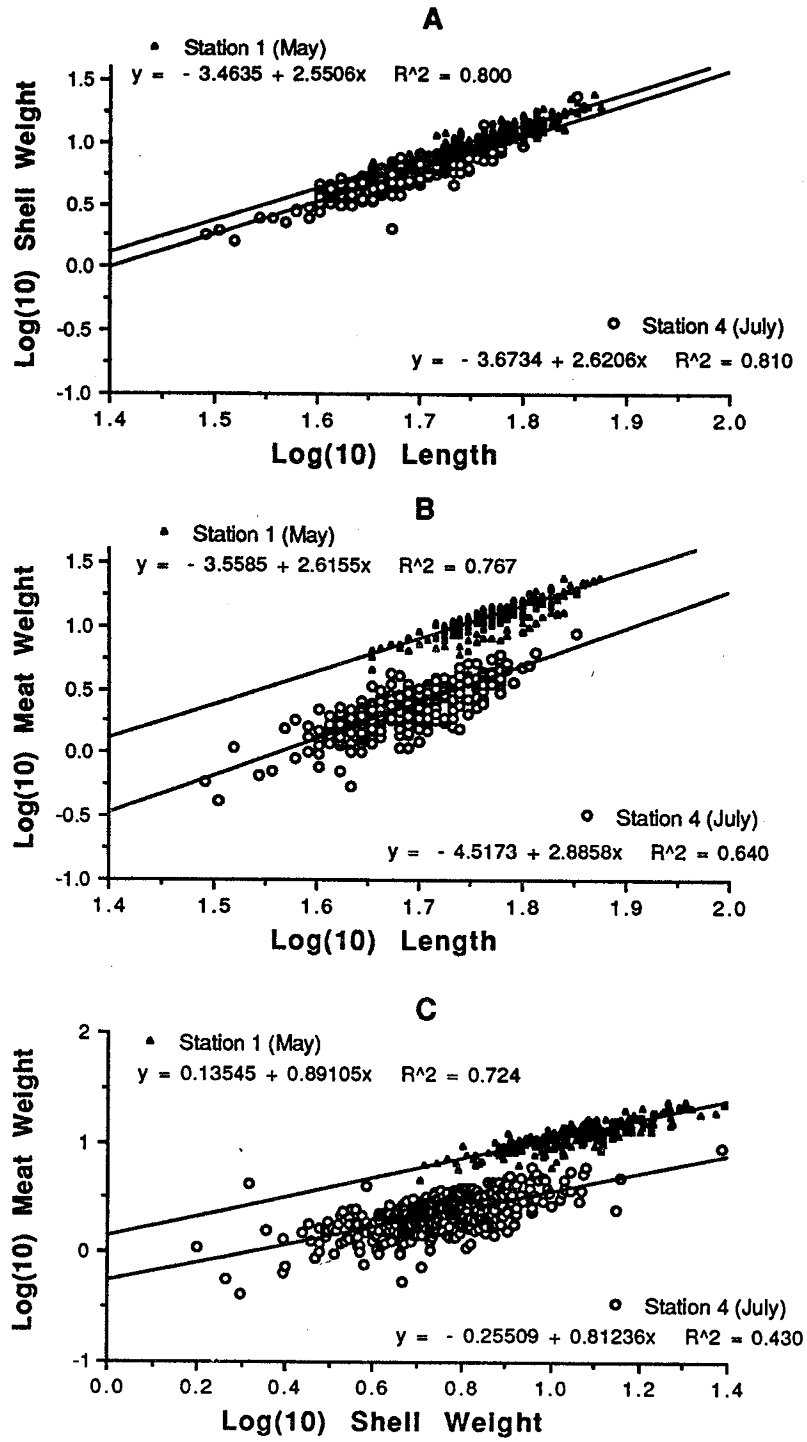

Figure 8. Mytilus edulis stations 1 and 4 in Lobster Bay.
8a. Shell length to shell weight relationship.
8b. Shell length to meat weight relationship.
8c. Shell weight to meat weight relationship.

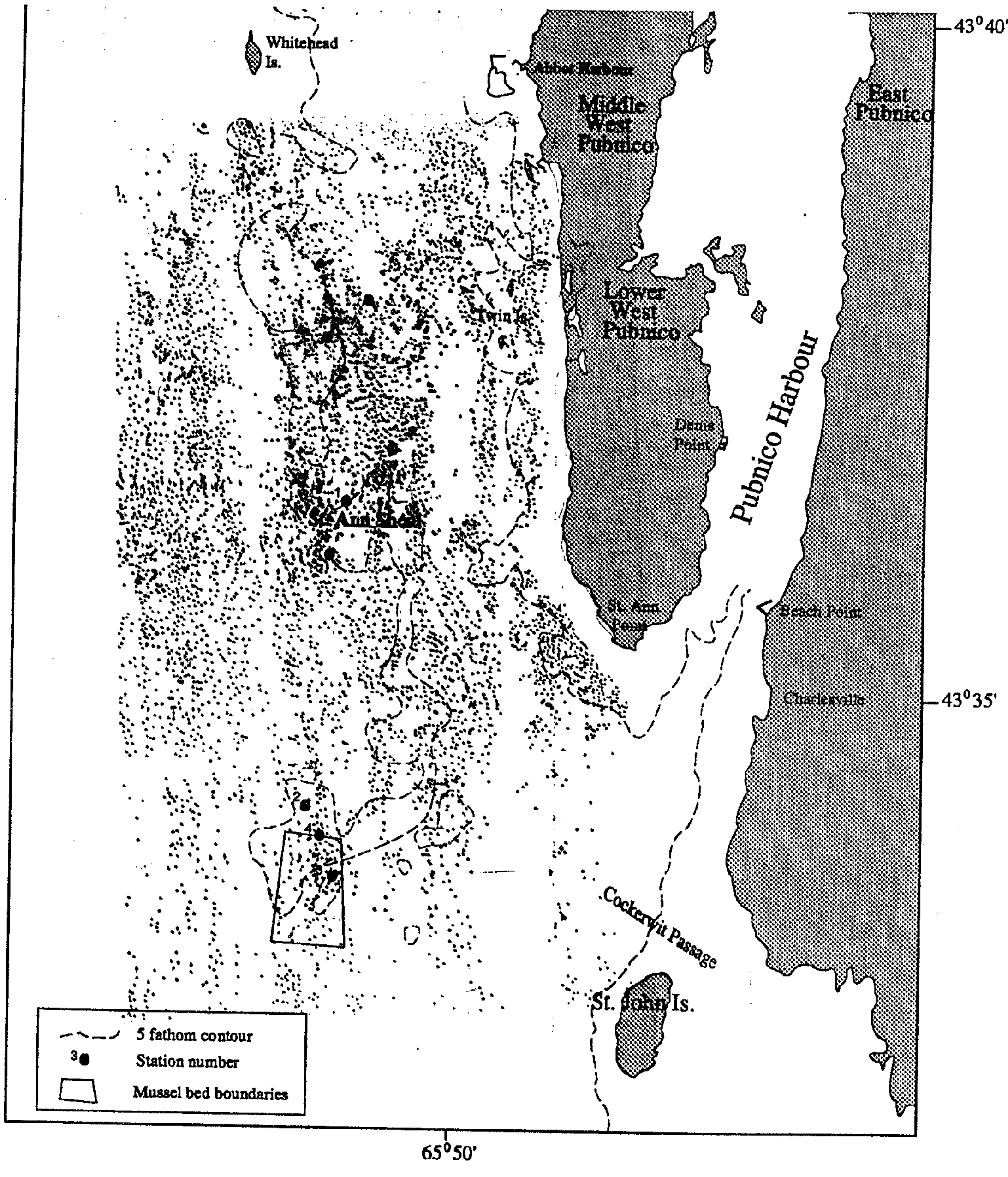

Figure 9. Lobster fishing effort (lobster buoy density) in the area of mussel beds in Lobster Bay.

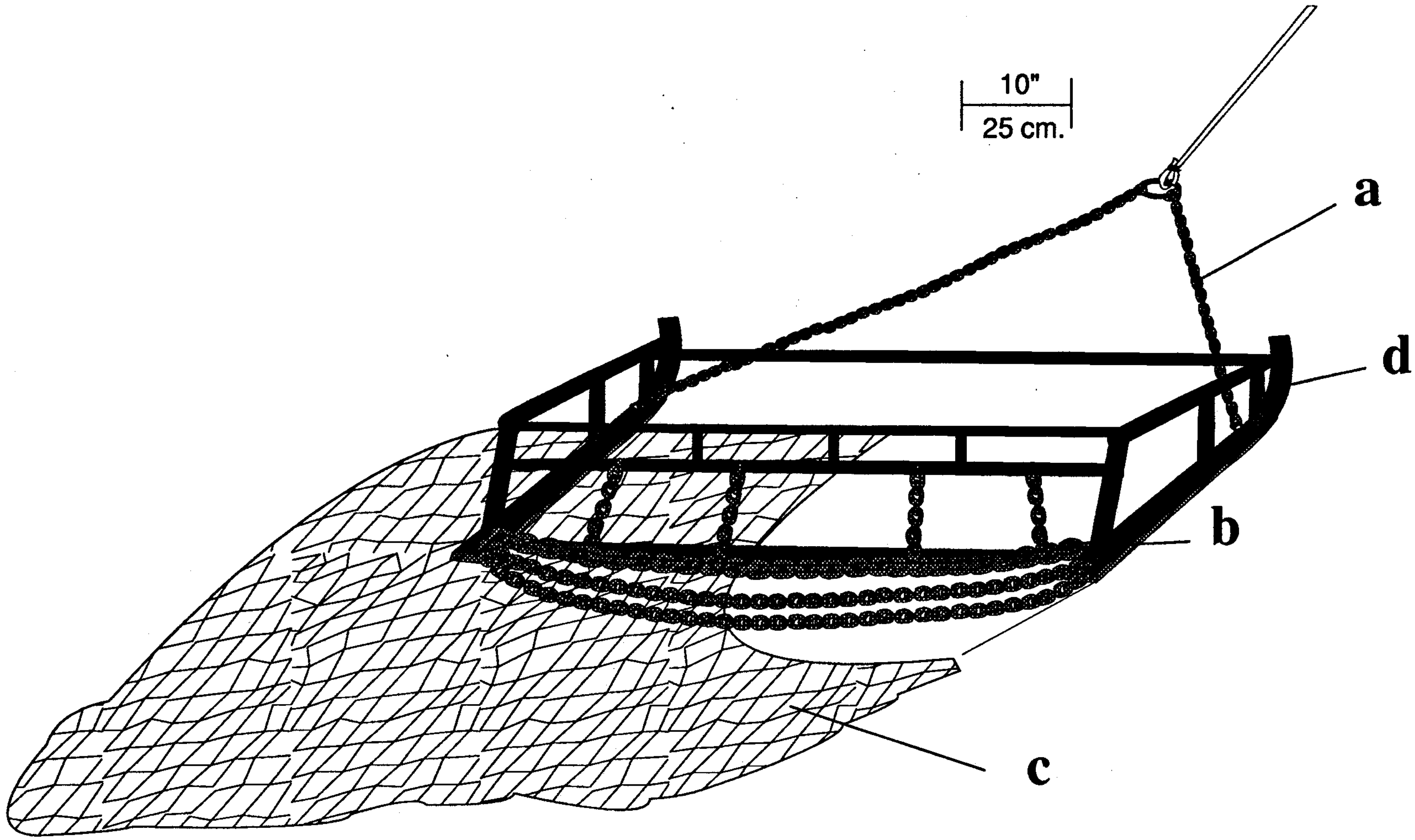

Figure 10. The bottom drag used in the exploratory mussel fishery, Lobster Bay, 1988.

a) bridle
b) chain
c) net bag
d) runners

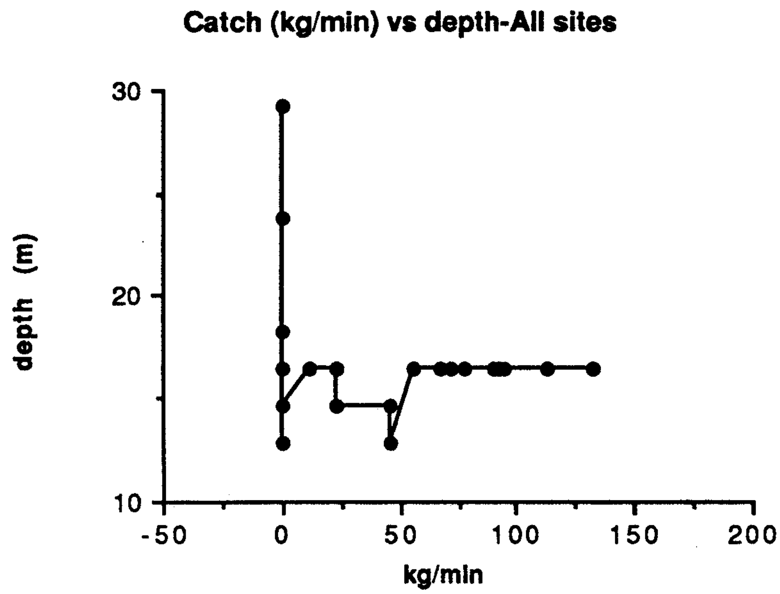

Figure 11a. CPUE (kg/min) of exploratory mussel fishery at various depths in Lobster Bay.

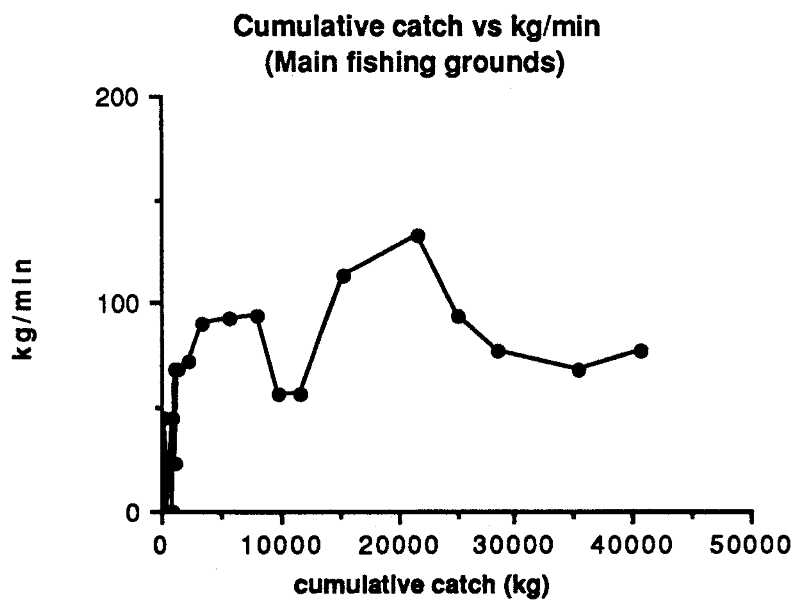

Figure 11b. CPUE (kg / min) of exploratory mussel fishery with the cumulative catch during the fishing season.

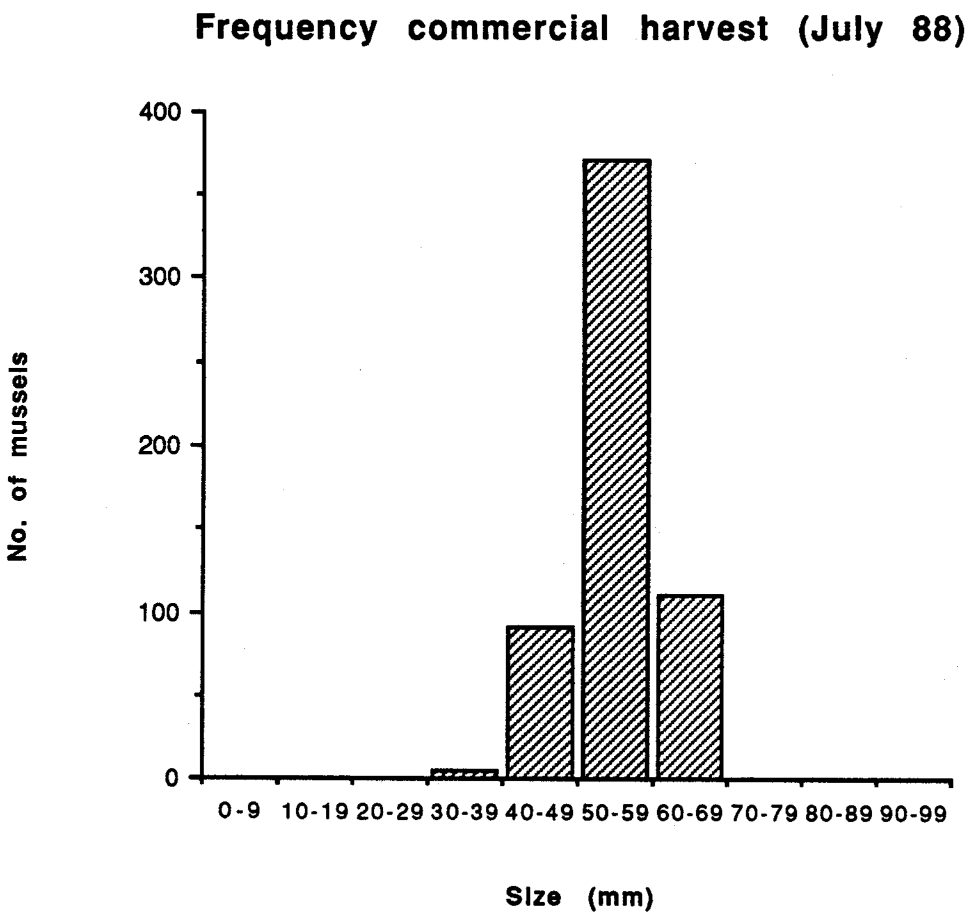

Figure 12. Size frequency (shell length) of "at sea" samples of the commercial mussel harvest.