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EXPLORATORY INTERTIDAL CLAM SURVEYS IN BRITISH COLUMBIA - 1994 AND 1996

by

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ABSTRACT

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Results of 1994 and 1996 exploratory surveys to assess populations of commercially important clams on selected beaches in the North Coast, Queen Charlotte Strait and Johnstone Strait areas of British Columbia are presented. These surveys were part of continuing program begun in 1990.

Surveys in 1994 and 1996 focused primarily on assessment of the distribution and population characteristics of Manila clams, *Venerupis philippinarum*, the clam species of most importance to the present commercial industry. Manila clam populations were either sparse or non-existent in the Johnstone Strait and Queen Charlotte Strait areas. Manila clams were abundant on some beaches in the North Coast, but sparse on beaches at the extremity of their distribution. Generally, on beaches with extensive Manila clam populations, there was a wide size and age distribution, indicating good recruitment in recent years. The northernmost population of Manila clams was found in Laredo Inlet at 52°50.6'N Lat.

Although sampling for butter clams, *Saxidomus giganteus*, and littleneck clams, *Protothaca staminea*, was limited, both species, particularly littlenecks, were generally abundant on most beaches visited in both years. Size and age frequency distributions indicated generally good recruitment in recent years.

Limited information is also presented for populations of cockles, *Clinocardium nuttallii*, soft-shell clams, *Mya arenaria*, and *Macoma* spp. found during both years.

Factors affecting the dispersal, population structure and potential for aquaculture of Manila clams in the North Coast are discussed.

RESUME

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Nous présentons ici les résultats des campagnes exploratoires menées en 1994 et 1996 pour évaluer les populations de coquillages intertidaux commercialement importants sur certaines plages de la côte Nord, du détroit de la Reine-Charlotte et du détroit de Johnstone, en Colombie-Britannique. Ces campagnes s'inscrivent dans un programme suivi lancé en 1990.

Au cours des deux années, les relevés ont visé principalement la distribution et les caractéristiques démographiques de la palourde japonaise (*Venerupis philippinarum*), qui est le bivalve le plus important actuellement dans la pêche commerciale. Les populations de palourde japonaise étaient clairsemées ou inexistantes dans les régions du détroit de Johnstone et du détroit de la Reine-Charlotte. Elles étaient abondantes sur certaines plages de la côte Nord, mais clairsemées sur les plages situées à l'extrémité de l'aire de répartition de l'espèce. En général, sur les plages où les populations de palourdes japonaises étaient abondantes, on observait une large distribution des tailles et des âges, signe d'un bon recrutement ces dernières années. La population la plus septentrionale a été observée dans le bras Laredo, par 52 ° 50,6 ' de latitude.

Bien que l'échantillonnage des palourdes jaunes (*Saxidomus giganteus*) et des palourdes du Pacifique (*Protothaca staminea*) ait été limité, les deux espèces, mais particulièrement la palourde du Pacifique, étaient généralement abondantes sur la plupart des plages visitées les deux années. La distribution des fréquences par taille et par âge indiquait un recrutement généralement bon ces dernières années.

Nous présentons aussi une information limitée sur les populations de coque (*Clinocardium nuttallii*), de mye (*Mya arenaria*) et de *Macoma* spp. observées au cours des deux années.

Les facteurs qui agissent sur la dispersion, la structure des populations et le potentiel aquacole de la palourde japonaise sont également analysés.

INTRODUCTION

Intertidal clam resources continue to be important to the economy of coastal British Columbia (B.C.); in 1996 commercial landings amounted to 1,290 tonnes (t) with a landed value of $3.968 million (Stocker and Joyce 1998). Aquaculture production increased total landings and value to 2,290 t and $8.718 million, respectively. Four species of clams provided virtually all commercial landings: razor, *Siliqua patula*; butter, *Saxidomus giganteus*; littleneck, *Protothaca staminea*; and Manila, *Venerupis* (=*Tapes*) *philippinarum*. Minor landings of four other species have occurred occasionally: cockle, *Clinocardium nuttallii*; soft-shell, *Mya arenaria*; and two species of horse clams, *Tresus capax* and *T. nuttallii*.

Since the mid 1970's, market demands have changed the intertidal clam fishery from the harvest of butter clams for a canned product to harvest of steamer clams (littlenecks and Manilas) for the fresh market. Since 1980, the industry has targeted on Manila clams for the fresh market and this species has comprised about 90% of landings in the intertidal clam fishery since that time. In 1996, Manila clams accounted for 81% of the landed weight of intertidal clams and 91% of the landed value (Fig. 1). This strong market has led to intense harvesting of Manila clams in all areas.

In 1990, a program was initiated to assess intertidal clam resources in B.C. and the work was continued in 1991 and 1993 (Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997). These surveys focused primarily on assessment of intertidal clams in the North Coast, but also included some work in the South Coast. Information was collected on all species of commercial interest, but targeted primarily on assessment of the distribution of Manila clam populations and factors that control northward dispersal of this species. As a result of these surveys, a fishery for Manila clams began in the Bella Bella area during the winter of 1992-1993. The fishery has continued with annual landings ranging from 10.7-114.1 t (Table 1).

The 1994 and 1996 surveys were a continuation of this work. As in previous years, they were carried out principally in the North Coast, but some work was also done in the South Coast (Table 2; Fig. 2). Major emphasis was again on obtaining further information on the dispersal of Manila clams and assessing populations where they existed, but information was also gathered on other clam species of commercial interest. Growth rates were calculated, to provide information relating to the potential for aquaculture of Manila clams in the North Coast. The surveys also included collaborative work with the Heiltsuk and Kitasoo First Nations, particularly in 1996, to develop standard sampling procedures to assess clam populations. Results of this part of the work will be reported elsewhere.

SURVEY METHODS

Survey methods employed in 1994 and 1996 were similar to those used in previous years and are only briefly described here (Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997).

Beaches were selected for survey by examining charts or from previous knowledge, information provided by Fishery Officers, or from the industry. As in previous years, it was decided to survey as many beaches in an area as possible, rather than sample one or two beaches intensively (except for work with First Nations), in order to obtain information on the distribution and extent of Manila clam populations along as much of the coast as possible (Table 2).

At the time of sampling, a brief exploration was made of each beach to assess the presence or absence of intertidal clams and to determine the approximate area of the clam bearing part of the beach. Beach areas were estimated by pacing dimensions or eyeball estimation, thus small beaches (which could be paced out) appear to be estimated with greater precision than larger beaches. Slope, type of substrate, and estimated area of beaches were recorded .

As in previous surveys, considerable exploratory digging was undertaken on many beaches. Exploratory plots (generally 0.25 m^2) were dug in sand-gravel areas in the mid intertidal area to determine the presence or absence of Manila clams, and to delineate the extent of the area inhabited by Manila clams. If Manila clams were found in these areas, survey quadrats were established in order to make a more detailed assessment of the population. Survey quadrats were selected in an *ad hoc* fashion, without formal randomization. Scattered survey quadrats of 0.25 m^2 were dug with rakes or scrapers to a depth of 15 cm. The substrate was worked through the fingers and reworked back into the quadrats. All detectable clams were removed, placed in plastic bags and labeled for later measurement.

In previous surveys, scattered quadrats 1.0 m^2 in area were established in the lower third of some intertidal beaches and dug to depths of 35 cm with potato forks to assess butter and littleneck clam populations (Bourne and Cawdell 1992; Bourne *et al.* 1994). No targeted assessment was made of butter clams in the present surveys, other than for occasional exploratory plots on some beaches, and hence no 1 m^2 quadrat samples were taken.

One detailed population assessment survey was undertaken in Gale Passage in 1996. A stratified random survey was completed using methods described in Gillespie *et al.* (1998).

Shell length of each clam from sampled quadrats was measured to the nearest millimeter (mm) with vernier calipers. Age of all Manila clams and most other bivalve species was determined by counting annuli (Quayle and Bourne 1972). Shell length was measured to the nearest mm at each annulus of a pooled sample of Manila clams from all areas and littleneck clams from most areas that showed normal growth (*i.e.*, they were not stunted). Means and standard errors of shell lengths at annuli were calculated. This provided growth rates for the unstunted portion of Manila clam populations at all locations.

In the 1996 survey, all Manila clams were weighed to the nearest 0.1 gm with a Mettler Balance. Length-weight relationships were calculated for Manila clams for all locations where they were found.

Surface water temperatures at a depth of 1 m and five minute surface plankton tows were taken in most areas in both years, the latter to determine the presence or absence of Manila clam larvae.

RESULTS

1994 SURVEY

1. Cameleon Harbour

Cameleon Harbour was sampled during the 1991 and 1993 surveys. Manila clams were found there, although the extent of the population was not determined (Bourne *et al.* 1994; Bourne and Heritage 1997). Additional sampling was undertaken in 1994, since commercial harvesting occurred there during the previous year and concern was expressed about the state of the stock (K. Spencer, DFO Fisheries Officer, pers. comm.). The beach is extensive, extending around the perimeter of the harbour, although it is divided to some extent by rock outcrops and streams (Fig. 3). The total area of suitable habitat for Manila clams is probably 3-4 ha. Part of the beach lies within the boundary of Thurston Bay Marine Park.

Physical Description of Beaches

A total of six sections of the beach, that included two on the south side, two at the southeast end and two on the north side of the harbour, were surveyed (Fig. 3). Width of the beach varied from 50 to 75 m and actual areas of beaches sampled ranged from 0.25 to 1 ha (Table 3). The slope of the beaches was gentle, with the exception of Beach 5, which was moderately sloped. Substrate ranged from sand-mud to coarse sand and gravel. The lower part of Beach 2 was a rock-mud berm. There was evidence of former logging activity at Beach 3. Old clam shell of several species was found on most beaches. The most extensive area of Manila clam habitat was found at Beach 4.

Clam Populations

Fifteen quadrats were dug on the six beaches and an additional 57 exploratory plots were dug to determine the presence or absence of clam populations (Table 3).

Butter Clams

Butter clams were found only at Beach 4 (Table 4). No samples were taken specifically for this species and all sampling was in the mid intertidal area, outside the zone of maximum butter clam occurrence. Incidental observations showed that butter clams were common at Beach

1 and they may have occurred in commercial quantities in parts of the lower third of the intertidal beach throughout the area.

Littleneck Clams

Littleneck clams were the most common bivalve found and ranged in density from 0 to 300 clams m^{-2} (Table 4). Shell length ranged from 16 to 50 mm (Fig. 4) but most (68%) were smaller than 38 mm shell length (minimum size in the commercial fishery). They ranged in age from 1 to 9 years, with a predominance of 4 and 5 year olds (Fig. 4). The large number of sublegal sized littlenecks indicates successful breeding has occurred recently in Cameleon Harbour. Some littlenecks, including some smaller than 38 mm, were stunted which may have been due in part to sampling in the mid intertidal beach area rather than in more optimum habitat lower in the intertidal zone.

Manila Clams

Manila clams were found on all beaches in modest abundance, density ranged from 4 to 132 clams m^{-2} (Table 4). Shell length ranged from 20 to 57 mm (Fig. 5), most (67%) were larger than 38 mm shell length (minimum size in the commercial fishery). They ranged in age from 2 to 9 years, most were 3 to 6 years old (Fig. 5). Growth was similar to that found under optimum conditions: about 3.5 years were required to attain a shell length of 38 mm (Fig. 6). A few Manila clams were stunted.

About 10% of Manila clams in this area had *Pinnixia* crabs, mostly *P. littorina* but some *P. fabia*.

Other Species

A few soft-shell clams and *Macoma* sp. were found on most beaches (Table 4).

Other Observations

Surface water temperature in the central part of the harbour was 15° C at 0930 on July 19, 1994.

A five minute surface plankton tow was made at the mouth of the harbour. There was a great amount of a chain forming diatom. Few bivalve larvae were found, which may have been due in part to the large amount of algae. Most larvae were straight hinge or early umbone mussels, *Mytilus* sp. One soft-shell clam larva was found.

2. *Troup Passage*

Sampling was undertaken in the Troup Passage area on two days, during the morning and evening of July 20, and the morning of July 21, 1994 (Table 2). Troup Passage extends between Return Channel and the north side of Seaforth Channel, and is close to the known northern limit of Manila clam dispersal in B.C. Sampling was confined to three locations in the passage (Fig. 7). Beaches 1 and 2 were at the northern end of the passage on the east side of Chatfield Island. Beach 3 was at the southern end of the passage on Chatfield Island. Beach 4 was located in a small bay on the west side of Cunningham Island about mid way along Troup Passage.

Physical Description of Beaches

Area of Beaches 1 and 2 on the east side of Chatfield Island were 2.5 and 1.0 ha (Table 3). The slope of both beaches was gentle to moderate. Substrate was mostly sand-gravel with some muddy sand. The lower part of both beaches was muddy with eelgrass, *Zostera marina*. Beach 3 on the south side of Chatfield Island was about one ha in area, with a gentle slope and a gravel-sand-cobble substrate. Beach 4 on the west side of Cunningham Island was about 2 ha in area, with a gentle slope and a substrate of sand-pea gravel and mud at higher beach levels. There was a varying amount of rock on all beaches.

Clam Populations

Nineteen quadrats were dug on beaches in the four areas (Table 3), and an additional 49 exploratory plots dug to determine the presence of clam populations.

Butter Clams

A few butter clams were found on beaches on Chatfield Island (Table 4). Again the scarcity of butter clams was expected due to the method of sampling.

Littleneck Clams

Littleneck clams were common on Beaches 1 and 3, ranging in density from 100 to 152 clams m^{-2} at Beach 1 and 152 to 328 clams m^{-2} at Beach 3 (Table 4). Few littlenecks were found at Beach 4. There was a preponderance of small clams, *i.e*,. under 38 mm shell length, 93% at Beach 1 and 96% at Beach 3. Most littlenecks at Beaches 1 were 4 and 5 years old, those at Beach 3 were 4 to 7 years old (Figs. 8 and 9). This size and age distribution showed that successful recruitment had occurred in the past few years. Many of the littlenecks were stunted which may have been due partly to clam density but also partly to the high location on the beach.

Manila Clams

Manila clams were abundant at all four locations. At Beaches 1 and 2 density ranged from 36 to 380 clams m^{-2}; at Beach 3 from 92 to 288 clams m^{-2} and at Beach 4 from 0 to 408 clams m^{-2} (Table 4). At Beaches 1, 2 and 3 there was a preponderance of clams larger than 38 mm shell length; 91% at Beaches 1 and 2 and 92% at Beach 3 (Figs. 10 and 11). At Beach 4 the reverse was true, clams smaller than 38 mm comprised 64% of the sample (Fig. 12). At Beaches 1, 2 and 3 most Manila clams were 4 to 7 years old (Figs. 10 and 11), at Beach 4 on Cunningham Island most were 2 to 4 years old (Figs. 12). Successful recruitment had occurred at Beach 4 recently but not at the beaches on Chatfield Island. Growth at all beaches was similar: about 3.5 years was required for Manila clams to attain the legal size of 38 mm (Fig. 13) . Some Manila clams, particularly at Beach 4 were stunted.

Manila clams occurred in commercial quantities at all locations, although distribution was patchy and the populations were not extensive.

Large quantities of old dead Manila clam shell were found on some beaches indicating that the population had been on these beaches for several years. The dead shell may have been the result of past mass mortalities resulting from winter kill (Bower *et al.* 1986; Bower 1992).

Other Species

A few *Macoma* sp. and soft-shell clams were found on beaches at Chatfield Island (Table 4).

Other Observations

Surface water temperature in the bay at Beach 4 on Cunningham Island was 24° C during the evening of July 20, 1994. A five minute surface plankton tow taken in the same area had few bivalve larvae. No Manila clam larvae were identified.

3. Lama Passage-Gunboat Passage

Sampling was undertaken in this area during previous surveys and Manila clams were found to be present (Bourne 1982; Bourne and Cawdell 1992). Sampling was undertaken during this survey to assess, in part, the effects of commercial harvesting and was confined to beaches at Rainbow and Cypress Islands at the western end of Gunboat Passage (Fig. 14). Part of the beach is a saddle beach between the two islands but work also included some sampling on beaches at Rainbow Island. Sampling with the Heiltsuk Bank was undertaken in this area.

Physical Description of Beaches

Three beaches were sampled, Beach 1 on the saddle between the two islands and Beaches 2 and 3 on the east side of Rainbow Island (Fig. 14). The clam bearing area of the beaches ranged in area from 0.3 to 2 ha (Table 3). Slope of the three beaches was gentle to moderate. Substrate was pea and fine gravel to coarse gravel with much broken rock. A berm was present on Beach 2 with gravel substrate in the central part. There was evidence of past digging on Beach 2.

Clam Populations

Eight quadrat samples were taken on these three beaches (Table 3) and an additional 14 exploratory plots were dug. There was abundant old butter, littleneck and Manila clam shell on the beaches.

Butter Clams

Butter clams were found on all three beaches, about half were 63 mm shell length or over, the lower size limit in the commercial fishery (Table 4). Old shell was common and undoubtedly commercial quantities of butter clams were present in the lower part of the beaches.

Littleneck Clams

Littleneck clams were the most abundant bivalve on the beaches and ranged in density from 0 to 700 clams m^{-2} (Table 4). Most were smaller than 38 mm shell length (88% at Beach 1, 67% at Beach 2 and 76% at Beach 4) (Table 4; Fig. 15). There was a preponderance of 4 year old clams but 5 to 7 year olds were also common (Fig. 15). Again the large number of small clams was a result in part of good recruitment, but also to the presence of large numbers of stunted clams.

Manila Clams

Manila clams were common on all three beaches and ranged in density from 24 to 420 clams m^{-2} (Table 4). Most were 38 mm or larger; 37% at Beach 1, 53% at Beach 2, and 82% at Beach 3 (Table 4; Fig. 16). There was a wide range in ages from 1 to 9 with most being 2 to 8 (Fig. 16). Reasonable recruitment occurred in this area recently. Growth was similar to that observed on other beaches in the area; it required about 3.5 years to attain a shell length of 38 mm (Fig. 17).

Commercial harvesting had occurred on these beaches and results of this survey indicate that harvests could continue.

Other Species

A few *Macoma* sp., soft-shell clams and cockles were found (Table 4).

4. Spiller Channel - Bullock Channel

Both Spiller and Bullock Channels have a similar physiography, with steep sides that plunge to considerable depths into the channels; there were few intertidal beaches. Existing beaches were small pocket beaches tucked into breaks in the sides of the channels or at the mouths of small creeks. Most sampling was in Bullock Channel and focused primarily on the determination of the dispersal of Manila clams in this area (Fig. 18).

Physical Description of Beaches

Most beaches in this area were small, half of them under 0.5 ha. The largest was beach 2 which was 4 to 5 ha (Table 3). Slopes of beaches varied considerably, a few were gentle but most were moderate to steep. Substrate also varied considerably from coarse sand through gravel to cobble. Habitat suitable for clams often occurred in patches. There was a lot of rock on most beaches. The lower part of most beaches was soft mud-sand-gravel, often with considerable amounts of eelgrass. In general the amount of habitat suitable for clams, particularly for Manila clams, was limited.

Clam Populations

Eight quadrat samples were taken (Table 3), and an additional 127 exploratory plots were dug. There was limited suitable clam habitat on most beaches; hence most sampling was of the exploratory type, to determine if Manila clams were present or absent.

Butter Clams

A few butter clams were found in the quadrats, all were less than legal size (Table 4). There were copious quantities of butter clam shell on most beaches and undoubtedly populations of this species were present at lower intertidal beach levels.

Littleneck Clams

Littleneck clams were common on most beaches and in sample quadrats ranged in density from 0 to 240 clams m^{-2} (Table 4). Shell length ranged from 13 to 46 mm but most (67%) were small, under 38 mm shell length (Fig. 19). There was a wide range in ages from 1 to 10, most were 2 to 8 (Fig. 19). Many small littlenecks were older, stunted clams.

Manila Clams

Manila clams were found on most beaches and ranged in densities from 0 to 320 clams m^{-2} (Table 4). Shell length ranged from 25 to 58 mm but 88% were 38 mm or larger (Table 4; Fig. 20). Few young Manila clams were found; most ranged in age from 4 to 7 years (Fig. 20). Recruitment has been sporadic in recent years. Growth was similar to that observed in other areas; about 3.5 years was required to attain a shell length of 38 mm (Fig. 21).

Beaches in this area were small and had limited habitat suitable for bivalves, particularly Manila clams. Manila clam distribution tended to be patchy; it is doubtful whether sufficient Manila clam populations exist in this area to warrant commercial harvesting.

Other Species

Cockles were fairly common in this area on beaches with soft muddy substrate with eelgrass (Table 4). A few *Macoma* sp. and soft-shell clams were found along with cockles. Frequently this habitat was in the lower part of the beach.

Other Observations

A five minute surface plankton tow was taken in Bullock Channel. There was a moderate amount of algae but few bivalve larvae, most of which were mussels.

5. Higgins Passage

Higgins Passage was included in the surveys because Manila clams were reported in this area. Requests had also been received about the possibility of using this area as a site for Manila clam culture. This passage receives waters directly from the Hecate Strait area and it was of interest to know whether oceanographic conditions in the passage would permit establishment of a large Manila clam population. An initial investigation was undertaken to assess the potential of the area for such culture. Only the eastern half of the passage was surveyed (Fig. 22), due to time constraints.

Physical Description of Beaches

Higgins Passage is a shallow water passage with a large lagoon at the eastern end and a similar lagoon at the western end (Fig. 22). There were extensive intertidal beaches on both sides of the passage and in the lagoon areas, however, much of the intertidal area was soft and muddy and unsuitable as clam habitat, particularly for Manila clams. For example, the total estimated area of Beach 1 was about 12 ha, but only about 800 m^2 was deemed suitable as Manila clam habitat (Table 3). The total area of all beaches surveyed that was suitable for Manila clams was

probably about 1 to 2 ha. Slope of most beaches was gentle to moderate, but a few were steep. Much of the substrate was soft mud-sand but there were areas with firm sand-gravel patches on most beaches. Sampling was confined to the patches of firm sand-gravel substrate.

Clam Populations

Butter Clams

As in other areas, no samples were taken to assess butter clam populations, but a few butter clams were found in other samples. About one quarter were 63 mm shell length or larger (Table 4). Butter clam shell was common on most beaches and two local people stated it was a favourite place to dig butter clams for personal use.

Littleneck Clam

Littleneck clams were common in all samples except at Beach 7; density ranged from 0 to 420 clam m^{-2} (Table 4). There was a wide range of sizes but most (76%) were smaller than 38 mm shell length (Table 4, Fig. 23). There was a preponderance of 5 to 7 year olds (Fig. 23). Although many of the smaller clams were young, indicating good recent recruitment, many were older stunted clams.

Manila Clams

Manila clams were found in modest numbers in all the sampled areas, density ranged from 12 to 100 clams m^{-2} (Table 4). Only one clam was under 38 mm shell length (Table 4); the youngest clam was 3 years old, but most were 7 and 8 years old (Fig. 24). Little recruitment had occurred in the past few years. Growth was slightly slower than observed in other areas, it required about 4 years to attain a shell length of 38 mm (Fig. 25).

It is doubtful if Manila clam populations in this area were sufficient to support commercial harvesting. If harvesting did occur, the population would be greatly reduced and there would be few young clams to recruit to the fishery. Erratic recruitment, as evidenced by the lack of small clams on the beaches, probably precludes any sustained commercial fishery in this area.

The potential for economically viable Manila clam culture is not promising in this area. The amount of habitat suitable for Manila clams is limited. Recruitment is erratic and culture operations would have to rely entirely on planted, hatchery raised seed, which is expensive. Growth rates were slower than observed in other areas, perhaps a result of cooler water temperatures.

Other Species

A few *Macoma* sp., soft-shell clams and cockles were found (Table 4). Soft-shell clams and cockles were probably abundant where suitable habitat occurred in the intertidal zone. The lagoon at the eastern end of the passage contained large quantities of the exotic seaweed, *Sargassum muticum*.

Other Observations

Surface water temperature opposite Beach 7 was 14° C at 1100 on July 23, 1994. A five minute surface plankton tow taken in the central channel had a modest amount of algae but few bivalve larvae. Most of the larvae were mussels, only a few were *Hiatella* sp.

6. *Aristazabal Island*

An important objective of this survey was to determine the northern limit of Manila clam distribution along the B.C. coast. Bourne (1982) postulated that Manila clam larvae were dispersed northward along the west coast of Vancouver Island, by a residual northerly current along the west coast of the island. A similar residual northerly current occurs along the east side of Hecate Strait (Thompson 1981), that could carry larvae northward from areas around Seaforth Channel. In 1990, no Manila clams were found in the Campania Islands area at the mouth of Douglas Channel (Bourne and Cawdell 1992). In the present survey, sampling was undertaken to determine the presence or absence of Manila clam populations between the Seaforth Channel and Campania Islands areas along the east coast of Hecate Strait.

Two areas were surveyed along the east side of Hecate Strait, Weeteeam Bay and Clifford Bay both on the west side of Aristazabal Island (Fig. 26).

Weeteeam Bay

Weeteeam Bay is an open bay on the southwest side of Aristazabal Island with several protected beaches. A cursory survey was made of one area (Beach 1) during the evening of July 23 and a survey of the entire area was made on July 24. Six beaches were sampled (Table 3, Fig. 26).

Physical Description of Beaches

There was limited clam habitat, particularly for Manila clams, on the six beaches. Slope of most beaches gentle to moderate (Table 3). Much of the substrate, particularly in the central part of the beaches, was soft mud with eelgrass. There was bedrock on some beaches and a

considerable amount of rock and boulders on the sides of the beaches interspersed to some extent with coarse sand-gravel patches. There was more sand-pea gravel substrate at Beaches 5 and 6 than at the other beaches but the total habitat suitable for Manila clams was limited.

Clam Populations

No quadrat samples were taken but 58 exploratory sample plots were dug on the six beaches (Table 3).

Butter Clams

No samples were taken for butter clams but dead shell was found on the surface of most beaches.

Littleneck Clams

Littleneck clams were found on all beaches in varying quantities. Many of the littlenecks appeared to be very stunted. No samples were taken.

Manila Clams

Manila clams were found on Beach 1 during the evening of July 23, 11 large clams from about 3 m^2. Unfortunately this area could not be sampled during the survey of July 24. On Beach 3, 6 Manila clams were found in an area of 3 m^2 and 6 more from a lagoon near the high tide zone. Some dead Manila clam shell was found on Beaches 5 and 6 but no live clams were found in 16 and 9 exploratory plots respectively.

Manila clams occurred in Weeteeam Bay but at very low densities. Part of the reason for the lack of Manila clam populations may be a lack of extensive suitable habitat, but the main reason was probably low survival of larvae and juveniles that settled in this bay. It is doubtful if the population is sufficient, or environmental conditions suitable, to permit successful Manila clam breeding in this area.

Other Species

Live cockles, soft-shell clams and *Macoma* sp. or dead shell were found on most of the beaches.

Other Observations

Surface water temperature near Soar Rock at 1000 hr was 15°C. A five minute surface plankton tow made in the center of the bay at 1000 hr had considerable algae but very few bivalve larvae. There were a few early umbone mussel larvae and some gastropods.

Clifford Bay

Clifford Bay is located on the west side of Aristazabal Island (Fig. 26). Since a few Manila clams were found in Weeteeam Bay, it was of interest to determine if they had spread farther north in Hecate Strait. Clifford Bay is fairly exposed, but it has some areas with protected intertidal beaches. Four beaches in the southern part, and one beach at the northeast corner were sampled.

Physical Description of Beaches

Area of Beaches 1 to 4 ranged from 2 to 7 ha but the amount of suitable clam habitat on each beach was limited (Table 3). Beach 5 was about 20 ha in area but again only about 5% was suitable as clam habitat. Slopes of the beaches ranged from gentle to moderate, particularly at the edges of the beaches. Substrate of the central part of most beaches was mostly soft and muddy with much eelgrass. There was considerable rock and cobble, with rock ridges on some beaches. There were areas of sand and pea gravel scattered throughout the rocky areas on most beaches that would appear to be suitable Manila clam habitat. Old fish weirs were observed on Beaches 4 and 5.

Clam Populations

No samples were taken to determine clam densities, because of the limited suitable habitat and low abundance of Manila clams. However, 68 exploratory plots were dug to determine the presence or absence of Manila clams, most (40) were taken on Beach 5 (Table 3).

Butter Clams

No sampling was undertaken to assess butter clam populations, but dead shell was found, and live animals were present in the lower part of most beaches where suitable habitat existed.

Littleneck Clams

Few littlenecks were found on any of the beaches and most appears to be very stunted. Large littlenecks were found only on Beach 3.

Manila Clams

Manila clams were only found on Beach 5. Forty exploratory plots were dug to determine whether they were present on this beach. After one clam was found, an area of 4 to 5 m^2 was dug, which yielded only 4 live Manila clams. The four clams measured 42, 46, 53 and 55 mm in length and were 5, 5, 7 and 7 years old respectively.

In addition to the four live Manila clams found at Beach 5, shells of ten dead clams were also found. Shells of both live and dead animals were used to calculate a growth rate for Manila clams in Clifford Bay. Growth rate was slow; about 4 years wre required to attain a shell length of 38 mm (Fig. 27).

Clifford Bay, 52°36' N is the farthest north that Manila clams have been found in the Hecate Strait area. The scarcity of Manila clams in this bay was due partly to the limited amount of suitable habitat, but more likely to adverse environmental conditions, *i.e.*, cold water temperatures and high salinities, that would limit larval development and survival of juveniles. Larvae that started this population probably came from spawnings farther south, *e.g.* the Seaforth Channel area, that drifted northward along the west side of Aristazabal Island. More than one year-class was present, which indicates that larval drift and settlement occurred more than once. It is unlikely that environmental conditions would permit successful breeding in Clifford Bay.

Other Species

Horse clams, *T. capax* were present on some beaches. Soft-shell clams were present in the upper parts of most beaches (Table 3). Cockles were found in the soft substrate of the lower part of most beaches. Shell of the ringed lucine, *Lucinoma annulata*, was found on two beaches. One *Diplodonta orbellus* was found in a tidal stream on Beach 4. *Sargassum muticum* was found in a lagoon at Beach 4.

Other Observations

Surface water temperature in the central part of Clifford Bay at 1030 was 14°C. There were few bivalve larvae in a five minute surface plankton tow. Larvae present were mostly early to late umbone mussels.

7. Laredo Inlet

Laredo Channel is located between the west side of Aristazabal Island and the east side of Princess Royal Island (Fig. 28). Since large populations of Manila clams have not become established on the Hecate Strait side of Aristazabal Island, it was of interest to determine if they had dispersed northward through Laredo Channel. Laredo Inlet originates in Laredo Channel to the north of Meyers Passage. This area was surveyed in 1990, but no Manila clams were found (Bourne and Cawdell 1992). More recent work reported finding a few Manila clams in this location (K. Cripps, Kitasoo First Nation, pers. comm.). Due to time constraints, sampling was confined to the southern end of Laredo Inlet (Fig. 28).

Three beaches were sampled in Laredo Inlet, and one beach was surveyed in Trahey Inlet, at the southern end of Laredo Inlet (Fig. 28).

Physical Description of Beaches

The area of the four beaches ranged from about 1.5 ha at Beach 2 to 30 to 40 ha at Beach 3 (Table 3). Clam habitat was generally extensive at all beaches, except Beach 3, where only about 0.5 ha at the mouth of Tyler Creek was deemed suitable as Manila clam habitat. Slope of all beaches was gentle to moderate. There was much cobble on all beaches, but the substrate was mostly sand-pea gravel, at times scattered among the rocks.

Clam Populations

Extensive experimental digging was undertaken on the four beaches and a total of 68 exploratory plots were dug (Table 3). Plots to assess Manila clam density were only dug at Beach 4 in Trahey Inlet (Table 4).

Butter Clams

No samples were taken to assess butter clam populations but shell was found on Beaches 1 and 3, and they were undoubtedly present in suitable habitat in the lower third of all beaches.

Littleneck Clams

Littleneck clams were found on all four beaches, and dead shell was abundant on the surface of beaches. Many of the littlenecks were very stunted. Pooled data totaling 1 m^2 dug at Beach 4 in Trahey Inlet had a density of 26 clams m^{-2} (Table 4). All were small, below 38 mm shell length and many were stunted (Fig. 29). Ages ranged from 1 to 8 years, most were 5.

Manila Clams

Manila clams or Manila clam shell were found on all beaches, but at low densities. Pooled quadrats totaling 1 m^2 dug in Trahey Inlet had 18 clams m^{-2}, most (89%) were larger than 38 mm shell length (Table 4, Fig. 30). Age distribution ranged from 2 to 8 years, most were 5 to 8 years (Fig. 30).

Growth was slower than that found in other locations in the North Coast; about 4.5 years were required to attain a shell length of 38 mm (Fig. 31).

Manila clam populations examined in the southern part of Laredo Inlet were too small to support commercial harvesting.

Manila clams found on Beach 3 at the Bay of Plenty, 52°50' N, are the farthest north the species has been found in B.C. Further survey work should be undertaken to determine if Manila clams occur farther north in Laredo Inlet.

Other Species

Cockles were found on Beach 1 and soft-shell clams on Beaches 1 and 3.

Other Observations

Surface water temperature in Trahey Inlet was 17.5°C.

A five minute surface plankton tow was made in Trahey Inlet. There were moderate numbers of mussel larvae in all stages and three species of clams: soft-shell and littleneck clams and *Hiatella sp.*

8. Port Elizabeth - Chatham Channel

In previous surveys (Bourne 1982; Bourne *et al.* 1994; Bourne and Heritage 1997), considerable effort was spent to determine the dispersal of Manila clams in the Queen Charlotte Strait-Alert Bay area. Results of these surveys showed that there were small isolated populations in a few locations in this area that were apparently able to maintain themselves, but were too small to support commercial harvesting.

Landings of Manila clams have been, and continue to be, reported from this area in DFO statistics, but these landings could not have been from the surveyed populations. Enquiries of Fishery Officers, other residents and the industry did not yield any information about the location of significant populations of Manila clams in this area that could support commercial harvesting. The DFO statistics are believed to be in error.

In the present survey, continued studies were carried out in the Queen Charlotte Strait-Alert Bay areas. Objectives of this part of the survey were: 1) to determine if any further dispersal of Manila clams had occurred in these areas, and 2) to determine if extensive populations of Manila clams existed in these areas that could support commercial harvesting. This part of the survey concentrated entirely on Manila clams; and no work was done with other species.

Three beaches were surveyed in the Port Elizabeth area and three beaches in the Chatham Sound area (Fig. 32).

Physical Description of Beaches

The area of the six beaches varied from 1 ha to 20 ha (Table 3), but the amount of suitable habitat for Manila clams on all beaches was restricted to no more than about 0.5 ha. Slope of the beaches ranged from gentle to steep, with a substantial berm at Beach 2. Substrate of all beaches, particularly in the lower intertidal, was mostly mud with some sand and cobble. Sand-pea gravel

areas existed on most beaches, particularly Beach 2, 3 and 6. Eelgrass was common at lower beach levels on Beaches 2 and 4.

Clam Populations

No survey quadrats were taken to assess clam density on any beach, but a total of 46 exploratory plots were dug on these six beaches (Table 3).

Butter Clams

Butter clams were found in exploratory plots on Beach 3 and 4 and dead shell was common on Beaches 1, 2, 3, 5 and 6. Commercially exploitable populations are undoubtedly present on most beaches in this area.

Littleneck Clams

Littleneck clams were found on all beaches. Some clams, particularly at higher beach levels, were stunted. Old shell was common on all beaches. There was evidence of commercial digging on Beach 2.

Manila Clams

No live Manila clams or dead shell were found on any of the six beaches. If Manila clams occurred on any beaches in this area, they were present at low densities, obviously too low to support commercial harvest.

Other Species

Cockles were common on all beaches except Beach 6. Soft-shell clams were found on Beach 1 (Table 3). *T. nuttallii* shell was found on Beach 4 and *T. capax* shell on Beach 6. Blue mussels were very abundant on Beach 2. *Macoma* sp. occurred on most beaches.,

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21. Port Harvey

Manila clams were first found in Port Harvey in the late 1970's; but only a few live animals were found at that time (Bourne 1982). A more extensive survey of this area was undertaken in 1993, but again, few Manila clams were found (Bourne and Heritage 1997). Landings of Manila clams continue to be reported from this general area, but to date surveys have not discovered populations that could support any commercial harvest. In 1993, the extensive

beach on the west side of Port Harvey was not surveyed because of time constraints. The present survey concentrated on determining the presence or absence of Manila clams in this area.

Physical Description of Beaches

Four beaches were visited: one beach at the north end of the inlet; two extensive beaches around the Mist Islets on the west side of the inlet; and a brief visit to Open Cove at the mouth of the inlet (Fig. 33). Beach 1 was visited during the 1993 survey and was about 5 ha in area with a gentle slope (Table 5). The substrate was mostly soft and muddy and generally unsuitable as Manila clam habitat. Beaches 2 and 3 were part of the large beach around the Mist Islets, which totaled about 5 ha in area (individual beach areas were not recorded). The lower porion of beach 2 was gently sloped mud-silt, the upper portion steeply sloped sand-shell. Beach 3 was gently sloped, with a substrate of sand and silt, covered by large areas of *Fucus*. There was considerable rock on the beach. Beach 4 was mostly cobble and small boulders.

Clam Populations

Manila Clams

Twenty five exploratory plots were dug on the first three beaches (Table 5). Some old Manila clam shell and one live animal was found at Beach 1. Some Manila clam shell was found at Beach 2, but no live animals were located. No live animals or dead shell were found at Beaches 3 and 4.

Results of this survey confirm results of previous surveys (Bourne and Heritage 1997). Manila clams were present in this area but in numbers much too low to support any harvest. Whether sufficient breeding occurs in the Port Harvey area to maintain the population, or whether the population is maintained by larvae from other locations that settle there is not known.

22. *Kakushdish Harbour*

This area was visited briefly during the 1990 survey but no sampling was undertaken because of time constraints (Bourne and Cawdell 1992). The area appeared suitable for Manila clams and it was recommended that a survey be undertaken there.

The harbour was visited on June 28 and 29, 1996 (Table 2). Sampling was mainly confined to digging exploratory plots; survey quadrats were only dug at Beaches 2 and 4 (Table 5).

On July 2 and 4, DFO personnel and members of the Heiltsuk First Nation carried out detailed stock assessment surveys on Beaches 2 and 4. Due to time constraints, these samples

were left with the Heiltsuk members to process and analyze. Results of these surveys will be presented elsewhere.

Physical Description of Beaches

Four beaches were visited in this area: two on the south side of the entrance to the harbour; and two beaches at the head of the harbour (Fig. 34). The area of those parts of beaches suitable for Manila clams ranged from 0.2 to 0.75 ha and had slopes that were gentle on the first two beaches but gentle to steep on Beaches 3 and 4 (Table 5). Substrate of the beaches was variable, but in those parts suitable for Manila clams it was rock-gravel through to sand. There was considerable rock on parts of all beaches.

Clam Populations

Manila Clams

Manila clams were abundant on all beaches and there was evidence of past digging. On Beaches 3 and 4, most Manila clams were in narrow strips around the perimeter of the beaches. There was considerable dead Manila clam shell on Beaches 1 and 2. Two 0.25 m^2 and one 0.5 m^2 quadrats were dug on Beach 4 (combined area 1 m^2) and three plots that gave a combined area of 2 m^2 were dug on Beach 2. Densities of Manila clams on Beach 2 were 61 clams m^{-2} and 165 clams m^{-2} at Beach 4 (Table 6).

There was a wide range in size and age frequency distribution of Manila clams on the two beaches, however, most were 5 to 8 year in age at Beach 2 and 2 to 8 years at Beach 4 (Figs. 35 and 36). Abundance of 2 and 3 year old Manila clams indicated good recruitment in recent years (Fig. 36). Growth was slightly slower than found on beaches in more optimum conditions; it required about 4 years to attain a shell length of 38 mm (Fig. 37).

A length-weight relationship was determined for Manila clams from this area (Fig. 38). The relationship was similar to that found in other areas, *e.g.*, Clayoquot Sound (Bourne and Farlinger 1982). Manila clams weighed about 15 gm at a shell length of 40 mm.

23. Return Channel-Bullock Channel-Johnson Channel-Troup Narrows

Part of this area was surveyed in previous years; Return Channel in 1991 (Bourne *et al.* 1994) and the northern part of Bullock Channel in 1994. In the present survey, the southern part of Bullock Channel was surveyed, along with the northern part of Return channel, Johnson Channel and the Troup Narrows area to provide further information on northward dispersal routes of Manila clams. A total of ten beaches were surveyed; two in Return Channel, three in Bullock Channel, two in Johnson Channel and three in the Troup Narrows area (Fig. 39).

Physical Description of Beaches

Most beaches in this area were small pocket beaches tucked into breaks in the sides of channels, or at the mouths of small creeks; those in Troup Narrows were slightly more extensive. The area of the beaches ranged from about 0.5 to 1 ha (Table 5). Slopes were generally low to moderate. Substrate was variable, ranging from soft mud through sand and gravel; there was a considerable amount of rock on most beaches. Frequently, sand-gravel substrate suitable as habitat for Manila clams occurred in patches scattered amongst rock.

Clam Populations

Manila Clams

Manila clams were found on all beaches except the two in Johnson Channel.

Three exploratory plots were dug on Beach 1 in Return Channel (Table 5). Some old Manila clam shell was found on the beach but no live animals.

Populations of Manila clams were generally sparse on Beaches 3, 4 and 5 in Bullock Channel (Table 5). Two sample plots dug on Beach 4 had densities of 72 and 56 clams m^{-2} (Table 6). Most clams were large; only 6% were under 38 mm shell length (Table 6; Fig. 40). Most Manila clams were 7 to 9 years in age, with a preponderance of 8 year olds. There was little recent recruitment in this area. Growth rate was similar to that found in other parts of this general area, it required about 3.5 years to attain a shell length of 38 mm (Fig. 41).

The lack of Manila clams on Beaches 6 and 7 in Johnson Channel (Fig. 39) was probably due in part to a lack of suitable habitat, as well as to a lack of recruitment (Table 5).

Manila clam abundance was higher in the Troup Narrows area than in Return or Bullock Channels. At Beach 8 density ranged from 13 to 140 clams m^{-2} (Table 6). There was a wide range in size and age frequency of Manila clams on this beach; 79% were 38 mm shell length or larger (Table 6; Fig. 42). Age distribution ranged from 2 to 10 years with most from 3 to 8 years (Fig. 42). Growth was slightly slower than under optimal conditions, it required about 4 years to attain a shell length of 38 mm (Fig. 43).

At Beach 9 in Troup Narrows, density ranged from 82 to 176 clams m^{-2} (Table 6). There was a wide range in size and age frequency distribution; 48% were 38 mm shell length or larger (Table 6; Fig. 44). Age distribution ranged from 2 to 9 years with a dominant mode of 3 year olds (Fig. 44). Good recruitment occurred on this beach in recent years. Growth was similar to that at Beach 8; it required about 4 years to attain a shell length of 38 mm (Fig. 45).

A length-weight relationship was calculated from a pooled sample of Manila clams from the entire area; Return Channel, Bullock Channel and Troup Narrows. Manila clams weighed about 15 gm at a shell length of 40 mm (Fig. 46).

24. Gale Passage

The Gale Passage area was surveyed in 1991 (Bourne *et al.* 1994). At that time, Manila clams were found in both the northern and southern parts of the passage, but were more abundant in the southern part. Reports indicated that considerable commercial harvest of Manila clams occurred in the southern part of the passage and concern was expressed about the state of the stock.

Two beaches were sampled in the southern part of Gale Passage during this survey (Fig. 47). The first was a small beach on the eastern side of the passage. The beach was in two parts (upper and lower section), and a detailed sampling program was carried out on this beach to provide an accurate assessment of the Manila clam population there and to determine the feasibility of undertaking such sampling in the North Coast. A total of 26 sample plots were dug (Table 6).

The second beach was a much larger beach to the west of Beach 1, and had evidence of considerable past harvesting. A brief survey was made of the beach and 3 sample plots were dug and samples pooled. A more extensive survey was curtailed because of time constraints.

Physical Description of Beaches

Beach 1 was divided into two strata: the first stratum was 660 m^2 in area, and the second stratum was 200 m^2 (Tables 5 and 7). Slope of both parts was gentle and the substrate was mainly sand-gravel, with some shell and rock.

Beach 2 was about 3 ha in area with a gentle slope and a substrate mainly sand to coarse gravel and some rock.

Clam Populations

Beach 1

At Beach 1, 20 samples were dug in the first stratum and six samples in the second stratum (Tables 5 and 7).

Butter Clams

Butter clams were found in a few samples at Beach 1. Most (81%) were smaller than 63 mm shell length. The scarcity of butter clams was undoubtedly due to the sampling location, which was high in the intertidal zone, outside the area of optimum abundance.

Littleneck Clams

Littleneck clams were found in about half the quadrats at Beach 1 (Table 6). Density ranged from 0 to 172 clams m^{-2} and half the clams were legal sized. There was a wide range in size and age distribution, with a preponderance of 5 to 7 year old clams (Fig. 48).

Total estimated legal size stock within the survey area was 12,029 clams, weighing 302 kg. Total estimated sublegal size stock was 11,925 clams, weighing 125 kg. Littleneck clams were probably more abundant on beaches lower in the intertidal zone.

Manila Clams

Manila clams were common on Beach 1 and were found in 20 of the 26 sample quadrats (Table 6). Density ranged from 0 to 192 clams m^{-2}; 54% were 38 mm or larger in shell length. There was a wide range in size and age distribution; most Manila clams were 2 to 6 years in age (Fig. 49). Good recruitment occurred in this area in recent years. Growth rate was similar to that found in other areas, it required about 3.5 years to attain a shell length of 38 mm (Fig. 50).

Total estimated legal size stock within the survey area was 21,287 clams, weighing 438 kg (Table 7). Mean legal biomass was therefore 0.5 t ha^{-2}, considerably less than commercially productive beaches in Georgia Strait. Total estimated sublegal size stock was 17,984 clams, weighing 116 kg.

The length-weight relationship of Manila clams at Beach 1 was similar to that recorded in other areas; clams 40 mm shell length were about 15 gm in weight (Fig. 51).

Beach 2

Tha area here was extensive; at least 3 ha. There was good Manila clam habitat which showed considerable signs of past harvesting. Extensive sampling could not be undertaken because of time constraints. Three samples were taken and the data pooled.

Littleneck Clams

Only a few littleneck clams were found (9 clams in 1 m^2) and all were under 38 mm shell length (Table 6).

Manila Clams

Manila clams were reasonably abundant at Beach 2; density was 93 clams m^{-2}, and 50% were 38 mm shell length or larger (Table 6; Fig. 52). There was a wide size and age frequency distribution of Manila clams at Beach 2; size ranged from 20 to 65 mm and age from 2 to 10 years with a strong mode of 3 year olds. The relative abundance of this mode indicates good

recruitment in recent years. Growth was slightly slower than under optimum conditions; about 4 years were required to attain a shell length of 38 mm (Fig. 53).

The length-weight relationship of Manila clams at beach 2 was similar to that at Beach 1 and to other locations in the North Coast; clams 40 mm shell length weighed about 15 gm (Fig. 54).

25. Joassa Channel-Boddy Narrows-Louise Channel

The Joassa Channel-Boddy Narrows-Louise Channel area was surveyed in 1990, and large populations of Manila clams were found there at that time (Bourne and Cawdell 1992). This discovery provided much of the impetus for initiating the commercial Manila clam fishery that began in the Bella Bella area in 1992. The present survey was undertaken to assess the state of Manila clam stocks in this area after commercial harvesting.

Three beaches were visited in the Joassa Channel area, one in Boddy Narrows and one in Louise Channel (Fig. 55).

Physical Description of Beaches

The three beaches in Joassa Channel ranged in area from 2 to 4 ha, had gentle to moderate slopes and substrates of mud through sand-gravel and shell (Table 5). Beach 4 in Boddy Narrows was 2 to 3 ha in area with a gentle slope and a substrate of mud-gravel. Beach 5 in Louise Channel was about 0.13 ha in area with a gentle slope and a substrate of gravel.

Clam Populations

Manila Clams

Manila clams were found on four of the five beaches in densities that ranged from 52 to 296 clams^{-2} (Table 6). There was a wide range in size and age frequency distribution, 46% of Manila clams were smaller than 38 mm shell length (Table 6, Fig. 56). Most Manila clams were 3 to 5 years in age with a dominant mode of 3 year olds, indicating good recruitment in recent years. Growth rate was slower than that found in other areas, it required over 4 years to attain a shell length of 38 mm (Fig. 57)

The length-weight relationship was similar to that found in other areas; Manila clams of 40 mm shell length weighed about gm (Fig. 58) .

26. Kwakshua Channel-Safety Cove

The Kwakshua Channel area was surveyed during the 1991 intertidal clam survey (Bourne *et al.* 1992). Few Manila clams were found there at that time. This was surprising, since the area has several protected beaches with suitable substrate for Manila clams. Further, the area is just south of the Bella Bella area, where Manila clams are abundant on many beaches. The natural assumption was that Manila clams should be abundant on beaches in Kwakshua Channel, and perhaps Manila clam populations were missed during the 1991 survey.

Another thorough survey of the area was undertaken in 1996 to determine if large populations of Manila clams were present in this area. Exploratory sampling was undertaken on seven beaches and another beach was briefly visited (Fig. 59). No quadrat sampling was undertaken (Table 5), but a total of 73 exploratory plots were dug.

In addition, the large beache in Safety Cove, on the east coast of Calvert Island, was visited (Fig. 59). No quadrat samples were taken (Table 5), but two exploratory plots were dug.

Physical Description of Beaches

The eight beaches visited in Kwakshua Channel ranged in area from 0.5 to about 10 ha. Slope varied from low to moderate and the substrate from silt through sand to gravel with considerable rock, bedrock and boulders on some beaches (Table 5).

The beach in Safety Cove was about 4 ha in area, with a gentle slope and a substrate of sand-silt with boulders.

Clam Populations

In Kwakshua Channel, one live Manila clam was found on each of Beaches 1 and 2, and two live animals on Beach 7 (Table 5). Small amounts of dead Manila clam shells were found on Beaches 1, 2 and 5. Beaches 4 and 6 were explored, but no Manila clams were found. Beaches 3 and 8 did not appear to have good Manila clam habitat, and were not explored.

No live Manila clams or dead shell were found on the beach in Safety Cove (Table 5).

This survey confirms the results of the 1991 survey. Manila clams were present in Kwakshua Channel but in very low numbers, much too small to support any fishery. Whether sufficient breeding occurs in Kwakshua Channel to maintain this small Manila clam population, or whether the population is the result of larvae from other locations settling there, is not known.

Reasons for the absence of large Manila clam populations in this area are unknown. There was good habitat for Manila clams on most beaches visited. It is possible that environmental conditions do not permit successful breeding, and hence establishment of large

populations in this area. Reasons for the lack of extensive Manila clam populations in the Kwakshua Channel area warrants further investigation.

DISCUSSION

Results of these two surveys added considerably to our knowledge of intertidal clam populations in British Columbia, both in areas previously surveyed and in areas not surveyed prior to the present work. Although both surveys concentrated on assessment of Manila clam populations, information was gathered on other species.

Butter Clams

No plots were dug to assess butter clam populations, but incidental observations showed that this species is widely distributed in suitable habitat, in the lower third of intertidal beaches in most of the areas surveyed. Live butter clams were common in the few exploratory plots dug in this zone and dead shell was abundant on many beaches. Substantial populations of butter clams exist on many beaches along the coast, which is not surprising since commercial harvest of this species has been minor for the past fifteen years (Fig. 1). It is doubtful if extensive commercial exploitation of butter clams will occur in the immediate future, because of the economics of harvesting and processing this species. The added cost of adequate monitoring for PSP (paralytic shellfish poisoning) in butter clam stocks, particularly in the North Coast, is a further deterrent to commercial utilization of this species.

Littleneck Clams

Littleneck clams were the most common bivalve found during both surveys. Although most sampling, particularly in 1996, was undertaken in the mid to upper part of the intertidal zone, outside the area of maximum littleneck abundance, densities as high as 700 littlenecks m^{-2} were found (Rainbow Island, Gunboat Passage, Table 4). In general, there was a wide range in size and age distribution indicating good recruitment in recent years.

It is unfortunate that present commercial markets do not favour littleneck clams, since large exploitable populations exist on many B.C. beaches. If suitable markets could be found for this species, littlenecks could be harvested with Manilas, which would add greatly to present landings and improve local economies.

As observed in previous years, many littlenecks, particularly in the North Coast, were veryy stunted. Reasons for this stunting are not known, but it is suspected to occur outside the area of optimum habitat (in the mid to upper part of beaches). Density dependent factors could also play a role, however, fast growing clams can be found in the same area along with stunted clams. It is also possible that stunting is genetically determined. The subject of stunting in littlenecks (and other bivalves) warrants further study.

Manila Clams

Results of these surveys provided further information on the distribution and population structure of Manila clams in B.C.

Dispersal

It was believed that Manila clams would not disperse northward through the Discovery Passage-Yuculta Rapids area because of the cold water barrier there (Quayle and Bourne 1972). Results of these and previous surveys (Bourne *et al.* 1994; Bourne and Heritage 1997) show that Manila clam populations are now well established in Cameleon Harbour, immediately north of this area (Fig. 2). There was a wide range in size and age frequency distribution of this population, indicating that successful breeding is occurring and the population is maintaining itself (Fig. 5).

It does not appear that further dispersal is occurring northward in Johnstone Strait, at least to any significant extent. Populations in Port Harvey (Fig. 31) were sparse and this minor population may only be maintaining itself by receiving larvae from spawnings elsewhere.

No Manila clams were found in the Port Elizabeth-Chatham Channel areas (Figs. 2 and 32), indicating that little, if any, further dispersal of this species has occurred in the Queen Charlotte Strait-Alert Bay area.

In the North Coast, only a few Manila clams were found at two locations on the west side of Aristazabal Island (Fig. 26), which indicates that they have not become widely dispersed along the relatively exposed east side of Hecate Strait. Successful breeding is probably not occurring at either of these two locations; the few individuals found probably resulted from spawnings farther south.

Larger Manila clam populations were found in the southern part of Laredo Inlet (Fig. 28). The population in Trahey Inlet was quite extensive and appeared to be maintaining itself through successful breeding since several year classes were present. (Fig. 29) The populations at the bay of Plenty (Lat 52°52' N) marks the farthest north this species has been found in B.C. Whether Manila clams occur farther north in Laredo Inlet is unknown, but should be investigated.

Manila clams do no appear to occur in abundance north of the north side of the Seaforth Channel-Troup Passage-Troup Narrows area (Figs. 2 and 39). Northward of this area, *e.g.*, Bullock Channel, populations are small and isolated. Limited populations in these areas may be due in part to the lack of extensive suitable habitat, but more likely they are due to unfavourable environmental conditions which do not permit successful breeding and survival of juveniles.

The area of extensive Manila clam populations in the North Coast is restricted to a rather narrow area, from approximately the northern part of Seaforth Channel to the southern end of

Lama Passage (Fig. 2). The lack of extensive populations northward of this zone is probably due to cold water temperatures and other adverse environmental conditions that do not permit successful breeding and survival of juveniles. The reason for the lack of extensive populations in suitable habitat south of this area, *e.g.* Kwakshua Channel (Fig. 59), is not known. It may be due to unfavourable environmental conditions (waters that are too oceanic with cold temperatures and high salinities), that do not permit successful breeding or satisfactory growth and survival of juveniles. Another explanation is that the lack of extensive Manila clam populations may be due to a more open circulation in areas such as Kwakshua Channel, that does not permit retention of larvae within these areas, and hence prevents successful recruitment. It is an interesting problem and warrants further investigation.

Populations

In areas where Manila clams were found in abundance during these two surveys, *e.g.* Troup Passage, Kakushdish Harbour, densities as high as 380 clams m^{-2} were recorded (Table 4) and populations were extensive. In areas with extensive Manila clam populations, there was generally a wide size and age distribution of the population indicating that successful breeding was occurring regularly in these areas. There was a slight difference in size and age frequency distribution from beach to beach in any one area, indicating some variability in recruitment within an area, but this would be expected. There did not appear to be a dominant single year class or year classes in the general North Coast area. although modes of 3 year olds were found in Gale Passage and Joassa Channel-Body Narrows-Louise Channel (Figs. 52 and 56). Few Manila clams older than 7 years were found in any area.

It should be noted that Manila clam populations in the North Coast are at the northern limit of their range in B.C. Therefore, successful recruitment is expected to be erratic.

Habitat

In the Strait of Georgia, maximum abundance of Manila clams occurs in a substrate of sand-gravel in the mid intertidal area and they may be found to within 1 m of the high tide line. Few Manila clams are found in the lower third of the intertidal zone.

Manila clams were found in similar habitats during these two North Coast surveys, *i.e.*, in sand-gravel substrate in the mid intertidal area. Few were found in the lower part of the intertidal zone. They did not appear to occur as high on intertidal beaches in the North Coast as in the Strait of Georgia.

Growth

Extensive measurements of growth of Manila clams have been undertaken in the North Coast (Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997). It is

interesting to note that in areas of Manila clam abundance in the North Coast, growth rates were similar to those found in the Strait of Georgia, where about 3.5 years were required to attain a shell length of 38 mm (Bourne 1982). In more unfavourable areas with poor habitat, high in the intertidal area or at the northern extremities of distribution, growth was slower and it required up to 4.5 years to reach 38 mm shell length.

A slower growth rate for Manila clams might be expected in the North Coast than in the Strait of Georgia because of colder temperatures, but this does not appear to be occurring. Further investigations of factors affecting growth of Manila clams should be undertaken.

Length-Weight Relationship

Length-weight relationships were similar in all areas where they were measured, clams 40 mm in shell length weighed about 15 gm. This is similar to results found in other areas (*e.g.*, Clayoquot Sound; Bourne and Farlinger 1982). The consistency in the length-weight relationship showed Manila clams from the North Coast have similar shapes. It also indicates that there was little stunting, since stunting tends to increase thickness of clams and increases weight compared to shell length.

Fishery

As a result of previous surveys, a commercial fishery for Manila clams began in the Bella Bella area in late 1992. Since then, about 425 t of Manila clams have been harvested from this area (Table 1). Evidence of extensive digging was found in some areas; Kakushdish Harbour, Rainbow Island, Gale Passage. Although harvesting has occurred in these areas, populations of Manila clams that remain can support continued harvesting in the short term. However, even though some successful breeding is occurring, annual recruitment may be too erratic to maintain these populations under heavy fishing pressure.

Stocks at the extremes of the range are small and probably of little interest to the commercial industry. Recruitment in these areas appears to be erratic. Harvesting these areas could quickly reduce populations, and erratic recruitment could mean that populations might not recover quickly.

Results of these two surveys along with previous ones have shown that there are few, if any, large beaches with extensive Manila clam populations in the North Coast that are not known or that have not been surveyed. Future success of the Manila clam fishery in this area will depend on consistent recruitment. Since annual recruitment could be erratic, continued close management of these stocks is required to preserve them in a healthy and satisfactory condition.

Breeding

Successful breeding of Manila clams is occurring in many areas besides the Strait of Georgia and the west coast of Vancouver Island, *e.g.*, Cameleon Harbour in Johnstone Strait and in some of the inner waters of the North Coast. This has been shown through histological work in previous surveys (Bourne 1982; Bourne *et al.* 1994; Bourne and Heritage 1997) and by the wide range of year classes found on many beaches. Such consistent breeding may seem surprising since surface water temperatures of 14°C and 15°C are required for gonadal development and breeding (Obah 1959; Mann 1979). Surface water temperature data from lighthouses indicates that temperatures of 14°C and above are rarely attained in these areas (Hollister and Sandes 1972). If such temperatures are attained, it is generally for short periods of time that may be too short to permit gonadal development.

Surface water temperature data taken during these and previous surveys show that water temperatures in inlets and coves, where Manila clams occur, are much higher than recorded at lighthouses; a temperature of 24°C was recorded in a bay in Troup Passage. Duration of these periods of elevated water temperatures is not known, but they are undoubtedly sufficient to permit successful breeding. Continuous recordings of spring-summer surface water temperatures of some of these areas are required and should be undertaken. It is possible that some of these coves and inlets serve as nursery areas for Manila clam larvae and provide recruitment over extensive areas in the North Coast.

Successful annual breeding is dependent on several environmental factors, particularly water temperature. Successful recruitment probably occurs over a wider area in years with above normal surface water temperatures, than in years with below normal summer water temperatures. Studies to determine factors controlling Manila clam recruitment in the North Coast are needed.

The possibility exists that a race of Manila clams has developed in the North Coast which undergoes gametogenesis and breeds successfully at colder water temperatures than in more southern areas. This could probably be determined by modern diagnostic techniques such as DNA testing, and should be undertaken, since it could be an important factor in further dispersal of Manila clams in colder water areas of B.C.

Mortalities

Considerable amounts of dead Manila clam shell were found on several beaches in the North Coast. Some of the shell was old, indicating that extensive populations had been on these beaches for some time, but some of the dead shell was more recent.

It is not known if this shell was the result of continuous accumulation from natural mortalities, or if it resulted from mass mortalities caused by winter kill (Bower 1992; Bower *et al.* 1986). There was no prevalent age or size class of the dead shell. Winter kill has been observed on beaches in the Strait of Georgia and occurs when air temperatures of less than -10°C coincide

with periods of low tides. Similar mortalities undoubtedly occur on beaches in the North Coast, and are probably more prevalent, since winter air temperatures there are colder than experienced in the Strait of Georgia.

The extent of winter kill in Manila clams in the North Coast has not been assessed, but should be determined.

Stunting

Stunting of butter and littleneck clams has been commonly observed in previous surveys, however, few stunted Manila clams were found. In the 1994 and 1996 surveys, stunted Manila clams were found in Cameleon Harbour, where about 10% of the population was stunted, and to a lesser degree at Beach 4 in Troup Passage. Stunted Manila clams are often found in the Strait of Georgia in animals that occur high in the intertidal area. Why stunting is not more prevalent in the North Coast is not known but it may be due in part to the fact that few Manila clams in this area are found high in the intertidal zone.

Pea Crabs

Pea crabs, *Fabia subquadrata*, *Pinnixia faba* and *P. littoralis*, are found consistently in some clams, *e.g.* horse clams, *Tresus capax*, and sometimes in other species such as butter and littleneck clams (Quayle and Bourne 1972; Hart 1982). The presence of pea crabs in butter clams was believed to cause slow growth and stunting (Bourne, unpub. manuscr.).

Pea crabs have been recorded in Manila clams, but it is not common (Bower *et al.* 1992). In 1994, pea crabs were only found in Manila clams in Cameleon Harbour; about 10% of sampled clams had pea crabs. This was an area where stunted Manila clams were found, but it is not known if stunting only occurred in clams with pea crabs.

Aquaculture

Manila clams are a valuable commercial species in B.C. As a result, there is considerable interest in culture or farming of Manila clams; about 40% of 1996 landings were from some form of culture operation. All present culture operations occur in the Strait of Georgia and some areas along southwest Vancouver Island. Manila clam growth rates in many areas of the North Coast are similar to those in the southern area, and the question arises as to whether Manila clams could be cultured in the North Coast. Successful Manila clam farming operations could increase landings and contribute further to the economy of the North Coast.

Differences in environmental conditions between the South Coast and North Coast could lead to differences in the aquaculture potential of the two areas.

Much of the farmed Manila clam production in the southern part of the Province is not "true culture" but "pseudo-culture", which is not a result of planting hatchery raised seed (juveniles), but rather from good husbandry of natural sets. Production is increased through habitat improvments, or placing netting over beaches to increase the survival of natural sets by excluding predators. In some South Coast areas, no seed is actually planted on leases. In the recent past, sufficient natural breeding has occurred in these areas to permit this type of culture.

In the North Coast, Manila clams occur at the northern extremity of their range and successful annual breeding may be erratic. Results of surveys indicate successful breeding is occurring in some areas, but not in others. This means that culture operations in the North Coast may be feasible only in protected areas where regular recruitment occurs. Otherwise it would have to rely entirely on planting hatchery seed, which could be so expensive as to make make culture operations uneconomic.

Another factor is mass mortality caused by cold winter temperatures, which has caused significant kills even in the Strait of Georgia (Bower *et al.* 1986; Bower 1992). Such mortalities may occur more frequently in the North Coast, because of colder winter temperatures there. Large quantities of dead shell found on some beaches in the North Coast could be evidence of winter mortalities. If winter mortalities occur frequently, they could quickly render culture operations uneconomic.

Manila clam culture, or husbandry in some form, has increased production of this valuable species in the South Coast. Experimental Manila clam culture should be undertaken in selected areas in the North Coast to determine the biological and economic viability of such culture there.

Other Species

Limited information was gathered on minor species, such as cockles and soft-shell clams. Although resources of these species would not support targeted fisheries, they could be harvested along with other species if suitable markets were found.

The occurrence of the nuisance sea weed, *Sargassum muticum*, in Clifford Bay (Lat 52° 36' N) is the farthest north this species has been recorded in B.C..

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Table 1. Annual landings of Manila clams (metric tonnes) from the North Coast 1992-1996.

Season	Landings (t)
1992/1993	79.3
1993/1994	64.8
1994/1995	114.1
1995/1996	81.9
1996/1997	74.1
1997/1998	10.7
Total	424.9

Table 2. Sampling dates for beaches visited during exploratory intertidal clam surveys in British Columbia in 1994 and 1996.

Location	Date
Cameleon Harbour	July 19, 1994
Troup Passage	July 20-21, 1994
Lama Passage - Gunboat Passage	July 21, 1994
Spiller Channel - Bullock Channel	July 22, 1994
Higgins Passage	July 23, 1994
Aristazabal Island	July 23-25, 1994
Laredo Inlet	July 26, 1994
Port Elizabeth - Chatham Channel	July 27, 1994
Port Harvey	June 26, 1996
Kakushdish Harbour	June 28-29, 1996
Return Channel - Bullock Channel - Johnson Channel - Troup Narrows	June 30, 1996
Gale Passage	July 1, 1996
Joassa Channel - Boddy Narrows - Louise Channel	July 3, 1996
Kwakshua Channel - Safety Cove	July 6, 1996

Table 3. Physical description of beaches and number of quadrats dug during exploratory intertidal clam surveys in 1994.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Cameleon Harbour		
1	0.25	3	gentle	coarse sand	Firm, mostly sand, some gravel and cobble. Good butters and horse clams, few Manilas, littlenecks most common. Some *Macoma inquinata* and one *M. balthica*.
2	0.50	4	gentle	sand/mud	Rocky berm at low tide level, gentle mud/sand beach above. Few Manilas, mostly littlenecks, one cockle. Some large *Macoma nasuta*, few *M. inquinata* and one *M. balthica*. Lots of dead *Mya arenaria*, few small live ones.
3	0.50	4	gentle	gravel/sand/mud	Logging debris, large population of sea stars, mixed Manila and littleneck population in all substrates, Manilas found in logging debris. Beach from right of creek to large rock.
4	0.40	3	gentle	coarse sand/gravel	Good Manila and littleneck habitat. Extensive beach at head of harbour. 1 Pacific oyster (live), and some shell near high tide mark.
5	1.00	1	gentle/ mod.	sand/gravel	Extensive heavy barnacle set (approx 2-3 yrs old), very few blue mussels.
6	0.50	0	gentle	sand/gravel	Head of Handfield Bay, within Thurston Bay Marine Park.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Troup Passage		
1	2.50	5	gentle	sand/gravel	Flat beach of clean sandy gravel, great numbers of Manilas. Fish weir at mid-high tide, Manila population below this. Moderate littleneck population, though badly stunted. Few Manilas above weir. Lots of dead topshell, possibly winter kill from previous years. Extensive eelgrass beds in subtidal, and to lesser extent in intertidal. Some Manilas in eelgrass beds on firm substrate.
2	1.00	4	gentle/ mod.	mixed, mostly sand/gravel, some mud/sand	Few butter clams, very few littlenecks, mostly Manilas. In areas of heavy algal mat, Manilas at or very near surface. Also saw *M. balthica*, *M. nasuta* and *M. inquinata*, *Mya arenaria* and *C. nuttalli*.
3	1.00	4	gentle	sand/pea gravel, mud near creek channel	Bay NE of Wood Island on Chatfield Island. Lower reaches of beach sandy mud and eelgrass cover. Eelgrass had stunted littlenecks and some Manilas, when substrate firm enough. Good concentrations of Manilas on gravel banks above eelgrass beds on west side of beach.
4	2.0	6	gentle/ mod.	mud/sand/gravel/broken rock	Many small Manilas, water temperature 24°C. Algal mat on lower part of beach. 36 Manilas in 5 fork-fulls. Narrow inlet with broken rock on edges, sloping through coarse sand and mud to mud and eelgrass in creek channel in center. Flooded when visited 7/20, revisited and sampled 7/21. Stunted Manilas and littlenecks concentrated in suitable substrate on sides of inlet, between rock and creek channel. Manilas in commercial concentrations, but patchy distribution. Juvenile Manilas on southeast side of inlet. Evidence of old mass mortality in area, lots of dead shells on top.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
Lama Passage - Gunboat Passage					
1	2.00	1	mod./ steep	pea gravel/fine gravel	Manilas present in commercial quantities, though little evidence of digging.
2	0.30	4	gentle/ mod.	pea gravel/sand	Small patch of beach separated from following beach by rocky headland. Evidence of digging (old holes, clam rake, etc.) on this beach.
3	0.75	3	gentle/ mod.	gravel	Mostly gravel and broken rock, with 10 x 25 m berm of gravel in center. Berm contained stunted littlenecks, most of rest of beach was Manilas. Lots of *Modiolus* sp. shell on lower reaches of beach.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Spiller Channel - Bullock Channel		
1	3.00	0	mod.	cobble/gravel	Mosquito Bay, Spiller Channel. Rough beach, two creek channels. Clam distribution patchy, digging tough. Some Manilas, few cockles and *Mya*.
2	4.00-5.00	1	gentle	mud/pea gravel/cobble	Mostly (3/4) mud and eelgrass, lots of cockles. Gravel above fish weir had small pockets of Manilas, usually in soft substrate between cobbles. Very little Manila habitat.
3	0.02	0	steep	sand/pea gravel	Half of beach covered in eelgrass. Lots of shell on top. Mainly stunted littlenecks.
4	0.01	0	mod.	sand/pea gravel/cobble	Lots of shell on top. Not good production, but a few juveniles present. Bottom 1/3 of beach is eelgrass.
5	0.18	2	gentle/ mod.	sand/gravel/cobble/mud	Long beach divided by saddle from shore to large rock. Lower third of beach gravel and sand, eelgrass cover, good butters in patches. Manilas in uniform 3 m strip between cobbles on upper beach and stunted littlenecks on flat lower half of beach.
6	0.005	2	gentle/ mod.	sand/pea gravel/cobble	Eelgrass covering bottom third of beach. Stream channel running down left side of beach, mud on either bank. *Fucus* covering most of upper beach, some Manilas living on surface.
7	0.002	1	gentle/ mod.	sand/pea gravel/mud	Not many clams found, though fair amount of shell on beach. Patches of clams in pea gravel ridge, midway up beach.
8	1.00	2	gentle/ mod.	coble/sand/wood debris/pea gravel	Stunted littlenecks living under algal mat and in wood debris. Some Manilas living on surface under algal mat, which covered a 10 m strip across most of beach. Very good barnacle set, some *Mya* found high on beach. Butter clams low on beach. Fair amount of shell on top.
9	0.52	0	mod.	pea gravel/sand/cobble	*Fucus* along high tide line. Manila and littleneck clams living on or near surface under algal mat. Good butter clam population further down.
10	2.00-3.00	0	gentle/ mod.	coble/gravel/sand	No good Manila habitat. Some stunted littlenecks and very old Manilas living on muddy sand surface under algal mat, midway up beach.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Higgins Passage	
1	12.00	2	mod.	sand/pea gravel/mud	Some bedrock ridges running perpendicular to water. Manila habitat only 800 m^2. Mainly butter clam beach, with *Macoma*, butters and soft-shells in lagoon, some horse clam shell (*T. capax*). Big littlenecks high on beach.
2	4.00	0	gentle	mud/sand/bedrock	No Manila habitat. Mostly butter, cockle and *Macoma*. Lower beach covered in eelgrass and *Ulva*, lots of moon snail collars and some shells. Several *Parastichopus* in eelgrass. Upper terrace was mainly bedrock with shallow cover of crushed shell and mud, no clams at all.
3	5.00	3	variable	sand/pea gravel/cobbles	Less than 5% Manila clam habitat. Algal mat covering much of lower half of beach. Mostly stunted littlenecks and butters found in scratches, butters more common higher on beach. Lots of very old littleneck shell and some Manila shell on beach. Beach becomes steep and rocky at about the proper depth for best Manila habitat.
4	1.20	2	mod./ steep	gravel/bedrock/crushed shell	Lots of old Manila shell on beach. Manilas restricted to 0.7 ha. plot of good habitat. Some areas of higher concentration observed than areas where samples were taken.
5	3.50	0	steep/ gentle	pea gravel/sand	Two small beaches on bays, separated by large lagoon on saddle. Algal mat covering 20% of small beach on NE. Large rocks along high tide line and across saddle, cobbles near low tide line. Clam distribution very patchy, many scratches barren. 2 Manilas found above lagoon. Lagoon full of *Sargassum*,, eelgrass, many leather stars, some moon snails. Upper tide pool has good concentration of *Pododesmus macrochisma*.
6	1.50	0	mod.	sand/pea gravel/cobble	Beach substrate was very dry. 6 m strip of *Fucus* in upper intertidal, 4 m strip of algal mat in lower intertidal. Only a few littlenecks, some juvenile littlenecks.
7	0.30	2	mod./ steep	pea gravel/rock	Manila habitat ~ 600 m^2. Lots of recent dead clam shell. Low concentrations of littlenecks. Only Manilas were collected in the two samples taken.
8	10.00	0	mod.	mud/pea gravel/clay/cobble	Cobbles (10-12 m) near high tide line, most of lower beach mud and eelgrass. Few Manila shells on beach, 2 Manilas found in scratches. Much of beach has butter and cockles, butter clams stunted.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Weeteeam Bay, Aristazabal Island		
1	1.00	0	gentle	mud/gravel/cobble	Mostly mud estuary about .25 km above bay. Very little Manila habitat, small patch near rocky area on edge of creek channel. Lots of stunted littlenecks with few large Manilas (11 taken from 3 m^2). Most of beach cockle and some butter clams.
2	3.50	0	mod./ steep	pea gravel/sand/cobble/mud	No Manila habitat, no Manilas found. Thick algal growth over mud and much of muddy gravel areas. Beach split by creek channel, rocky headland. Area of beach in bay entirely mud, with eelgrass cover. Some cobble above fish weir in bay, but lots of mud in between, few stunted littlenecks and some fast growing littlenecks found. *Macoma*, cockles and *Mya* present.
3	0.005	0	gentle	shell/sand	Manila clam density ~2 m^{-2}. Probably cockles in soft substrate.
4	11.00	0	gentle	mud/pea gravel/sand	Tidal estuary for small creek, which runs down center of beach. Littleneck, cockle and soft-shell and some butter shell on surface. *Mya* and *Macoma balthica* shell. Dug one cockle.
5	1.00	0	mod.	sand/pea gravel	Manila and litttleneck shell on surface. Some littlenecks in scratches, very few and fairly deep. No Manilas found. Some cockle shell on surface, and some dug in scratches.
6	1.50	0	mod.	sand/pea gravel	Some very old Manila shell, no Manilas found.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Clifford Bay, Aristazabal Island		
1	5.00	0	gentle	mud/sand/cobble	Poor clam beach, virtually no Manila habitat. Five ridges of bedrock run perpendicular to tide line. 2/3 of beach covered by eelgrass. Some shell on beach: horse, butter, littleneck, soft-shell, one rock scallop. No evidence of Manila clams.
2	2.00	0	gentle	sand/pea gravel	Cobbles at high tide line. Lower half of beach under eelgrass. Lower quarter butter clams. Very little shell on beach, some horse, butter, cockle, soft-shell, littleneck. No clams in scratches. No evidence of Manilas.
3	2.00	0	mod.	pea gravel/sand/cobble	Top third of beach all cobbles. Lower quarter covered in eelgrass. Very little shell on beach: horse, butter, cockle, littleneck, fragment of sunset clam shell.
4	7.00	0	gentle/ mod.	sand/shell/pea gravel/cobble	Cobbles and *Fucus* at mid-tide level. Main beach on bay ~2ha., tidal channel from large 5 ha. lagoon and beach inland. Some cockle and butter shell on main beach, stunted littlenecks and large butters living in tidal stream. Eelgrass and *Sargassum* in lagoon. Lagoon at least 15' deep in one place. Lots of red rock and *gracilis* crabs, sunset clams, butters and horse clams. A couple of geoducks in lower intertidal, one *Diplodonta orbellus*.
5	20.00	0	gentle	sand/pea gravel/cobble	Large cockles and much cockle shell on lower beach in eelgrass bed. Extremely large fish weir on midbeach. Some shell above weir, soft-shell, cockle, Manila, littleneck, butter. Some littlenecks and cockles living near creek channel. Manilas found in sand/gravel knoll, rising 0.6 m above surrounding beach.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Laredo Inlet	
1	4.00	0	mod.	sand/pea gravel/cobble	Mostly barren beach. Very little suitable habitat. Some shell on beach: butter, cockle, soft-shell, littleneck, Manila. No live Manilas found.
2	1.50	0	mod.	cobble/sand	Not much suitable habitat. Butter, littleneck and Manila shell on beach. Stunted littlenecks and 3 Manilas dug.
3	30.00-40.00	0	gentle	sand/cobble/gravel/wood debris	Bay of Plenty. Very little suitable habitat. Not great amounts of shell on beach, but reasonable proportion is Manila, all sizes. Manilas mainly near low tide line, near mouth of Tyler Creek, in low concentration.
4	2.00	1	gentle	mud/pea gravel/cobble/wood debris	Head of Trahey Inlet. Difficult to assess beach, as tide chased us off. Manilas, littlenecks and soft-shell found at rising tide line. Surface wter temperature 17.5°C.

Table 3. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Port Elizabeth - Chatham Channel		
1	7.00	0	gentle	mud/sand/cobble	Port Elizabeth. Only about 50 m^2 of Manila habitat. Most of mud covered in eelgrass. Few *Mya*, *Macoma* and littlenecks. Some cockle and *Macoma* shell. Not much shell of any kind on beach. No evidence of Manilas.
2	1.00	0	steep	sand/pea gravel/cobble	Port Elizabeth. Fair concentrations of littlenecks on berm on beach. Smaller littlenecks higher on beach. Lots of blue mussel shell, some butter and cockle shell. Found old bag of clams, entirely littleneck. No evidence of Manilas.
3	4.50	0	mod.	sand/mud/pea gravel/cobble	Port Elizabeth. Eelgrass covering much of lower half of beach. Lots of cockle and some *Macoma* shell on beach. Dug butters, *Macoma* and littlenecks in scratches. Water temperature 16°C. No evidence of Manilas.
4	20.00	0	gentle	mud/sand	Cutter Cove. Lots of cockle and *Macoma* shell, live cockles on surface. Found *T. nuttalli* shell. Small shell piles were 90% cockle, some littleneck. No steamer clam habitat. No evidence of Manilas.
5	15.00	0	gentle	mud/cobble	Pearley Lagoon. Lots of eelgrass and wood debris. Lots of butter and cockle shell on surface. Stunted littlenecks, soft-shell, cockles and butters in scratches. Mouth of lagoon had numerous small pinkish-white *Cucmaria*. No evidence of Manilas.
6	1.50	0	mod./ steep	cobble/pea gravel	Hadley Bay. Algal mat over much of beach. Butter clam, littleneck and horse mussel shell on beach. Reasonable concentrations of small, stunted littlenecks. No evidence of Manilas.

Table 4. Densities of butter, littleneck and Manila clams, along with densities of soft-shell clams, cockles and *Macoma* sp. (clams m^{-2}) from exploratory intertidal clam surveys, July 19-27, 1994. (P) = data pooled from a number of quadrats. Legal size for Manila and littleneck clams is 38 mm, for butter clams is 63 mm.

		Butter		Littleneck		Manila				
Beach	Quadrat	Legal	Sublegal	Legal	Sublegal	Legal	Sublegal	Macoma	Soft-shell	Cockle
					Cameleon Harbour					
1	1	0	0	88	28	16	0	0	4	0
1	2	0	0	116	184	8	12	24	4	0
1	3	0	0	20	104	8	20	0	0	0
2	1	0	0	4	8	48	4	0	0	0
2	2	0	0	16	0	12	8	28	16	0
2	3	0	0	56	88	8	0	8	4	0
2	4	0	0	44	188	4	8	36	0	0
3	1	0	0	36	204	4	0	0	0	0
3	2	0	0	24	44	48	12	4	0	0
3	3	0	0	8	8	76	20	0	4	0
3	4	0	0	0	0	52	0	0	0	0
4	1	0	0	76	68	36	16	0	0	0
4	2	0	0	56	84	20	20	16	8	0
4	3	0	4	40	192	56	76	36	0	0
5	1	0	0	0	60	8	8	0	0	0
					Troup Passage					
1	1	0	0	0	120	84	12	0	0	0
1	2	0	8	0	100	188	12	0	0	0
1	3	0	20	20	84	80	0	4	0	4
1	4	0	0	0	152	364	16	8	0	4
2	1	4	4	8	0	36	0	0	0	0
2	2	0	0	4	0	100	16	12	0	0
2	3	0	0	0	0	300	32	0	0	0
2	4	0	0	0	4	232	64	0	0	0
2	5	0	0	0	0	348	20	0	0	0
3	1	0	4	0	328	88	16	0	0	0
3	2	0	0	36	140	80	12	44	0	0
3	3	0	4	0	232	268	20	0	0	0
3	4	0	4	0	152	236	12	0	0	0
4	1	0	0	0	8	32	20	0	0	0
4	2	0	0	0	0	60	140	0	0	0
4	3	0	0	0	0	44	44	0	0	0
4	4	0	0	0	0	0	0	0	0	0
4	5	0	0	0	0	92	316	0	0	4
4	6	0	0	0	4	60	0	0	0	0

Table 4. (cont.)

Beach	Quadrat	Butter		Littleneck		Manila		Macoma	Soft-shell	Cockle
		Legal	Sublegal	Legal	Sublegal	Legal	Sublegal			
Lama Passage - Gunboat Passage										
1	1	0	16	152	476	76	128	0	56	4
2	1	0	0	0	0	92	12	0	0	0
2	2	0	0	12	28	180	12	0	0	0
2	3	0	0	0	16	108	312	0	0	0
2	4	12	0	92	8	12	12	0	0	0
3	1	4	0	8	332	144	28	0	0	0
3	2	0	0	12	688	120	48	0	12	0
3	3	4	0	28	396	168	16	4	0	0
Spiller Channel - Bullock Channel										
2	1	0	0	0	0	260	60	4	0	0
5	1	0	0	0	4	140	8	4	0	0
5	2	0	4	24	72	100	20	0	12	4
6	1	0	8	0	0	96	20	0	0	0
6	2	0	0	0	56	48	8	0	0	4
7	1	0	4	0	16	148	4	0	0	0
8	1	0	0	0	72	164	8	0	8	0
8	2	0	0	136	104	0	0	0	24	4
Higgins Passage										
1	1	4	4	56	64	16	4	0	12	0
1	2	0	4	40	164	12	0	4	16	8
3	1	0	24	20	344	12	0	0	8	0
3	2	0	0	36	120	100	0	0	12	0
3	3	0	20	16	404	72	0	0	12	0
4	1	20	16	88	60	28	0	0	0	0
4	2	0	0	184	220	48	0	4	0	0
7	1	0	0	0	0	44	0	0	0	0
7	2	0	0	0	0	52	0	0	0	0
Laredo Inlet										
4	(P)	0	0	0	26	16	2	0	0	0

Table 5. Physical description of beaches and number of quadrats dug during exploratory intertidal clam surveys in 1996.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Port Harvey	
1	5.0	0	Low	silt/sand	Poor tide, visited before 2.0 m low. Large beach area, but very poor substrate. Thick covering of silt, patches of blue mussels. Large midden in bank above beach. Some layers of white shell, likely littleneck and butter, with a deeper thick layer of soft purple shell. Too badly broken down to be sure, but likely blue mussel shell or urchin test. *Salicornia* at top of beach, *Zostera* below. 10 scratches.
2	n/a	0	Mixed	Upper beach sand/shell with high slope, lower beach silt with low slope.	Upper beach had Manila shell, stunted littlenecks, both *Macoma nasuta* and *M. inquinata* and a few *M. balthica*, found one small live Manila. Lower beach under water, showed many mud shrimp burrows in silty substrate. Midden had similar deeper purple layer, was blue mussel, not as deteriorated as at beach 1. 5 scratches.
3	n/a	0	Low	sand/silt	Much of beach covered in *Fucus*. Lots of large, old littlenecks, most with good growth. Some butters, lots of blue mussels in *Fucus* . Substrate under rockweed was soft and smelly. Open areas between *Fucus* were firm sand/silt, contained most of the littlenecks and butters. *Macoma nasuta* plentiful. 10 scratches.
4	n/a	0	Steep	cobble/small boulders	Visit only - did not land.

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Kakushdish Harbour		
1	0.20	0	Gentle	broken rock/crushed gravel.	Outer part of beach on right side entering the harbour. Much of beach covered by a mat of filamentous algae. Large quantities of Manila shell, possibly from a winter kill. Many Manilas of about 4 year classes (1994-95 yr. class present)); littlenecks , *Mya* and *Macoma* present, one young butter clam shallow in substrate. Intertidal sea cucumbers and anemones
2	0.75	3	Gentle	Fine broken rock like crushed gravel.	Inner part of beach on right side entering the mouth of the harbour inside a fish weir. Same as beach 1.
3	0.50	0	Terraced -steep	Sand-gravel, crushed gravel.	North side head of harbour. Large fish weir with sand-gravel substrate above it contained stunted Manilas. Slight terrace below weir contained larger Manilas and some smaller year classes, mostly 1994 and 1995. Steep part of beach contained Manilas, probably a narrow strip.
4	0.25	3	Gentle - steep	Sand- crushed gravel and broken rock	South side head of harbour. Manila habitat follows a narrow strip on both sides of creek channel and up to a broader area within the creek. Steep sides of beach contained stunted Manilas. *Macoma* and *Mya* also present.

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
Return Channel - Bullock Channel - Johnson Channel - Troup Narrows					
1	1.00	0	mod.	broken rock/cobble/boulders	Return Channel. Lots of barnacles and rockweed (*Fucus*) in upper intertidal. Beach slope greatly increased below low water break, lots of eelgrass (*Zostera*). Horse clams, butters, littlenecks, cockles and soft-shells present. Some old Manila shell, no live Manilas.
2	1.00	0	mod.	Creek estuary, broken rock/cobble/sand.	Return Channel beach east of Ellershank Point. Lots of rockweed and barnacles in upper intertidal, greatly increased slope and eelgrass coverage below low water break. Butter, littleneck, cockles and horse clams present. Some old Manila shell, no live Manilas.
3	1.00	0	mod/ low	Creek estuary, broken rock/cobble, some mud/silt on lower beach.	Bullock Channel, southwest side. Barnacles and rockweed in upper intertidal, eelgras below water line. Littleneck, butter and cockles present. Some old Manila shell, but no live Manilas.
4	0.50	2	high/ mod	Rock/cobble on lower slope (relatively hgh slope), flat sand/gravel berm at mid-tide level.	Bullock channel, southwest side. Eelgrass at lower margin of beach, runs right into rockweed on steep lower slope. Barnacles on rocks and shell in berm, no vegetation. Lots of stunted littlenecks, some butters and horse clams present. Moderate densities (64/m^2) of Manilas on berm, mostly large, old clams.
5	0.50	0	mod/ow	Lower beach packed sand/rock/cobble. Upper beach is a large, shallow meadow (estuarine) of sand/silt.	Bullock Channel, northeast side. Moderate slope on beach on northwest side, mostly sand and rocks, some Manila shell, a few littlenecks, lots of soft-shell clams. Three live Manilas in ~0.5 m^2. Large flat "*Fucus* meadow" at top of beach is packed sand with some rocks and wood debris. Dominated by rockweed and a thick, stringy green algae in tangled mats. No clams in upper beach.
6	<0.50	0	low	Sand/large rocks	Johnson Channel, southeast side of peninsula south of Beaumont Island. Blue mussels and barnacles adhered to rocks, mostly in upper intertidal. Lots of logs and wood above high tide line. Total beach area approaching 4 ha., very little Manila or littleneck habitat. Some cockles present. No Manila shell.
7	1.00	0	low	Lower beach sand, upper beach gravel.	Johnson Channel, northwest side of penninsula south of Beaumont Island. Eelgrass at lower margin of beach. A few cockles and horse clams, some stunted littlenecks. Not a very productive area, clam-wise.

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
Return Channel - Bullock Channel - Johnson Channel - Troup Narrows (cont.)					
8	<0.50	2	low/mod	Lower beach broken rock, upper beach gravel/sand with some rock.	Troup Narrows, outlet of creek from Webster Lake. Very rocky lower beach, large fish weir. Lots of stunted littlenecks and large Manilas around edges of fish weir. Lots of Manila shell. Visited beach at head of bay, not much habitat, possibly littlenecks and some Manilas.
9	1.00	3	low	gravel/sand/shell/small rocks	Lots of eelgrass at low tide margin of beach, not much rockweed o upper beach. Creek channels (3-4) run across beach. Lots of Manilas mid-upper beach, in clean gravel, even close to creek channels.
10	0.50	0	low	hard-packed sand/silt.	Hard beach, not much living in it. Some butters, littlenecks and soft-shells. Some Manila shell, no living Manilas found.

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Gale Passage		
1	0.86	26	low	sand/shell/gravel	Pocket beach above the passage. Evidence of digging recently on beach. Two strata placed on Manila portion of beach. First stratum 660 m^2, 20 samples taken. Second sample 200 m^2, 6 samples taken. Manilas, littlenecks and butters present. Tide pool had *Parastichopus*, *Hinnites*, and *Pododesmus*. Some *Modiolus* shell and several species of limpet present.
2	3.00	3	low	sand/gravel/shell	Broad beach below tidal lagoon. Lots of evidence of recent digging for Manilas. Manilas, littlenecks present. Manilas in wide band at mid-beach in appropriate substrate around standing pool of water. Some *Searlesia* in substrate. Tidal lagoon above supports large number of huge sea mussels (*Mytilus californiensis*).

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
Joassa Channel - Boddy Narrows - Louise Channel					
1	2.00	4	mod/low	Gravel/mud/shell	Beach horseshoes around small rocky island with kayakers camped on it. Lots of littlenecks and butters on lower beach. Cockle and butter shell on lower beach. Manilas in a band at mid beach on the western side, more extensive patch above and below small fish weir on northern sideof island. Manila area less than 0.5 ha. Eastern side of beach intertidal eelgrass bed, soft mud/shell substrate, lots of butters, littlenecks, and some cockle shell. The area near the weir had been dug recently.
2	2.00	0	low	Mud/shell	Sharply sloped lip on lower beach, extensive intertidal eelgrass bed in channel. Large littlenecks and butters numerous. Lots of *Gari* shell, *Polinices* egg cases, and *Picopodium* and *Dermasterias* in eelgrass, *Pododesmus* and *Cucmaria* (?) in rocky edges. No Manilas or shell.
3	3.00-4.00	2	low	Sand/gravel in bay, shell/mud/gravel in channel.	Small beach in bay, walked over a small rock ridge to an extensive intertidal channel with some large tide pools. Tide pools had lots of *Parastichopus*, *Picnopodium*, *Dermasterias*, and large white and brown anemones (*Metridium* ?). Some *Gari* , *Tresus capax* and cockle shell, lots of littleneck and butter shell. Large butters and littlenecks shallow in substrate, easily turned out with scraper. Manilas in a small patch in the upper channel, and a patch of ~1/8 ha. in the bay. Two samples taken in the channel, one in the bay. Both the bay and the channel had been dug recently.
4	2.00-3.00	2	low	Gravel/mud	Boddy Narrows. Long triangular bay with steep rocky shore on eastern side, gently sloped gravel on western side. Lots of stunted littlenecks and lots of *Modiolus modiolus* shell. Manilas in a broad band across the mid-beach, probably over a hectare in total. Evidence that a lot of the beach had been dug recently.
5	0.13	1	low	Gravel	Louise Channel. Small beach inside fish weir. Lots of Manilas and stunted littlenecks. No evidence of digging. Fast visit as the tide had arrived.

Table 5. (cont.)

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Kwakshua Channel - Safety Cove		
1	2.00	0	low	sand	Large lagoon draining through narrows near resort dock. Lots of *Macoma*, cockles, littlenecks. Cockles and littlenecks especially abundant in narrows. Some butters, *Mya*, *T. capax*. *Natica clausa* and bright orange *Thais* found. Some Manila shell and 1 live Manila found.
2	8.00	0	low	sand/silt above, gravel below	Upper portion of beach extensive (6 ha.) sand flat with cockles, littlenecks and butters. Lower portion of beach (2 ha.) gravel with lots of littlenecks and butters. Shell of *Mya*, *Macoma nasuta* an d *M. inquinata*, blue mussels. One Manila shell and 1 live Manila found. Only explored 1/4 of way up sand flat.
3	2.00	0	low	sand	Sandy flats with eelgrass extending all the way up to rocks in the upper intertidal. Visit only, did not sample.
4	3.00	0	low/mod	sand/silt, some boulders	Beach divided into upper and lower portions by a ridge of boulders. Few clams above rock line, mostly *Macoma* and littlenecks. Moderate densities of clams below rock line, primarily butter and littleneck, with some *T. capax*. No Manilas or shell found.
5	1.50	0	low	sand	Small beach with creek channel on right side (facing water). Low to moderate densities of clams, mostly cockles, littlenecks and butters, some *Macoma nasuta* and *T. capax*. Lots of broken shell on large rock outcrop in center of beach, 90% cockle shell, some large old (8+ yr) Manila shell in rock, couldn't locate live ones.
6	0.50	0	mod	sand/shell, boulders and bedrock	Did not visit large beach at head of inlet, looked like sand covered in eelgrass up to rocky high tide line. Stopped at small strip beach on western side of inlet. High densities of butters, some littlenecks and *Macoma*. No Manila or shell found.
7	10.00	0	low	sand, some gravel in ridge	Extensive sandy beach, large shell/gravel bank mid-beach on one side, near old pilings. Generally low densities of clams, mostly butters, *Macoma* and some littlenecks. No Manila shell, but 2 live Manilas found.
8		0	low	sand	Did not sample, low slope sand beach with eelgrass cover up to high tide line. Plankton tow (5 min.) done in center of Kwakshua.
9	4.00	0	low	sand/silt, some boulders	Safety Cove. Sand beach with eelgrass at low water and creek channel down center. Moderate densities of cockles, butters, with some *T. capax* and littlenecks. No Manilas or shell found.

Table 6. Densities of butter, littleneck and Manila clams, along with densities of soft-shell clams, cockles and *Macoma* sp. (clams m^{-2}) from exploratory intertidal clam surveys, June 26-July 5, 1996. (P) = data pooled from several quadrats. Legal size for Manila and littleneck clams is 38 mm, for butter clams is 63 mm.

		Butter		Littleneck		Manila				
Beach	Quadrat	Legal	Sublegal	Legal	Sublegal	Legal	Sublegal	Macoma	Soft-shell	Cockle
Kakushdish Harbour										
2	(P)	0	0	0	0	52	9	0	0	0
4	(P)	0	0	0	0	85	80	0	0	0
Return Channel - Bullock Channel - Johnson Channel - Troup Narrows										
4	1	0	0	0	0	72	0	0	0	0
4	2	0	0	0	0	48	8	0	0	0
8	1	0	0	0	0	116	24	0	0	0
8	(P)	0	0	0	0	5	8	0	0	0
9	(P)	0	0	0	0	24	58	0	0	0
9	2	0	0	0	0	52	104	0	0	0
9	3	0	0	0	0	124	52	0	0	0
Gale Passage										
1	1	0	0	0	0	0	12	0	0	0
1	2	0	0	0	0	36	32	0	0	0
1	3	0	0	0	0	0	4	0	0	0
1	4	0	0	0	0	0	0	0	0	0
1	5	4	4	84	80	0	0	0	0	0
1	6	4	0	84	28	12	0	0	0	0
1	7	0	0	0	0	4	16	0	0	0
1	8	4	3	96	52	4	0	0	0	0
1	9	0	0	0	0	4	40	0	0	0
1	10	0	0	0	8	28	56	0	0	0
1	11	0	0	0	4	84	56	0	0	0
1	12	0	0	20	0	0	8	0	0	0
1	13	0	0	4	8	24	4	0	0	0
1	14	0	0	0	0	0	0	0	0	0
1	15	0	0	0	4	24	52	0	0	0
1	16	0	0	12	12	96	44	0	0	0
1	17	0	0	12	28	68	76	0	0	0
1	18	0	0	0	0	0	12	0	0	0
1	19	0	0	0	0	0	0	0	0	0
1	20	0	0	0	0	156	36	0	0	0
1	21	0	0	0	0	0	4	0	0	0
1	22	0	0	0	0	0	0	0	0	0
1	23	0	0	0	4	48	60	0	0	0
1	24	0	0	0	0	0	0	0	0	0
1	25	4	8	8	4	52	28	0	0	4
1	26	8	64	44	128	4	4	0	0	0
2	(P)	0	0	0	8.5	46.5	46	0	0	1

Table 6. (cont.)

Beach	Plot	Butter		Littleneck		Manila		Macoma	Soft-shell	Cockle
		Legal	Sublegal	Legal	Sublegal	Legal	Sublegal			
Joassa Channel - Boddy Narrows - Louise Channel										
1	1	0	0	0	0	28	24	0	0	0
1	2	0	0	0	0	72	40	0	0	0
1	3	0	0	0	0	40	32	0	0	0
1	4	0	0	0	0	48	4	0	0	0
3	1	0	0	0	0	28	44	0	0	0
3	2	0	0	0	0	128	12	0	0	0
4	1	0	0	0	0	72	224	0	0	0
4	2	0	0	0	0	48	12	0	0	0
5	1	0	0	0	0	44	36	0	0	0

Table 7. Biomass and abundance estimates of Manila and littleneck clams for Beach 1, Gale Passage, July 1, 1996.

Manila Clam Biomass

Stratum	Area (sq.m.)	Mean Wt Legals (kg/sq.m.)	S.E. Legals (kg/sq.m.)	Mean Wt Sublegals (kg/sq.m.)	S.E. Sublegals (kg/sq.m.)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	660	0.559	0.190	0.145	0.038	20	369	251	96	51
2	200	0.349	0.201	0.101	0.072	6	70	80	20	29
Total	860					26	438	273	116	62
				df Legals	23.69		t Legals	2.0687	Leg Prec.	62%
				df Subl	15.31		t Subl	2.1315	Subl. Prec.	53%

Manila Clam Abundance

Stratum	Area (sq.m.)	Mean No. Legals (#/sq.m.)	S.E. Legals (#/sq.m.)	Mean No. Sublegals (#/sq.m.)	S.E. Sublegals (#/sq.m.)	n	Estimated Legal Stock (#)	95% CI	Estimated Sublegal Stock (#)	95% CI
1	660	27.000	9.434	22.400	5.411	20	17,820	12,452	14,784	7,143
2	200	17.333	10.323	16.000	9.761	6	3,467	4,129	3,200	3,904
Total	860					26	21,287	13,570	17,984	8,676
				df Legals	23.49		t Legals	2.0687	Leg Prec.	64%
				df Subl	15.87		t Subl	2.1315	Subl. Prec.	48%

Littleneck Clam Biomass

Stratum	Area (sq.m.)	Mean Wt Legals (kg/sq.m.)	S.E. Legals (kg/sq.m.)	Mean Wt Sublegals (kg/sq.m.)	S.E. Sublegals (kg/sq.m.)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	660	0.398	0.169	0.114	0.053	20	263	223	75	70
2	200	0.198	0.164	0.249	0.215	6	40	66	50	86
Total	860					26	302	241	125	131
				df Legals	23.97		t Legals	2.0687	Leg Prec.	80%
				df Subl	7.11		t Subl	2.3646	Subl. Prec.	105%

Littleneck Clam Abundance

Stratum	Area (sq.m.)	Mean No. Legals (#/sq.m.)	S.E. Legals (#/sq.m.)	Mean No. Sublegals (#/sq.m.)	S.E. Sublegals (#/sq.m.)	n	Estimated Legal Stock (#)	95% CI	Estimated Sublegal Stock (#)	95% CI
1	660	15.600	2.503	11.200	4.702	20	10,296	9,339	7,392	6,207
2	200	8.667	8.543	22.667	21.003	6	1,733	2,864	4,533	8,401
Total	860					26	12,029	10,103	11,925	12,780
				df Legals	23.87		t Legals	2.0687	Leg Prec.	84%
				df Subl	6.72		t Subl	2.4469	Subl. Prec.	107%

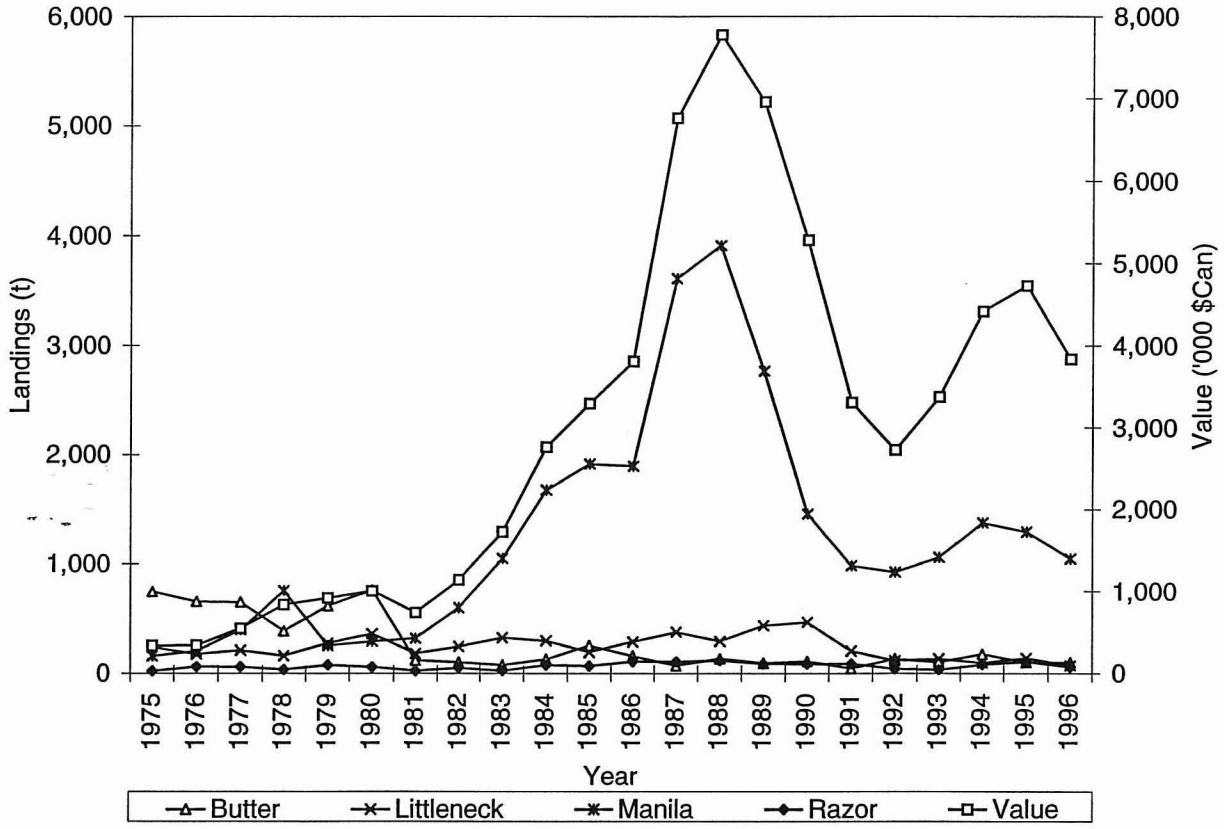

Figure 1. Landings of intertidal clams (t) and value ($Can) in British Columbia commercial fisheries, 1975-96.

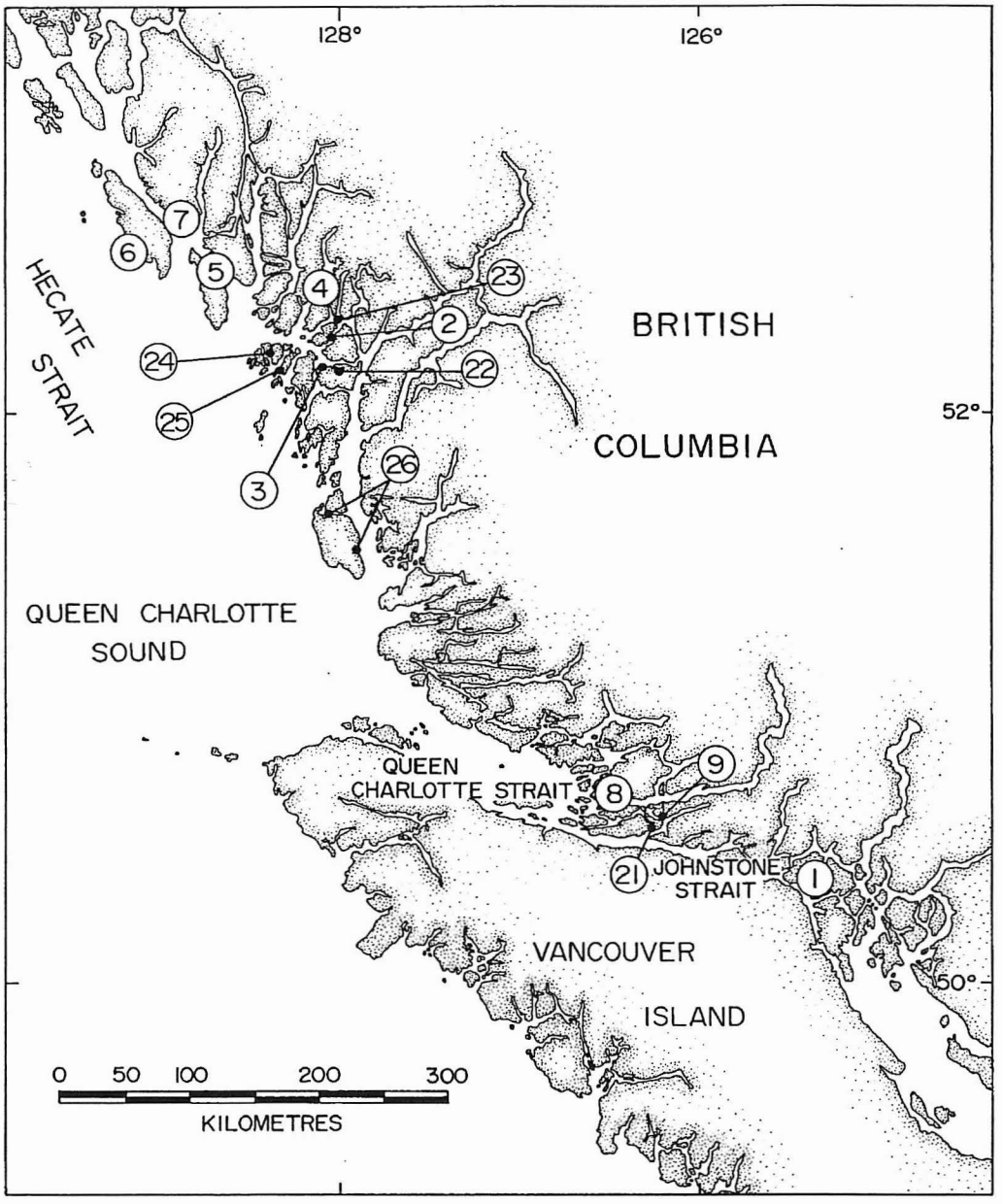

Figure 2. Location of beaches visited during exploratory clam surveys in 1994 and 1996.

Legend: 1994: 1. Cameleon Harbour, 2. Troup Passage, 3. Lama Passage-Gunboat Passage, 4. Spiller Channel-Bullock Channel, 5. Higgins Passage, 6. Aristazabal Island, 7. Laredo Inlet, 8. Port Elizabeth, 9. Chatham Channel; 1996: 21. Port Harvey, 22. Kakushdish Harbour, 23. Return Channel-Bullock Channel-Johnson Channel-Troup Narrows, 24. Gale Passage, 25. Joassa Channel-Boddy Narrows-Louise Channel, 26. Kwakshua Channel-Safety Cove.

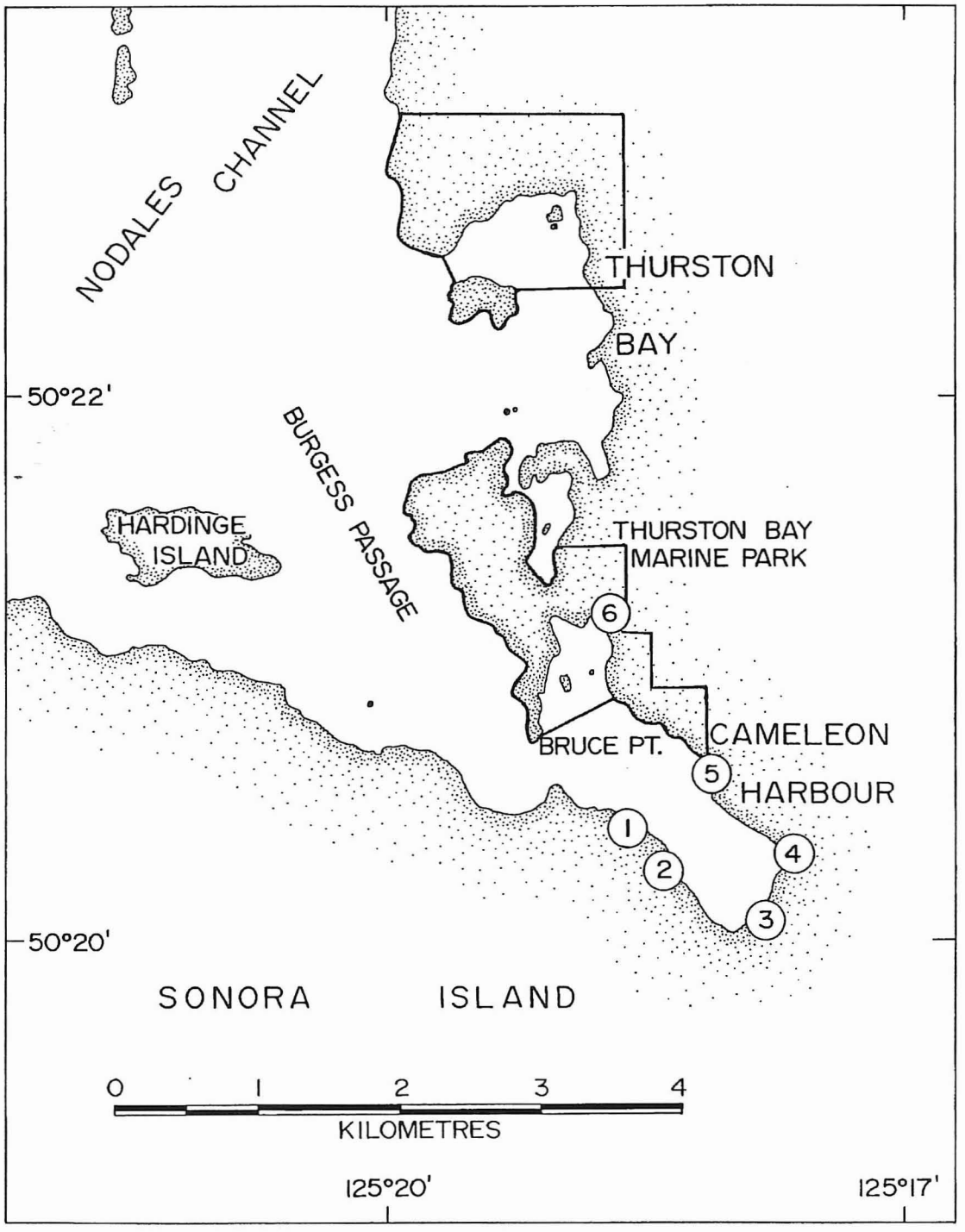

Figure 3. Location of beaches visited in Cameleon Harbour, July 19, 1994.

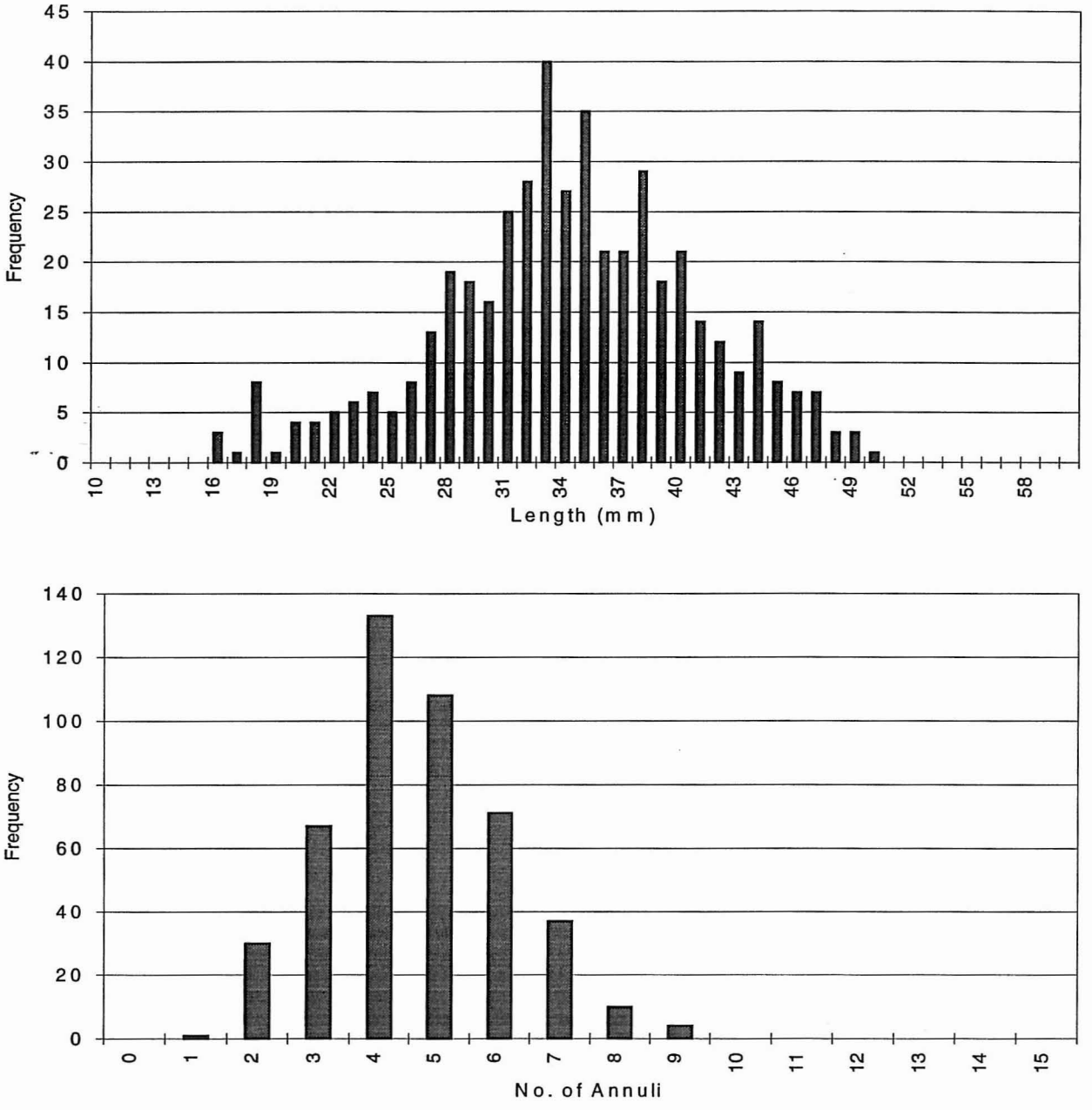

Figure 4. Length and age frequency distribution of littleneck clams sampled in Cameleon Harbour, July 19, 1994.

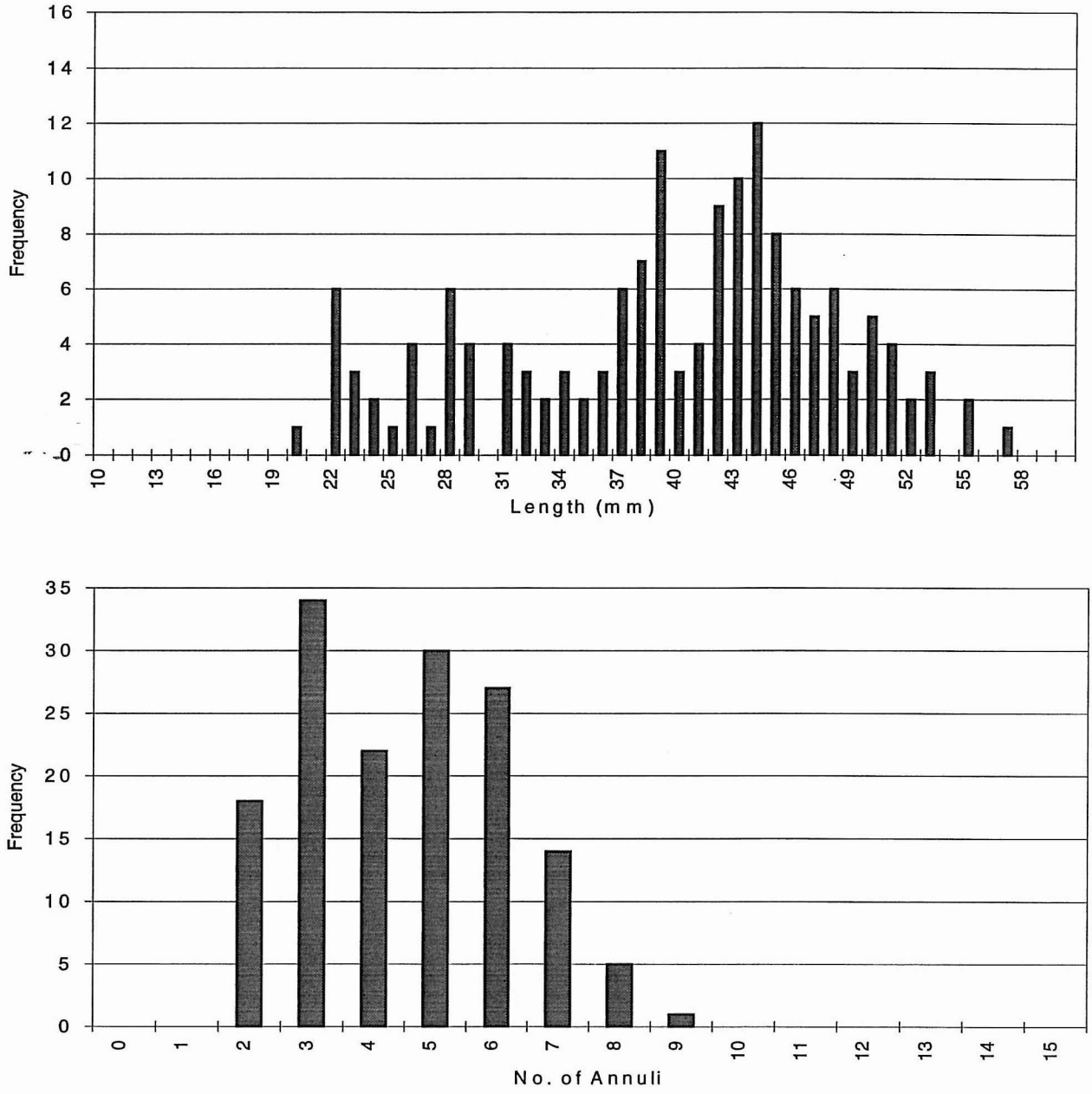

Figure 5. Length and age frequency distribution of Manila clams sampled in Cameleon Harbour, July 19, 1994.

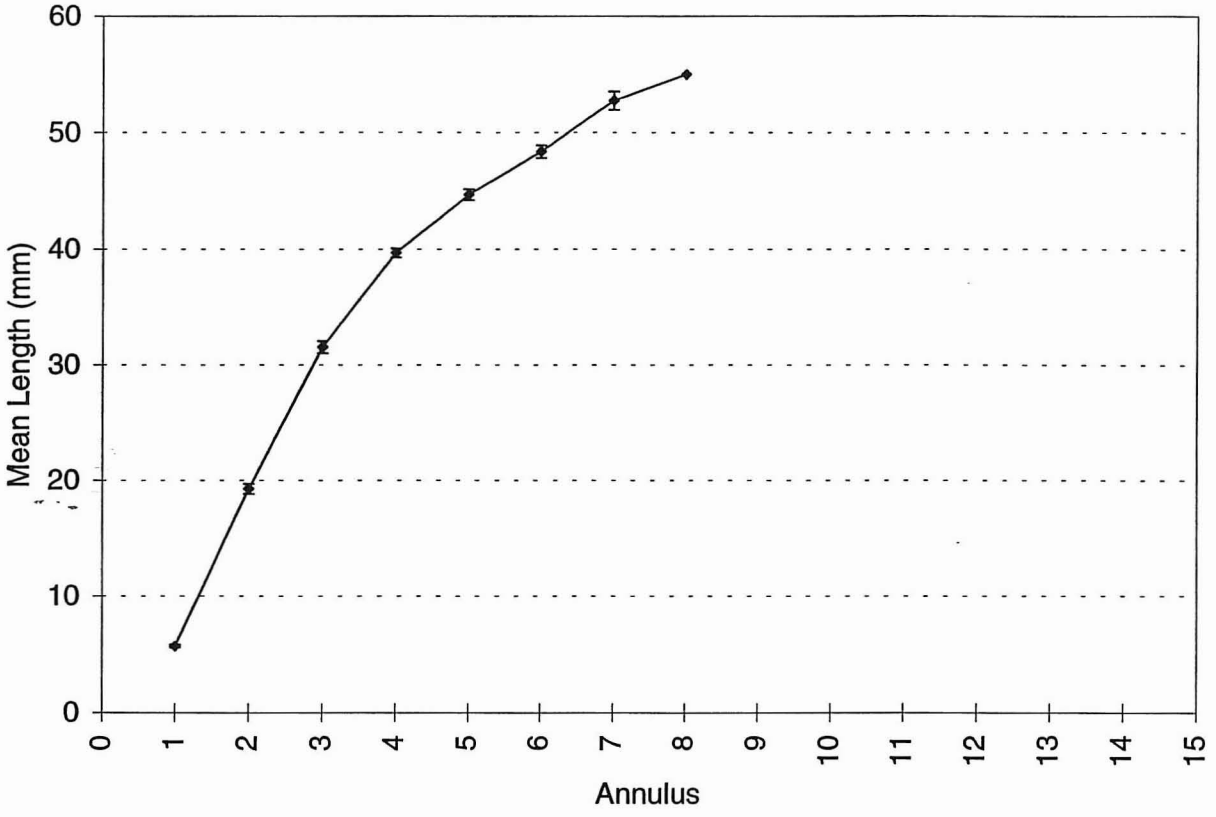

Figure 6. Growth rate of Manila clams sampled in Cameleon Harbour, July 19, 1994. Error bars = +/- 1 SE.

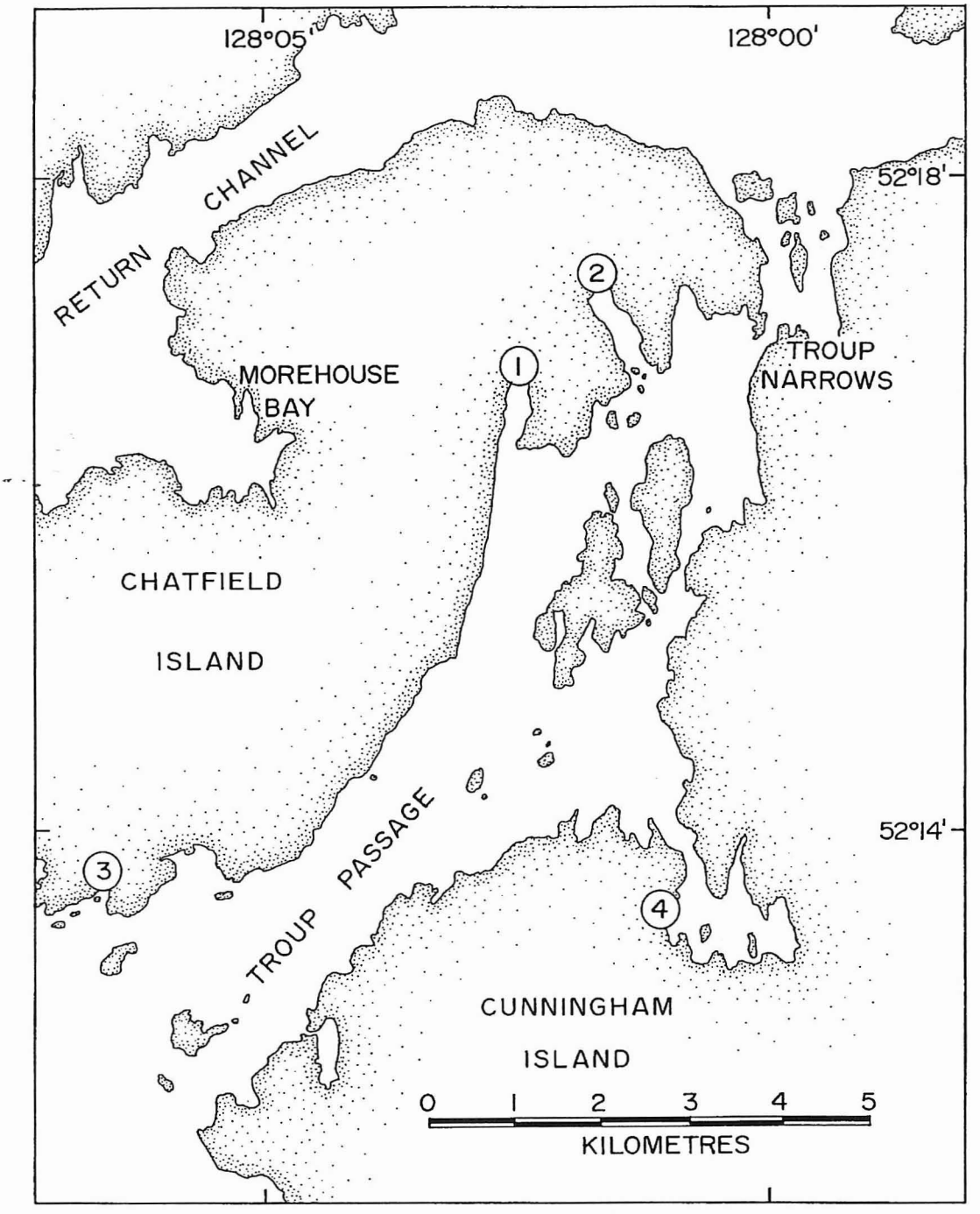

Figure 7. Location of beaches visited in Troup Passage, July 20-21, 1994.

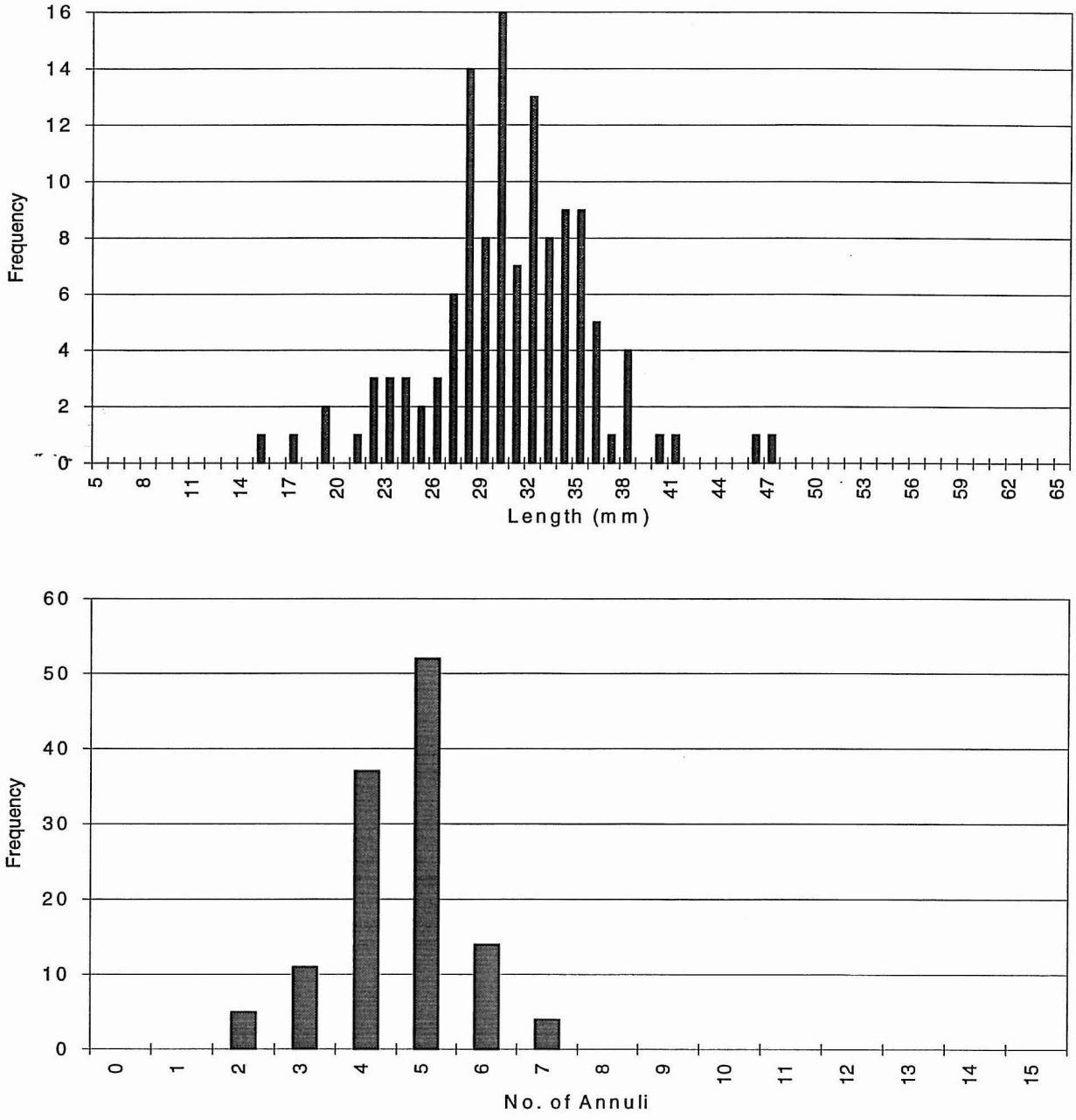

Figure 8. Length and age frequency distribution of littleneck clams sampled at beaches 1 and 2 in Troup Passage, July 20, 1994.

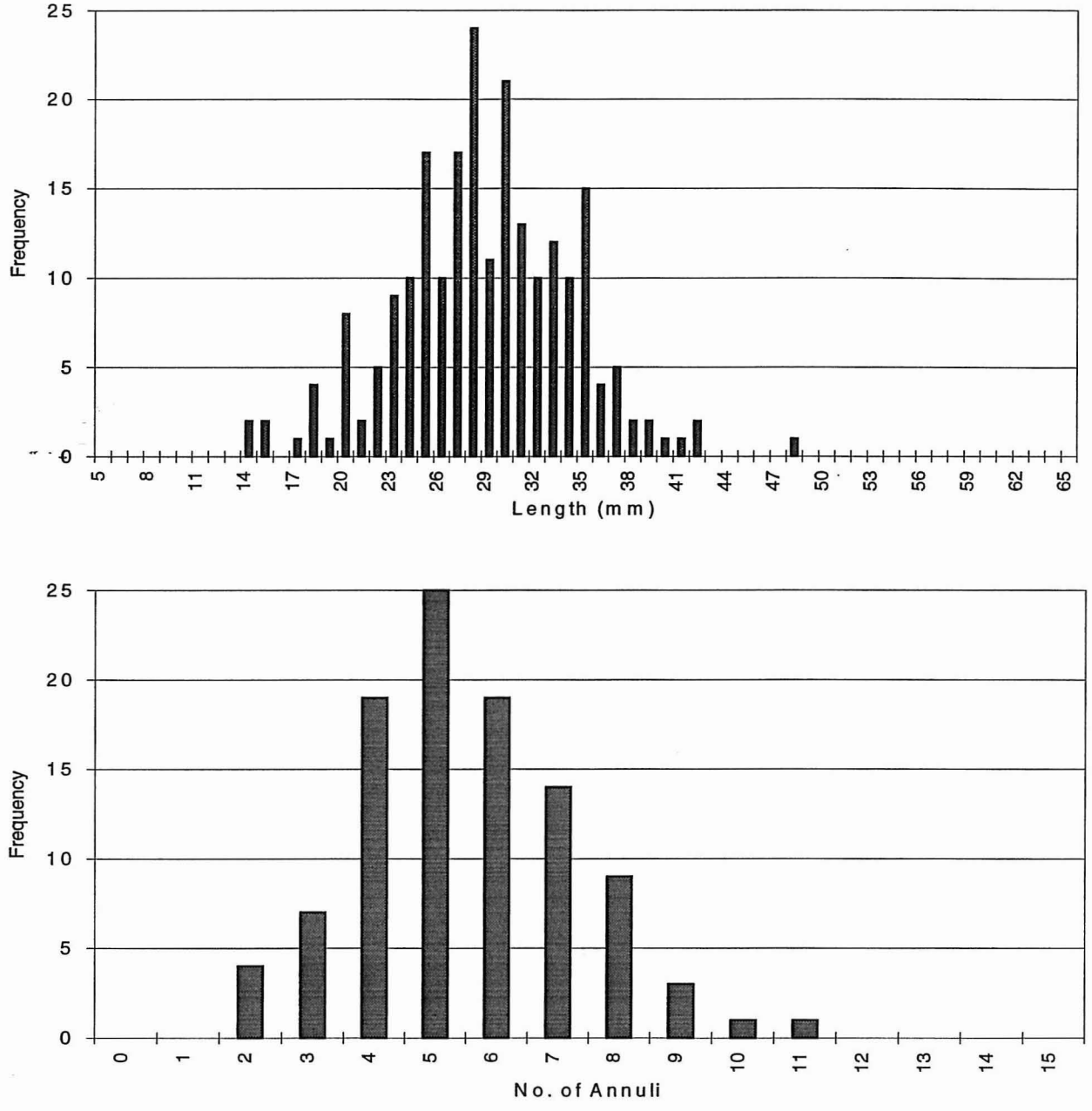

Figure 9. Length and age frequency distribution of littleneck clams sampled at beach 3 in Troup Passage, July 21, 1994.

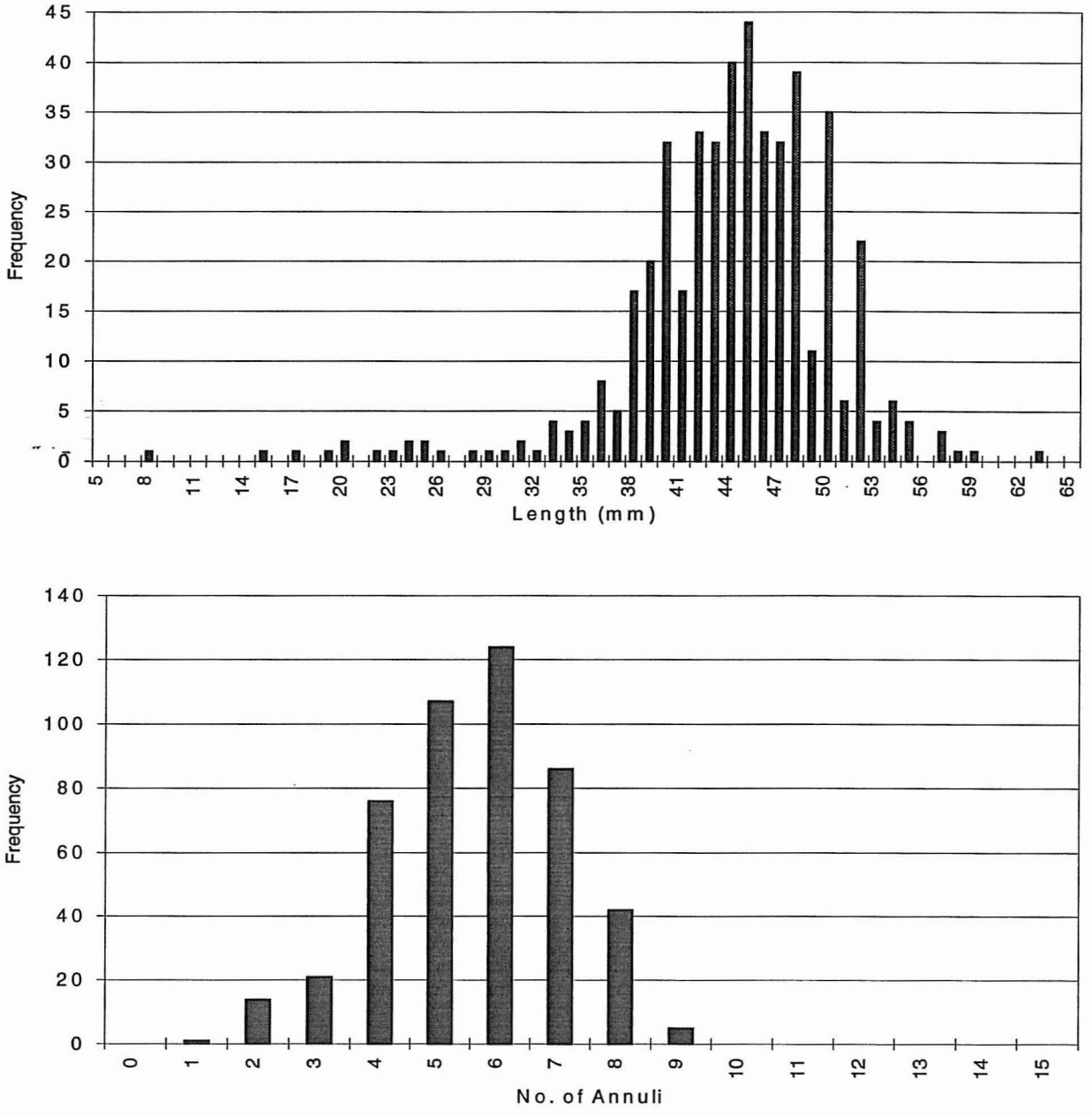

Figure 10. Length and age frequency distribution of Manila clams sampled at beaches 1 and 2 in Troup Passage, July 20, 1994.

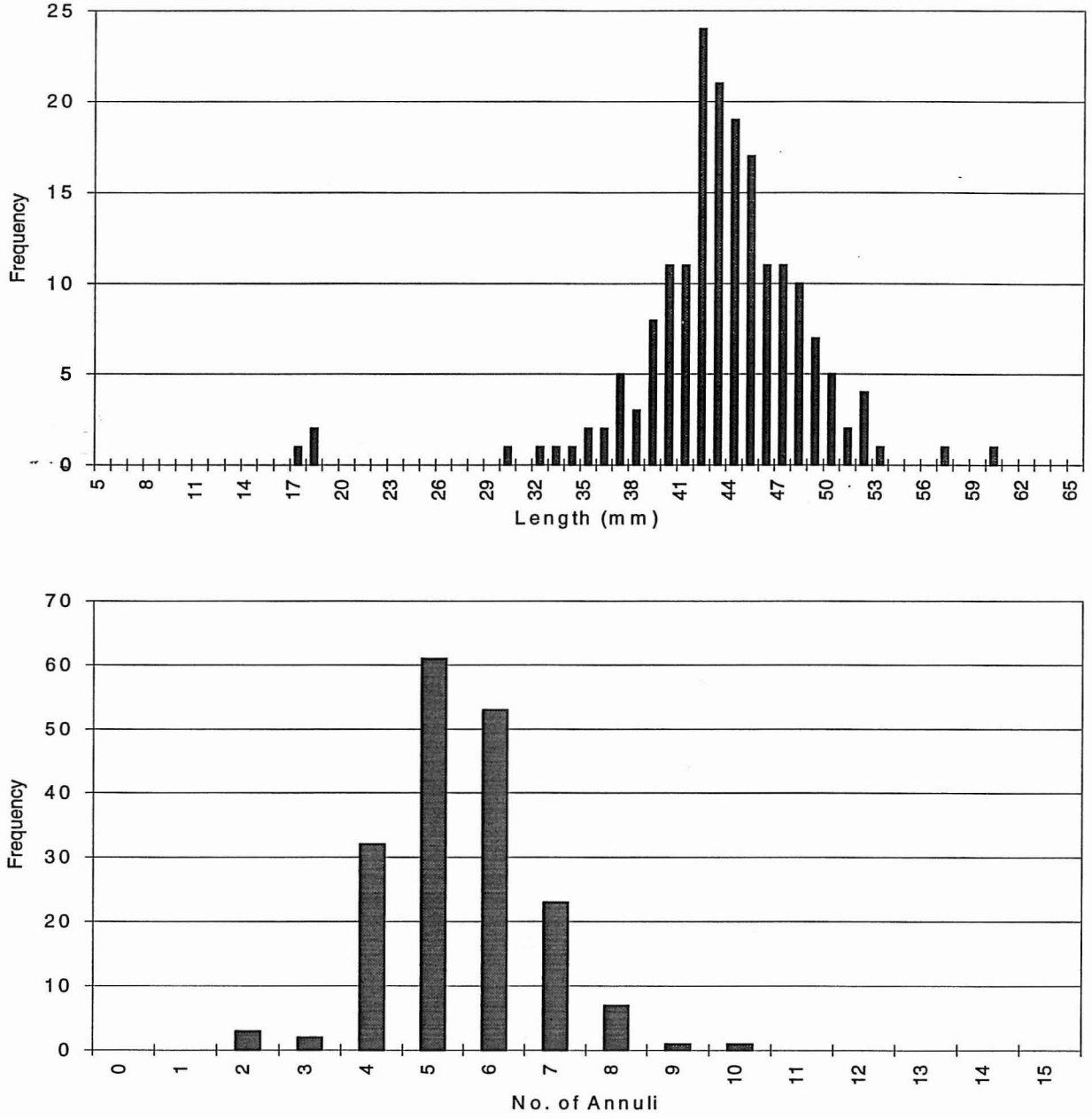

Figure 11. Length and age frequency distribution of Manila clams sampled at beach 3 in Troup Passage, July 21, 1994.

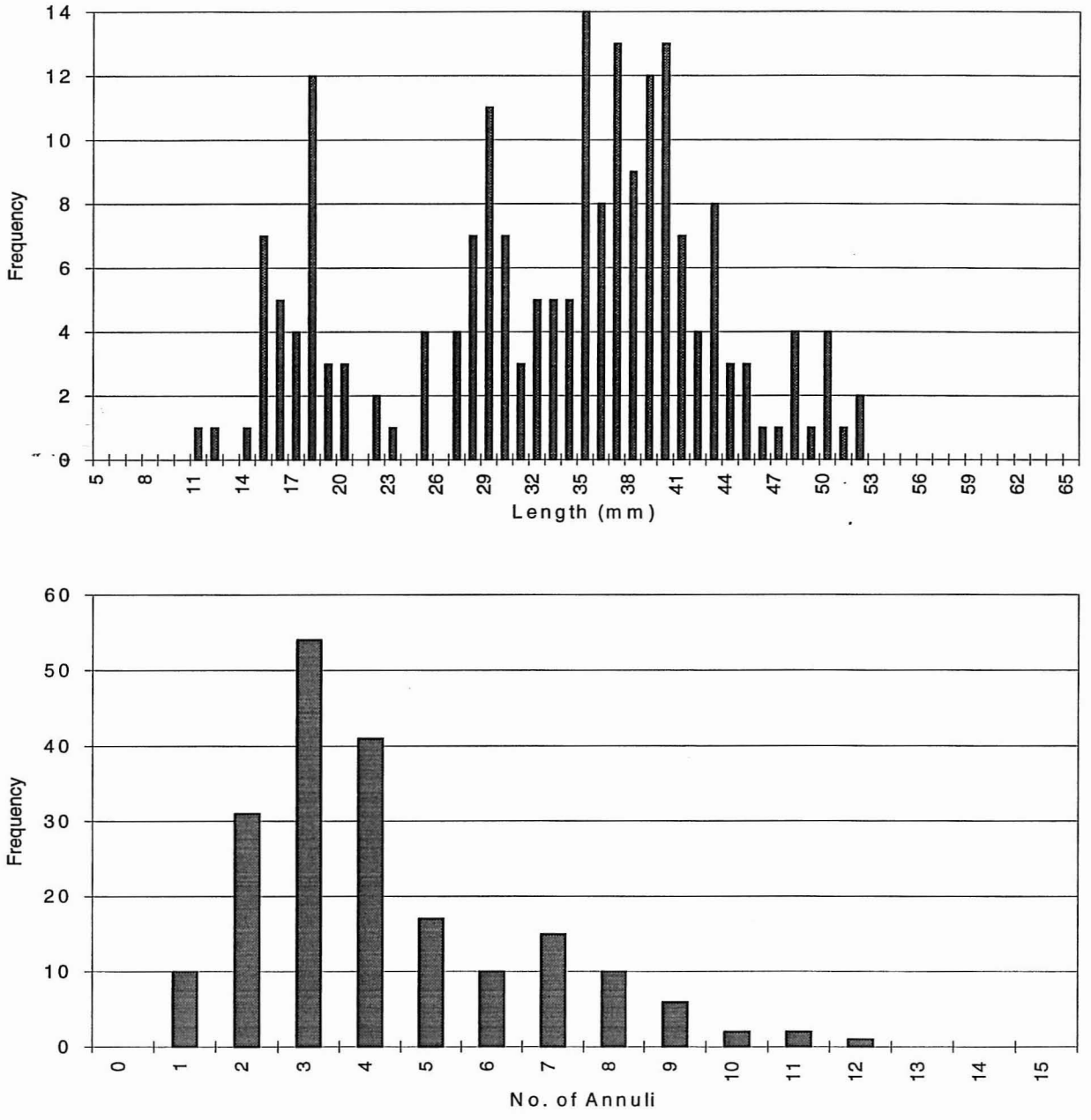

Figure 12. Length and age frequency distribution of Manila clams sampled at beach 4 in Troup Passage, July 21, 1994.

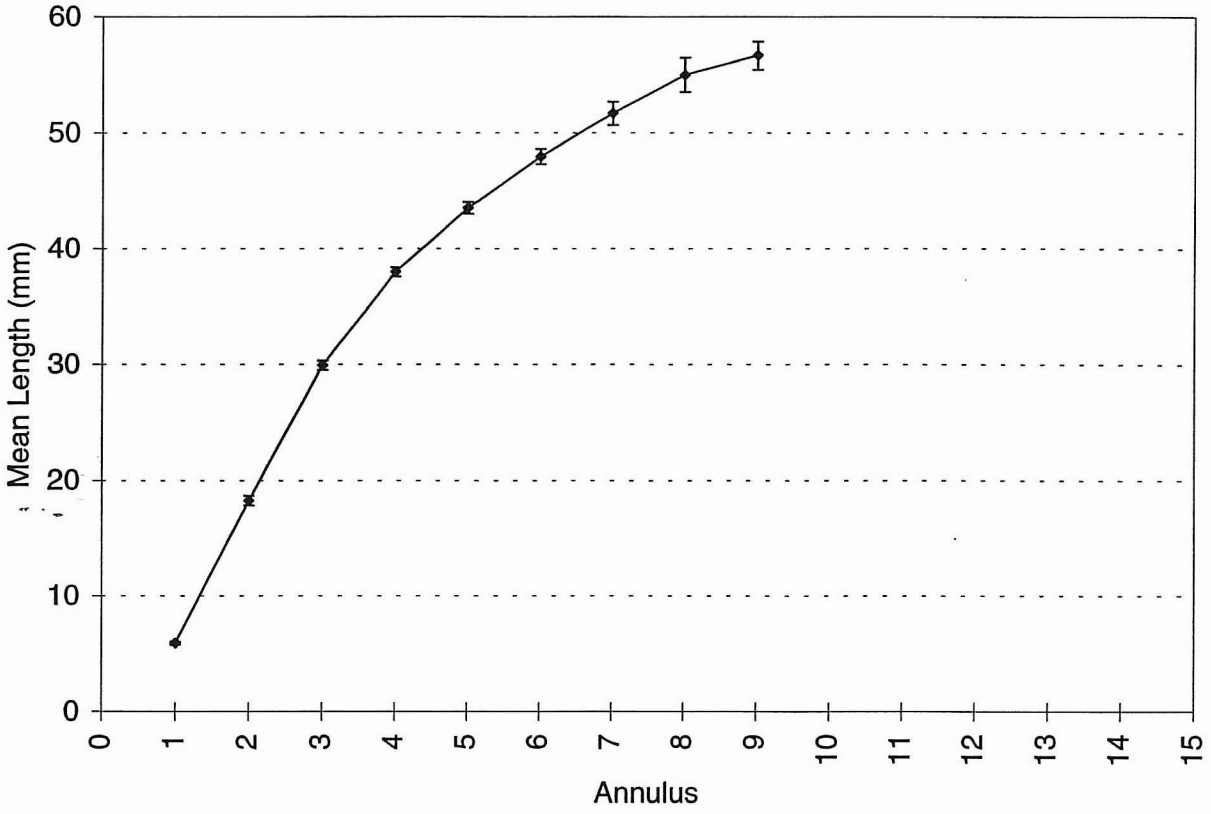

Figure 13. Growth rate of Manila clams sampled in Troup Passage (all beaches pooled), July 20, 1994. Error bars = +/- 1 SE.

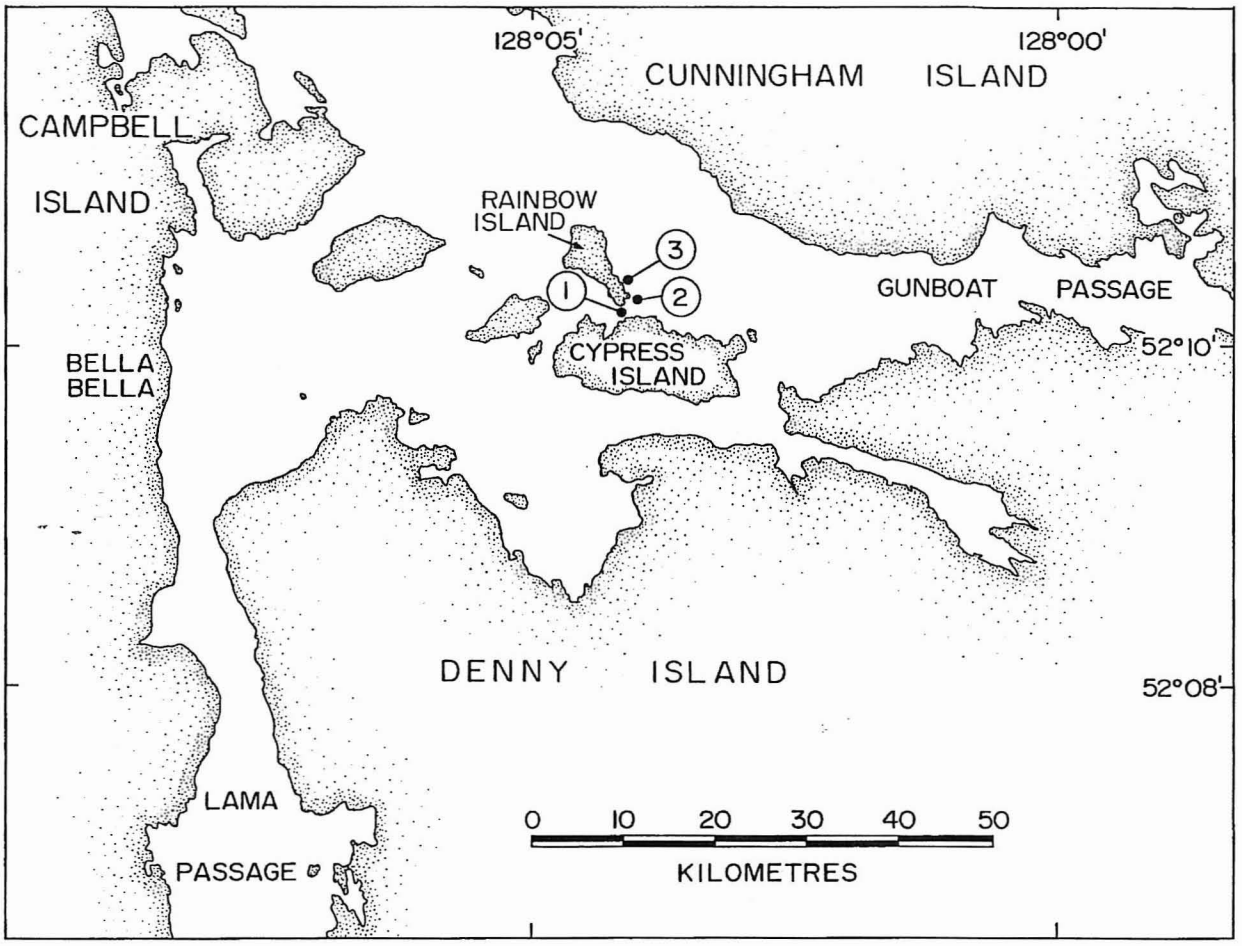

Figure 14. Location of beaches visited in the Lama Passage-Gunboat Passage area, July 21, 1994.

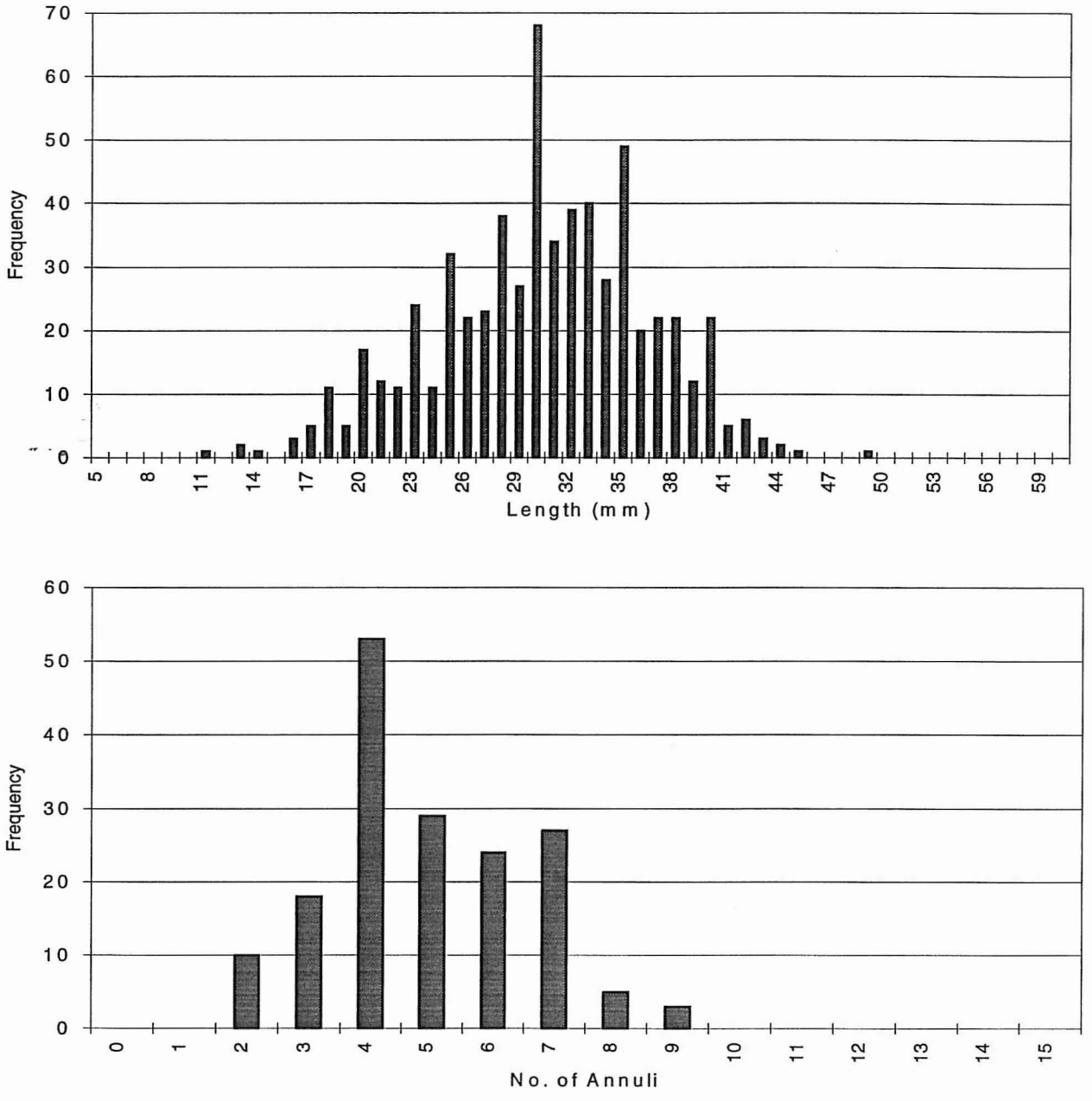

Figure 15. Length and age frequency distribution of littleneck clams sampled in the Lama Passage-Gunboat Passage area, July 21, 1994.

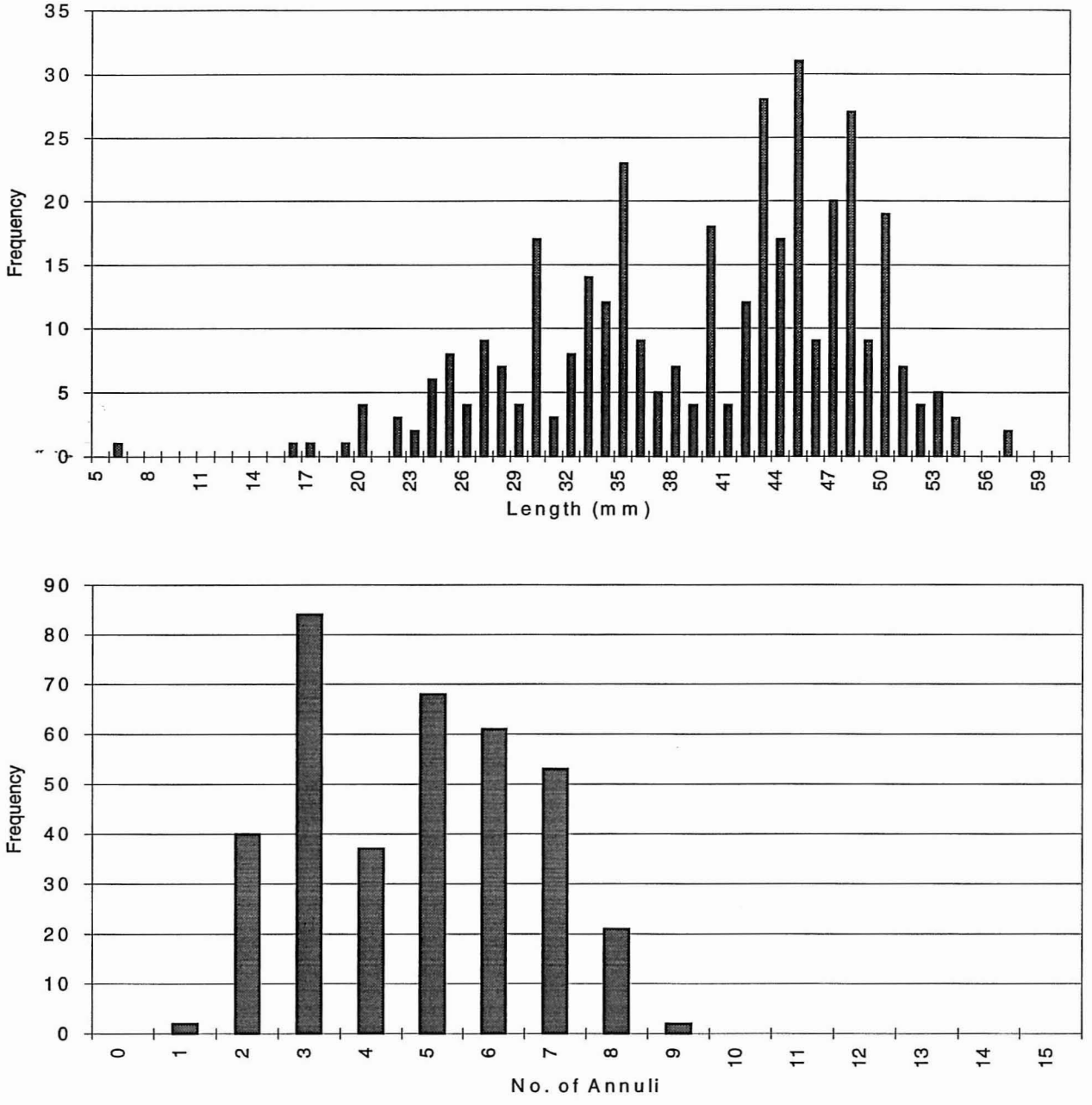

Figure 16. Length and age frequency distribution of Manila clams sampled in the Lama Passage-Gunboat Passage area, July 21, 1994.

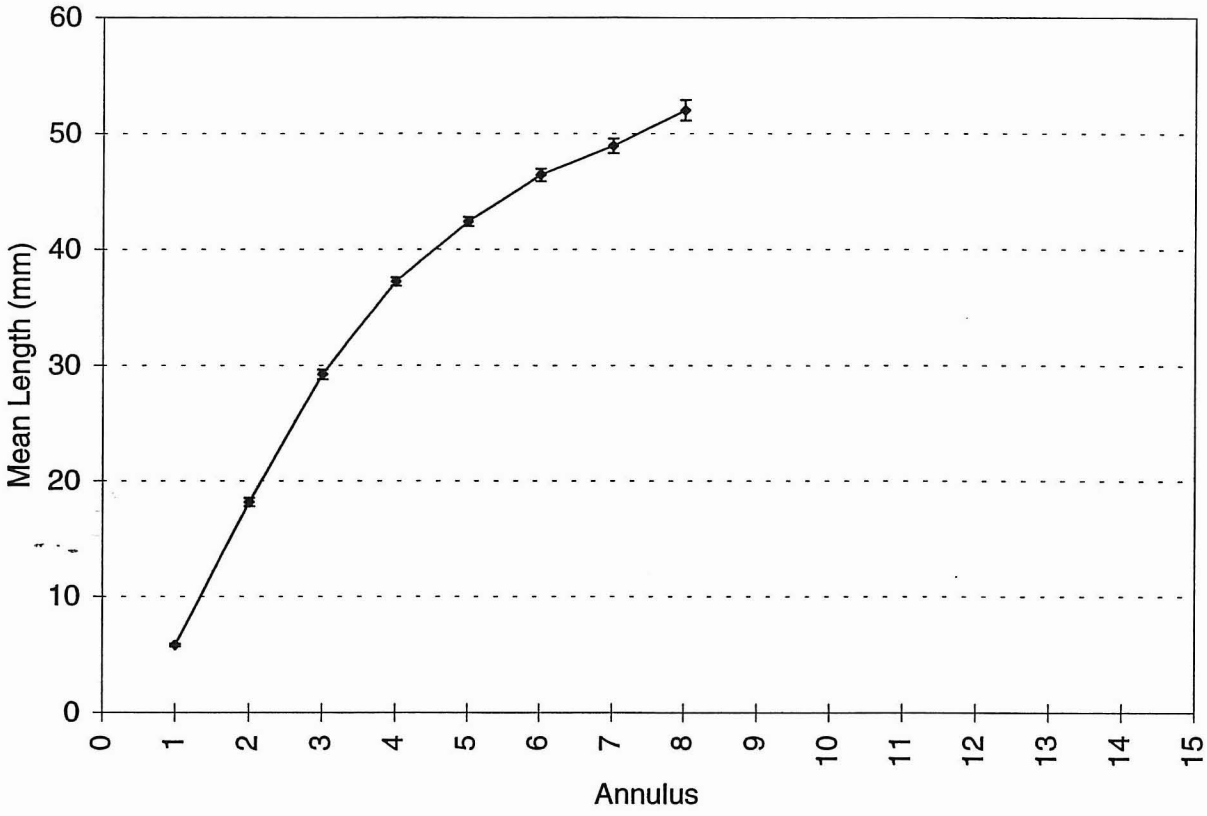

Figure 17. Growth rate of Manila clams sampled in the Lama Passage-Gunboat Passage area, July 21, 1994. Error bars = +/- 1 SE.

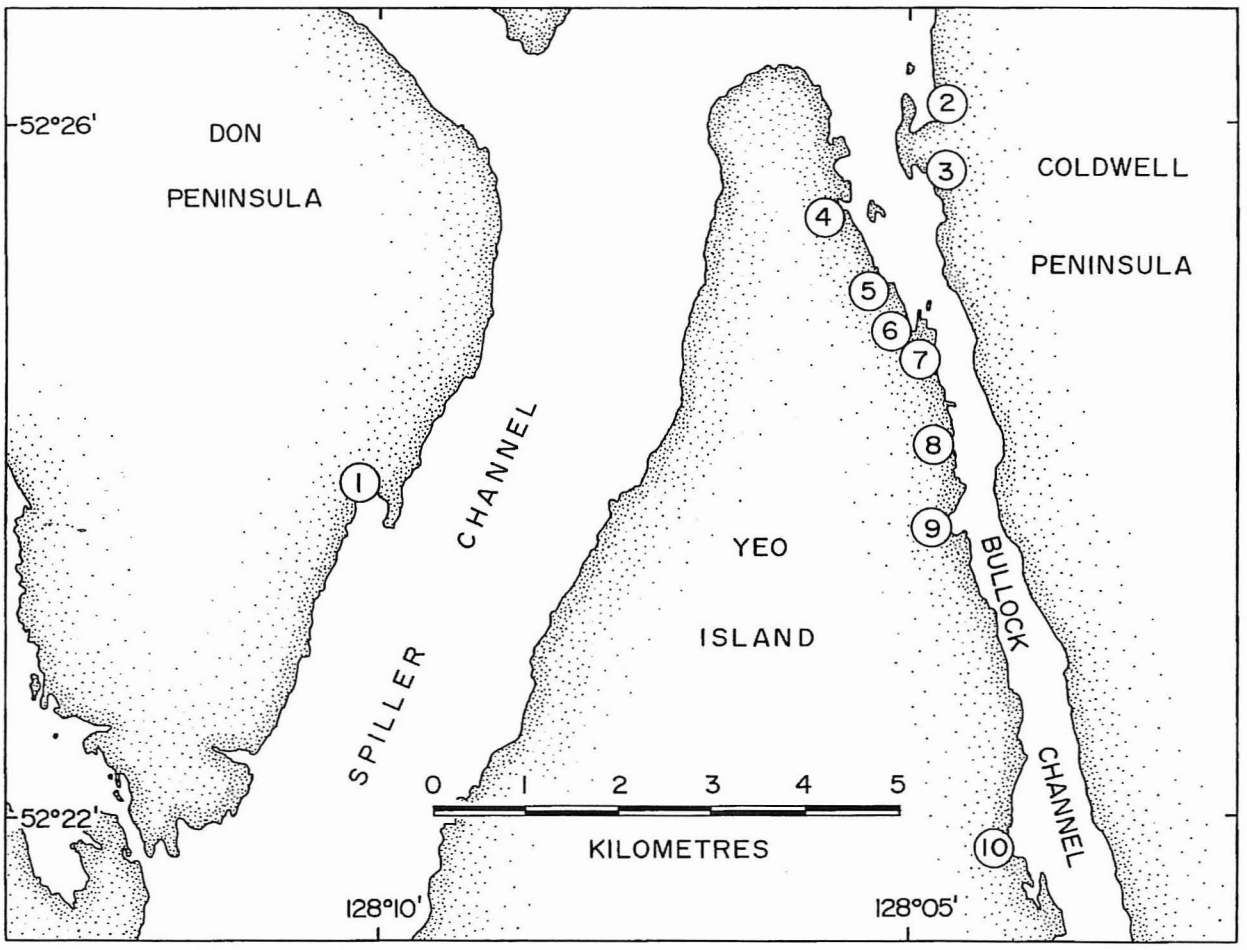

Figure 18. Location of beaches visited in the Spiller Channel-Bullock Channel area, July 22, 1994.

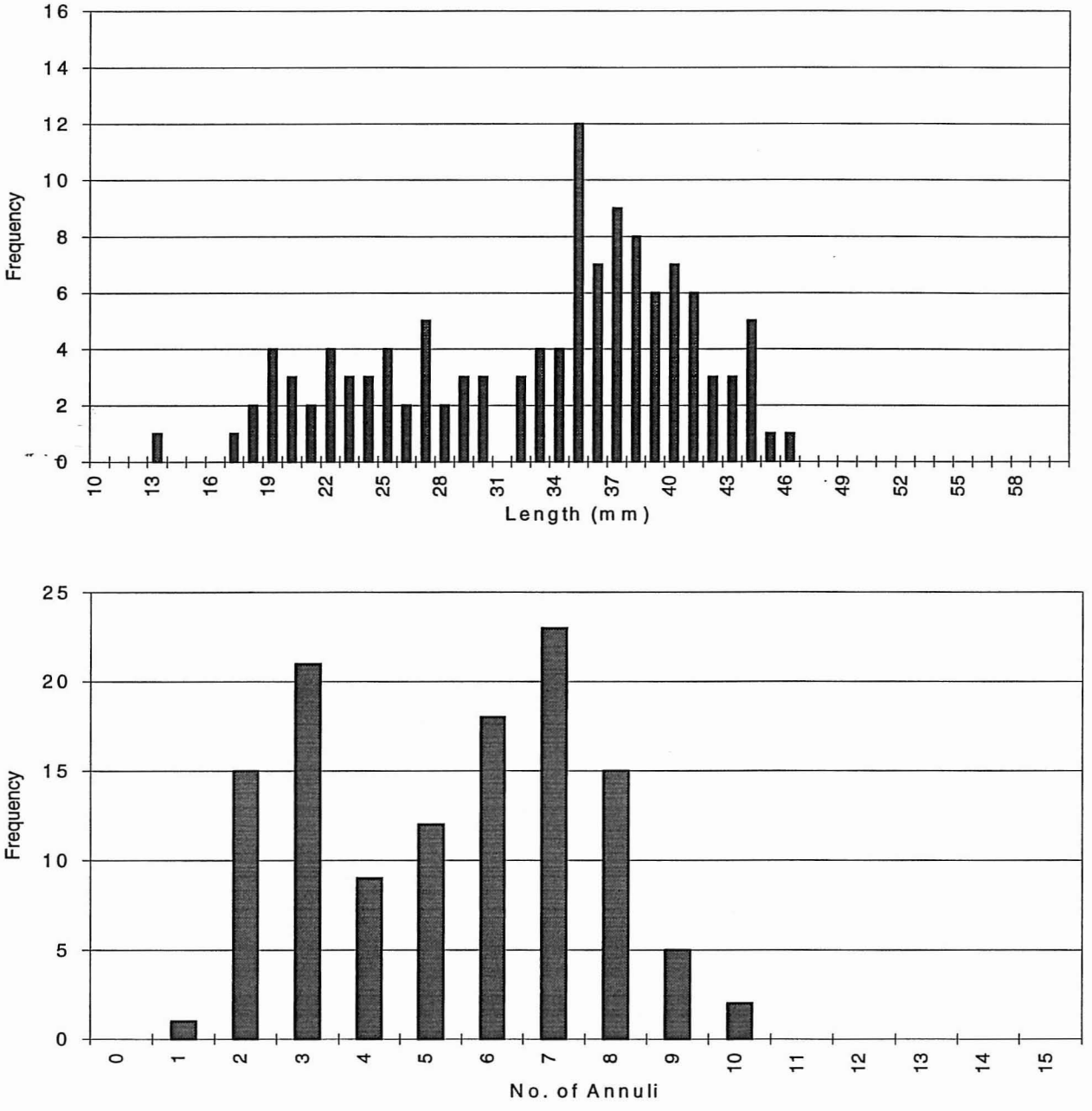

Figure 19. Length and age frequency distribution of littleneck clams sampled in the Spiller Channel-Bullock Channel area, July 22, 1994.

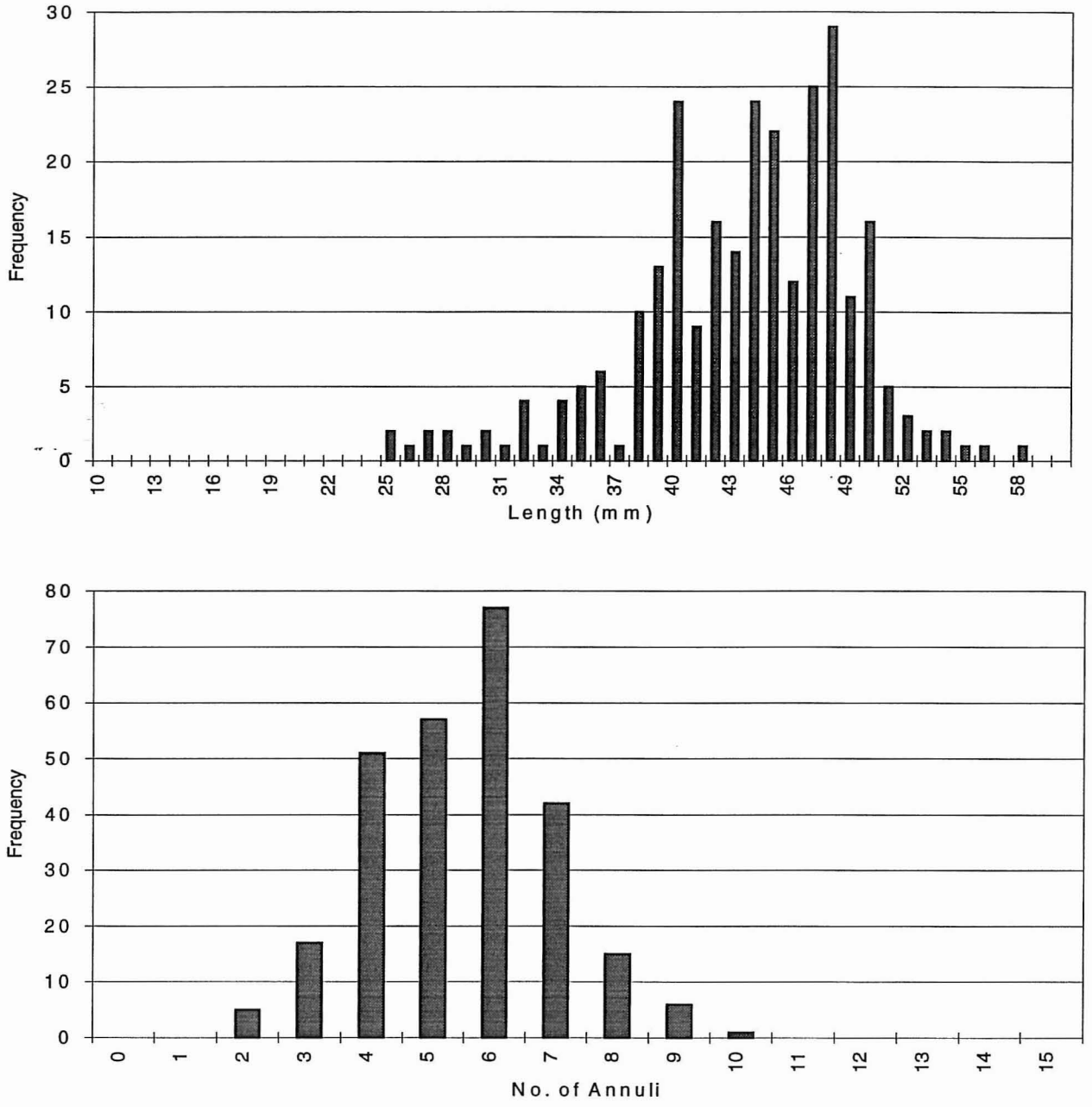

Figure 20. Length and age frequency distribution of Manila clams sampled in the Spiller Channel-Bullock Channel area, July 22, 1994.

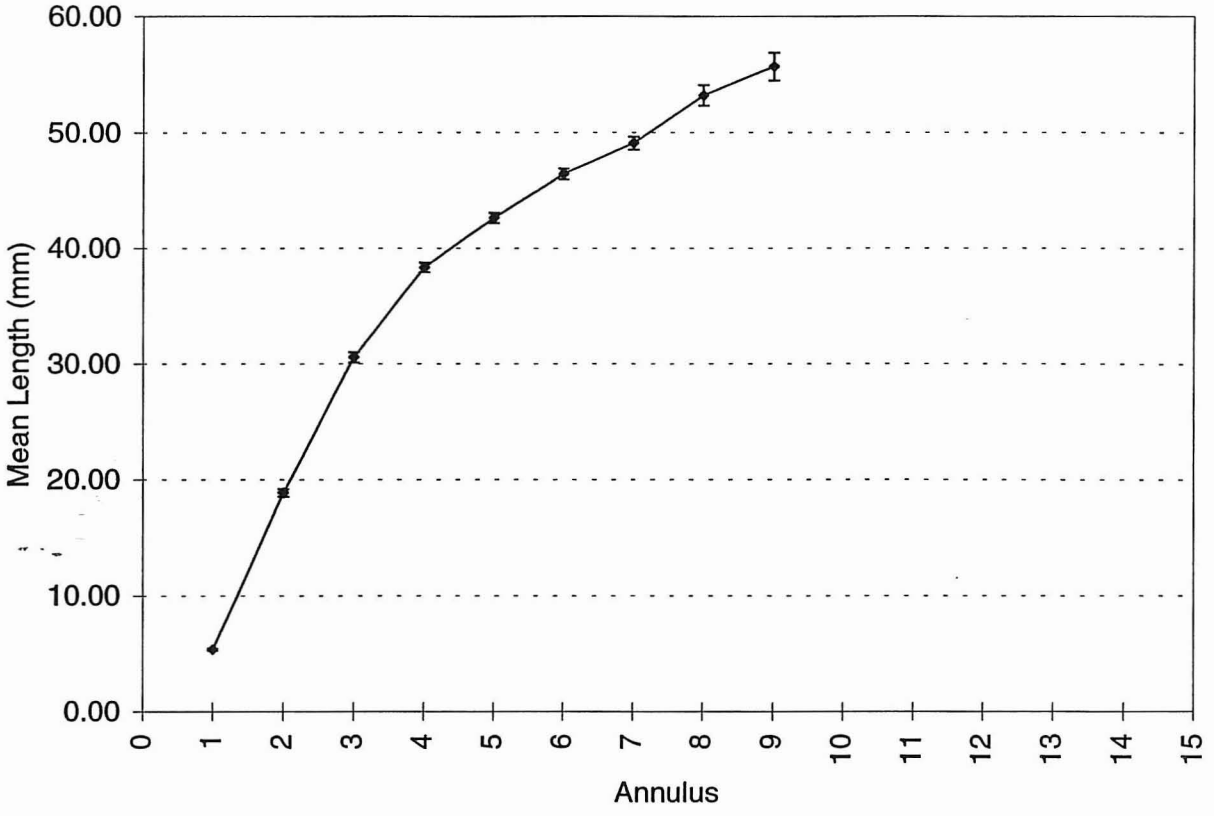

Figure 21. Growth rate of Manila clams sampled in the Spiller Channel-Bullock Channel area, July 22, 1994. Error bars = +/- 1 SE.

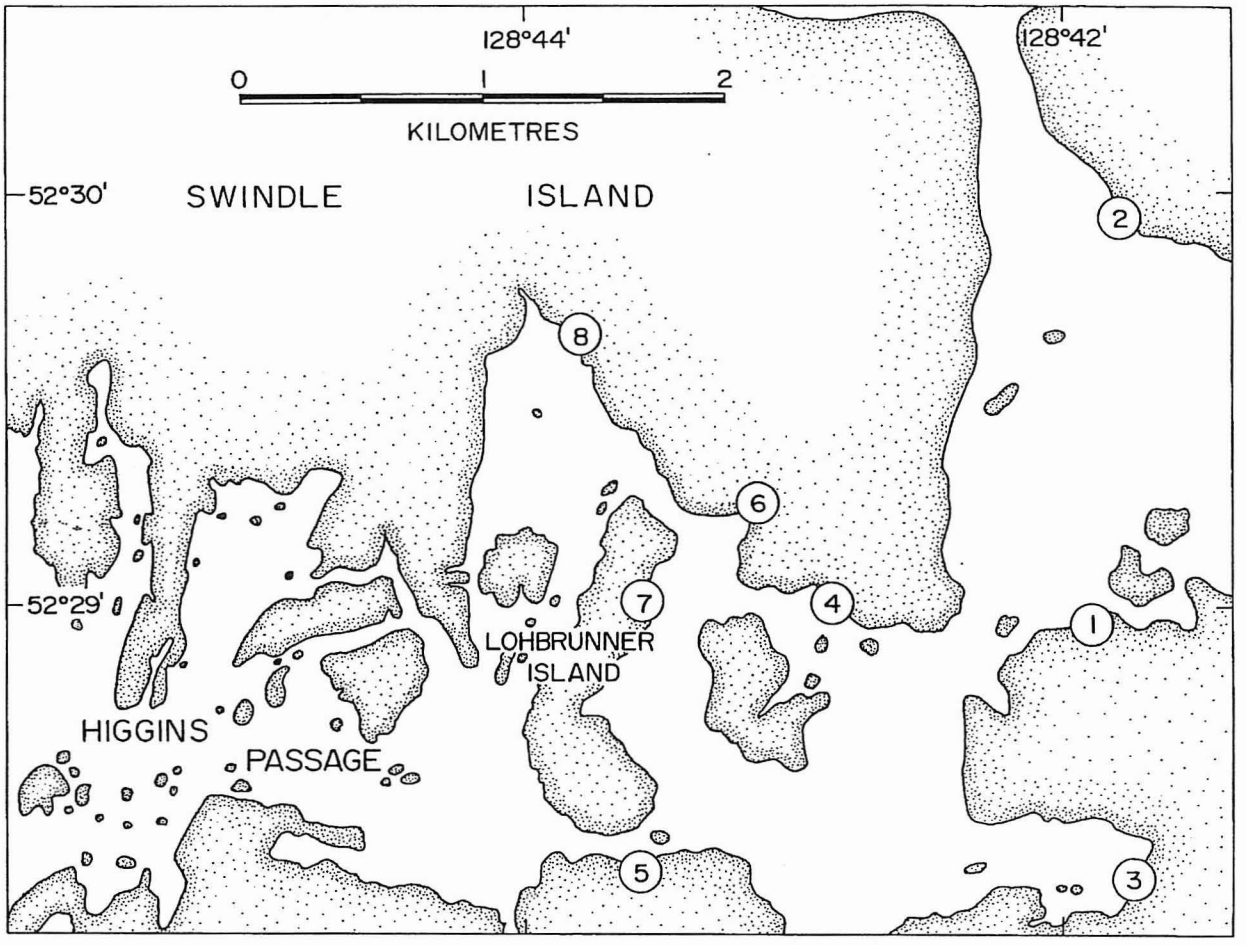

Figure 22. Location of beaches visited in the Higgins Passage area, July 23, 1994.

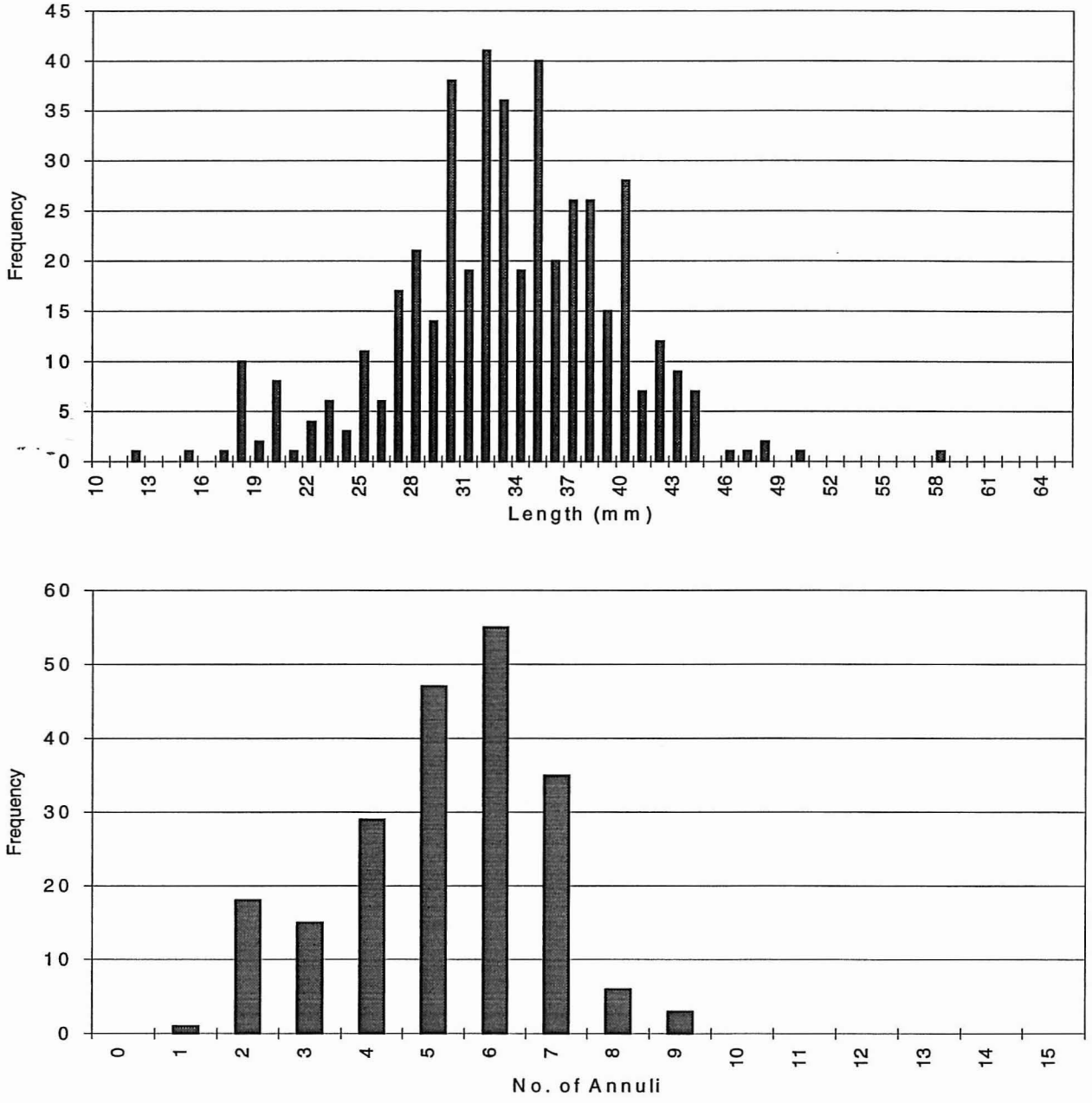

Figure 23. Length and age frequency distribution of littleneck clams sampled in Higgins Passage, July 23, 1994.

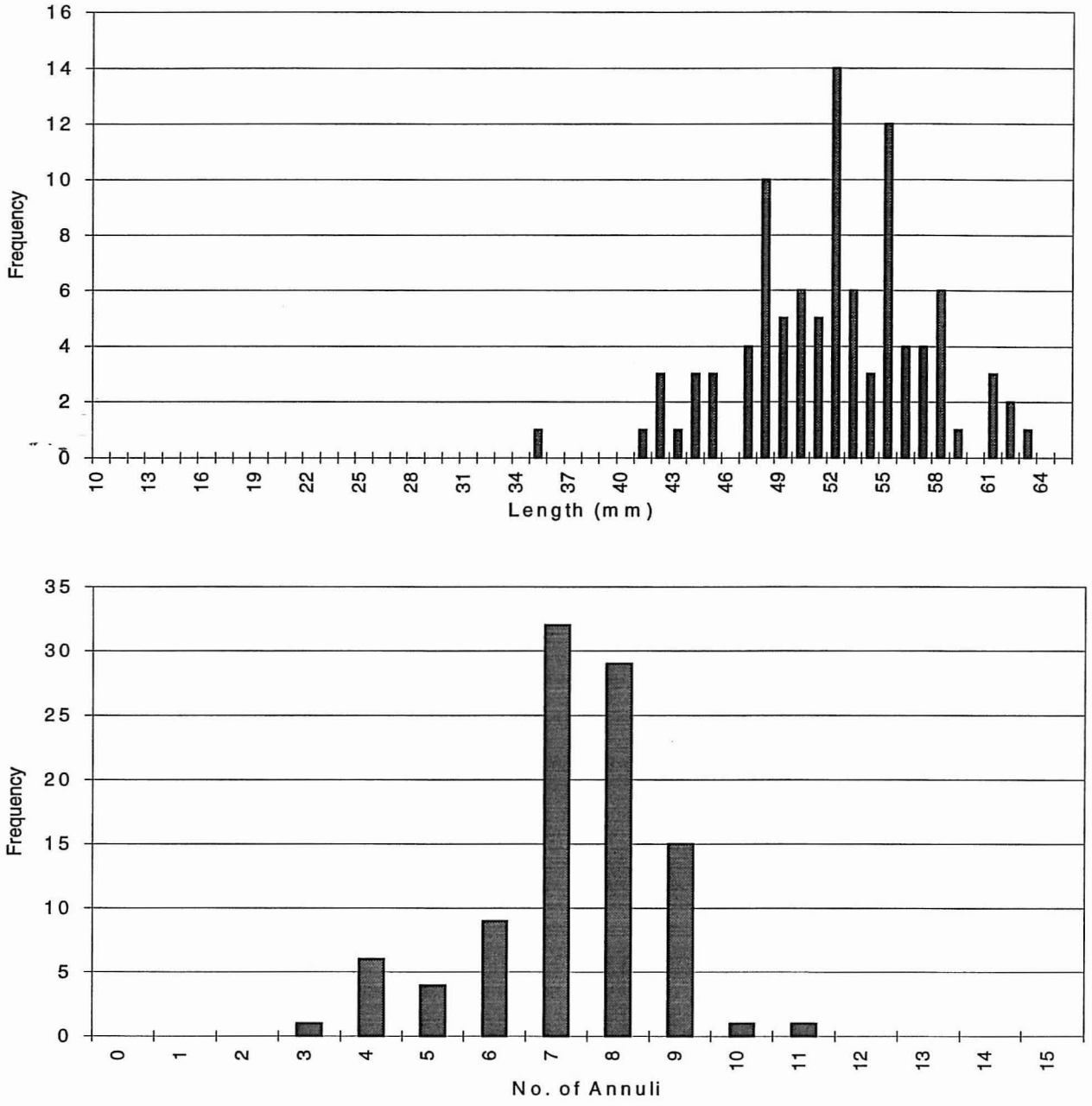

Figure 24. Length and age frequency distribution of Manila clams sampled in Higgins Passage, July 23, 1994.

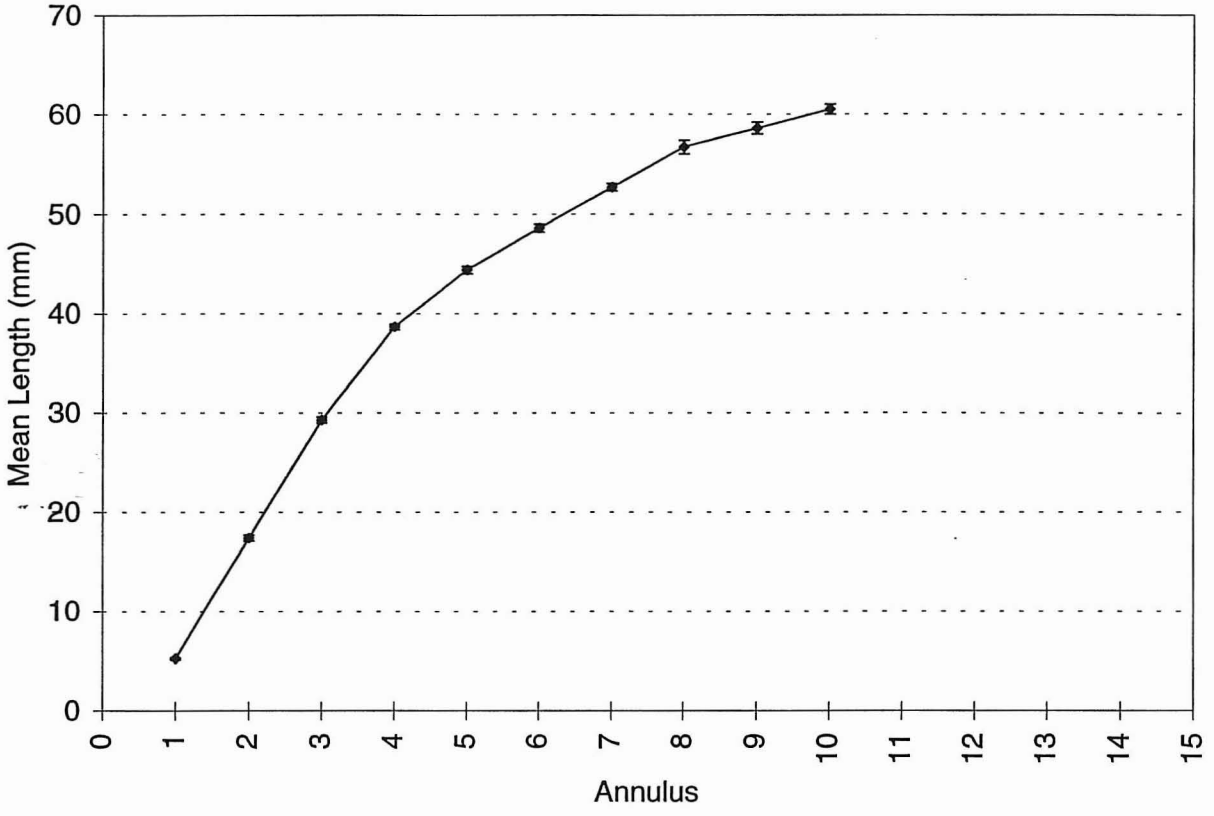

Figure 25. Growth rate of Manila clams sampled in Higgins Passage, July 23, 1994. Error bars = +/- 1 SE.

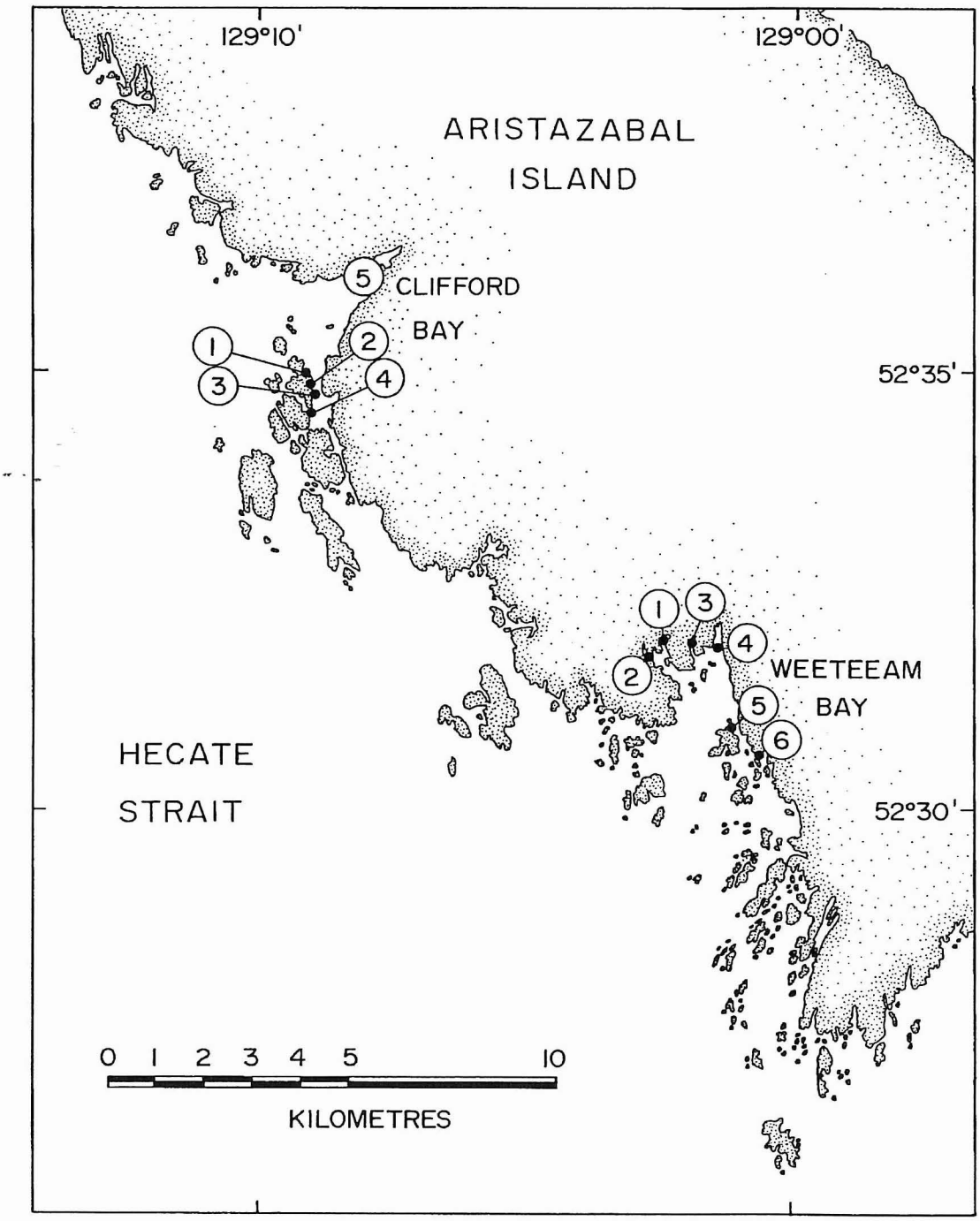

Figure 26. Location of beaches visited in Weeteeam Bay and Clifford Bay, Aristazabal Island, July 23-24, 1994.

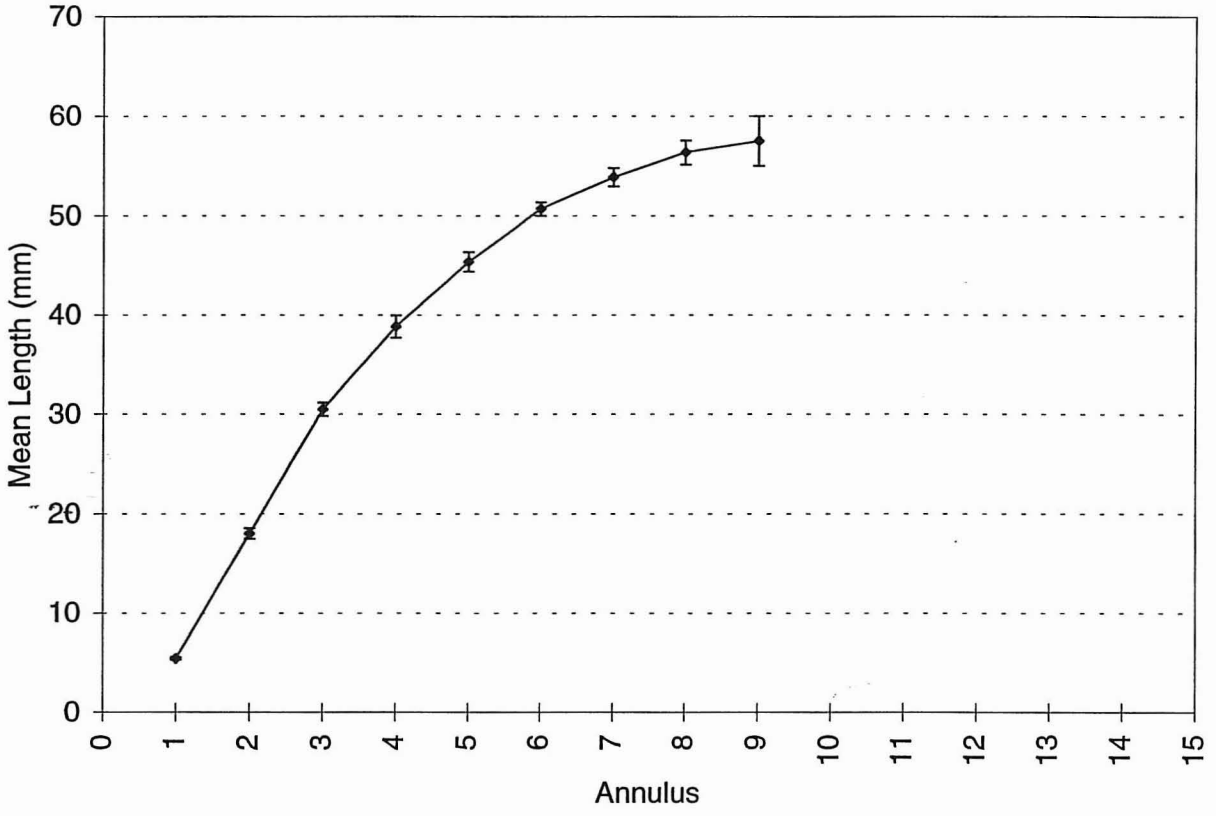

Figure 27. Growth rate of Manila clams sampled in Clifford Bay, Aristazabal Island, July 25, 1994. Error bars = +/- 1 SE.

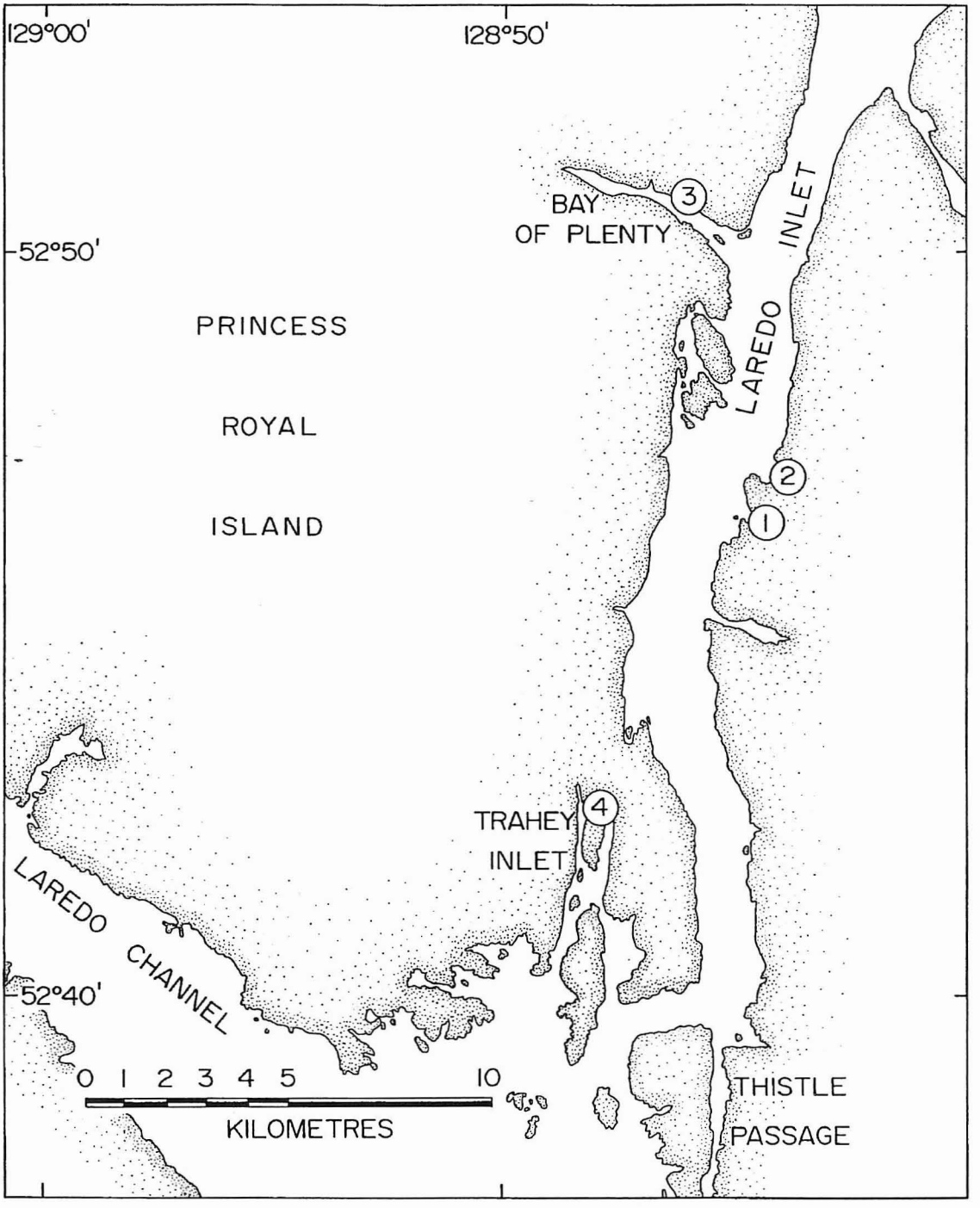

Figure 28. Location of beaches visited in the Laredo Inlet area, July 26, 1994.

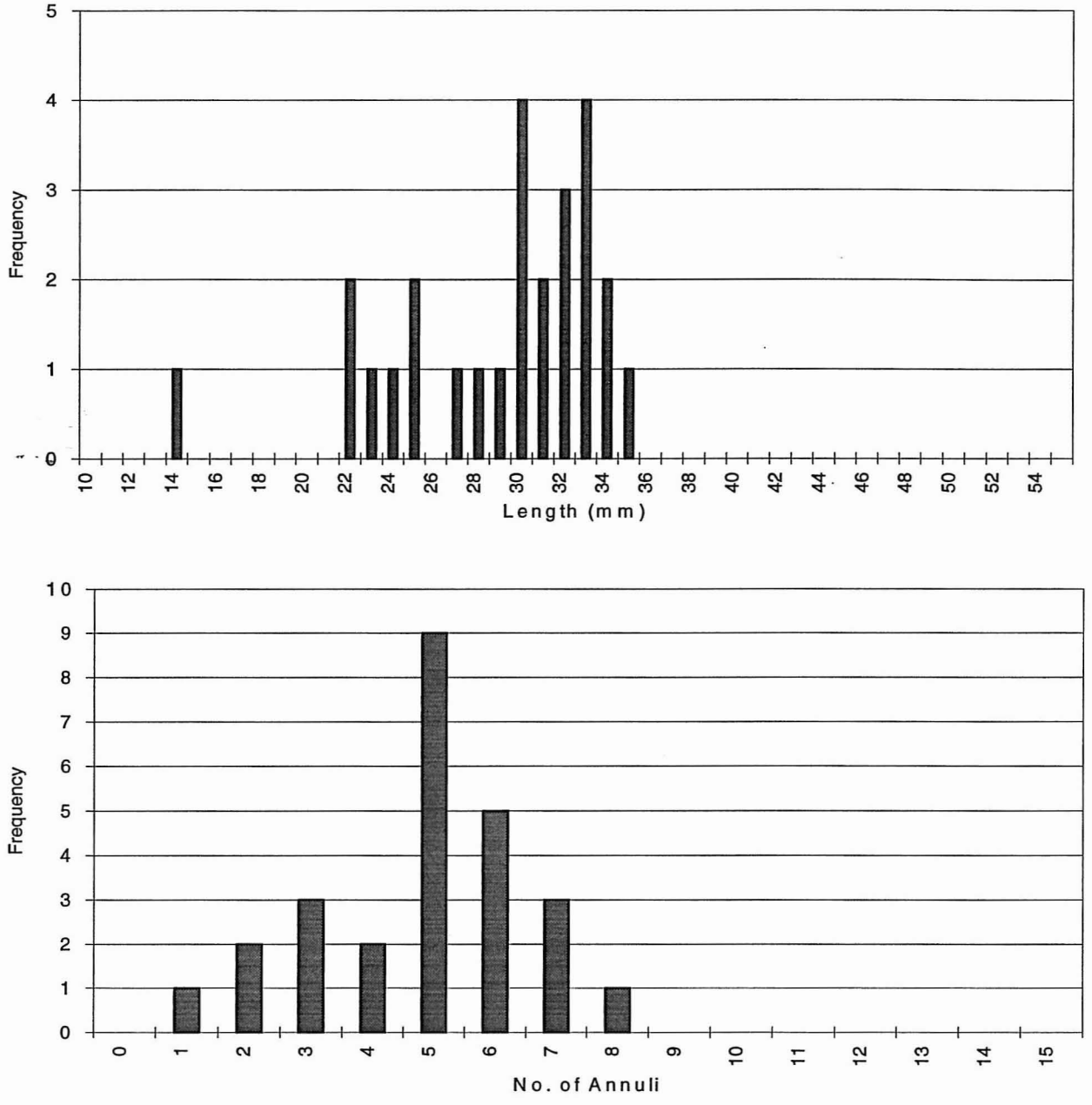

Figure 29. Length and age frequency distribution of littleneck clams sampled in the Laredo Inlet area, July 26, 1994.

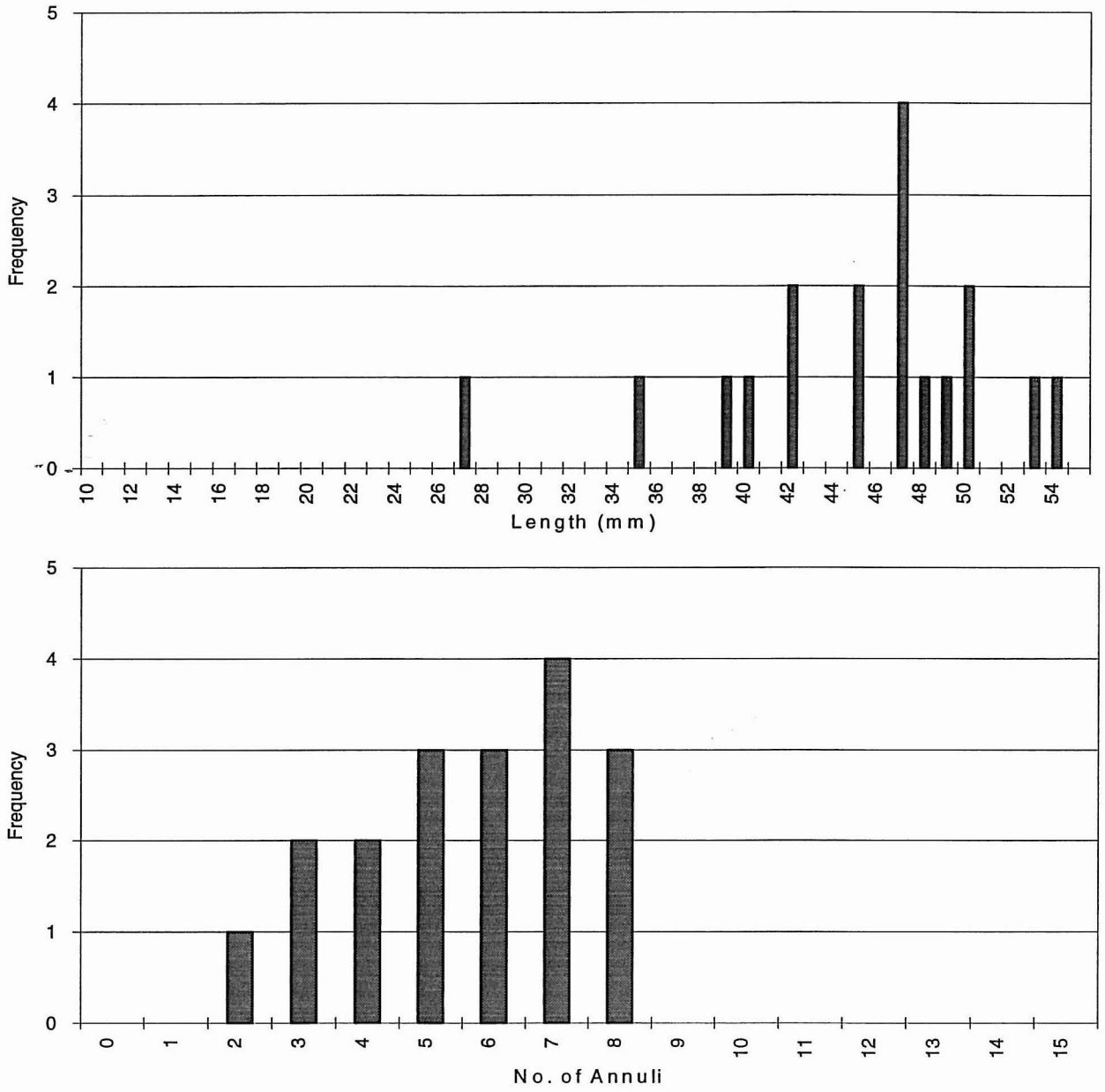

Figure 30. Length and age frequency distribution of Manila clams sampled in the Laredo Inlet area, July 26, 1994.

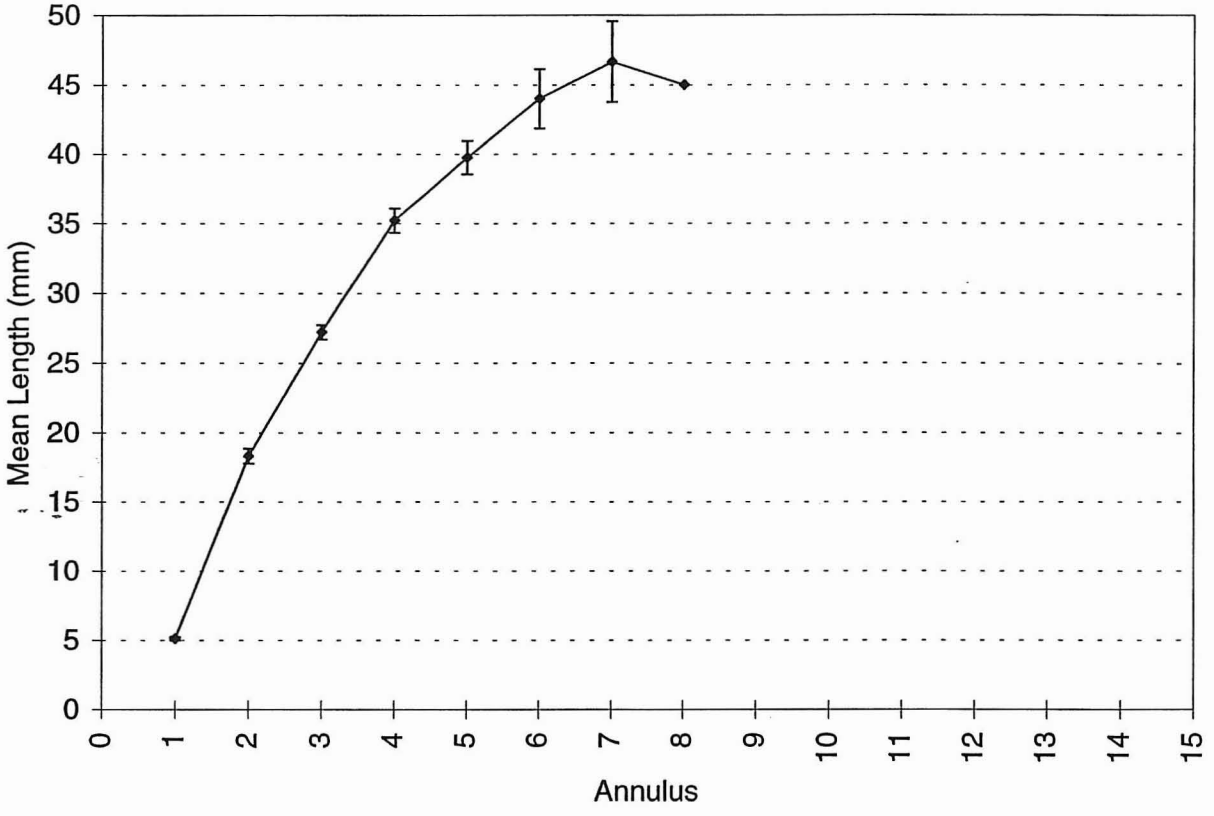

Figure 31. Growth rate of Manila clams sampled in the Laredo Inlet area, July 26, 1994. Error bars = +/- 1 SE.

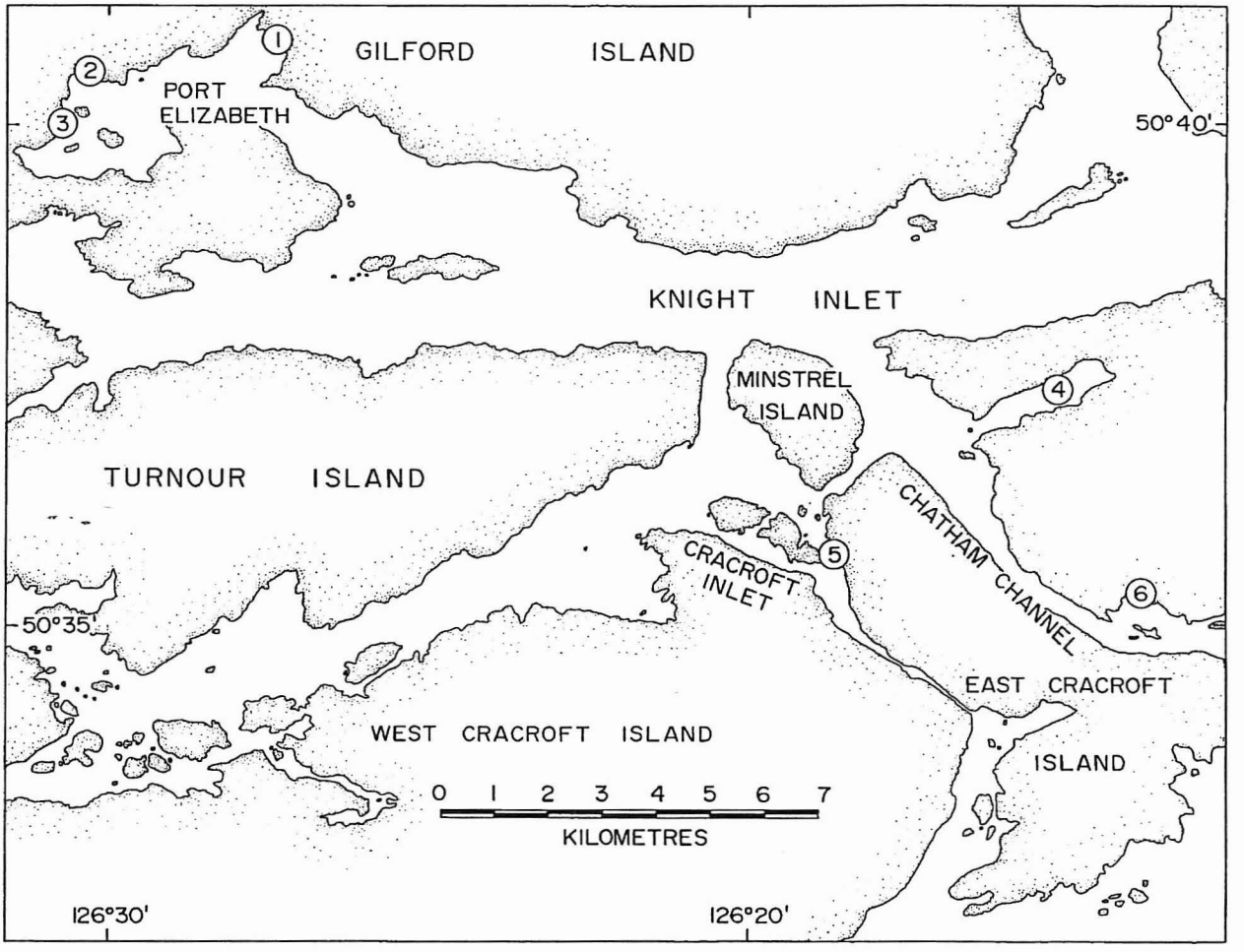

Figure 32. Location of beaches visited in the Port Elizabeth - Chatham Channel areas, July 27, 1994.

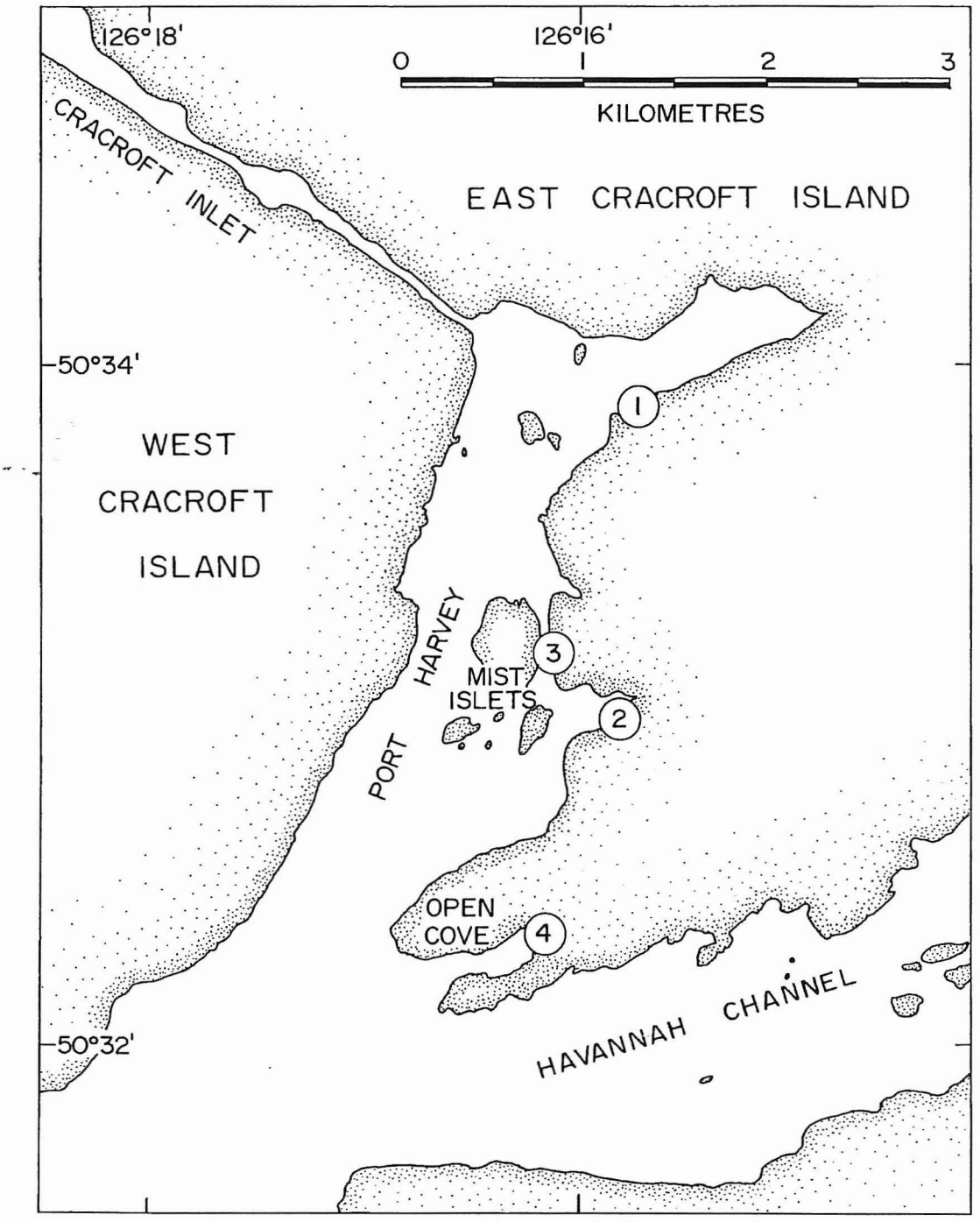

Figure 33. Location of beaches visited in the Port Harvey area, June 26, 1996.

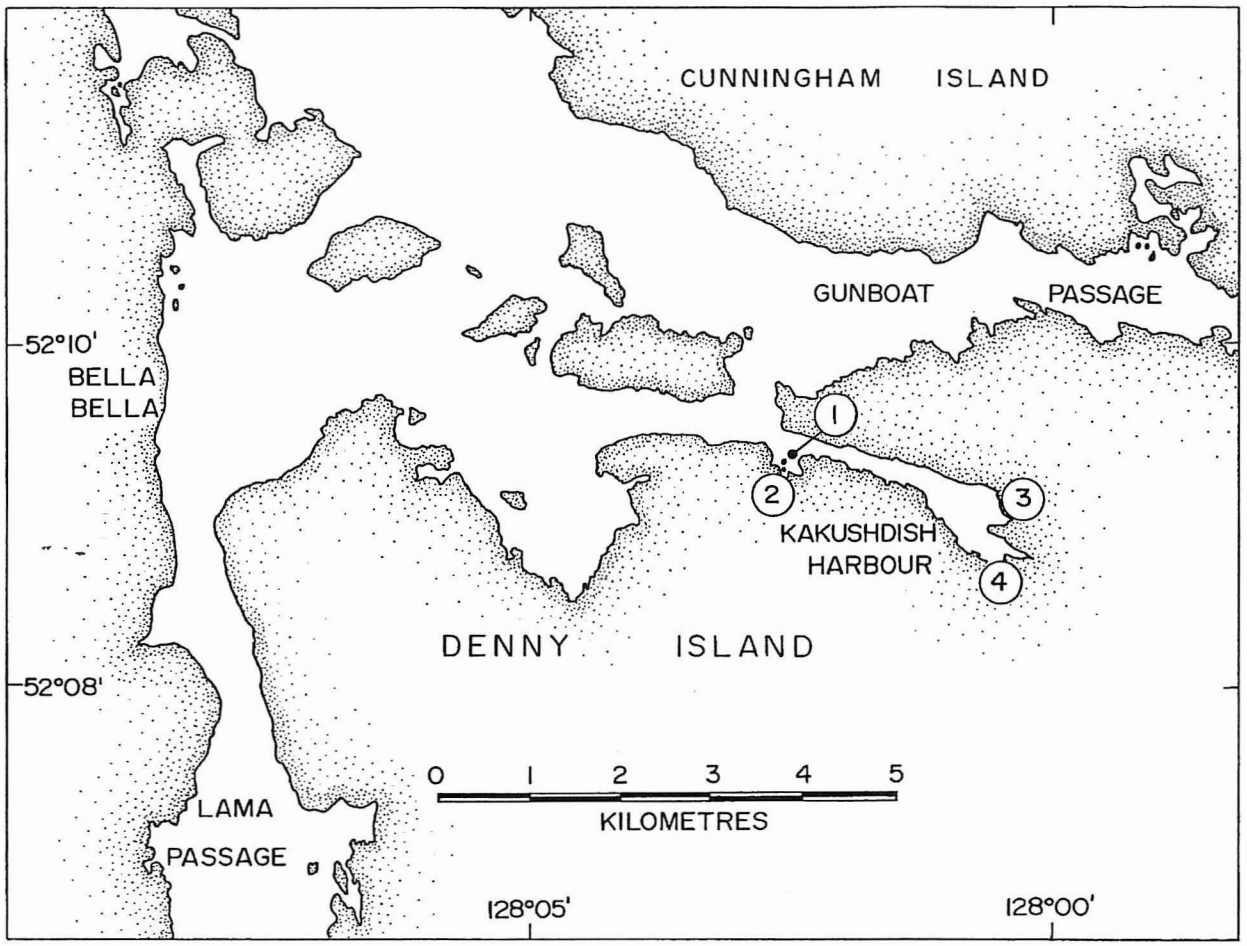

Figure 34. Location of beaches visited in Kakushdish Harbour, June 28-29, 1996.

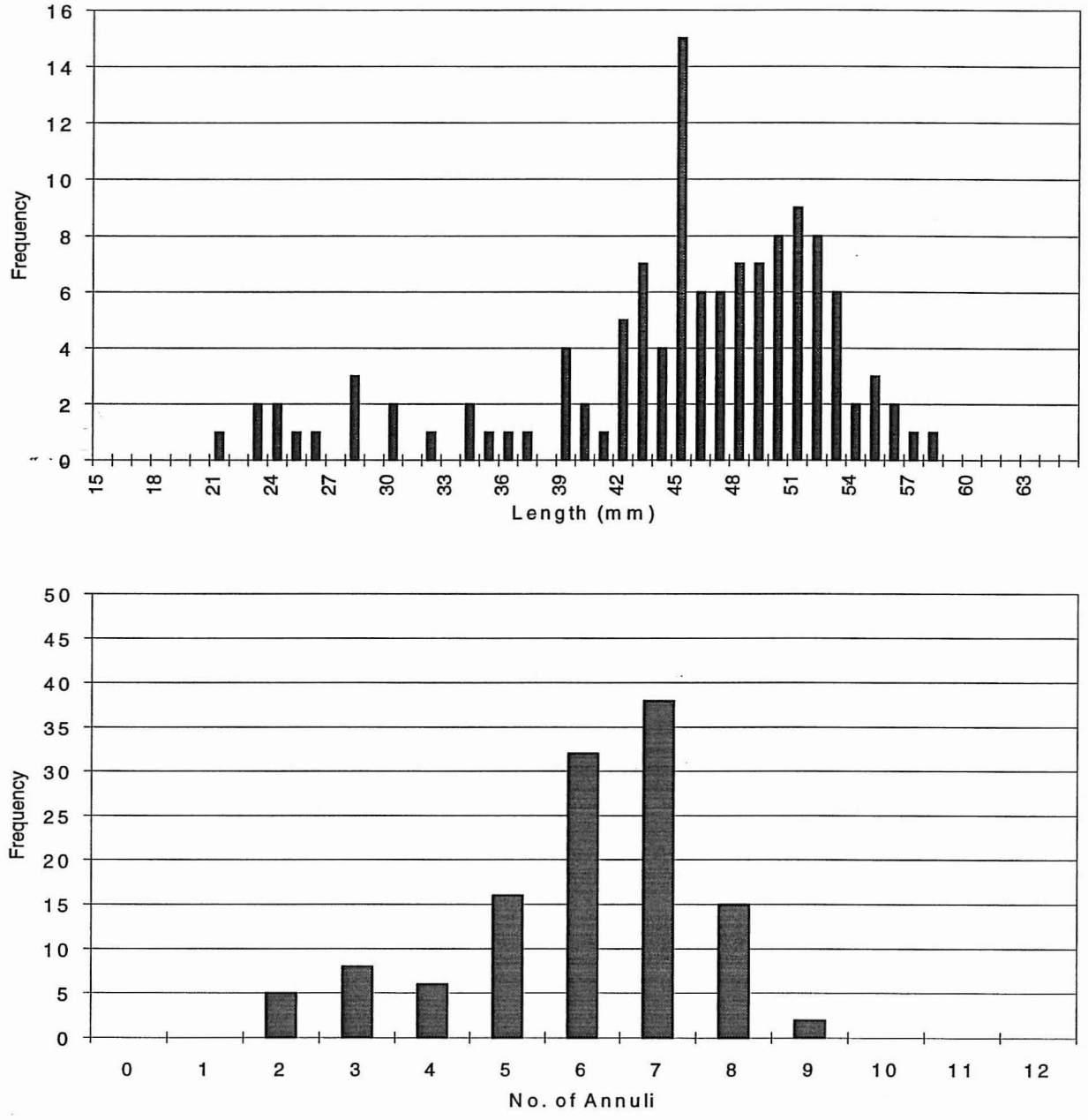

Figure 35. Length and age frequency distribution of Manila clams sampled at Beach 2, Kakushdish Harbour, June 29, 1996.

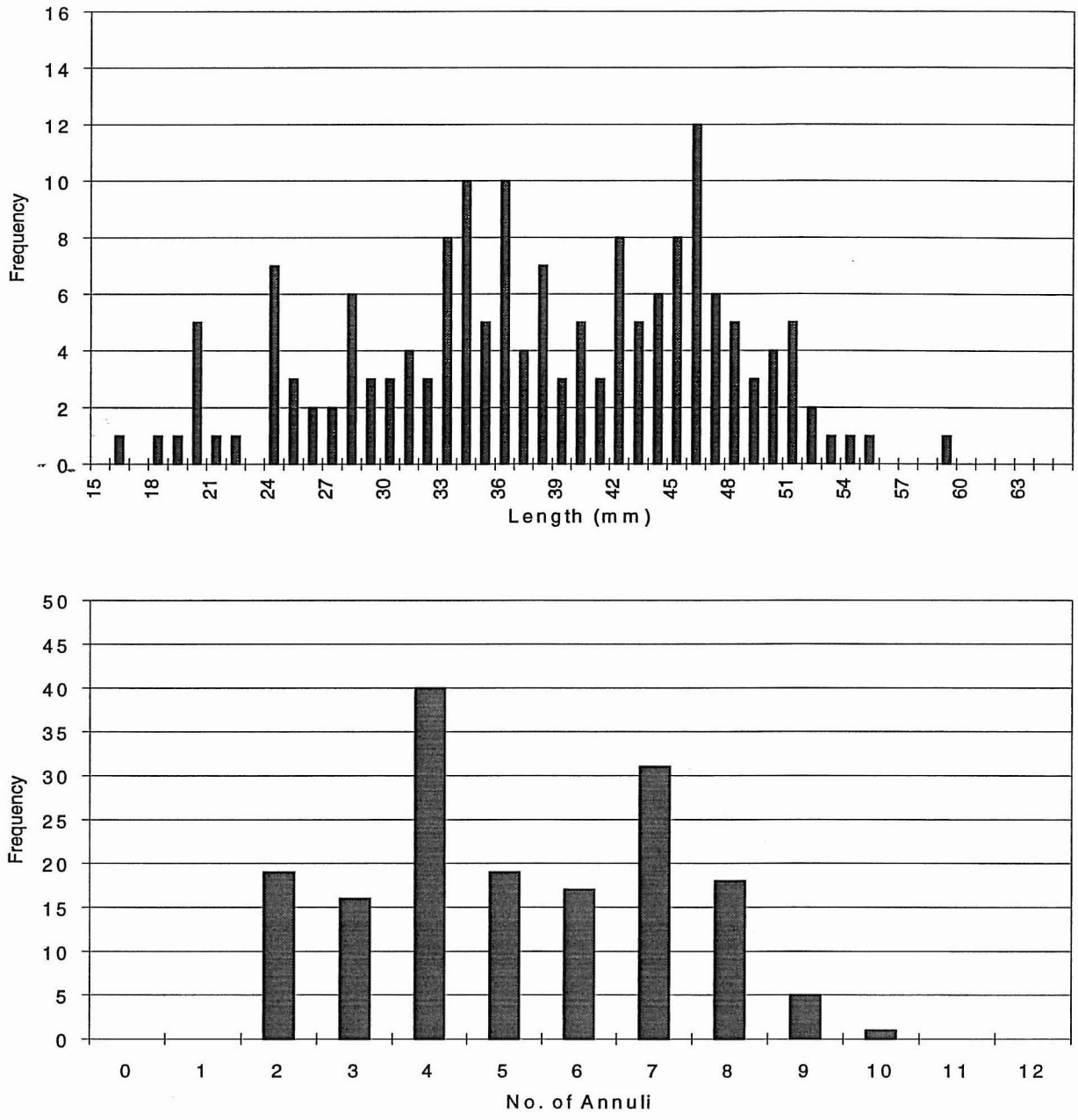

Figure 36. Length and age frequency distribution of Manila clams sampled at Beach 4, Kakushdish Harbour, June 29, 1996.

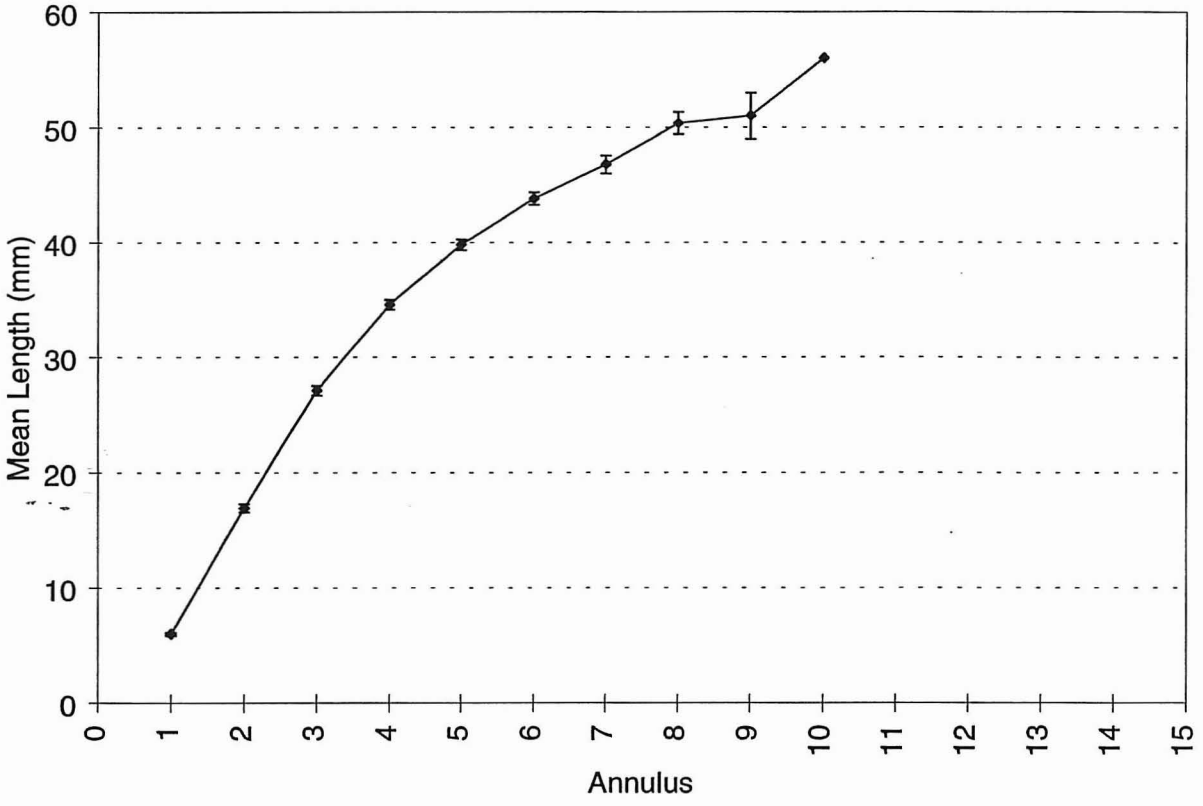

Figure 37. Growth rate of Manila clams sampled in Kakushdish Harbour, June 29, 1996. Error bars = +/- 1 SE.

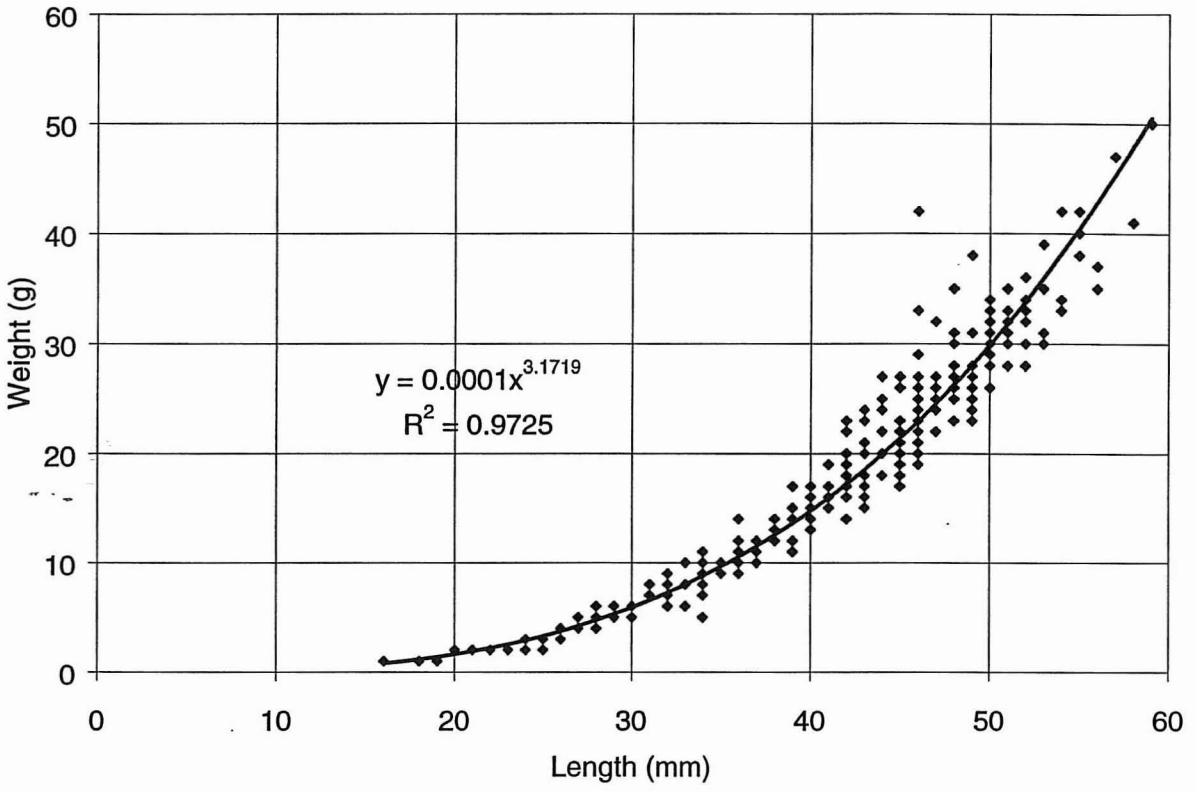

Figure 38. Length-weight relationship of Manila clams sampled at Kakushdish Harbour, June 28-29, 1996.

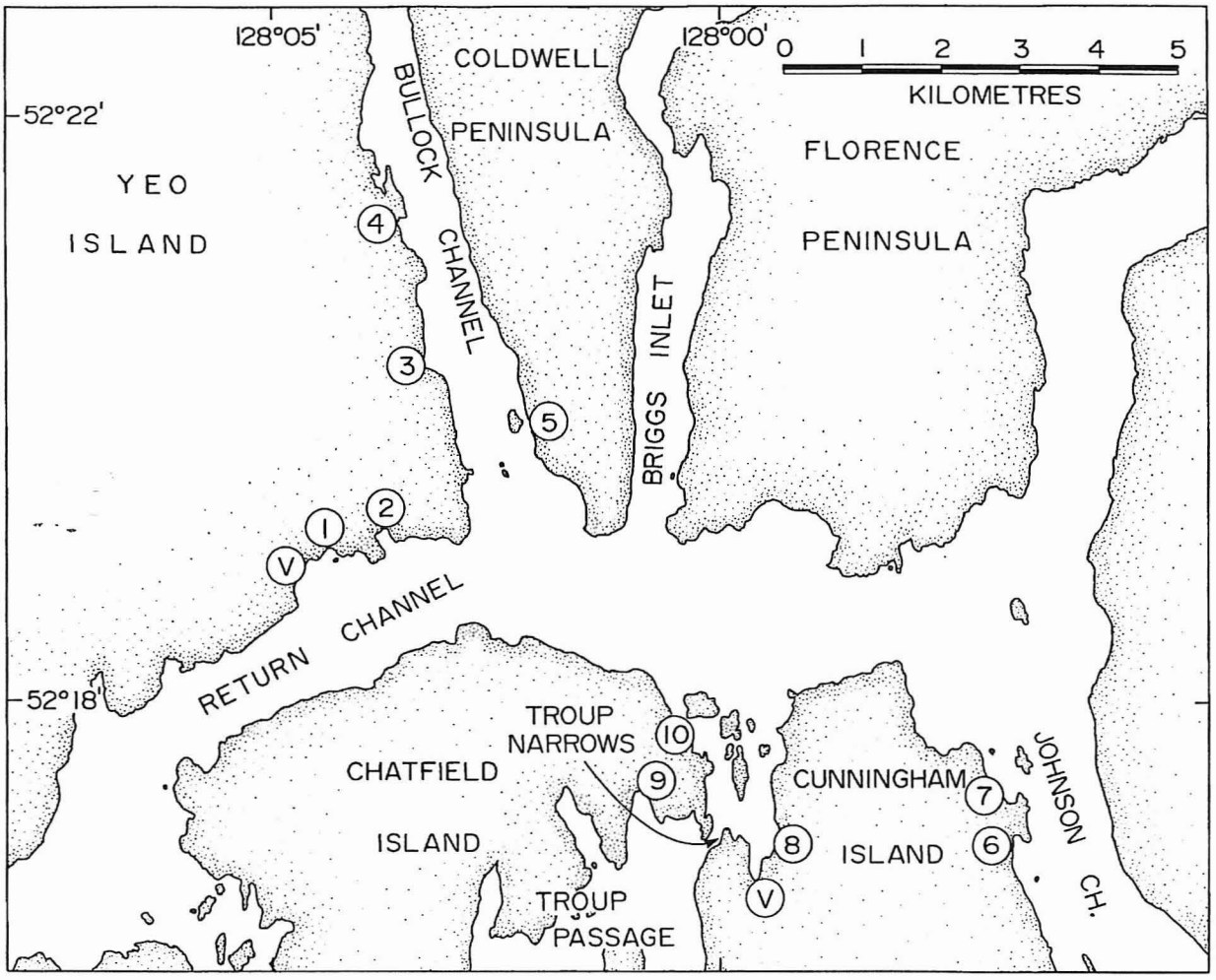

Figure 39. Location of beaches visited in the Return Channel - Bullock Channel - Johnson Channel - Troup Narrows areas, June 30, 1996. V denotes a beach that was visited, but not explored.

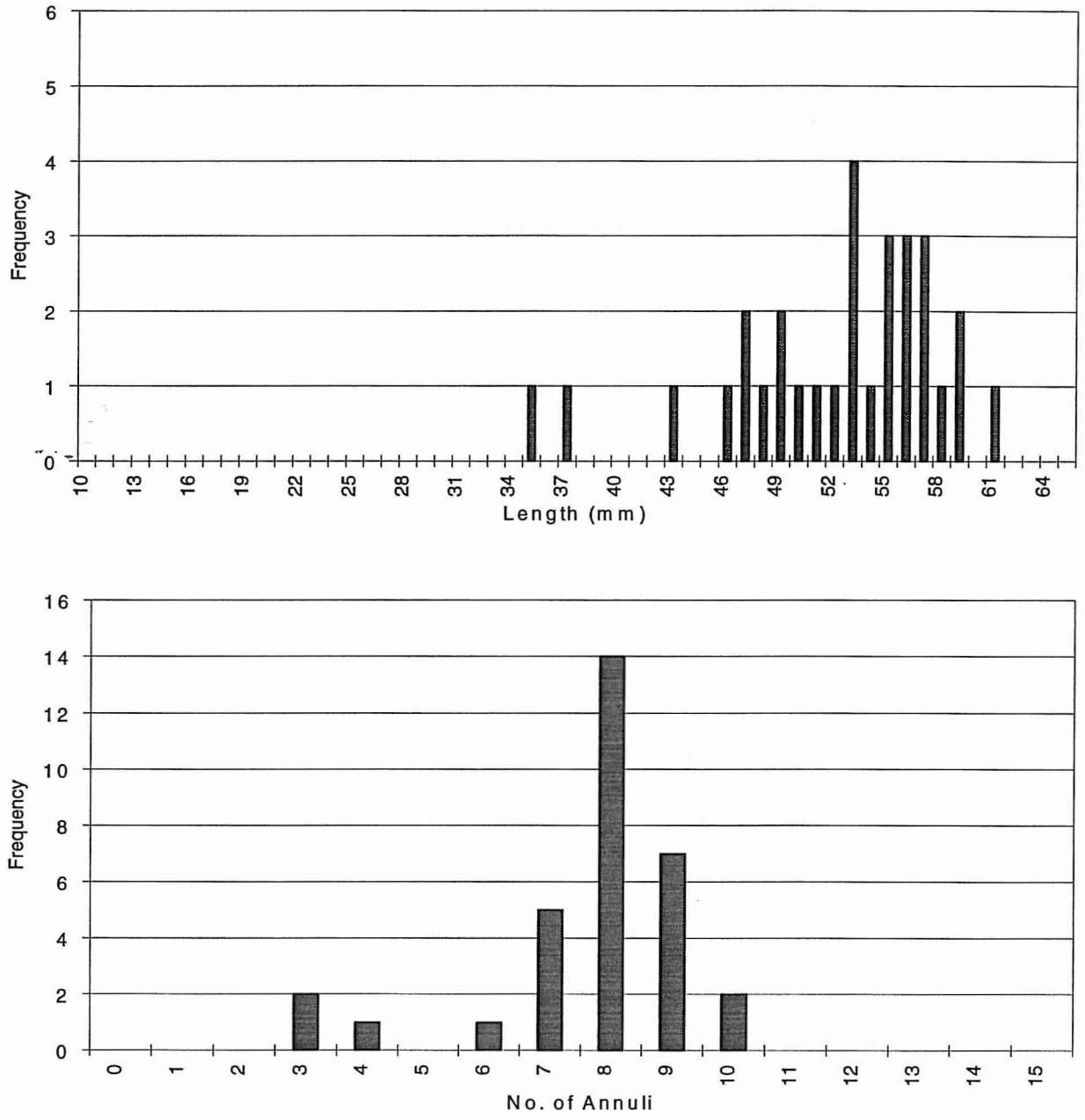

Figure 40. Length and age frequency distribution of Manila clams sampled at Beach 4 in Bullock Channel, June 30, 1996.

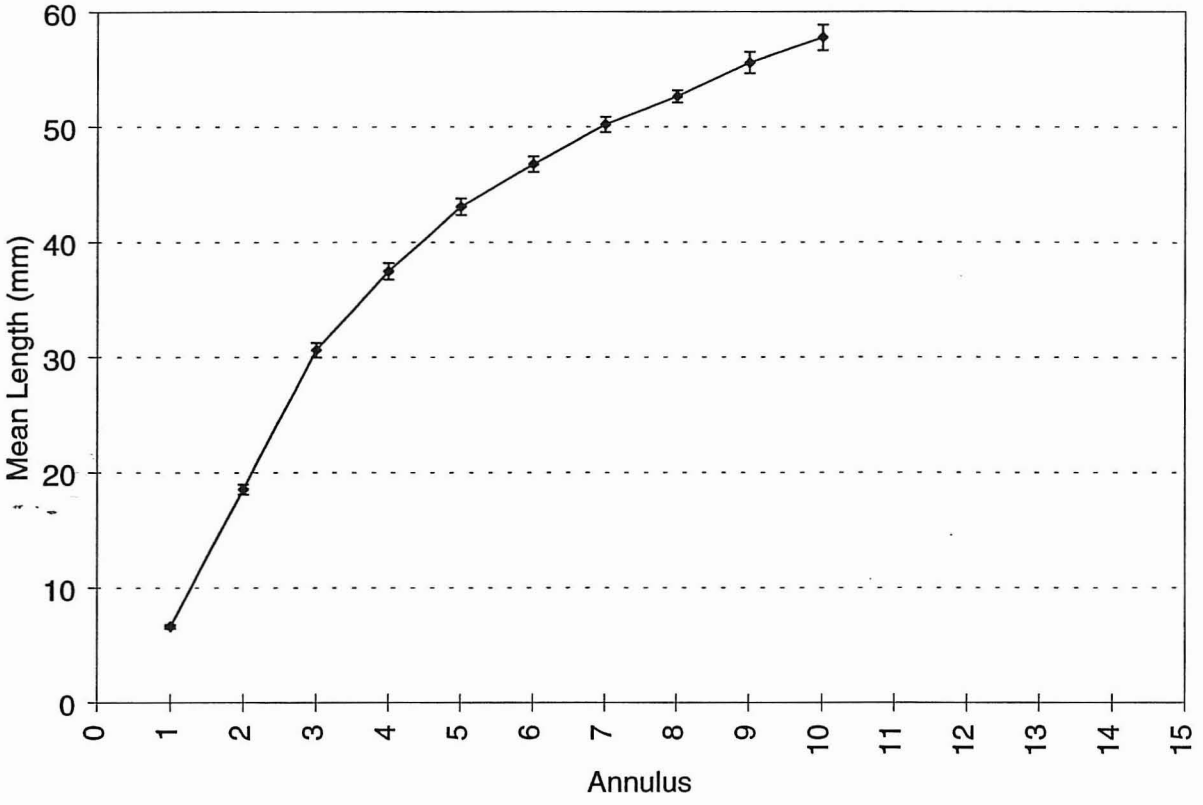

Figure 41. Growth rate of Manila clams sampled at Beach 4 in Bullock Channel, June 30, 1996. Error bars = +/- 1 SE.

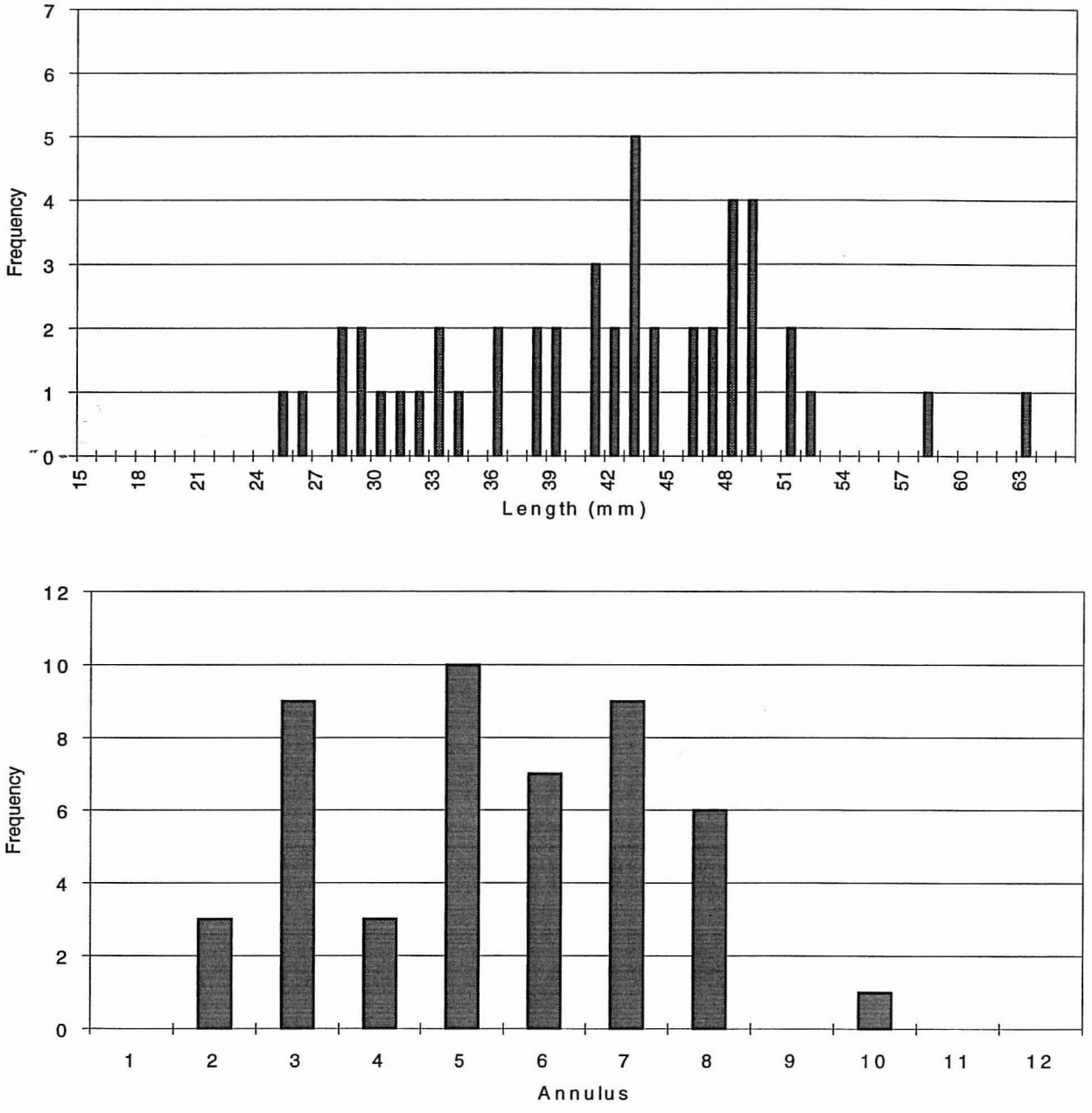

Figure 42. Length and age frequency distribution of Manila clams sampled at Beach 8 in Troup Narrows, June 30, 1996.

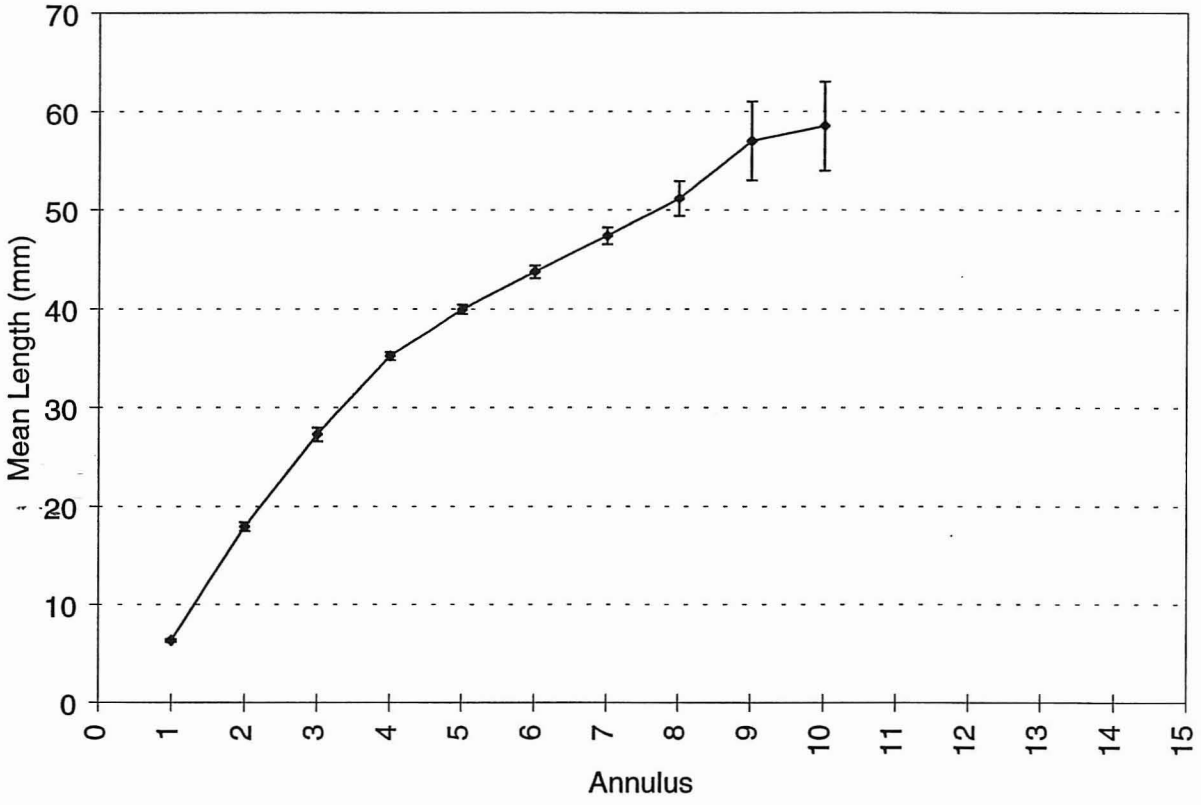

Figure 43. Growth rate of Manila clams sampled at Beach 8 in Troup Narrows, June 30, 1996. Error bars = +/- 1 SE.

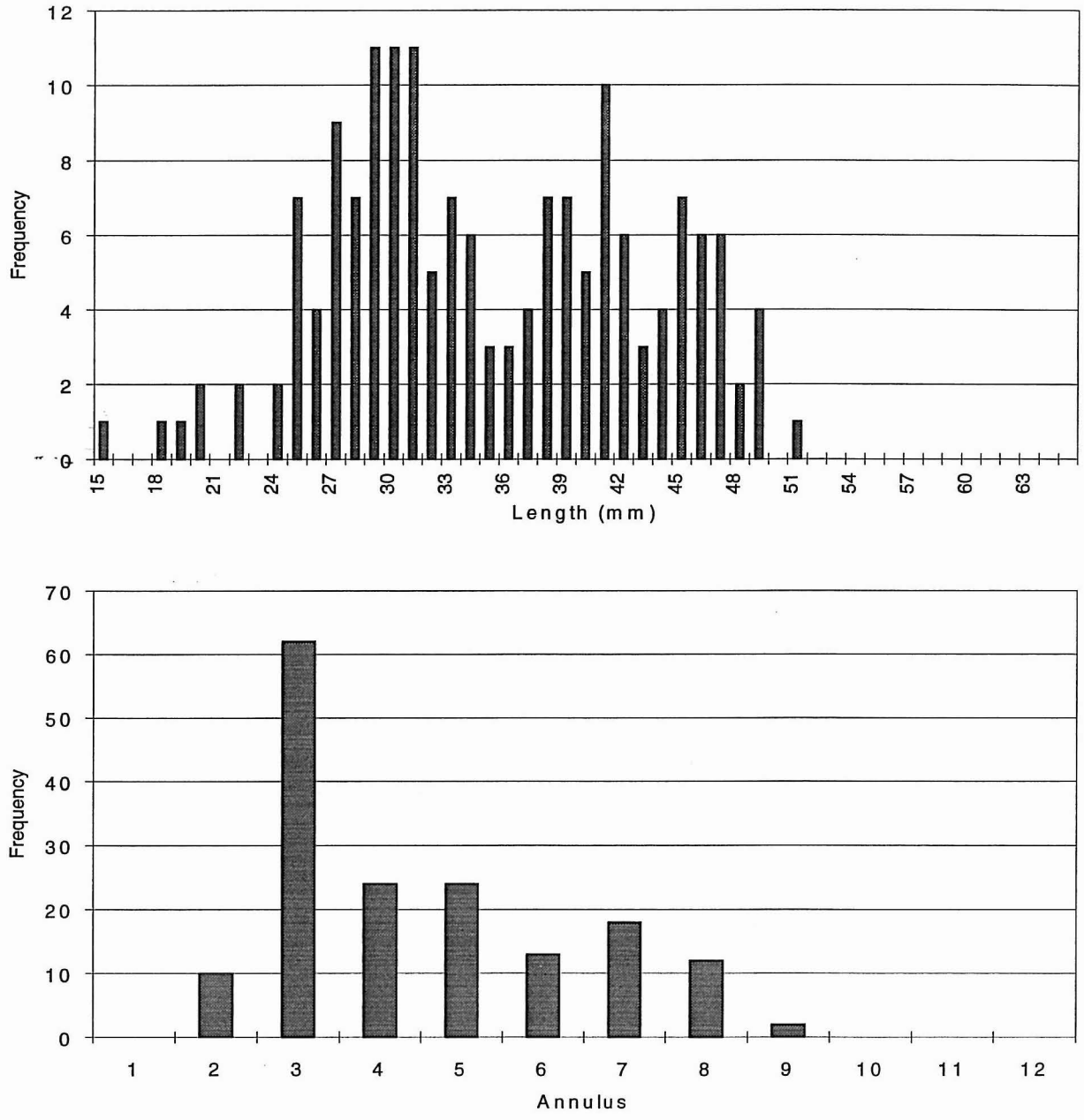

Figure 44. Length and age frequency distribution of Manila clams sampled at Beach 9 in Troup Narrows, June 30, 1996.

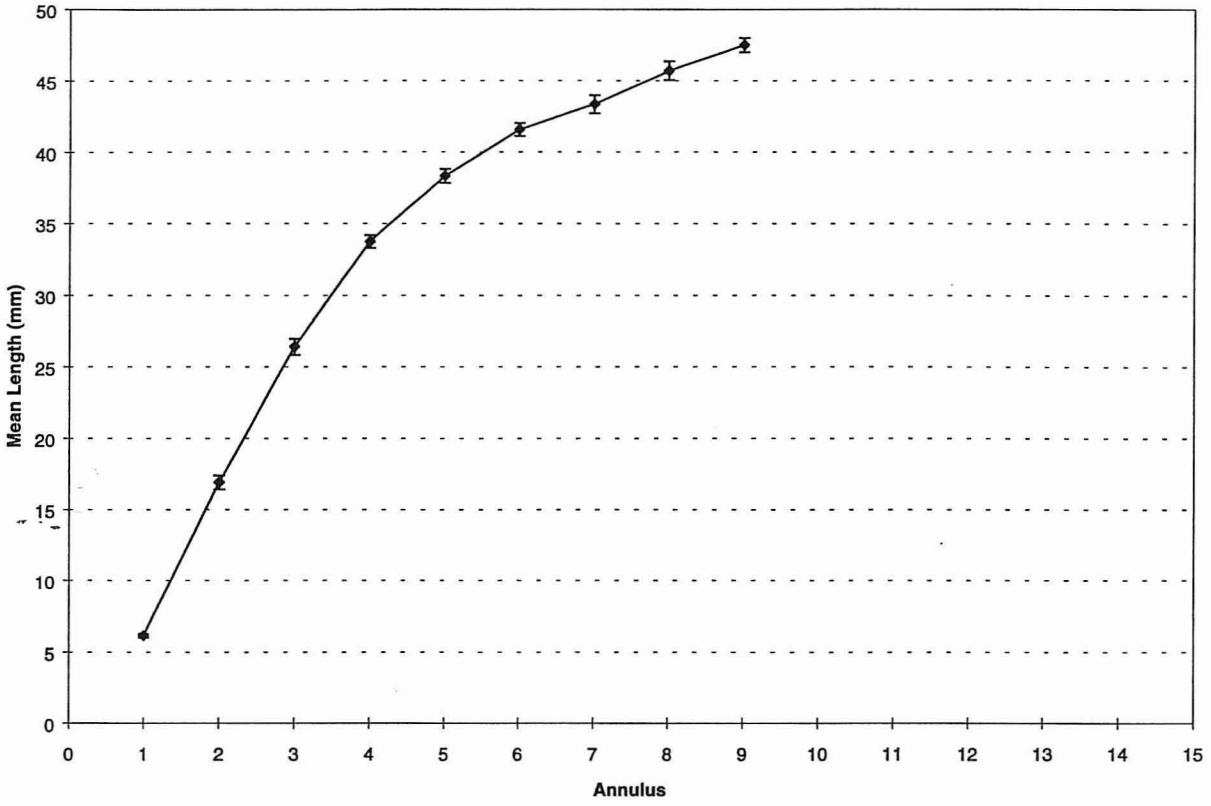

Figure 45. Growth rate of Manila clams sampled at Beach 9 in Troup Narrows, June 30, 1996. Error bars = +/- 1 SE.

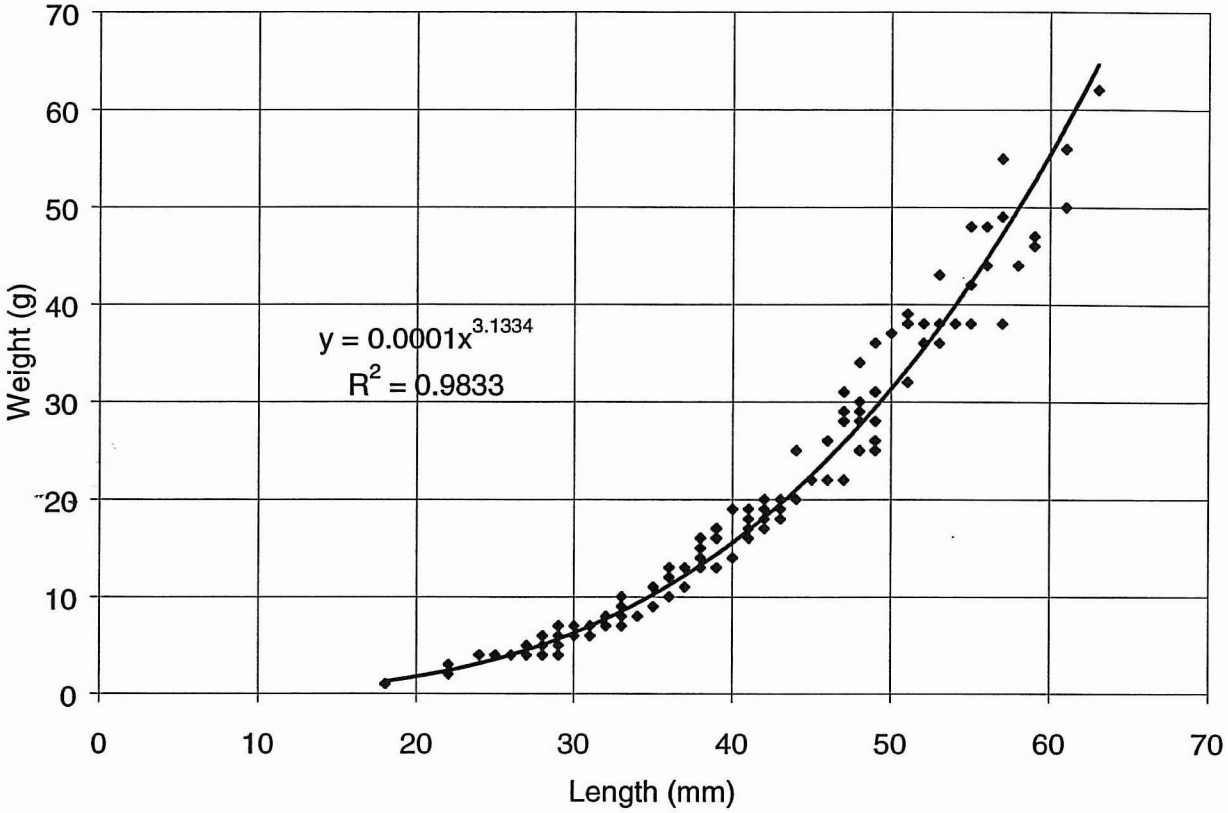

Figure 46. Length-weight relationship of Manila clams sampled at Beaches 4, 8 and 9 in the Return Channel - Bullock Channel - Johnson Channel - Troup Narrows area, June 30, 1996.

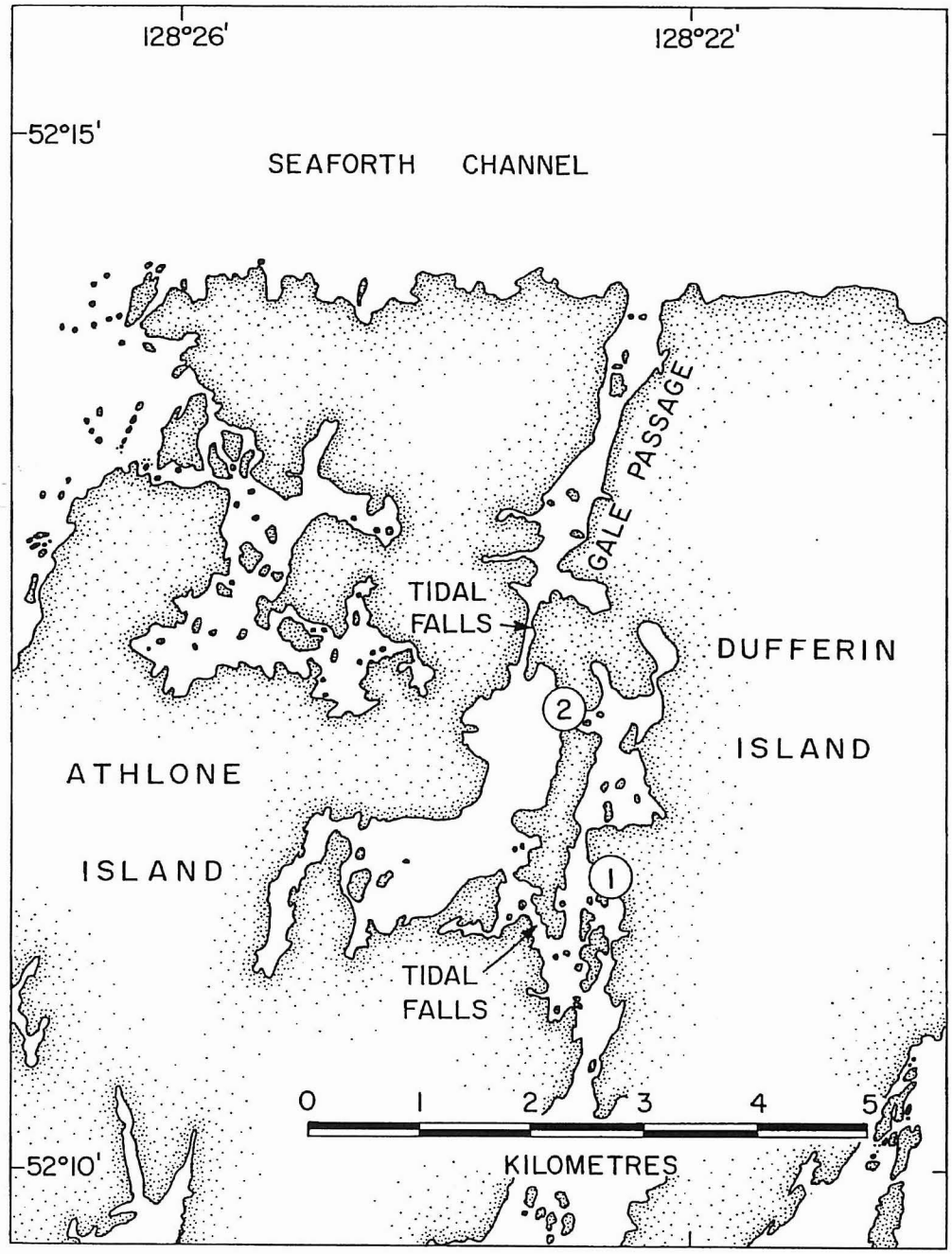

Figure 47. Location of beaches visited in Gale Passage, July 1, 1996.

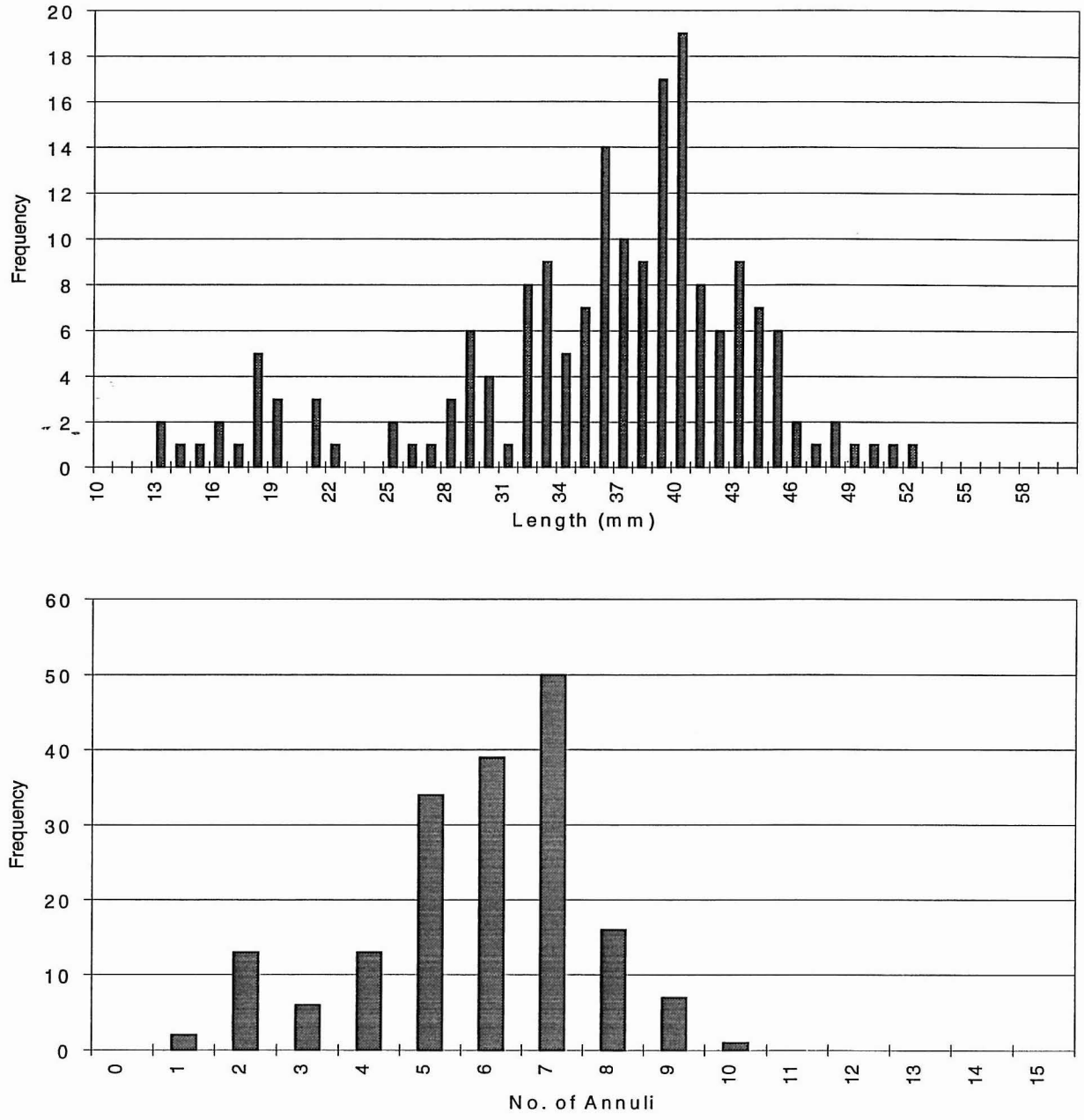

Figure 48. Length and age frequency distribution of littleneck clams sampled at Beach 1, Gale Passage, July 1, 1996.

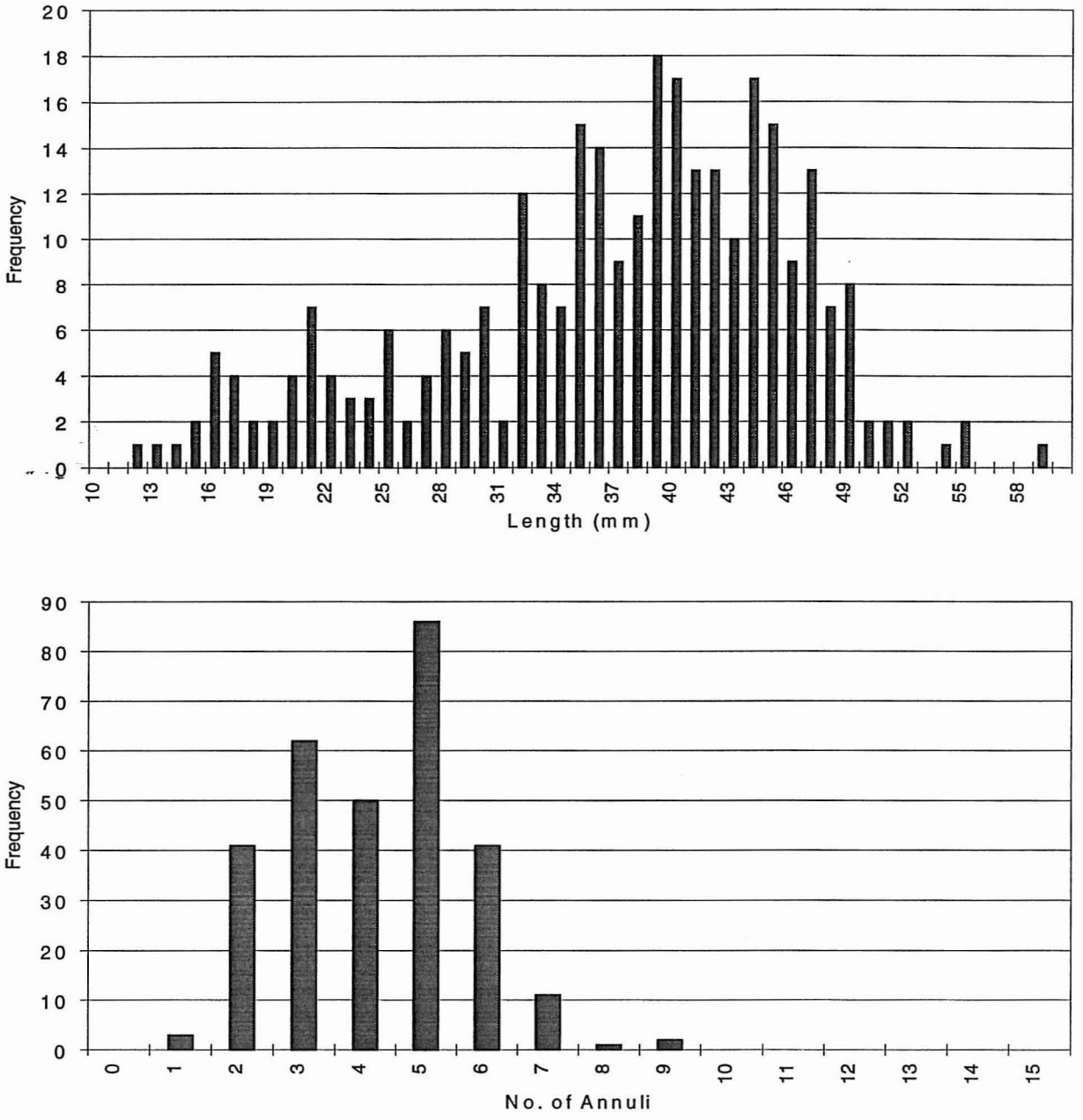

Figure 49. Length and age frequency distribution of Manila clams sampled at Beach 1, Gale Passage, July 1, 1996.

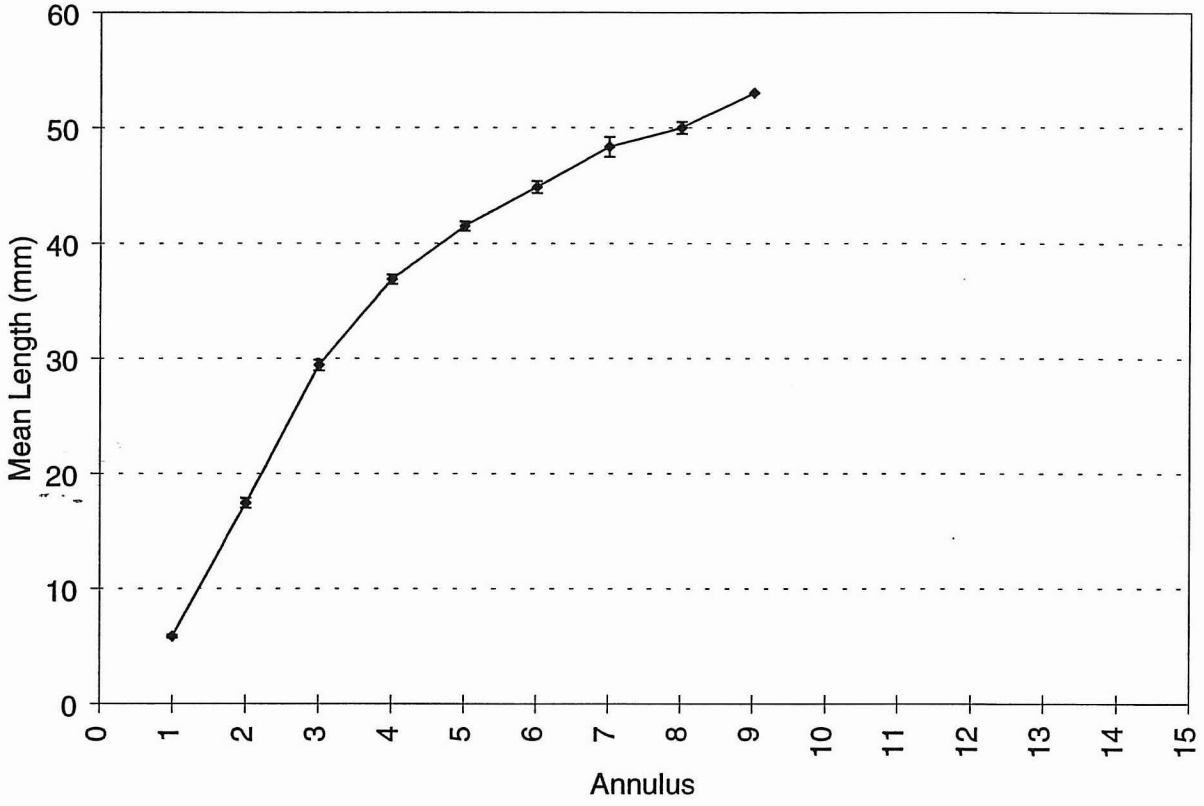

Figure 50. Growth rate of Manila clams sampled from Beach 1, Gale Passage, July 1, 1996. Error bars = +/- 1 SE.

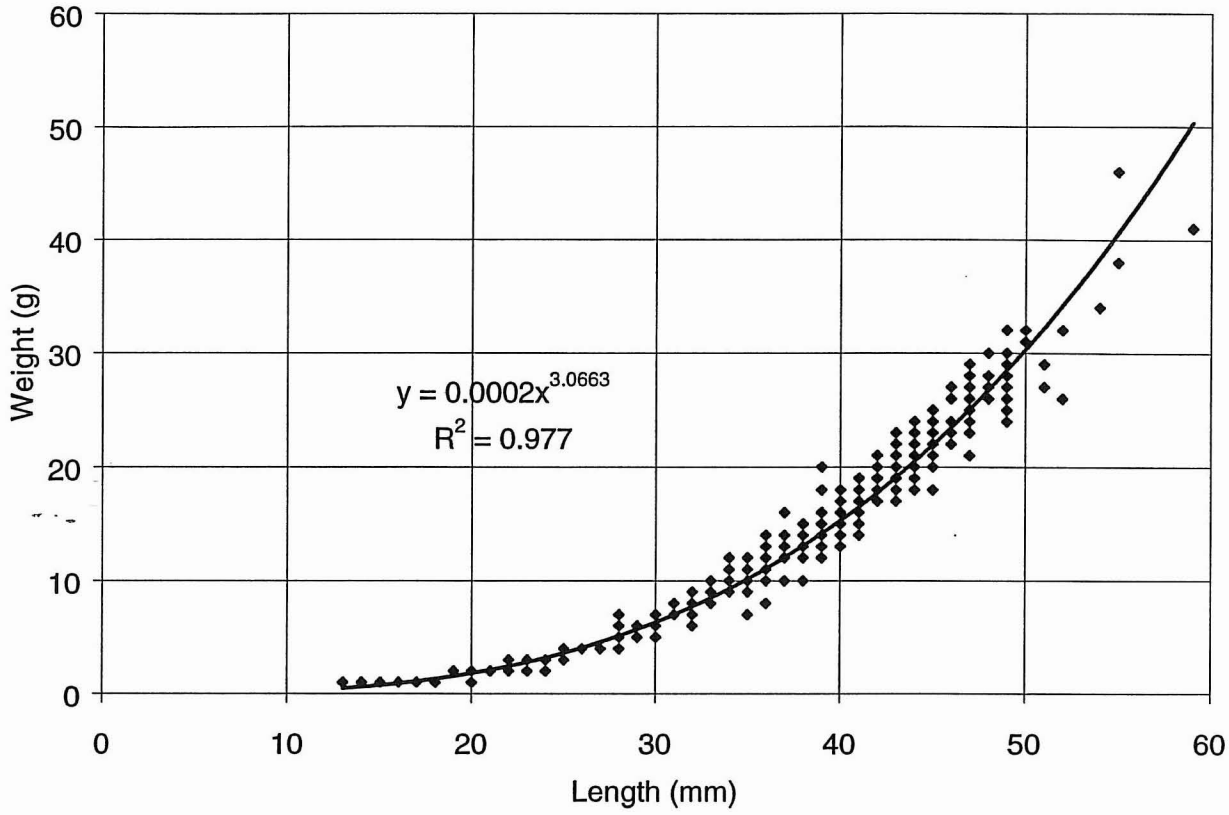

Figure 51. Length-weight relationship of Manila clams sampled at Beach 1, Gale Passage, July 1, 1996.

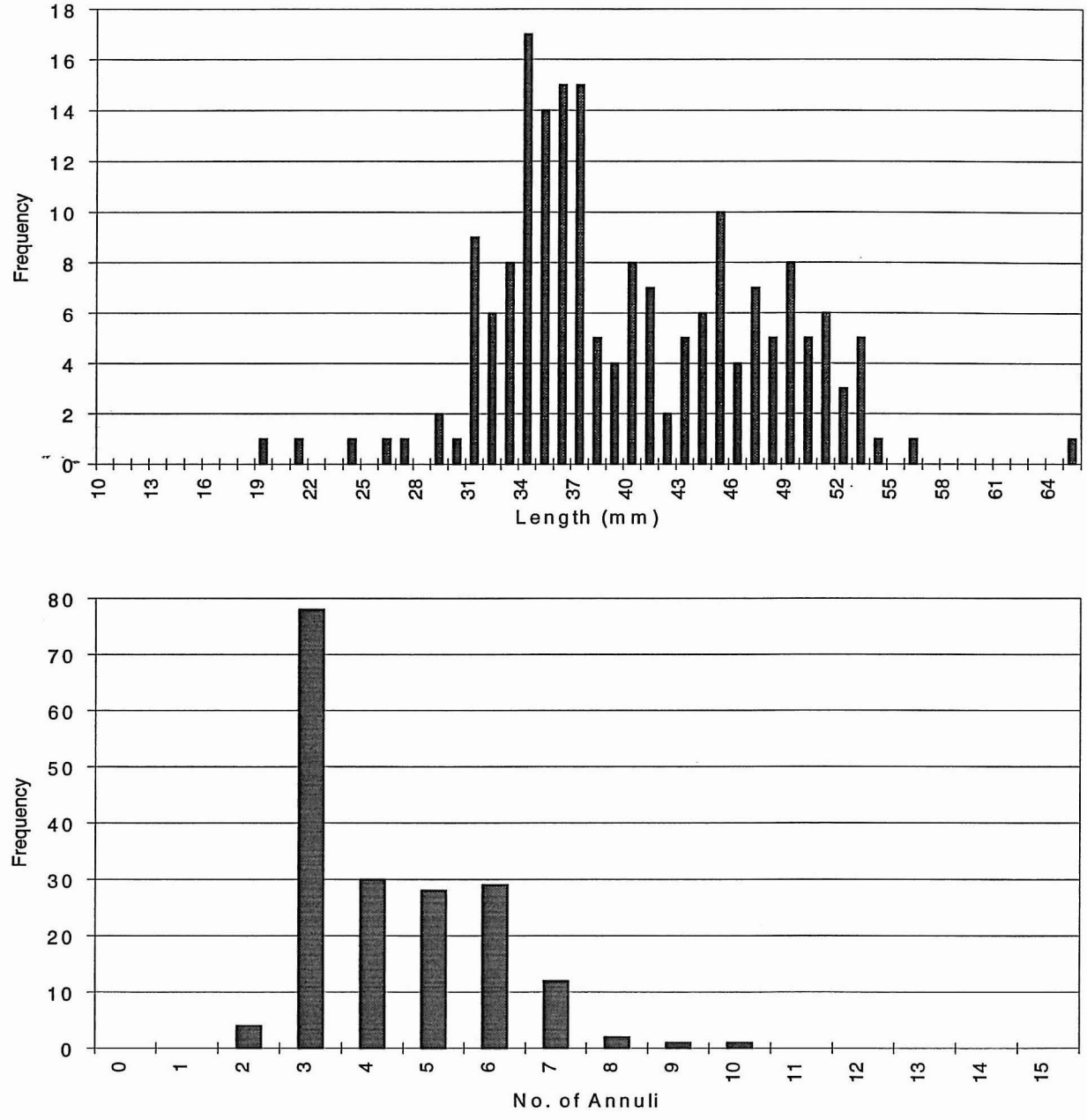

Figure 52. Length and age frequency distribution of Manila clams sampled at Beach 2, Gale Passage, July 1, 1996.

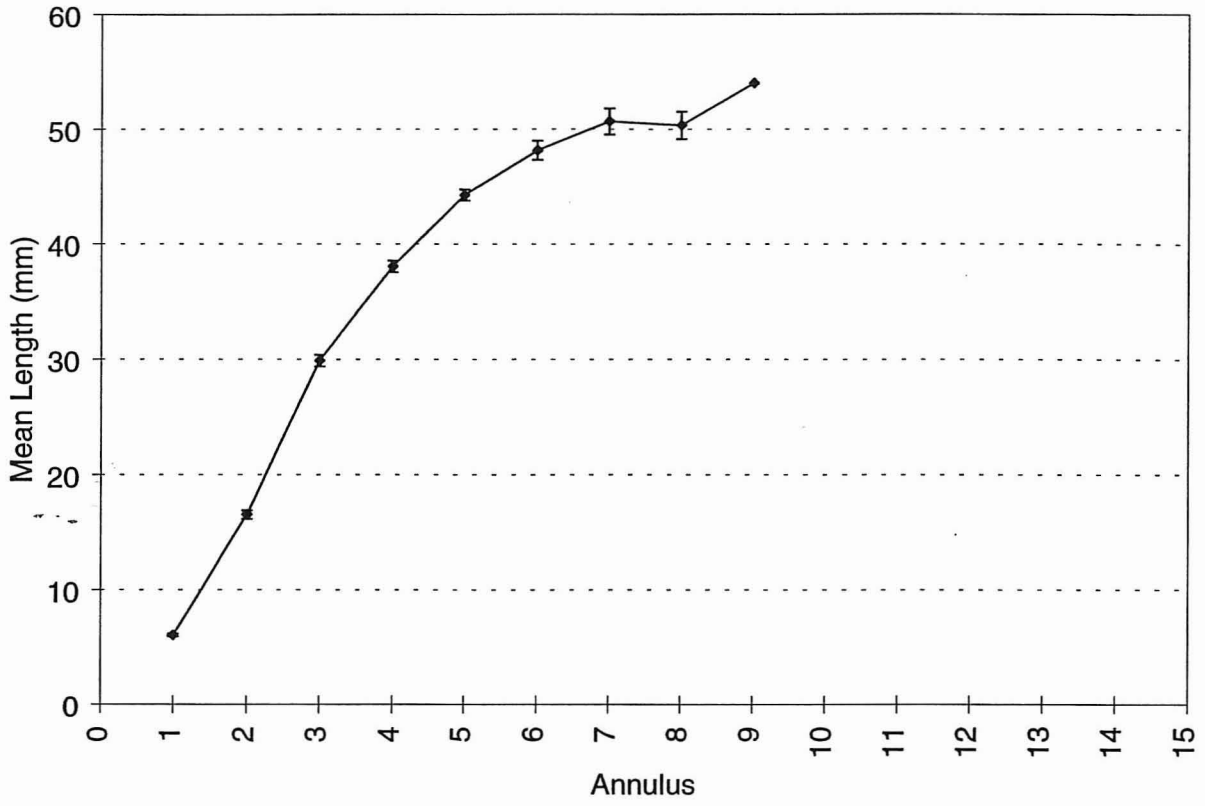

Figure 53. Growth rate of Manila clams sampled at Beach 2, Gale Passage, July 1, 1996. Error bars = +/- 1 SE.

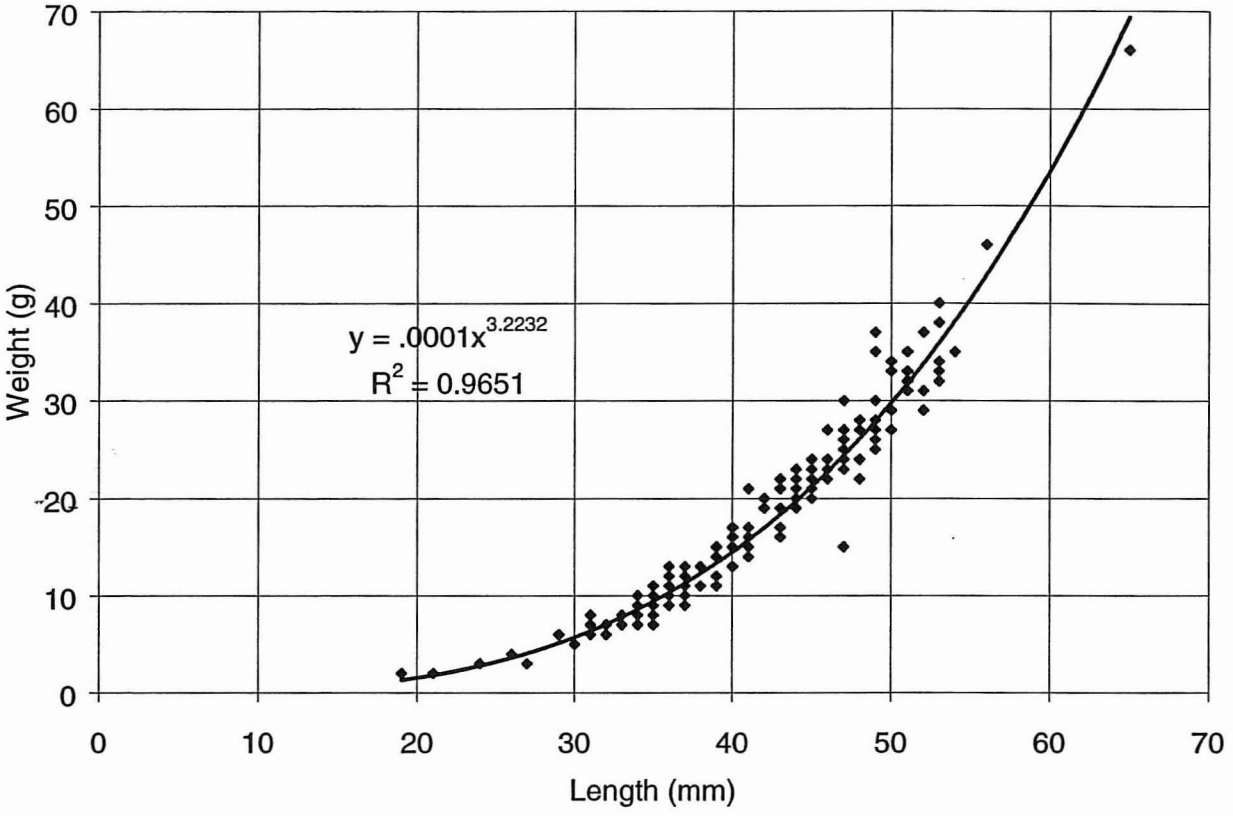

Figure 54. Length-weight relationship of Manila clams sampled at Beach 2, Gale Passage, July 1, 1996.

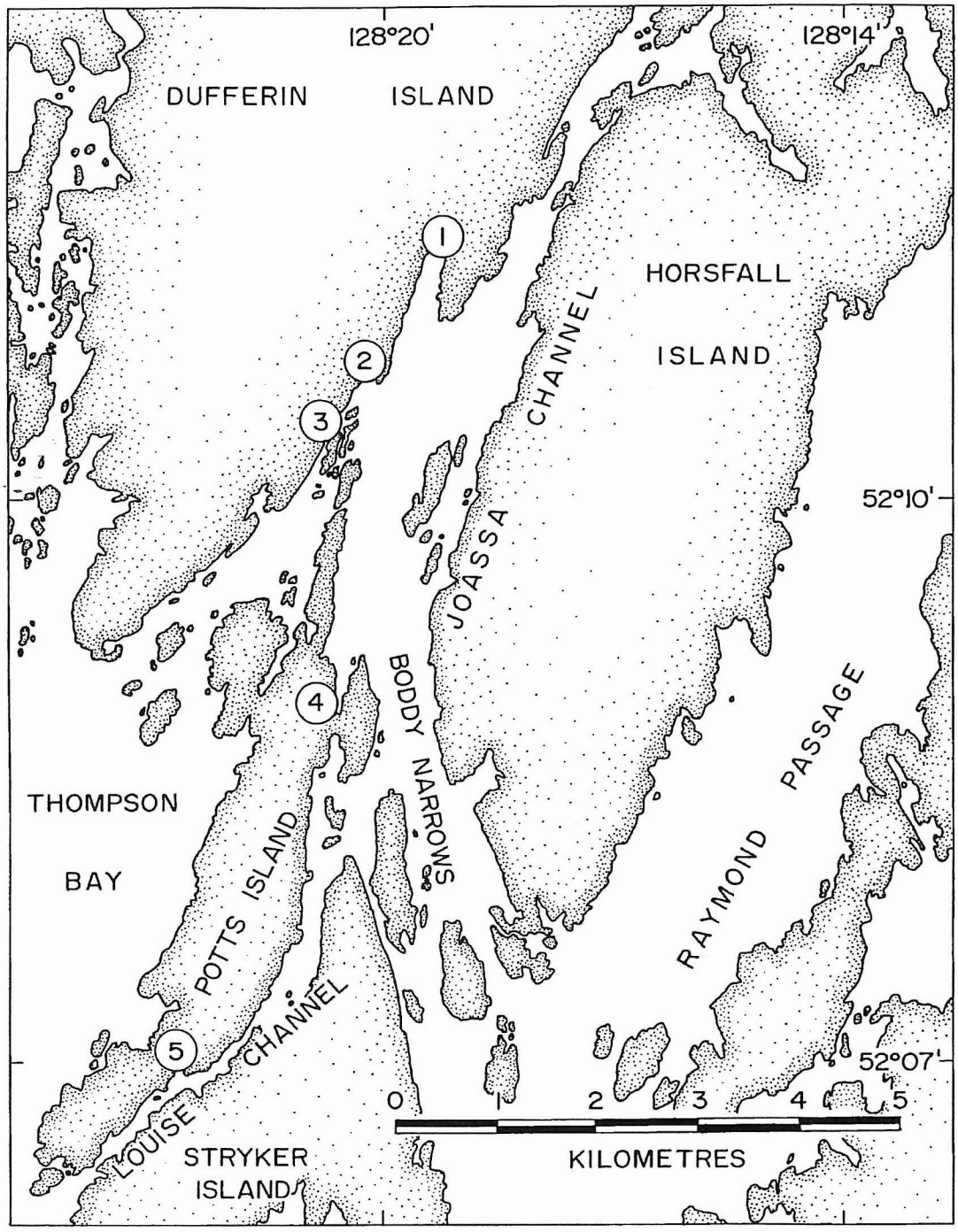

Figure 55. Location of beaches visited in the Joassa Channel - Boddy Narrows - Louise Channel areas, July 3, 1996.

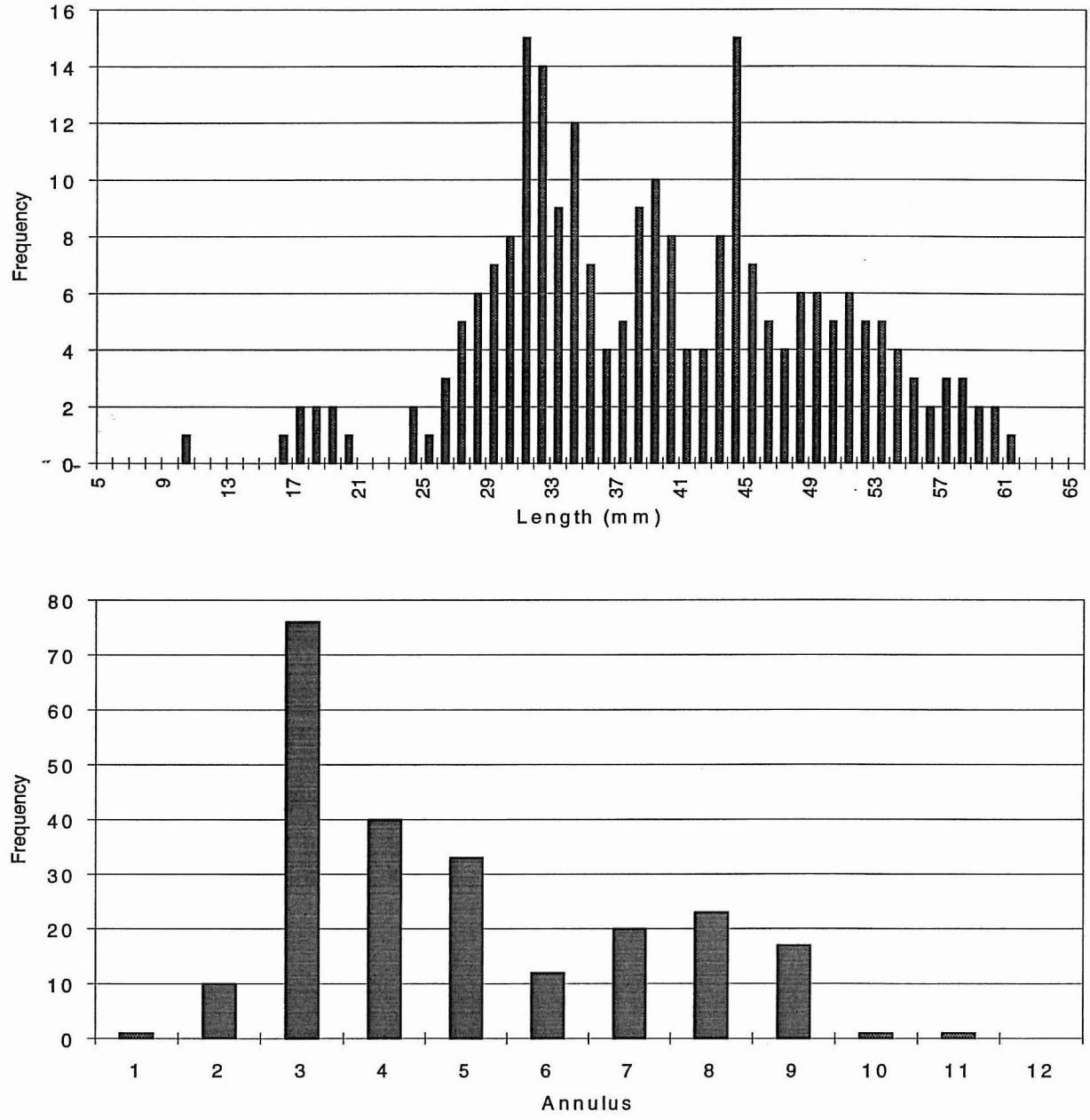

Figure 56. Length and age frequency distribution of Manila clams sampled in the Joassa Channel - Boddy Narrows - Louise Channel areas, July 3, 1996.

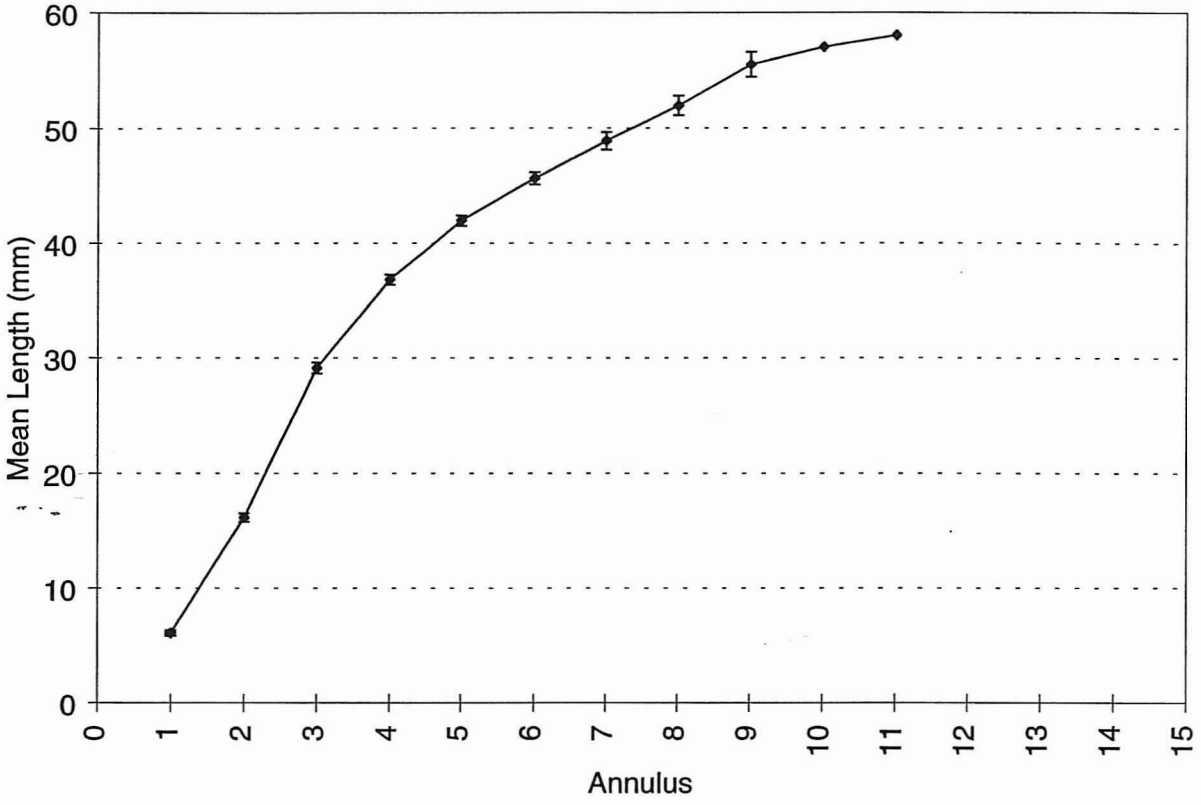

Figure 57. Growth rate of Manila clams sampled in the Joassa Channel - Boddy Narrows - Louise Channel areas, July 3, 1996. Error bars = +/- 1 SE.

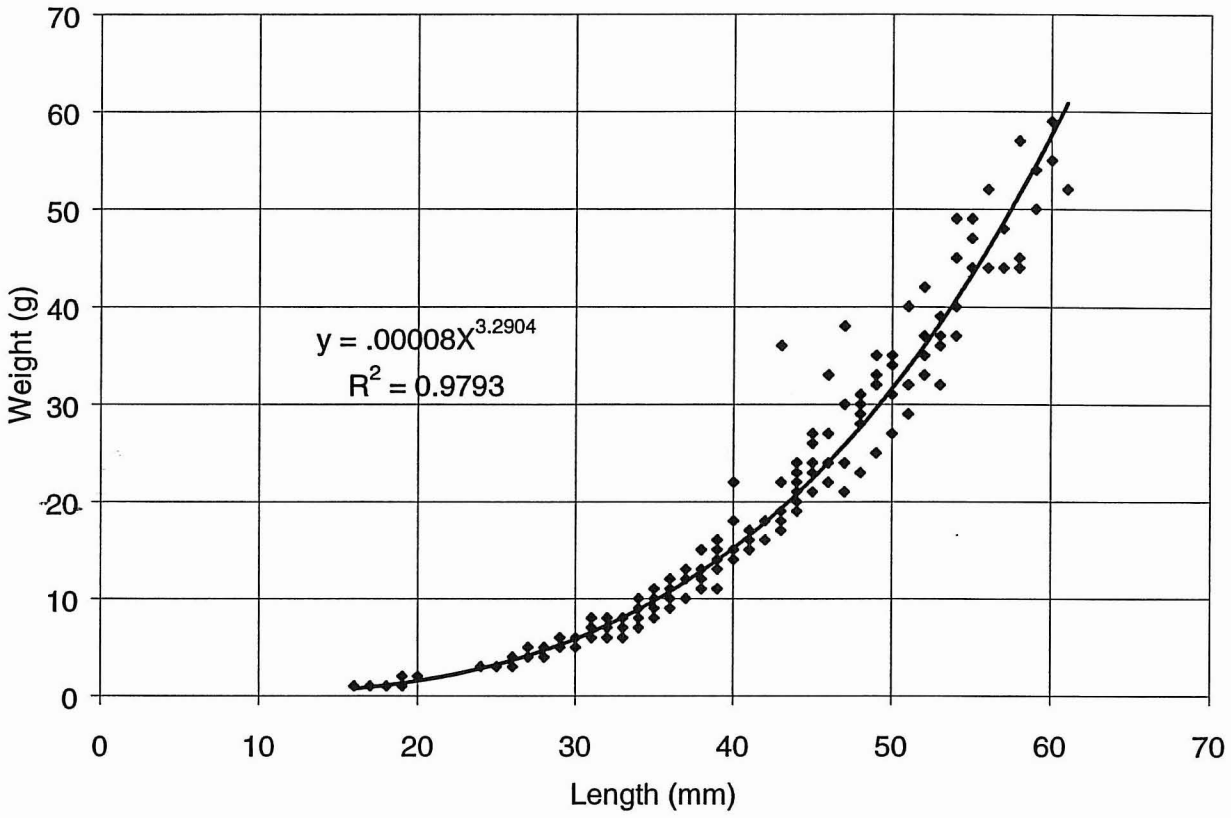

Figure 58. Length-weight relationship of Manila clams sampled in the Joassa Channel - Boddy Narrows - Louise Channel areas, July 3, 1996.

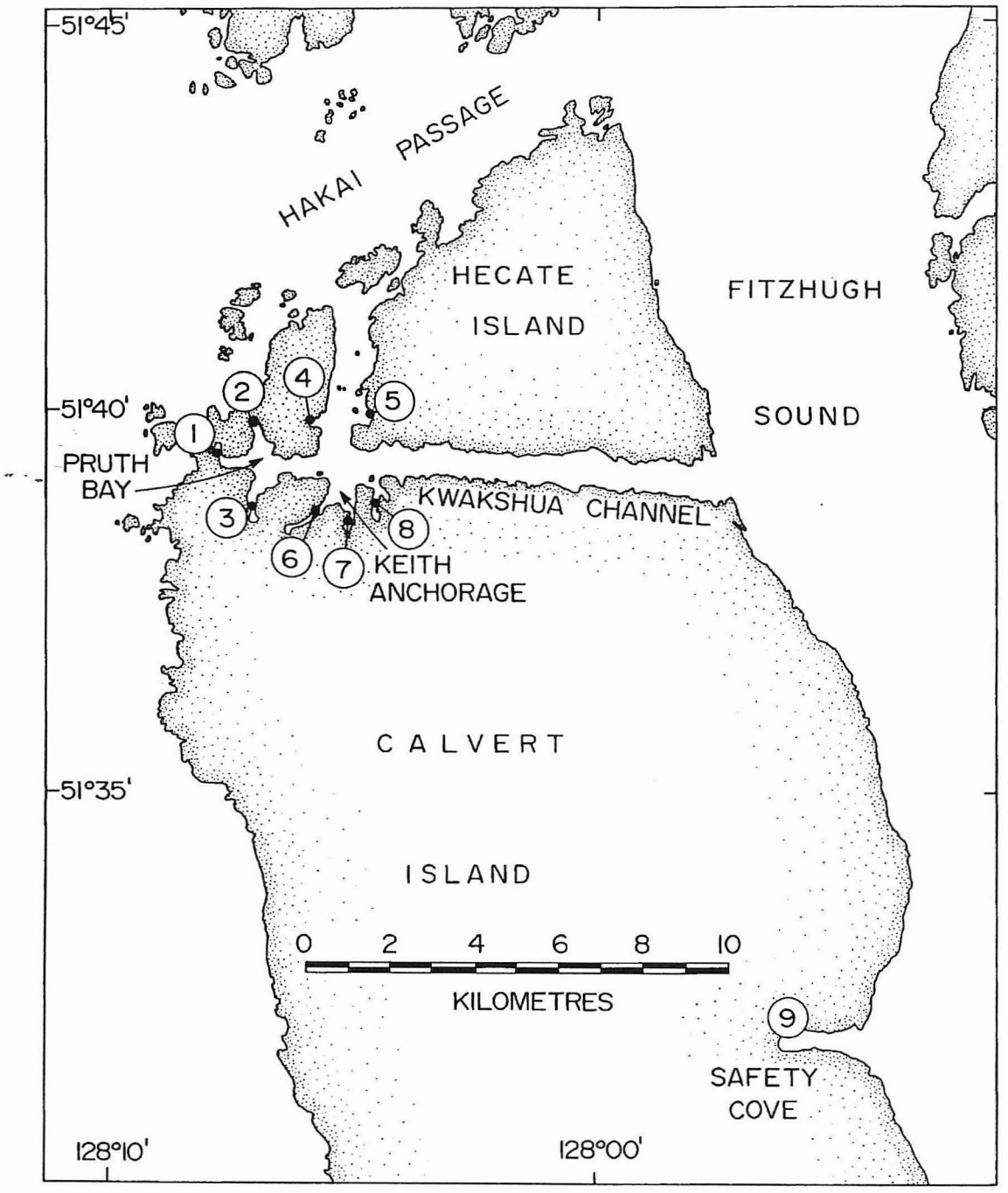

Figure 59. Location of beaches visited in the Kwakshua Channel - Safety Cove areas, July 6, 1996.