Intertidal Clam Surveys in British Columbia - 1992 and 1993

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Results of 1992 and 1993 surveys to assess populations of commercially important intertidal clams on selected beaches in the Strait of Georgia, Queen Charlotte Strait, Johnstone Strait and North Coast district areas of British Columbia are presented.

Surveys in both years focussed primarily on assessment of Manila clam, *Tapes philippinarum*, populations, the clam species of most importance to the present commercial industry. On beaches visited in the Strait of Georgia, Manila clams were generally abundant and densities as high as 748 clams m^{-2} were recorded. There was evidence of good recent recruitment. On beaches visited outside the Strait of Georgia, Manila clam abundance was low and ranged from <1 - 56 clams m^{-2}. Most Manila clams found outside the Strait of Georgia were large and old indicating inconsistent recruitment in recent years.

Although sampling for butter clams, *Saxidomus giganteus*, and littleneck clams, *Protothaca staminea*, was limited, both species, but 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 on populations of cockles, *Clinocardium nuttallii*, horse clams, *Tresus capax*, and soft-shell clams, *Mya arenaria*, found during the surveys.

The potential for commercial exploitation of clam species found during the surveys is discussed.

RÉSUMÉ

Bourne, N.F. and G.D. Heritage. 1997. Intertidal clam surveys in British Columbia - 1992 and 1993. Can. Tech. Rep. Fish. Aquat. Sci. 2168: 95 p.

Nous présentons ici les résultats des campagnes menées en 1992 et 1993 pour évaluer les populations de certains coquillages intertidaux commercialement importants sur certaines plages du détroit de Géorgie, du détroit de la Reine-Charlotte, du détroit de Johnstone et du district de la côte nord, en Colombie-Britannique.

Au cours des deux années, les relevés ont visé principalement l'évaluation des populations de palourde japonaise (*Tapes philippinarum*), espèce la plus importante actuellement pour la pêche commerciale. Sur les plages du détroit de Géorgie visitées, cette palourde était généralement abondante, puisqu'on a relevé des densités de 748 individus par m^2. Des signes de bon recrutement récent étaient apparents. Sur les plages visitées à l'extérieur du détroit de Géorgie, l'abondance de palourdes japonaises était faible, et se situait entre < 1 et 56 palourdes par m^2. La plupart des palourdes japonaises trouvées à l'extérieur du détroit de Géorgie étaient grosses et âgées, ce qui indique un recrutement inégal ces dernières années.

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

Nous présentons aussi des données limitées sur les populations de coque (*Clinocardium nuttallii*), de fausse-mactre (*Tresus capax*) et de mye (*Mya arenaria*) observées pendant les relevés.

Nous analysons le potentiel d'exploitation commerciale des espèces de bivalves fouisseurs observées pendant les relevés.

INTRODUCTION

Intertidal clam fisheries continue to be important to the economy of many British Columbia coastal communities. Since 1951 landings have fluctuated greatly, but have declined slightly in the last few years (Fig. 1).

Four species of clams have provided virtually all landings in these fisheries: razor, *Siliqua patula*; butter, *Saxidomus giganteus*; littleneck, *Protothaca staminea*; and Manila, *Tapes philippinarum*. Incidental minor landings of four other species have occurred: cockles, *Clinocardium nuttallii*; soft-shell, *Mya arenaria*; and two species of horse clams, *Tresus capax* and *T. nuttallii*.

In recent years the industry has targeted on Manila clams for the steamer clam market. Landings of this species increased in the 1980's to a peak of 3,909 t in 1988 but have declined to 1,047 t in 1991, as accumulated stock was harvested (Fig. 1). Until 1992 all landings of Manila clams were from the South Coast district and the industry expanded to exploit all possible areas in this region to supply markets.

Surveys were conducted in 1990 and 1991 to assess intertidal clam resources, mostly in the North Coast district, however the 1991 work included some assessments in the South Coast district (Bourne and Cawdell 1992; Bourne *et al.* 1994). As a result of these surveys a fishery for Manila clams developed during the fall-winter season of 1992/93 in the Bella Bella area (DFO Statistical Area 7) and 90 t of Manila clams were harvested (Anon).

Further surveys were undertaken in 1992 and 1993 to provide information on intertidal clam abundance and distribution of Manila clams. The 1992 survey was undertaken primarily to assess intertidal populations of steamer clams, littleneck and Manila clams, on selected beaches in the northern part of the Strait of Georgia (Fig. 2). The 1993 survey was a continuation of work begun in 1990 and 1991 and had two main objectives; 1) obtain information on intertidal clam populations in selected areas along the British Columbia coast from Quatsino Sound, at the northwest corner of Vancouver Island, north to Fish Egg Inlet and south to the southern end of Johnstone Strait, and 2) collect additional information on the distribution of Manila clams in British Columbia (Fig. 3).

SURVEY METHODS

Sampling methods in both 1992 and 1993 were similar to those used in the 1990 and 1991 surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994).

Beaches selected for survey were chosen from chart surveys, previous experience, or from information supplied by Fishery Officers. Three areas were surveyed in 1992 and eleven in 1993 (Figs. 2 and 3). As in previous assessments, it was decided to survey as many beaches in an area as possible, rather than sample one or two beaches intensively, in order to obtain a general estimate of clam distribution and abundance in each area.

At the time of sampling a brief exploration was made of each beach to assess the presence or absence of intertidal clams and determine the approximate area of the clam bearing portion of the beach. Slope and substrate type of the beaches were recorded.

Scattered quadrats of 0.25, 0.5 or 1.0 m^2 were marked out in the clam bearing part of the beach. Quadrats in the lower third of intertidal beaches were established to assess butter and littleneck clam populations and were dug with potato forks to a depth of about 35 cm. Quadrats in the mid portion of the beach, with firmer sand-gravel substrate, were established to assess Manila clam populations and were dug with rakes or scrapers, to a depth of about 15 cm. In both types of quadrats the substrate was worked through the fingers and reworked back into the quadrats. All clams were removed, placed in plastic bags and labelled for later measurement.

Additional observations were made on many beaches for the presence or absence of Manila clam shell at the high tide line and on large rocks used by birds to drop and break clams.

Shell length of each clam from sampled quadrats was measured to the nearest millimeter (mm) with vernier calipers. Age of most clams was determined by counting annuli (Quayle and Bourne 1972). In addition a pooled sample of Manila clams that showed normal growth patterns (ie. were not stunted) was taken from most areas where they occurred and shell length at each annulus was measured to the nearest mm. Means and standard errors of shell lengths at annuli were calculated. This provided a measurement of age distribution of all clams and a growth rate for the unstunted portion of the populations of Manila clams at most locations.

In the 1993 survey, gonad samples of Manila clams from most areas were collected, preserved, blocked in paraffin, sectioned, stained and examined microscopically to determine the stage of gonadal development as described in Quayle, *et al.* 1972.

Surface water temperatures and five minute surface plankton tows were made in most areas in 1993, the latter to determine the presence or absence of Manila clam larvae and larval stages (Quayle, *et al.* 1972). Surface tows were made using a 60 μ mesh conical net with a 34 cm diameter opening.

PART 1

NORTHERN STRAIT OF GEORGIA SURVEY - 1992

Three areas were visited at the northern end of the Strait of Georgia on July 2 and 3, 1992: Von Donop Inlet, Marina Island and Drew Harbour (Fig. 2, Table 1).

1. VON DONOP INLET

Von Donop Inlet has supported extensive clam harvesting in the past. In recent years most of the harvest has been Manila clams. Three beaches in this area were sampled in 1991 (Bourne *et al.* 1994). In the present survey two beaches sampled in 1991 were resurveyed and sampling was undertaken at one additional beach (Fig. 4).

Physical Description of Beaches

Beach 1

This beach, located on the south side of the entrance to Von Donop Inlet, was sampled in 1991 (Bourne *et al.* 1994). It was about 0.75 hectares(ha) in area (Fig. 4) and had a gentle slope. Substrate of the lower portion was mud-gravel-shell, a good habitat for butter clams. Substrate of the upper portion was mostly sand-gravel with some rock. There was evidence of previous digging.

Beach 2

This beach, located at the south end of the inlet, was also sampled in 1991 (Bourne *et al.* 1994). It was about 1.5 ha in area with a medium slope. Substrate of the lower portion was soft mud, the upper part had a firmer substrate with gravel. There was evidence of past digging.

Beach 3

Beach 3 was slightly to the west of Beach 2. The two beaches are essentially the same beach separated by a large rock outcrop. Area, substrate and slope of Beach 3 were similar to Beach 2.

Clam Populations

Butter Clams

A few butter clams were found only at Beach 1, most were sublegal size (< 63 mm shell length) (Table 2). This was not unexpected since the main area of butter clam abundance is in the lower third of intertidal beaches. Sampling in 1992 was confined to the upper part of the beach and digging was by scrapers to shallow substrate depths (15 cm).

Littleneck Clams

Littleneck clams were common at the first beach where density ranged from 64 to 248 clams m^{-2} (Table 2). Abundance at Beach 2 was low and none were found at Beach 3. Low numbers at the latter two beaches were probably due to confining sampling to the mid part of the beach. Most littlenecks were under legal size (< 38 mm shell length) and the presence of wide size and age distributions indicated good recruitment in recent years (Fig. 5). No growth rates were calculated since this was done in the previous year (Bourne *et al.* 1994).

Manila Clams

Manila clams were abundant at all three beaches, density ranged from 24 to 748 clams m^{-2} (Table 2). Clams were most abundant at Beach 1. Most Manila clams at Beach 1 (77%) and Beach 3 (68%) were sublegal size (< 38 mm shell length), 43% were sublegal size at Beach 2. There were wide size and age distributions indicating good recruitment in recent years (Fig. 6).

No growth rates were calculated because they were done in 1991 (Bourne *et al.* 1994).

2. MARINA ISLAND

The west side of Marina Island has an extensive sand-gravel beach interspersed among large boulders. According to reports (K. Spencer, pers. comm.) considerable commercial harvesting of steamer clams occurred in this area in 1990 and 1991. The area was surveyed in 1991 (Bourne *et al.* 1994) and was briefly resurveyed in 1992 (Fig. 7).

Physical Description of the Beach

The gently sloped beach along the northwest side of Marina Island varied in width from about 100-300 m. The substrate was mostly sand-gravel, with many large boulders scattered along the beach. The substrate was excellent for littleneck and Manila clams. However, the beach is exposed to northwest winds which may produce too much wave action to make the beach a suitable clam habitat.

Clam Populations

Extensive sampling was undertaken on this beach in 1991, but few clams were found in the mid and lower parts of the beach (Bourne *et al.* 1994). Littleneck and Manila clams were found only in scattered patches among the large rocks in the upper portion of the beach . During the 1992 survey, sampling was confined to the upper part of the beach within 1.5 m of the high tide level.

Butter Clams

No butter clams were found (Table 2), which was expected since sampling was confined to the upper beach and sampling was with scrapers to shallow depths.

Littleneck Clams

Density of littleneck clams was low and ranged from 24-92 clams m^{-2} (Table 2), probably because sampling was limited to the high intertidal area. Most littlenecks (79%) were sublegal size and many were stunted, again because of the high intertidal location (Fig. 8).

Growth rate was not determined.

Manila Clams

Density of Manila clams ranged from 172-476 clams m^{-2}(Table 2). They were evenly divided between legal and sublegal sized clams. Length and age frequency distribution showed there was a preponderance of 2 year old clams but only a few individuals in other age classes were found (Fig. 9). Abundance of 2 year old clams indicated good recruitment in 1990.

Growth rate was not determined.

3. DREW HARBOUR

The Heriot Bay-Drew Harbour area was important to the commercial industry for many years. At the present time part of

Drew Harbour lies within the boundary of Rebecca Spit Provincial Park. Further there is a seasonal closure there from May 31-September 30 because of bacterial contamination caused mainly by pleasure boats anchoring in the area. A 2 km strip was sampled along the mid-elevation of this beach and 12 scattered quadrats taken along it (Fig. 10).

Physical Description of Beach

The beach was more or less continuous and extended about 4 km around Drew Harbour. On the western side the slope was moderate to steep. The substrate was mud-gravel-sand. In the mid portion there were extensive firm gravel areas. At the southern end the slope was gentle and the beach extensive, with areas of clam habitat interspersed with sand and some tidal pools. On the Rebecca Spit side the beach tended to be steep and the substrate was sand-coarse gravel-stones. The western and southern part of the intertidal beach had areas of good clam habitat.

Clam Populations

Butter Clams

No butter clams were found (Table 2) which was expected since sampling was confined to the mid portion of the beach and digging was by scrapers to shallow depths in the substrate.

Littleneck Clams

A few littleneck clams were found in most plots, density ranged from 0-130 clams m^{-2} (Table 2). Most (72%) were smaller than the legal size. Length and age distribution indicated reasonable recruitment in recent years (Fig. 11).

Manila Clams

Manila clams were abundant in Drew Harbour, density ranged from 100-512 clams m^{-2} (Table 2). Most (87%) were sublegal size which indicated good recruitment in 1989 and 1990(Fig. 12).

Growth of Manila clams in Drew Harbour was typical of growth at other locations in the Strait of Georgia. It required about 3.5 years to attain the legal size of 38 mm shell length (Fig. 13).

DISCUSSION

Extensive commercial harvesting, mostly for Manila clams, occurred in Von Donop Inlet and on the northwest side of Marina

Island since these areas were surveyed in 1991. Results of the present survey show there has been little change in population structure of littleneck and Manila clams since the 1991 survey. Recent recruitment has replaced harvested stock.

Manila and littleneck clam populations were difficult to assess at Marina Island because of the scattered nature of the beds. A much more detailed survey is required to delineate these beds and make an accurate assessment of clam populations. Populations of both littleneck and Manila clams were stunted probably because of their high intertidal location. The lack of clam populations lower in the beach, where good habitat occurs, could be due to two factors; overharvesting or excessive exposure to northerly winds shifting the substrate and making it unsuitable as clam habitat.

The survey at Drew Harbour indicated the presence of commercially harvestable Manila clam populations. Recruitment appeared to have been good which should ensure continued populations in this area.

PART 2

1993 SURVEY

The 1993 survey was a continuation of work carried out in 1990 and 1991 (Bourne and Cawdell 1992; Bourne *et al.* 1994), but differed slightly from those two surveys. In the 1990 and 1991 surveys, considerable sampling was undertaken to assess butter and littleneck clam populations. In the present survey, work targeted on assessment of Manila clam populations and only incidental sampling was undertaken to determine butter and littleneck populations. Manila clams are the species of major importance in the present commercial fishery and thus it was desirable to obtain information on the extent of populations of this species in the survey area and determine factors controlling their distribution.

As described previously, sampling to assess Manila clam populations involved digging scattered $0.25m^2$ quadrats on beaches with suitable habitat using rakes or scrapers to a depth of 15 cm. The substrate was carefully sifted through the fingers and all Manila clams removed, placed in bags and labelled for later measurement.

In addition to this sampling, considerable exploratory digging was undertaken on many other beaches that were visited. Exploratory quadrats (generally 0.25 m^2) were dug in sand-gravel areas in the mid-intertidal area of these beaches to determine the presence or absence of Manila clams and to delineate the extent of the area

inhabited by Manila clams. As many as 50 such quadrats were dug on some beaches. If Manila clams were found in these areas, survey quadrats were established and careful digging was undertaken to obtain a rough density estimate and biological characteristics of the population. In this manner it was possible to obtain information on the presence or absence of Manila clams on many beaches in the survey area as well as general descriptions of the characteristics of populations on beaches where they occurred in abundance.

RESULTS

1. Quatsino Sound - Holberg Inlet

Quatsino Sound has supported limited commercial harvest of butter, littleneck and Manila clams. Manila clams were first found in this area on beaches near Winter Harbour in 1966 (Bourne 1982). Minor commercial landings of Manila clams were reported there in 1973, 1981 and 1982 and small landings have been reported since 1985 (Anon). It is postulated that spawnings of Manila clams from this area populated beaches in the central coast and Queen Charolotte Strait areas (Bourne 1982).

Physical Description of Beaches

A total of 18 beaches in Quatsino Sound, extending from the mouth of the Sound into Holberg Inlet, were surveyed on two days (Fig. 14). Area of the beaches ranged from 0.2-6 hectares and most had gentle slopes (Table 3). Substrates varied considerably. On many beaches the substrate was mostly mud. Gravel patches which had firmer substrate were found on some beaches. Other beaches had mud at lower elevations but sand-gravel with cobble at higher elevations. Many of the beaches had small to large amounts of rock. Some beaches (1, 2, 4, 5, 7, 13, 15, and 17) were used entirely or in part for logging activities and much of the clam habitat had been badly disrupted. Old clam shell was scarce on most beaches. Indications of prevous clam harvesting were found on Beaches 6 and 7. Suitable Manila clam habitat was found only on about half the beaches.

Clam Populations

Over 270 quadrats were dug on the 18 beaches, primarily to assess Manila clam populations, but some assessment was undertaken for butter and littleneck clams.

Butter Clams

Although minor commercial harvest of butter clams occurred in Quatsino Sound in the past, no commercial fishery has existed in recent years (Anon). Previous sampling indicated there were harvestable populations of butter clams on beaches at the mouths of the Kewquodie and Klootchlimmis Creeks, Beaches 6 and 7 (Fig. 14) (Bourne Unpub. MS), however, in recent years the populations have not been exploited commercially although they have been used locally in the recreational fishery.

No sampling was undertaken for butter clams during this survey, partly because of poor tides. Butter clam shell was found on some beaches, particularly on Beaches 6 and 7.

Littleneck Clams

Littleneck clams were common on some beaches although sampling targeting on this species was carried out only on Beaches 11 and 12 in Holberg Inlet. On Beach 11 most littlenecks were legal size and on Beach 12 most were sublegal size (Table 4). Length and age frequency distribution showed all clams, but one, were smaller than 38 mm and the presence of 1 and 2 year old cohorts indicated some spawning success in 1991 and 1992 (Fig. 15).

Manila Clams

In spite of extensive sampling, Manila clams were found only at the head of Kultus Cove (Beach 18, Fig 14). Most of this beach was unsuitable for Manila clams because the substrate was soft and muddy and the beach had been used for logging operations. Manila clams were found in gravel patches about 1 m from the high tide line. A total of 10 m^2 was dug and 63 Manila clams found, a density of 6.3 clams m^{-2}. Almost all the Manila clams were sublegal in size and 3 or 4 years old (Fig. 16).

Growth of Manila clams in Quatsino Sound was slower than observed under optimum conditions in the Strait of Georgia. It required about 4.5 years to attain a shell length of 38 mm (Fig. 17).

Manila clams are now known to occur from the mouth of Quatsino Sound as far up the Sound as Kultus Cove. They do not appear to have spread into Holberg Inlet which may be due to low water temperatures preventing successful breeding or lack of suitable habitat. The presence or absence of Manila clams in Rupert Arm was not determined.

Commercial landings of Manila clams in Quatsino Sound ranged from 1.1 to 28.4 t during the period 1985-90. (Anon). It is doubtful if any commercial landings came from beaches surveyed in

1993. If these landings were indeed from Quatsino Sound then they were probably from beaches at the mouth of the Sound and near Winter Harbour.

Other Species

Cockles, *Clinocardium nuttallii*, were common on Beaches 8 and 14 (Table 3). A few soft-shell clams, *Mya arenaria*, were found on Beach 1 and they were common on Beaches 8, 11 and 14 (Table 3).

Other Observations

Surface water temperature in Hecate Cove at 1925h (PDT) on July 15 was 14°C.

A 5 minute surface plankton tow off Hecate Cove at 1950h (PDT) on July 15 had many unidentified copepods. Bivalve larval numbers were moderate, most were blue mussels, *Mytilus edulis,* with a few *Hiatella* sp. No Manila clam larvae were identified.

Examination of Manila Clam gonads showed most males and females were in the ripe stage (Table 5). Two females were partially spent and one male was in the late active stage.

2. Fish Egg Inlet

Previous surveys in 1990 and 1991 assessed intertidal clam populations north and south of Fish Egg Inlet (Bourne and Cawdell 1992; Bourne *et al.* 1994). Although no commercial clam landings have been reported from the Inlet, it was important to sample beaches there and determine if Manila clams were present in commercial abundance since the Inlet appeared to have protected waters with numerous intertidal beaches.

Physical Description of Beaches

A total of ten beaches were visited and 109 exploratory quadrats dug (Fig. 18; Table 1). Area of the beaches varied from 100 m^2 to about 2 ha (Table 3). Slope of most beaches was gentle to moderate. Substrate of most beaches was soft mud and unsuitable as clam habitat; e.g Beach 5 was extensive but the entire beach had a substrate of soft mud. There were firm sand-gravel patches on several of the beaches but these areas were generally small, under 300 m^2. The total area of suitable clam habitat on beaches surveyed was probably less than 2 ha.

Clam Populations

The survey in Fish Egg Inlet targeted on assessment of Manila clams.

Butter Clams

There was little suitable habitat for butter clams. A few butter clams were found on Beaches 1, 2, 4, 6 and 10 (Fig. 18). No samples were taken and many of the butter clams on Beach 1 were stunted.

Littleneck Clams

There was limited suitable littleneck clam habitat however they were found on Beaches 2, 3, 4 and 10 (Table 3); they were abundant on Beach 3 (Fig. 18). No samples were taken.

Manila Clams

Limited habitat for Manila clams was found. Live Manila clams were found on Beaches 2, 5 and 10, shell was found on Beaches 1, 5, 7 and 8 (Table 3; Fig 18). Shell was abundant at the edge of Beach 1. Few live Manila clams were found. The substrate at Beach 5 was very muddy and one sank above one's ankles into the substrate. Live Manila clams were found lying on the surface of this beach. Because some Manila clams were collected from the surface of Beach 5, density could not be determined but it was estimated to be less than 1 clam m^{-2} on beaches throughout the Inlet. No commercial concentrations of Manila clams, or other bivalve species, were found in Fish Egg Inlet mainly because of limited habitat.

A total of 46 live Manila clams were collected. There was a wide length frequency distribution, 28-53 mm shell length, and most Manila clams were five years or older, with a preponderance of 6 year olds (Fig. 19).

Growth was slow and it required 4.5-5 years to attain a shell length of 38 mm (Fig. 20).

Other Species

Cockles were common on Beaches 1 and 2 (Table 3). Native oysters, *Ostrea conchaphila*, were common at the low tide line on Beaches 5 and 8.

Other Observations

Surface water temperature at 0940h (PDT) on July 17 was 17.7 °C.

A 5 minute surface plankton tow made at 0940 on July 17 contained moderate numbers of bivalve larvae. Most were mussels with some native oysters (straight hinge stage), littlenecks, soft-shell clams and a few umboned Manila clams present.

Examination of Manila clam gonads showed that most males and females were in the ripe or partially spent stages. One male and two females were spent (Table 5).

3. Smith Sound

Modest harvest of butter clams occurred in Smith Sound until the mid 1960's, when the north coast district was closed because of chronic low levels of paralytic shellfish poison (PSP) in isolated butter clam populations (Quayle 1969; Quayle and Bourne 1972). The last reported harvest from the area was in 1980 (Anon). No landings of littleneck clams have been reported from Smith Sound but trace landings of Manila clams were reported in 1975 and 1987, although these reports might be in error.

Surveys for intertidal bivalves had not been undertaken in Smith Sound for over twenty years.

Physical Description of Beaches

Nine beaches were visited in Smith Sound and 60 quadrats dug (Fig. 21). Area of the beaches ranged from 200 m^2 to about 30 ha, slopes were mostly gentle to moderate (Table 3). Substrate was variable, the lower part of some beaches was soft mud with eelgrass, *Zostrea marina*. There were sand-gravel ridges and sand-gravel areas around the perimeter of many beaches. Two Beaches, 5 and 8, were good clam habitat. Beach 6, in Fly Basin, actually included 2 extensive beaches (Beach 6, Fig 21) but the substrate was mostly soft mud. Another extensive beach about 30 ha in area was located at the head of Broad Reach (Beach 7, Fig 21) but the substrate was virtually all soft mud.

Clam Populations

Although most sampling in Smith Sound targeted on assessment of Manila clam populations, some sampling was undertaken to assess butter and littleneck clam populations.

Butter Clams

A few butter clams were found in samples taken by scrapers (Table 4). Two quadrats were dug by fork on Beaches 4 and 8. Density of commercial size clams was 152 and 102 butter clams m^{-2} and 100 and 28 clams m^{-2} for sub-legal sized clams. Butter clams were undoubtedly present in commercial quantities in suitable habitat.

Length and age frequency distribution of butter clams showed a wide range of sizes and ages which indicated successful settlement from 1976 - 1992(Fig. 22).

Littleneck Clams

Littleneck clams were abundant in Smith Sound and ranged in density from 12-356 m^{-2} (Table 4). Most littlenecks were smaller than 38 mm shell length, however lengths ranged from 14 - 67 mm (Fig. 23). A wide range of ages were present and showed a very strong cohort around 5 years. It appeared that successful spatfalls of littlenecks had taken place during the 7 year period prior to this survey.

Manila Clams

Manila clams were found on most beaches where suitable habitat was present however abundance was low. Densities ranged from 2-56 clams m^{-2} (Table 4). Most Manila clams were large and 4-7 years old (Fig. 24). Shells of most Manila clams from Beach 9 were almost black which may have been due to a high sulphur content in the substrate. Growth was slower than under optimum conditions, it required 4 years to attain a shell length of 38 mm (Fig. 25).

Other Species

Cockles were moderately abundant, particularly in soft substrate (Table 3). Horse clams were found only at Beach 8(Table 3). Soft-shell clams were found in low densities at Beaches 1, 2, 4, 6, 8 and 9 (Table 3).

Other Observations

Surface water temperature near Fish Rocks was 17.5°C at 1855 on July 17.

A five minute surface plantkon tow was made near Fish Rocks during the evening of July 17. The sample contained large numbers of bivalve larvae. Most larvae were mussels, but there were some soft-shell clams, a few *Hiatella sp* and unidentified clam larvae.

A Manila clam gonad sample was not taken in Smith Sound.

4. Rivers Inlet

Beaches among the islands located at the north side of the mouth of Rivers Inlet were surveyed in 1991 (Bourne *et al.* 1994). No Manila clams were found during that survey although they have been reported from the Rivers Inlet area.

A brief survey was made during the evening of July 18 of Goose Bay at the southern entrance to Rivers Inlet (Fig. 26). Although the low tide was only 1.7 m it did permit a brief survey for Manila clams.

Physical Description of Beaches

There was an extensive beach at the southern end of Goose Bay, however, most of the substrate was soft sand-mud covered with eelgrass, *Zostera marina*, at the lower levels (Table 3). There were a few areas of firmer sand-gravel substrate around the perimeter of the beach.

Clam Populations

A total of 20 exploratory quadrats were dug in the firmer areas of the beach. Butter and littleneck clam shell was present. No live Manila clams were found, but a pair of valves of a dead clam (shell length 55 mm) was found. The valves appeared old and had been on the beach for two or three years. This indicated that Manila clams are present in the area although their abundance is probably low because of limited habitat.

Other Observations

Surface water temperature in Goose Bay was 18°C at 1900h (PDT) on 18 July.

5. Walker Group and Deserters Group, Queen Charlotte Strait

In previous years, landings of butter clams were reported from the Walker and Deserters Group of Islands in Queen Charlotte Strait. Manila clams have been found only on the eastern side of Queen Charlotte Strait and it was postulated this population orginated from spawnings in Quatsino Sound (Bourne 1982). It was of interest to determine if Manila clams now occur in the Walker and Deserters Groups of Islands.

Physical Description of Beaches

Three beaches were visited and 72 exploratory quadrats dug (Fig. 27). Beach 1 was about 8 ha in area, the other two beaches were smaller, about 0.3 ha in area (Table 3). Slope of Beaches 1 and 2 was gentle and at Beach 3 it was moderate. Substrate of the first two beaches was mud-sand with large boulders and some gravel areas. *Fucus* sp. covered the rocks at lower beach levels. A few areas of suitable Manila clam habitat, firmer sand-coarse sand substrate, were found along the upper fringes of Beach 3.

Clam Populations

Most sampling targeted on Manila clams, but observations were made of other species.

Butter Clams

Butter clams were present and considerable quantities of old shell were found on all three beaches (Table 3).

Littleneck Clams

Littleneck clams were found in small quantities only at the third beach. There was little shell on the beach (Table 3).

Manila Clams

No Manila clams or dead shell were found on any of the beaches.

Other Species

Cockles were common on Beach 2 and there was considerable *Macoma* spp. and cockle shell on all three beaches. Horse clams were common on all three beaches. Northern abalone, *Haliotis kamtschatkana*, and red sea urchins, *Strongylocentrotus franciscanus*, were found on rocks at the low intertidal level at Beach 2.

6. Blunden Harbour

Considerable harvesting of butter and limited harvesting of littleneck clams has occurred in Blunden Harbour in the past. Manila clams were found in this area in the late 1970's (Bourne 1982) although no commercial harvest has occurred. The intent of the 1993 survey was to determine if commercially harvestable quantities of Manila clams now occur in this area.

Physical Description of Beaches

Six beaches, which ranged in area from 0.5 to 8 ha, were sampled (Fig. 28). Beaches 2 and 3 are part of a continuous extensive beach located along the western and northern part of the Harbour. Over 80 exploratory quadrats were dug. Slope of the beaches ranged from gentle to moderate (Table 3). The substrate of most beaches was generally sand-mud with much cobble and rock. Most beaches had a sand-shell-gravel strip that varied from 5-10 m in width around the perimeter of the beach. Eelgrass was abundant at lower beach levels. There was considerable rock on most beaches that made digging difficult.

Clam Populations

Although the survey was intended primarily to assess Manila clam populations, observations were made of other species.

Butter Clams

Butter clams were common in the lower third of all beaches and they appeared to have a wide size distribution. The area would support commercial harvest of this species.

Littleneck Clams

Littleneck clams were abundant in the lower half of most beaches and there was a wide size and age distribution.

Manila Clams

Manila clam shell was found on Beaches 1 and 3 (Fig. 28). In a sand-gravel ridge high in the intertidal area on Beach 6, 67 live Manila clams were found in a 6 m^2 area, a density of 11.2 clams m^{-2} (Table 4). There was little shell on the beach. This was the only beach where live Manila clams were found and the total area of the Manila clam bearing portion was about 100 m^2. Clams ranged in size from 33 to 59 mm shell length and in age from 3 to 9 years (Fig. 29). There were 2 cohorts, one was 3-5 year olds (33-43 mm) and the other was 6-9 year olds (46-59 mm).

Growth was slow and Manila clams from this beach attained the legal size in about 4.5 years (Fig. 30).

Manila clams were found in the same location as in the late 1970's (Bourne 1982). It appears that this species had not spread throughout the Harbour and is confined to a single beach. Size and age distribution suggested that breeding had occurred and that the population is maintaining itself, although at a low level. No Manila clam populations were found in Blunden Harbour that would support commercial exploitation.

Other Species

Cockles were common in the lower muddy areas of all beaches (Table 3). Soft-shell clams were abundant in the upper muddy areas of all beaches. Horse clams were common at the lower intertidal level on most beaches.

Other Observations

Surface water temperature off Beach 6 was 14°C.

Examination of Manila clam gonads showed most males were in the ripe stage, one was in the late active stage and another was partially spent (Table 5). One female was in the ripe stage, the others were in the late active or partially spent stages.

7. Drury Inlet

Considerable harvesting of butter clams has occurred in Drury Inlet and landings of littlenecks have also been reported. There was a report that Manila clams had been harvested commercially in Drury Inlet (K. Tuttle, pers. comm.) The main intent of the 1993 survey was to determine the distribution and abundance of Manila clams in this Inlet.

Physical Description of Beaches

Sixteen beaches were surveyed in Drury Inlet and 153 quadrats were dug (Fig. 31). In general the beaches were small and ranged in area from 300 m^2 to 1 ha (Table 3). Slope of most beaches was gentle to moderate although there were steep slopes in parts of some beaches. Substrate of most beaches was sand-mud-shell with varying amounts of gravel. There was much rock on some beaches that made digging difficult. The central portion of some beaches was soft but there were firmer sand-gravel areas around the perimeter. Most beaches had good butter and littleneck clam habitat. Several beaches had varying amounts of suitable Manila clam habitat. Small amounts of eelgrass were found and *Ulva* sp. and *Enteromorpha* sp. were common on several beaches.

Clam Populations

Most sampling in Drury Inlet was for Manila clams, however, a few samples were taken to assess butter and littleneck clam populations.

Butter Clams

Butter clams were common on beaches in Drury Inlet and densities ranged from 0-140 clams m^{-2} (Table 4), The density of commercial sized clams ranged from 0-80 clams m^{-2}. There was a wide range in length and age frequency distribution indicating consistent recruitment in recent years (Fig. 32). Butter clams occurred in commercially harvestable quantities on many Drury Inlet beaches.

Littleneck Clams

Littleneck clams were the most abundant bivalve found on all but one Drury Inlet beach. Density in sample quadrats ranged from 0-364 clams m^{-2} (Table 4). The wide size frequency distribution

indicated good recruitment in recent years with substantial cohorts of 4 - 6 year olds (Fig. 33).

Manila Clams

Shells of two dead Manila clams were found on Beach 12. The shells were 46 mm shell length (6 yrs) and they had been on the beach for 2-3 years. No live Manila clams were found in Drury Inlet.

Reports of Manila clams in Drury Inlet appear to have been erroneous.

Other Species

Cockles were abundant in the lower muddy areas on 3 of the 16 beaches in the Inlet (Table 3). Soft-shell clams were abundant on 2 beaches, in muddy areas in the higher intertidal area (Table 3). Horse clams were found in the lower third of the intertidal area on some beaches.

Other Observations

Surface water temperature on July 19 and 20 was 12°C.

A 5 minute surface plankton tow taken on July 20 had large quantities of an unidentified green algae. Few bivalve larvae were found; most were mussels, a few *Hiatella* sp. and a few unidentified clam larvae.

8. Nowell Channel - Fife Sound

Commercial harvest of butter clams has occurred in the Nowell Channel-Fife Sound area in the past and some harvesting of littlenecks has been reported (K. Tuttle, pers. comm.). Manila clams were found on previous occasions in Booker Lagoon, Broughton Island (Bourne 1982). The present survey was designed to re-assess Manila clam populations in Booker Lagoon and determine if they were present in other areas in close proximity to the Lagoon.

Physical Description of Beaches

Seven beaches were surveyed in three areas, two beaches to the west of Booker Lagoon, four beaches in Booker Lagoon and one beach on Eden Island, in Fife Sound, to the east of Booker Lagoon (Fig. 34). A total of 144 quadrats were dug.

The area of the beaches east and west of Booker Lagoon were large and ranged in area from 1-5 ha (Table 3). Slopes of these beaches were gentle and the substrates were sand-mud with rock.

Firmer shell-gravel patches were present on most beaches or around the perimeter. *Ulva* sp. covered much of the surface at Beach 2 and *Fucus* sp. covered much of Beach 7.

Beaches in Booker Lagoon were small and ranged in area from 0.1-0.5 ha. All the beaches had berms with gentle slopes. Beach 5 had a rock dam at the lower level and a berm with a large lagoon in it. Substrate of all beaches was sand-mud-gravel with some rock. Most of the berm area was good Manila clam habitat.

Beach 7 on Eden Island was extensive but the substrate was mostly soft and muddy.

Clam Populations

Observations were made of butter and littleneck clam populations in addition to the assessment for Manila clams.

Butter Clams

Butter clams were found on beaches east and west of Booker Lagoon, Beaches 1, 2 and 7 (Table 3). Butter clams were also present at lower intertidal levels on most Booker Lagoon beaches. No samples were taken.

Littleneck Clams

Littleneck clams were the most abundant bivalve on all beaches sampled. One sample of littlenecks at Beach 3 in Booker Lagoon had a density was 208 clams m^{-2} (Table 4). The wide size and age frequency distribution indicated consistent recruitment in recent years, although most of the littlenecks were 6 and 7 years old (Fig. 35).

Manila Clams

Manila clams were found on beaches in Booker Lagoon and on Beach 7 on Eden Island (Fig. 34). At Beach 3, 23 Manila clams were found in 6 m^2, a density of 3.8 clams m^{-2} and at Beach 5, 41 clams were found in 7 m^2, a density of 5.8 clams m^{-2} (Table 4). Only a few clams were found in exploratory quadrats dug at the other beaches in Booker Lagoon. Two small Manila clams were found in firm sand-gravel patches on Beach 7.

Most Manila clams were large (over 40 mm shell length) and most were 6 years or older, which indicated poor recruitment since 1989 (Fig. 36). Growth of Manila clams was slow, it required 4 years to attain a shell length of 38 mm (Fig. 37).

Commercial quantities of Manila clams were not found on any beaches surveyed. In Booker Lagoon it appeared that a small

population is barely maintaining itself. On Eden Island there were only a few scattered individual clams.

Other Species

There were considerable numbers of Pacific oysters, *Crassostrea gigas*, on Beach 3 in Booker Lagoon. Undoubtedly these were spread there after the experimental raft culture project was terminated. No small oysters or spat were found indicating no recent recruitment.

Cockles were common on Beaches 1, 2 and 6 and in softer substrate on beaches in Booker Lagoon (Table 3). Soft-shell clams were common on Beaches 1, 2 and 6 (Table 3). Horse clams were found on beaches 1, 2, 4 and 6 (Table 3).

Other Observations

Surface water temperature was 16°C in the lagoon at Beach 5 and 14°C in the main body of Booker Lagoon.

Examination of Manila clam gonads showed most males were in the ripe stage, two were in the late active stage and one was partially spent. One female was ripe, the rest were in the late active stage (Table 5).

9. Port Harvey, Johnstone Strait

The Port Harvey area has supported commercial clam harvesting in the past and Manila clams were found there in the late 1970's (Bourne 1982). Some commercial harvesting of Manila clams had been reported in this area therefore the 1993 survey attempted to assess Manila clam stocks.

Physical Description of Beaches

Six beaches were surveyed in the Port Harvey area and 66 exploratory quadrats dug (Fig. 38). Area of the beaches varied from about 5 ha for the extensive beach at the head of Port Harvey to smaller beaches about 0.1 ha in area in other areas (Table 3). Slope of most beaches was moderate. Substrate varied considerably. Substrate of the beach at the head of Port Harvey was mostly soft mud with firmer mud-gravel patches around the perimeter. Substrate of the other beaches was a mixture of sand-mud and sand-gravel with cobble and rock.

Clam Populations

Butter and Littleneck Clams

Butter and littleneck clams were found on all beaches visited however no samples were retained for analysis.

Manila Clams

Manila clams were found only on Beach 1, the extensive beach at the head of Port Harvey. A total of 25 quadrats dug in the firmer sand-gravel areas around the edge of the beach produced only 18 Manila clams. All were small, stunted and from 2-5 years of age (Fig. 39). Growth was slow and it required about 5 years to attain 38 mm shell length (Fig. 40).

Commercial harvest of Manila clams had been reported from Port Harvey (K. Tuttle, pers. comm.). It appeared that none of the beaches sampled during this survey could support a commercial Manila clam harvest. The large beach on the east side of Port Harvey could not be sampled because of boat problems. It is possible this beach or other unsurveyed beaches have more extensive Manila clam populations that could support some commercial harvest.

Other Species

Cockles were common on Beaches 1, 2 and 6 (Table 3). Soft-shell clams were found on all beaches except Beach 4 (Table 3). *Fucus* sp. was abundant on Beach 1 while *Laminaria* sp. and *Enteromorpha* sp. covered much of Beach 6 (Table 3).

Other Observations

Examination of Manila clam gonads showed two males were in the late active stage and two were ripe (Table 5). Two females were in the late active stage and one was ripe.

10. Port Neville, Johnstone Strait

The Port Neville area has supported commercial harvest of butter clams for many years. An extensive Manila clam survey was undertaken in this area in 1980 but none were found (Bourne 1982). The 1993 survey was undertaken to determine if Manila clams were now present in this area.

Physical Description of Beaches

Three beaches were surveyed and 59 quadrats dug (Fig. 41). The three beaches surveyed were all large and varied in area from 3-10 ha (Table 3). Slopes of the beaches were gentle or moderate.

Substrate of Beach 1 was mud-sand with scattered patches of firmer sand-gravel and large boulders. Substrate of Beaches 2 and 3 was mud-sand at the lower levels and sand-gravel at higher levels with much rock. The abundance of rock at Beach 3 made digging difficult. Beach 3 had a strip of sand-gravel in the mid to upper part of the beach that was 5-10 m in width and extended for about 300 m.

Clam Populations

Butter Clams

Butter clams were present on all beaches and abundant at the lower levels of Beaches 2 and 3. No samples were taken.

Littleneck Clams

Littleneck clams were abundant in the lower half of all three beaches. No samples were taken.

Manila Clams

Pieces of old Manila clam shell were found on Beaches 1 and 2, however, there was limited suitable habitat for this species on both beaches. There was considerable Manila clam shell on Beach 3, mostly in the 5-10 m strip in the central part of the beach. Approximately 3.5 m^2 was dug in this strip and 118 Manila clams were found, a density of 33.7 clams m^{-2}. Most Manila clams were large, over 40 mm shell length, and over six years old (Fig. 42). Growth was slow and required 4 years to attain the legal size of 38 mm shell length (Fig. 43).

Beach 3 was surveyed in 1980 but no Manila clams were found at that time. This presence of Manila clams in one survey and not in the other may have been due to two factors:

1. The localized nature of the population and a slight difference in sampling location. Sampling in 1980 was confined to the part of the beach to the west of the area sampled in 1993. No Manila clams were found in this area in 1993.

2. Another explanation might be that Manila clams arrived in Port Neville after the 1980 survey. Some support for this argument is indicated by the age structure of the present population (Fig. 42).

The present population is small but might support limited commercial harvesting. Few small clams were found which indicates recruitment is probably inconsistent.

Other Species

Cockles were found in abundance on beaches 1 and 3 (Table 3). Soft-shell clams and sand clams, *Macoma* sp, were common at higher beach levels on Beaches 1 and 3 (Table 3). Horse clams were abundant on Beaches 1 and 3 (Table 3). Pacific oysters were present on Beach 2 but it is postulated they had probably been planted there.

Other Observations

Surface water temperature off Beach 3 was 11.5°C.

Examination of Manila clam gonads showed most males were ripe, one was in the late active stage and one was spent (Table 5). Most females were ripe, two were in the late active stage.

11. Nodales Channel

In 1991 recently dead Manila clam shell was found on a beach at Cameleon Harbour (Bourne *et al.* 1994). Intensive sampling was not feasible at that time because of a flooding tide. Commercial harvest of Manila clams had been reported in this area (K. Spencer, pers. comm.). The 1993 survey was designed to determine Manila clam distribution and abundance in this area and to obtain further information on the northward dispersal of this species through Discovery Passage.

Physical Description of Beaches

Five beaches were sampled, 2 in Hemming Bay on East Thurlow Island, 2 in Thurston Bay and 1 in Cameleon Harbour on Sonora Island (Fig. 44). Over 35 exploratory quadrats were dug. Beaches 1 and 2 in Hemming Bay were small, about 0.2 ha in area (Table 3). Beaches 3, and 4 in Thurston Bay were variable in size from 0.3 to 8 ha. In Cameleon Harbour the total area was approximately 10 ha but sampling was confined to the southwest part of the harbour at Beach 5 (Table 3). All the beaches had gentle or moderate slopes. Substrate of the Hemming Bay beaches was coarse sand-gravel with rock. Logging operations had occurred on Beach 1. Substrate of Beaches 3 and 4 was soft mud-sand with patches of firmer sand-gravel substrate at higher elevations and much rock. Substrate of Beach 5 was sand-gravel with rock.

Clam Populations

Butter Clams

Butter clams were abundant on Beaches 3 and 4 but no samples were taken.

Littleneck Clams

Littleneck clams were found on all beaches but no samples were taken.

Manila Clams

No Manila clams were found on Beaches 1, 2 and 3 (Fig. 44). Although Beach 3 was extensive the substrate was mostly soft-mud with an abundance of ghost shrimp, *Callianassa* sp. There was limited suitable habitat for Manila clams on Beach 4, but modest quantities of Manila clam shell were found on this beach. Three 1 m^2 quadrats were dug and had 13, 8 and 13 Manila clams, a mean density of 11.3 clams m^{-2}. Most of these Manila clams were stunted. There was considerable Manila clam shell on Beach 5 which had good Manila clam substrate (Table 3). A total of 9.25 m^2 was dug on this beach and 83 Manila clams were found, a mean density of 9 clams m^{-2} (Table 4).

Most Manila clams on Beach 5 were over 40 mm shell length and age ranged from 1-8 years (Fig. 45). Growth was slower than in the Strait of Georgia: it required about 4 years for Manila clams to attain a shell length of 38 mm (Fig. 46).

Beach 5 was actually part of a large beach that extends around Cameleon Harbour. Time did not permit further sampling but additional survey work should be undertaken to determine if Manila clam populations extend throughout this area.

Beaches 3, 4 and part of Cameleon Harbour lie within the boundaries of Thurston Bay Marine Park (Fig. 44).

Other Observations

Surface water temperature off Beach 5 was 14.5°C.

Examination of Manila clam gonads showed males were either in the ripe or partially spent stages (Table 5). Most females were partially spent but one each were in the late active, ripe and spent stages.

DISCUSSION

The 1993 survey provided further information on intertidal clam resources in areas not sampled during the surveys in 1990 and 1991 (Bourne and Cawdell 1992; Bourne *et al.* 1994). Although the 1993 work focussed primarily on assessment of Manila clam

populations, information was gathered on butter, littleneck and other clam species.

Butter Clams

Butter clams were found in the lower third of most intertidal beaches where suitable habitat was present. Densities as high as 252 butter clams m^{-2} were recorded (Table 4). Generally there was a wide range in size and age frequency distribution indicating consistent recruitment in recent years. No dominant year classes were observed. Growth was generally slow and it required 6-8 years to attain the legal commercial size of 63 mm shell length compared to 5-6 years in the Strait of Georgia (Quayle and Bourne 1972). Stunting was observed in some populations but the cause of this phenomenon was not determined.

Littleneck Clams

As observed in previous surveys, littleneck clams were the most abundant clam species found during the survey and formed the largest bivalve biomass on many beaches. Densities as high as 364 clams m^{-2} were recorded (Table 4). When suitable habitat was present, littlenecks occurred on all beaches to the mid intertidal beach level.

There was a wide range of size and age distribution indicating consistent recent recruitment. Growth was slow and required more than 4 years to attain the legal size in the commercial fishery, 38 mm shell length.

As observed during the two previous surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994) many littlenecks were badly stunted, some were so badly stunted that it was difficult to identify them as littleneck clams.

Manila Clams

Few Manila clams were found during this survey, most occurred only in local situations. The only populations of modest size were in Port Neville and Cameleon Harbour. Maximum density found during the survey was 56 clams m^{-2} (Table 4). The reason for low populations in the survey area was due probably to unfavourable environmental conditions and a lack of suitable habitat in some areas e.g. Quatsino Sound, Fish Egg Inlet.

Large quantities of old shell were not found on any beaches as was observed on some beaches during previous surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994). This indicates that Manila clam populations have not been extensive in these areas in the past and further that no mass mortalities have occurred there recently (Bower 1992).

It was of interest to find a population of Manila clams in Port Neville and a more extensive population in Nodales Channel. The previously held hypothesis was that Manila clams would not spread northward through the Discovery Passage-Yuculta Rapids area because this area was a thermal barrier preventing such northward dispersal (Quayle and Bourne 1972; Bourne 1982). This hypothesis is incorrect, as northward dispersal of Manila clams through the Discovery Passage-Yuculta Rapids area has occurred. It remains to be seen if extensive populations will develop in the Nodales Channel-Johnstone Strait areas.

As observed during the two previous surveys, most Manila clams were large and old, most (71%) were larger than the legal size of 38 mm shell length. The lack of extensive populations of small Manila clams in surveyed areas shows recruitment has been low or inconsistent in recent years. Recruitment would appear to be too inconsistent to consider establishment of a continuous commercial fishery.

Results of microscopic examination of Manila clam gonads showed that most (54%) were in the ripe stage. Mann (1979) stated that a temperature of 14°C was required for gonadal development and a temperature of 15°C for spawning. Surface water temperatures of 14°C or higher were found in most areas and in Fish Egg Inlet the temperature was 17.7°C. The duration of periods when water temperatures are above 14°C in these areas is unknown but it is sufficient to allow gonadal development and probably spawning and larval development in most years. Support for this hypothesis is seen from results of the microscopic examination of gonads. Most gonads were in the ripe or partially spent stages indicating that gonadal development and some spawning had occurred in most areas surveyed. Manila clam larvae were found in the plankton tow made in Fish Egg Inlet. The lack of extensive Manila clam populations in the survey areas is not due entirely to water temperatures that are too low to permit gonadal development and spawning. It may be due more to a lack of suitable habitat and excessive mortalities after settlement. Water temperatures in the Alert Bay area are probably too low to support annual gonadal development, spawning and larval development except under local conditions such as in Booker Lagoon.

Stunting

As observed during previous surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994) many butter and littleneck clams, particularly littlenecks, were badly stunted. In the 1993 survey some Manila clams were stunted.

The cause of stunting in bivalves is not completely understood but it cannot be due entirely to density since many stunted clams

were found in areas of low clam density. High beach position, poor environmental conditions, and insufficient food supply probably contribute to stunting. It would be of interest to determine if lowering densities or moving animals to improved habitat would reduce the incidence of stunting.

Commercial Potential

Development of commercial clam fisheries depends both on the extent of clam populations and on economic factors.

In previous years most of the commercial clam harvest in British Columbia was butter clams (Fig. 1) (Quayle and Bourne 1972). In recent years, the price paid for butter clams has been so low there has been little incentive for commercial harvest of this species, even in the South Coast district. Although extensive populations of butter clams were found in the surveyed areas, it is doubtful if there would be any commercial interest in them because of the economics of harvesting.

Similarly the price paid for littlenecks is too low to make harvest of this species commercially attractive, even in some areas in the south coast district. It is doubtful if there would be much interest in harvesting littleneck clams in any areas surveyed in 1993, except perhaps the most southerly areas, Port Neville and Nodales Channel.

Although the price paid for Manila clams is high and they are the species of most interest in the present commercial fishery, it is doubtful if populations in any areas surveyed were sufficiently abundant to be of interest to the commercial fishery except perhaps the small population in Port Neville and the possibly larger population in Cameleon Harbour. Recruitment of Manila clams in all areas appeared to be inconsistent. Hence establishment of a commercial fishery in any area could be discontinuous because of recruitment patterns.

Other Species

Cockles, horse and soft-shell clams were present in most areas (Table 3). All horse clams sampled were *Tresus capax*. It is doubtful that intertidal stocks of these three species are sufficient to support targeted commercial harvesting, although they could be harvested along with other species.

GENERAL SUMMARY

Intertidal clam surveys in 1992 and 1993 added to our knowledge of butter, littleneck and Manila clam stocks in British Columbia.

At the northern end of the Strait of Georgia stocks of Manilas are sufficient to support continued commercial harvest in Von Donop Inlet, at Marina Island and in Drew Harbour. Stocks of littleneck and butter clams could be harvested in some of these areas also.

Results of this work along with that of previous surveys confirm that Manila clams have dispersed northward through the Discovery Passage-Yuculta Rapids area and have become established in areas of Johnstone Strait.

Unlike findings in previous surveys, no stocks of Manila clams were found that would support commercial harvesting except perhaps the small population in Port Neville and the more extensive population in Cameleon Harbour. Further information on the size and age structure of the Manila clam population in Cameleon Harbour is required for management of a possible commercial fishery there.

Most Manila clams found north of the Discovery Passage-Yuculta Rapids area were large and old which reflects inconsistent recruitment. Such recruitment patterns may be due to low water temperatures in some years that prevent successful breeding, cold winter temperatures which cause extensive mortalities of juveniles or to limited habitat for Manila clams in some areas. In some areas, it appeared that recruitment was only sufficient to maintain a small population, e.g. Fish Egg Inlet, Booker Lagoon, Blunden Harbour. Extensive general breeding has not occurred. This small, inconsistent local breeding is preventing build up of a population and establishment of a commercial fishery.

As reported in previous surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994) extensive stocks of butter and littleneck clams were found in most areas. However, development of commercial harvesting for these two species will depend on the economics of harvesting and processing and establishment of attractive markets.

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Table 1. Location of beaches and sampling dates for intertidal clam surveys along the British Columbia coast during 1992 and 1993.

LOCATION	DATE
Von Donop Inlet	July 2, 1992
Marina Island	July 2, 1992
Drew Harbour	July 3, 1992
Quatsino Sound / Holberg Inlet	July 15-16, 1993
Fish Egg Inlet	July 17, 1993
Smith Sound / Smith Inlet	July 18, 1993
Rivers Inlet	July 18, 1993
Deserters Group	July 19, 1993
Blunden Harbour	July 19, 1993
Drury Inlet	July 20, 1993
Nowell Channel / Fife Sound	July 21, 1993
Port Harvey	July 22, 1993
Port Neville	July 22, 1993
Nodales Channel	July 23, 1993

Table 2. Densities of butter, native littleneck and Manila clams (clams m^{-2}) on selected beaches sampled at the north end of the Strait of Georgia, July 2-3, 1992.

BEACH	QUADRAT	METHOD	BUTTER		LITTLENECK		MANILA	
			Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
			VON DONOP INLET					
1	1	R[1]	0	8	4	232	52	176
	2	R	0	0	4	92	184	564
	3	R	4	4	4	108	160	236
	4	R	0	0	16	100	124	340
	5	R	0	0	12	52	24	276
	6	R	0	0	12	236	64	484
2	1	R	0	0	0	8	40	36
	2	R	0	0	0	4	120	96
	3	R	0	0	0	4	132	132
	4	R	0	0	0	12	120	36
	5	R	0	0	0	8	172	148
3	1	R	0	0	0	0	12	12
	2	R	0	0	0	0	48	284
	3	R	0	0	0	0	200	256
			MARINA ISLAND					
1	1	R	0	0	8	84	256	220
	2	R	0	0	16	8	60	112
			DREW HARBOUR					
1	1	R	0	0	0	0	40	60
	2	R	0	0	4	0	64	192
	3	R	0	0	0	4	8	372
	4	R	0	0	0	16	12	256
	5	R	0	0	12	0	36	476
	6	R	0	0	12	24	24	192
	7	R	0	0	24	28	48	308
	8	R	0	0	8	120	8	124
	9	R	0	0	0	0	36	288
	10	R	0	0	8	0	16	216
	11	R	0	0	4	0	11	4
	12	R	0	0	4	0	36	164

[1] R = dug with rake or scraper

Table 3. Physical description of beaches visited during the 1993 intertidal clam survey along the British Columbia coast.

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
			QUATSINO SOUND		
1	2	20	Gentle	Soft mud with some gravel patches.	Beach used for log booming. Very little clam shell in the beach. A few *Mya arenaria*.
2	5-6	0	Gentle	Soft mud.	Beach used for log booming. Poor clam habitat. Much eel grass. Very little shell. A few cockles.
3	2-3	20	Gentle	Soft mud with gravel ridges.	Little clam shell.
4	2-3	0	Gentle	Mud.	Extensive logging activity; no sampling.
5	2-3	0	Gentle	Mud with gravel ridges.	Extensive logging activities; no sampling.
6	4-5	10	Gentle	Soft mud with gravel ridges; badly rutted.	No manila clams or shell observed.
7	3-4	20	Gentle	Mud with extensive gravel patches.	Booming ground at western end of beach. No manila clams or shell.
8	2.5	50	Gentle	Gravel-sand,mud at lower levels.	Many cockles and soft-shell clams. Beach covered with *Ulva* sp.,eel grass at lower levels.
9	0.5	6	Moderate	Cobble-shell, sand-gravel areas.	Eel grass at lower levels; Dungeness crab; butter and littleneck shell.
10	1.5	50	Moderate	Mud-broken shell.	A lot of eel grass at lower level.

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
11	3.0	25	Gentle	Mud, some firm sand-shell areas.	Flattish beach with many ravines. Much littleneck and soft-shell clam shell; some butters.
12	0.2	-	Gentle	Sand-mud with rock. Good clam habitat.	Good Manila clam habitat.
13	2.0	10	Steep	Soft mud with some shell; much rock.	Appears to have been used for log booming; very little shell. Poor clam beach.
14	4.0	25	Steep	Soft mud with rock.	A lot of *Ulva* sp., some *Macoma* sp., soft-shell and cockles.
15	3.0	20	Steep	Soft mud with rock.	Poor clam habitat; area has been used for log booming. Few barnacles on last 3 beaches.
16	3.0	20	Steep	Soft mud with rock. Very little shell.	Poor clam habitat; very little old shell.
17	1.0	0	Gentle	Soft mud with rock. Very little shell.	Poor clam habitat; area used for log booming.
18	3.0	Samp.	Gentle	Soft mud with rock. A few gravel patches at head.	Little of beach suitable for clams; gravel patches with clams about 1m from high tide lines.
			FISH EGG INLET		
1	0.05	20	Moderate	Mud-sand-gravel; firm and hard.	A lot of Manila clam shell on eastern side of beach. Fair number of cockles.
2	0.15	6	Gentle	Mud in middle; sand-shell along the	One live Manila; cockles and littlenecks.

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				edge.	
3	0.25	10	Gentle	Sand-mud.	3 small beaches; eel grass at lower level; littlenecks plentiful.
4	0.01	5	Steep	Sand-shell with rock.	Butter and littleneck.
5	2.0	50	Moderate	Soft mud; very soft mud; rock.	Creek runs through beach; poor clam habitat; Manila clams lying on surface.
6	0.01	8	Moderate	Sand-shell, gravel with rock.	Small pocket beach; butters at lower levels.
7	0.02	20	Gentle	Mud-gravel-rock; sand-gravel-mud.	Two-tiered beach; Manila shell but no live ones.
8	0.02	10	Gentle	Soft mud; head is cobble and rock.	Large creek runs through centre of beach. Eel grass at lower level; some Manila clam shell; none live.
9	0.3	10	Moderate	Lowerpart rock; upper part sand-mud.	Good clam habitat in upper part of beach.
10	0.03	10	Gentle	Sand-gravel-shell.	Butter; littlenecks and *Mya*. A saddle beach between 2 small islands.
				SMITH SOUND	
1	0.3	10	Gentle	Lower part soft mud; sand-gravel-shell strip around the edge.	Area is clam bearing area; lower part eel grass; moon-snail predation evident; one live Manila, butter, littleneck, soft-shell and some cockle present.
2	1.0	20	Gentle	Sand-clay-mud, some cobble; main beach soft	Eel grass at lower levels; *Macoma*, *Mya*, cockles and a few

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				mud.	littlenecks.
3	0.3	3	Moderate	Thin sand covering mud; gravel-sand-shell with some cobble and rock.	3 areas sampled; eel grass covered much of lower half of beach; good habitat for littlenecks in places; Manila clams present.
4	0.1	1	Moderate	Soft mud to gravel and coarse sand.	Lower part soft mud with eel grass; higher portions firmer; no sign of Manila clams; sample taken for butter clams.
5	0.03	6	Moderate	Coarse sand and shell.	Butter clam beach; Manila clams found on beach.
6	3.0	2	Gentle	Most of beach was soft mud; a 3-5 m strip of coarse sand-shell occurs on perimeter of west side.	Large beach but mostly soft mud with eel grass; sand-shell strip not good clam habitat but had some Manila clams.
7	20-30	0	Gentle	Sand-mud.	A large extensive beach at the head of Broad Reach but virtually all sand-mud. Virtually no clam habitat; cockles numerous.
8	0.02	2	Moderate	Sand-shell amongst rock.	A butter clam beach; large numbers of butter and horse clams; some littlenecks, no Manila clams.
9	0.3	4	Steep	Mud-gravel-sand with gravel ridges.	A lot of junk on beach; smell of hydrogen sulphide in parts; a lot of butter and littleneck shell; Manila clams present in gravel ridges.

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
			GOOSE BAY, RIVERS INLET		
1	>9.0	20	Gentle	Soft sand-mud.	Much eel grass at low water.
			WALKER GROUP AND DESERTERS GROUP,QUEEN CHARLOTTE SOUND		
1	8.0	30	Gentle	Fine mud with some gravel areas; large boulders on the sides.	A lot of *Macoma* sp.; some old butter and horse clam shell; no littlenecks or Manilas.
2	0.3	12	Gentle	Sand-mud-gravel with boulders along border.	Butter, horse, cockle and *Macoma* shell; no littlenecks or Manilas; red sea urchins and abalone on rocks.
3	0.3	30	Moderate	Rock-gravel with some sand over hard mud. A few firmer areas with sand-coarse sand.	*Fucus* covered rocks at lower levels; much butter, horse and *Macoma* old shell. Few live clams; upper fringe of beach good Manila clam habitat but none found.
			BLUNDEN HARBOUR		
1	0.5	20	Moderate	Soft mud in central and lower parts; remainder cobble with mud- sand; some sand-gravel patches.	Eel grass at lower parts of beach. Butter and littlenecks plentiful, a lot of old dead shell. 4 old large Manila clam shells but no live clams. *Mya*.
2	8.0	20	Gentle	Sand-mud with much rock. 5 m strip of sand-shell-gravel around	20% of beach is suitable clam habitat. Butter and littlenecks common. Much shell. Cockles common in soft substrate. Some areas suitable for Manila clams but none

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				perimeter.	found. Mya.
3	8.0	15	Moderate	Lower part sand-mud with rock. 5-10 m sand-shell-gravel strip around perimeter.	40% suitable as clam habitat. Butter and littlenecks common. Littlenecks common at higher levels. Cockles in softer substrate. No live Manilas but some old dead shell found. *Mya* common.
4	0.3	15	Gentle	Sand-mud with much rock. A 5-10 m strip of sand-coarse gravel-shell at higher beach level. Some gravel patches.	Butter and horse clams common at lower beach levels, littlenecks common at higher levels. Cockles in softer substrate. *Mya* common. No live Manilas or dead shell found. Little old clam shell on beach.
5	0.60	15	Gentle	Mud-sand with much rock. A 5 m sand-gravel strip at higher beach level.	Beach inside Deer Cove about 5 ha in area and appeared similar to beach sampled. Hard digging because of rock. Eel grass at lower levels. Butter and horse clams common at lower beach levels; littlenecks at slightly higher levels. Cockles and *Mya* present. No live Manilas or dead shell found.
6	5.0	$6m^2$	Gentle	Mud-sand with much rock.	Hard digging because of rock. Butter and littlenecks common, some horse clams, cockles and *Mya*. In high intertidal in sand-gravel-shell dug $6m^2$ and got 67 Manila clams. Little old dead shell.
				DRURY INLET	
1	0.1	8	Moderate	Cobble-gravel-sand	Butters and littlenecks common; some horse

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				with some shell.	clams. No live Manilas or dead shell. Good Manila clam habitat.
2	0.06	6	Moderate	Silt-sand, some shell.	Butter clams abundant; 0.25 m^2 sample taken for littlenecks. Much *Fucus* on rocks. No live Manilas or dead shell.
3	0.2	9	Gentle	Sand with cobble and rock at edges. Upper level gravel with rock.	Excellent littleneck habitat. Littlenecks common; butters and cockles present. Horse clams in lower part of beach. Butter clam sample taken. no live Manilas or dead shell.
4	0.3	10	Steep	Lower part mud-sand. Upperpart sand-shell.	Excellent littleneck habitat and they were common. *Ulva* covered much of lower part of beach.
5	0.05	6	Moderate	Lower part fine sand. Upper part gravel-rock.	Beach was terraced. Mid portion was good littleneck habitat and they were common. No live Manilas or dead shell.
6&7	0.03	0	Steep	Lower part soft mud; 5 m strip with firmer substrate.	Only observations done; no samples taken. Bubbles rising from substrate; poor clam beach.
8	0.15	10	Gentle	Lower part sand-mud. Upper part gravel-coarse sand.	Littlenecks abundant; sample of butter clams taken.
9	2.0	8	Gentle	Mostly sand-mud with patches of sand-gravel.	Littlenecks common in sand-gravel patches; *Macoma* and cockles in softer substrate. Shell butter and horse clams.
10	0.4	6	Variable	Fine sand-mud with	Not a clam beach; tidal pools on beach; *Fucus* on

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				rock.	rocks; very few clams.
11	1.0	10	Gentle-moderate	Lower part sand-mud with rock, higher up more rock.	Butter clam beach but tough digging because of rock. Littlenecks abundant at higher beach levels; extensive beach; horse clams cockles and *Mya* present. No live Manilas or dead shell.
12	1.0	20	Gentle-moderate	Lower part sand-mud; rises to a berm that is sand-mud-gravel with rock. Coarse sand-shell at edges.	Rock cliff around edge of beach with large boulders. Butter and littleneck clams abundant. Very little good habitat for Manilas. Found 2 old dead maila clam shells but no live animals. Looked for Manila clams around the corner from the head (area about 0.3 ha). Poor Manila clam habitat and no live animals or dead shell found.
13	0.5	20	Gentle-moderate	Lower part sand-mud with rock up to berm that has firmer mud-sand substrate. Coarse sand-shell at edges.	Visited two areas of this beach; butters and littlenecks abundant; *Mya* and cockles present. No live Manilas or dead shell.
14	0.3	15	Gentle	Lower part mud-sand with much rock. Berm area is firmer with more gravel. Sand-gravel around perimeter.	Similar to previous beach. Butter and littleneck clams abundant in lower portions of the beach and in the berm area. Poor Manila clam habitat. No live Manilas or dead shell found.
15	0.25	15	Gentle-	Lower part	Lower portion had

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
			moderate	sand-mud with much rock. Berm area has more gravel. Sand-gravel around edges.	abundant butter clams but digging difficult because of rock. Littlenecks plentiful in berm area. poor Manila clam habitat. No live Manilas or dead shell found.
16	0.53	10	Moderate-steep	Lower part sand-mud with much rock. Berm is mostly gravel. Coarse sand around edges.	Butter clams plentiful in lower part. Berm ideal for littlenecks and abundant there. No live Manilas or dead shell found.
			NOWELL CHANNEL - FIFE SOUND		
1	1.0	20	Gentle	Lower part sand-mud. Some ridges have firmer sand-mud substrate.	Butter clams and littlenecks in lower portion and in ridges. Horse clams, *Mya* and a few cockles. no Manila clam habitat and no live or dead shell found.
2	5.0	20	Gentle	Mostly sand-mud, with rock. sand-shell along the perimeter.	Butters and littlenecks in lower part and in ridges. Cockles, *Mya* and horse clams. *Ulva* covered much of lower beach. No Manila clam habitat and no live or dead shell found.
3	0.1	6	Moderate	Lower part sand-gravel and rock. Substrate of berm area mostly gravel.	Berm area good Manila clam habitat. A lot of Pacific oysters on the beach from previous culture operations. Littlenecks abundant. collected about 20 Manila clams, all large. Some dead shell found on the beach.
4	0.5	40	Gentle	Rock at lower levels. Berm	Berm area has abundant littlenecks many of which are stunted. Good

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				is mostly gravel with some mud.	Manila clam habitat but only one live one found. Some old shell on the beach and on the rocks where birds dropped them. A few butter and horse clams and cockles.
5	0.2	20	Gentle	Sand-mud-shell gravel in main portion of beach. Quite a bit of rock.	Rock dam is at lower part of beach. Main beach is berm at a fairly high intertidal area that has several tidal pools that don,t drain completely at low tide. Dug about 7 m^2 and found 30 live Manila clams. All Large. Some Manila clam shell on the beach.
6	0.1	20	Moderate	Rock at lower levels. Berm area has sand-mud with shell and gravel. Much rock.	Rock cobble or cliffsaround much of beach. Very few live Manila clams but some shell on beach. Littlenecks abundant. Butters, horse, cockles and *Mya* present.
7	1.0	20	Gentle	Sand-mud with gravel patches and some rock. Coarse sand-shell substrate at edges.	Much of beach covered with *Fucus*. Much of beach is soft substrate. A butter-littleneck beach. Found 2 live stunted Manilas. Very little Manila clam habitat.
			PORT HARVEY		
1	5.0	25	Moderate-steep	Mostly soft mud with clumps of mussels. Firmer patches at the edges.	Butter clams at lower levels and some littlenecks. A lot of *Fucus* at higher levels. *Mya*, *Macoma* and cockles. Some Manila clam shell. Found 18 live Manilas in 25 plots, all were small. Very little habitat for Manila

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
					clams.
2	0.1	2	Moderate	Sand-mud.	Not a clam beach. A few butters, cockles and *Mya*. Little old shell. No Manila clams.
3	0.5	20	Moderate	Mud-silt in upper part; rock-cobble in lower zone.	Poor clam beach. A few littnecks, *Mya* and clumps of mussels. Estuarine type of beach.
4	2.0	8	Moderate	Sand- coarse sand- mud and shell.	Estuarine type of beach. A lot of shell. A few littlenecks. No Manila clams.
5	0.4	6	Gentle	Thin packed sand in lower zone to coarse sand and cobble in higher areas.	A few littlenecks, butters, *Mya*, *Macoma* and cockles. No Manila clams.
6	0.3	6	Medium	Coarse sand-gravel to cobble in lower area.	Cockles, *Mya*, *Enteromorpha*, and *Laminaria* on cobble. no Manila clams.
			PORT NEVILLE		
1	5.0	30	Gentle	Mud-sand with scattered firm gravel patches. Huge boulders.	Large beach, about 10% suitable for butters and littlenecks. Reasonable populations of both. Little good Manila clam habitat. Found 1 piece of Manila clam shell on the beach and 1 that had been dropped by birds on a large rock. Most of the beach is soft mud with eel grass. Cockles, *Macoma*, *Mya* and horse clams present.
2	3.0	25	Moderate	Sand-mud with rock at lower	Extensive beaches on east and west side of point. East side

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
				portions. At higher elevations sand-gravel with shell.	sampled. Butters and littlenecks present at lower-middle beach levels. A lot of rock. Lower part has eel grass and *Ulva*. Found 1 old Manila clam shell but not live animals. Not good Manila clam habitat. Pacific oysters present, planted by someone.
3	10.0	4 m^2	Moderate	Lower part mud-gravel-rock and eel grass. 5-10 m strip that extends for 300 m has coarse sand-graveland rock. Tough digging.	Butter clams abundant in lower part of beach.Littlenecks abundant slightly higher up. A lot of butter and littleneck shell. Horse clams, *Mya*, *Macoma* and cockles. A lot of Manila clams on surface in 5-10 m strip. Manila clams in areas with suitable habitat.
			NODALES CHANNEL		
1	0.2	15	Gentle	Coarse sand-gravel; rock at upper level.	Logging operations had occurred on this beach. Good habitat for Manila clams but didn't find any live animals or dead shell. Little shell of any clam species.
2	0.2	10	Gentle	Sand-gravel.	Good habitat for Manila clams but didn't find any live animals or dead shell. Little shell of any clam species.
3	0.3	10	Moderate	Soft mud with rock. Firmer patches at higher elevations have sand-gravel with rock.	Lower portion has reasonable populations of butter clams and littlenecks. No live Manilas or dead shell.

Table 3. (cont'd)

BEACH NO.	AREA (ha)	NO.OF QUADRATS	SLOPE	SUBSTRATE	REMARKS
4	8.0	3 m^2	Moderate	Soft mud-sand. Patches of firmer substrate at higher elevations, sand-gravel-mud with rock.	Modest quantities of butters and littlenecks at lower beach levels. A lot of old dead Manila clams on the surface. live Manila clams are badly stunted. Very little good Manila clam habitat on this beach.
5	1.0	8 m^2	Gentle	Sand-gravel with rock.	Although beach sampled was about 1 ha the beach extends around Cameleon Harbour, including Thurston Park and is probably about 10 ha. Good habitat for Manila clams. Some commercial digging may have occurred here.

Table 4. Densities of butter, littleneck and Manila clams (clams m^{-2}) on beaches sampled in the Central and South Coast areas, July 15-23, 1993.

BEACH	QUADRAT	METHOD	BUTTER		LITTLENECK		MANILA	
			Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
QUATSINO SOUND / HOLBERG INLET								
11	1	F[1]	0	0	28	8	0	0
12	1	F	0	0	1	41	0	0
18	(P)[2]	R[3]	0	0	0	0	0.2	6.1
FISH EGG INLET								
1-10	(P)	R	0	0	0	0	37	9
SMITH SOUND / SMITH INLET								
1	1	R	0	4	2	24	0	2
1	2	R	12	4	112	36	0	8
2	1	R	0	0	100	8	0	4
3	1	R	0	0	152	16	4	0
3	2	R	0	4	124	76	24	4
3	(P)	R	0	0	0	12	26	3
3	4	R	0	12	40	252	0	4
4	1	F	152	100	92	44	0	0
6	1	R	0	4	8	36	24	0
6	2	R	0	0	20	92	56	0
8	1	F	102	28	12	0	0	0
9	1	R	0	32	36	320	36	4
9	2	R	0	0	12	24	20	20
9	3	R	0	0	88	68	16	0
9	4	R	0	4	12	164	32	4
BLUNDEN HARBOUR								
1	1	R	0	0	0	0	8.2	3
DRURY INLET								
2	1	R	80	60	72	72	0	0
3	1	R	4	12	94	142	0	0
5	1	R	0	0	80	60	0	0
8	1	F	45	3	0	0	0	0
12	1	R	36	20	232	132	0	0

[1] F = dug with potato fork
[2] (P) = data pooled from a number of quadrats
[3] R = dug with rake or scraper

Table 4, cont'd.

BEACH	QUADRAT	METHOD	BUTTER		LITTLENECK		MANILA	
			Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
		NOWELL CHANNEL / FIFE SOUND						
3	1	R	4	0	124	84	0	0
3	(P)	R	0	0	0	0	3.5	0.3
5	(P)	R	0	0	0	0	5.7	0.1
6	(P)	R	0	0	0	0	4	1
7	(P)	R	0	0	0	0	1	1
		PORT HARVEY / HAVANNAH CHANNEL						
1	(P)	R	0	0	0	0	0.5	2.4
		PORT NEVILLE						
3	1	R	0	0	0	0	40	12
3	2	R	0	0	0	0	16	0
3	3	R	0	0	0	0	37	3
3	4	R	0	0	0	0	18	0
		NODALES CHANNEL						
3	1	R	0	0	0	0	9.3	2
3	2	R	0	0	0	0	8	0
5	1	R	0	0	0	0	13	7
5	2	R	0	0	0	0	11	1
5	3	R	0	0	0	0	5	1
5	4	R	0	0	0	0	5	1
5	5	R	0	0	0	0	7	1
5	6	R	0	0	0	0	1	4
5	7	R	0	0	0	0	8	8
5	8	R	0	0	0	0	4	2
5	9	R	0	0	0	0	3	0
5	10	R	0	0	0	0	5	8

Table 5. Stages of gonadal development of Manila clams collected during the 1993 intertidal clam survey along the coast of British Columbia.

	STAGE OF DEVELOPMENT				
DATE	EARLY ACTIVE	LATE ACTIVE	RIPE	PARTIALLY SPENT	SPENT
QUATSINO SOUND					
16 July	0 M 0 F	1 M 0 F	4 M 7 F	0 M 2 F	0 M 0 F
FISH EGG INLET					
17 July	0 M 0 F	0 M 0 F	4 M 4 F	4 M 6 F	1 M 2 F
BLUNDEN HARBOUR					
19 July	0 M 0 F	1 M 3 F	5 M 1 F	1 M 3 F	0 M 0 F
BOOKER LAGOON					
21 July	0 M 0 F	2 M 2 F	7 M 1 F	1 M 0 F	0 M 0 F
PORT HARVEY					
22 July	0 M 0 F	2 M 2 F	2 M 1 F	0 M 0 F	0 M 0 F
PORT NEVILLE					
22 July	0 M 0 F	1 M 2 F	8 M 3 F	0 M 0 F	1 M 0 F
CAMELEON HARBOUR					
23 July	0 M 0 F	0 M 1 F	5 M 1 F	4 M 3 F	0 M 1 F

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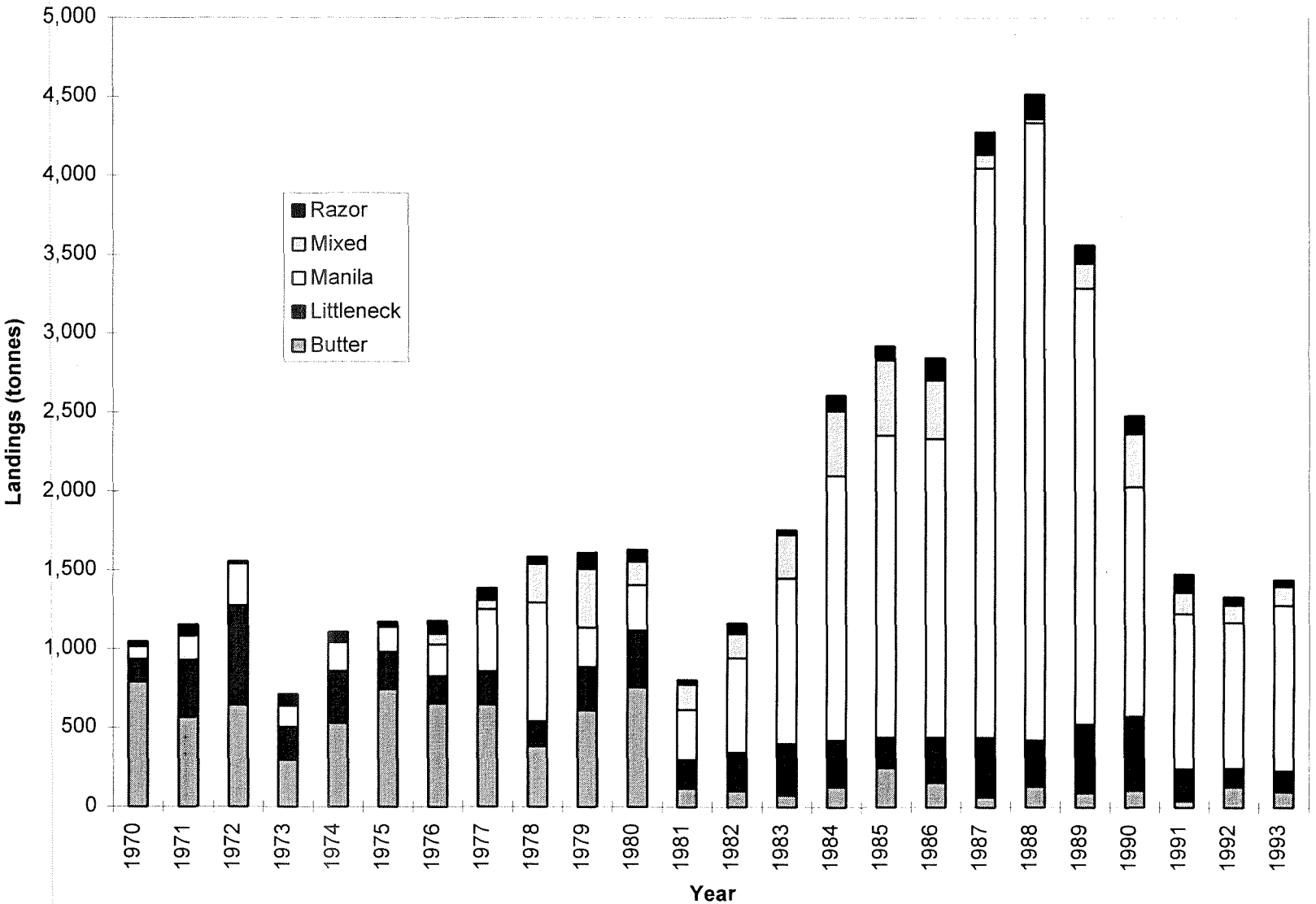


Figure 1. Landings of intertidal clams, including razor, butter, littleneck, Manila and mixed, in British Columbia commercial fisheries, 1970-1993.

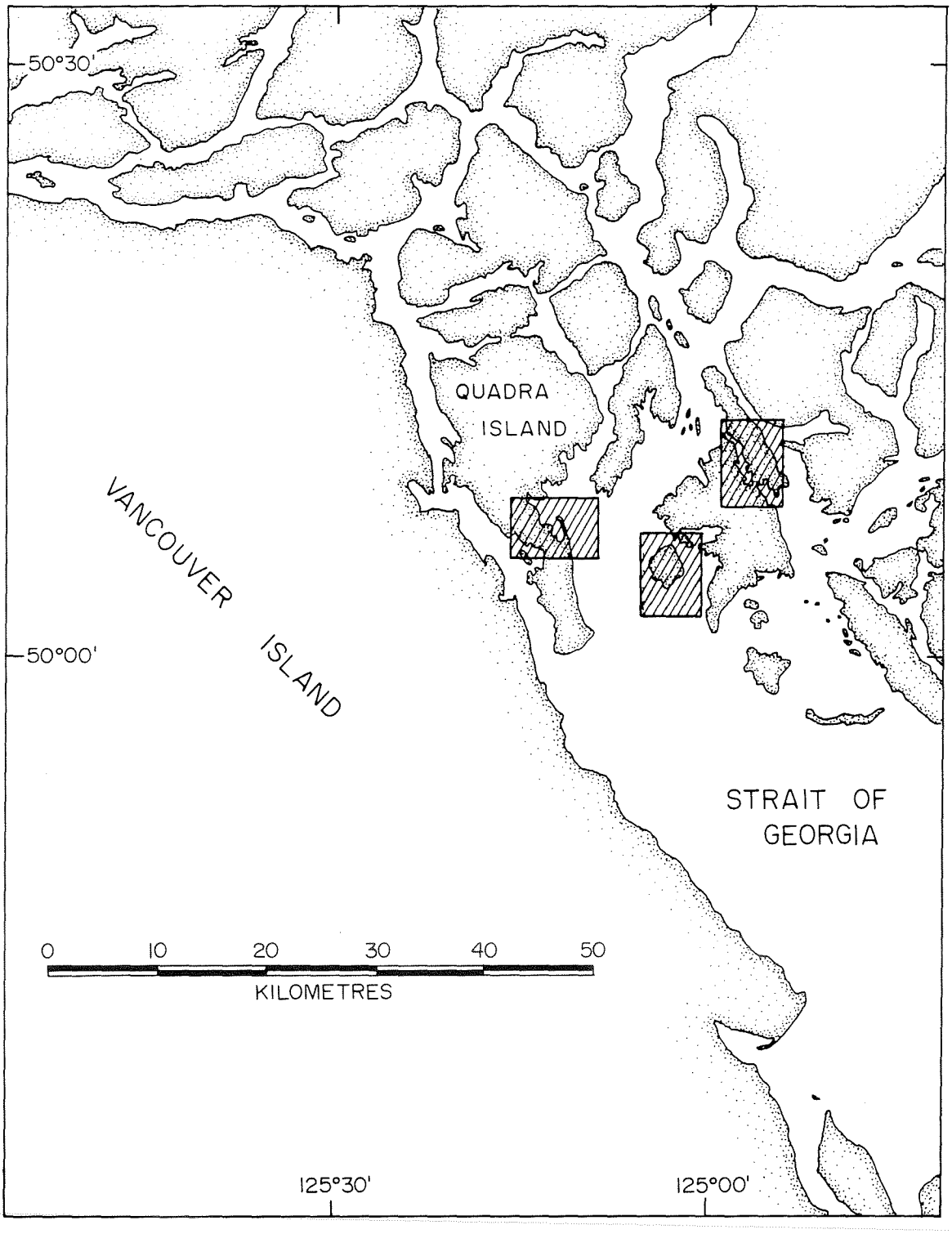
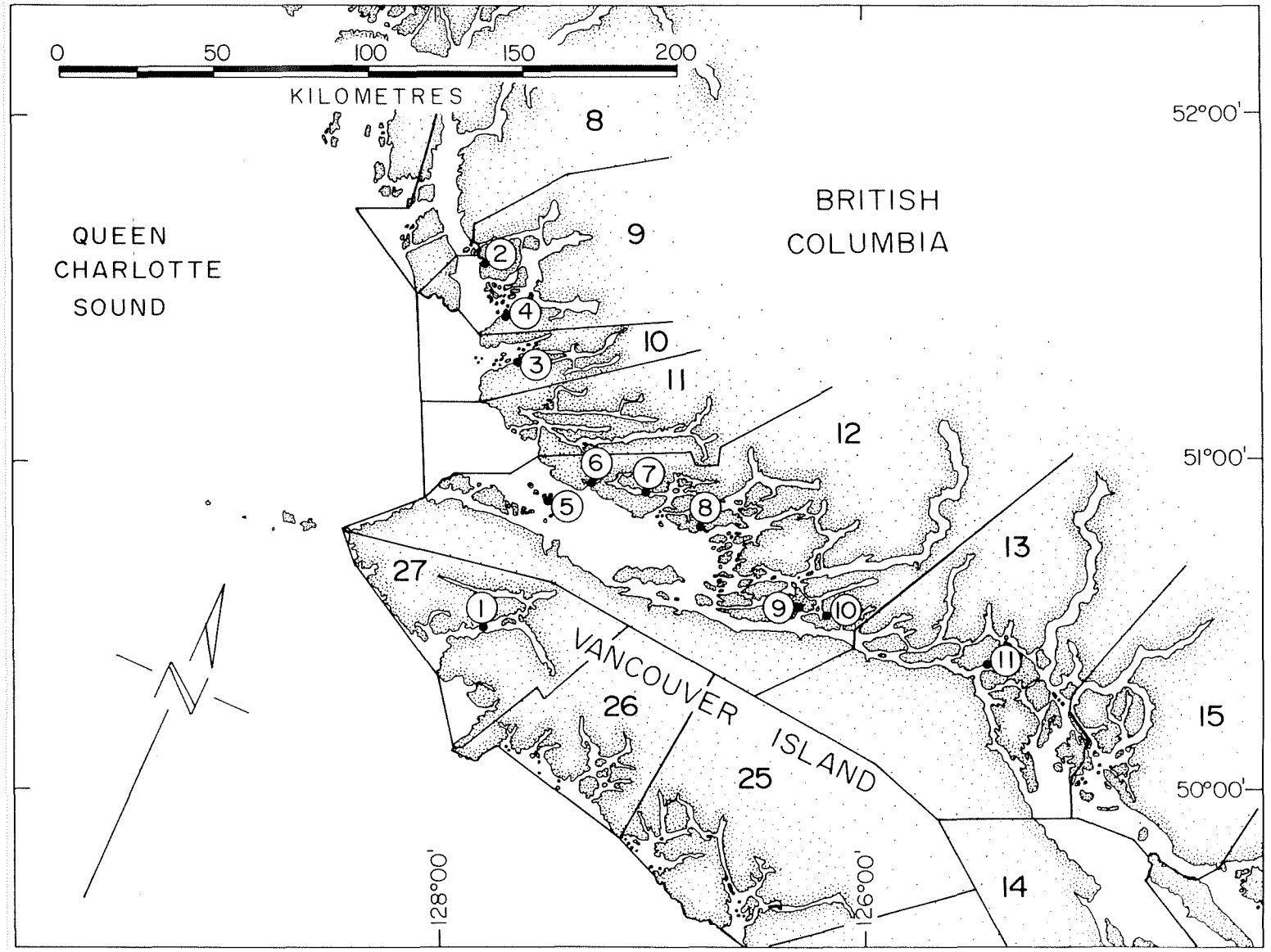


Figure 2. Map of the northern Strait of Georgia, British Columbia, showing the location of beaches visited, July 2 and 3, 1992.

Figure 3. Map of part of coastal British Columbia showing the location of beaches visited during the 1993 intertidal clam survey.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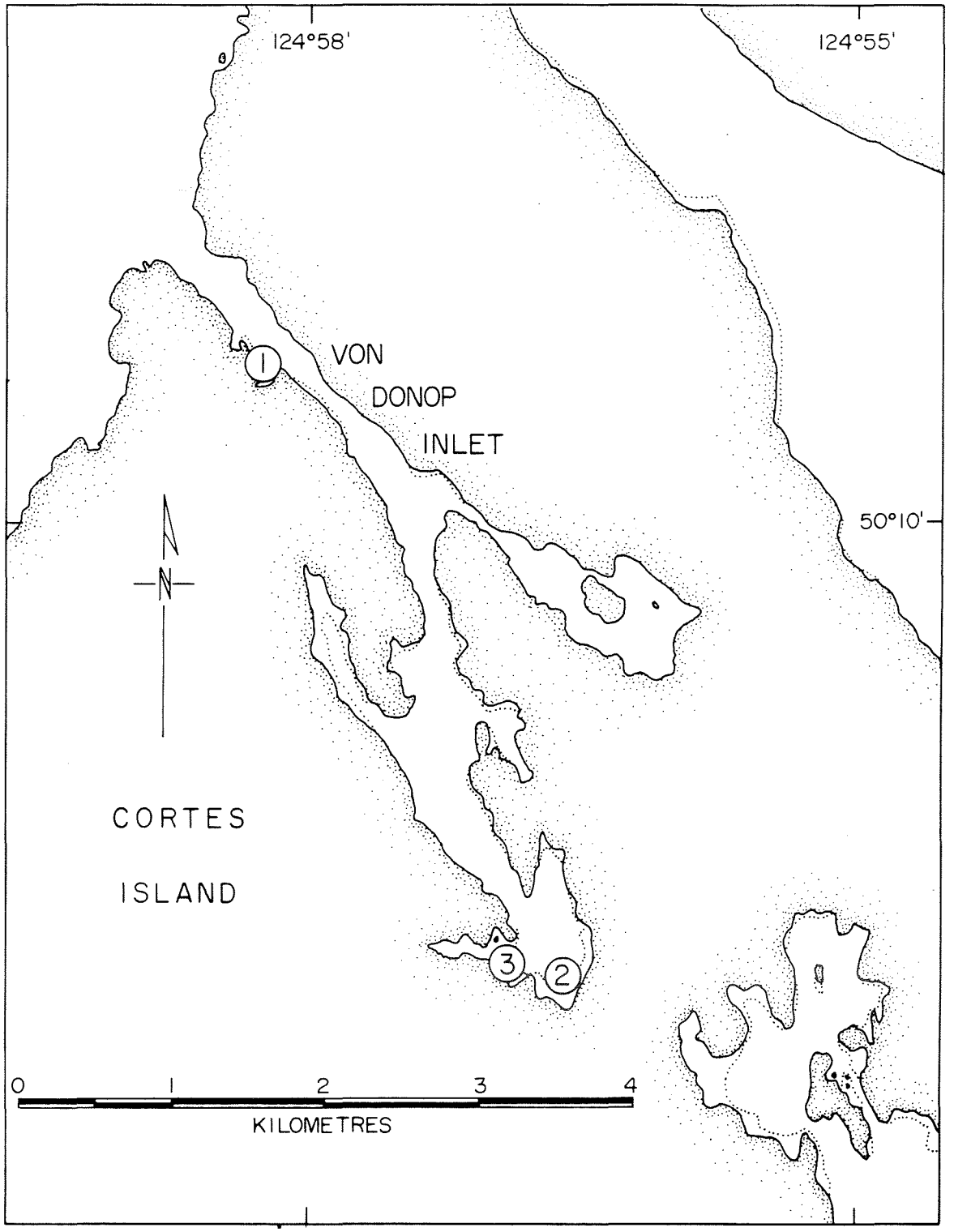

Figure 4. Map of Von Donop Inlet showing the lcation of the three beaches sampled, July 2, 1992.

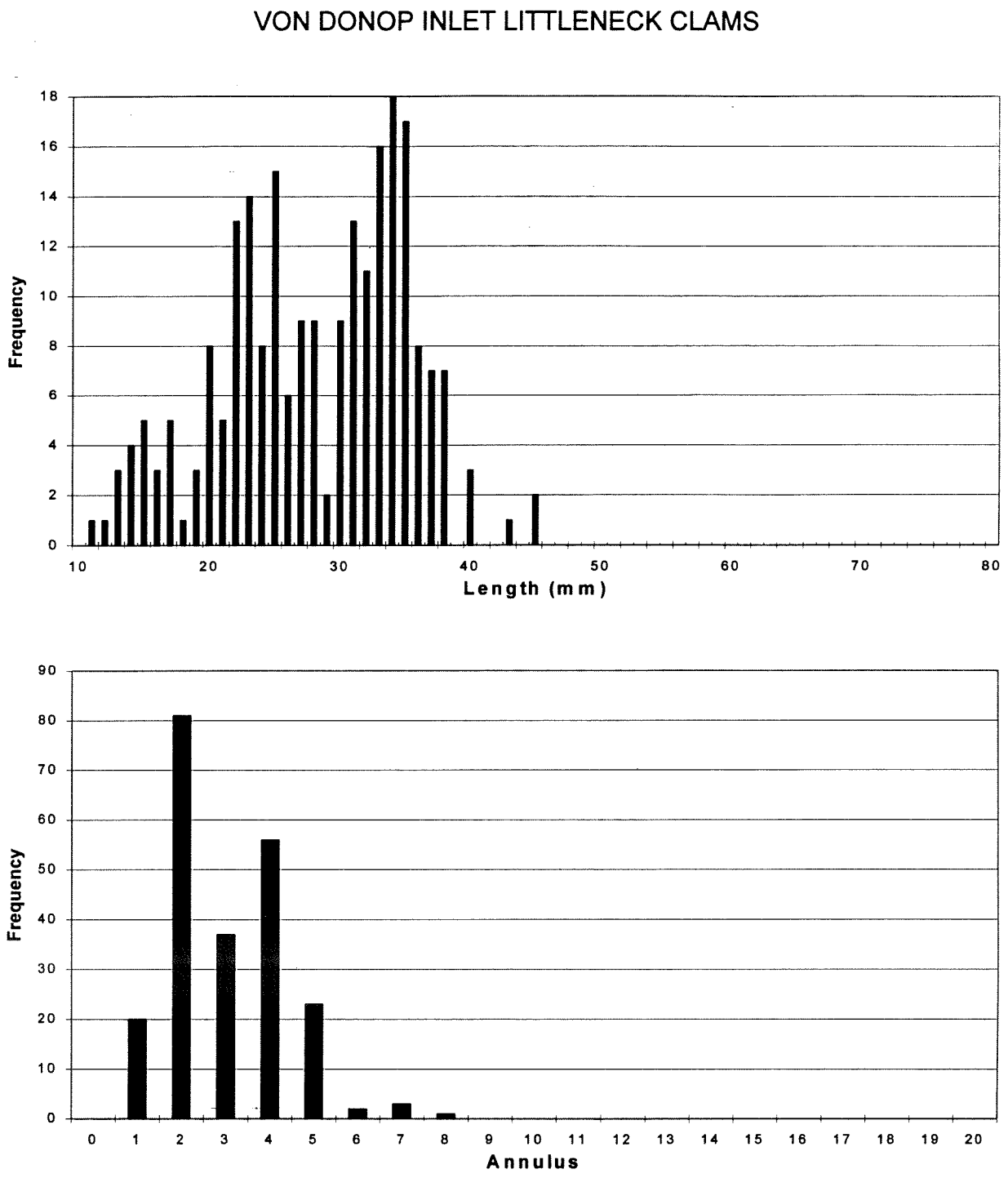

Figure 5. Length and age frequency distribution of littleneck clams sampled in Von Donop Inlet, July 2, 1992.

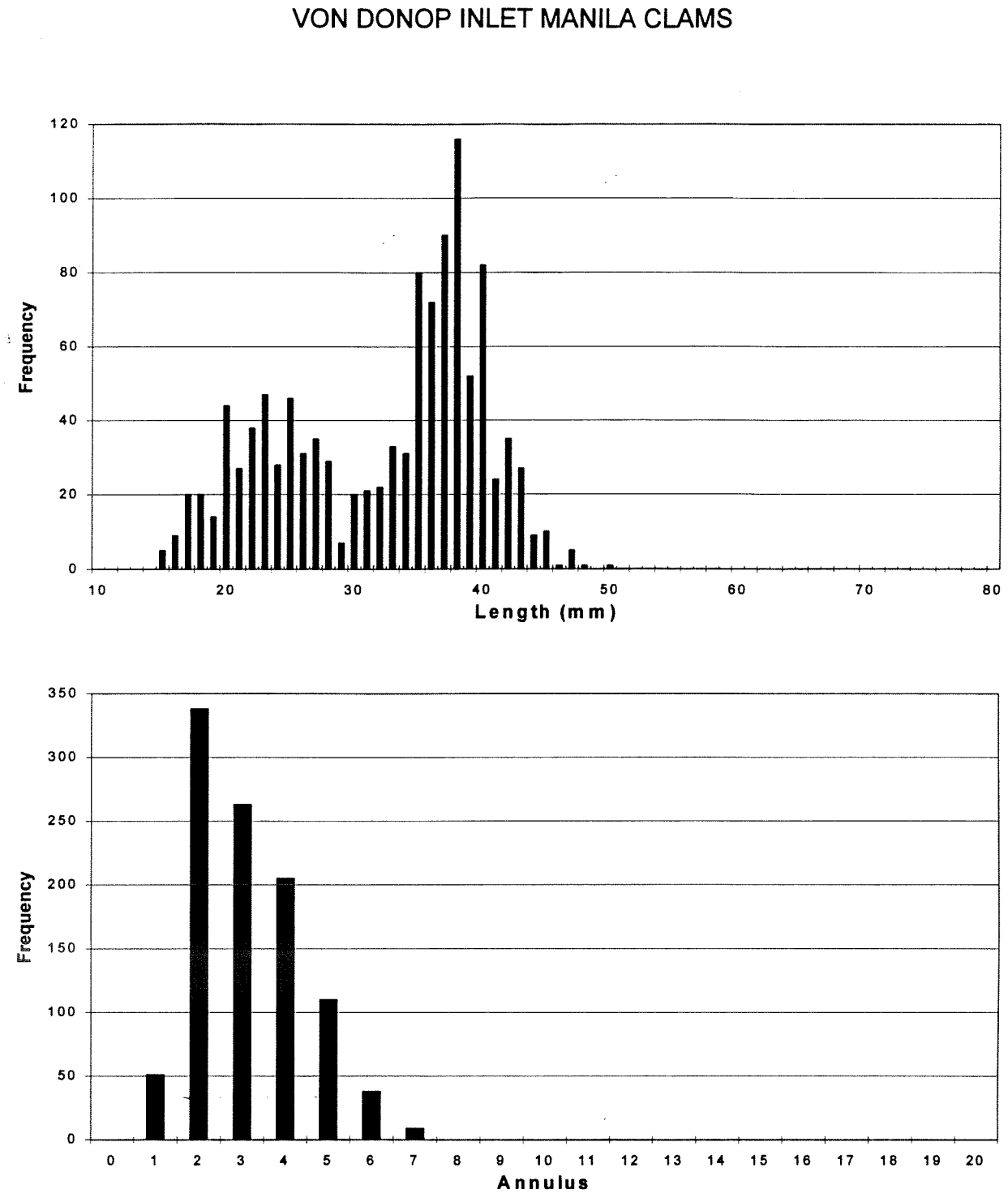

Figure 6. Length and age frequency distribution of Manila clams sampled in Von Donop Inlet, July 2, 1992.

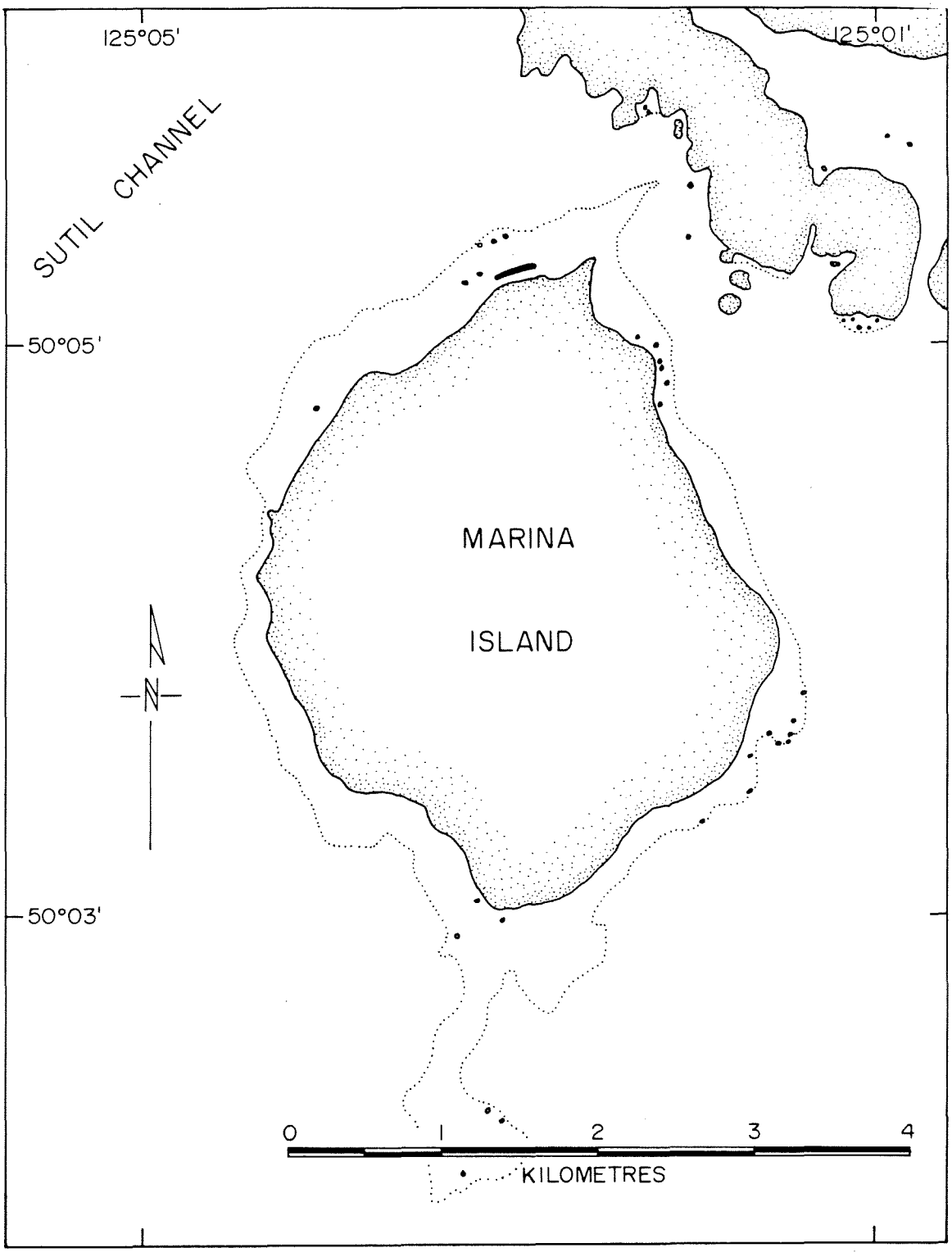

Figure 7. Map of Marina Island showing the location of the area sampled July 2, 1992.

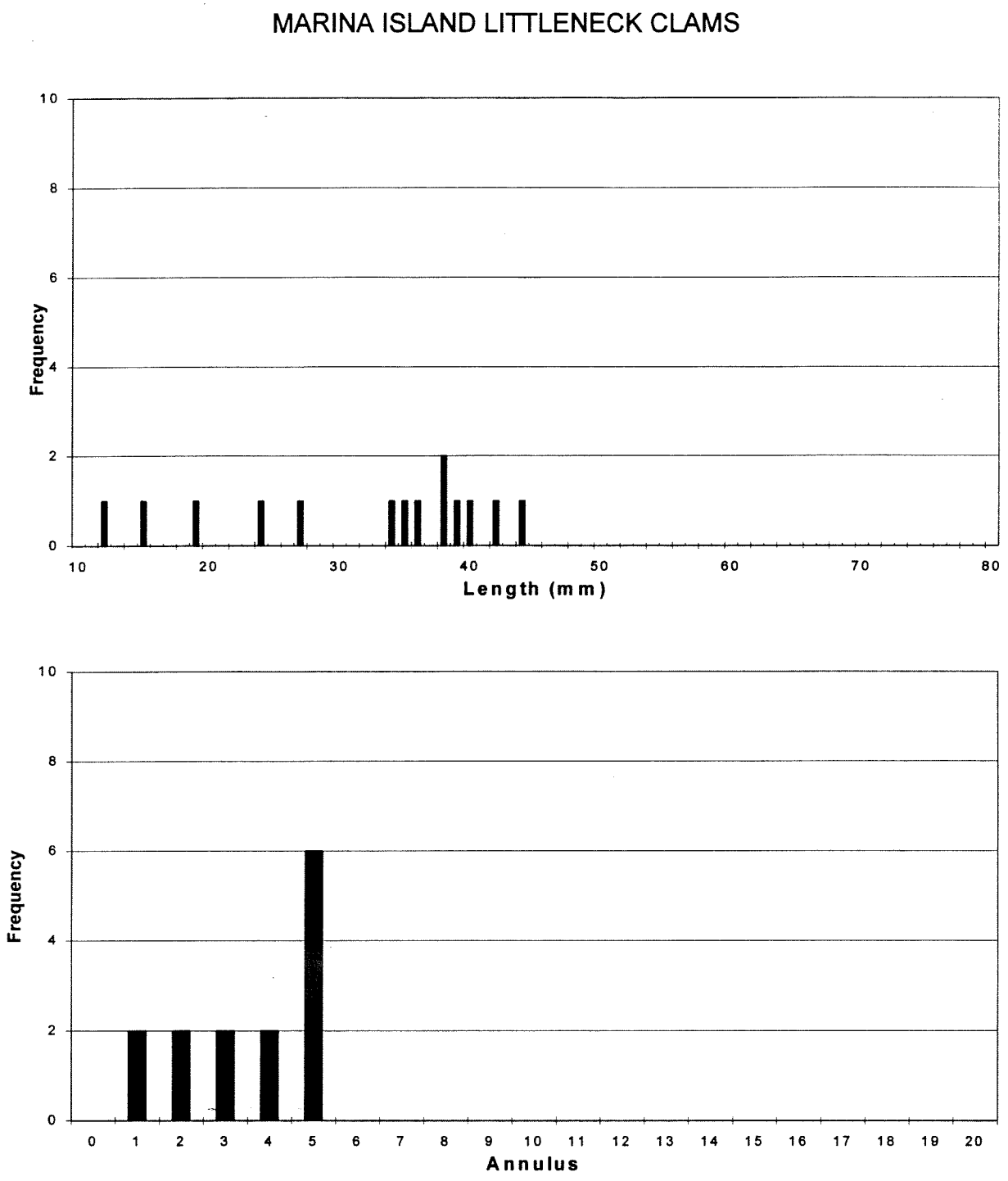

Figure 8. Length and age frequency distribution of littleneck clams sampled at Marina Island, July 2, 1992.

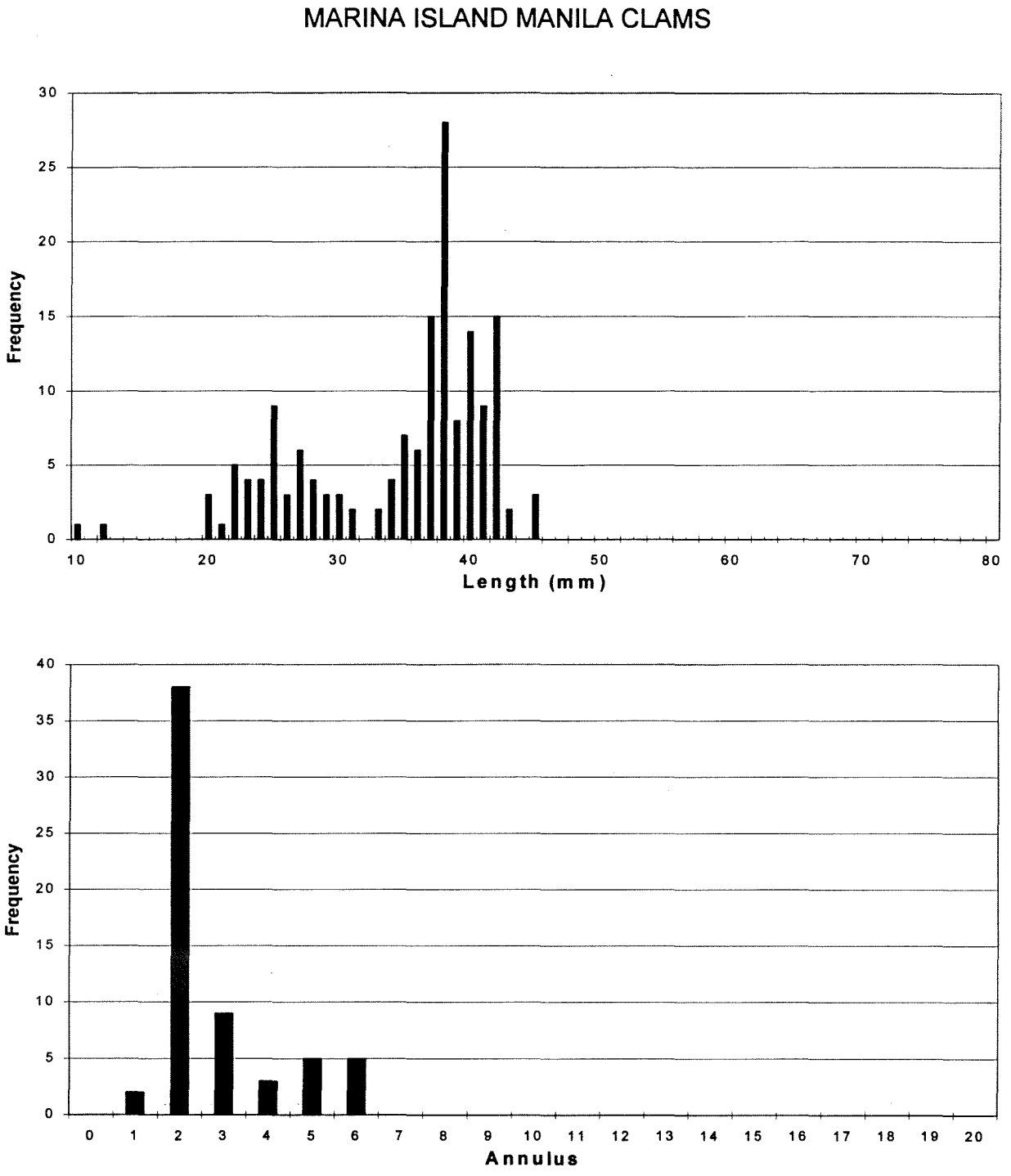

Figure 9. Length and age frequency distribution of Manila clams sampled at Marina Island, July 2, 1992

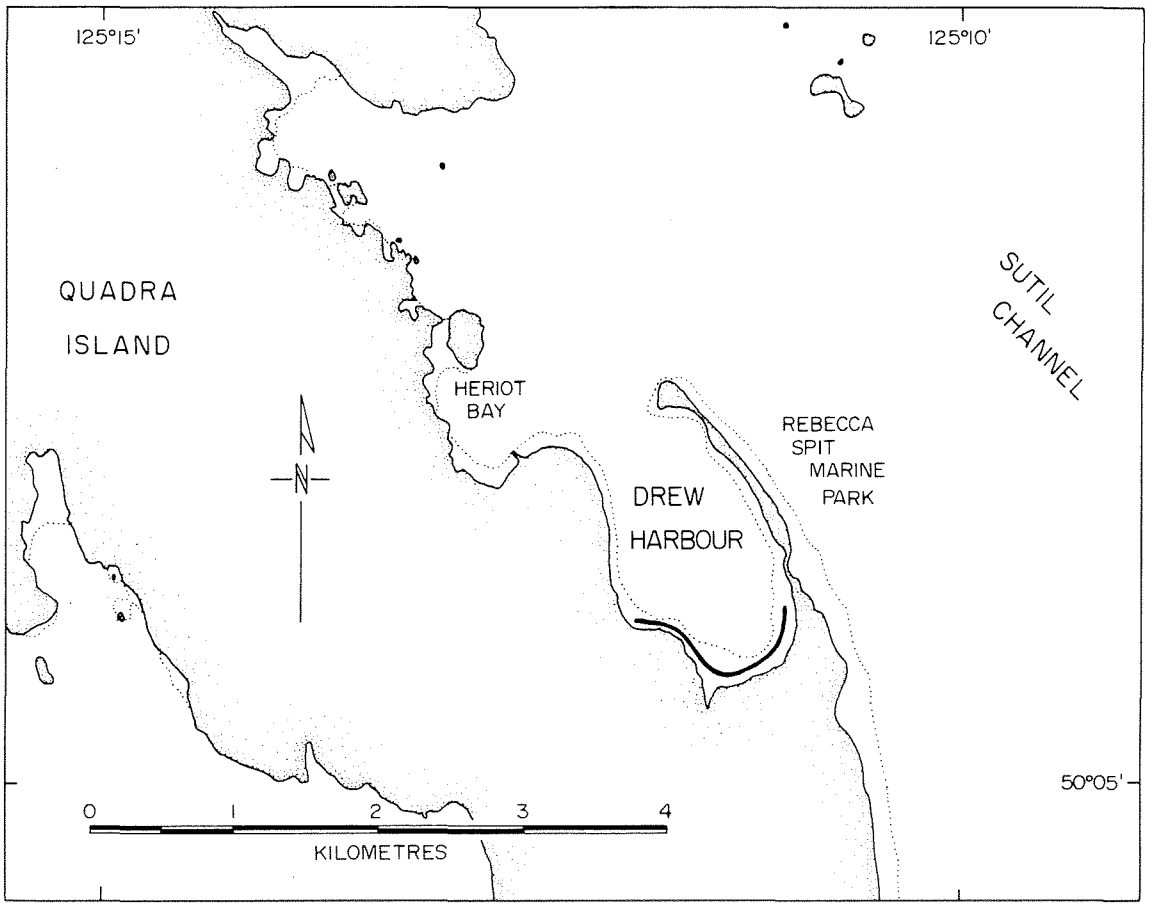

Figure 10. Map of Drew Harbour showing the location of the beach sampled, July 3, 1992.

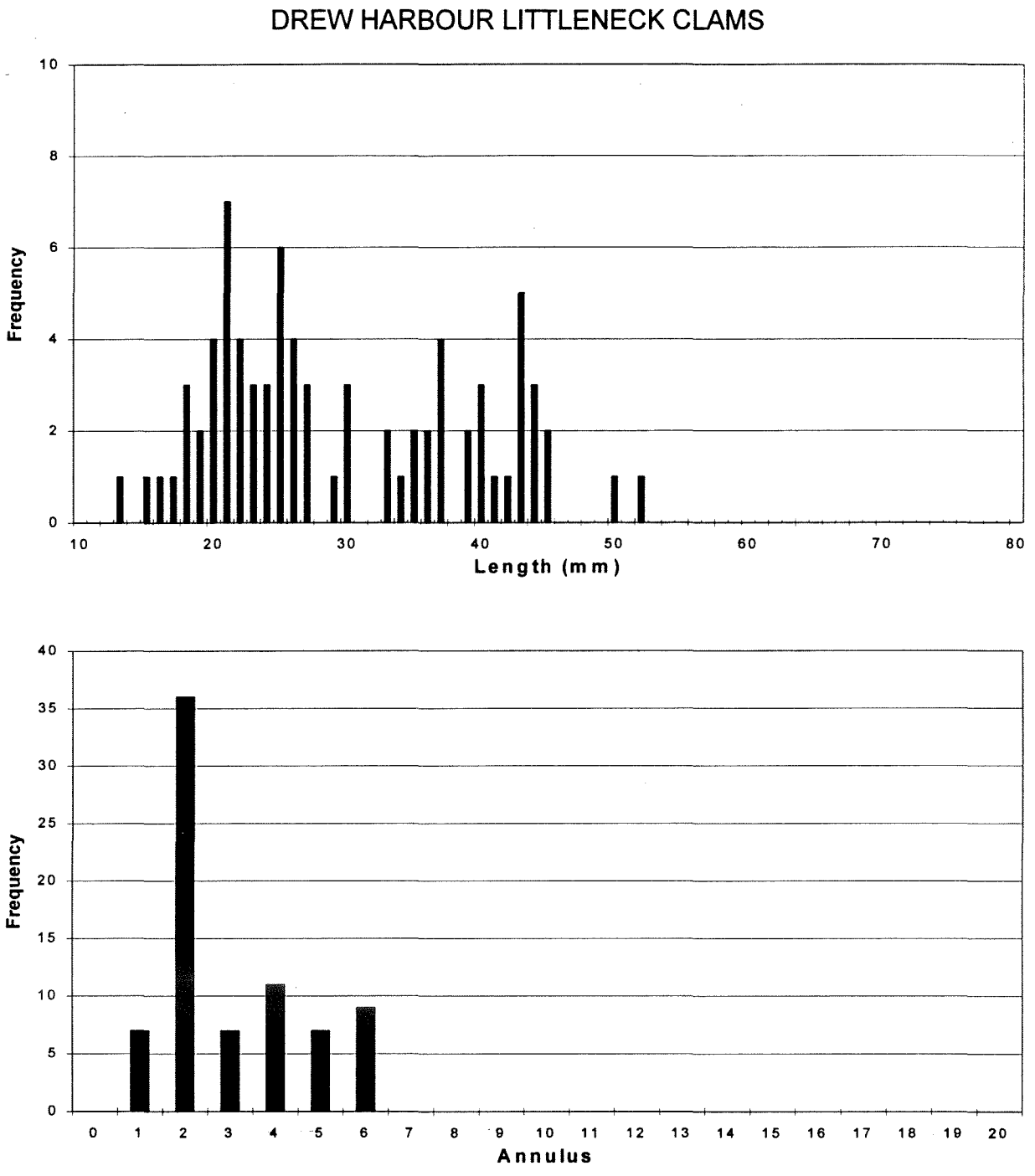

Figure 11. Length and age frequency distribution of littleneck clams sampled at Drew Harbour, July 3, 1992.

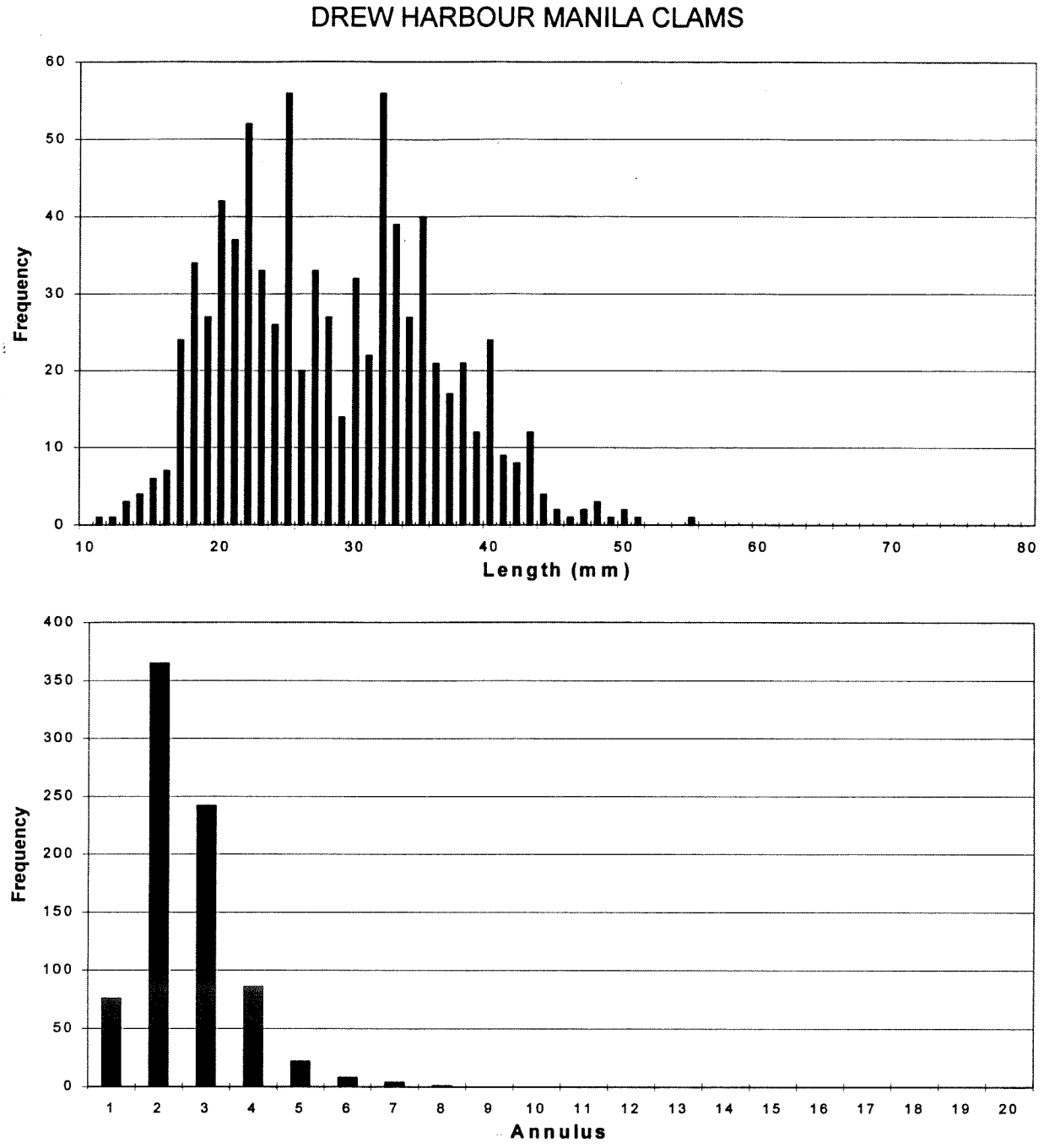

Figure 12. Length and age frequency distribution of Manila clams sampled at Drew Harbour, July 3, 1992.

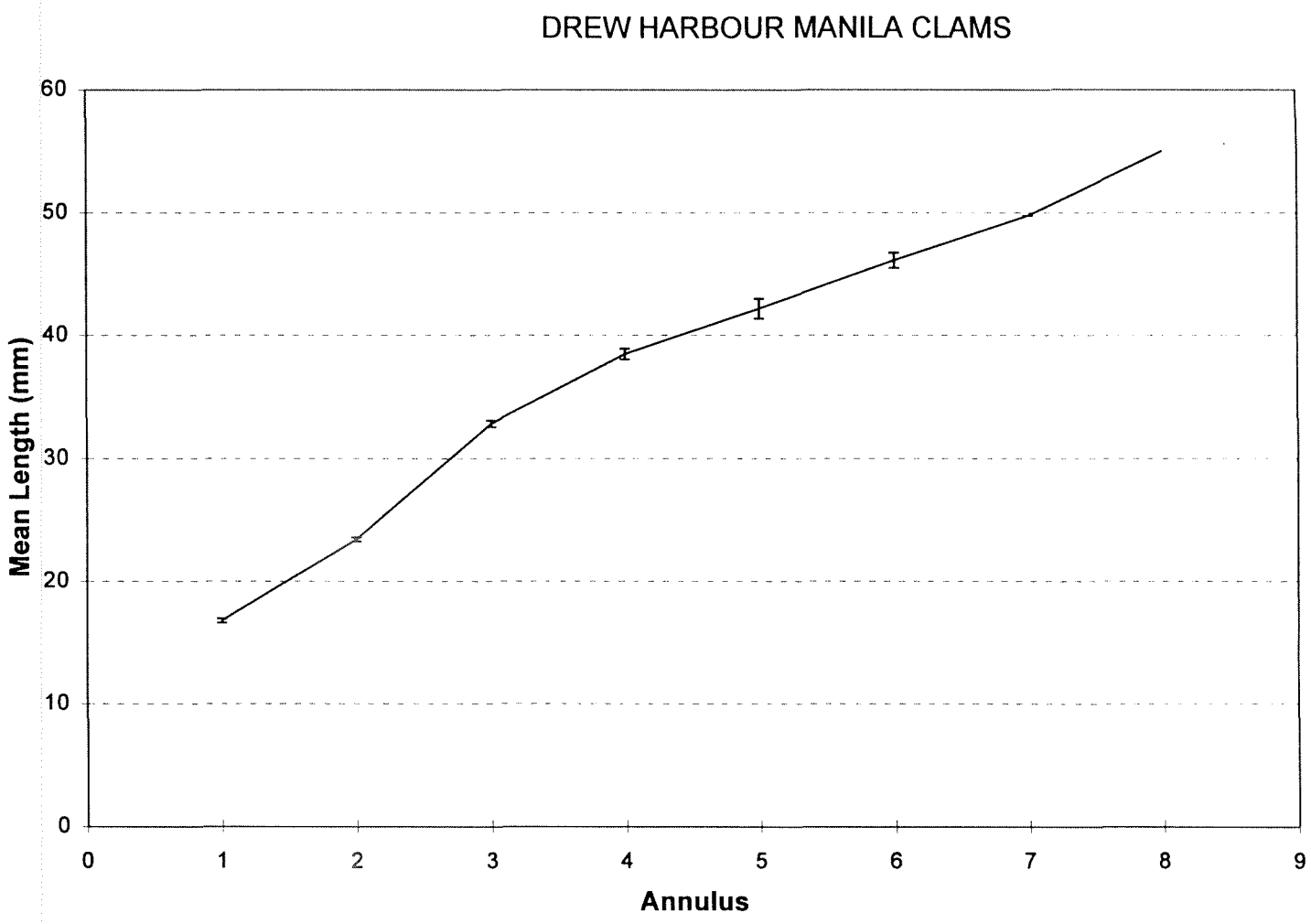

Figure 13. Growth rate of Manila clams from Drew Harbour, July 3, 1992. Error bars = +/- 1 SE.

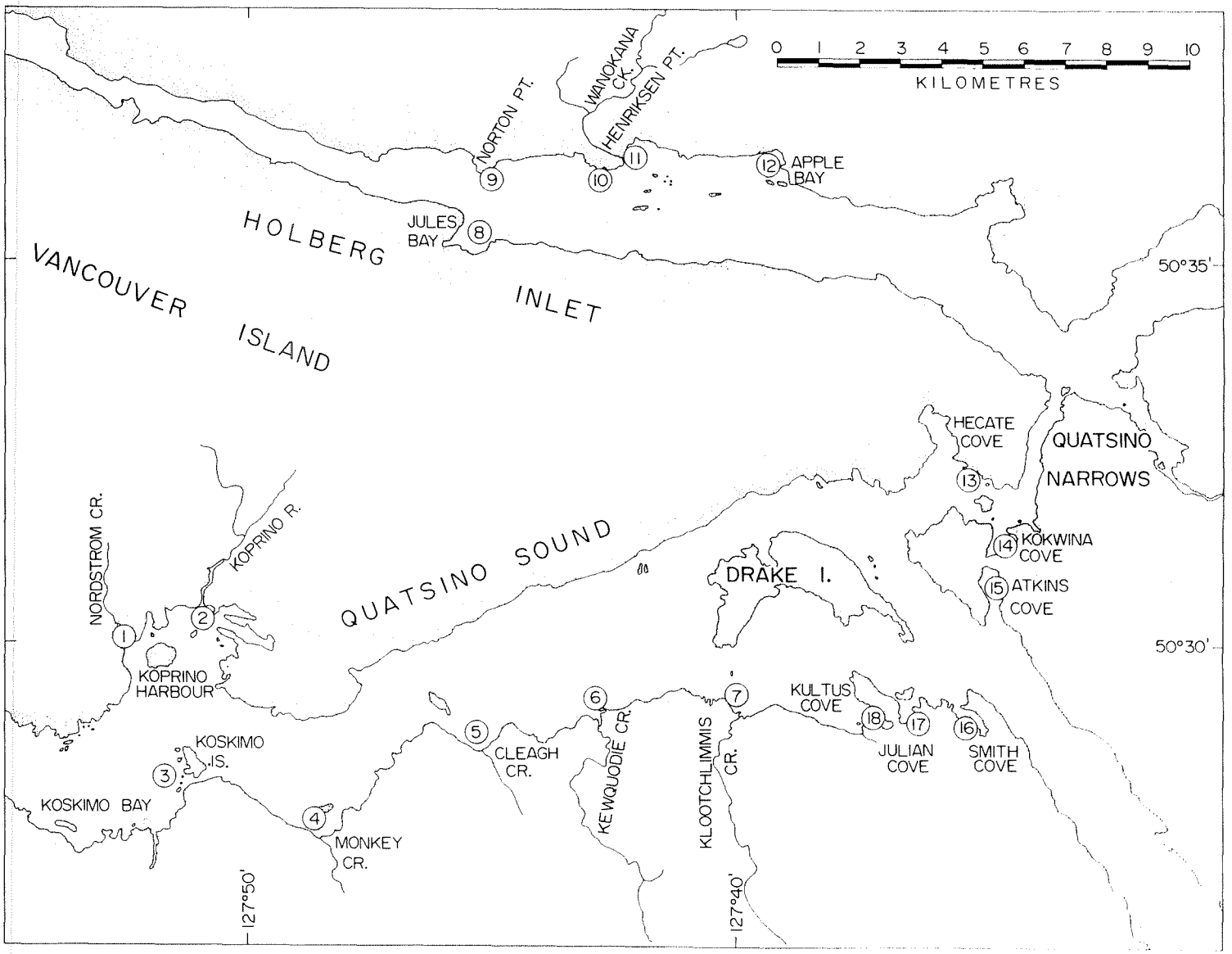

Figure 14. Map of the Quatsino Sound - Holberg Inlet area showing the location of beaches visited, July 15 and 16, 1993.

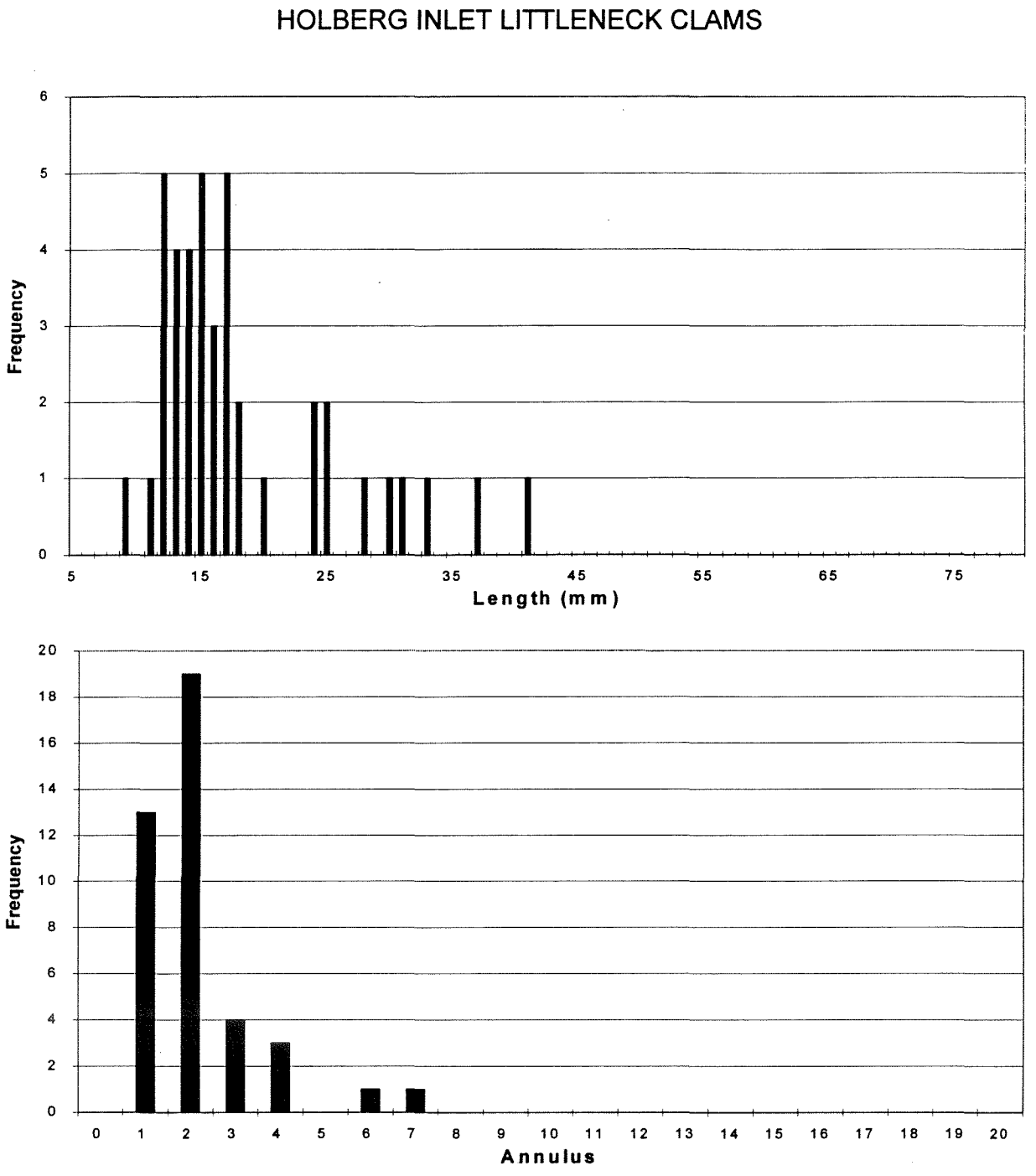

Figure 15. Length and age frequency distribution of littleneck clams sampled at Holberg Inlet, Quatsino Sound, July 16, 1993

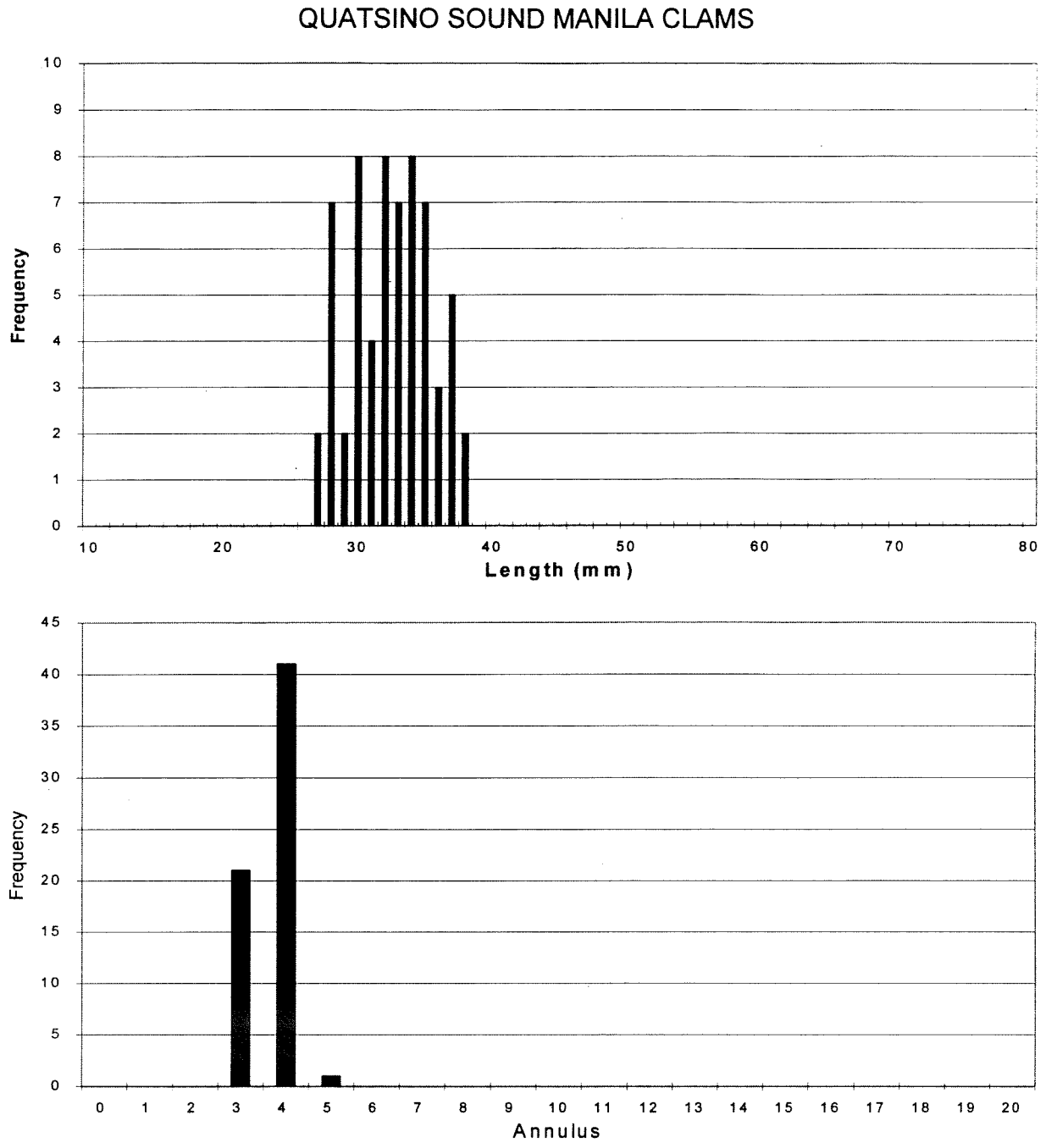

Figure 16. Length and age frequency of Manila clams sampled at Quatsino Sound, July 16, 1993.

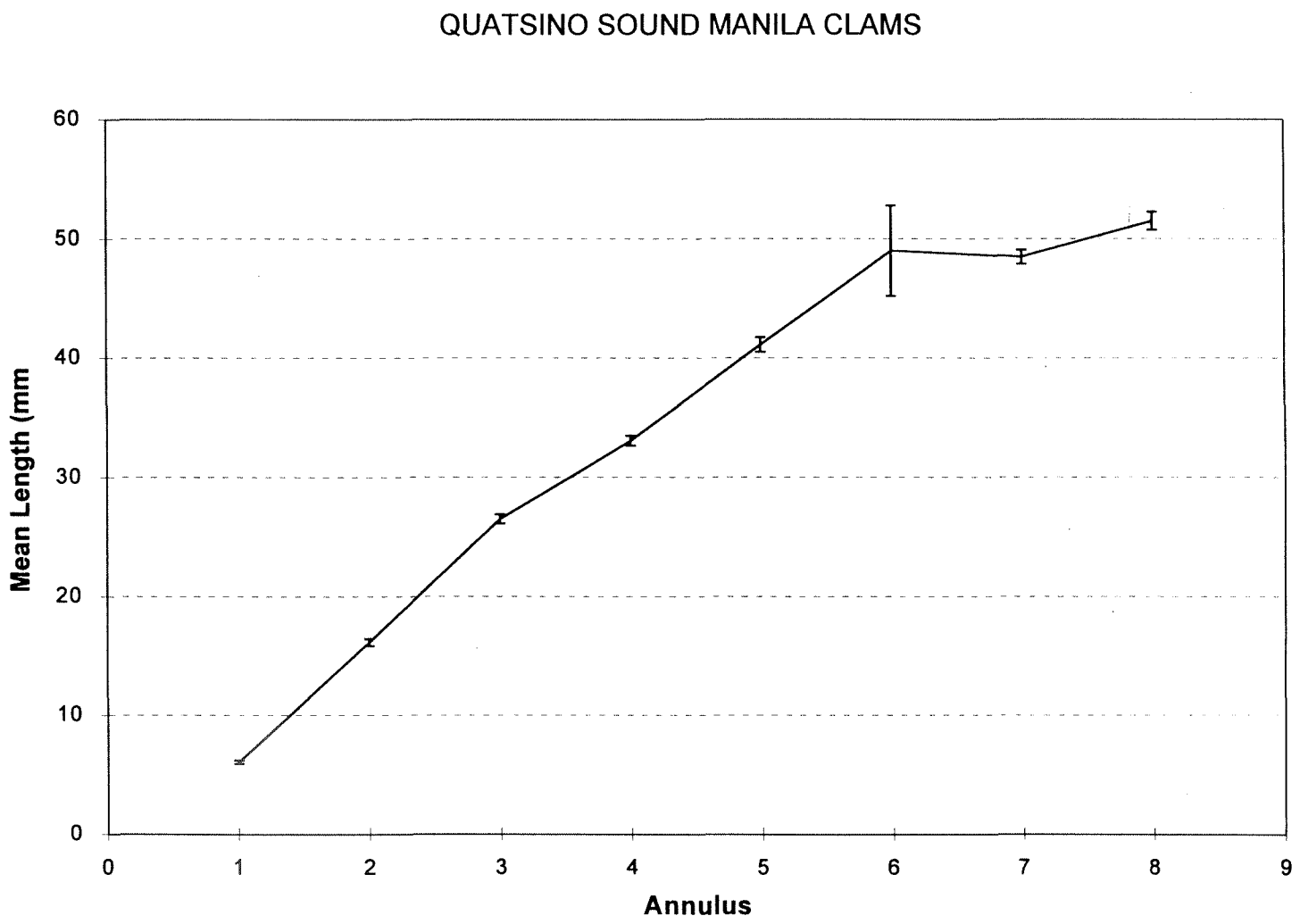

Figure 17. Growth rate of Manila clams from Quatsino Sound, July 16, 1993. Error bars = +/- 1 SE.

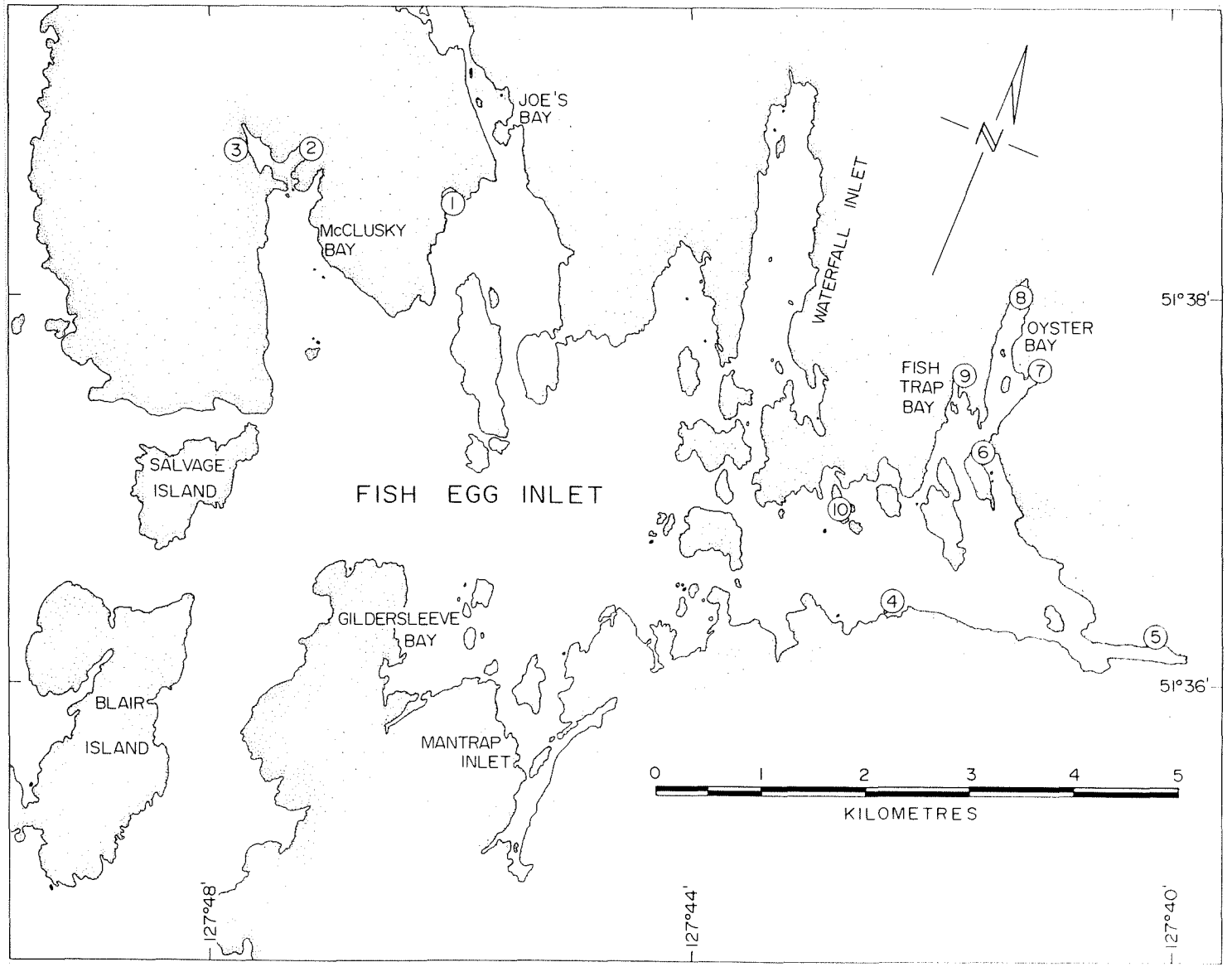

Figure 18. Map of Fish Egg Inlet showing the location of beaches visited, July 17, 1993.

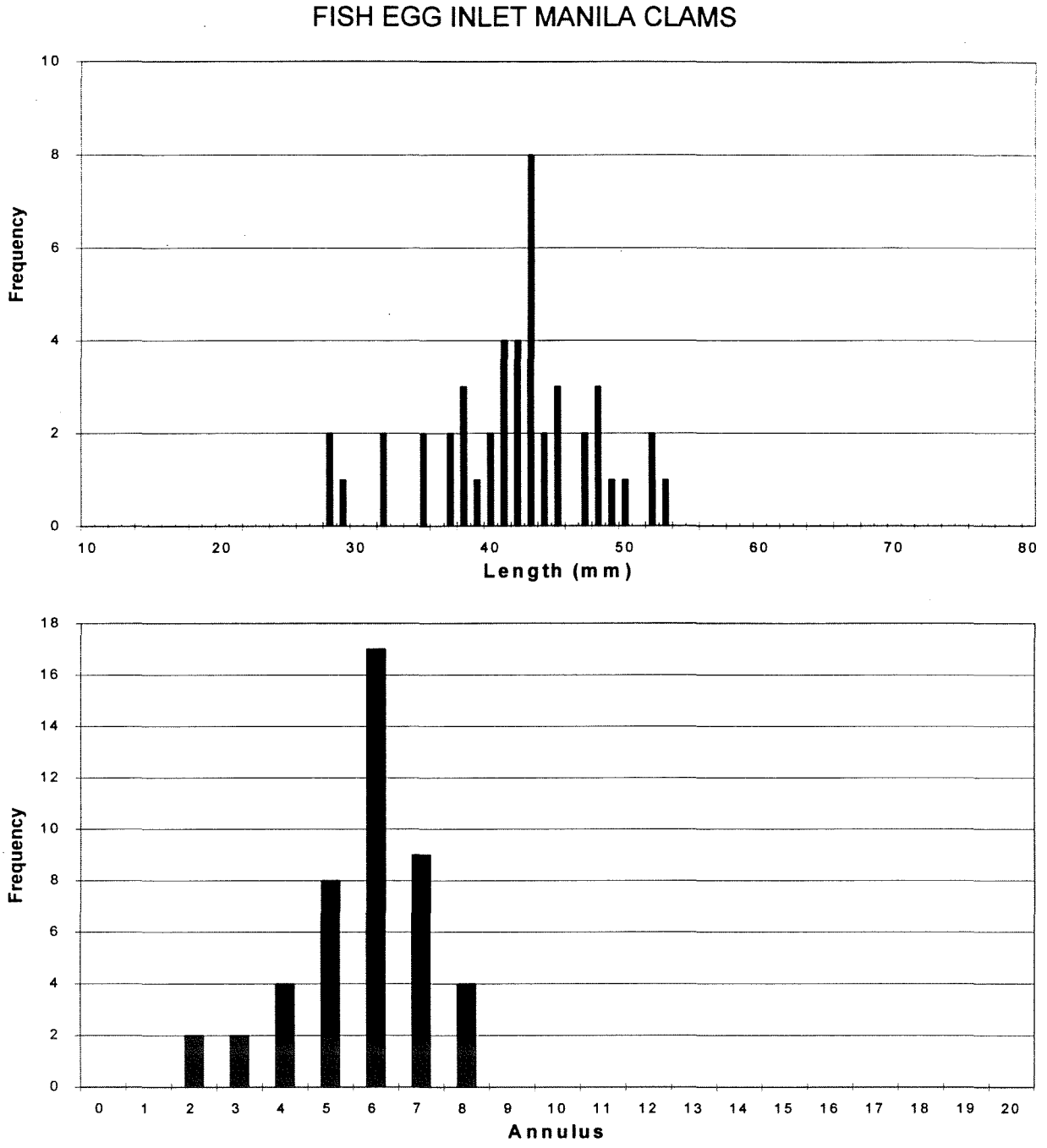

Figure 19. Length and age frequency distribution of Manila clams sampled in Fish Egg Inlet July 17, 1993.

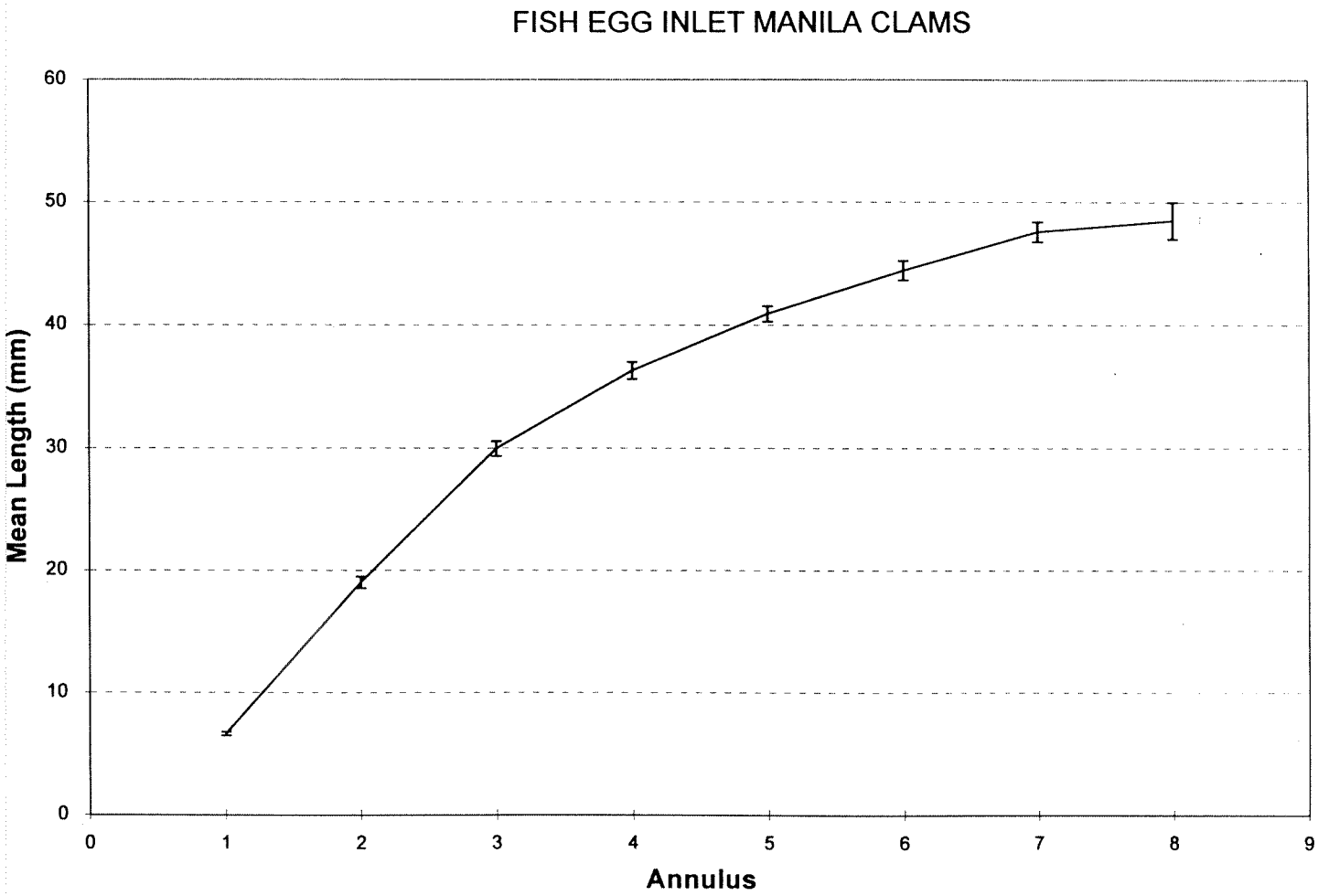

Figure 20. Growth rate of Fish Egg Inlet Manila clams , July 17, 1993. Error bars = +/- 1 SE,

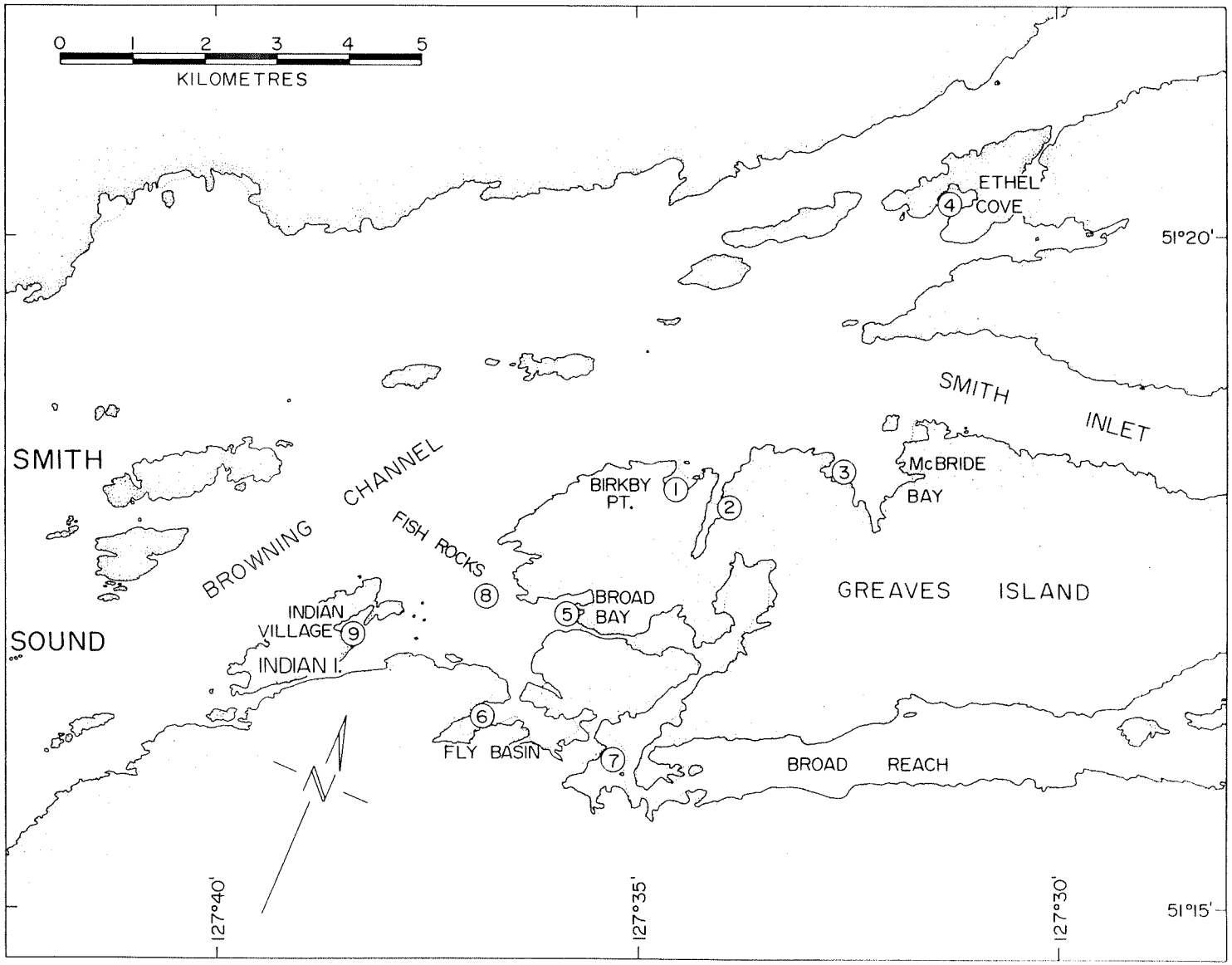

Figure 21. Map of Smith Sound showing the location of beaches visited, July 18, 1993.

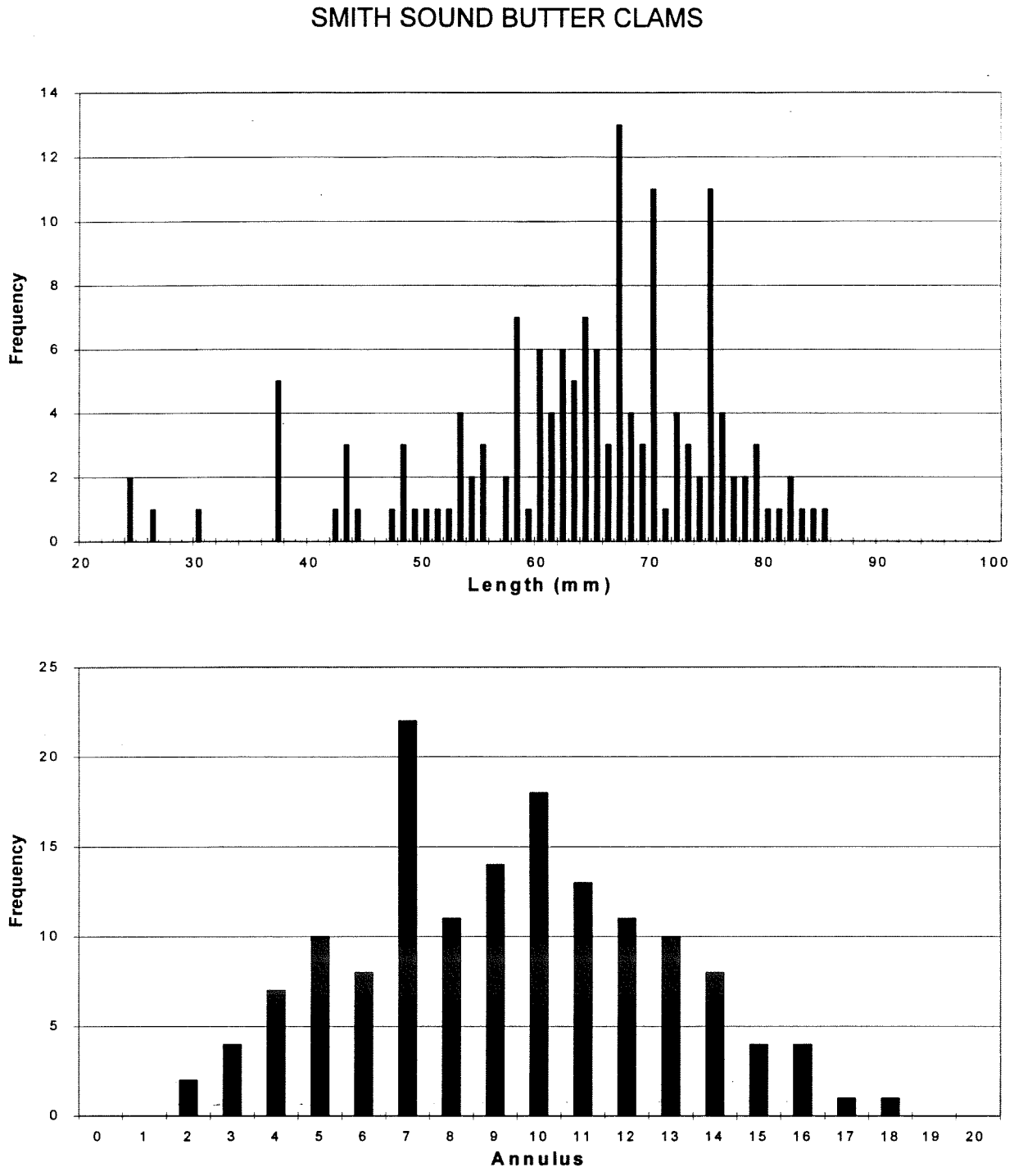

Figure 22. Length and age frequency distribution of butter clams sampled in Smith Sound, July 18, 1993.

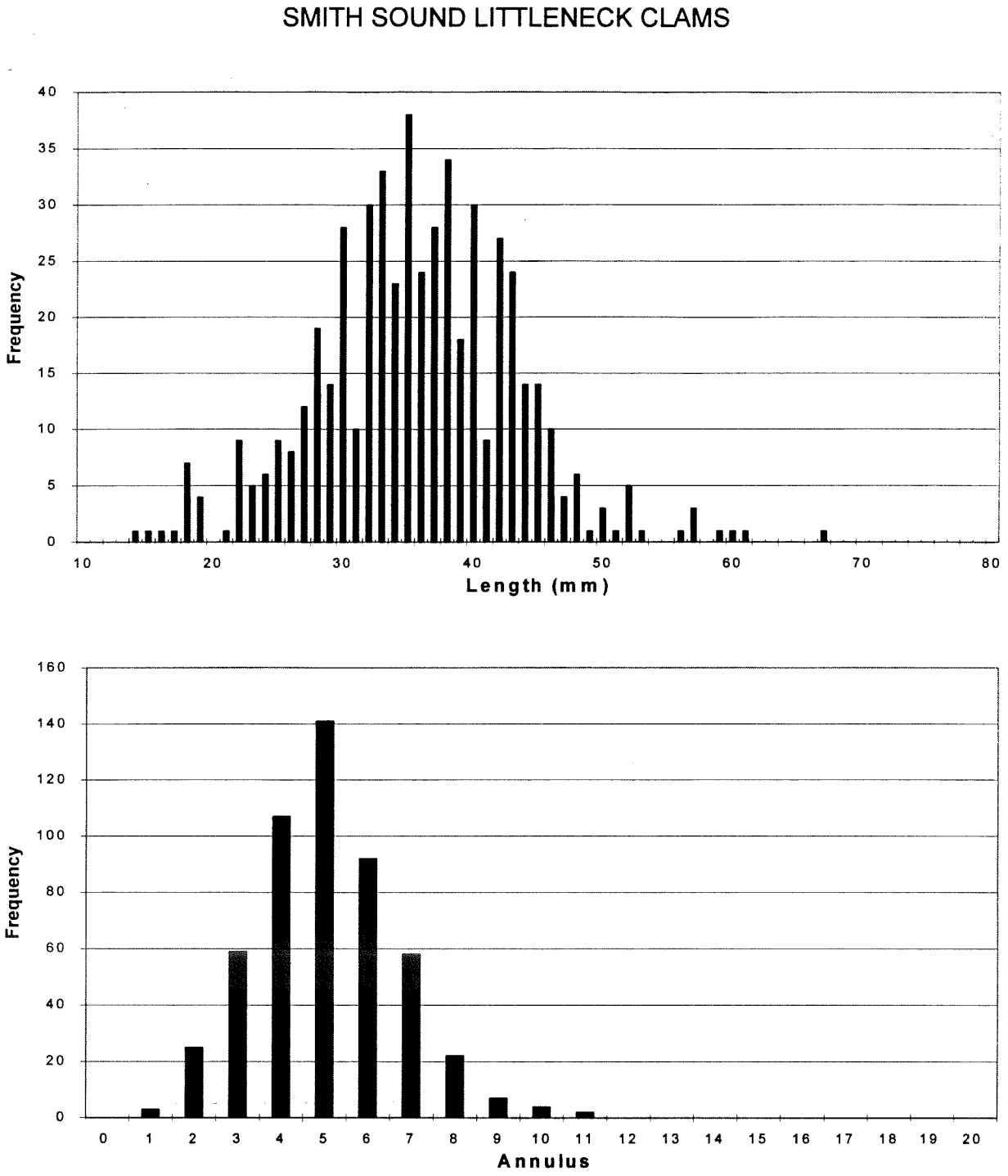

Figure 23. Length and age frequency distribution of littleneck clams sampled in Smith Sound, July 18, 1993.

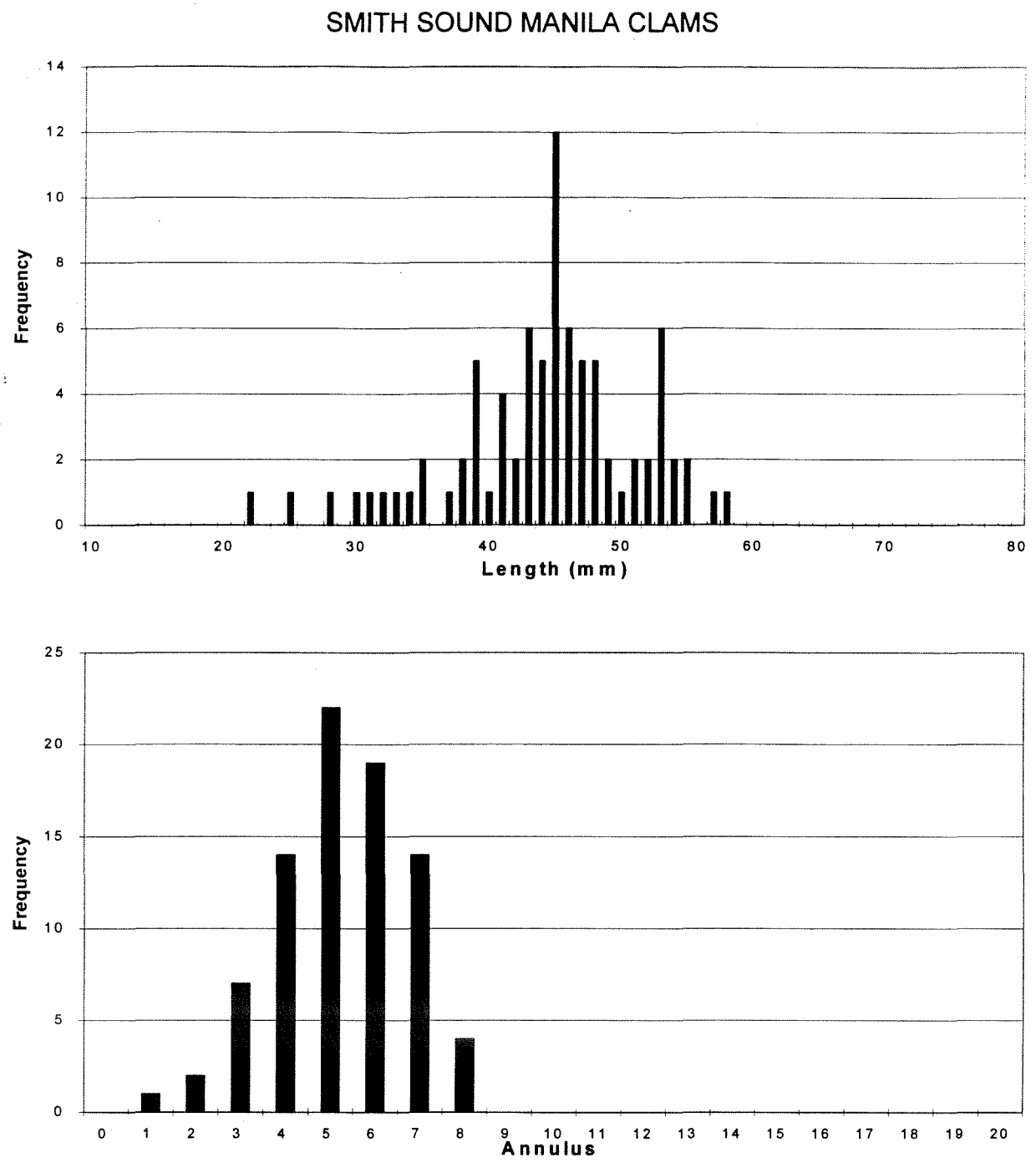

Figure 24. Length and age frequency distribution of Manila clams sampled in Smith Sound, July 18, 1993.

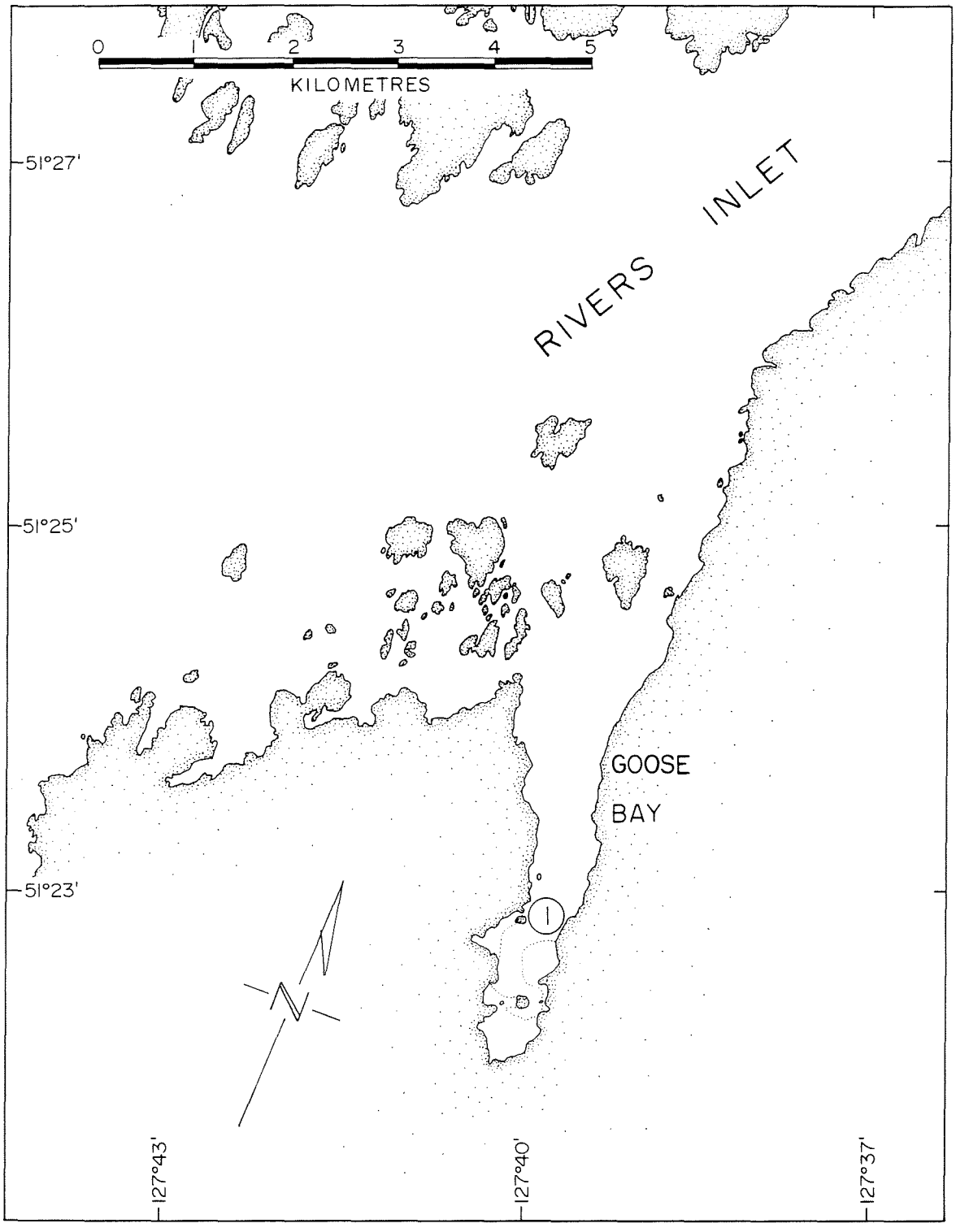

Figure 26. Map of Goose Bay, Rivers Inlet, showing the location of beaches visited, July 18, 1993.

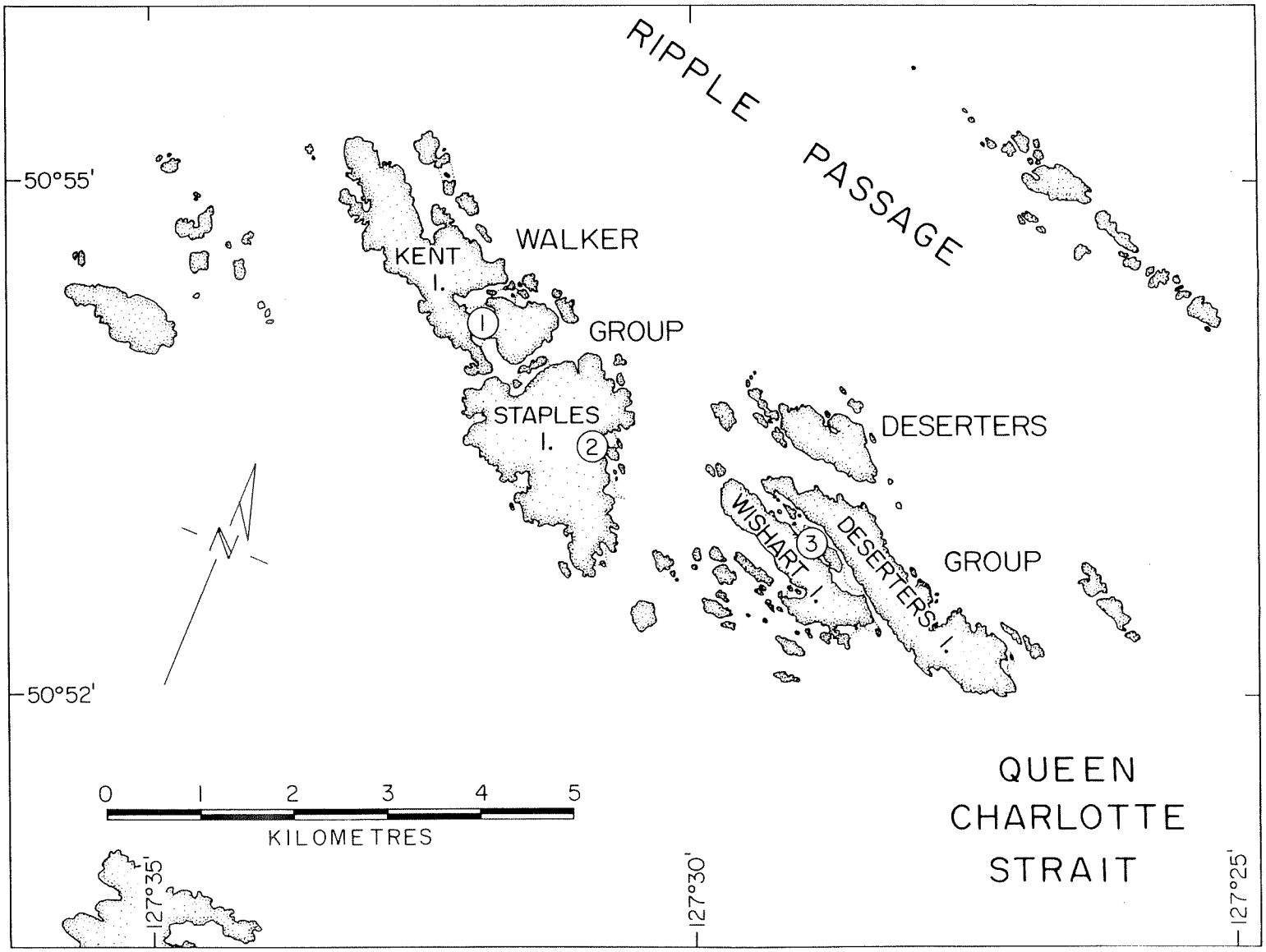

Figure 27. Map of the Walker and Deserters Groups, Queen Charlotte Strait, showing the location of beaches visited, July 19, 1993.

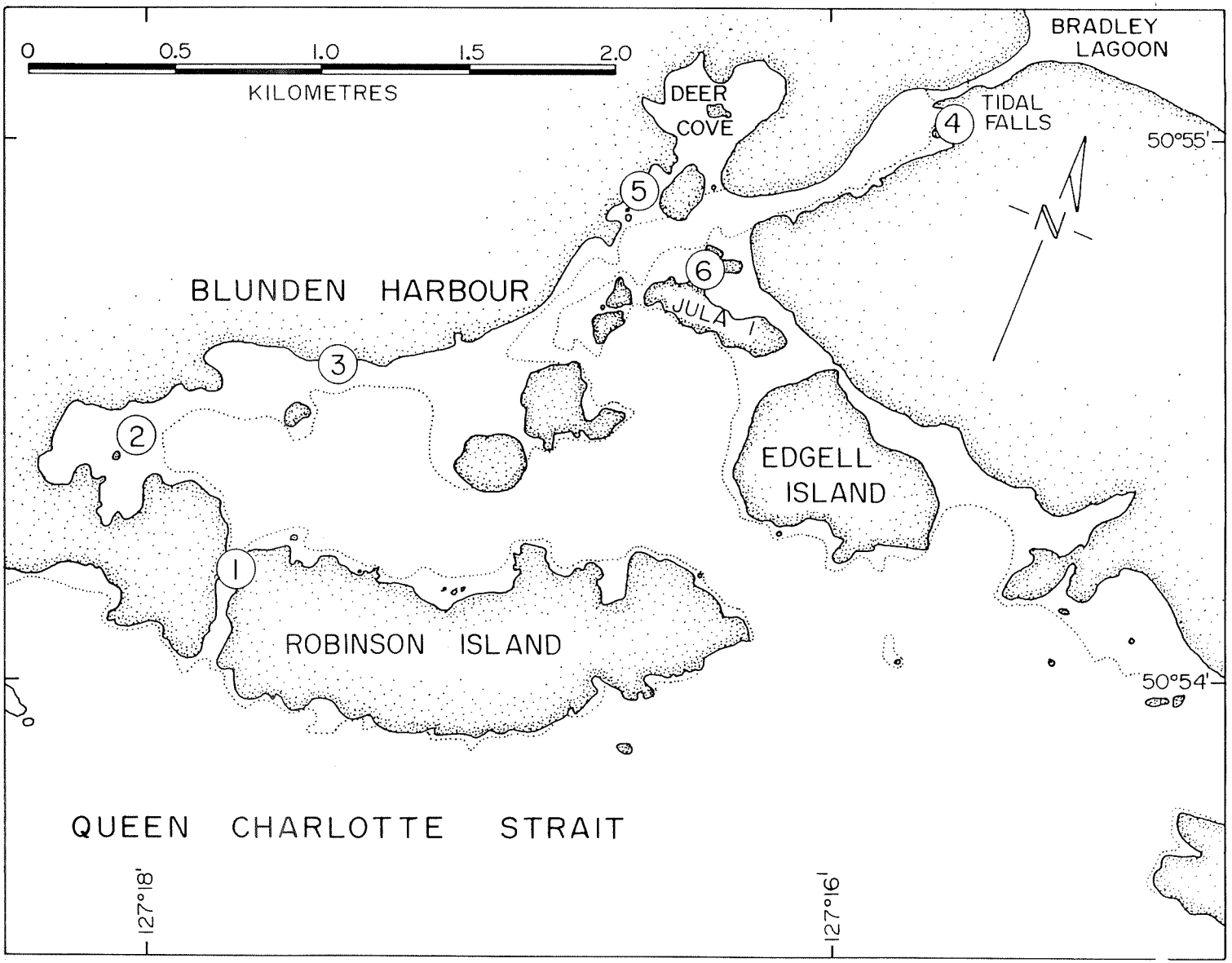

Figure 28. Map of Blunden Harbour, Queen Charlotte Strait, showing the location of beaches visited, July 19, 1993.

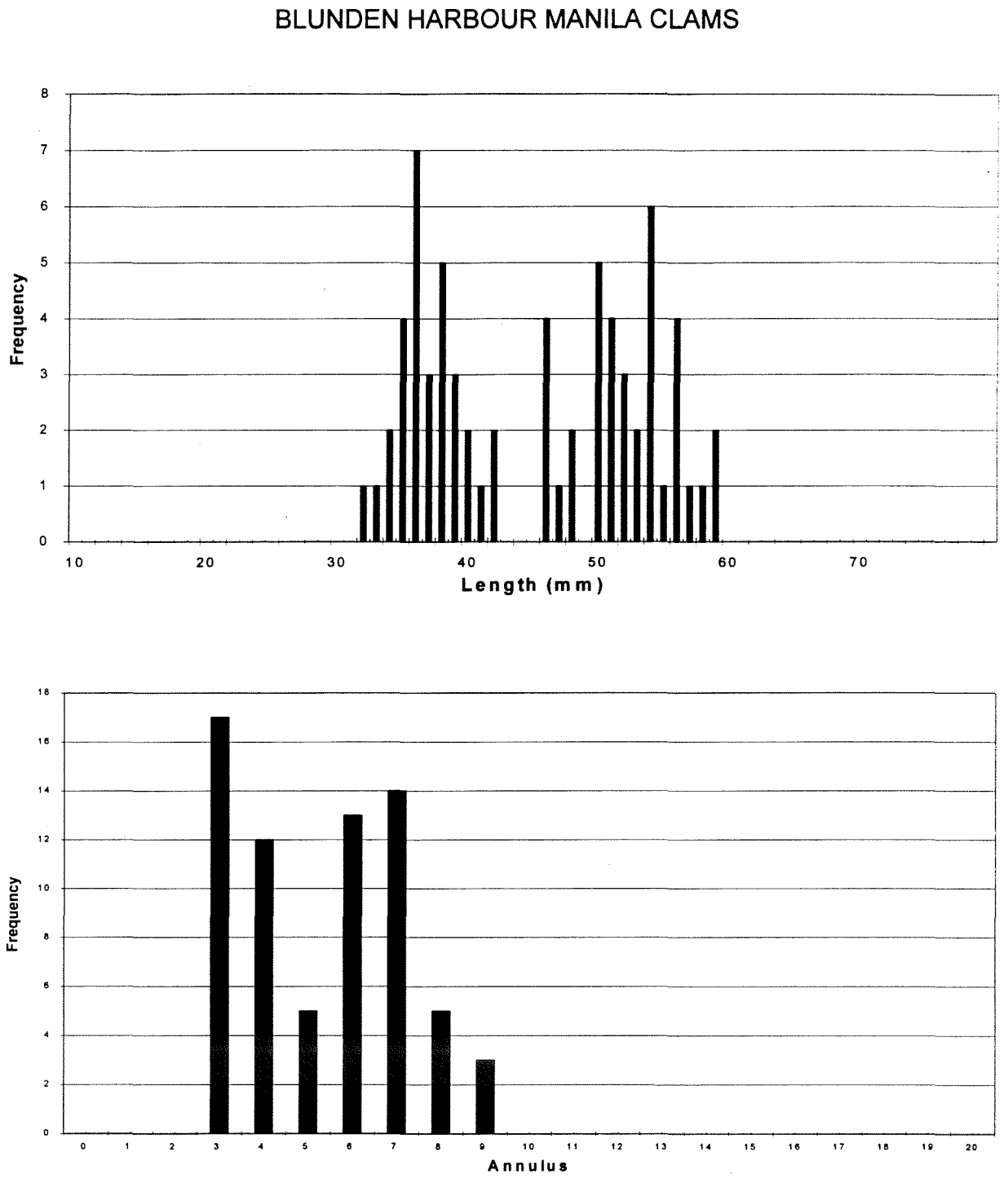

Figure 29. Length and age frequency distribution of Manila clams sampled in Blunden Harbour, July 19,1993.

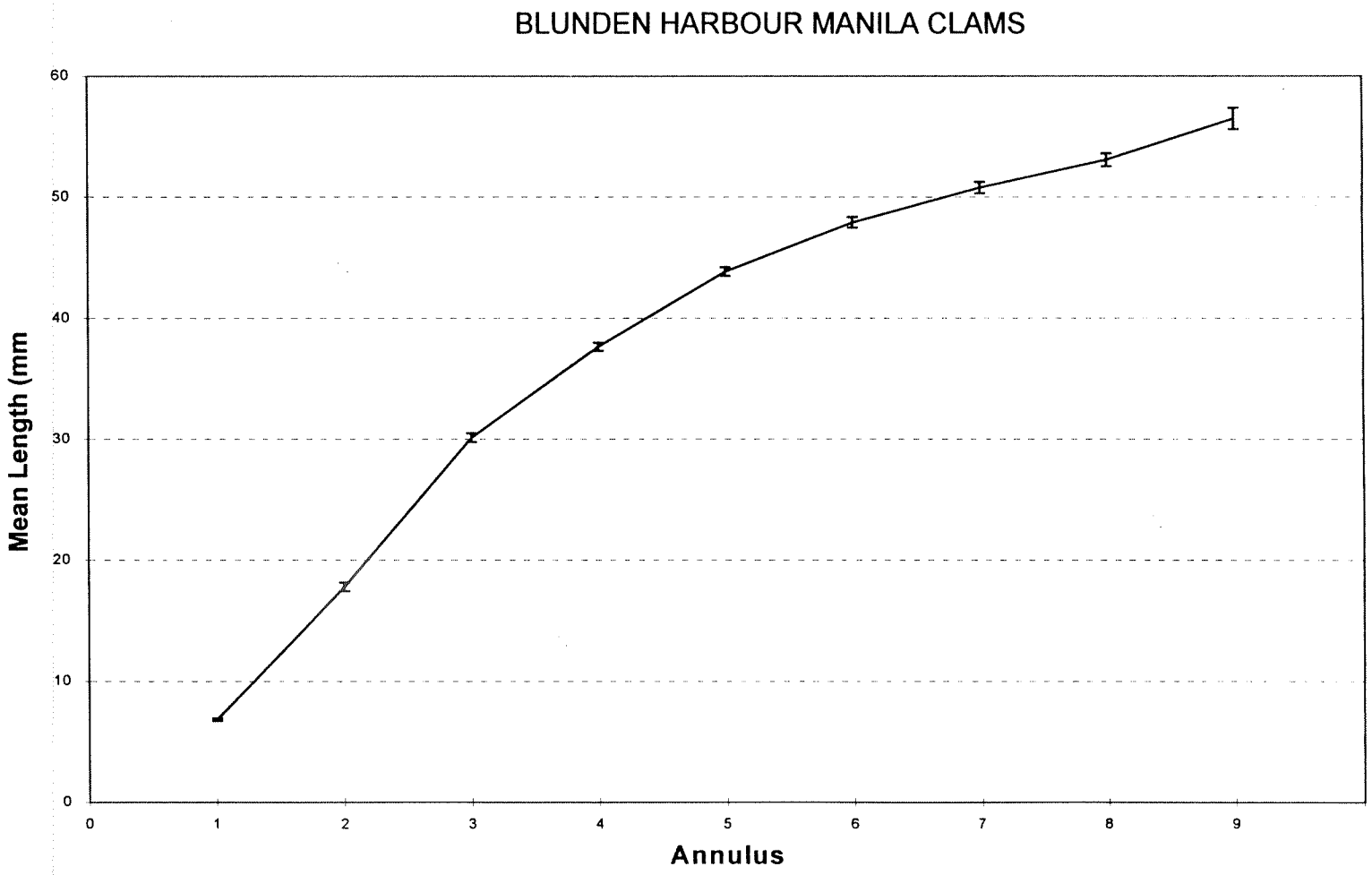

Figure 30. Growth rate of Manila clams from Blunden Harbour, July 19, 1993. Error bars = +/- 1 SE.

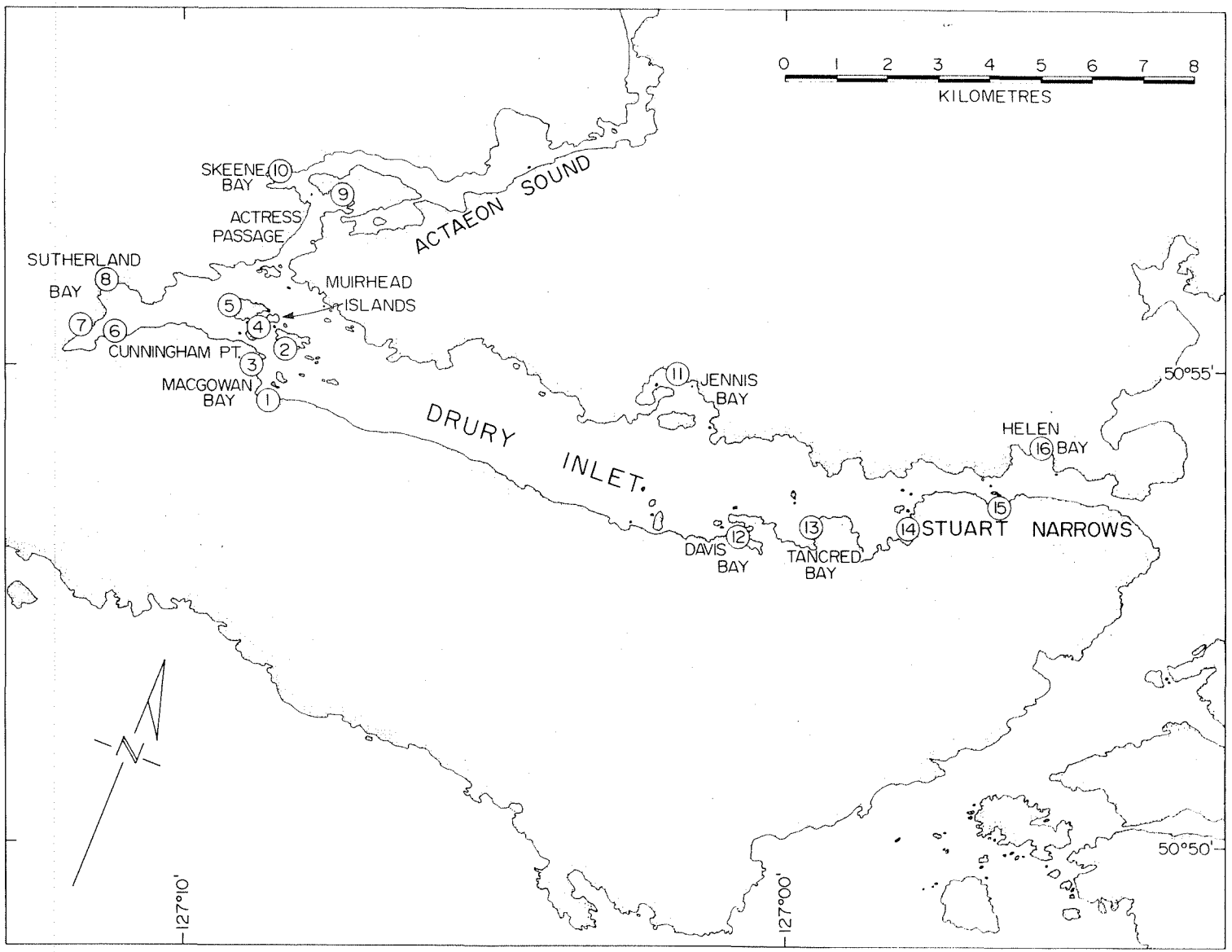

Figure 31. Map of Drury Inlet showing the location of beaches visited, July 20, 1993.

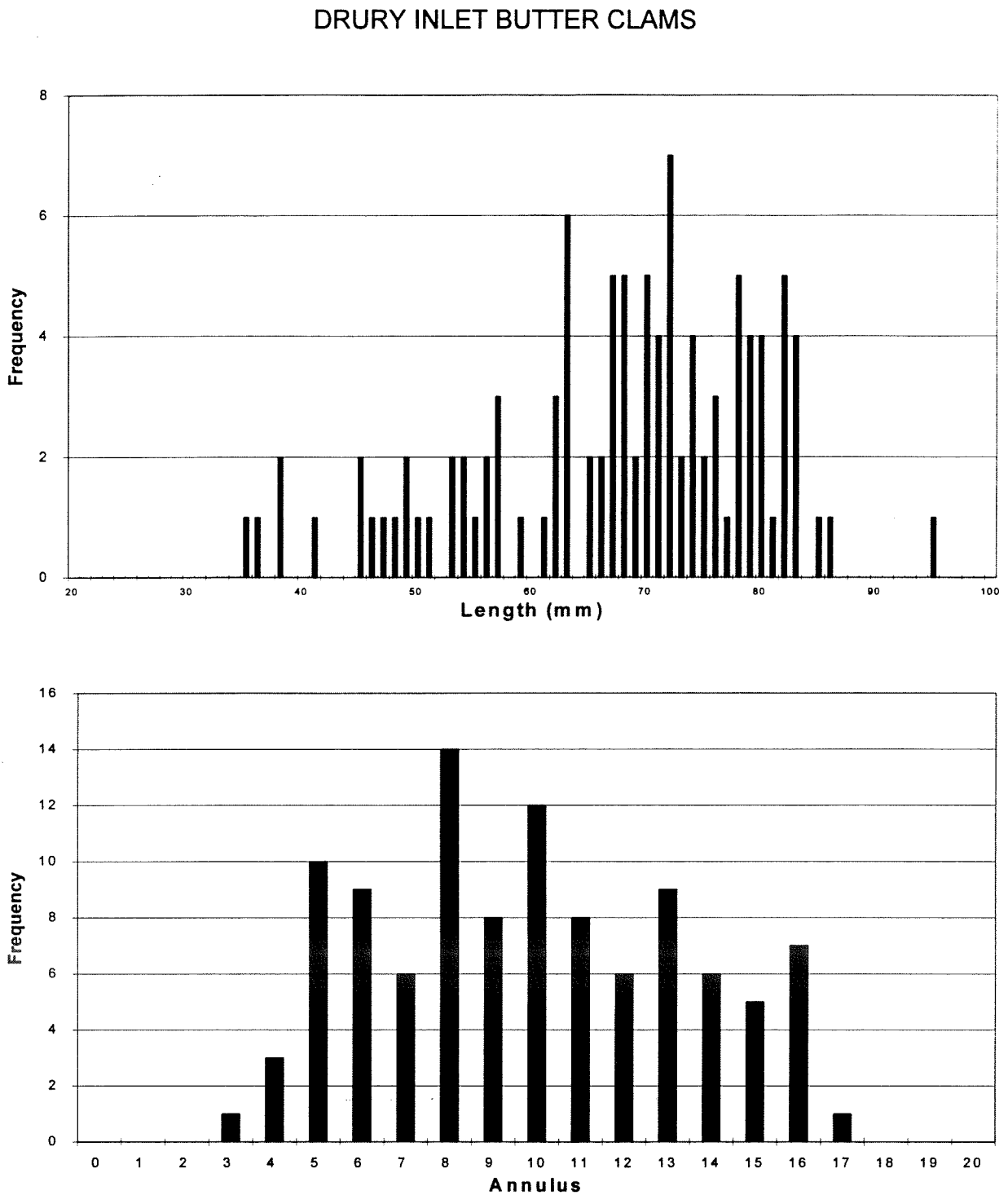

Figure 32. Length and age frequency distribution of butter clams sampled in Drury Inlet, July 20, 1993.

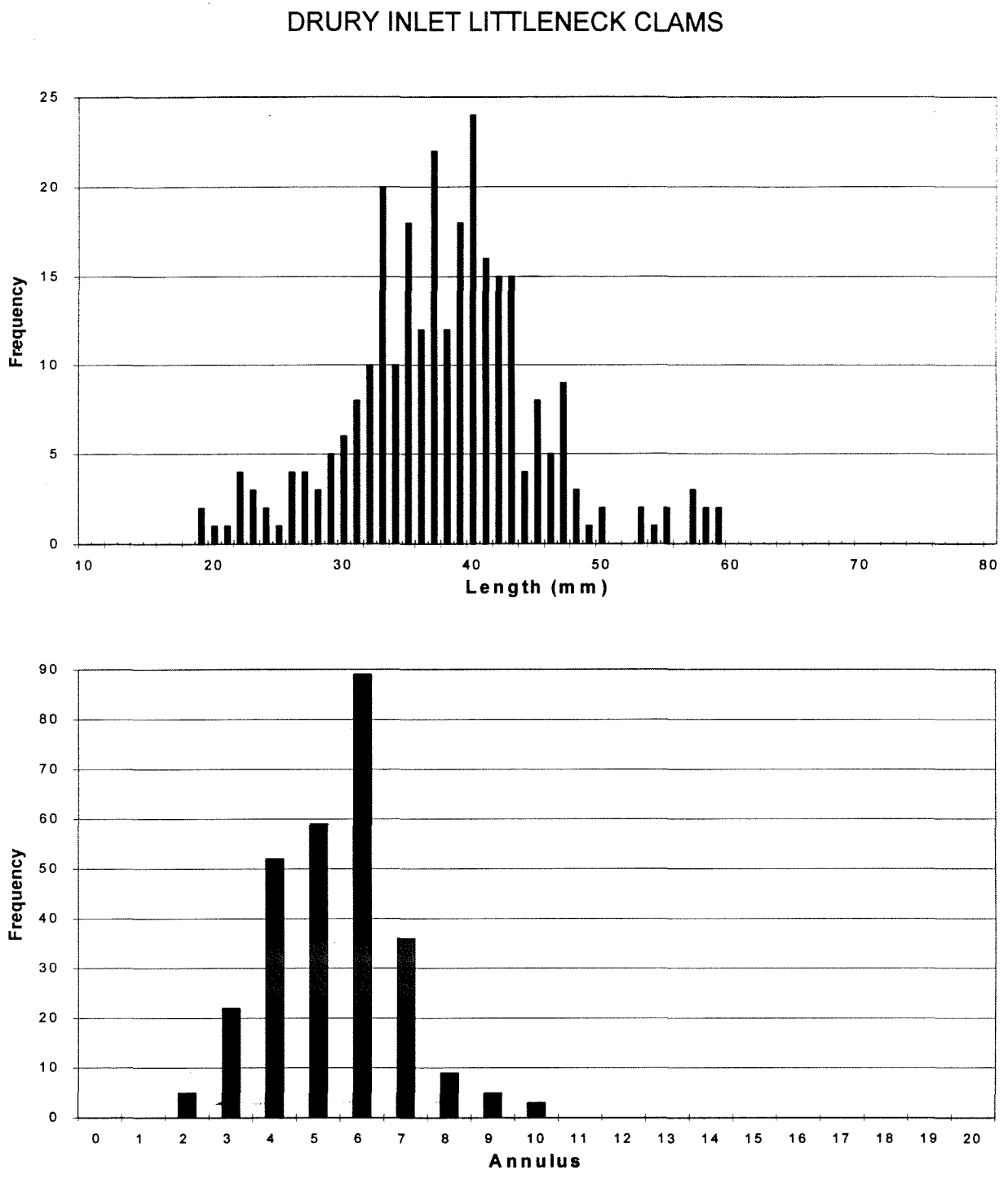

Figure 33. Length and age frequency distribution of littleneck clams sampled in Drury Inlet, July 20, 1993.

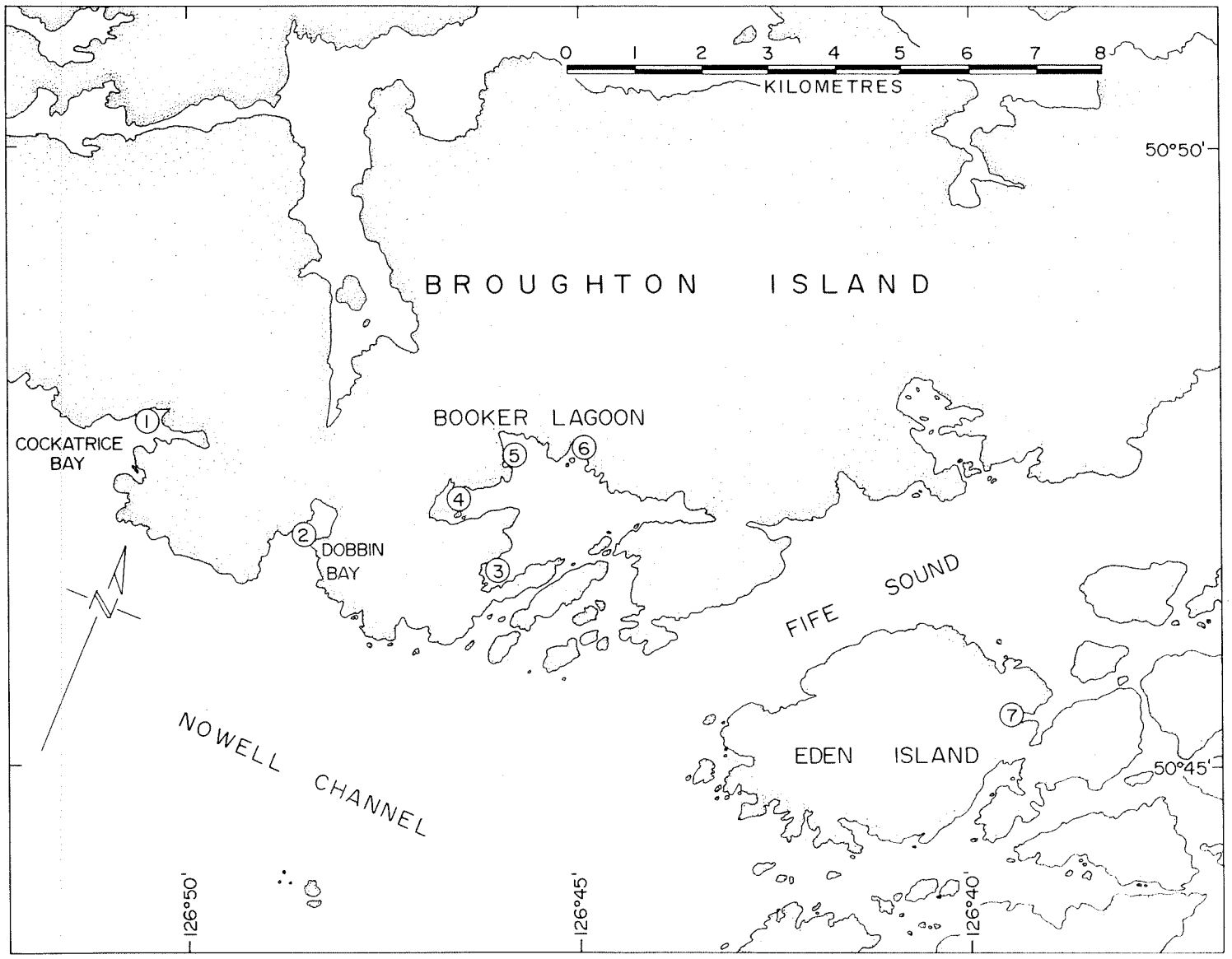

Figure 34. Map of the Nowell Channel - Fife Sound area showing the location of beaches visited, July 21, 1993.

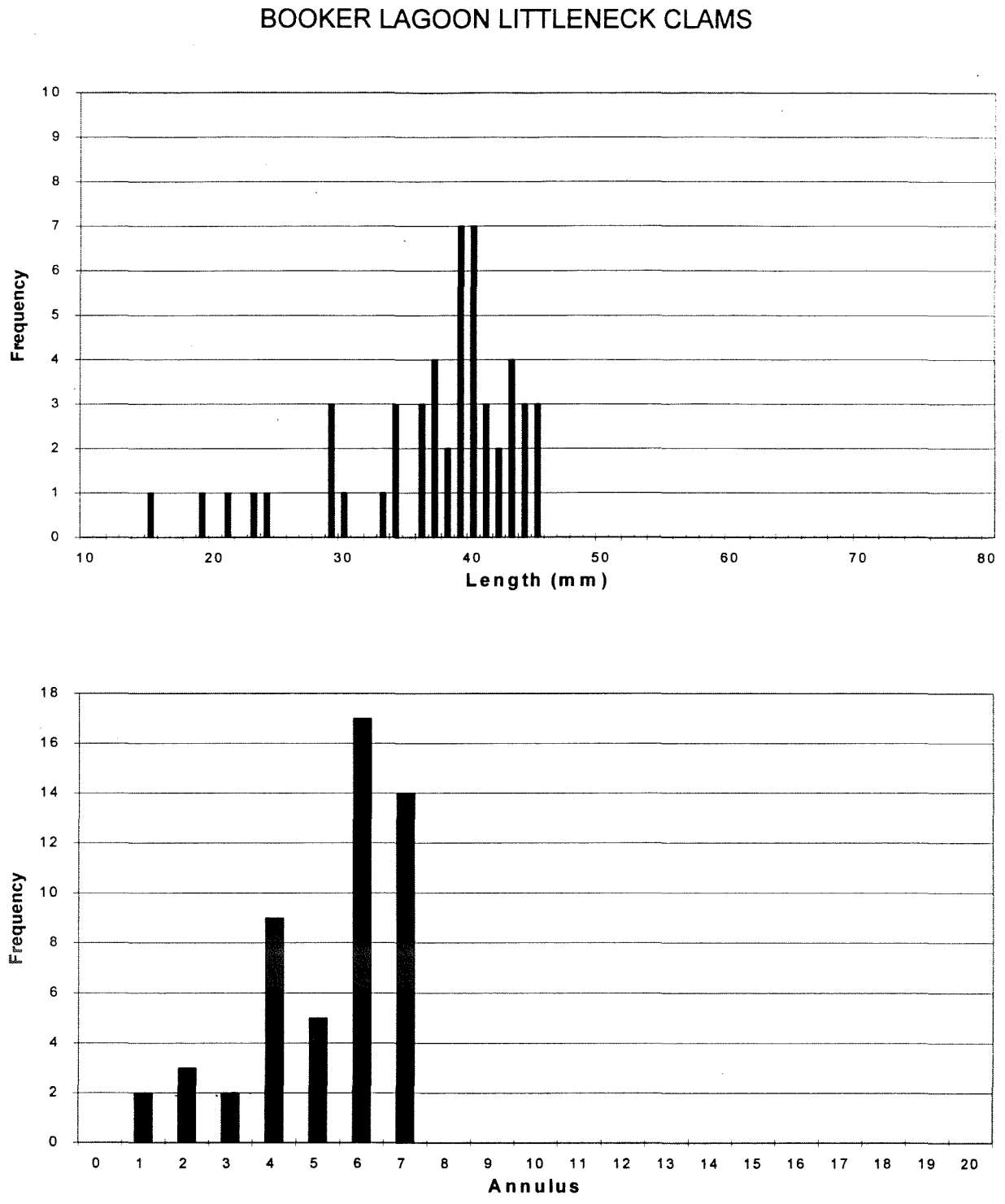

Figure 35. Length and age frequency distribution of littleneck clams sampled in Booker Lagoon, July 23, 1993.

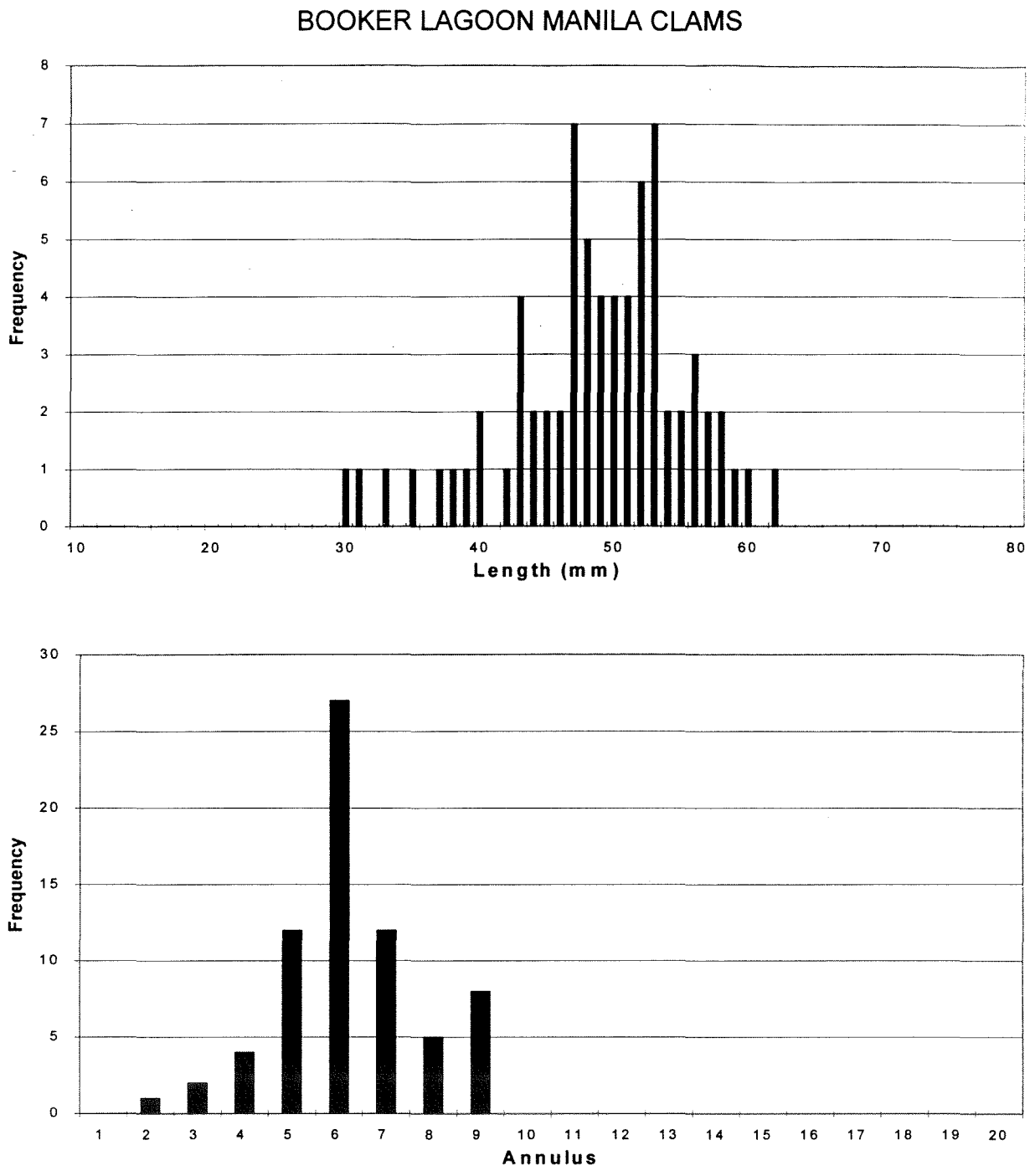

Figure 36. Length and age frequency distribution of Manila clams sampled in Booker Lagoon, July 21, 1993.

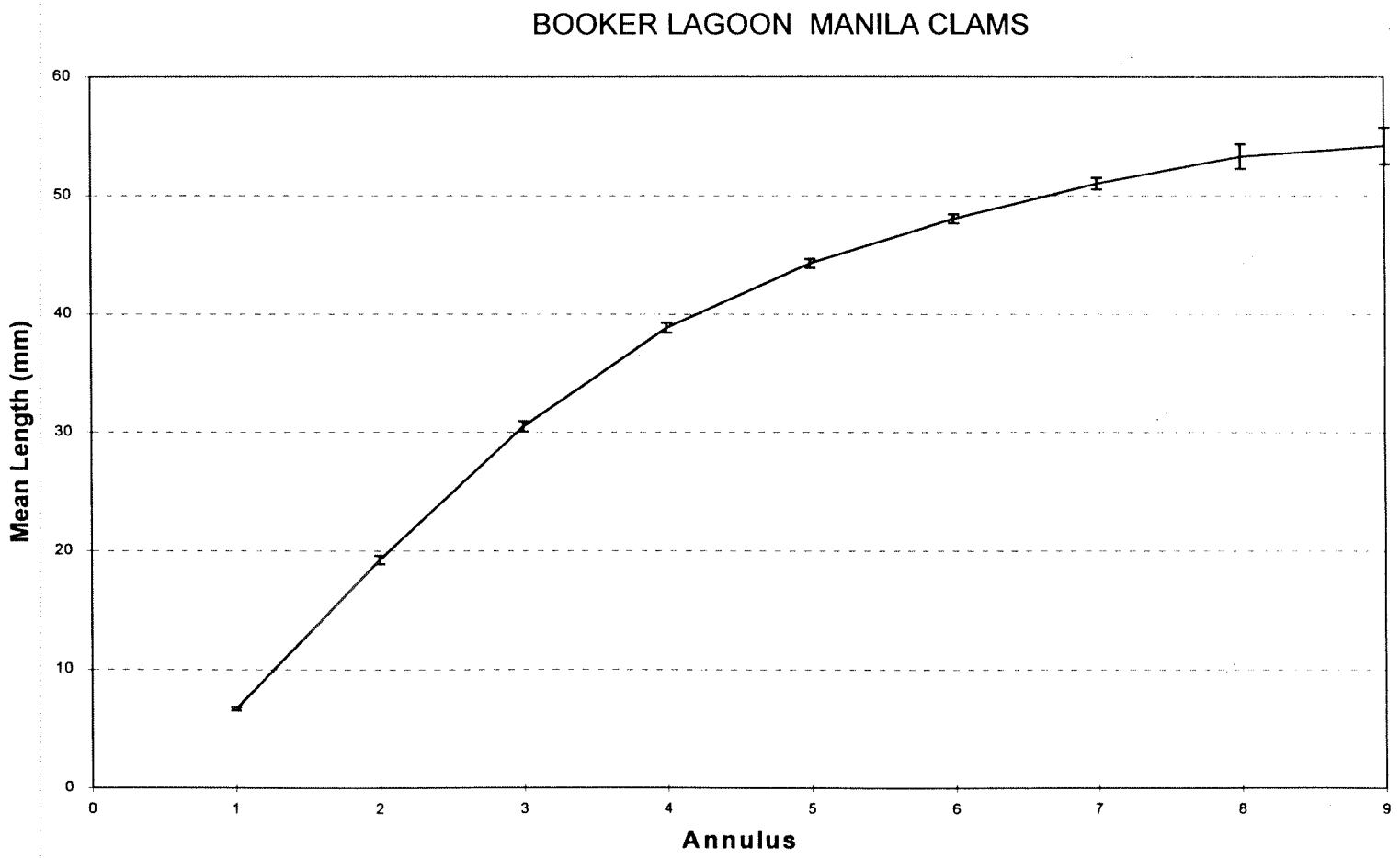

Figure 37. Growth rate of Manila clams from Booker Lagoon July 21, 1993. Error bars = +/- 1 SE.

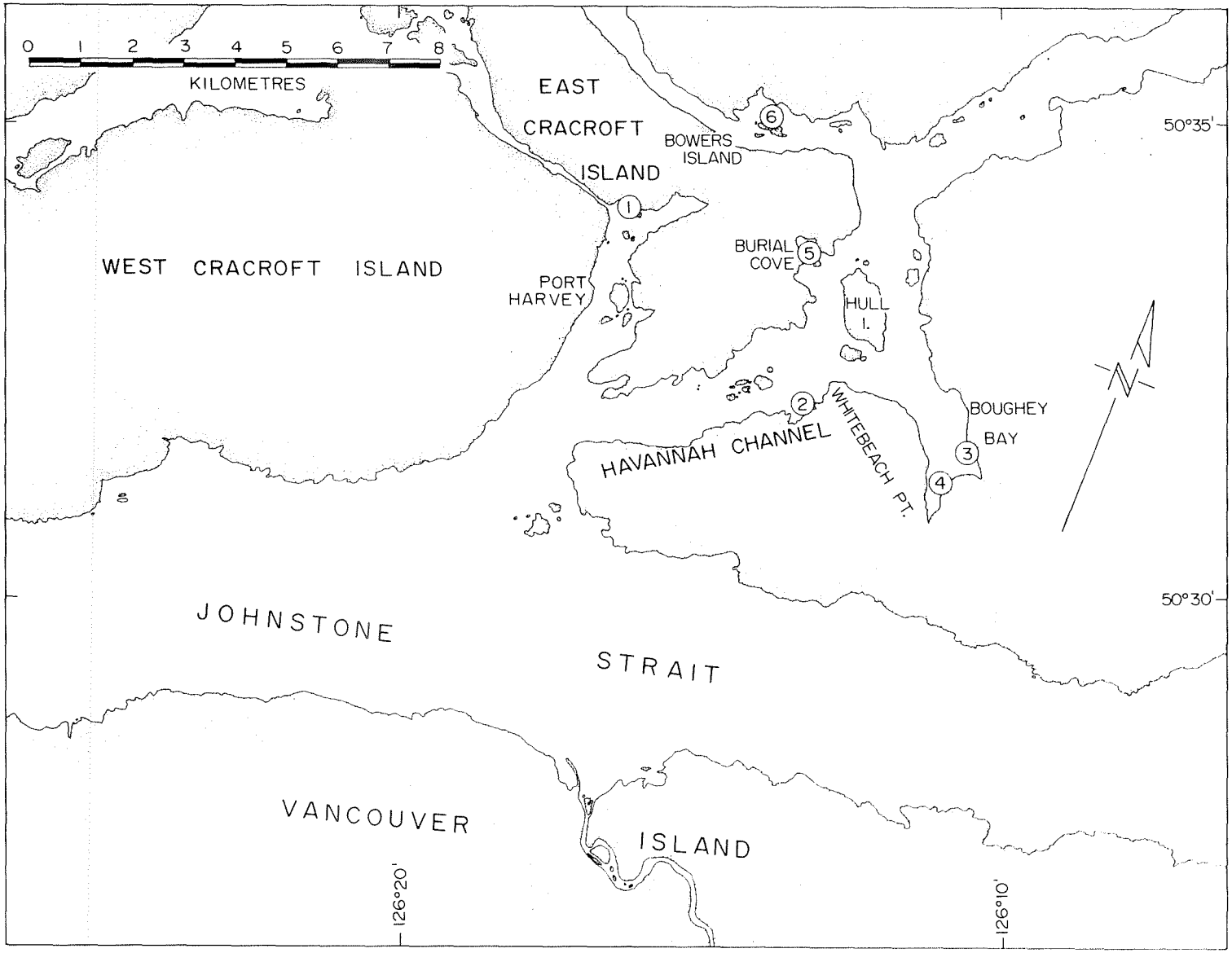

Figure 38. Map of Port Harvey, Johnstone Strait, showing the location of beaches visited, July 22, 1993.

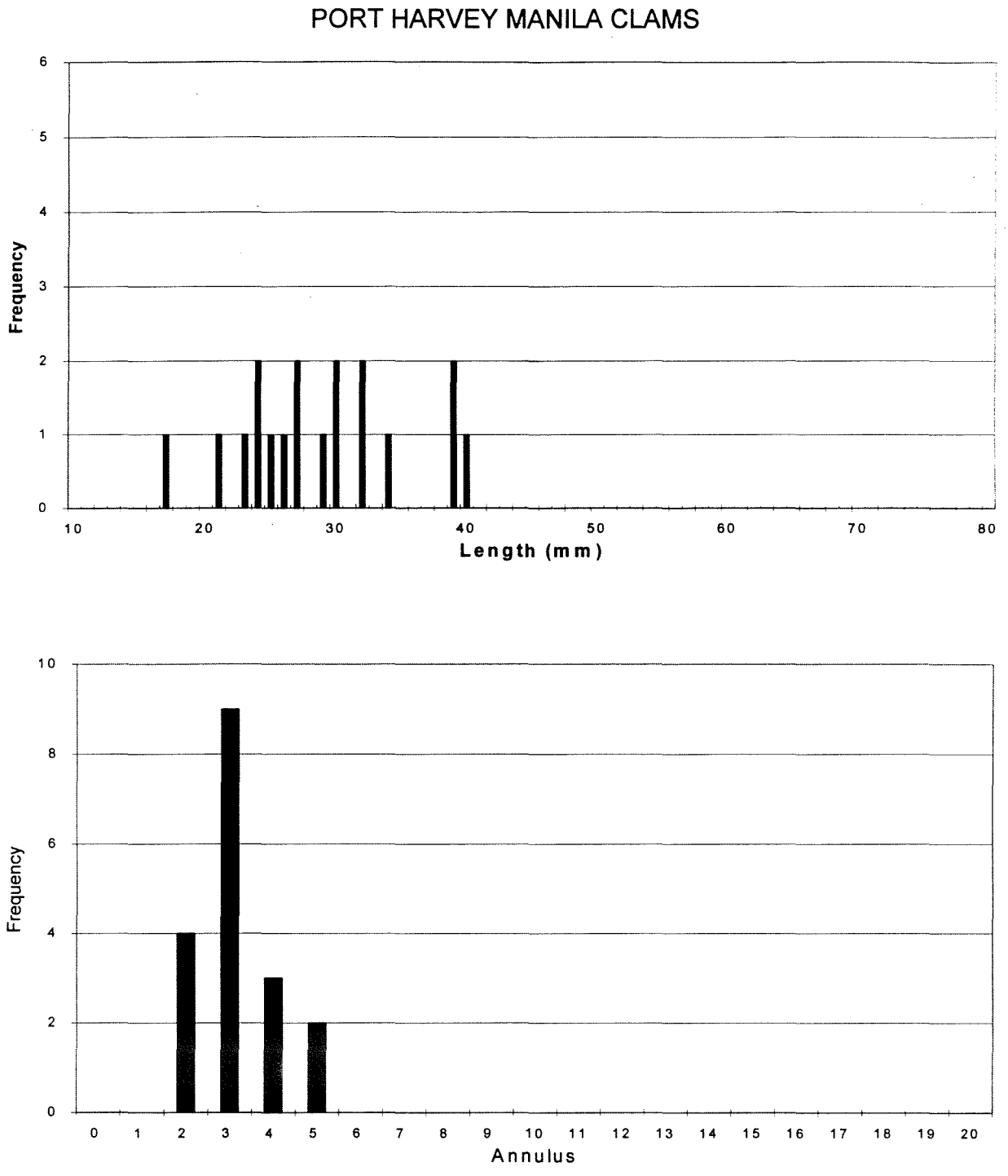

Figure 39. Length and age frequency distribution of Manila clams sampled in Port Harvey, July 22,1993.

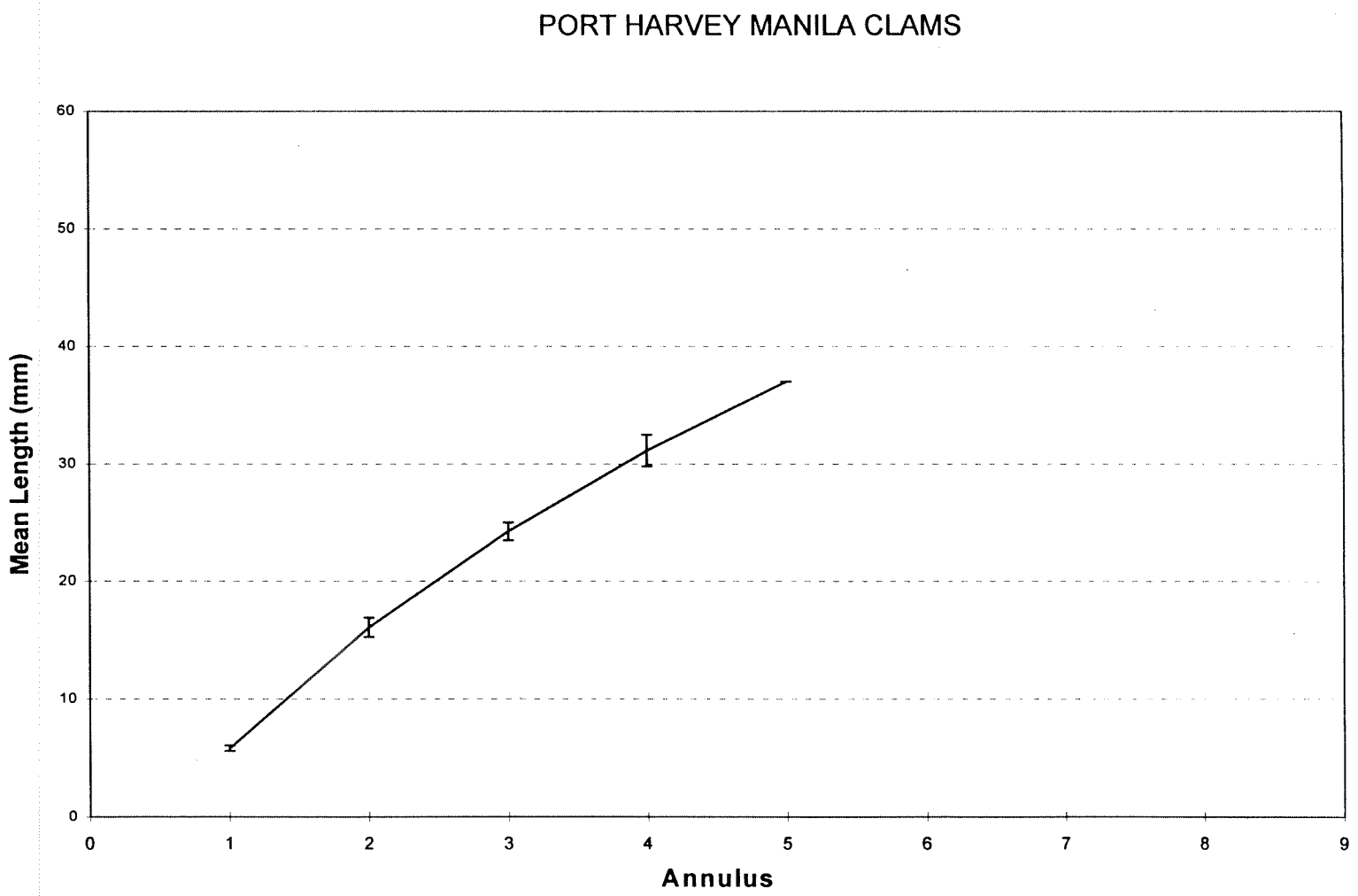

Figure 40. Growth rate of Manila clams from Port Harvey, July 22, 1993. Error bars = +/- 1 SE.

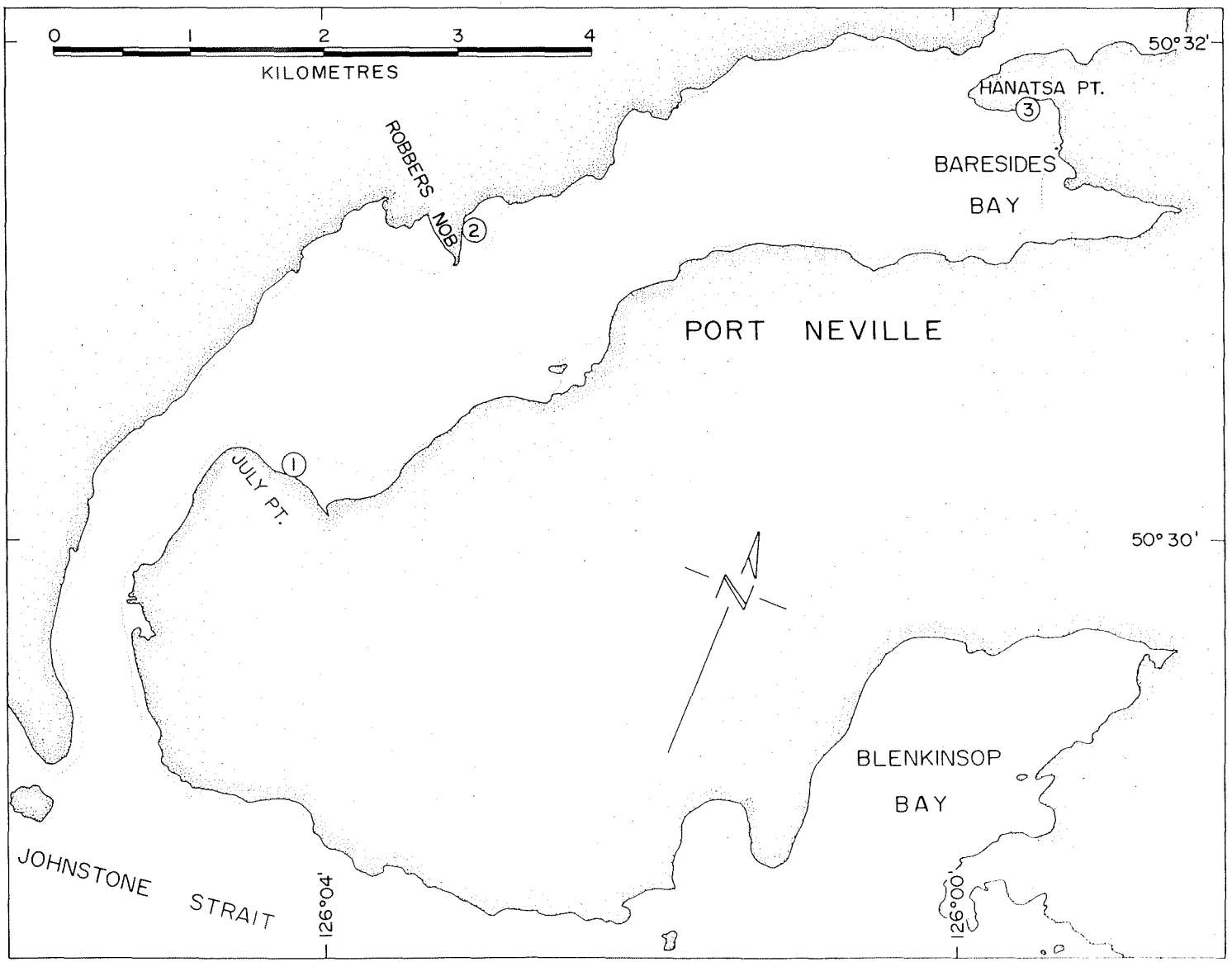

Figure 41. Map of Port Neville, Johnstone Strait, showing the location of beaches visited, July 22, 1993.

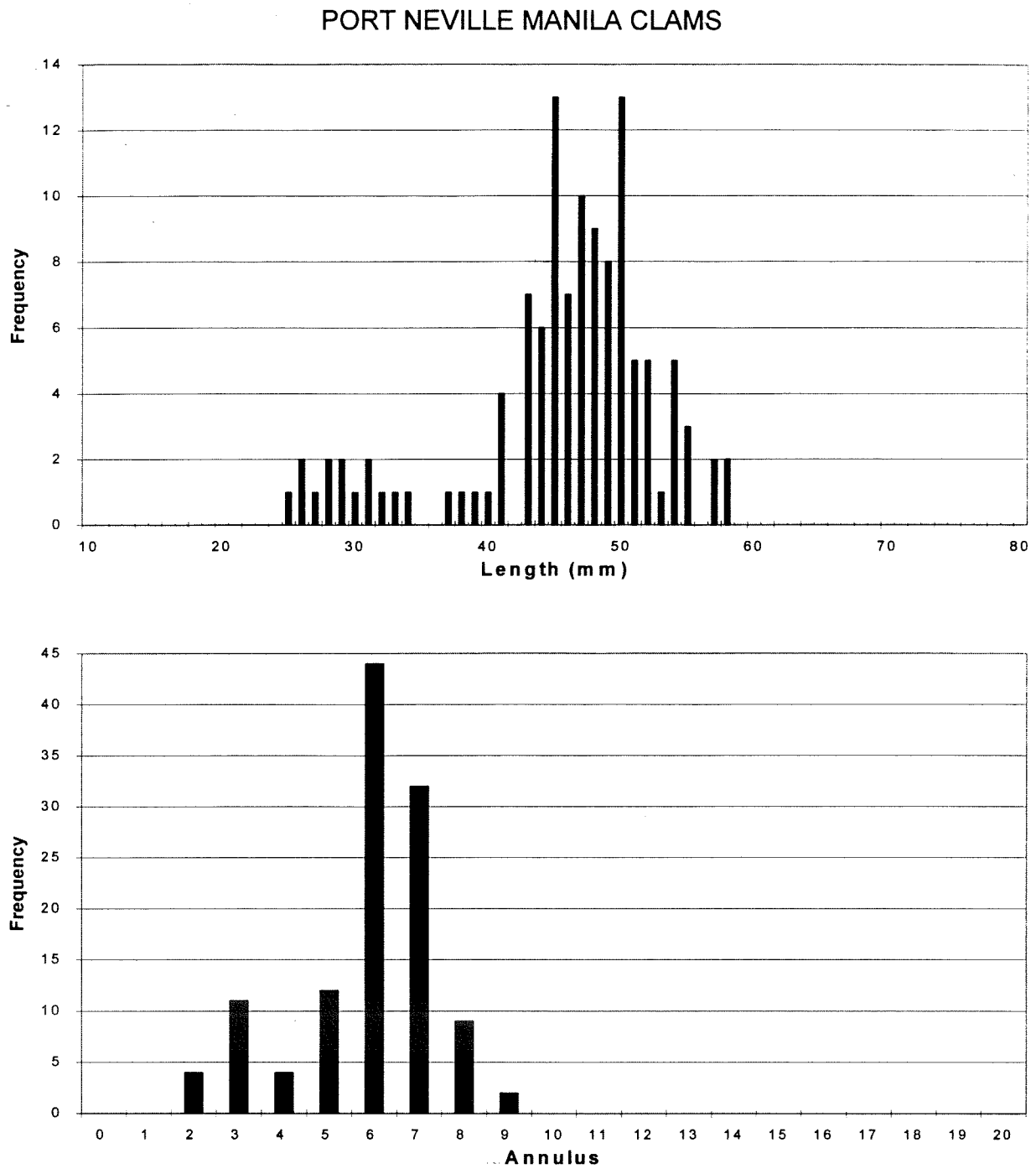

Figure 42. Length and age frequency distribution of Manila clams sampled in Port Neville, July 22, 1993.

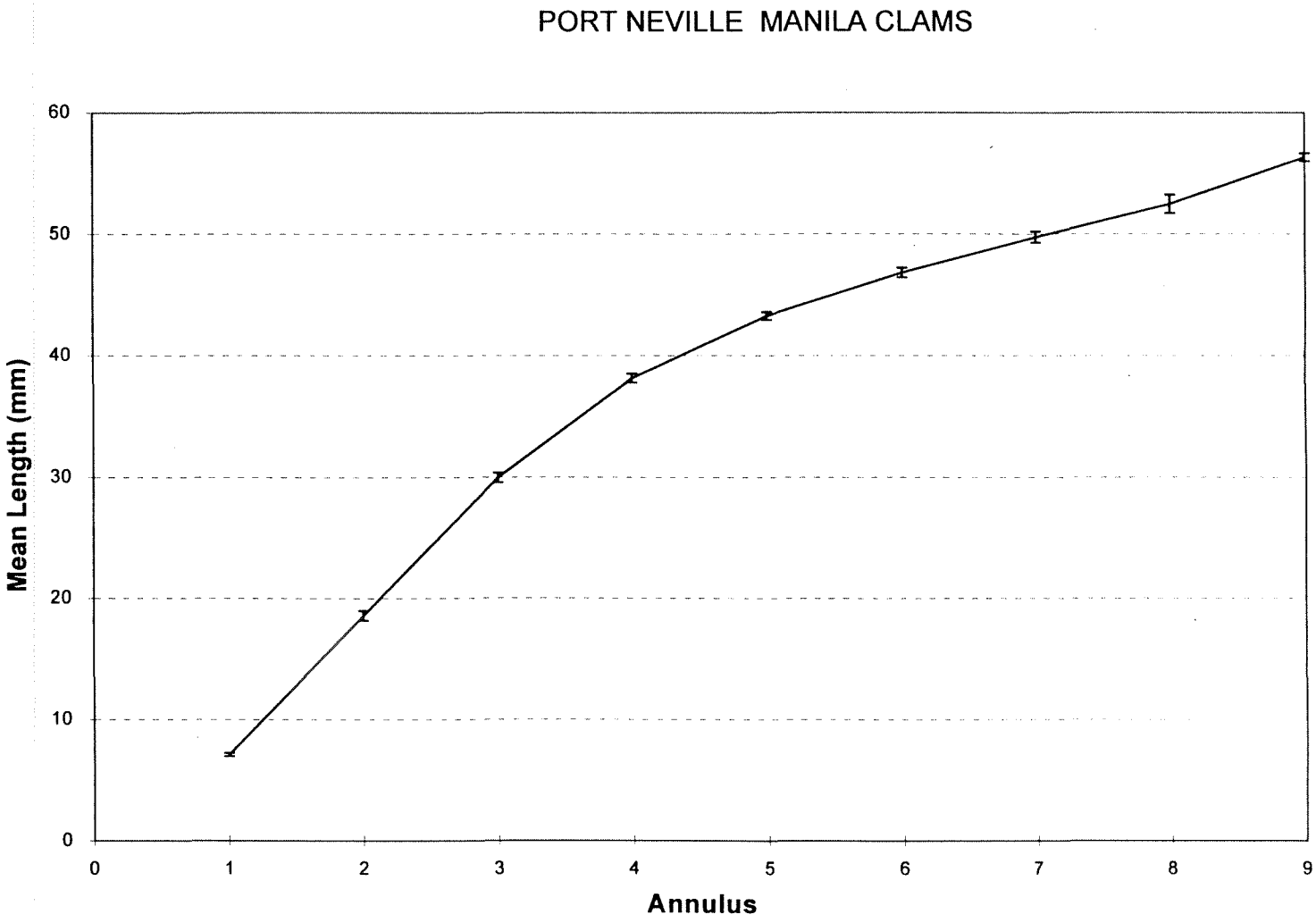

Figure 43. Growth rate of Manila clams from Port Neville, July 22, 1993. Error bars = +/- 1 SE.

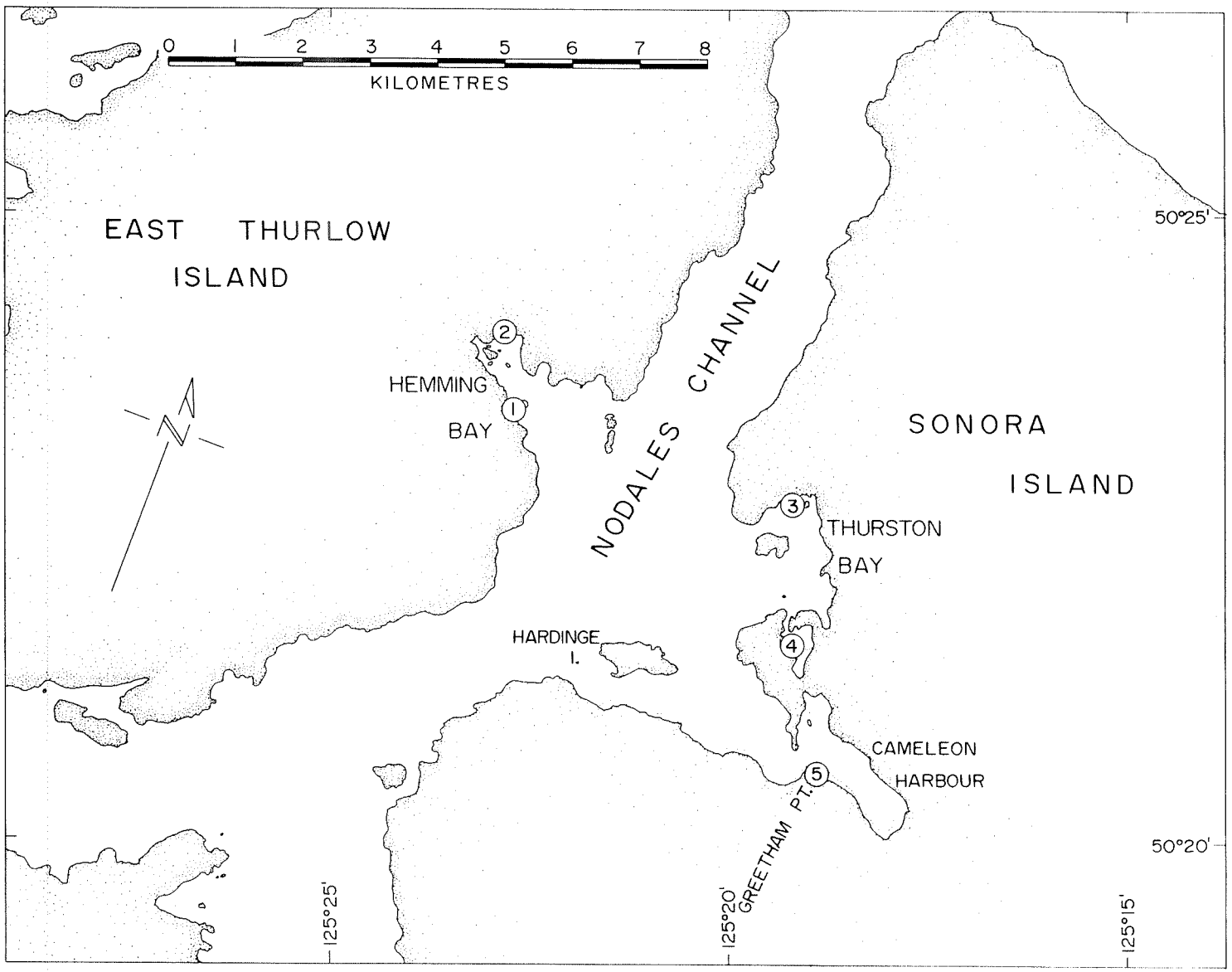

Figure 44. Map of the Nodales Channel area showing the location of beaches visited, July 23, 1993.

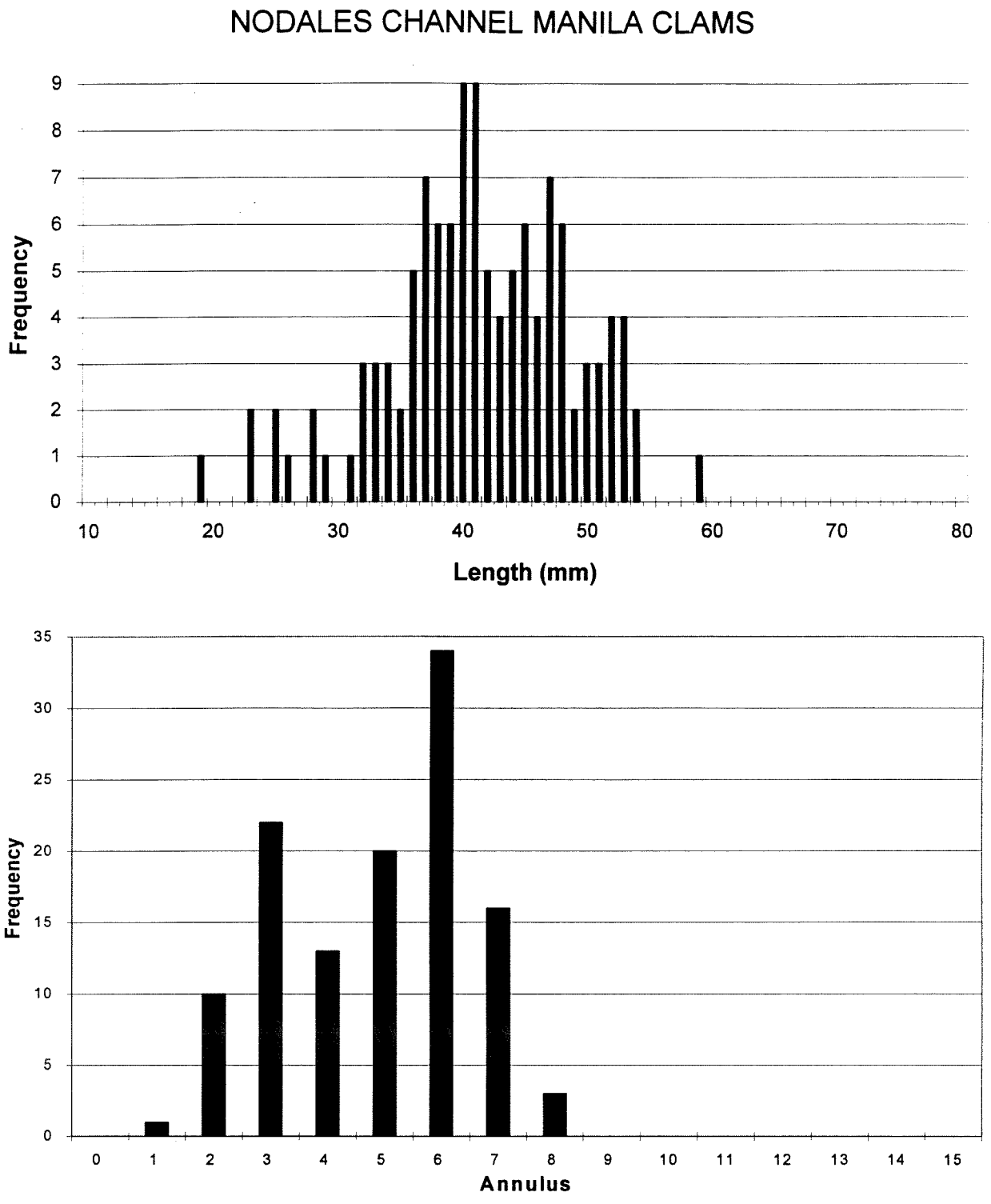

Figure 45. Length and age frequency distribution of Manila clams sampled in the Nodales Channel area, July 23, 1993.

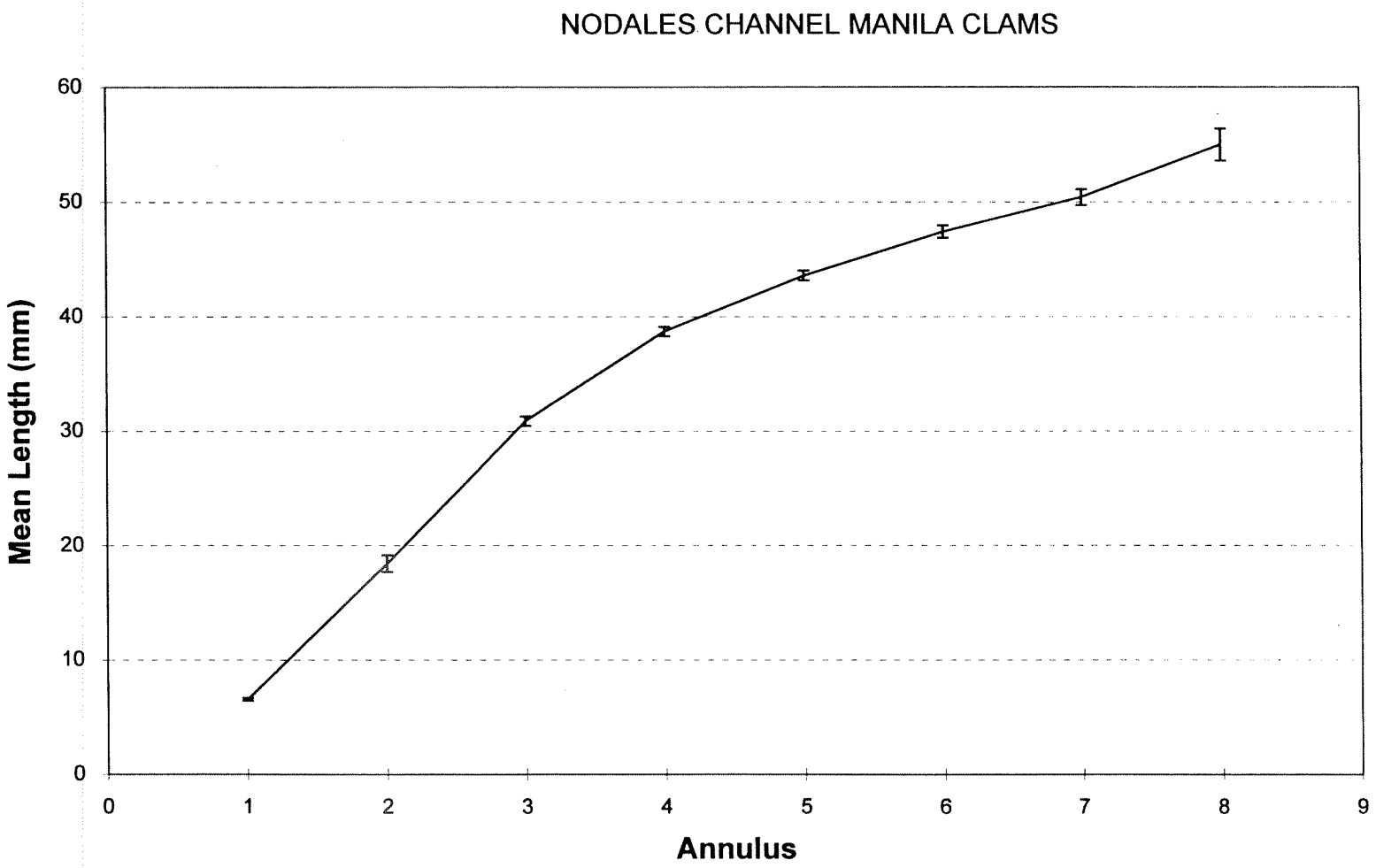

Figure 46. Growth rate of Manila clams sampled in the Nodales Channel area, July 23, 1993. Error bars =+/- 1 SE.