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Intertidal Clam Survey of the North Coast Area of British Columbia - 1990

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INTERTIDAL CLAM SURVEY OF THE NORTH COAST AREA OF BRITISH COLUMBIA - 1990

by

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Results of a 1990 survey to assess populations of commercially important intertidal clams on selected beaches in the north coast area of British Columbia and to determine the northward distribution of manila clams, Tapes philippinarum, are presented.

Butter clams, Saxidomus giganteus, were widely distributed on beaches throughout the sampling area. Densities as high as 440 butter clams m^{-2} were observed. In general there was a wide distribution of size and age classes that indicated recruitment has been consistent in recent years.

Littleneck clams, Protothaca staminea, were the most common clam sampled during the survey, densities as high as 504 littleneck clams m^{-2} were observed. There was a wide distribution of size and age classes in most areas indicating consistent recruitment.

Manila clams were found as far north as Hird Point in Mathieson Channel, latitude 52° 34′ N. The Seaforth Channel-Mathieson Channel area appears to be a biological barrier preventing further northward dispersal of this species in British Columbia. This is probably due to cold water temperatures that prevent successful breeding. Manila clams were abundant on many beaches in the Bella Bella area (DFO statistical area 7), densitites as high as 350 manila clams m^{-2} were recorded. There was a preponderance of older, larger clams on many beaches. Size and age frequency distribution showed that recruitment may be sporadic in some areas.

The potential for commercial exploitation of these three species in north coast area is discussed along with suggestions for future studies.

RÉSUMÉ

Bourne, N. and G. Cawdell. 1992. Intertidal clam survey of the North Coast area of British Columbia - 1990. Can. Tech. Rep. Fish. Aquat. Sci. 1864: 151 p.

Le présent document contient les résultats d'un relevé, effectué en 1990, visant à évaluer des populations de bivalves fouisseurs de la zone intertidale d'intérêt commercial sur des plages choisies de la côte nord de la Colombie-Britannique, et à établir l'aire de distribution vers le nord des asaris (*Tapes phillippinarum*).

Les palourdes jaunes (*Saxidomus giganteus*), étaient répandues sur les plages de toute la région d'échantillonnage. Des densités atteignant 440 palourdes par mètre carré ont été relevées. En général, une large distribution de tailles et de classes d'âge montrait que le recrutement avait été constant au cours des dernières années.

Les petites palourdes (*Protothaca staminea*) étaient les bivalves les plus communs échantillonnés pendant le relevé, avec des densités atteignant 504 petites palourdes par mètre carré. Dans la plupart des régions, on a relevé une large répartition par taille et par classe d'âge ce qui est signe d'un recrutement constant.

Des asaris ont été observés vers le nord jusqu'à Hird Point dans le chenal Mathieson, par une latitude de 52 ° 34' N. La région du chenal Seaforth - chenal Mathieson semble être une barrière biologique qui empêche la dispersion plus au nord de cette espèce en Columbie-Britannique. Cette situation est sans doute attribuable à la présence d'eau froide qui est un obstacle à la réussite de la reproduction. Les asaris abondaient sur de nombreuses plages de la région de Bella Bella (zone statistique 7 du MPO), avec des densités atteignant 350 asaris par mètre carré. Des bivalves âgés de grande taille prédominaient sur de nombreuses plages. La répartition selon la fréquence de tailles et des âges a montré que le recrutement pouvait être sporadique dans certains secteurs.

Le potentiel d'exploitation commerciale de ces trois espèces dans la région de la côte nord est abordé de même que les propositions concernant l'exécution d'autres études.

INTRODUCTION

The north coast district of British Columbia (Fig 1) has supported intertidal clam fisheries for many years (Quayle and Bourne 1972).

The only fishery for razor clams, Siliqua patula, in British Columbia occurs on oceanic beaches that extend from Masset Inlet to Rose Spit on Graham Island in the Queen Charlotte Islands. Landings in this fishery have never been large, in general under 100 t since 1951, although there has been a resurgence in the fishery in the past four years and landings have ranged from 116 to 155 t (Fig 2).

Prior to 1980 the main intertidal clam species harvested in the coast wide commercial fishery was the butter clam, Saxidomus giganteus. Approximately half the butter clams dug in the commercial fishery were from the north coast district. From 1951 to 1963 annual butter clam landings for the entire coast ranged from 828 to 2,491 t; those from the north coast ranged from 427 to 1,516 t (Quayle and Bourne 1972). In 1963 the north coast district was closed to the harvest of intertidal clams, except for razor clams, due to PSP (paralytic shellfish poisoning), (Quayle 1969), and it has remained closed since then because of chronic low levels of PSP in many locations. A permit system was developed to allow commercial harvest of intertidal clams in the north coast district but landings of butter clams from there from 1969 to 1982 were small. Processing of butter clams became uneconomic and the annual harvest of butter clams has declined to under 100 t coast wide in the last three years (Fig 2).

Although there are extensive populations of littleneck clams, Protothaca staminea, in the north coast district, they have never been harvested commercially, mainly because of the PSP closure and difficulties in transporting them to live markets. Littleneck clams are marketed fresh and must be handled quickly after digging in order to reach markets in good condition.

Manila clams, Tapes philippinarum, are an exotic in British Columbia that were accidently introduced with Pacific oyster, Crassostrea gigas, seed in the 1930's (Quayle 1964; Bourne 1979, 1982). The species spread quickly throughout most of the south coast district and probably spread to the southern part of the north coast area in the late 1960's (Bourne 1982). Surveys conducted in 1980 and 1981 showed that populations of manila clams extended to just north of Bella Bella (Fig 2) (Bourne 1982). No commercial harvest of this species has occurred in the north coast region. Occasional small landings of manila clams have been reported from the north coast district in annual DFO statistics but they are believed to be in error.

Minor landings of cockles, Clinocardium nuttallii, soft-shell clams, Mya aarenaria, and horse clams, Tresus capax, and T. nuttallii, may have occurred in the north coast but they are not recorded in the DFO statistics. A dive fishery for subtidal stocks of geoducks, Panope abrupta, began in the south coast area in 1976 and in the north coast region in 1980 and has continued to the present (Harbo and Jamieson 1987).

Recently there has been renewed interest in harvesting intertidal clams in the north coast district because of strong markets for steamer clams, littleneck and manila clams, particularly manila clams. Manila clam landings in the south coast district increased sharply in the past ten years (Fig 2). Landings peaked at 3,833 t in 1988 and have declined slightly since then. Digging pressure on many beaches in the south coast district increased and this led to closures and limited digging in many areas. Many beaches have been redug several times in a single year and clam resources on some beaches have been over-harvested. This has led industry to enquire if some areas in the north coast area could be opened for commercial harvest of intertidal clams, particularly steamer clams.

The 1990 survey was undertaken to assess intertidal clam populations on selected beaches in the north coast area, determine if manila clams had spread farther north than recorded in 1981 and determine if commercial harvest of steamer clams, particularly manila clams, is possible in the Bella Bella area (DFO Management Area 7) (Fig 1).

SURVEY METHODS

Beaches selected for sampling were chosen from chart surveys (examination of charts to locate suitable clam beaches), previous experience or from information supplied by Fishery Officers. Nine areas were surveyed during a cycle of low tides from June 20 to 27, 1990, inclusive (Fig 1, Table 1). 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 survey was made of each beach to assess the presence or absence of intertidal clams and determine the area of the clam bearing part of the beach. Slope of the beach and substrate type were recorded.

Three types of samples were taken during the survey.

The first type of sample was undertaken primarily to assess butter and littleneck clam populations. Random plots of either 1.0, 0.5 or 0.25 m^2 (square meters) were marked out in the clam bearing part of the lower third of the intertidal beach. Sampling was carried out after the manner described by Bourne and Farlinger (1981): plots were dug with forks to a depth of about 30 cm, the soil was worked through the fingers and reworked back into the plots and all clams removed. All sampled clams were placed in plastic bags and labeled for later measurement.

Considerable sampling was undertaken to determine the presence or absence of manila clams and to estimate populations of this species when present. Random plots of either 1.0, 0.5 or 0.25 m^2 were marked out in sand-gravel areas of the central portion of intertidal beaches. These plots were dug with rakes to a depth of about 15 cm. The soil was worked through the fingers and reworked back into the plots.

In the second type of sample, only the harvested manila clams from individual plots were placed in plastic bags and labeled for later measurement.

In the third type of sample, counts were made of all manila clams dug in individual plots of 0.25 m^2. Clams from these plots were pooled and placed in plastic bags for later measurement.

Observations were also made for the presence or absence of dead 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 was measured to the nearest mm with vernier calipers. The age of each clam was determined by counting annuli (Quayle and Bourne 1972). In addition a sample of butter, littleneck and manila clams was selected from most areas and the shell length at each annuli measured to the nearest mm with vernier calipers. The means of shell lengths at annuli were calculated along with standard deviations. This provided a measurement of age distribution and growth rate of populations of butter, littleneck and manila clams at most locations.

RESULTS

Results for each location are discussed separately. A brief description of the physical characteristics of each beach is provided followed by observations of the clam populations.

1. WILCOX GROUP-KITKATLA INLET

Four beaches were sampled at the head of Kitkatla Inlet, Fisheries Management Subareas 5-7 and 5-8 (Fig 3).

Physical Description of Beaches

Beach 1

A beach that was located at the spit on the north end of Clamshell Island (Fig 3). A ridge extended down the centre of this spit; the beach on the western side was steep sloped and had a gravel-mud substrate with small amounts of rock. Much of the beach was covered by the green algae, Ulva sp. At higher elevations there was more gravel. The beach on the eastern side was extensive but was mostly soft mud with eelgrass Zostera marina. There was a band of sand-gravel around the perimeter of the beach that had large numbers of butter and littleneck clams. Total area of the clam bearing part of the beach was about 2 hectares (ha).

Beach 2

A saddle beach that was located between two islands of the Wilcox Group to the north of Beach 1 (Fig 3). The south side had much rock along with considerable clam bearing areas. The north side consisted of fine gravel and was excellent habitat for littleneck clams. Sampling was undertaken in the saddle part of the beach. Total area of the beach was about 2.5 ha.

Beach 3

A saddle beach situated to the north of Beach 2 that extended to the northwest (Fig 3). The beach rose steeply on the south side to a ridge and then sloped gently to the north. The south side had considerable rock but a lot of clam bearing areas. The north side had more gravel and was a typical littleneck clam beach. Total clam bearing area was about 2 ha.

Beach 4

The fourth area was the extensive beach at the head of Kitkatla Inlet; only the southern part was sampled (Fig 3). Although this is an extensive beach most of the substrate was soft mud with rock and was unsuitable as clam habitat. In areas where the bottom was firmer with gravel there were populations of butter clams and large populations of littleneck clams. It was difficult to estimate the clam bearing area but it was probably about 4 ha.

Clam Populations

Two, 1 m^2 plots were dug at each of the first and second beaches and one, 0.25 m^2 plot at each of the third and fourth beaches.

Butter Clams

Butter clams were common at all four beaches and ranged in density from 10 per square meter (10 clams m^{-2}) at the second site of the first beach to 80 clams m^{-2} at the fourth beach (Table 2). They were abundant around the perimeter of the first beach and were particularly abundant at the second beach.

Shell length ranged from 32 to 85 mm, 57.3% were legal size ,63 mm shell length or larger, (≥63 mm) and 42.7% were sublegal size (Fig 4). Most of the butter clams were between 6 and 12 years of age but there was a peak of three year old clams (Fig 5). The number of small clams indicated reasonable levels of recruitment had occurred in recent years.

Many of the butter clams were thick shelled and stunted and had many false annuli on the shells. Stunting was particularly prevalent in clams from the last beach. The cause of stunting and false annuli are unknown.

Growth was slow. It required seven years for butter clams to attain the legal commercial size of 63 mm shell length (Fig 6).

Littleneck Clams

Littleneck clams were the most common clam found in Kitkatla Inlet. Abundance ranged from 9 clams m^{-2} at the first site of the second beach to 388 clams m^{-2} at the fourth beach (Table 2). Most of the littleneck clams (59%) were sublegal size (<38 mm shell length) (Fig 4). The majority of littleneck clams were between 2 and 6 years old with a small peak at six years (Fig 5). The large number of clams <38 mm shell length indicated good recruitment in recent years.

Many of the littleneck clams were stunted with thickened shells and many false annuli. Most of the shells were pale brown in colour with no angular colour patches which are common on shells of littleneck clams from the south coast area. The causes of stunting, false annuli and colouration are not known.

Growth was similar to many locations in the south coast area (Quayle and Bourne 1982). It required about 4 years to attain the legal size of 38 mm shell length (Fig 6).

Manila Clams

A total of ten random plots were dug in the mid portion of the four beaches to determine the presence of manila clams but none was found (Table 3). No dead manila clam shells were found at the high tide line.

Other Species

A total of 27 horse clams, Tresus capax, were found at the first two beaches. Density ranged from 3 to 14 clams m^{-2} (Table 4).

Growth was slower than observed in south coast locations (Bourne and Smith 1972) (Fig 7).

Cockles, Clinocardium nuttallii, were common on all the beaches and ranged in density from 2 to 17 cockles m^{-2} (Table 4). Cockle shell was found among rocks at the high tide line indicating that birds were probably feeding on them.

A few soft-shell clams, Mya arenaria, were found in random plots dug at higher elevations on all four beaches.

2. CAMPANIA ISLAND - WEINBERG INLET

Six beaches were sampled in the Weinberg Inlet area of Campania Island, Fisheries Management Subarea 6-10 (Fig 8).

Physical Description of Beaches

Beach 1

An extensive saddle beach that was located between a small island and Campania Island between Dunn and Anderson Passages (Fig 8). It was mostly soft mud in the centre with a lot of rock. There were firm areas in the lower part of the beach and around the perimeter where butter and littleneck clams occurred. Digging was difficult because of the rock. Total clam bearing area was about 2 ha.

Beach 2

A saddle beach that was situated between a small island and Campania Island at the head of Anderson Passage that was similar to the first beach (Fig 8). The central part was mostly soft mud with a lot of rock but butter and littleneck clams occurred in the firmer parts and around the edge of the beach. Digging was difficult. Total clam bearing area was about 1 ha.

Beach 3

A beach that was located on the northeast side of Langthorne Island that was mostly soft mud in the centre with a lot of rock (Fig 8). Butter and littleneck clams occurred in the firmer parts of the central part of the beach and around the perimeter. Total clam bearing area was about 1 ha.

Beach 4

A beach that was situated on the eastern side of Langthorne Island that was mostly soft mud with much rock (Fig 8). There were a few patches with firm substrate that were suitable for

butter and littleneck clams. Digging was difficult because of the rock.

Beach 5

An extensive beach that was located between two islands and the south side of Langthorne Island (Fig 8). The central part of the beach was soft mud with much rock. Butter and littleneck clams were abundant in the firmer parts of the central part of the beach and around the perimeter. Total clam bearing area was about 2.5 ha.

Beach 6

An extensive beach that was located at the head of the inlet south of Dunn Passage that was mostly soft mud with much rock (Fig 8). In the firmer portions and around the perimeter there was good substrate for butter and littleneck clams. Total clam bearing area was about 0.5 ha.

Clam Populations

A 1 m^2 plot was dug on beaches 1, 2, 3 and 6 and two 1 m^2 plots on beach 5. No plots were dug on beach 4.

Butter Clams

Butter clams were common on beaches where suitable habitat was present in Weinberg Inlet. However, there was a great deal of rock on the beaches that would hinder digging. Density of butter clams ranged from 3 clams m^{-2} on the second beach to 67 clams m^{-2} at the first site of the fifth beach (Table 2).

There was a wide size distribution of butter clams, 67% were legal size (≥63 mm) and 33% sublegal size (Fig 9). Most of the clams were between 6 and 13 years of age (Fig 10). The number of small clams indicated there had been good recruitment in recent years.

As observed at Kitkatla, many of the butter clams were thick shelled and stunted and had many false checks on the shells.

Growth was slightly slower at Weinberg Inlet than at Kitkatla. It required about 8 years for butter clams to attain the legal commercial size of 63 mm shell length (Fig 11).

Littleneck Clams

Littleneck clams were much less abundant at Weinberg Inlet than at Kitkatla Inlet (Table 2). This was due probably to the lack of suitable habitat for this species in Weinberg Inlet. Abundance ranged from 0 at beach 2 to 25 clams m^{-2} at beach 6.

Length frequency data showed 58.3% of littleneck clams were ≥38mm, the legal size, 41.6% were <38 mm (Fig 9). Most of the littlenecks were from 3 to 6 years in age (Fig 10). The size

distribution indicated that recruitment had been consistent in recent years.

Almost all the littleneck clams had thickened shells with many false checks. As at Kitkatla all the shells were a pale brown in colour with no angular colour patches.

Growth of littleneck clams at Weinberg Inlet was similar to that at Kitkatla, requiring about four years to attain the legal size of 38 mm shell length (Fig 11).

Manila Clams

Ten 1 m^2 plots were dug in the central area of the six beaches to determine the presence of manila clams but no live animals or dead shells were found (Table 3).

Other Species

One horse clam, T. capax, 112 mm shell length, was found at the second site on beach 5 (Table 4).

Cockles were found at all beaches and ranged in density from 1 to 7 cockles m^{-2} (Table 4). They ranged in size from 23 to 79 mm shell height and in age from 1 to 8 years.

A few soft-shell clams were present at higher intertidal levels on most beaches.

Moon snails, Polinices lewisii, and their egg collars were abundant on the lower part of beaches in this area. Much of the lower part of the beaches had a pitted appearance. These depressions were probably caused by moon snails or sunflower stars, Pycnopodia helianthoides, preying on clams, particularly butter clams.

3. KITASU BAY - MEYERS PASSAGE

Two areas were sampled at this location, one in Kitasu Bay, Fisheries Management Subarea 6-18 and the other to the north in Meyers Passage, Fisheries Management Subarea 6-25 (Fig 12).

Physical Description of Beaches

Beach 1

A saddle beach that was located in the Marvin Islands group in Kitasu Bay (Fig 12). The south side was steep sloped with muddy substrate at the lower part, much rock and few clams. A berm was present in the central part of the beach. The north side of the

beach was mostly rock and poor habitat for clams. The berm was excellent substrate for butter and littleneck clams. Total clam bearing area of the beach was about 1.5 ha.

Beach 2

A small beach that was located to the east of Beach 1 on Swindle Island (Fig 12). The bottom half of the beach was rock. There was a gravel band about 5 m in width at the mid-intertidal level that was good substrate for butter and littleneck clams. The clam bearing area of the beach was about 500 m^2.

Beach 3

An extensive beach that was at Parsons Anchorage (Fig 12). The lower third was soft mud with a lot of eelgrass. There was a 20-30 m width of sand-gravel substrate at about the mid-intertidal beach level that extended for the entire beach. The substrate was slightly soft underneath because of the abundance of ghost shrimp, Upogebia sp., but it was excellent habitat for littleneck clams. Total area of this gravel band was about 4 ha.

Beach 4

A beach on Princess Royal Island situated about the middle of Meyers Passage (Fig 12). The lower part was soft mud and eelgrass but the area above this was sand-mud-gravel with some shell and excellent habitat for butter and littleneck clams. Area of the clam bearing part of the beach was about 1 ha.

Beach 5

A beach that was located between Beach 4 and Saunders Point on Princess Royal Island in Meyers Passage (Fig 12). The lower portion was soft mud with eelgrass but an area of about 1 ha above this was sand-mud-gravel and excellent substrate for butter and littleneck clams.

Beach 6

A beach on Swindle Island that was situated at the eastern end of Meyers Passage (Figs 12). The lower portion was soft mud with eelgrass. There was a lot of rock on the beach. At about the mid intertidal level there were gravel-mud patches that were suitable habitat for littleneck clams.

Clam Populations

In Kitasu Bay a 0.5 m^2 plot was dug at the first beach and a 1 m^2 plot at Beach 3. No plots were dug at Beach 2. In addition, ten 1 m^2 plots were dug at beaches 1 and 3 and five 1 m^2 plots at Beach 2 to determine the presence of manila clams.

In Meyers Passage three 1 m^2 plots were dug at Beaches 4, 5 and 6 to determine the presence of manila clams.

Butter Clams

Butter clams were abundant at the first beach where the density was 206 clams m^{-2}, 76.% were ≥63 mm and 23.3% <63 mm (Table 2, Fig 13). Most of the butter clams were 7 to 10 years old (Fig 14). At Beach 3 only 9 butter clams were found, all of which were <63 mm. The amount of suitable habitat for butter clams was limited in Kitasu Bay and was present only at the first beach. Beach 2 was small and the habitat at Beach 3 was more suited to littleneck clams. There were few small butter clams indicating low recruitment in recent years (Fig 13).

Growth was slow; it required about 8 years to attain the legal size of 63 mm shell length (Fig 15). Many of the butter clams were stunted, the shells had many false checks and were difficult to age.

Although no plots were dug specifically to assess butter and littleneck clam populations in Meyers Passage, butter clams were abundant in a few test plots dug on Beaches 4 and 5. Ten to 12 legal sized butter clams were turned out with each fork of substrate.

Littleneck Clams

Littleneck clams were moderately abundant in Kitasu Bay. Abundance ranged from 36 clams m^{-2} on Beach 1 to 93 clams m^{-2} on Beach 3 (Table 2). The third beach had good habitat for littleneck clams although ghost shrimps, Upogebia sp., were abundant making the substrate slightly soft.

Littleneck clams were almost equally divided between legal and sublegal size, 55.5% were ≥38 mm, 44.5% <38 mm (Fig 13). The age distribution indicated there had been good recruitment in recent years (Fig 14).

Growth of littleneck clams at Kitasu Bay was slow, requiring almost 5 years to attain 38 mm shell length (Fig 15).

Littleneck clams were abundant on beaches 4 and 5 in Meyers Passage.

Manila Clams

Dead shells of two manila clams were found on Beach 1 and one live clam, 48 mm shell length, age 7, was found in the plot dug on Beach 3 at Kitasu Bay (Table 2). No manila clams were found in any plots dug specifically to assess manila clam populations in Kitasu Bay (Table 3). Although manila clams occur in Kitasu Bay they are not abundant.

No manila clams were found in Meyers Passage and no shell was observed at the high tide line on any of the three beaches sampled there (Table 3).

Other Species

Three small horse clams, T. capax, 28 to 35 mm shell length, were found in the plot on the first beach (Table 4).

One cockle was found in the plot on Beach 1 and two at Beach 3. They ranged in size from 28 to 49 mm shell height (Table 4).

Twelve soft-shell clams, ranging in size from 28-83 mm shell length, were found in the plot on Beach 3 (Table 4).

The lower third of the intertidal beach at Parsons Anchorage (Beach 3) had a sand-mud substrate with much eelgrass, Zostera marina. There were large numbers of geoducks, Panope abrupta, in this area, approximate density was 1 geoduck 2 m^{-2}.

4. MATHIESON CHANNEL

Seven beaches were sampled in the Mathieson Channel area, four in Rescue Bay, one in Jackson Narrows and two in Mathieson Channel (Fig 16). These areas are in Fisheries Management Subareas 7-9 and 7-10.

Physical Description of Beaches

Beach 1

A small beach that was located at the eastern entrance to Rescue Bay, between a small island and Susan Island (Fig 16). The lower part of the beach had much eelgrass and rock but butter clams occured in gravel-mud patches. At higher elevations the beach was mud-gravel with much rock. Total area that could be dug was small, about 500 m^2.

Beach 2

A more extensive beach that was situated below Beach 1 on Susan Island (Fig 16). The lower portion was soft mud with eelgrass and at higher elevations there was much rock. Gravel patches in the upper two thirds of the beach formed good clam habitat. Total clam bearing area was about 1,000 m^2.

Beach 3

A fairly extensive beach that was located at the southern end of Rescue Bay but much of it was not suitable clam habitat (Fig 16). The lower portion was muddy with eelgrass and much rock. At higher elevations there were numerous gravel patches which had large quantities of clams. A gravel berm in the central part of the

beach was also good clam habitat. Total clam bearing area was about 1 ha.

Beach 4

An extensive beach that was situated on the western side of Rescue Bay but most of it was soft mud-sand with eelgrass (Fig 16). Total area of the gravel patches that had good clam habitat was about 0.5 ha.

Beach 5

A small beach that was located on Roderick Island at the eastern end of Jackson Passage (Fig 16). Most of the substrate was mud-gravel with eelgrass and much rock. There was a small gravel ridge with suitable clam habitat at a higher elevation. The clam bearing area was about 500 m^2.

Beach 6

Two small beaches that were situated east of Hird Point in Mathieson Channel (Fig 16). There was evidence of previous logging operations above both beaches which probably ruined the beaches for clam habitat. The beaches were mostly rock with some soft muddy areas in the lower part and a few gravel patches in the mid-intertidal area. The area of each beach was about 0.5 ha.

Beach 7

A beach that was located in the southern part of Salmon Bay in Mathieson Channel (Fig 16). Most of the beach was rock with gravel patches. The bottom portion was mud-gravel with eelgrass. Digging was difficult because of the rock. The clam bearing area was about 0.5 ha.

Clam Populations

A 0.25 m^2 plot was dug on Beach 1 and a 1 m^2 plot on Beach 3 to assess butter and littleneck clam populations.

Extensive sampling was undertaken to assess manila clam populations in this area. A 0.5 m^2 plot was dug and all clams retained for measurement at beach 7 (Table 5). Eight, seven, ten, five and ten 0.5 m^2 plots were dug at beaches 1, 3, 4, 5, and 6 (Fig 16) respectively to determine abundance of manila clams on these beaches (Table 3). No plots were dug at Beach 2.

Butter Clams

Butter clams were not abundant in Rescue Bay, the only area in Mathieson Channel where samples were taken. Density ranged from 16 clams m^{-2} on Beach 1 to 38 clams m^{-2} on Beach 3 (Table 2). All were < 63 mm on Beach 1, 94.7% were ≥ 63 mm on beach 3 (Table 2, Fig 17). Most of the clams were 9 to 11 years old (Fig 18).

Growth was slow but similar to growth rates found at the other locations. It required about 7.5 years to attain the legal size of 63 mm shell length (Fig 19).

Although no quantitative samples for butter clams were taken outside Rescue Bay, they were abundant at beach 5, but virtually none was found at beaches 6 and 7.

Littleneck Clams

Littleneck clams were particularly abundant in Rescue Bay. Density ranged from 192 to 504 clams m^{-2} at Beaches 1 and 3 (Table 2). Most of the clams, 73.2%, were < 38 mm (Fig 17). Age frequency distribution showed peaks at ages 2 and 3 and 6 and 7 (Fig 18) indicating there had been excellent recruitment in recent years.

As observed at previous locations, many of the littleneck clams were stunted and growth was slow, requiring about 4.5 years to attain the legal size of 38 mm shell length (Fig 19).

Manila Clams

Manila clams were found at all sampling locations in Mathieson Channel except Beaches 4 and 5 (Table 3). At Beaches 1 and 3 in Rescue Bay, densities were 8 and 20 clams m^{-2} , 32.1% were ≥38 mm shell length and 67.9% were <38 mm (Table 2). In plots dug specifically to assess manila clam populations, densities ranged from 0 to 10 clams m^{-2} (Table 3). Two manila clams were found on the beach at Hird Point (Beach 6), (latitude 52° 34′ N) which is the farthest north that manila clams have been recorded along the British Columbia coast.

Density of manila clams in the plot at Salmon Bay (Beach 7) was 22 clams m^{-2} legal size (37.9%) and 36 m^{-2} sublegal size (62.1%), (Table 5).

Manila clams from the Mathieson Channel area ranged from 27-50 mm in shell length and 3 to 7 years in age (Fig 20). There was a preponderance of three and four year old manila clams.

Growth rate of manila clams was similar at both Rescue Bay and Salmon Bay. At both locations it required about four years for manila clams to attain a shell length of 38 mm (Fig 21). Old dead manila clam shell was abundant on the beaches and on rocks where birds had dropped them. Manila clams have been present on beaches in this area for probably fifteen years.

Other Species

One horse clam, T. capax, 102 mm shell length was found on the Beach 3 (Table 4).

Cockles were not found in sample plots but considerable dead shell was found at the high tide line.

5. ST. JOHN HARBOUR

Beaches in the St. John Harbour area, Fisheries Management Subarea 7-20, were sampled during an evening tide on June 23, 1990 (Fig 22). Sampling was only done to assess manila clam populations since the low tide of 1.7 m was too high to permit adequate sampling for butter and littleneck clams.

Physical Description of Beaches

Beach 1

A small beach that was located in the southern part of Dyer Cove which was about 200 m^2 in area (Fig 22). The substrate was a mixture of sand-gravel and shell.

Beach 2

A small beach that was situated at the southeast corner of Dyer Cove that was about 300 m^2 in area (Fig 22). The substrate was a mixture of sand-gravel and shell.

Beach 3

A beach that was located on Athlone Island on the south side of the entrance to St. John Harbour (Fig 22). The substrate was sand-gravel with no shell and the beach had an area of about 1 ha.

Beach 4

This site was three beaches among three islands at the southern end of Louisa Cove (Fig 22). The beaches had a total area of about 3 ha and were sand-gravel with minor amounts of shell.

Beach 5

A beach that was located south of Louisa Cove on Wurtele Island (Fig 22). The beach had a substrate of sand-gravel with little shell and some rock and was about 1 ha in area.

Beach 6

This beach was on the west side of Louisa Cove on Wurtele Island (Fig 22). The beach was mostly rock with some gravel patches and was about 1 ha in area.

Beach 7

A beach that was on the east side of Louisa Cove on Athlone Island (Fig 22). It was mostly rock with gravel patches with minor amounts of shell and had an area of about 1.5 ha.

Beach 8

A beach that was located on the northeast side of the entrance to St. John Harbour (Fig 22). The substrate was mostly

sand-gravel with minor amounts of mollusc shell. It had an area of about 0.25 ha.

Clam Populations

Manila Clams

Live manila clams were found only on the first two beaches in Dyer Cove. At Beach 1, density ranged from 0 to 12 manila clams m^{-2} and at Beach 2 from 72 to 236 clams m^{-2} (Table 3). Some dead shell was found on beach 4 and a lot of dead shell was found on beach 8. Larger manila clam populations may have been present in the area at lower tidal levels.

In one plot on Beach 2, 91.4% of manila clams were ≥38 mm and 8.6% were <38 mm (Table 5). There was a preponderance of large clams in the other plots, the largest was 65 mm shell length (Fig 23). Most of the manila clams were seven years old (Fig 23). Few small manila clams were found indicating poor recruitment in recent years.

Growth was rapid. The legal size was attained in about 3.5 years, which is about the same as the optimum growth rate found in the Strait of Georgia (Fig 24) (Quayle and Bourne 1972).

6. SEAFORTH CHANNEL - JOASSA CHANNEL

Two beaches were surveyed at Dearth Island in Seaforth Channel, Fisheries Management Subarea 7-12 and three beaches in Joassa Channel, Fisheries Management Subarea 7-23 (Figs 25 and 26).

Physical Description of Beaches

Beach 1

A beach that was located on the northwest side of Dearth Island. It was steep sloped and mostly sand-gravel-shell with much rock (Fig 25). It had an area of about 0.5 ha.

Beach 2

A beach that was on the southeast side of Dearth Island (Fig 25). The substrate was mostly soft mud-gravel with eelgrass at the lower level but otherwise it was sand-gravel-shell with much rock. It had an area of about 1 ha.

Beach 3

A beach with a gentle slope that was located at about the middle of the west side of Joassa Channel on Dufferin Island (Fig

26). The lower part was sand-mud-gravel with some eelgrass. At higher elevations it was mostly sand-gravel-shell. There was a lot of old dead clam shell (butter, littleneck and manila) on the surface of the beach. Total area was about 2 ha.

Beach 4

A flat beach with a gentle slope that was situated on the lower west side of Joassa Channel on Dufferin Island (Fig 26). The lower area had some eelgrass but the main part of the beach had a substrate of sand-gravel-shell. It had large quantities of old dead butter, littleneck and manila clam shell on the surface. Total area was about 2 ha.

Beach 5

A beach that was on the northern end of Potts Island at the southern end of Joassa Channel (Fig 26). The beach had a gentle slope and a gravel substrate with a lot of old dead littleneck and manila clam shell on the surface. Total area was about 2 ha.

Clam Populations

A 0.25 m^2 plot was dug on Beaches 1 and 2 and two 0.25 m^2 plots were dug on Beaches 3 and 4 to assess butter and littleneck clams populations.

Considerable sampling was undertaken to assess manila clams populations in this area. A 0.25 m^2 was dug on Beach 3 and two 0.25 m^2 plots on Beach 4 and all clams retained for measurement (Table 5). Three, four, four, four, and four 0.25 m^2 plots were dug on Beaches 1, 2, 3, 4, and 5 respectively to determine abundance of manila clams on these beaches (TAble 3).

Butter Clams

Butter clams were moderately abundant at Dearth Island (Beaches 1 and 2) where densities ranged from 28 to 108 clams m^{-2} (Table 2). In Joassa Channel butter clams were moderately abundant at Beach 3 and particularly abundant at Beach 4 where densities were as high as 440 clams m^{-2} (Table 2).

At Dearth Island 43.2% were ≥63 mm in Joassa Channel only 37.6% were ≥63 mm (Table 2). No large clams were found at any site and many of the clams were stunted (Figs 27 and 28). The largest butter clams at Dearth Island and in Joassa Channel were only 76 mm and 78 mm shell length respectively. At Dearth Island there was a wide distribution of age classes but in Joassa Channel most of the butter clams were between 5 and 9 years of age (Figs 29 and 30). The number of sublegal sized clams indicated good recruitment in recent years.

Growth rates were only calculated for butter clams from Joassa Channel and they showed that growth was slow; it required about 8 years for butter clams to attain a shell length of 63 mm

(Fig 31). Butter clams from Joassa Channel were stunted with many false checks on the shells.

Littleneck Clams

Littleneck clams were not abundant in samples at Dearth Island (Beaches 1 and 2) where densities were only 12 clams m^{-2}. In Joassa Channel (Beaches 3 and 4) they were abundant and densities ranged from 112 to 320 clams m^{-2} (Table 2).

Most of the littleneck clams were large, 81.8% and 73.1% were ≥38 mm at Dearth Island and in Joassa Channel, respectively (Table 2, Figs 27 and 28). At Dearth Island all the littlenecks were 5 to 7 years old but in Joassa Channel there was a wide range of age classes, from 2 to 10 years (Figs 29 and 30). Recruitment had been low at Dearth Island but good in Joassa Channel in recent years.

Growth of littleneck clams in Joassa Channel was similar to that observed in other areas. It required about 4.5 years to attain a shell length of 38 mm (Fig 31). Many of the littleneck clams were stunted with thickened shells.

Manila Clams

Manila clams were moderately abundant at Dearth Island and very abundant in Joassa Channel (Tables 3 and 5).

In plots dug at lower intertidal levels to assess abundance of butter and littleneck clams, manila clam abundance was only 46 and 56 clams m^{-2} at Dearth Island and 0-4 clams m^{-2} in Joassa Channel (Table 2). However, in plots dug specifically to assess manila clam abundance, density ranged from 0 to 56 clams m^{-2} at Dearth Island and from 32 to 156 clams m^{-2} at Beach 3 in Joassa Channel and from 52 to 248 clams m^{-2} at beach 4 (Tables 3 and 5).

Most of the clams were large at both locations. In Joassa Channel 91.4% of the manila clams were ≥38 mm (Table 5). In Joassa Channel the largest clam measured 63 mm and at Dearth Island 59 mm shell length (Fig 32). At Dearth Island manila clams ranged from 2 to 8 years in age and in Joassa Channel from 1 to 10 years of age (Fig 33). The low number of smaller clams indicates that recruitment has been low at both locations in recent years.

Growth of manila clams was rapid (Fig 34). At both locations the legal size of 38 mm shell length was attained in about 3.5 years which is similar to optimum growth rates found in the Strait of Georgia (Bourne 1982).

Other Species

Cockles occurred in low abundance at both Dearth Island and in Joassa Channel (Table 4).

Two horse clams, T. capax, were found, one at Dearth Island and one in Joassa Channel (Table 4).

7. LAMA PASSAGE - HUNTER CHANNEL

Nine beaches were surveyed in this area, six in the lower part of Lama Passage, Fisheries Management Subarea 7-17 and three in the Hunter Channel area, Fisheries Management Subarea 7-25 (Figs 35 and 36).

Physical Description of Beaches

Beach 1

A steep sloped beach that was located at the southern end of Lama Passage between Westminister and Hunter Islands (Fig 35). The lowest part was soft mud-gravel with eelgrass but above this the substrate was mud-sand-gravel and some rock. The area was about 2 ha.

Beach 2

A beach that was at the northwest entrance to Lizzie Cove (Fig 35). The lower part of the beach was mostly gravel with some rock. The upper portion was mostly rock with gravel ridges and some shell. The area was about 1.5 ha.

Beach 3

A beach at the southern end of Lizze Cove was visited briefly (Fig 35). It was mostly soft mud with some gravel patches and the clam bearing area is limited. No sampling was done there.

Beach 4

A beach at the southern end of Fannie Cove had a substrate that was mostly gravel with some rock (Fig 35). A river mouth transected the beach. Digging was difficult because of the rock. Total area was about 1 ha

Beach 5

A beach that was situated at about the middle of the western side of Fannie Cove (Fig 35). The substrate was mostly gravel with much rock that made digging difficult. It was about 1 ha in area.

Beach 6

A saddle beach that was located between two islands at the entrance to Fannie Cove that had steep slopes on both sides (Fig 35). The eastern side had much rock and digging was difficult. The western side had a substrate of sand-gravel-shell with some rock. The area was about 0.5 ha.

Beach 7

A small beach that was on the east side of the lower part of Hunter Channel (Fig 36). It had a gravel ridge in the central part and the substrate was mostly gravel-sand-shell with moderate amounts of rock making digging difficult. Total area was about 1 ha.

Beach 8

A beach that was located on the west side of lower Hunter Channel (Fig 36). The substrate was sand-gravel-shell with a lot of rock in places. Digging was difficult where rock was present but easy in many of the gravel areas. Total area was about 2 ha.

Beach 9

A beach that was at Sans Peur Passage (Fig 36). The lower portion had eelgrass but the main part has a sand-gravel-shell substrate. Total area was about 2 ha.

Clam Populations

Two 0.25 m^2 plots were dug on beaches 1, 2, 6 and 8 and one 0.25 m^2 plot 7 to assess butter and littleneck clam populations. No sampling ws done on Beaches 3, 4, and 5.

Considerable sampling was undertaken to assess manila clam populations and included three 0.25 m^2 plots on beaches 1, 2, 7 and 9 and four similar plots on beach 8. Sampling to assess abundance and size distribution of manila clams included 0.25 m^2 plots on beaches 1, 2, 7, 8 and 9.

Butter Clams

Butter clams were common in the area. In lower Lama Passage abundance ranged from 36 to 84 clams m^{-2} and in Hunter Channel from 8 to 184 clams m^{-2} (Table 2). There was considerable dead butter clam shell on most of the beaches. A wide range in the size and age distribution of butter clams was observed in this area (Figs 37-40). Abundance of clams <63 mm shell length indicates there has been good recruitment in recent years. Growth of butter clams in lower Lama Passage and in Hunter Channel was similar, it required about 7.5 years to attain the legal size of 63 mm shell length (Figs 41 and 42). Growth rates were similar to those observed for butter clams in other parts of the central coast.

Littleneck Clams

Littleneck clams were moderately abundant in the Lama Passage and Hunter Channel areas, particularly when digging occurred in areas of suitable habitat. Abundance ranged from 8-40 clams m^{-2} in Lama Passage and from 52 to 312 clams m^{-2} in Hunter Channel (Table 2).

There was a wide size distribution of littleneck clams in the Lama Passage area but less so in Hunter Channel (Fig 37 and

38). Age distribution in Lama Passage was widespread but in Hunter Channel most littlenecks were 5 years old (Figs 39 and 40). Abundance of smaller clams indicated that recruitment had been good in recent years.

Growth of littleneck clams was similar in Lama Passage and Hunter Channel; it required about four years to attain the legal size of 38 mm shell length (Figs 41 and 42).

Manila Clams

Manila clams were abundant in both Lama Passage and Hunter Channel. There was a considerable quantity of old manila clam shell on most of the beaches and at the high tide line indicating they have been abundant there for probably fifteen years.

No manila clams were found in plots dug to assess butter and littleneck clam resources (Table 2). However, they were abundant in plots dug specifically to assess manila clam populations and densities ranged from 4 to 128 clams m^{-2} (Tables 3 and 5).

Most of the manila clams in both Lama Passage and Hunter Channel were large and over five years of age (Figs 43 and 44). The low number of small clams indicates that recruitment has been low in recent years.

Growth of manila clams at both Lama Passage and Hunter Channel was rapid, requiring about 3.5 years to attain the legal size of 38 mm, which is similar to growth rates in other parts of the Bella Bella area (Fig 45).

Other Species

Cockles were abundant at beach 2 where densities were as high as 48 cockles m^{-2} (Table 4).

Horse clams, T. capax, were found only on beach 7 and all were small (Table 4).

8. SEAFORTH CHANNEL-RAYMOND PASSAGE

Nine beaches were visited in the Seaforth Channel and northern entrance to Raymond Passage areas, Fisheries Management Subareas 7-12 and 7-22, although sampling was confined to only seven beaches (Fig 46).

Physical Description of Beaches

Beach 1

A small beach that was located at the eastern entrance to Norman Morrison Bay, Campbell Island (Fig 46). The lower part of the beach was mud-gravel with rock. The upper part had a gravel substrate. Total area ws about 1 ha.

Beach 2

A saddle beach that was situated at the eastern entrance to Norman Morrison Bay (Fig 46). The northern side had much rock but the substrate on the southern side was mostly sand-shell-gravel with some rock. Total area was about 1 ha.

Beach 3

A beach that was at the southern end of Norman Morrison Bay (Fig 46). Substrate of the lower part of the beach was mud-gravel with some rock, the upper part was sand-gravel-shell. Total area was about 1.5 ha.

Beach 4

A beach that was located at the western entrance to Norman Morrison Bay (Fig 46). The beach was steep sloped and rose to a sand-gravel-shell berm that was excellent habitat for manila clams. Total area was about 1 ha.

Beach 5

A beach that was situated at the southern end of Odin Cove (Fig 46). The substrate of the lower part was sand-mud-gravel with some eelgrass but not much rock. The main part of the beach had a substrate of sand-gravel that was excellent habitat for manila clams. Total area was about 2 ha.

Beach 6

An extensive beach that was located at the bottom of Ormidale Harbour between a small island and Campbell Island (Fig 46). The beach was steep sloped at the lowest level but rose to an extensive berm that had a substrate of sand-gravel. Total area was about 3 ha.

Beach 7

A small beach that was at the southeast corner of Ardmillan Bay (Fig 46). Substrate of the lower part was soft mud-gravel and eelgrass, with rock and gravel patches. The main part of the beach was mostly a gravel-shell substrate. Total area was about 1 ha.

In addition to the above seven beaches, three beaches in Kynumpt Harbour were quickly surveyed although no samples were taken (Fig 46). Most of these beaches had a gentle slope, the lower portions were mud-gravel bottom with rock that made digging

difficult. The upper part was mostly sand-gravel and good habitat for manila clams. Total area of the beaches was about 3 ha.

A brief visit was made to one beach in Cavin Cove to determine the presence or absence of manila clams but no samples were taken (Fig 46).

Clam Populations

Most of the sampling undertaken in this area was to determine the abundance of manila clams but two 0.25 m^2 plots were taken on beaches 2, 5 and 6 to assess butter and littleneck clam populations.

Sampling to assess manila clam populations included two 0.25 m^2 square plots on beaches 1 and 3 and three similar plots on beach 7. Sampling to assess abundance and size distribution of manila clams included 0.5 m^2 plots on beaches 1, 3, 4 and 7.

Butter Clams

Butter clams were moderately abundant in all areas, particularly when sampling occurred in suitable habitat. Densities ranged from 32 to 88 clams m^{-2} (Table 2).

Butter clams in Seaforth Channel had a wide size distribution (Fig 47), most were 6 years old (Fig 48). The prevalence of smaller sized clams indicated reasonable recruitment in recent years.

No estimate of growth was made of butter clams in this area, however, most of the butter clams were stunted.

Littleneck Clams

Littleneck clams were abundant in all areas and density ranged from 24 to 136 clams m^{-2} (Table 2). Most littlenecks were <38 mm shell length (Fig 47). There was a wide age distribution (Fig 48). The abundance of small littlenecks indicated good recruitment in recent years.

Manila Clams

Manila clams were common throughout the area. In plots dug in Ormidale Harbour (Beach 6) densities were as high as 392 clams m^{-2} (Table 2). In other plots densities ranged from 156 to 300 clams m^{-2} (Table 3) and in still other plots densities ranged from 160 to 350 clams m^{-2} (Table 5). The quick census in Kynumpt Harbour indicated manila clams were abundant in that area. A single sample in Cavin Cove indicated manila clams were present there.

There was a wide spread in size distribution of manila clams and this was also reflected in the age distribution (Table 4; Figs 49 and 50). In Norman Morrison Bay manila clams ≥38 mm shell length ranged from 24.6% to 84.5% of the catch and in Adrmillan Bay

they were 50.9% of the sampled population. Many of the clams were large, the largest was 59 mm shell length.

Growth was rapid requiring about 3.5 years to attain a shell length of 38 mm (Fig 51).

Other Species

Small numbers of cockles were found on Beaches 2 and 5 and soft-shell clams on Beach 2.

9. GUNBOAT PASSAGE

An extensive survey of beaches was undertaken in the Gunboat Passage area, Fisheries Management Subarea 7-17 (Fig 52). A total of nine beaches were sampled. Most of the sampling was directed towards determining the distribution and abundance of manila clams.

Physical Description of Beaches

Beach 1

Several beaches were sampled in Bainbridge Cove at the eastern entrance to Gunboat Passage (Fig 52). Most of the beaches were mud with with much rock. There were really no clam beaches in this area.

Beach 2

A small clam beach was sampled at Forit Bay (Fig 52). The lower part was soft mud with great amounts of eelgrass and rock. Sand-gravel areas are limited.

Beach 3

A small beach that was located at the southern end of Hampden Bay (Fig 52). Most of the beach had a substrate of soft mud with rock. There were a few small gravel patches.

Beach 4

A small beach that was situated just west of Shave Point that was about 200 m^2 in area (Fig 52). The substrate was mostly mud with much large rock.

Beach 5

A beach was sampled at the upper end of Gosse Bay (Fig 52). The lower part was mud with much rock and eelgrass, the upper part had some gravel patches. The total area was about 2 ha but only about 25% of the beach was suitable as clam habitat.

Beach 6

A beach that was located on the east side of Draney Point between a small island and Cunningham Island (Fig 52). The lower part was soft mud-gravel with eel rass but there were gravel patches in the main part of the beach. Total area was about 1 ha but only about 25% was suitable as clam habitat.

Beach 7

A beach west of Draney Point between Dingle and Cunningham Islands was sampled (Fig 52). Much of the beach was soft mud with much large rock and eelgrass at lower levels. There were several gravel ridges that were good clam habitat. Total area of the beach was about 3 ha but only about 0.5 ha was suitable as clam habitat.

Beach 8

A small beach that was located in Dunn Bay (Fig 52). Most of the beach was soft mud with large rock and eelgrass at lower levels. There were a few gravel ridges that were suitable clam habitat. Total area of the beach was about 1.5 ha but only about 0.25 ha was suitable as clam habitat.

Beach 9

Several small beaches at the mouth of the lagoon to the west of Dunn Point were sampled (Fig 52). The substrate was sand-gravel-shell and excellent clam habitat although the area was limited to a total of about 0.5 ha.

Clam Populations

Butter and Littleneck Clams

The survey in Gunboat Passage was essentially to assess the distribution and abundance of manila clams. No plots were dug to assess butter or littleneck clam populations but both species were present on most beaches.

Manila Clams

Manila clams were not found at the first site in Bainbridge Cove. Low numbers were found on Beaches 2 and 3, a total of 10 manila clams in 6 plots at Beach 2 and 8 Manila clams in five plots at Beach 3 (Table 3). On beaches 4 to 7 densities ranged from 0 to 96 clams m^{-2}. No manila clams were found on Beach 8 but they were present on Beach 9. The tide was high at the last three beaches and accurate sampling could not be undertaken.

A brief survey was made in Kakushdish Harbour. There were several beaches in this area that appeared to be excellent habitat for manila clams, however, no sampling was undertaken.

DISCUSSION

Populations of clams in the north coast district can be considered as unexploited populations. Although there may have been minor harvest of clams in the native food and recreational fisheries there has been no commercial harvest of butter clams there since 1982 and no commercial harvest of littleneck and manila clams has ever occured in this area.

Butter Clams

Butter clams were widely distributed and found at all sampling locations in the lower third of the intertidal zone where suitable substrate was present. Abundance ranged from 3 to 440 clams m^{-2} (Table 2). Differences in abundance at different geographic locations or beach sites were due probably to variations in recruitment patterns, predation, habitat type or sampling error rather than to environmental factors.

Generally there was a wide size and age distribution of butter clams at all locations indicating there had been consistent recruitment in the north coast area in recent years. Three year old butter clams were abundant at most of the more northern locations. The reason why the 1987 year class was so successful is unknown. Few large butter clams, e.g. ≥90 mm shell length, were found in any area. The reason for the lack of large butter clams is unknown. It is possible that stunting prevents butter clams growing to a large size.

Growth of butter clams was slow and there was little difference in growth rates throughout the geographic area sampled. It required 7 to 8 years to attain the commercial size of 63 mm shell length compared to 5 to 6 years in the Strait of Georgia (Quayle and Bourne 1972). Slower growth rates in the northern area are probably due to colder water temperatures.

It should be stressed that growth rates recorded here were undoubtedly optimum growth rates. Only those butter clams with good annuli were used to estimate growth rates and these were generally the faster growing clams. Many butter clams were stunted and difficult to age because of numerous false annuli. Stunted clams were not used to assess growth rates but they were obviously slower growing clams than clams with good annuli.

Littleneck Clams

Littleneck clams were the most common clam found during the survey and were widely distributed at all locations. Density ranged from 0 to 504 clams m^{-2} (Table 2). They occurred in areas with a firmer more gravelly type substrate and at slightly higher

intertidal beach levels than butter clams, up to about the mid intertidal level.

Generally there was a wide size and age distribution of littleneck clams at most sampling sites indicating consistent recruitment in recent years. No single year class dominated littleneck clam populations throughout the sampling area.

As observed with butter clams, there was little difference in growth rates with geographic distribution. Growth was slower than in south coast areas requiring 4 to 4.5 years to attain the legal size of 38 mm shell length compared to 3 to 4 years in the Strait of Georgia (Quayle and Bourne 1972). The slower growth rates in the north coast area are again probably due to colder water temperatures.

Growth rates observed for littleneck clams also reflect optimum growth rates since only clams with good annuli were used to assess growth. They were the faster growing, non-stunted clams.

Manila Clams

Results of this survey provided further information on the northward distribution of manila clams in British Columbia. The most northern manila clams found in the survey were at Hird Point in Mathieson Channel, 52° 34′ N. latitude (Fig 16). Manila clams do not appear to have spread north of the Seaforth and Mathieson Channel areas, probably because cold water temperatures north of this area prevent successful breeding. Manila clams were found in Kitasu Bay (Fig 12) where full oceanic conditions exist, however, abundance was low. Only one live clam and dead shells of two animals were found there.

Manila clams were found from approximately the lower third of the intertidal beach to well above the mid beach level in areas with firm sand-gravel substrate. This is similar to the habitat occupied by manila clams in the southern part of the Province (Quayle and Bourne 1972).

Density of manila clams on beaches in Area 7 ranged from 0 to 350 clams m^{-2} (Tables 3 and 5). Manila clams were particularly abundant in Joassa Channel, Hunter Channel and the Seaforth Channel-Raymond Passage areas (Tables 3 and 5). Differences in abundance on various beaches probably reflect differences in recruitment patterns, habitat types, mortalities and sampling error rather than any general environmental factors.

There were large quantities of old dead manila clam shell on many beaches in Area 7. Some of the shell was recently dead and may have been the result of winter kill after an extremely cold period during the winter of 1989/90. Extensive areas of dead manila clams were reported in the Strait of Georgia in the spring of 1990

which were attributed to winter kill resulting from this cold period (Bourne, Unpub. MS). However, much of the dead shell found during the survey was old and it is believed that large populations of manila clams have existed on many beaches in Area 7 for ten to fifteen years.

There was a great number of large sized manila clams on many beaches, the largest clam found was 65 mm shell length in the St. John Harbour area (Fig 23). Manila clam populations have never been harvested commercially in the central coast and the present populations reflect this situation with a preponderance of larger sized animals.

Abundance of small manila clams (<38 mm shell length) varied from area to area and beach to beach. This may be due to inconsistent annual recruitment. Manila clams in Area 7 are at the periphery of their northern distribution and recruitment is probably sporadic and varies greatly with local environmental conditions. The fact that recruitment is probably sporadic should be considered if commercial harvest is undertaken.

Growth varied slightly with geographic distribution. In Mathieson Channel, which was the farthest north population sampled, it required 4 to 4.5 years to attain the legal size of 38 mm shell length. In most other parts of Area 7 this size was attained in about 3.5 years. This growth rate is of interest since it is similar to optimum growth rates of manila clams in the Strait of Georgia (Quayle and Bourne 1972). Water temperatures in Area 7 are colder than in the Strait of Georgia and one would expect that growth of manila clams in Area 7 would be slower than in the Strait of Georgia.

Unlike butter and littleneck clams, virtually no stunting was observed in manila clams at any sampling location.

Stunting and Other Physical Characteristics

Many butter and littleneck clams at all sampling sites were stunted. The shells were thick and heavy and the ventral margins were thickened. The posterior and anterior edges of the shells tended to be involuted. There were many false checks on the surface of the shells which may have been caused by stressful environmental conditions. The colour of the outer surface of the shells was generally an uncharacteristic pale brown for both species. There were no angular colour patches on the shells of littleneck clams that are characteristic for this species in southern parts of the Province.

No explanation can be given for the stunting or colouration of the shells. It did not appear to be density dependent since stunted clams were found in areas of low and high

clam abundance. Similarly beach location and substrate type did not appear to be responsible for stunting. It is doubtful if it is due to any genetic differences between north and south coast stocks.

Virtually no manila clams were stunted although stunted manila clams are frequently found in the Strait of Georgia area where the condition is usually associated with high beach location.

Commercial Potential of North Coast Clam Populations

Whether populations of butter, littleneck and manila clams can be harvested commercially in the north coast district will depend on the economics of harvesting, processing and the strength of markets.

Approximately half the annual landings of butter clams formerly came from the north coast district. However, commercial landings of this species are now reduced to low levels because of the high cost of processing. It is unlikely that commercial harvest of this species will occur in the north coast district in the near future in spite of large populations on many beaches.

Markets for steamer clams, littleneck and manila clams, are strong and industry is interested in attempting to harvest these species, particularly manila clams, from the north coast area. Density of manila clams on some beaches in the north coast is higher than on beaches harvested in the south coast area and there is a preponderance of larger sized clams on north coast beaches. Further, extensive populations of manila clams could exist on beaches that were not sampled during the present survey. However, some of the beaches are small and there is the increased cost of transporting clams to markets. Recruitment of manila clams appears to be inconsistent in some areas and it is not known if a continuing fishery could be established for this species.

If a commercial fishery for steamer clams is established in the north coast district it is hoped that industry would be encouraged to harvest both littleneck and manila clams since littleneck clams are abundant on most beaches.

Before commercial harvesting can occur the necessary sanitary surveys would have to be undertaken to obtain certification for the harvesting areas. Also an adequate program would have to be installed to monitor PSP levels to insure that only safe shellfish reached the markets. The cost of such surveys might preclude commercial harvest.

Other Species

Cockles were moderately abundant in most areas surveyed, particularly where the substrate was soft. The size distribution indicated that recruitment has been consistent in recent years.

There is probably no commercial potential for this species although it is used in the native food fishery.

Only one species of horse clam, T. capax, was found in this survey, no T. nuttallii were observed. T. capax were not abundant at any location except in Kitkatla Inlet.

A few soft-shell clams were found at most sampling locations. The low number found is due partly to sampling procedure. Soft-shell clams tend to occur high in the intertidal area in soft substrate and almost no sampling was done in these areas.

The only site where intertidal geoducks were found was Parsons Anchorage in Kitasu Bay (Fig 12). This was probably the only beach visited during the survey that had extensive suitable substrate for geoducks.

Moon snails and their eggs collars were abundant at most sampling locations, particularly the first two areas. The sea stars, sunflower star, Pycnopodia helianthiodes, and mottled star, Evasterias troschellii, which are major predators of butter and littleneck clams, were common on many beaches at the low tide line.

The exotic nuisance seaweed, Sargassum muticum, was accidently introduced into southern British Columbia waters from Japan with Pacific oyster seed (Quayle 1964; Bourne 1979). It was thought that is would not spread to the north coast area because of cold water temperatures (Bourne 1979). However, it was found in abundance at and just below the low tide level at many beaches in Area 7 including St. John Harbour, Joassa Channel and Hunter Channel. According to Fishery Officers, it has been abundant in the area for several years and herring, Clupea pacifica, eggs are frequently deposited on it. It is possible that it may have arrived in the area about the same time as manila clams.

FUTURE STUDIES

The present survey, although cursory, provided considerable information on butter, littleneck and manila clam populations in the north coast area. Further work is required to conduct more detailed surveys and obtain better estimates of intertidal clam populations, particularly manila clams, on these and other beaches in the area.

Surveys of beaches north of the Seaforth and Mathieson Channel areas should be undertaken to determine the northward

distribution of manila clams and assess if this area is a biological barrier to the northward dispersal of this species.

Surveys should also be undertaken in the area south of Area 7 to determine if manila clams are abundant on beaches in this area. If manila clams are abundant on beaches south of Area 7 it might make commercial harvest of steamer clams in the north coast area more economically viable.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Captain J. Roche and the crew of the Fisheries Patrol Vessel Surge Rock for their kind hospitality while we were on board the vessel and for their assistance during this survey. The help of L.D. Townsend with the computer work is greatly acknowledged. We thank S. Farlinger for making arrangemnts for the survey. Thanks are extended to S. Farlinger and R. Harbo for review of the manuscript.

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Table 1. Location of nine areas (shown as numbers in circles, Fig 1) where sampling was carried out during an intertidal clam survey in the north coast area of British Columbia, June 19-27, 1990.

Location	Date Sampled
Wilcox Group-Kitkatla Inlet	June 20, 1990
Weinberg Inlet-Campania Island	June 21, 1990
Kitasu Bay-Meyers Passage	June 22, 1990
Mathieson Channel	June 23, 1990
St. John's Harbour	June 23, 1990
Seaforth Channel-Joassa Channel	June 24, 1990
Lama Passage-Hunter Channel	June 25, 1990
Seaforth Channel-Raymond Passage	June 26, 1990
Gunboat Passage	June 27, 1990

Table 2. Number of butter, littleneck and manila clams, expressed as clams per square meter (clams m^{-2}), found in the lower third of intertidal beaches sampled in the north coast district of British Columbia, June 19-27, 1990.

Beach	Plot	Butter clams m^{-2}		Littleneck clams m^{-2}		Manila clams m^{-2}	
Number	Number	Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
				Wilcox Group-Kitkatla Inlet			
1	1	31	46	16	0	0	0
1	2	7	3	20	5	0	0
2	1	45	7	3	6	0	0
2	2	15	15	17	19	0	0
3	1	60	4	160	116	0	0
4	1	4	76	92	296	0	0
				Weinberg Inlet-Campania Island			
1	1	36	7	11	1	0	0
2	1	2	1	0	0	0	0
3	1	14	2	0	2	0	0
5	1	37	30	4	5	0	0
5	2	46	20	9	3	0	0
6	1	21	7	10	15	0	0
				Kitasu Bay			
1	1	166	40	24	12	0	0
3	1	0	9	48	45	1	0

Table 2 (cont'd)

Beach Number	Plot Number	Butter clams m^{-2}		Littleneck clams m^{-2}		Manila clams m^{-2}	
		Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
				Mathieson Channel			
1	1	0	16	68	436	4	16
3	1	36	2	119	73	5	3
				Seaforth Channel - Joassa Channel			
1	1	52	56	10	2	46	0
2	1	12	16	8	4	24	32
3	1	48	48	116	8	0	0
3	2	76	52	76	52	0	0
4	1	140	300	88	24	4	0
4	2	136	264	220	100	4	0
				Lama Passage - Hunter Channel			
1	1	4	36	0	24	0	0
1	2	60	4	12	0	0	0
2	1	40	36	8	32	0	0
2	2	32	48	12	12	0	0
6	1	44	40	4	4	0	0
6	2	8	28	12	12	0	0

Table 2 (cont'd)

Beach Number	Plot Number	Butter clams m^{-2}		Littleneck clams m^{-2}		Manila clams m^{-2}	
		Legal	Sublegal	Legal	Sublegal	Legal	Sublegal
				Lama Passage - Hunter Channel			
7	1	4	4	40	12	0	0
8	1	164	20	48	8	0	0
8	2	40	44	224	88	0	0
				Seaforth Channel - Raymond Passage			
2	1	0	32	16	112	100	0
2	2	12	40	12	84	44	24
5	1	20	24	20	4	0	0
5	2	0	68	28	0	0	0
6	1	4	84	4	132	372	20
6	2	0	60	20	96	36	0

Table 3. Number of manila clams, expressed as clams per square meter (clams m^{-2}), found in the mid portion of beaches sampled in the north coast district of British Columbia, June 19-27, 1990.

Location	Beach Number	Number of Plots Dug	Area of Plots in m^2	Number of Manila Clams m^{-2}
Wilcox Group-Kitkatla Inlet	1-4	10	1	0
Weinberg Inlet-Campania Island	1-6	10	1	0
Kitasu Bay-Meyers Passage	1	10	1	0
	2	5	1	0
	3	10	1	0
	4-6	3	1	0
Mathieson Channel	1	8	0.5	8,10,0,2,0,9,6,10
	3	7	0.5	8,2,4,6,0,4,4
	4	10	0.5	0
	5	5	0.5	0
	6	10	0.5	2,0,0,0,0,2,0,0,0,0
St. John Harbour	1	3	0.25	12,0,4
	2	3	0.25	72,80,236
	3-8	20	0.25	0

Table 3 (cont'd)

Location	Beach Number	Number of Plots Dug	Area of Plots in m^2	Number of Manila Clams m^{-2}
Seaforth Channel-	1	3	0.25	28,12,56
Joassa Channel	2	4	0.25	4,24,24,0
	3	4	0.25	32,156,132,136
	4	4	0.25	248,176,52,204
	5	4	0.25	84,44,52,52
Lama Passage-	1	3	0.25	28,4,20
	2	3	0.25	20,52,32
	7	3	0.25	8,4,20
	8	4	0.25	12,16,44,36
	9	3	0.25	124,76,56
Seaforth Channel-	1	2	0.25	184,272
Raymond Passage	3	2	0.25	192,276
	7	3	0.25	156,300,228
Gunboat Passage	1	6	0.25	0
	2	6	0.25	10 clams total
	3	5	0.25	8 clams total
	4	4	0.25	24,32,16,20

Table 3 (cont'd)

Location	Beach Number	Number of Plots Dug	Area of Plots in m^2	Number of Manila Clams m^{-2}
Gunboat Passage	5	3	0.25	16,36,80
	6	3	0.25	16,16,8
	7	4	0.25	64,44,88,96
	8	4	0.25	0
	9	5	0.25	Clams numerous

Table 4. Number, shell height or length and age of cockles, horse clams and soft-shell clams found in the lower third of intertidal beaches sampled in the north coast district of British Columbia, June 19-27, 1990.

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
Wilcox Group-	1	1	1	73	7	59	3	
Kitkatla Inlet				56	4	34	1	
				55	4	37	1	
				53	3	33	1	
				50	3	28	1	
				52	3			
				49	2			
				48	2			
				42	2			
				16	1			
				12	1			
	1	2	1	31	2	123	10	
				26	1	128	8	
						120	9	
						111	7	
						83	4	

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
	2	1	1	80	6	136	15	
				74	6	98	5	
				66	3	97	5	
				58	3	96	5	
				55	3	95	5	
				55	3	93	5	
				52	3	91	5	
				48	3	89	4	
				48	3	87	4	
				48	3	86	4	
				43	2	82	5	
				27	1	81	5	
				23	1	54	2	
				23	1	27	1	
				23	1			
				26	2			
				14	1			

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
	2	2	1	74	8	120	17	
				72	7	75	3	
				71	6	58	3	
				63	6			
				63	6			
				59	4			
				55	4			
				39	2			
				20	1			
				20	1			
	3	1	0.25	21	1			
	4	1	0.25	55	4			
				13	1			
				13	1			

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
Weinberg Inlet-	1	1	1	47	3			
Campania Island				46	3			
	2	1	1	79	6			
	3	1	1	50	4			
	5	1	1	52	2			
				43	2			
				42	2			
				23	1			
	5	2	1	47	3	112	9	
				43	3			
				42	3			
				41	3			
				38	2			
				28	1			

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
				24	1			
	6	1	1	73	8			
				63	6			
				62	6			
				61	5			
				61	4			
	6	1	1	57	4			
				34	2			
Kitasu Bay-	1	1	0.5	28	2	35	1	
Meyers Passage						35	1	
						28	1	
	3	1	1	49	4			83
				48	5			69
								67

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
								60
								51
								43
								37
								36
								35
								35
								34
								28
Mathieson Channel	3	1	1			102	6	
Seaforth Channel	1	1	0.5			87	5	
Joassa Channel								
	2	1	0.25	55	4			
				31	1			
				27	1			

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
				25	1			
	3	2	0.25	62	3			
				32	1			
				28	1			
				28	1			
	4	1	0.25			110	7	
	4	2	0.25	51	4			
Lama Passage-	2	1	0.25	68	7			
Hunter Channel				53	5			
				32	2			
				27	1			
				25	1			
				25	1			
				23	1			
				22	1			

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
				21	1			
				21	1			
				19	1			
				18	1			
	2	2	0.25	26	1			
				23	1			
				21	1			
				18	1			
	6	1	0.25	52	2			
				48	2			
				47	2			
	7	1	0.25			40	2	
						28	1	
						27	1	
						19	1	

Table 4 (cont'd)

Location	Beach Number	Plot Number	Area of Plot in m^2	Cockles Height (mm)	Cockles Age	Horse Clams Length (mm)	Horse Clams Age	Soft-shell Clams Length (mm)
	8	1	0.25	58	3			
Seaforth Channel-	2	2	0.25	25	2			63
Raymond Passage								48
								47
	5	1	0.25	38	1			
	5	2	0.25	65	7			

Table 5. Number of legal (≥38 mm shell length) and sublegal (<38 mm shell length) sized manila clams, expressed as clams per square meter (clams m^{-2}), foudnd in selected plots at the mid-intertidal level of beaches sampled in the north coast area of British Columbia, June 19-27, 1990.

Location	Beach Number		Manila Clams m^{-2}	
	Legal	Sublegal		
Mathieson Channel		7	22	36
St. John Harbour		2	64	6
Joassa Channel		3	93	10
		4	136	6
		4	47	10
Lama Passage-Hunter Channel		1	40	8
		2	96	9
		7- 9 (pooled)	112	16
Seaforth Channel-Raymond Passage		1	56	172
		3	102	58
		4	186	34
		7	178	172

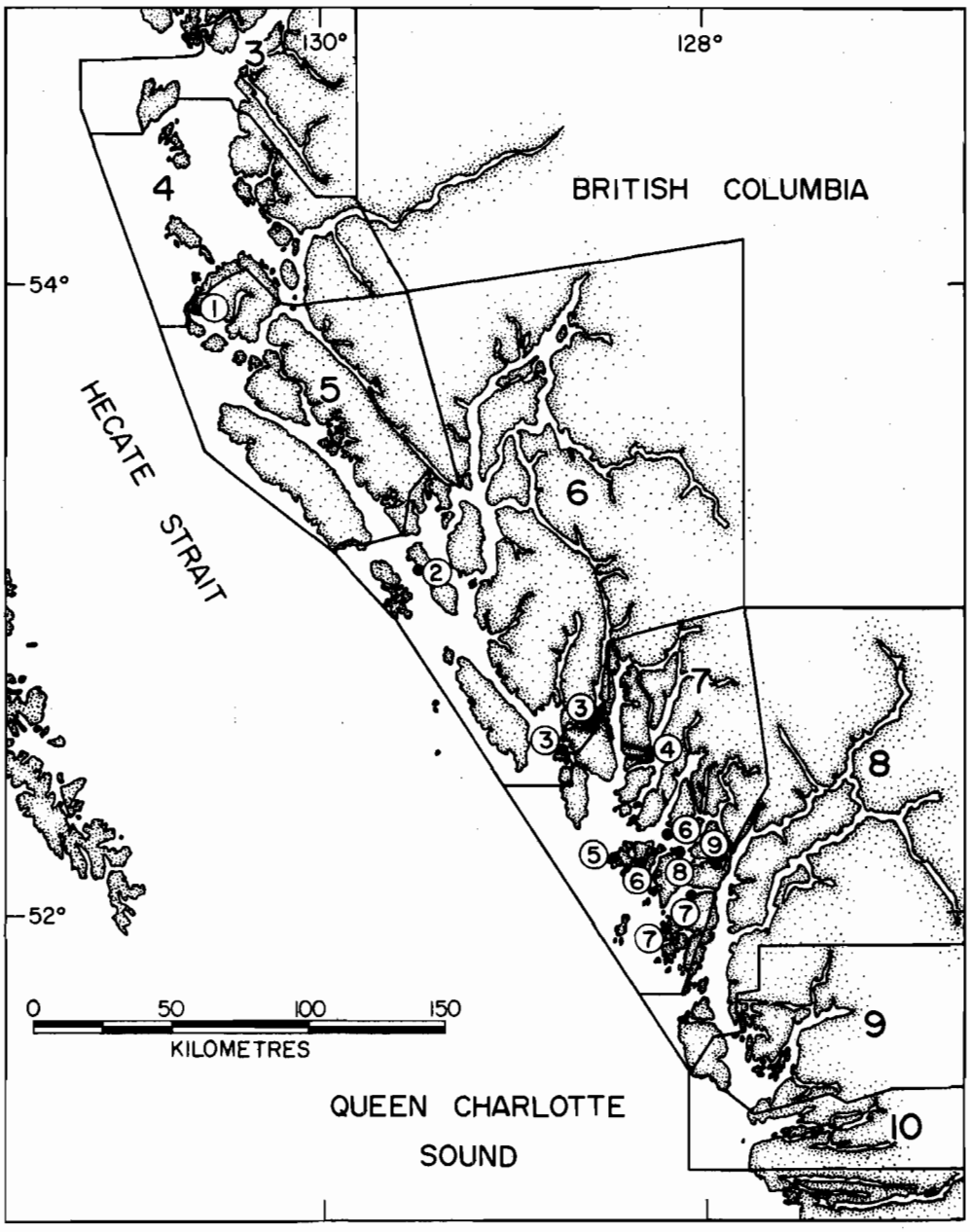


Fig. 1. Map of part of the north coast area of British Columbia showing the location od Department of Fisheries and Oceans statistical areas and the location of nine areas (numbers in circles) sampled during the intertidal clam survey in 1990.

BRITISH COLUMBIA LANDINGS
INTERTIDAL CLAMS

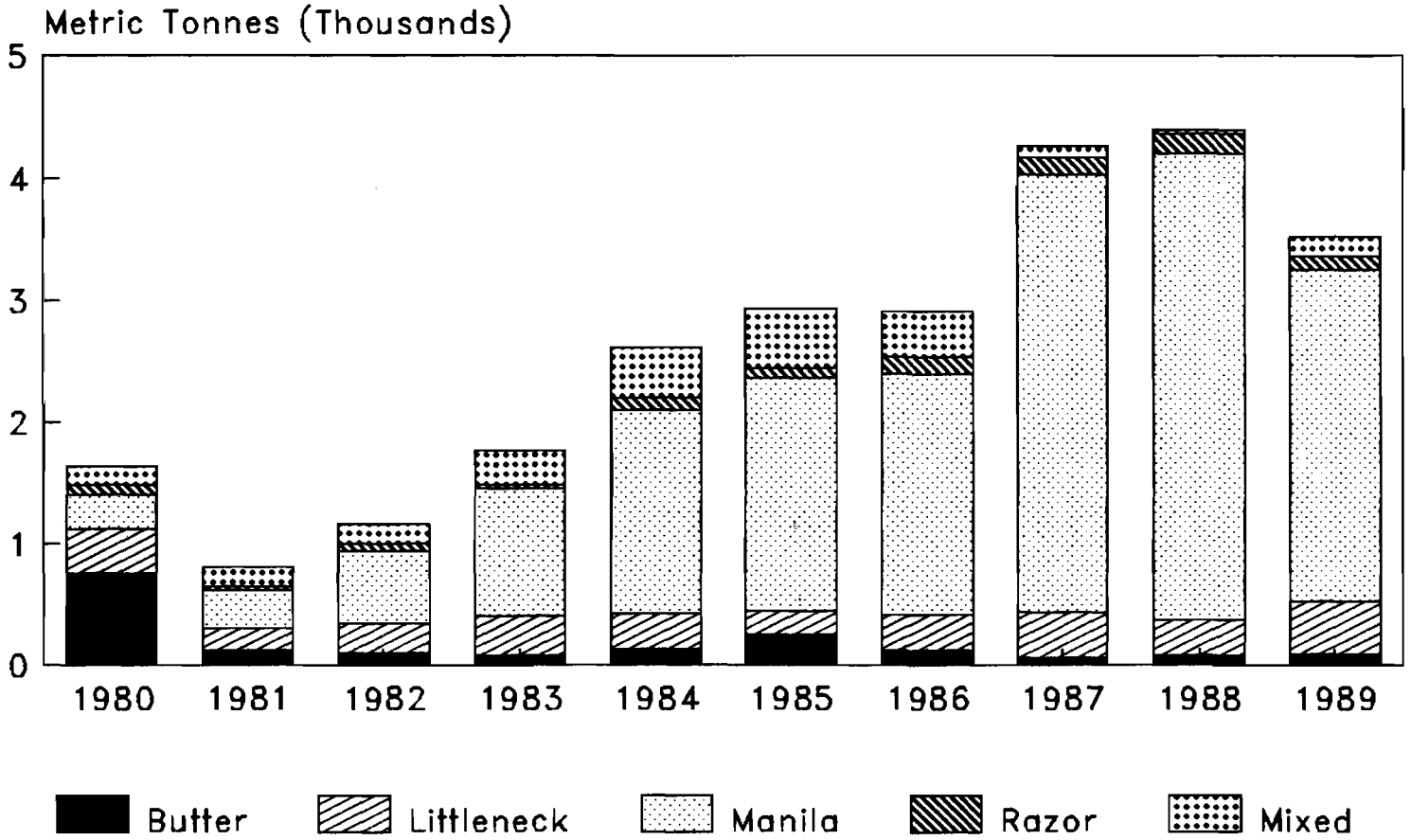


Fig. 2. Landings of intertidal clams in commercial fisheries in British Columbia 1980-1989.

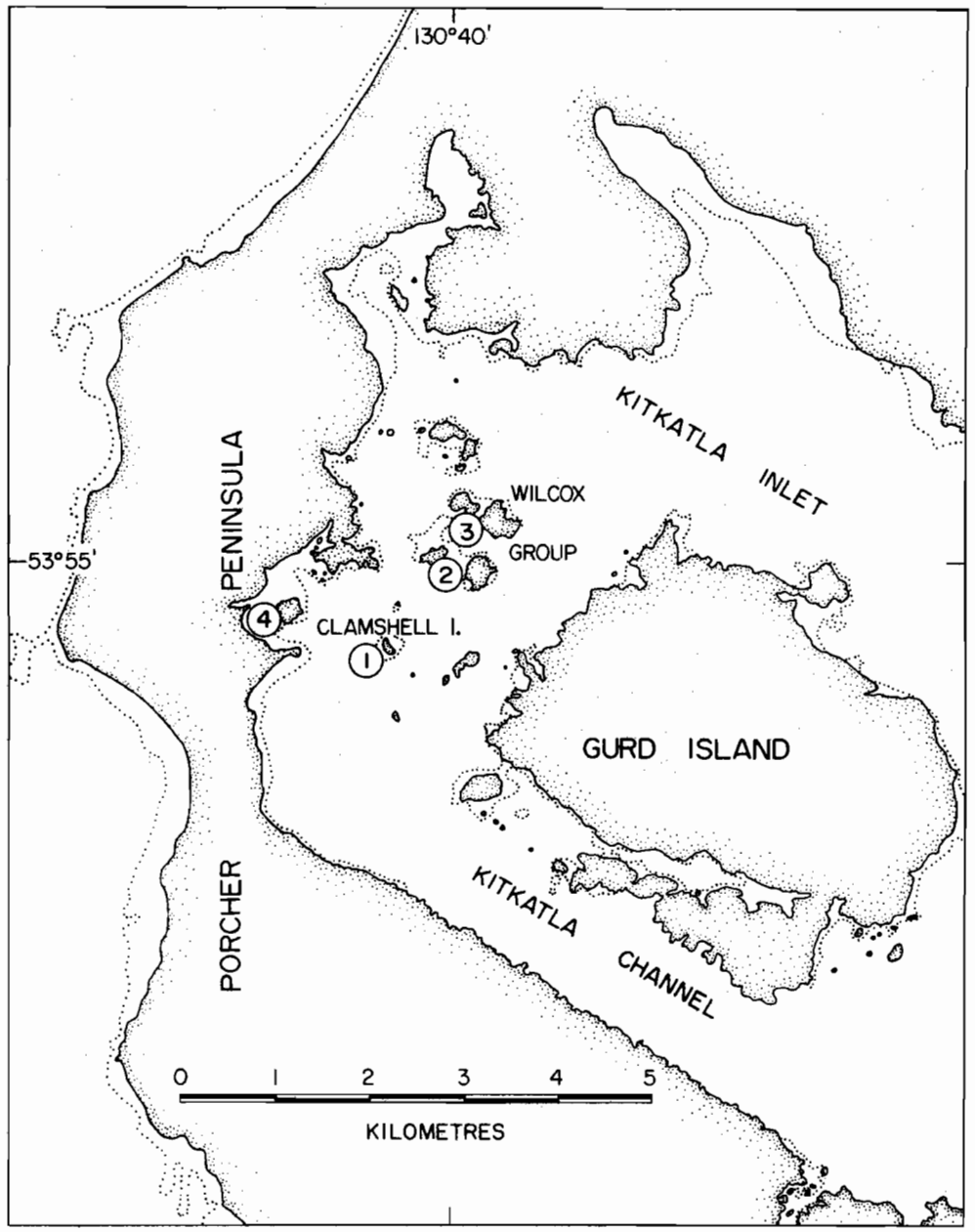
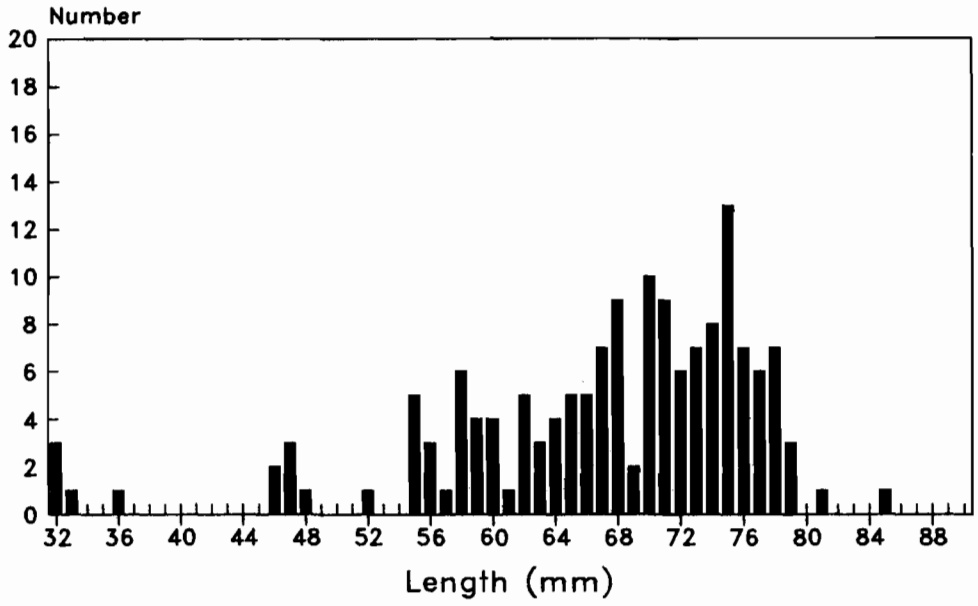


Fig. 3. Map of the upper part of Kitkatla Inlet showing the location of four beaches sampled there, June 20, 1990.

Fig. 4. Size frequency distribution of butter and littleneck clams sampled at Kitkatla Inlet, June 20, 1990.

KITKATLA
Butter Clams



KITKATLA
Littleneck Clams

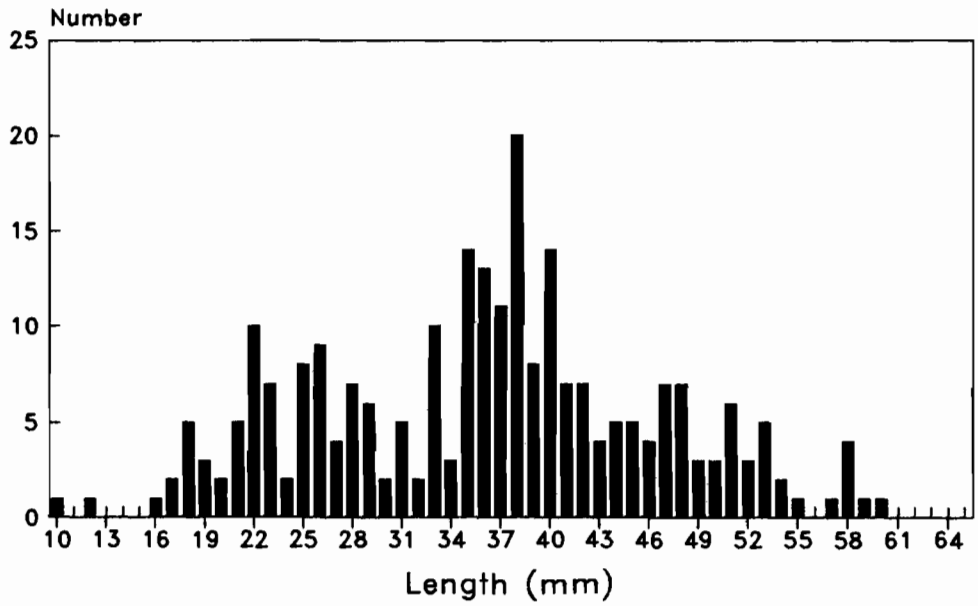
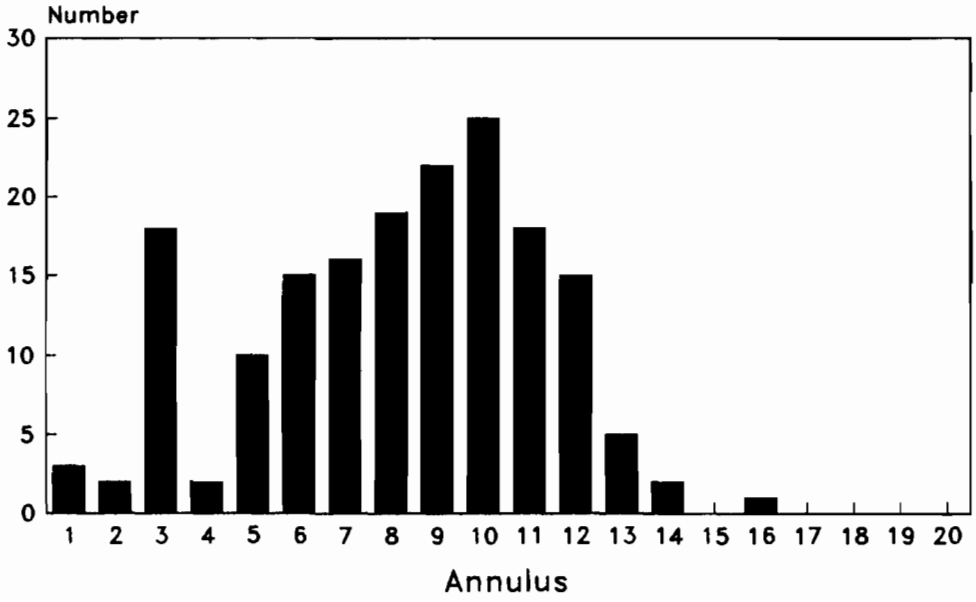


Fig. 5. Age frequency distribution of butter and littleneck clams sampled at Kitkatla Inlet, June 20, 1990.

KITKATLA
Butter Clams



KITKATLA
Littleneck Clams

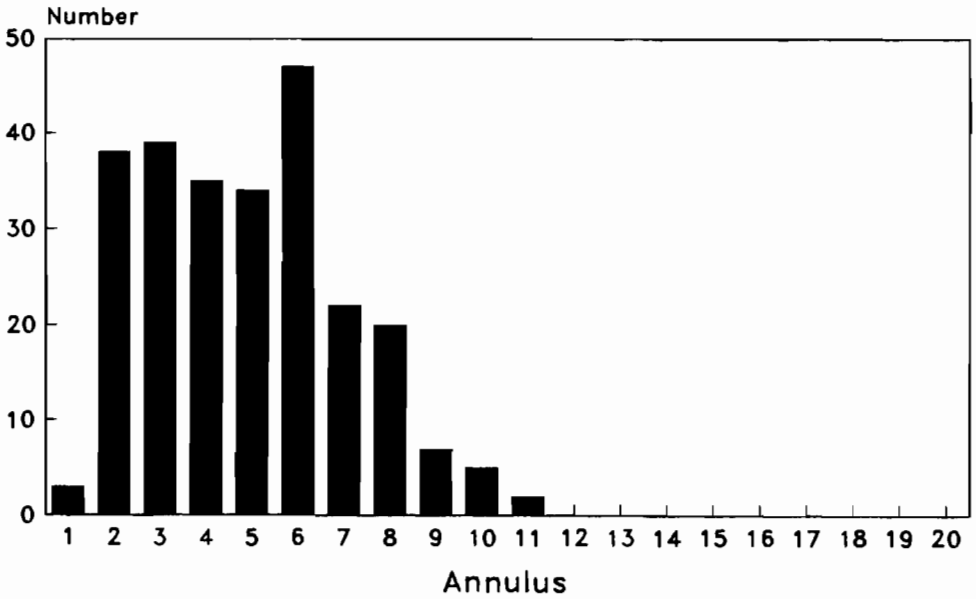
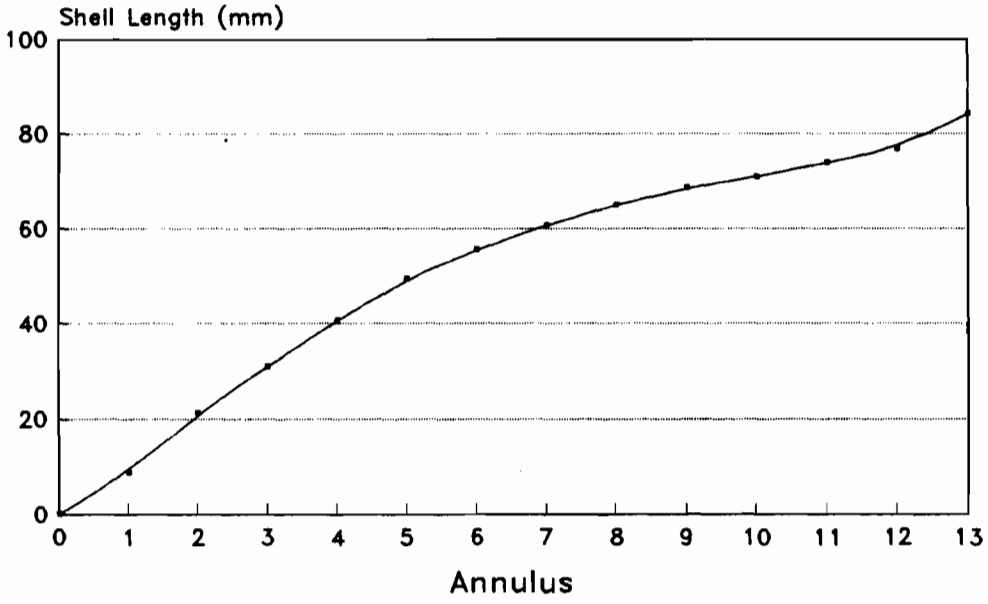
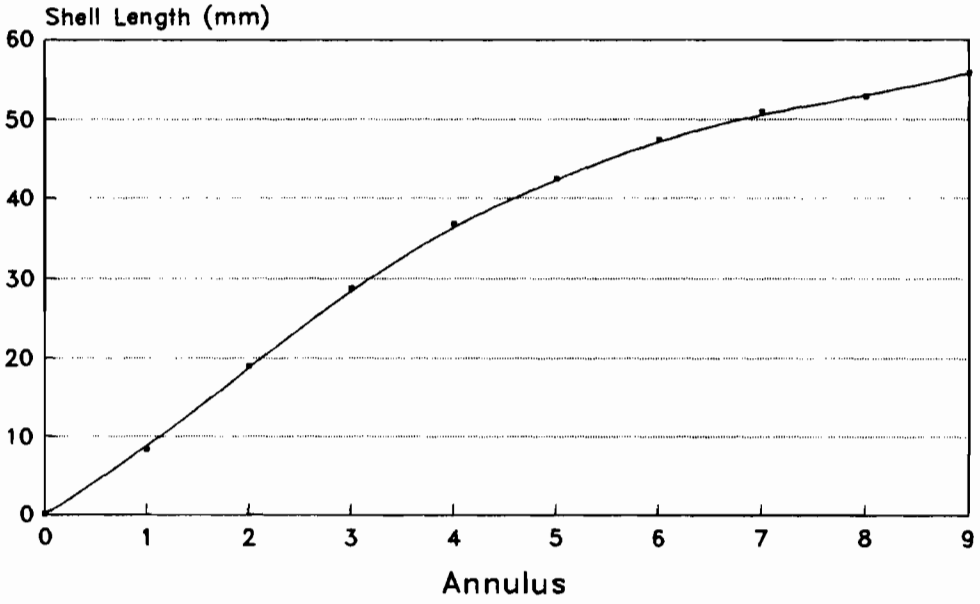


Fig. 6. Growth rate of butter and littleneck clams sampled at Kitkatla Inlet, June 20, 1990.

KITKATLA
Butter Clams



KITKATLA
Littleneck Clams



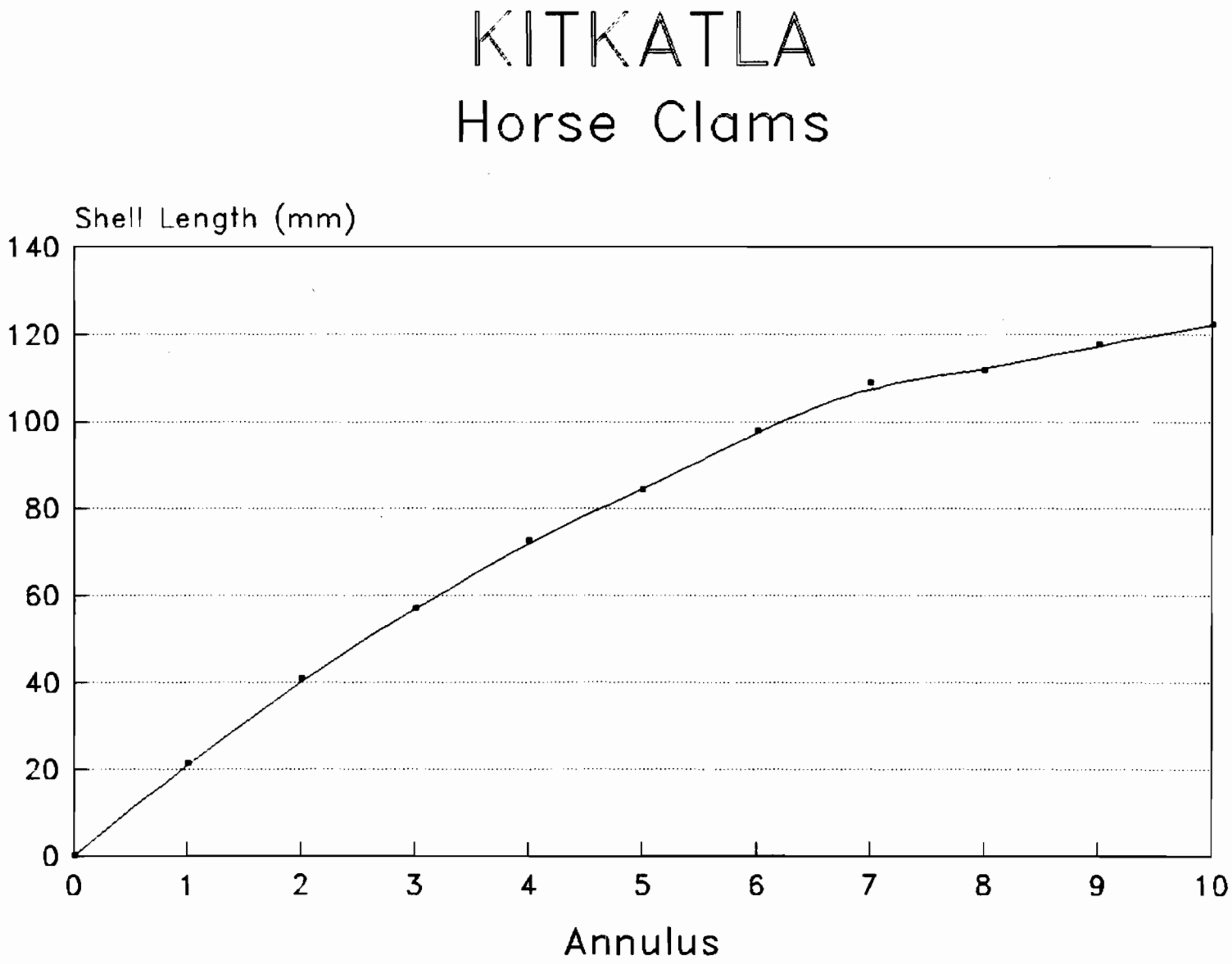


Fig. 7. Growth rate of horse clams, Tresus capax, sampled at Kitkatla Inlet, June 20, 1990.

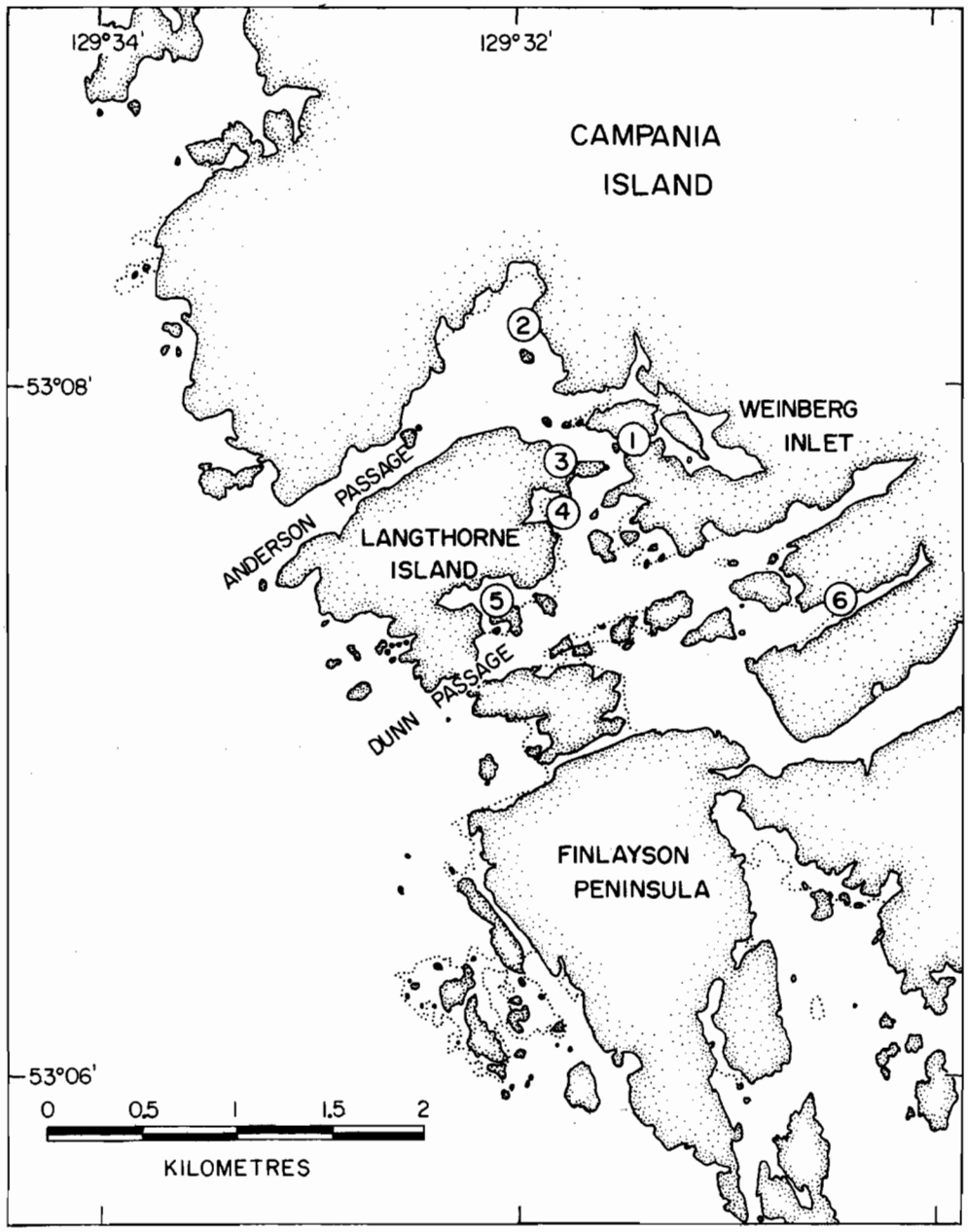
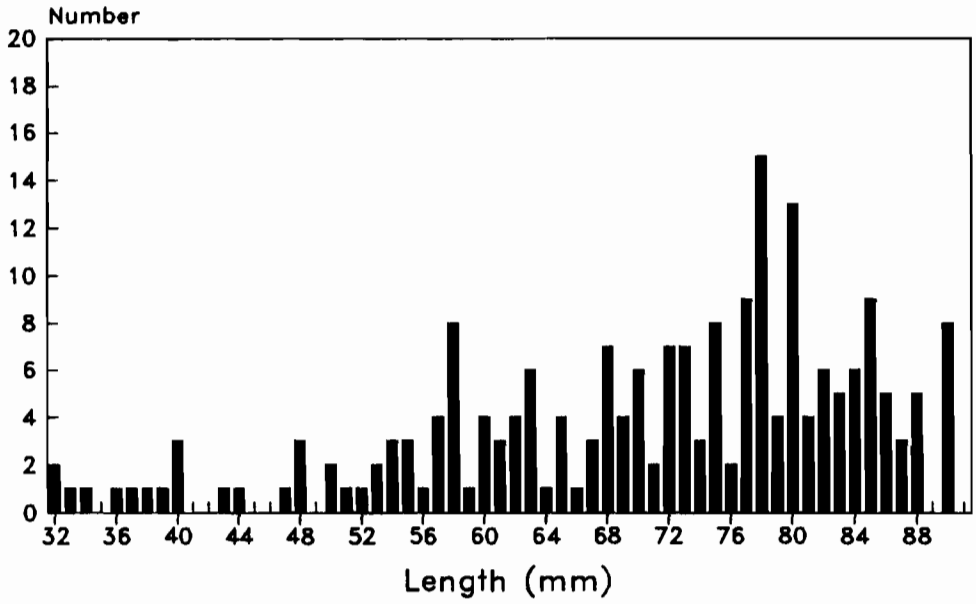


Fig. 8. Map of Weinberg Inlet, Campania Island, showing the location of six beaches sampled there, June 21, 1990.

Fig. 9. Size frequency distribution of butter and littleneck clams sampled at Campania Island, June 21, 1990.

CAMPANIA ISLAND
Butter Clams



CAMPANIA ISLAND
Littleneck Clams

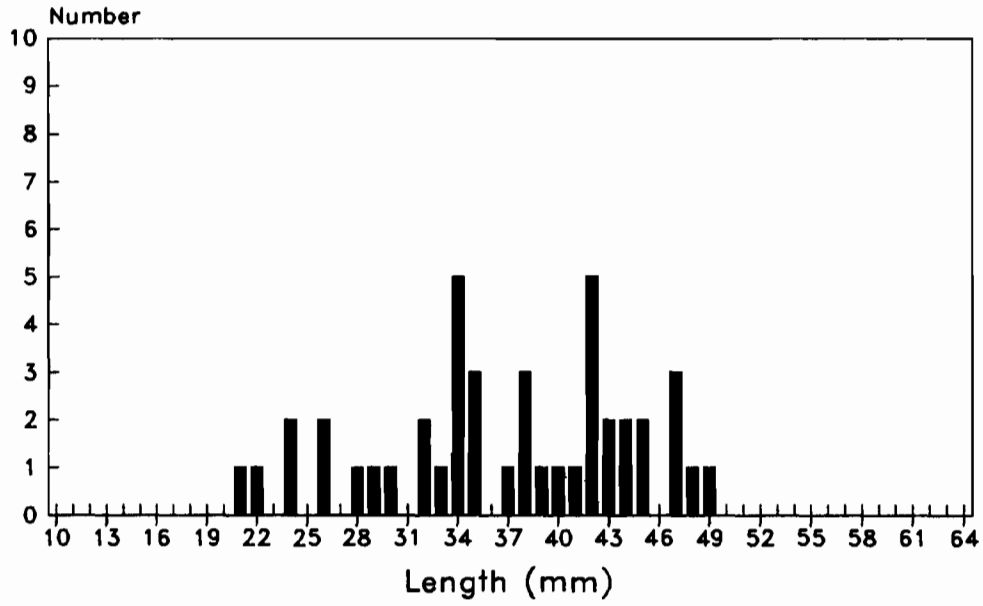
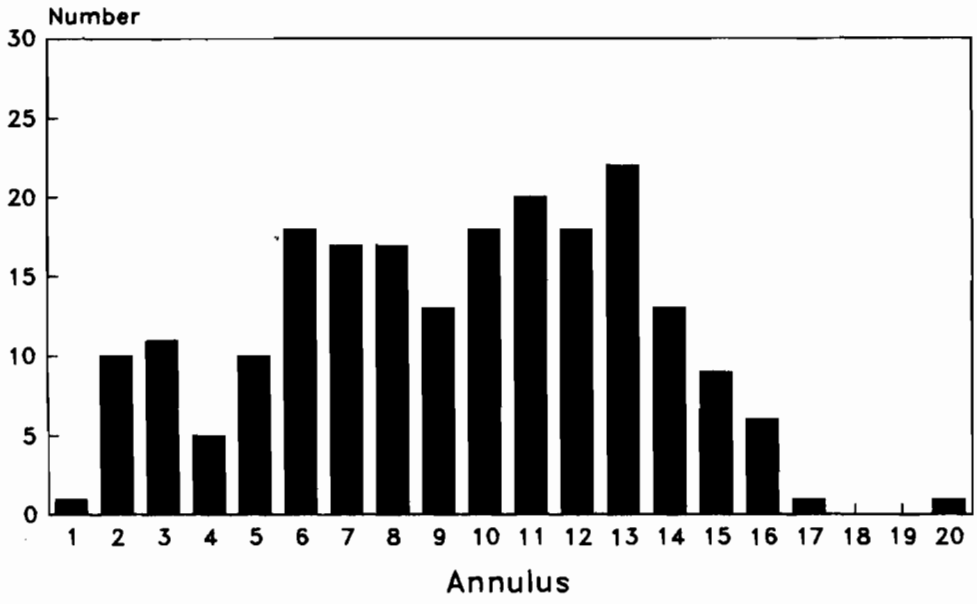


Fig. 10. Age frequency distribution of butter and littleneck clams sampled at Campania Island, June 21, 1990.

CAMPANIA ISLANDS
Butter Clams



CAMPANIA ISLANDS
Littleneck Clams

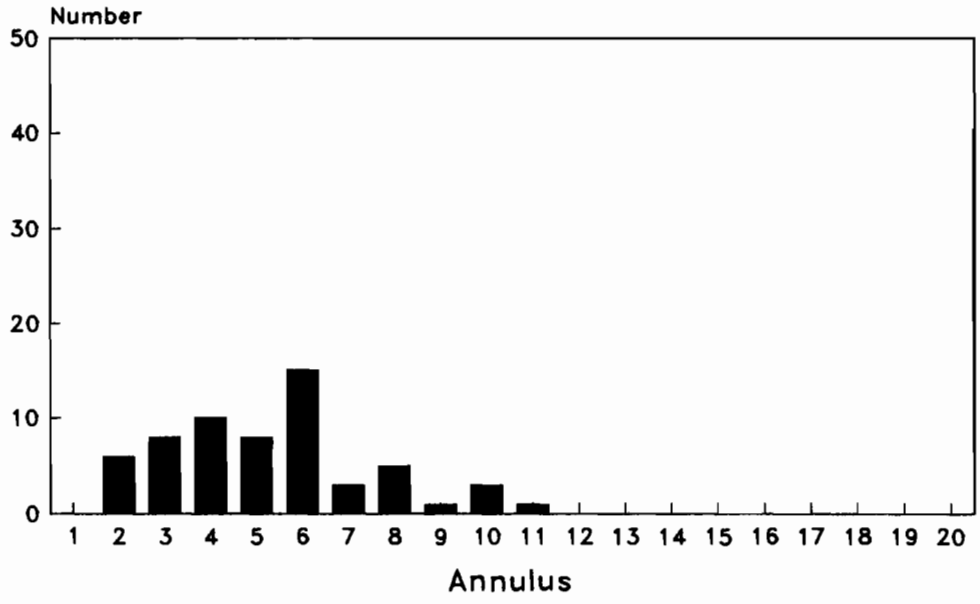
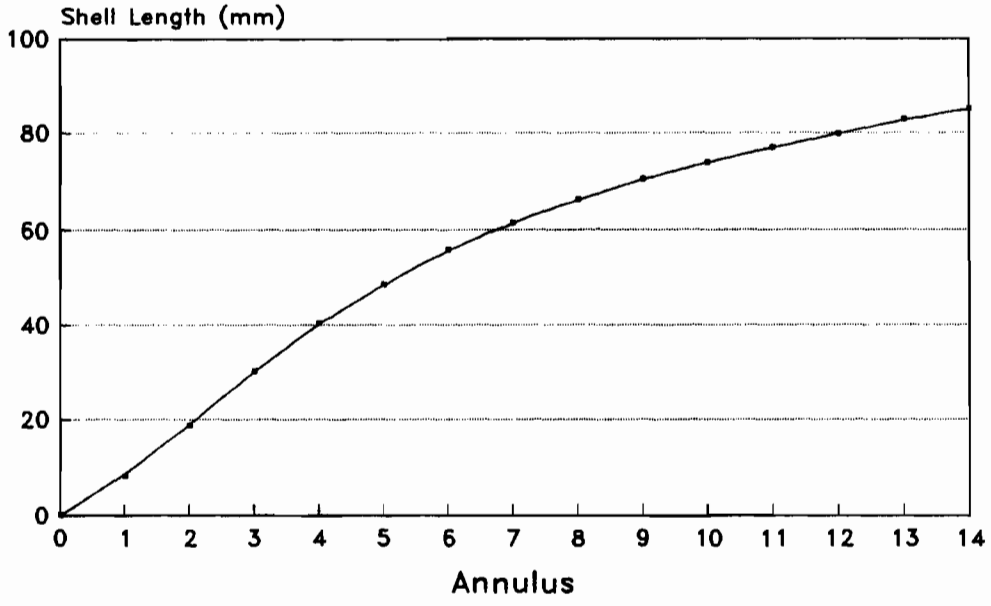
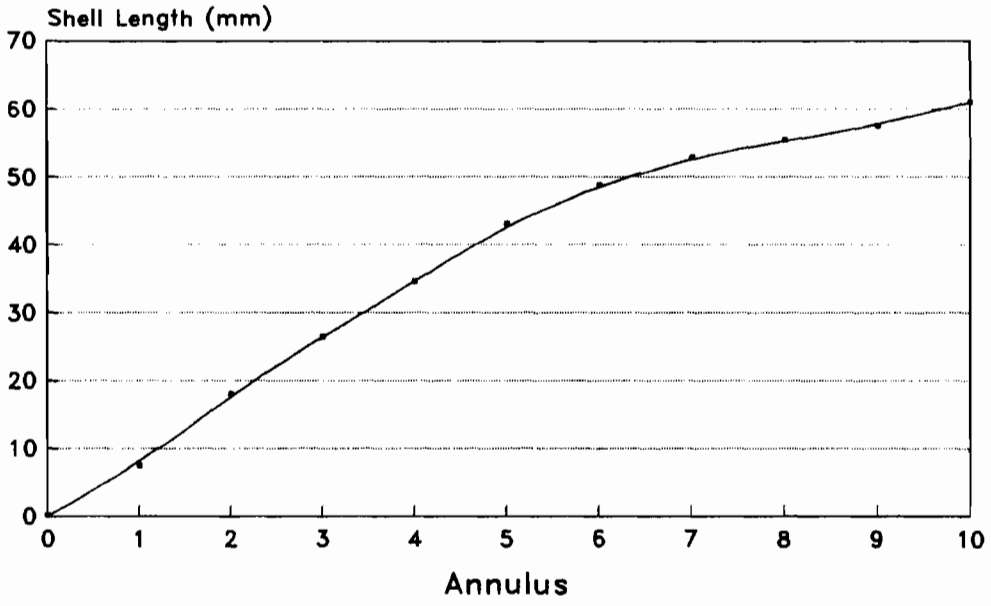


Fig. 11. Growth rate of butter and littleneck clams sampled at Campania Island, June 21, 1990.

CAMPANIA ISLANDS
Butter Clams



CAMPANIA ISLANDS
Littleneck Clams



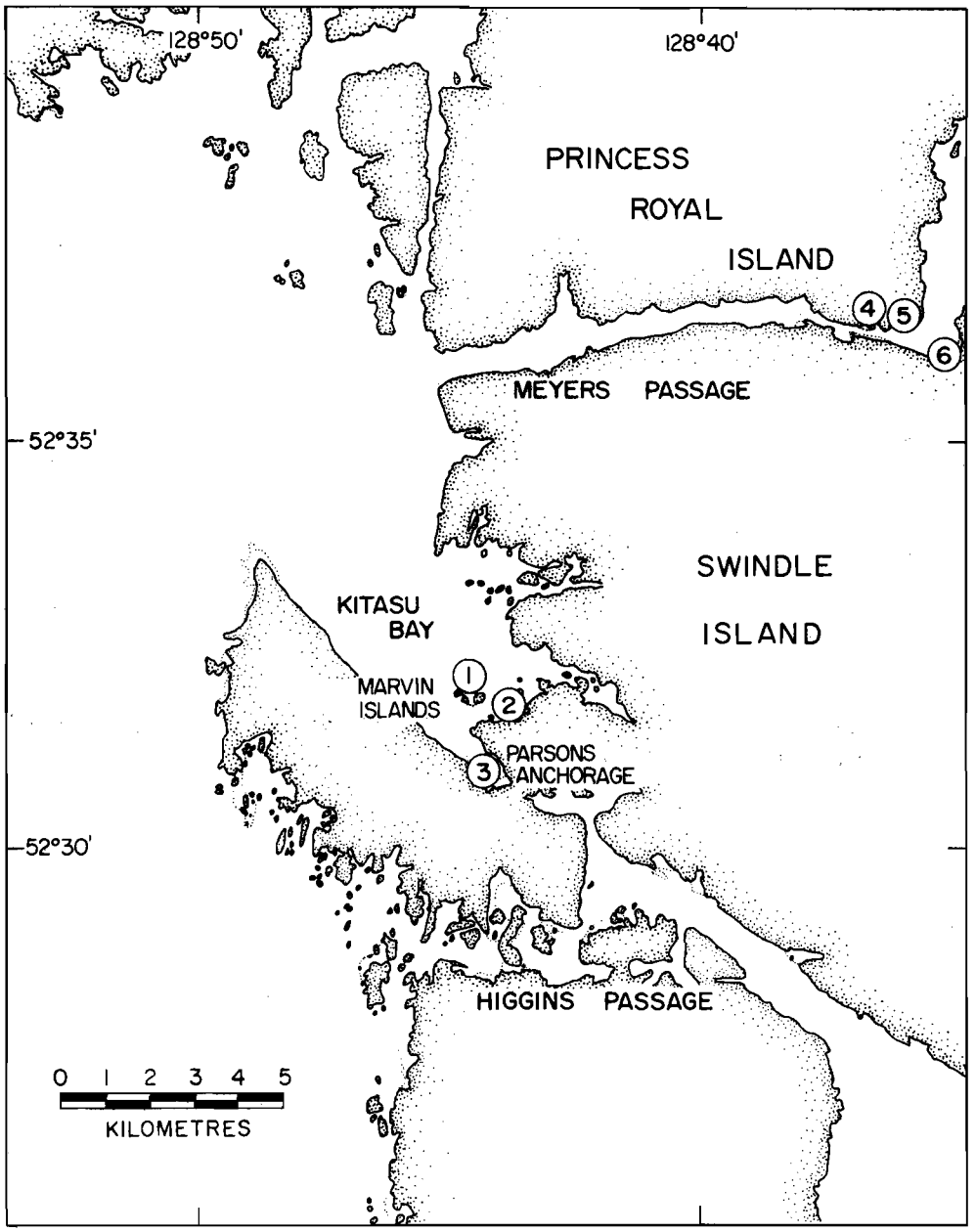
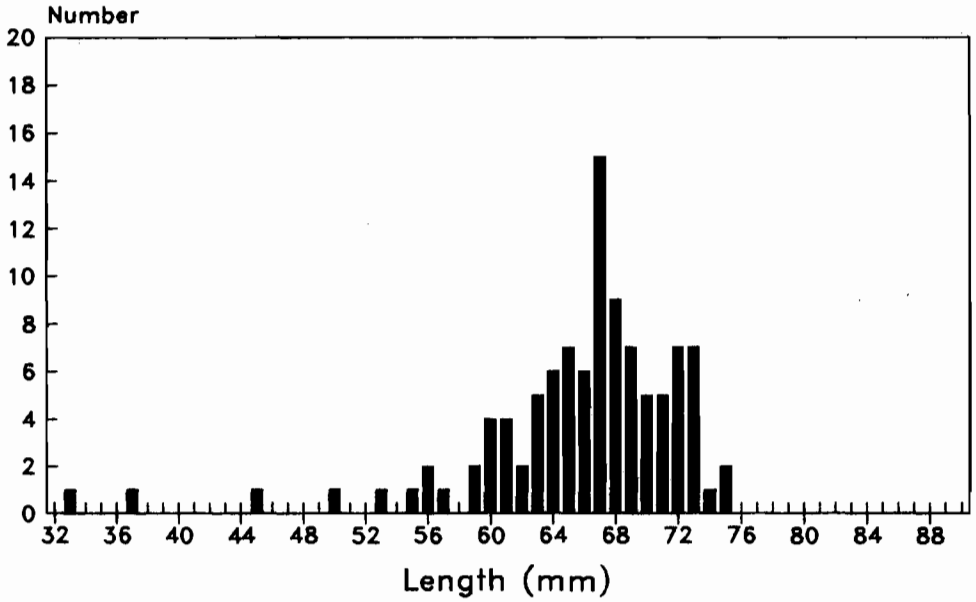


Fig. 12. Map of the Kitasu Bay-Meyers Passage area showing the location of six beaches sampled there, June 22, 1990.

Fig. 13. Size frequency distribution of butter and littleneck clams sampled at Kitasu Bay, June 22, 1990.

KITASU BAY
Butter Clams



KITASU BAY
Littleneck Clams

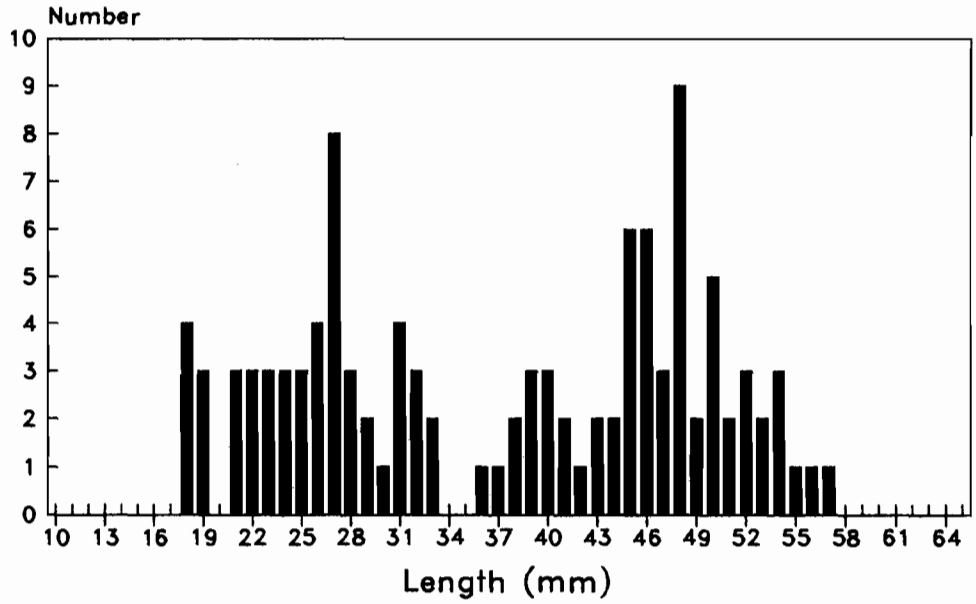
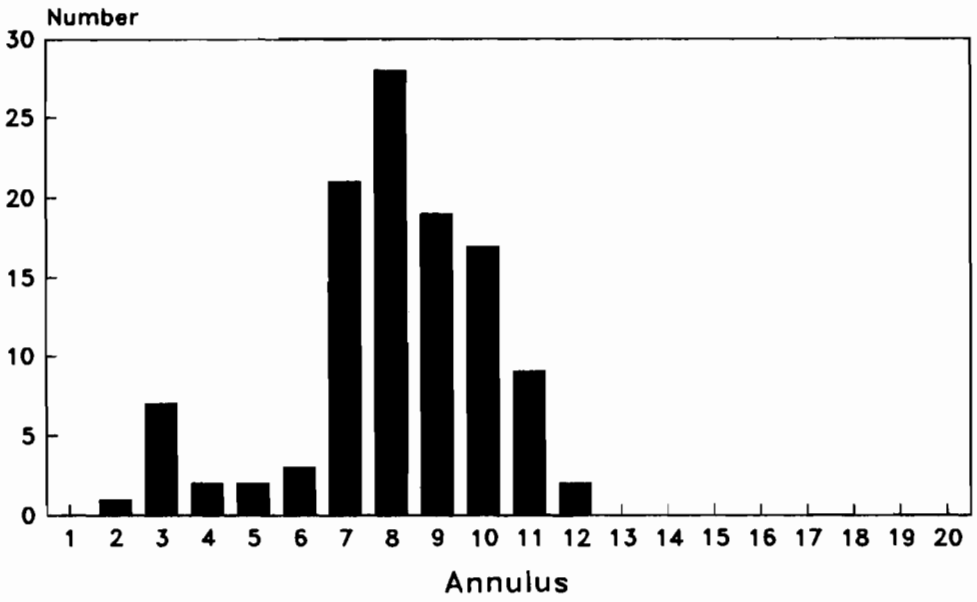


Fig. 14. Age frequency distribution of butter and littleneck clams sampled at Kitasu Bay, June 22, 1990.

KITASU BAY
Butter Clams



KITASU BAY
Littleneck Clams

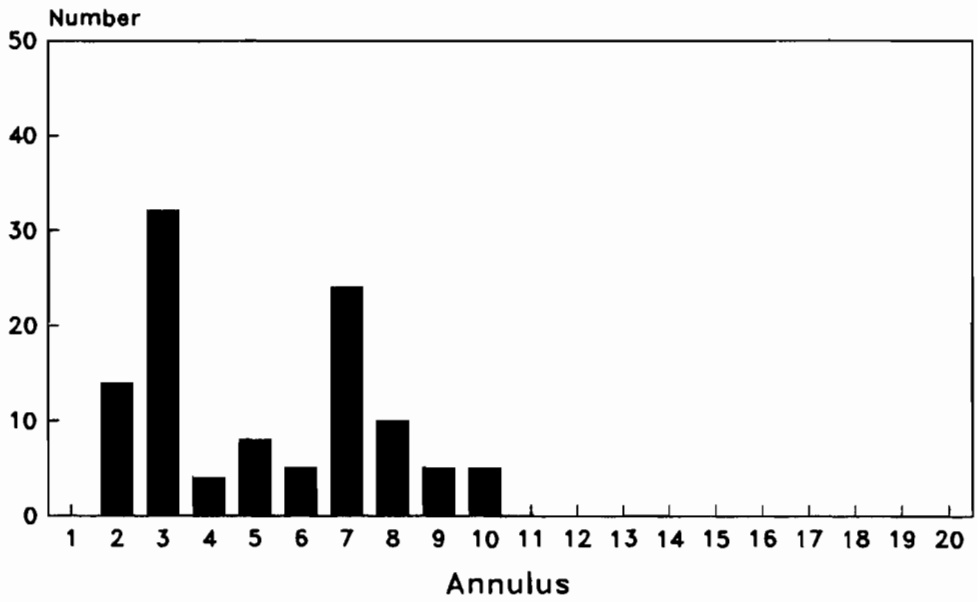
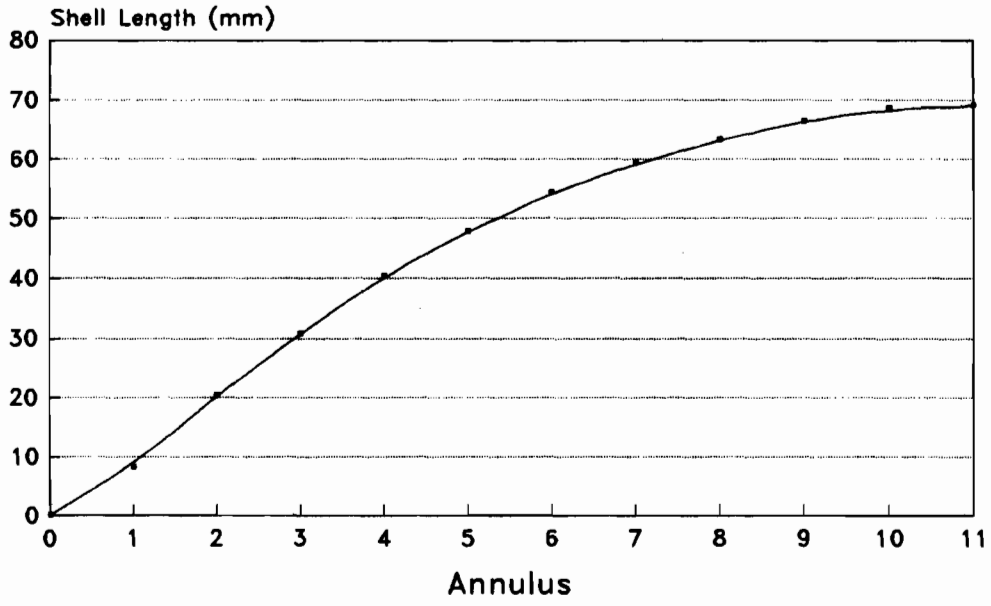
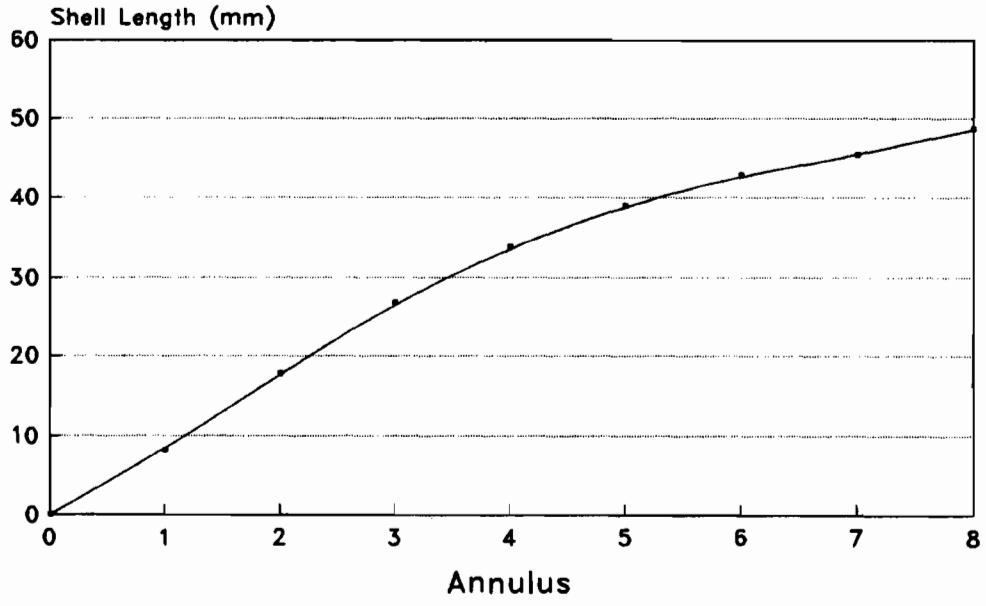


Fig. 15. Growth rate of butter and littleneck clams sampled at Kitasu Bay, June 22, 1990.

KITASU BAY
Butter Clams



KITASU BAY
Littleneck Clams



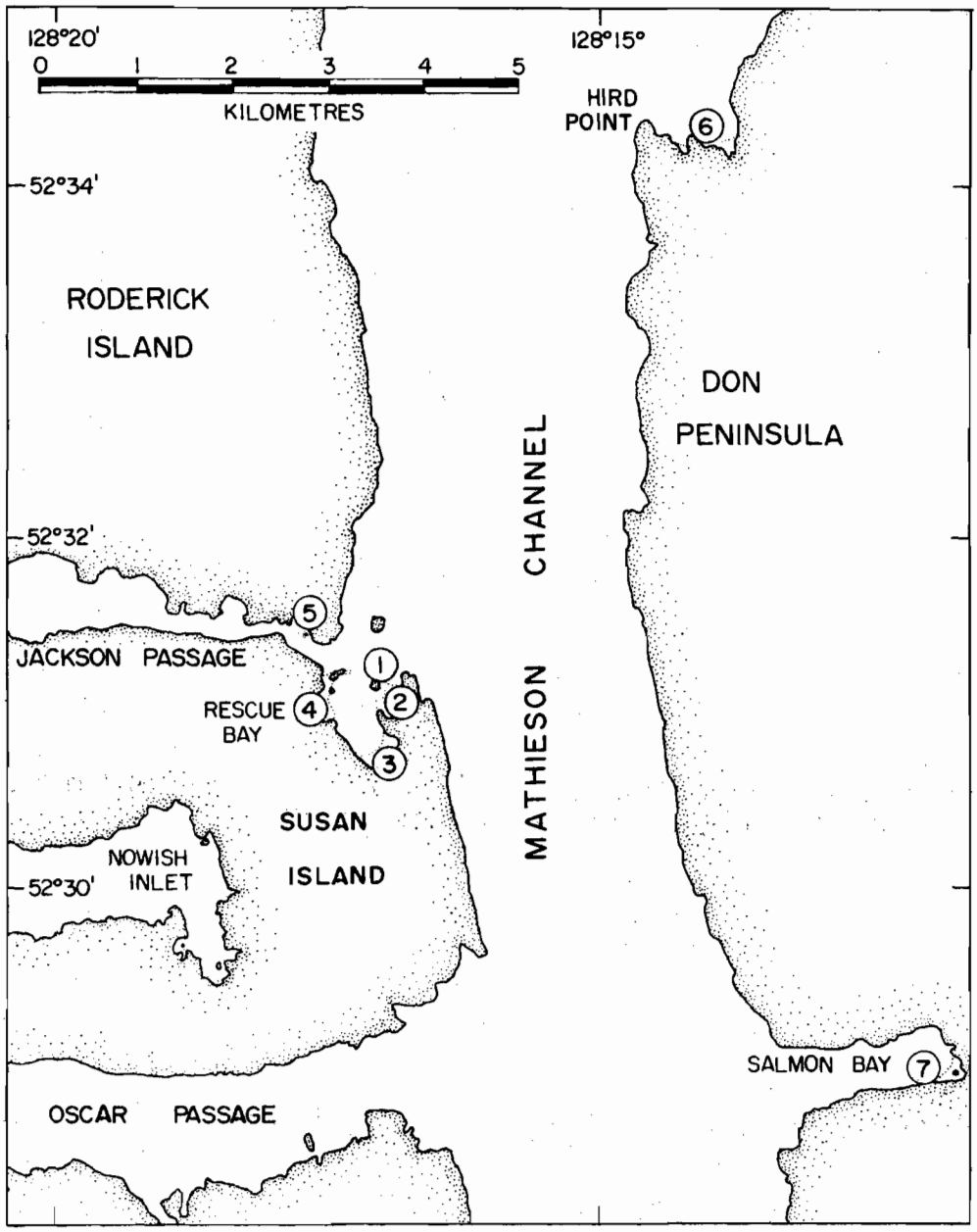
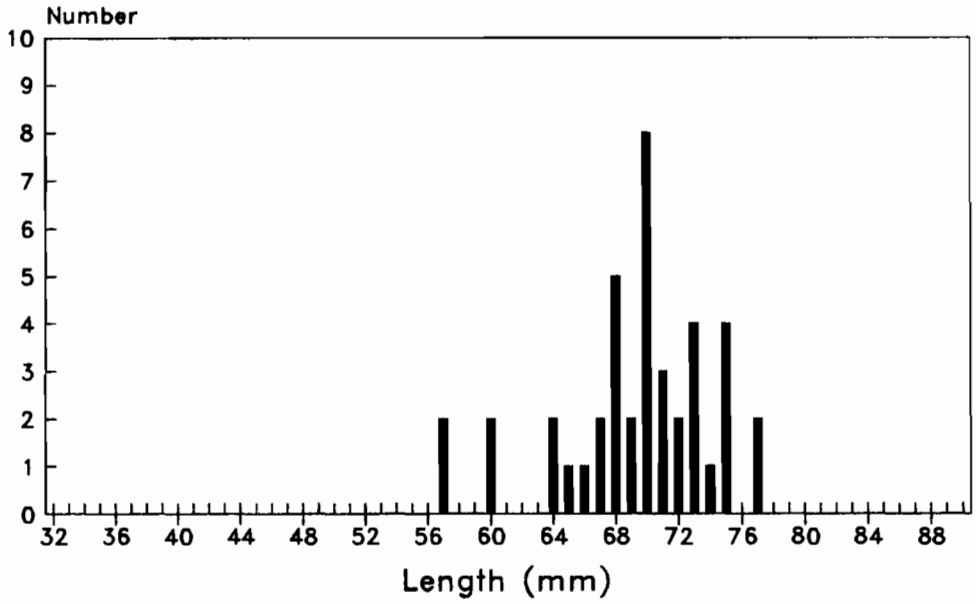


Fig. 16. Map of the Mathieson Channel area showing the location of seven beaches sampled there, June 23, 1990.

Fig. 17. Size frequency distribution of butter and littleneck clams sampled in the Mathieson Channel area, June 23, 1990.

MATHIESON CHANNEL
Butter Clams



MATHIESON CHANNEL
Littleneck Clams

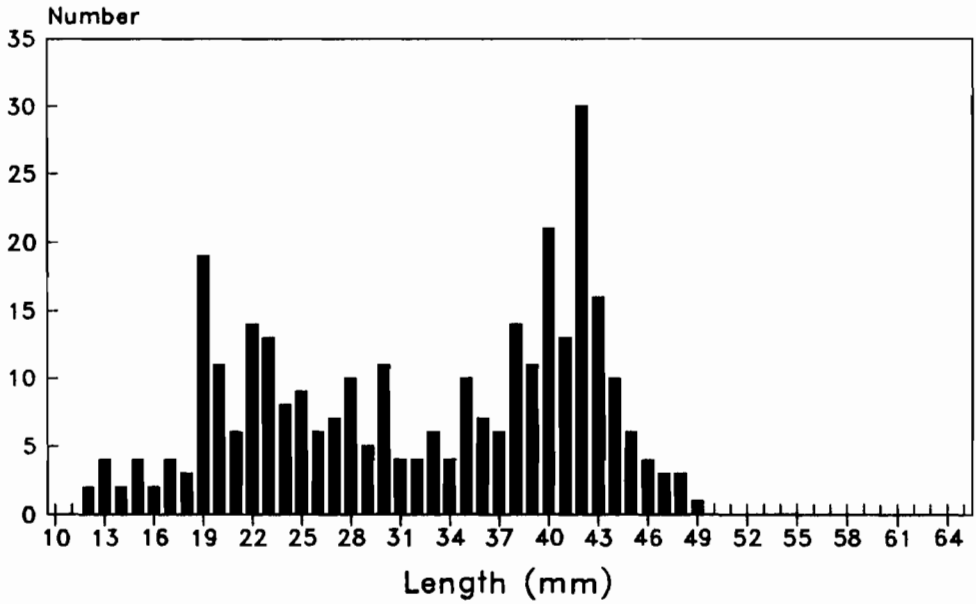
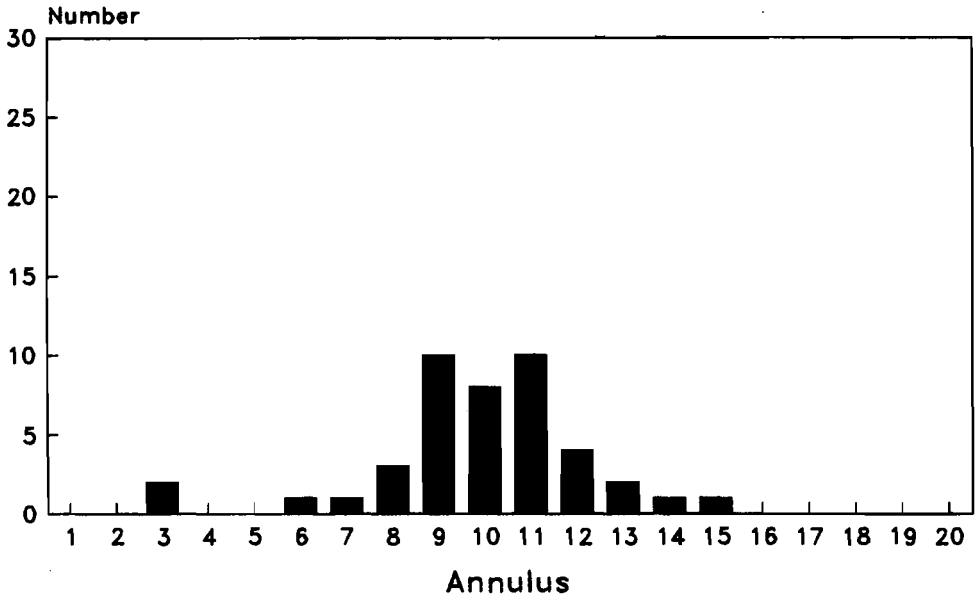


Fig. 18. Age frequency distribution of butter and littleneck clams sampled in the Mathieson Channel area, June 23, 1990.

MATHIESON CHANNEL
Butter Clams



MATHIESON CHANNEL
Littleneck Clams

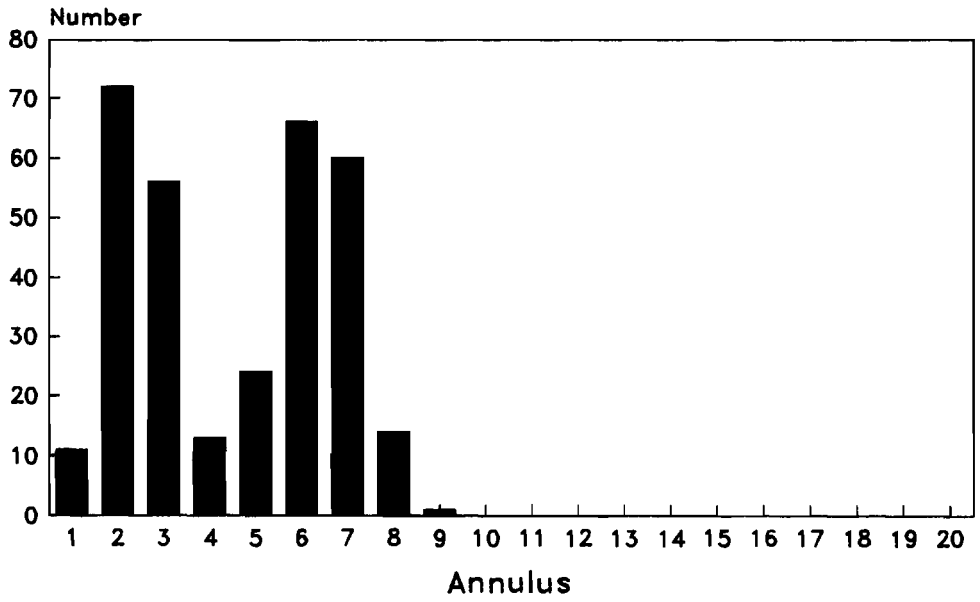
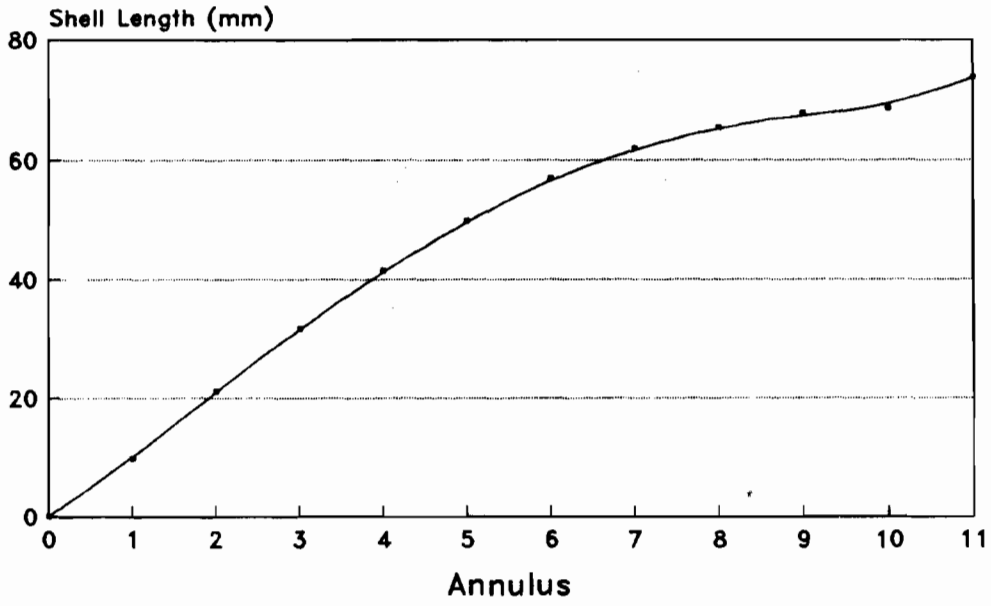


Fig. 19. Growth rate of butter and littleneck clams sampled in the Mathieson Channel area, June 23, 1990.

MATHIESON CHANNEL
Butter Clams



MATHIESON CHANNEL
Littleneck Clams

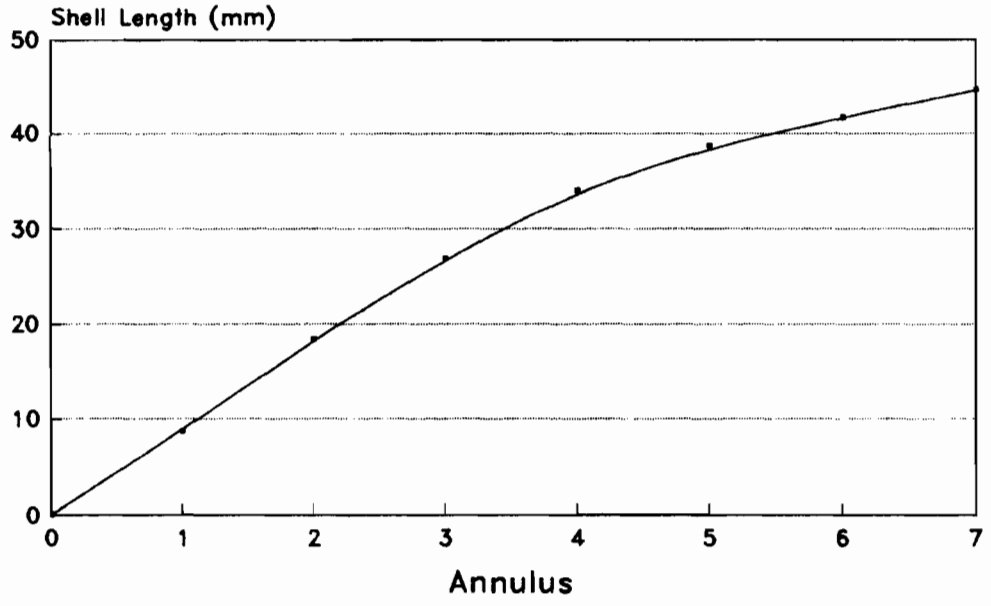
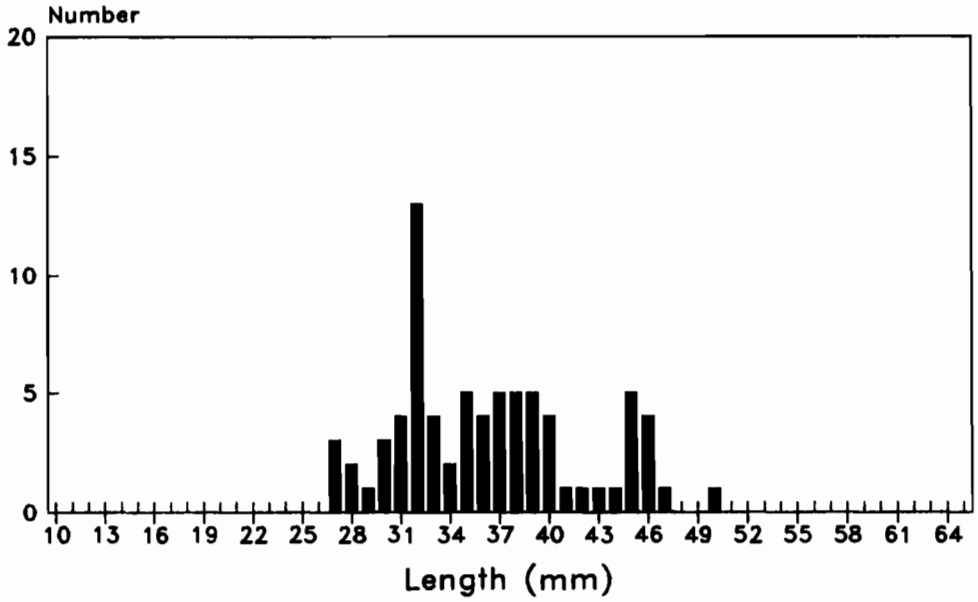


Fig. 20. Size frequency distribution of manila clams sampled in the Mathieson Channel area, June 23, 1990.

MATHIESON CHANNEL
Manila Clams



MATHIESON CHANNEL
Manila Clams

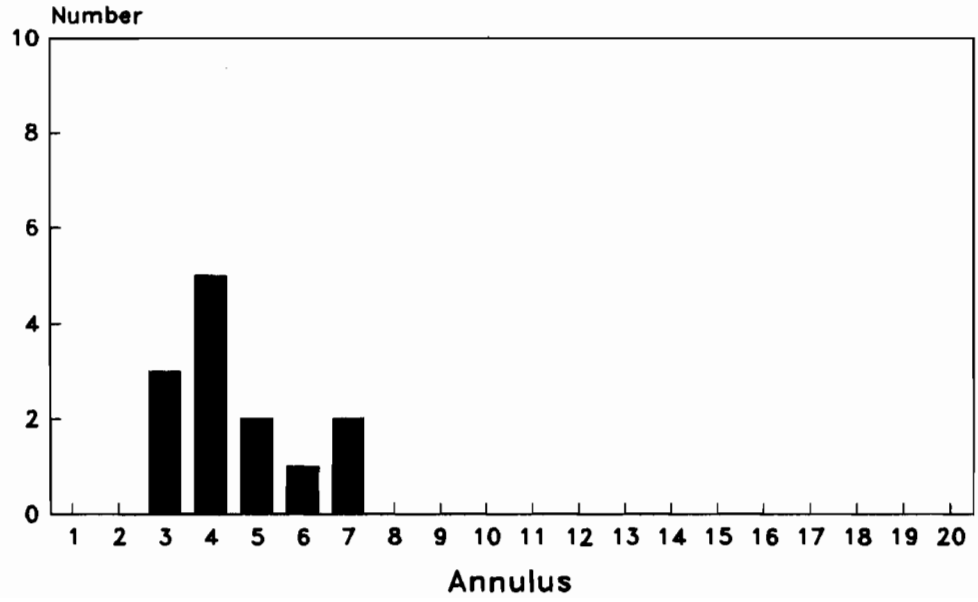
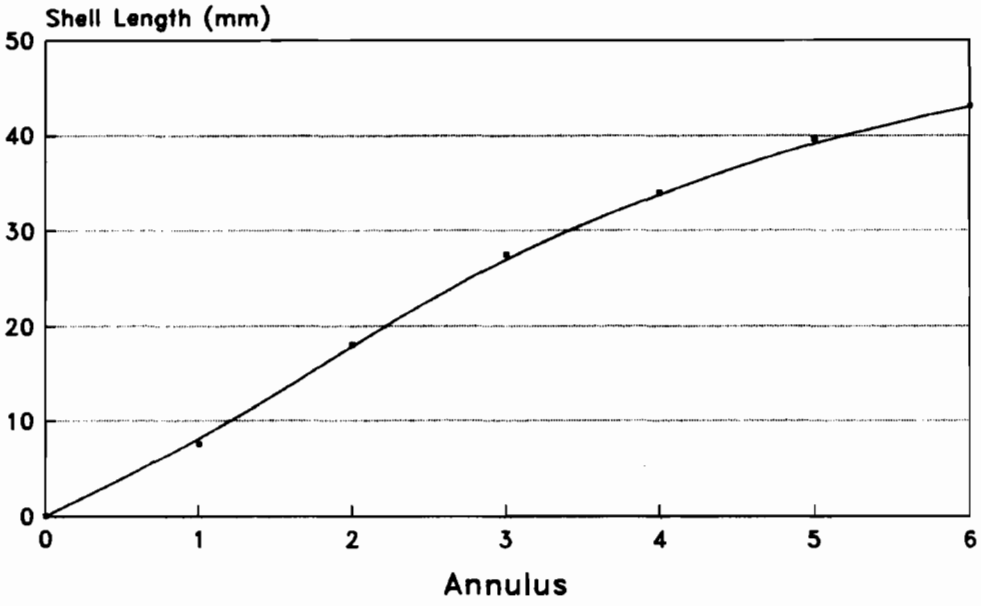
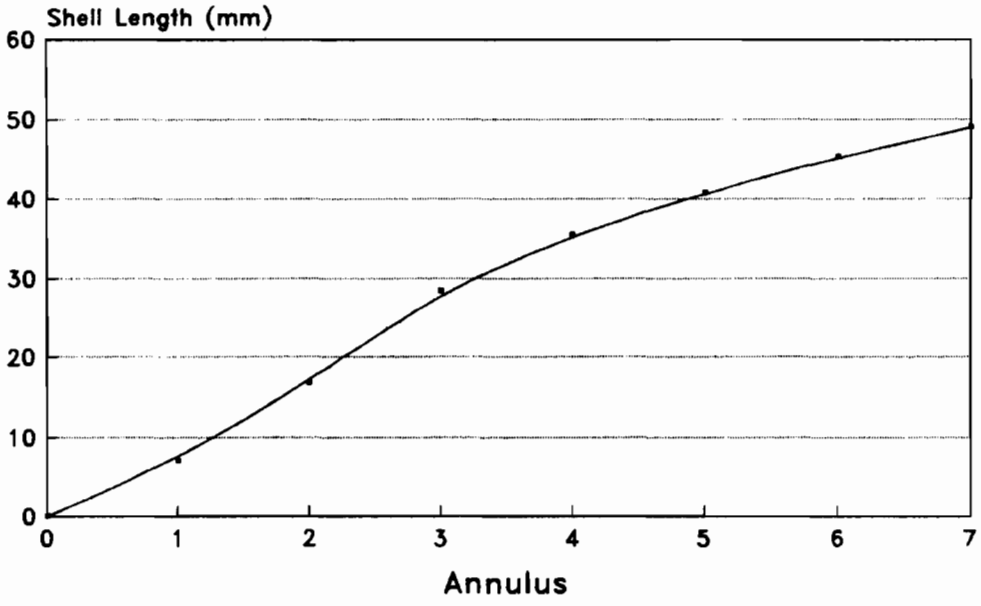


Fig. 21. Growth rate of manila clams sampled in the Mathieson Channel area, June 23, 1990.

RESCUE BAY
Manila Clams



SALMON BAY
Manila Clams



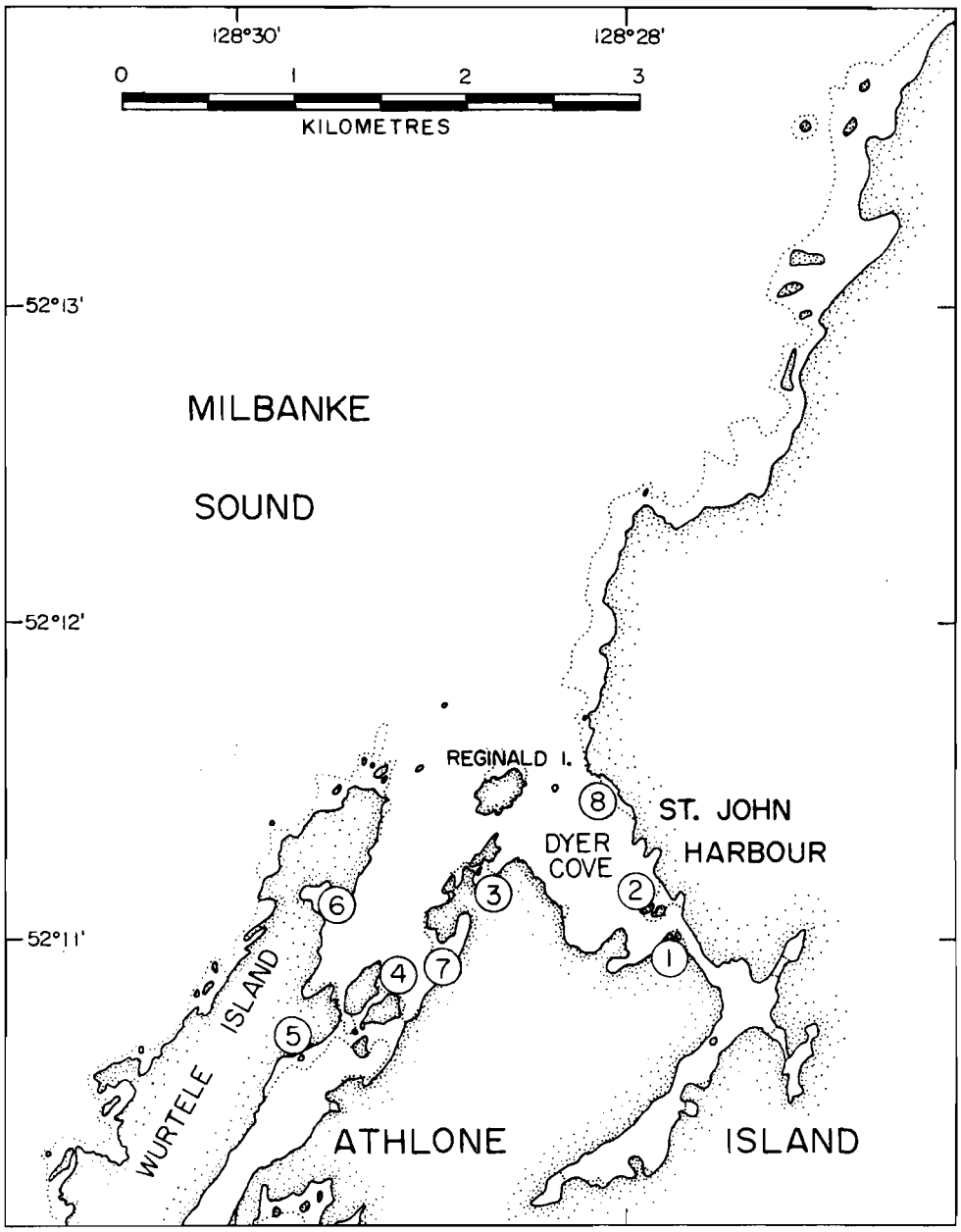
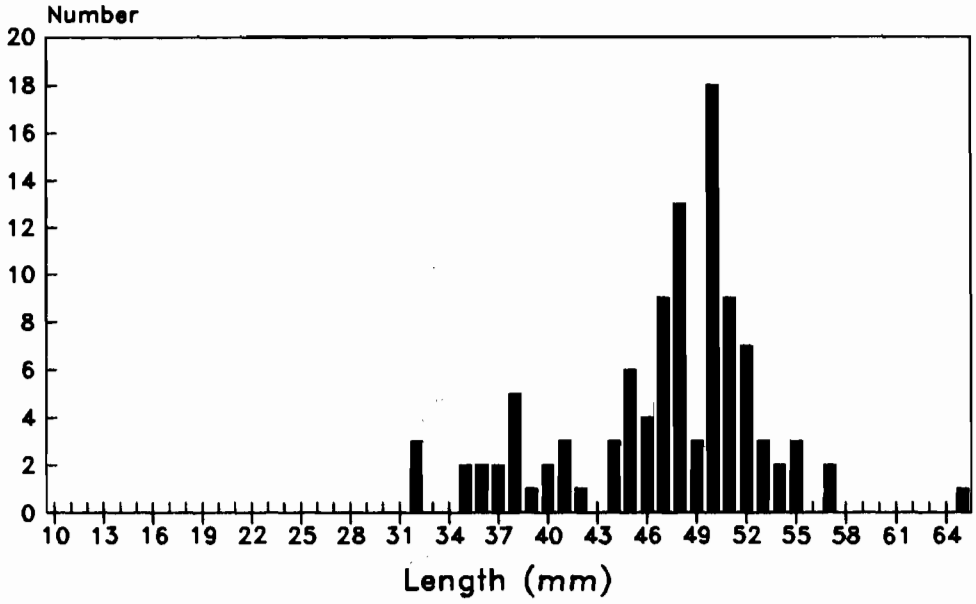


Fig. 22. Map of the St. John Harbour area showing the location of eight beaches sampled there, June 23, 1990.

Fig. 23. Size and age frequency distribution of manila clams sampled in the St. John Harbour area, June 23, 1990.

ST.JOHN HARBOUR
Manila Clams



ST. JOHN HARBOUR
Manila Clams

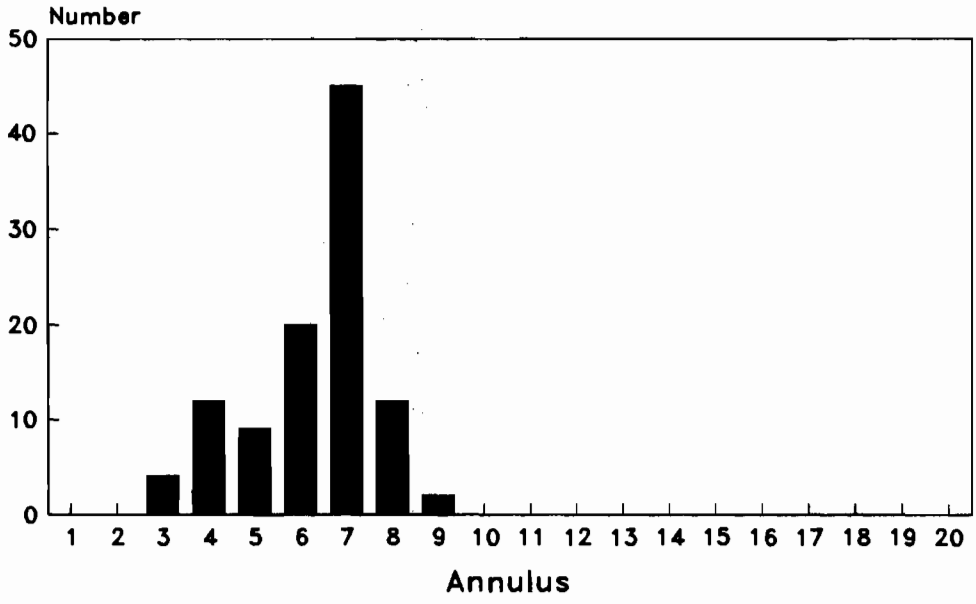
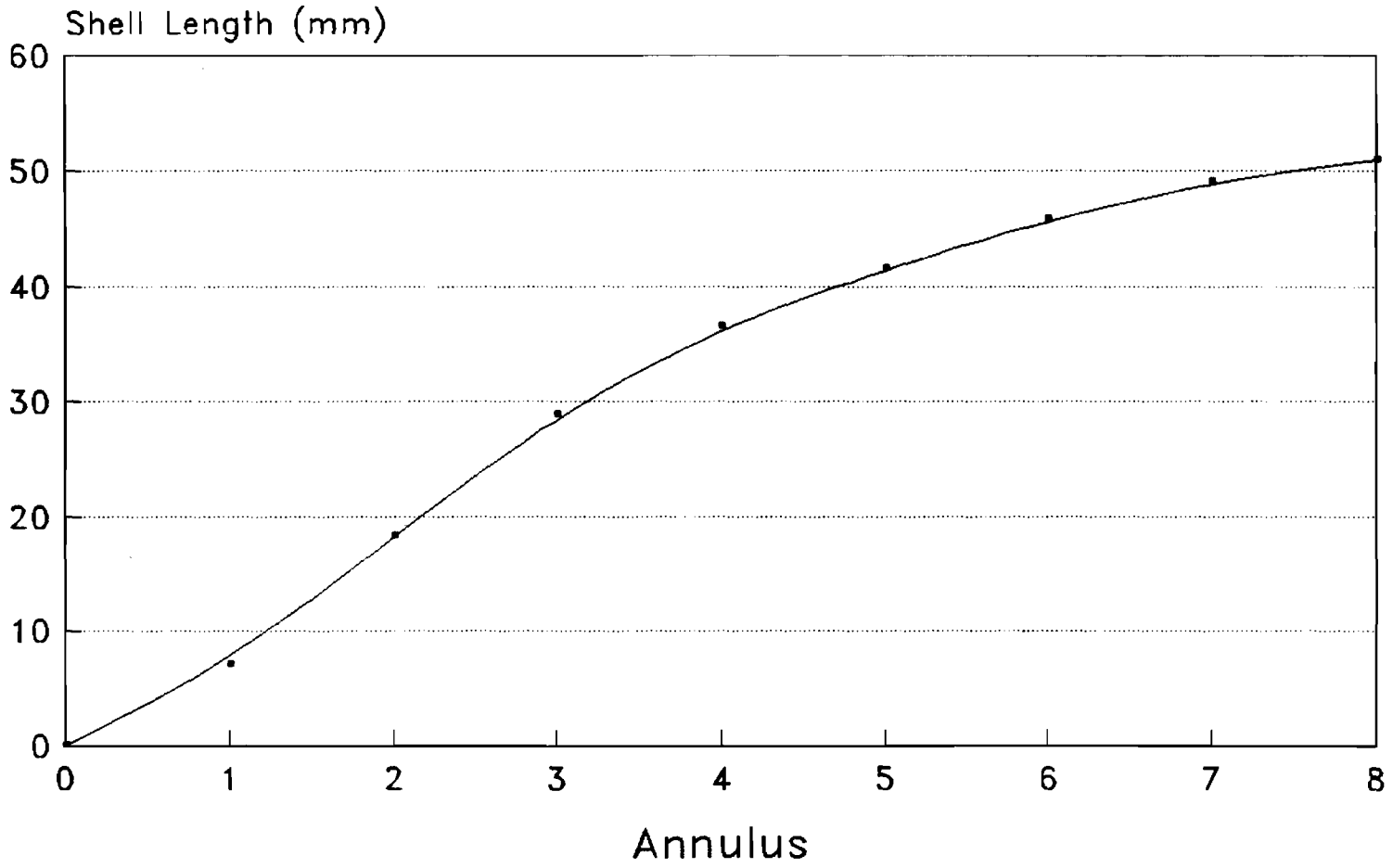


Fig. 24. Growth rate of manila clams sampled in the St. John Harbour area, June 23, 1990.

ST. JOHN HARBOUR

Manila Clams



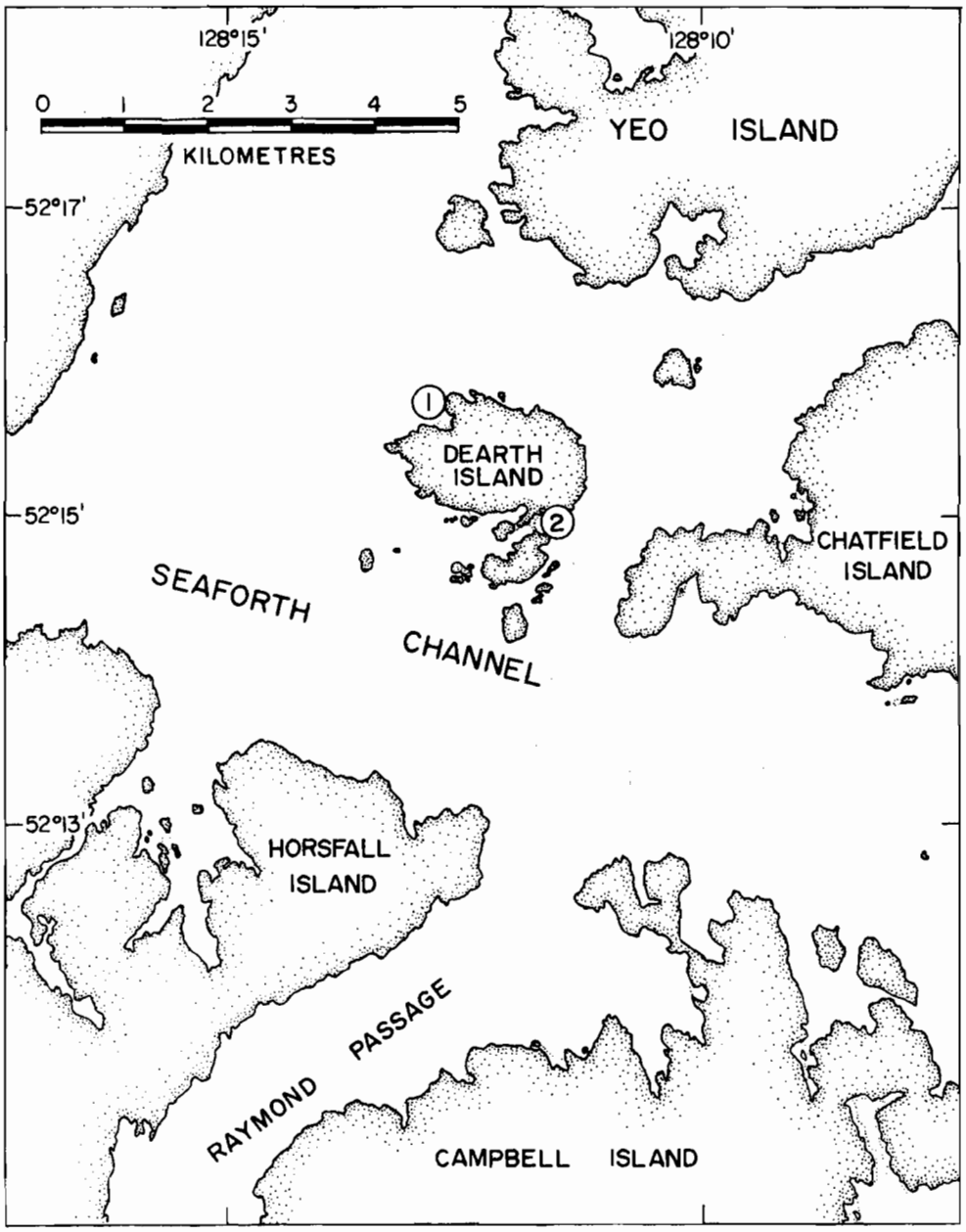


Fig. 25. Map of the Seaforth Channel area showing the location of two beaches sampled at Dearth Island, June 24, 1990.

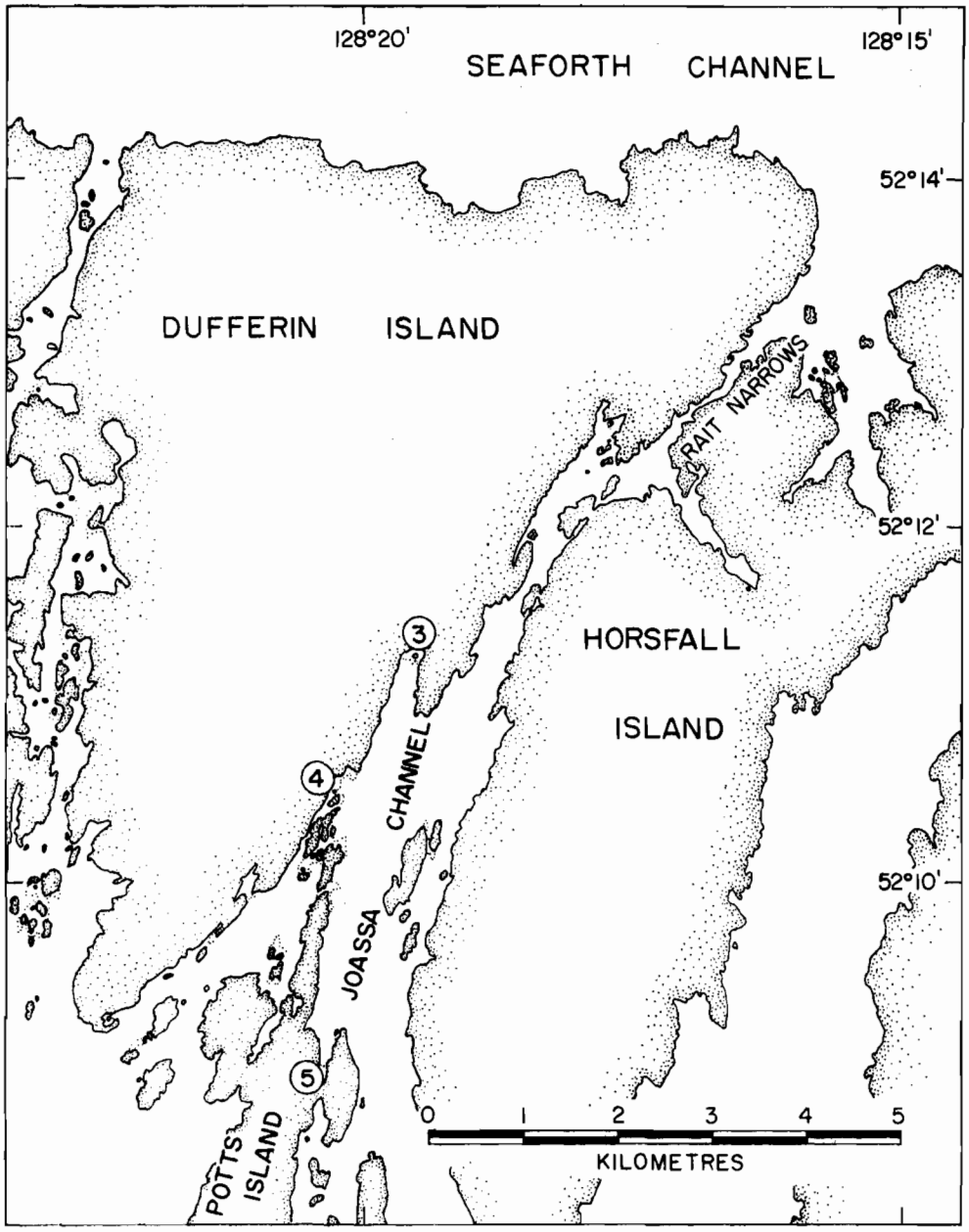
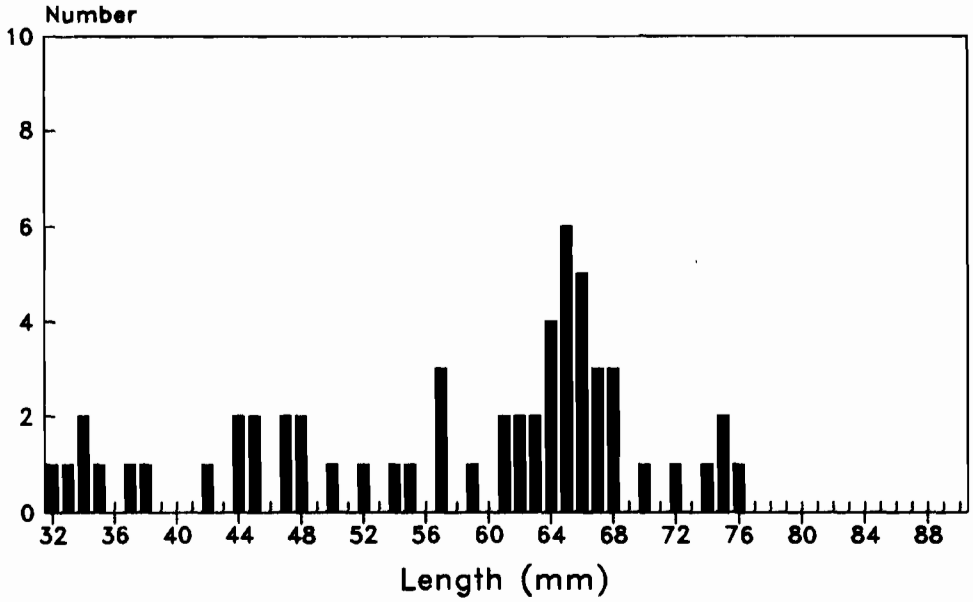


Fig. 26. Map of the Joassa Channel area showing the location of three beaches sampled there, June 24, 1990.

Fig. 27. Size frequency distribution of butter and littleneck clams sampled at Dearth Island, June 24, 1990.

DEARTH ISLAND
Butter Clams



DEARTH ISLAND
Littleneck Clams

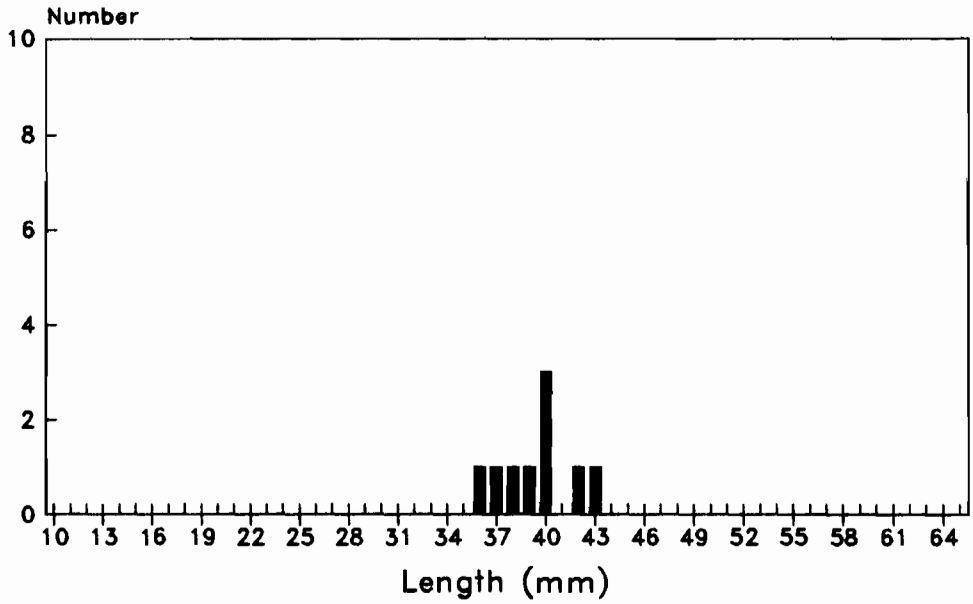
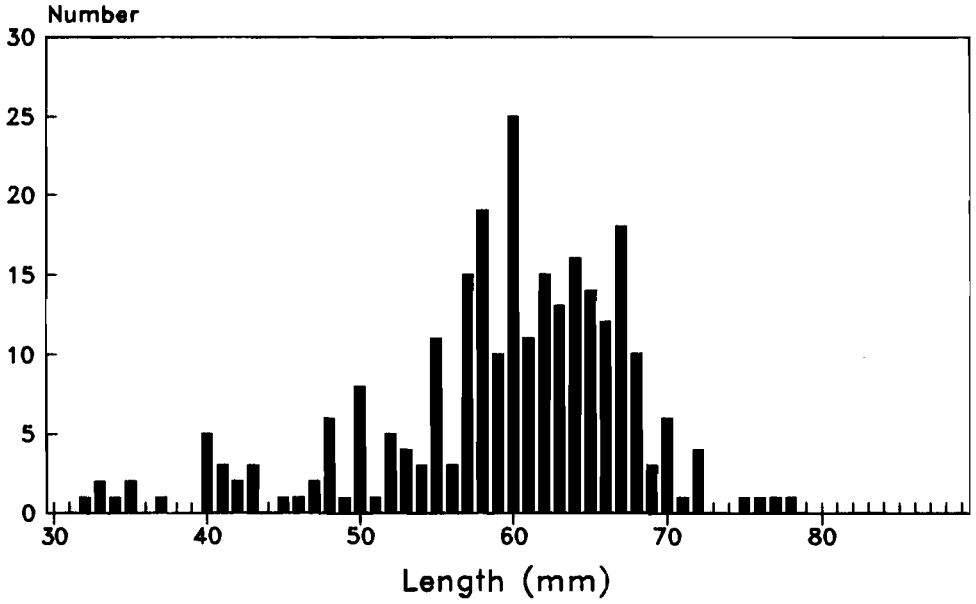


Fig. 28. Size frequency distribution of butter and littleneck clams sampled in Joassa Channel, June 24, 1990.

JOASSA CHANNEL
Butter Clams



JOASSA CHANNEL
Littleneck Clams

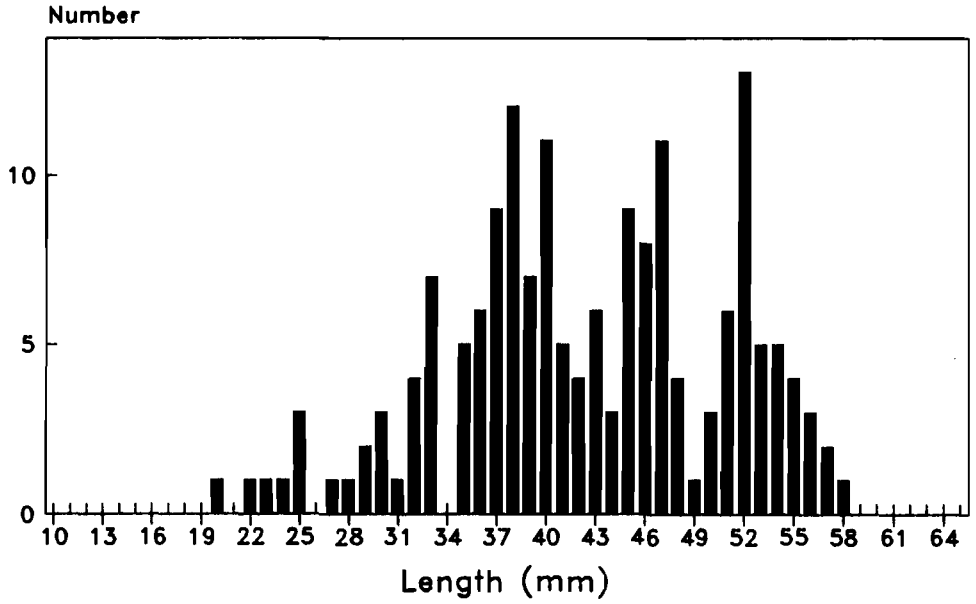
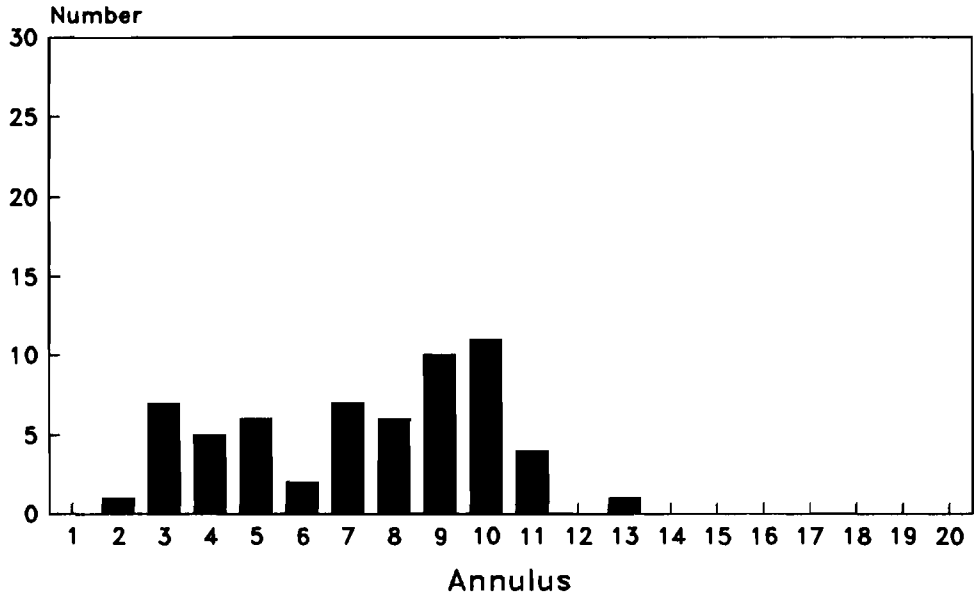


Fig. 29. Age frequency distribution of butter and littleneck clams sampled at Dearth Island, June 24, 1990.

DEARTH ISLAND
Butter Clams



DEARTH ISLAND
Littleneck Clams

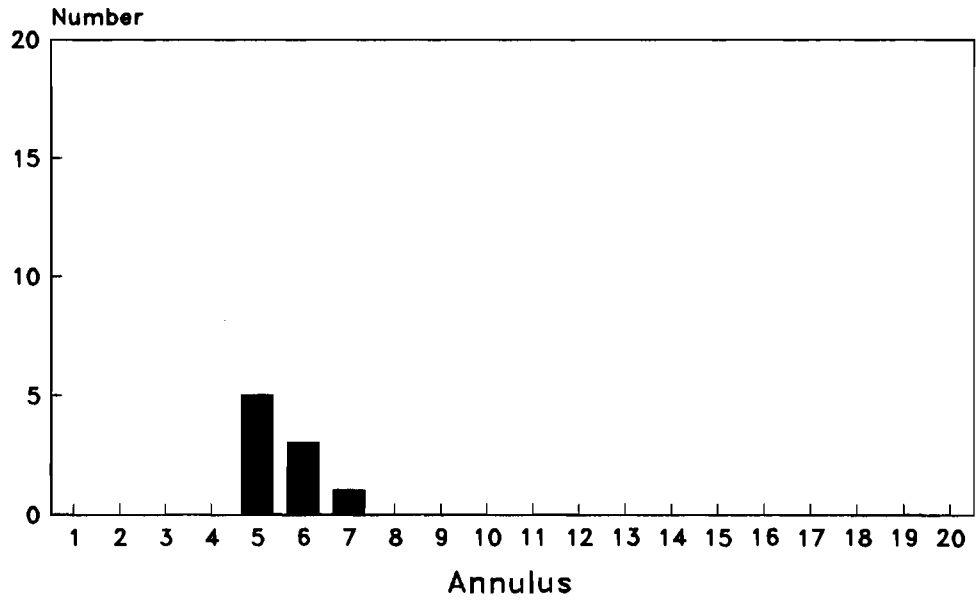
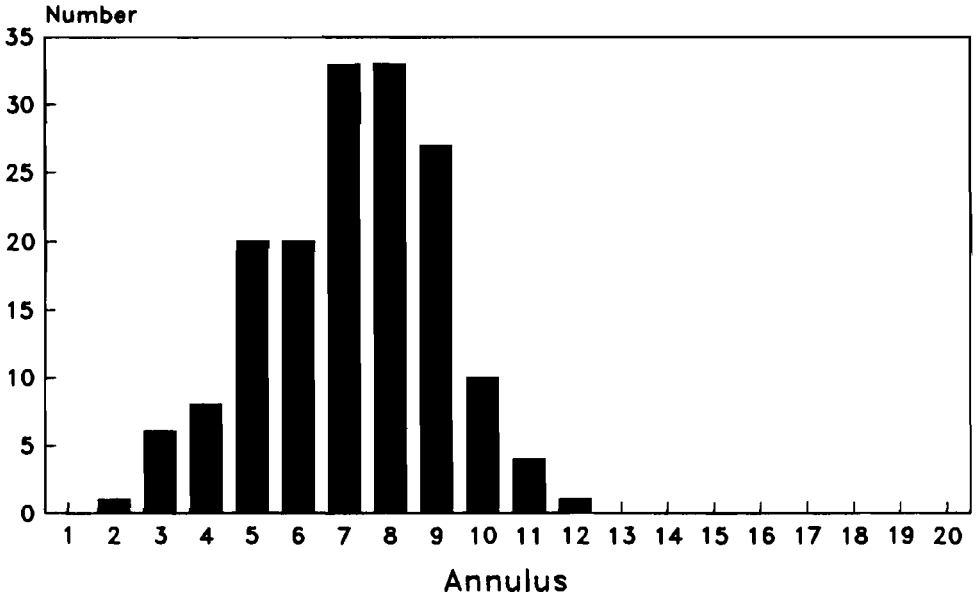


Fig. 30. Age frequency distribution of butter and littleneck clams sampled in Joassa Channel, June 24, 1990.

JOASSA CHANNEL
Butter Clams



JOASSA CHANNEL
Littleneck Clams

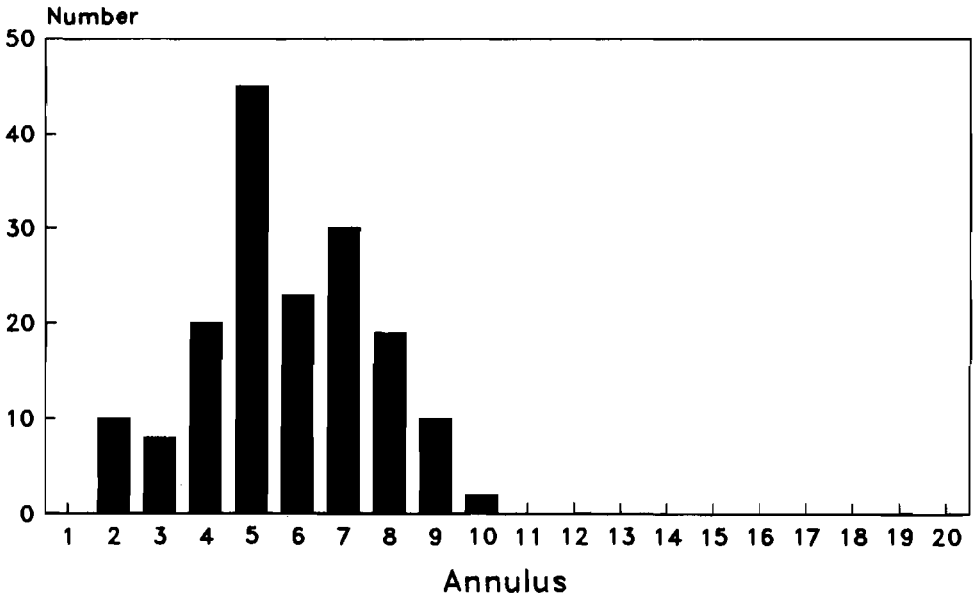
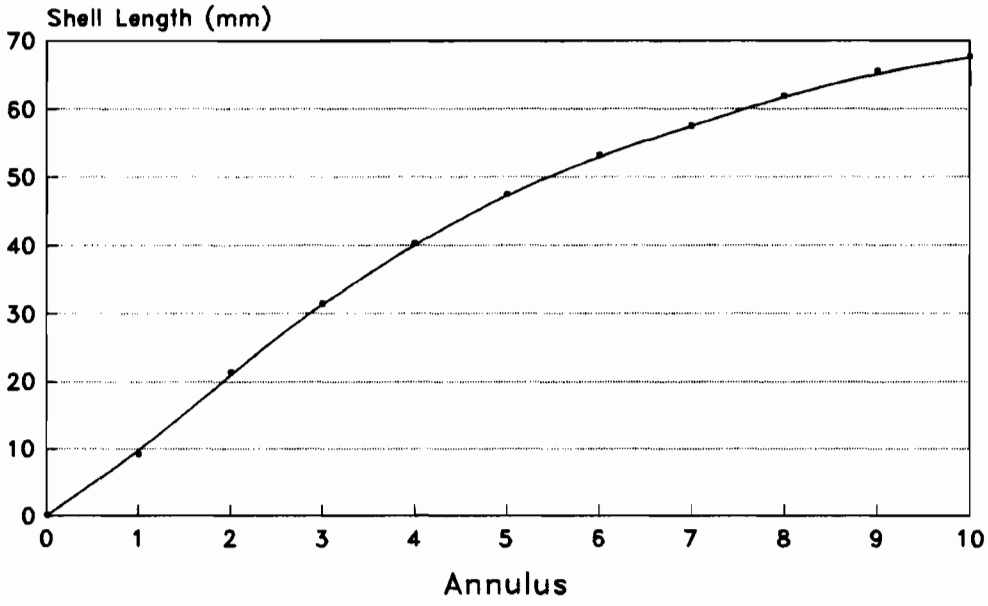


Fig. 31. Growth rate of butter and littleneck clams sampled in Joassa Channel, June 24, 1990.

JOASSA CHANNEL
Butter Clams



JOASSA CHANNEL
Littleneck Clams

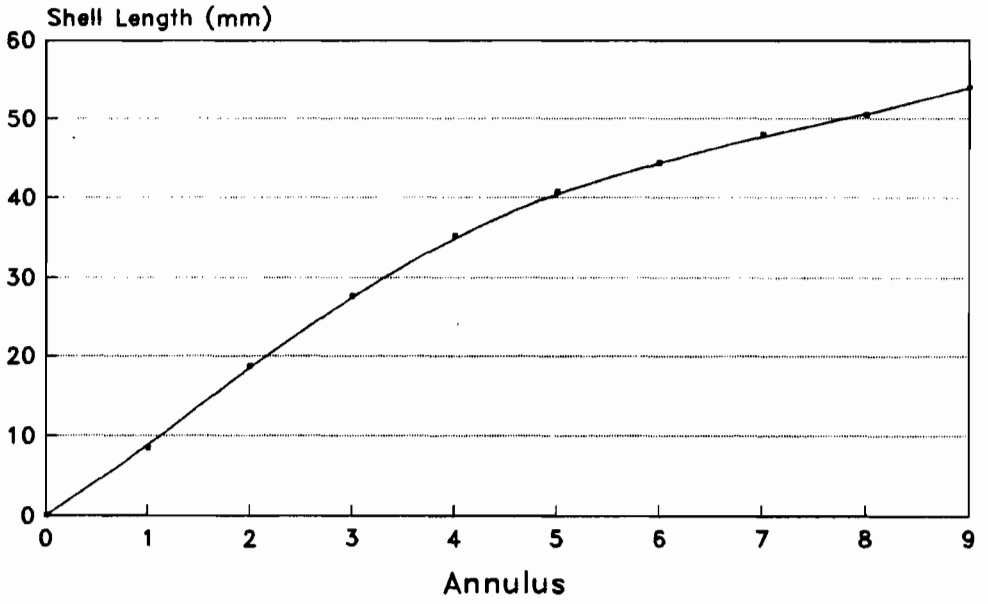
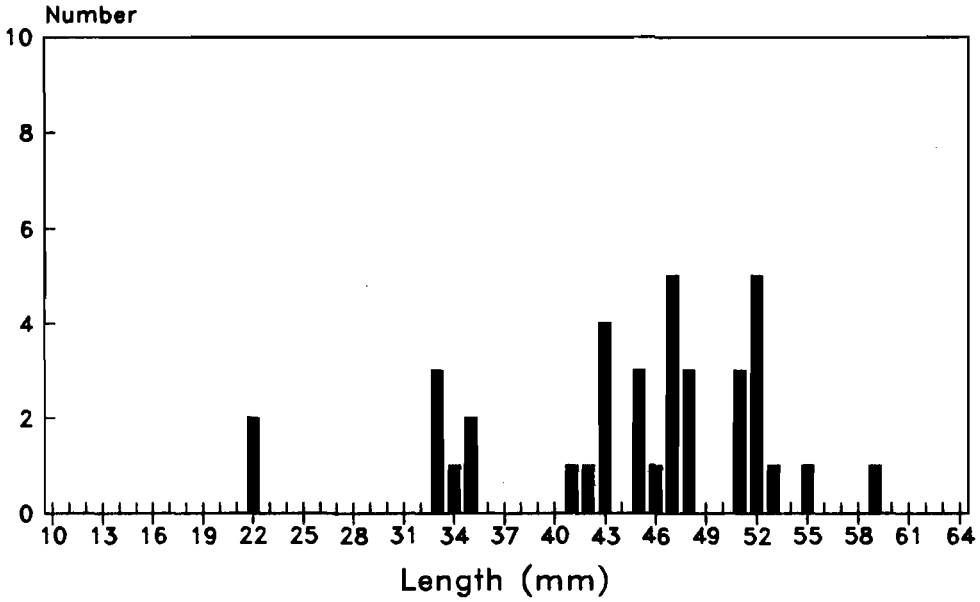


Fig. 32. Size frequency distribution of manila clams sampled at Dearth Island and Joassa Channel, June 24, 1990.

DEARTH ISLAND
Manila Clams



JOASSA CHANNEL
Manila Clams

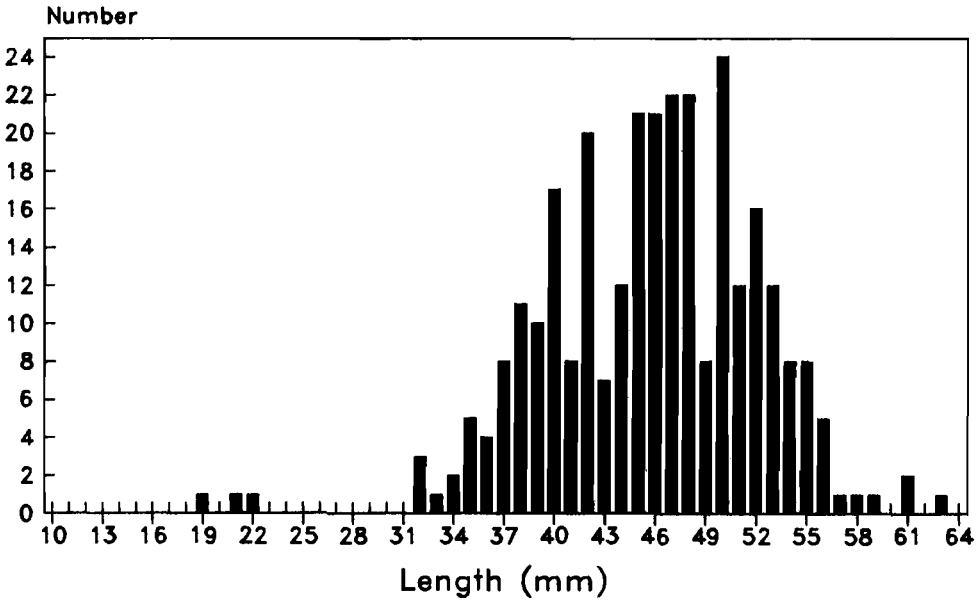
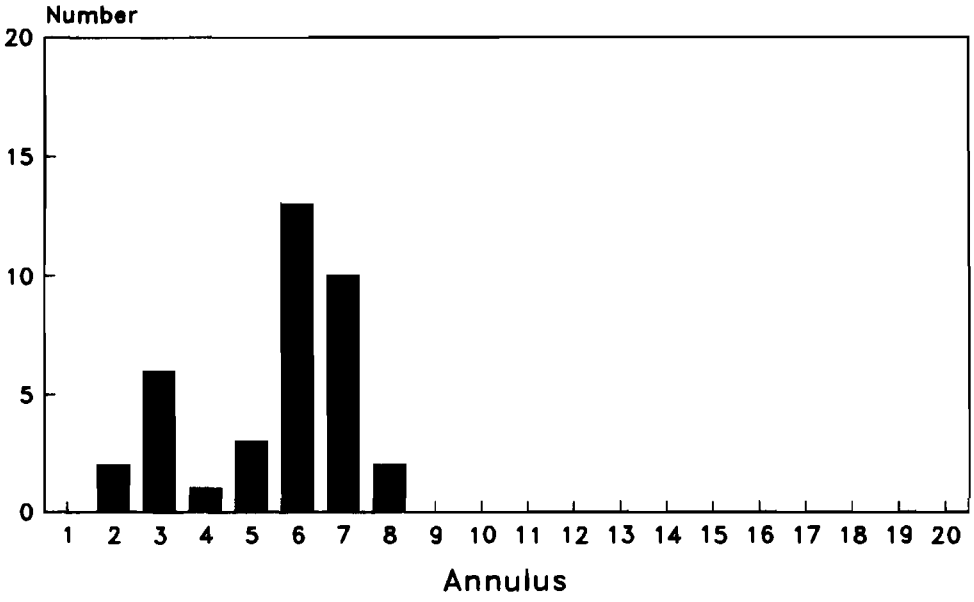


Fig. 33. Age frequency distribution of manila clams sampled at Dearth Island and Joassa Channel, June 24, 1990.

DEARTH ISLAND
Manila Clams



JOASSA CHANNEL
Manila Clams

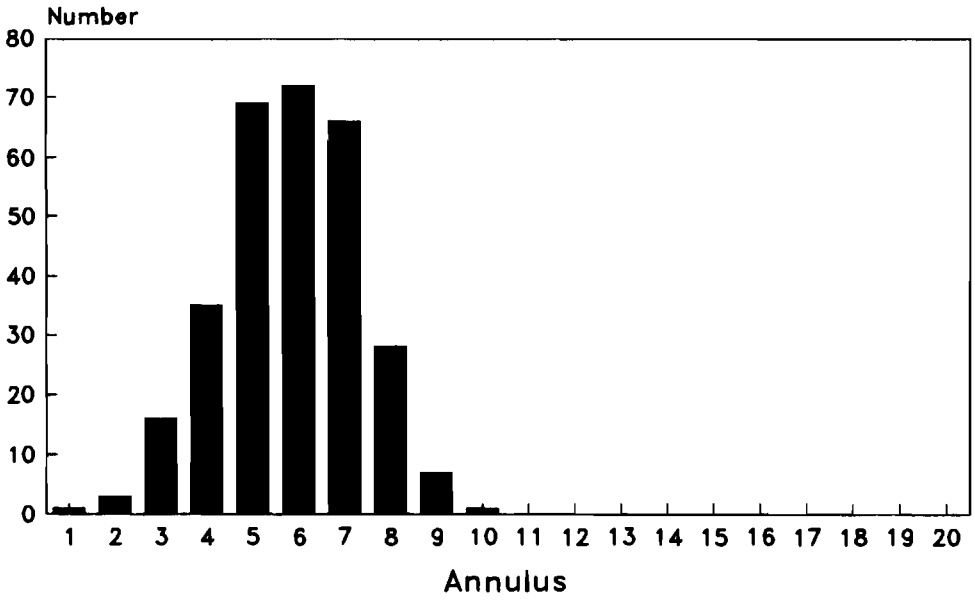
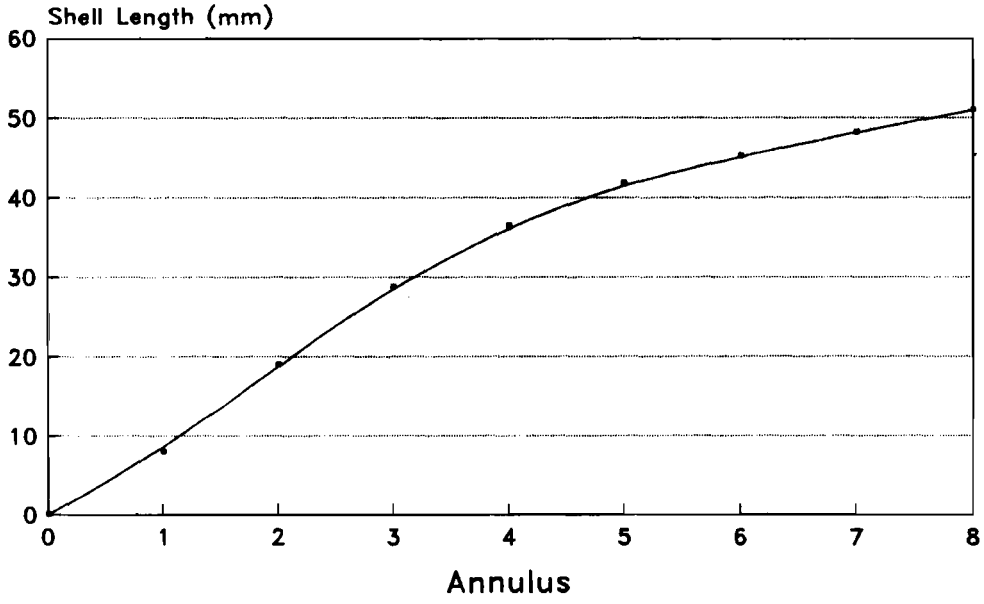
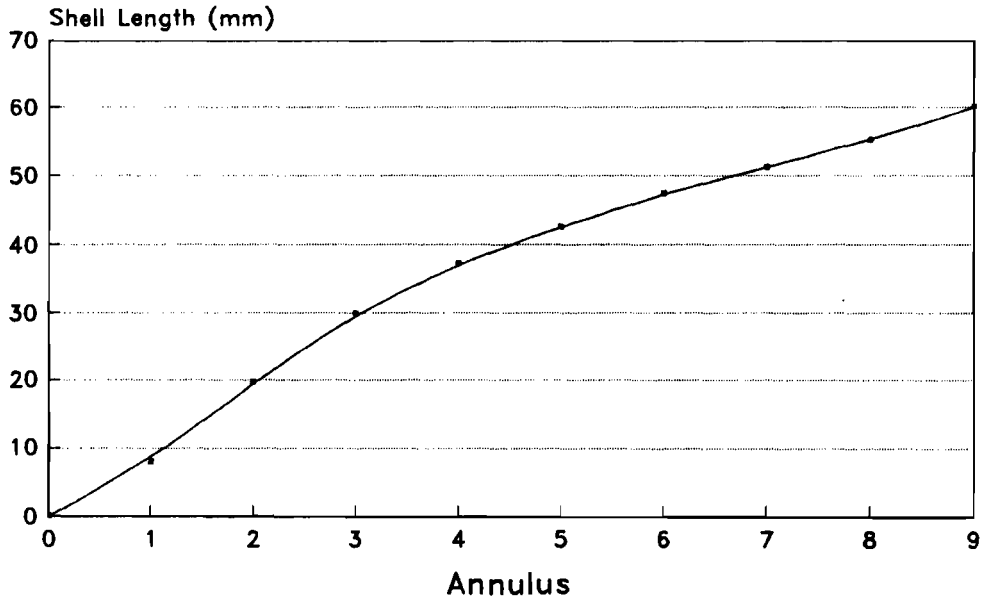


Fig. 34. Growth rate of manila clams sampled at Dearth Island and Joassa Channel, June 24, 1990.

DEARTH ISLAND
Manila Clams



JOASSA CHANNEL
Manila Clams



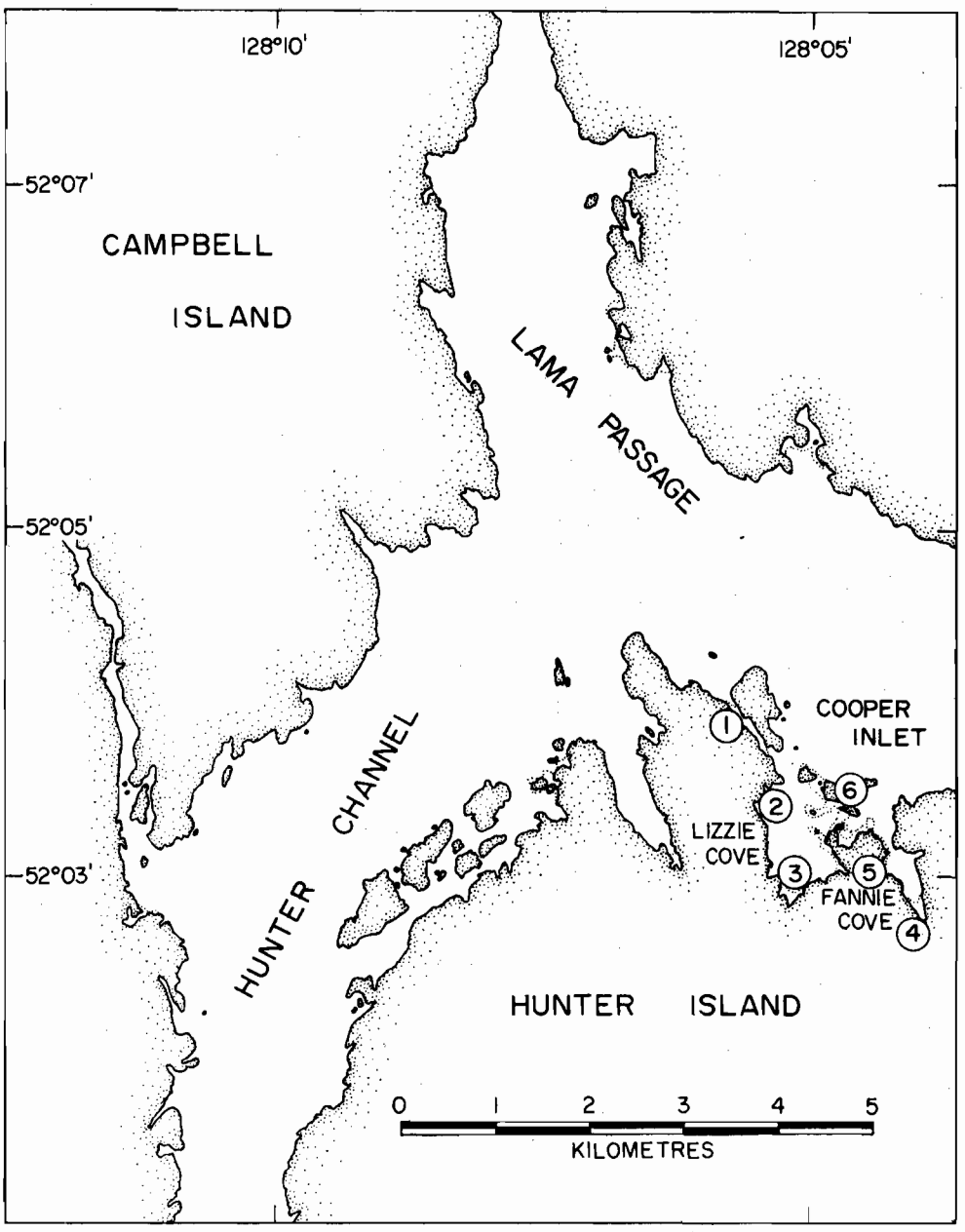


Fig. 35. Map of the Lama Passage area showing the location of six beaches sampled there, June 25, 1990.

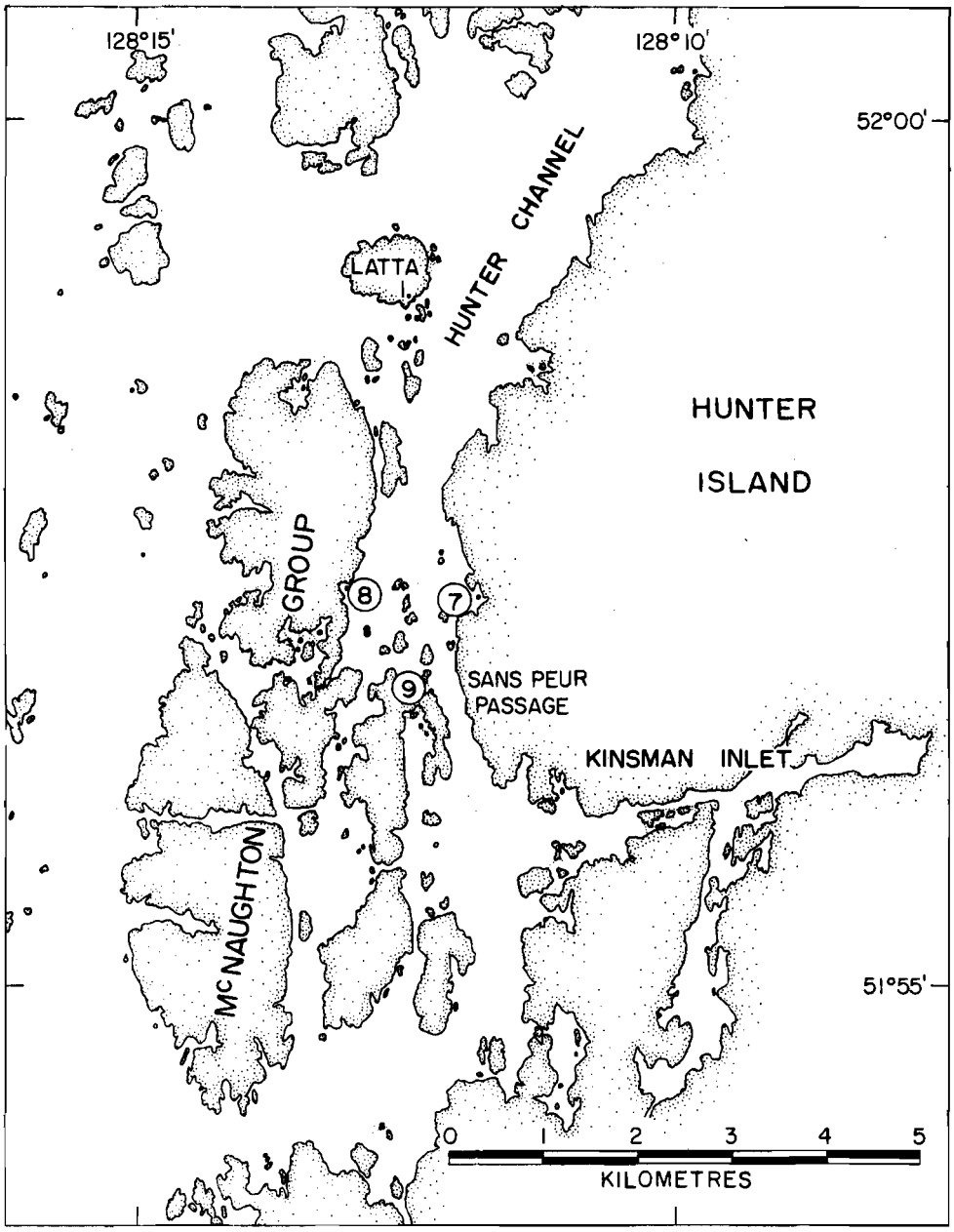
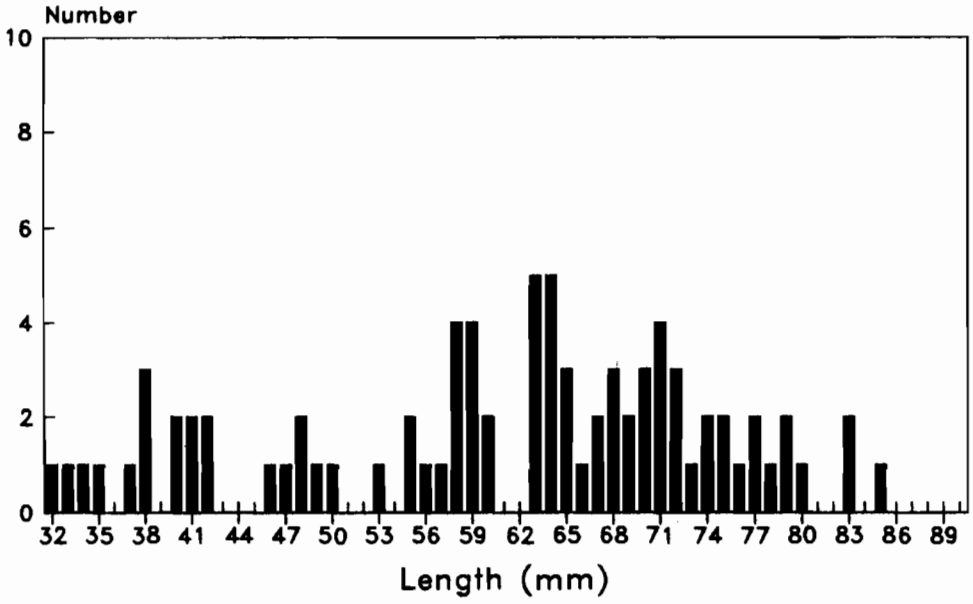


Fig. 36. Map of the Hunter Channel area showing the location of three beaches sampled there, June 25, 1990.

Fig. 37. Size frequency distribution of butter and littleneck clams sampled in the Lama Passage area, June 25, 1990.

LAMA PASSAGE
Butter Clams



LAMA PASSAGE
Littleneck Clams

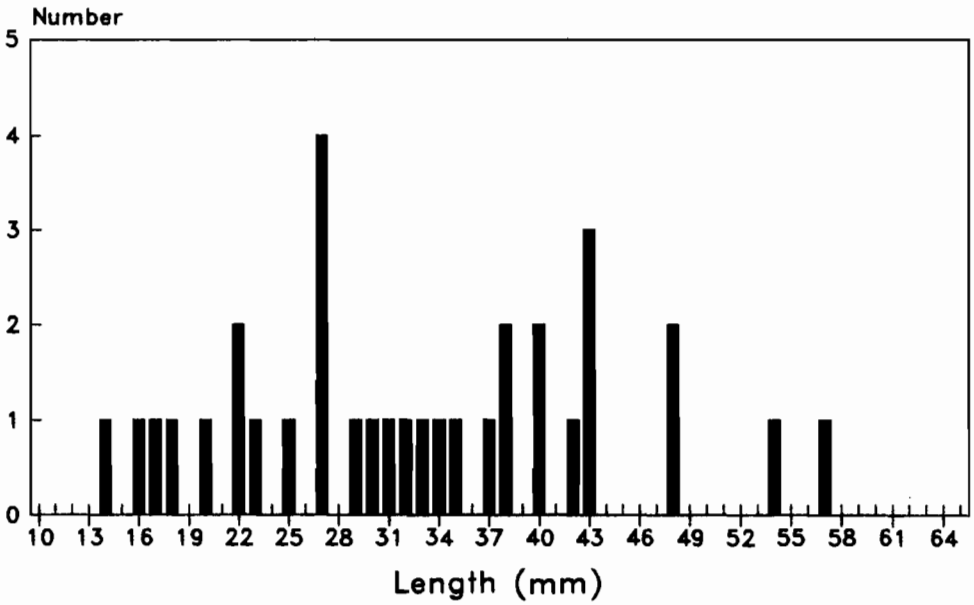
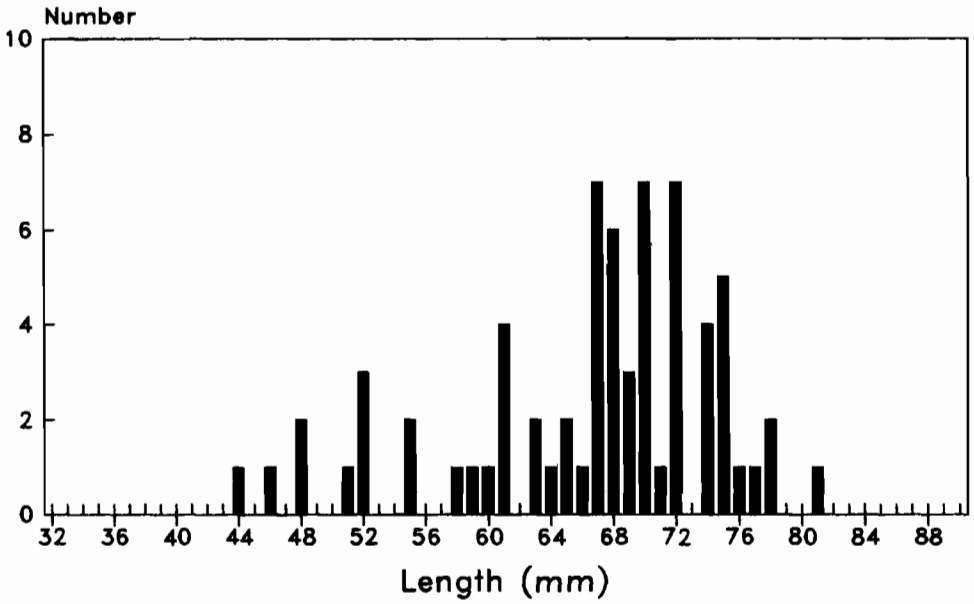


Fig. 38. Size frequency distribution of butter and littleneck clams sampled in the Hunter Channel area, June 25, 1990.

HUNTER CHANNEL
Butter Clams



HUNTER CHANNEL
Littleneck Clams

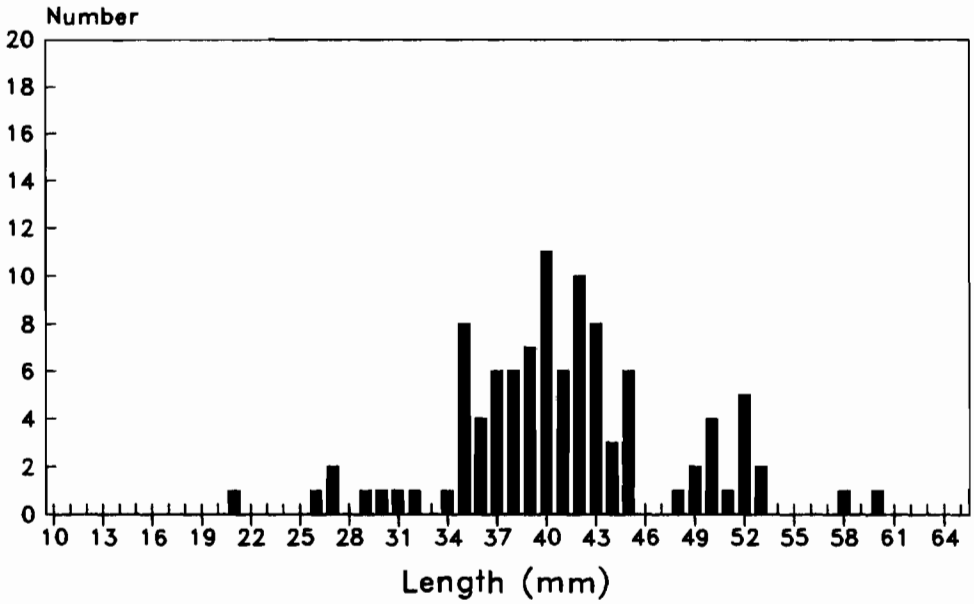
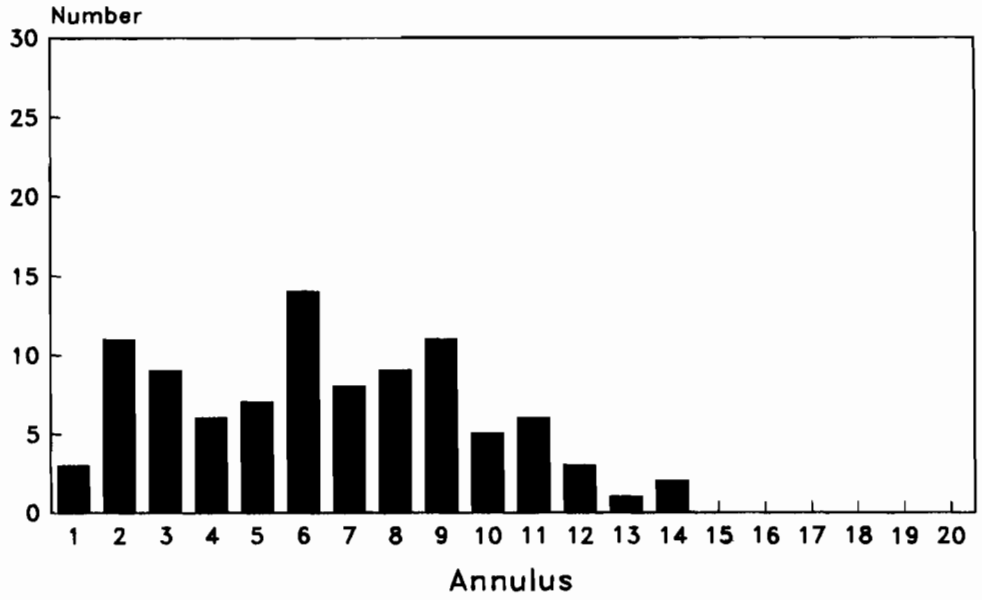


Fig. 39. Age frequency distribution of butter and littleneck clams sampled in the Lama Passage area, June 25, 1990.

LAMA PASSAGE
Butter Clams



LAMA PASSAGE
Littleneck Clams

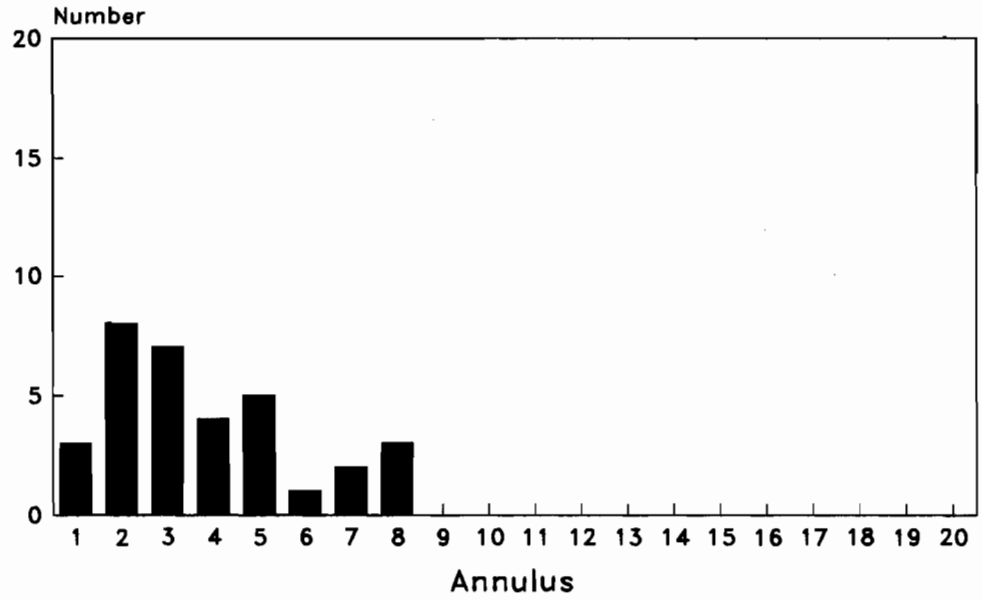
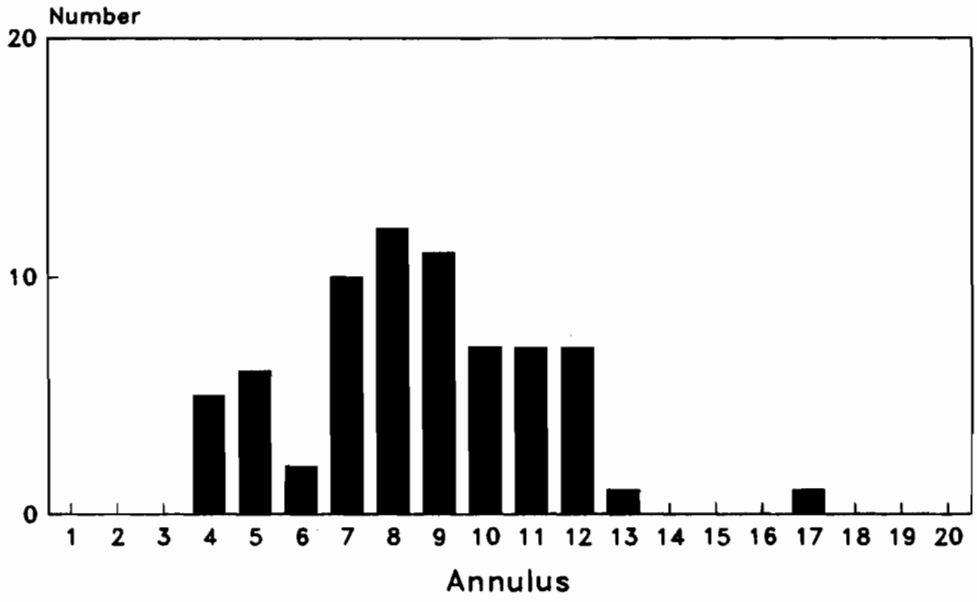


Fig. 40. Age frequency distribution of butter and littleneck clams sampled in the Hunter Channel area, June 25, 1990.

HUNTER CHANNEL
Butter Clams



HUNTER CHANNEL
Littleneck Clams

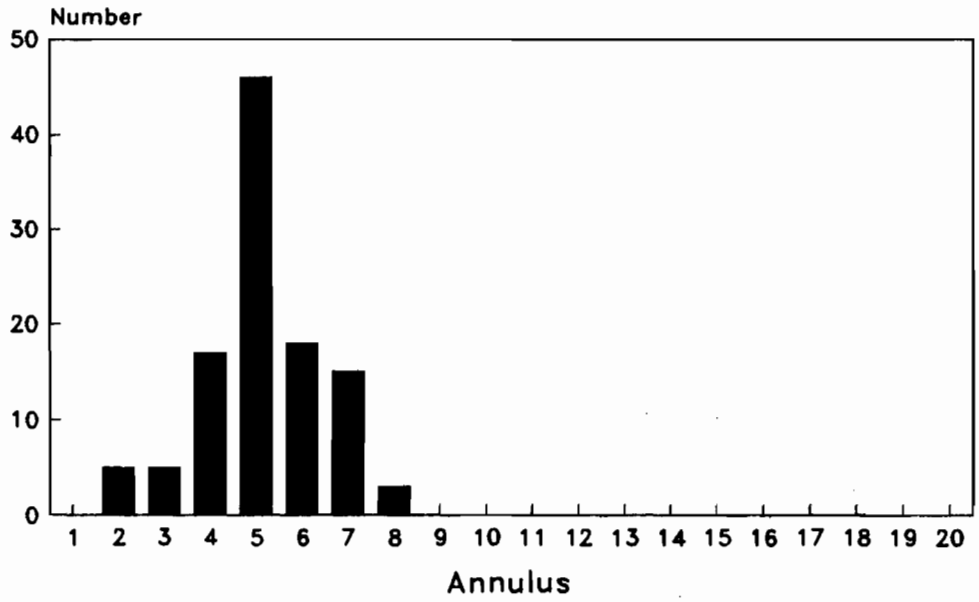
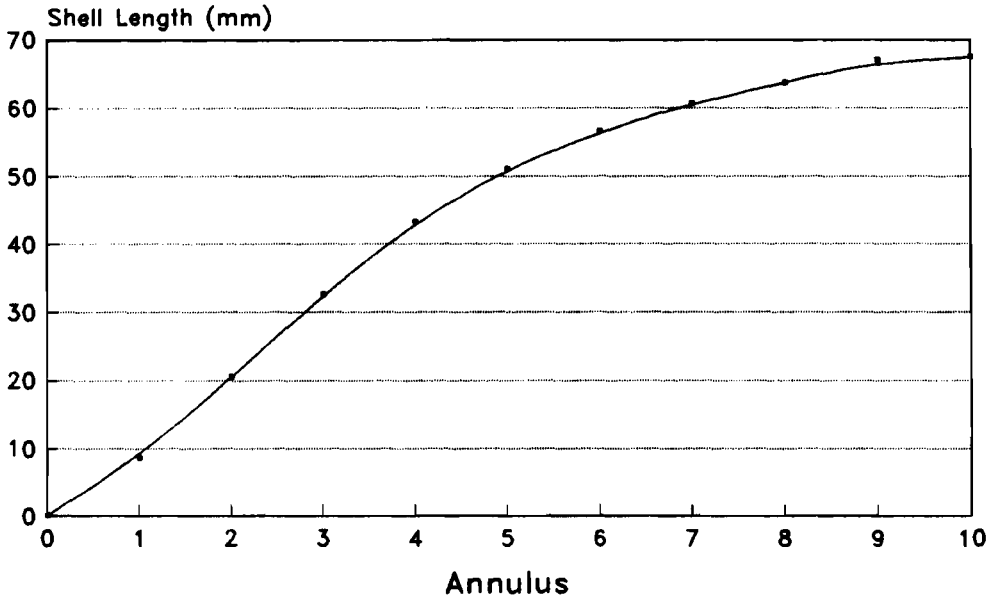


Fig. 41. Growth rate of butter and littleneck clams sampled in the Lama Passage area, June 25, 1990.

LAMA PASSAGE
Butter Clams



LAMA PASSAGE
Littleneck Clams

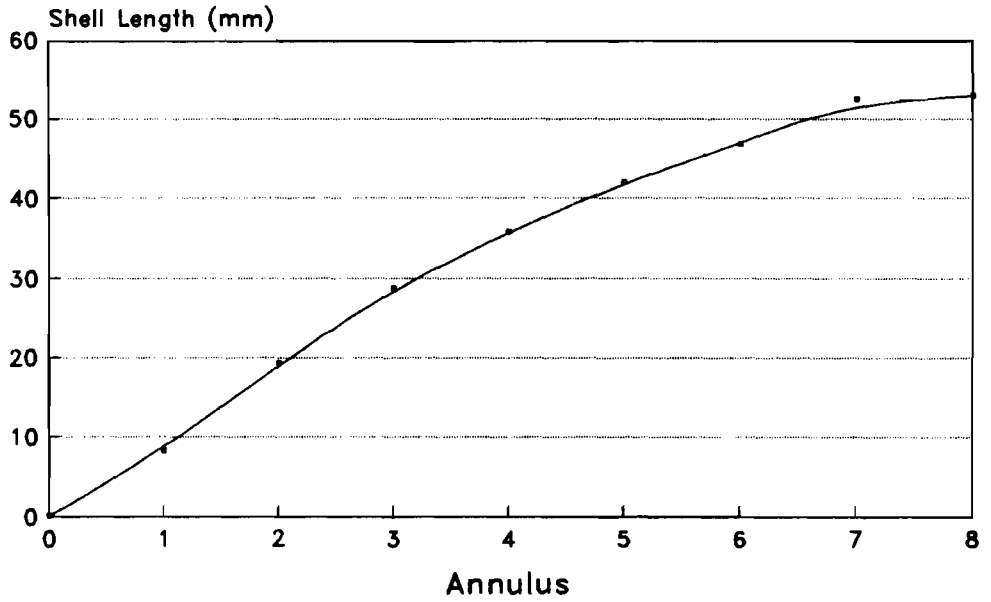
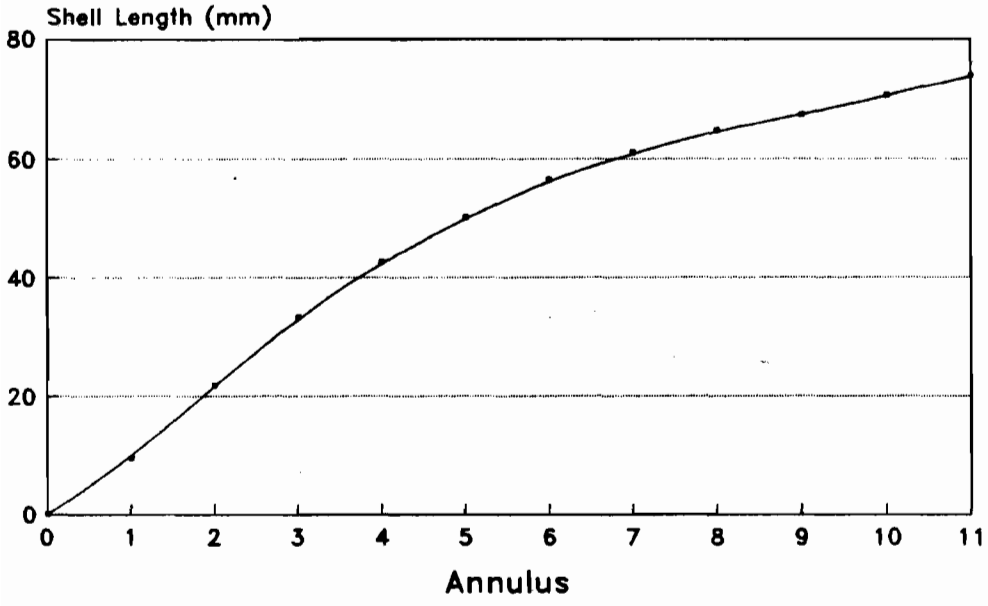


Fig. 42. Growth rate of butter and littleneck clams sampled in the Hunter Channel area, June 25, 1990.

HUNTER CHANNEL
Butter Clams



HUNTER CHANNEL
Littleneck Clams

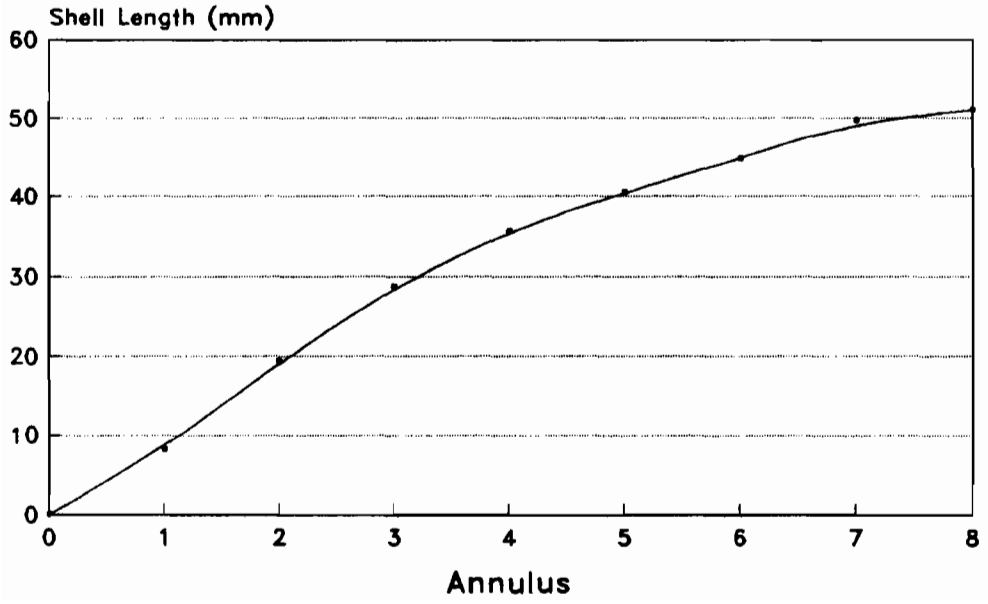
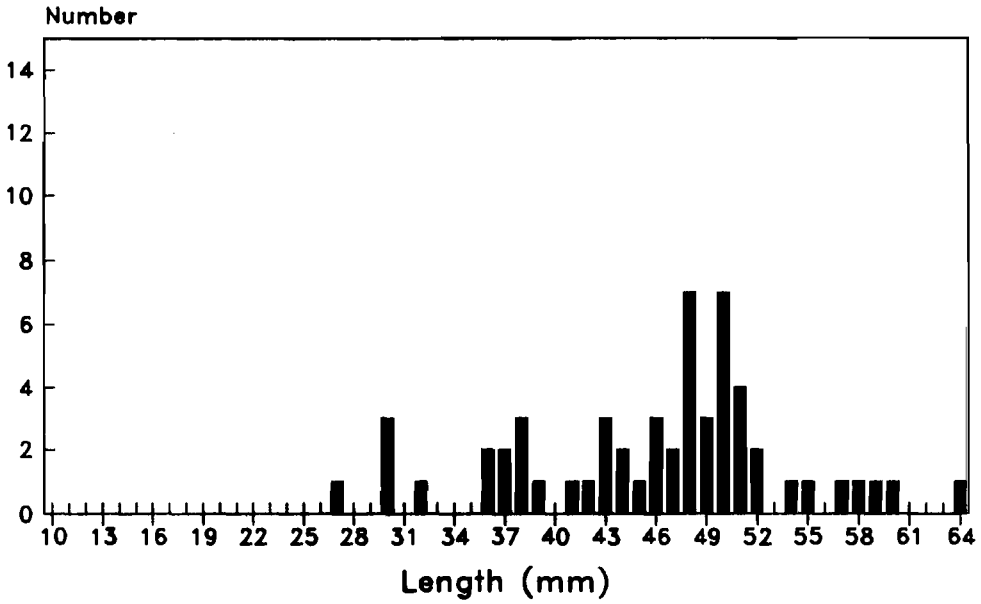


Fig. 43. Size frequency distribution of manila clams sampled in the Lama Passage and Hunter Channel areas, June 25, 1990.

LAMA PASSAGE
Manila Clams



HUNTER CHANNEL
Manila Clams

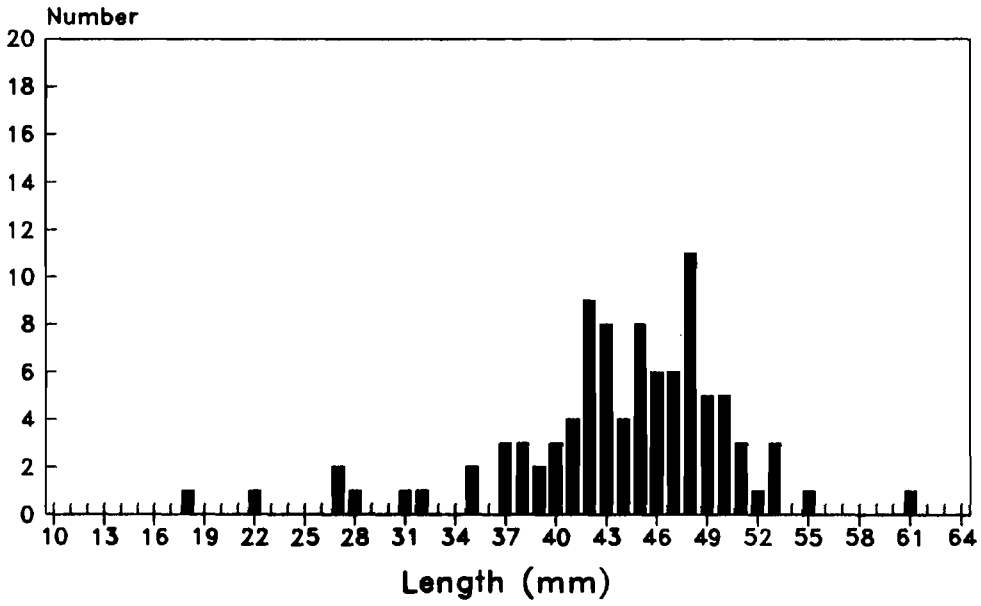
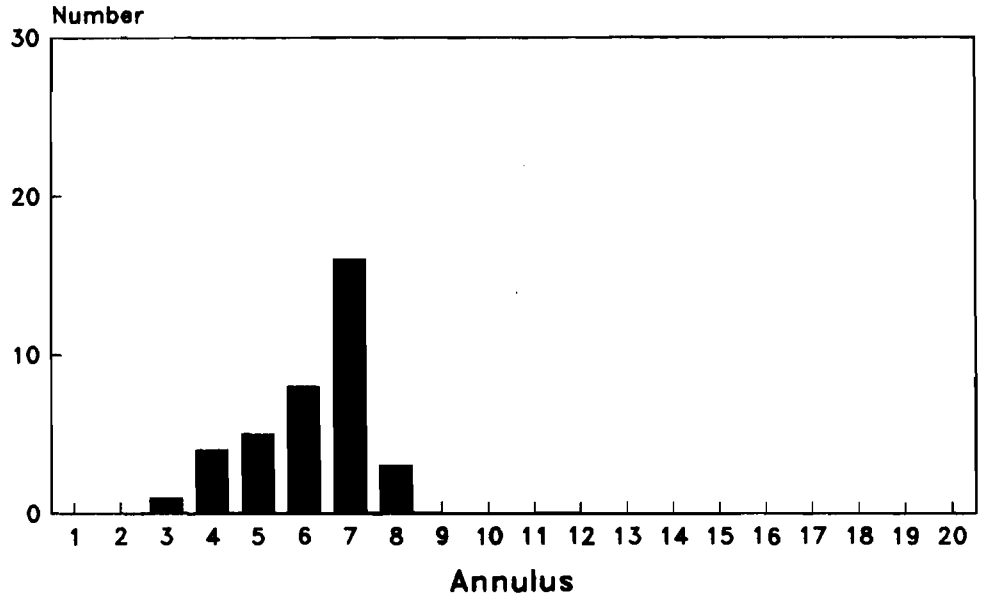


Fig. 44. Age frequency distribution of manila clams sampled in the Lama Passage and Hunter Channel areas, June 25, 1990.

LAMA PASSAGE
Manila Clams



HUNTER CHANNEL
Manila Clams

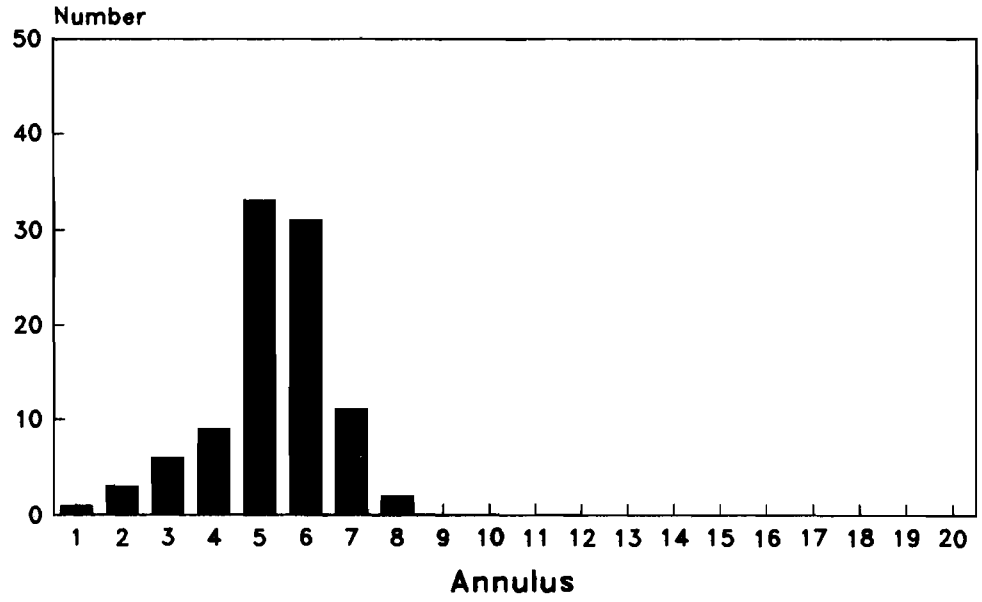
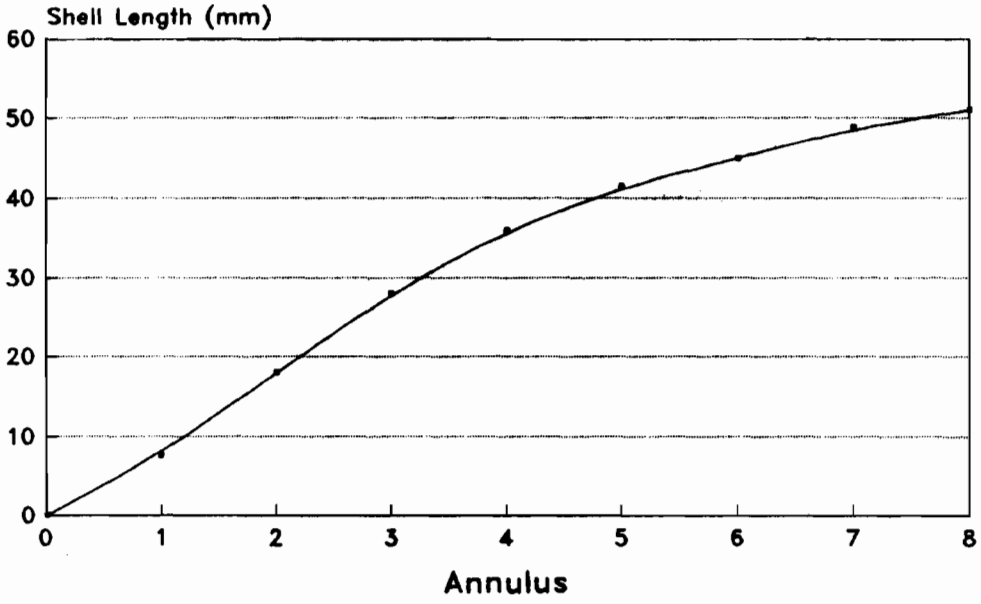
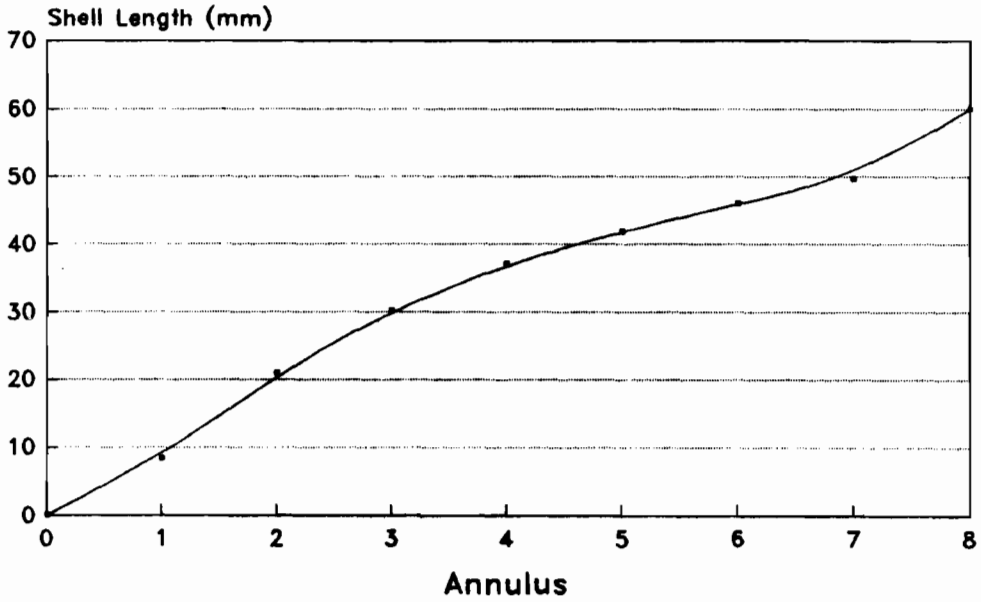


Fig. 45. Growth rate of manila clams sampled in the Lama Passage and Hunter Channel areas, June 25, 1990.

LAMA PASSAGE
Manila Clams



HUNTER CHANNEL
Manila Clams



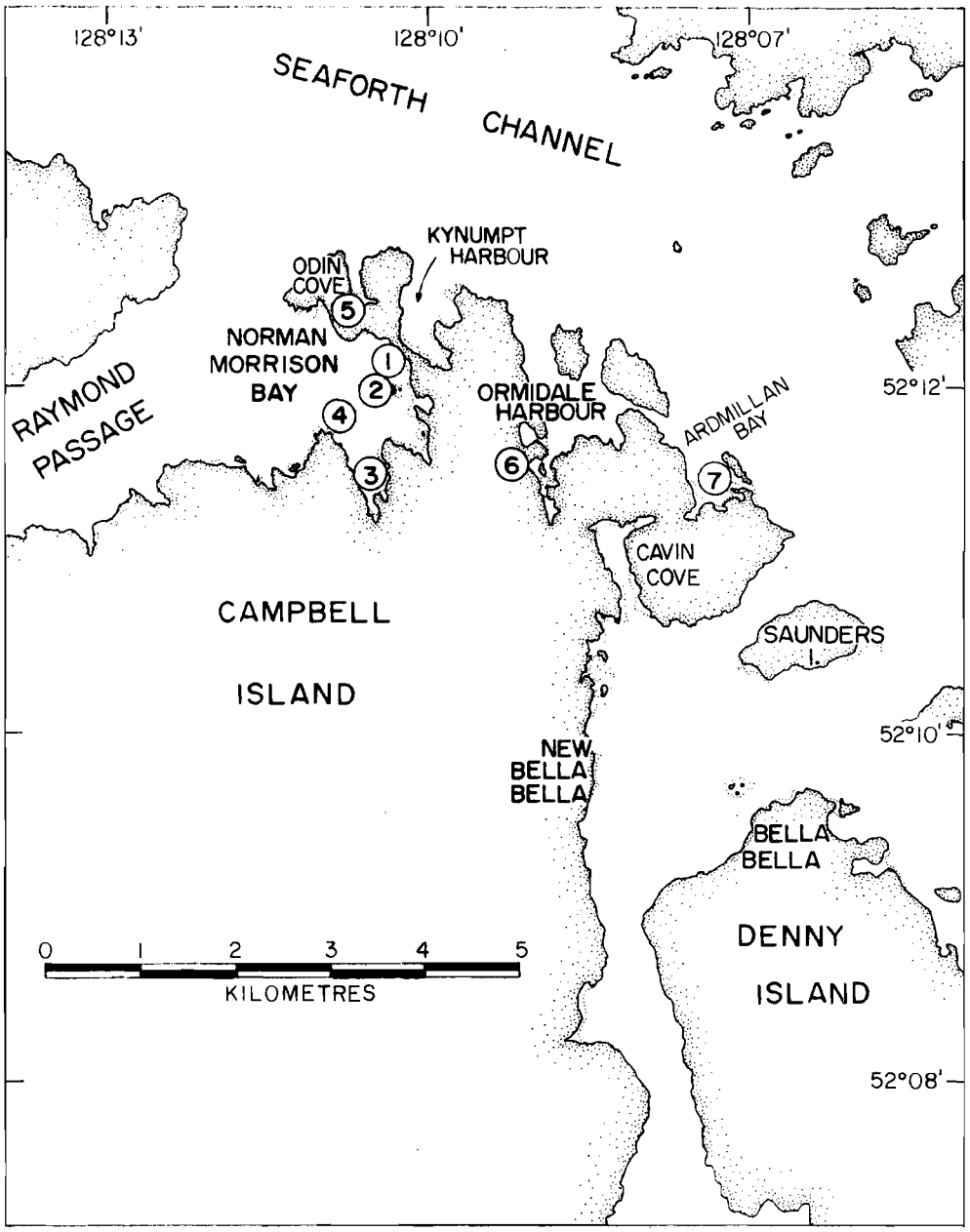
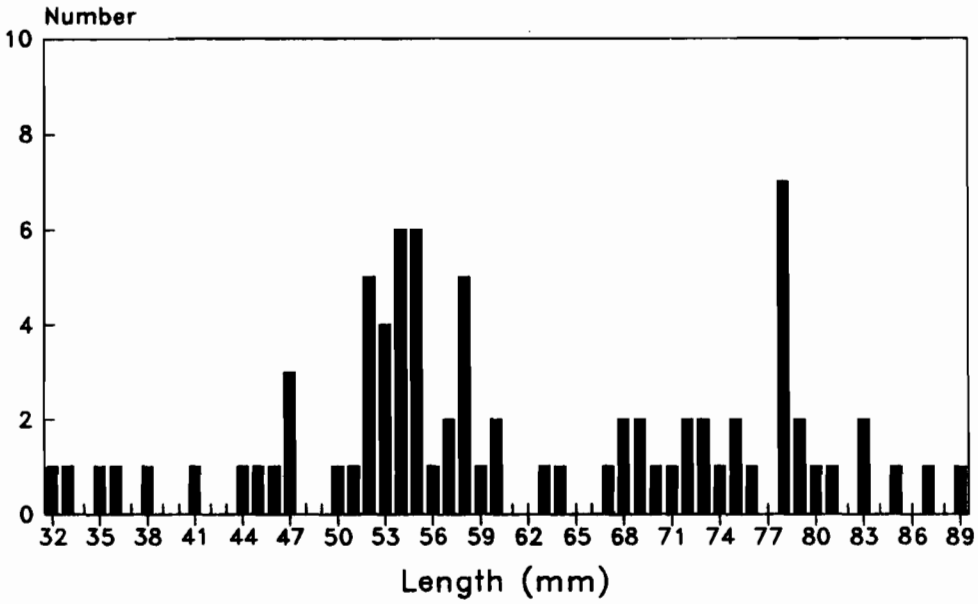


Fig. 46. Map of the Seaforth Channel-Raymond Passage area showing the location of seven beaches sampled there, June 26, 1990.

Fig. 47. Size frequency distribution of butter and littleneck clams sampled in the Seaforth Channel-Raymond Passage area, June 26, 1990.

SEAFORTH CHANNEL
Butter Clams



SEAFORTH CHANNEL
Littleneck Clams

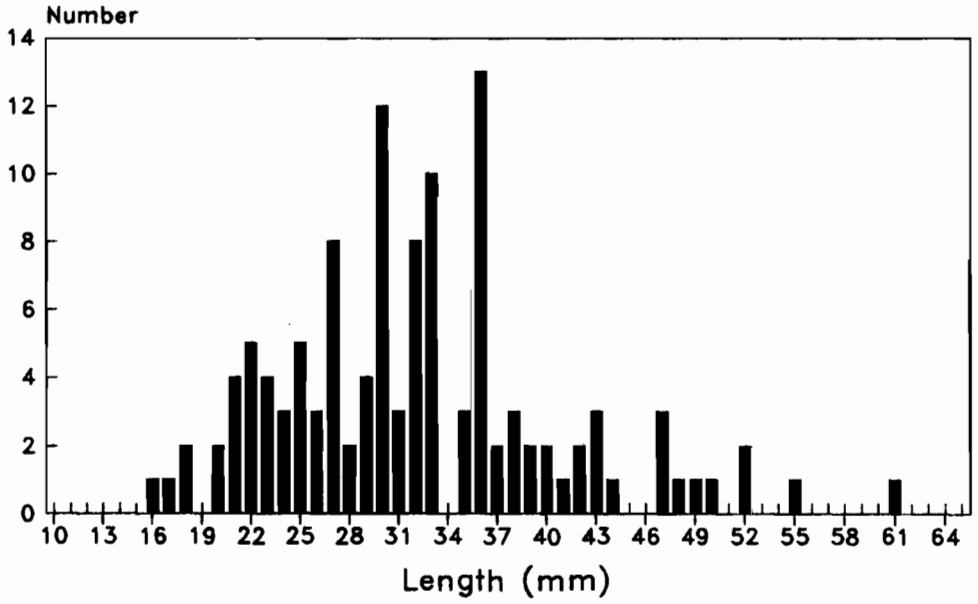
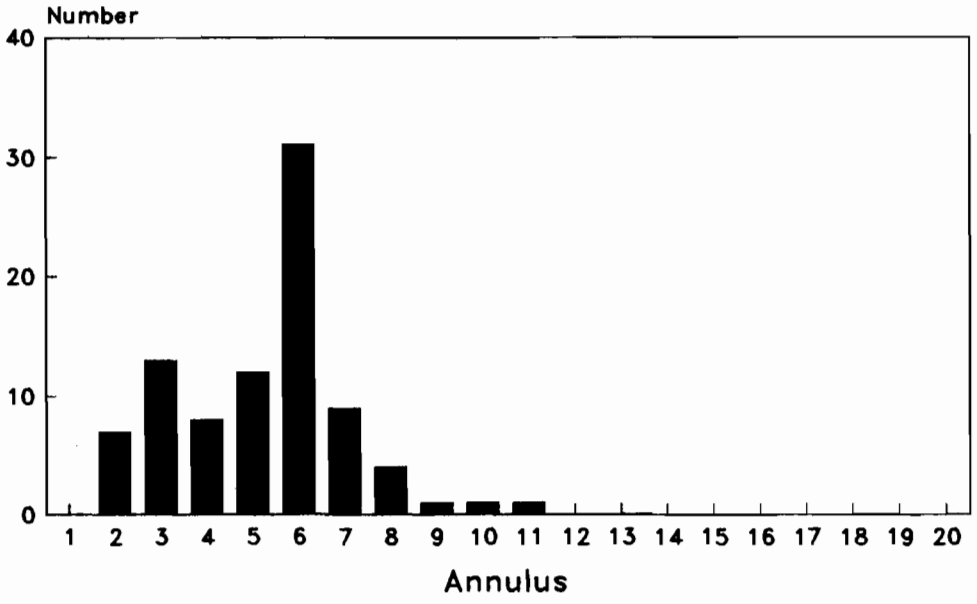


Fig. 48. Age frequency distribution of butter and littleneck clams sampled in the Seaforth Channel-Raymond Passage area, June 26, 1990.

SEAFORTH CHANNEL
Butter Clams



SEAFORTH CHANNEL
Littleneck Clams

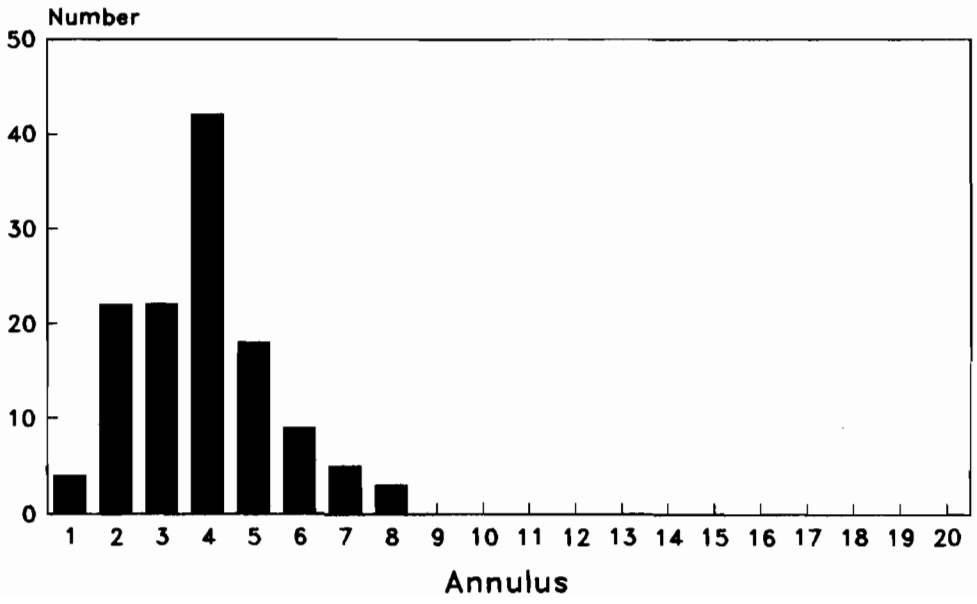
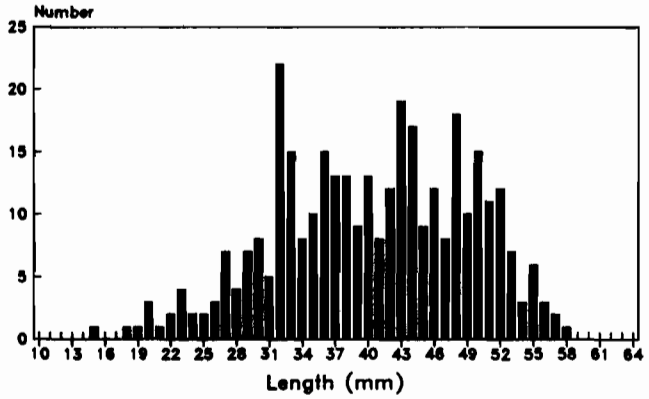
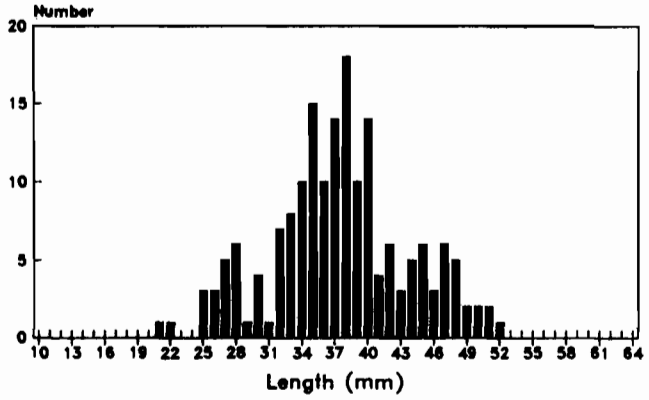


Fig. 49. Size frequency distribution of manila clams sampled in the Seaforth Channel-Raymond Passage area, June 26, 1990.

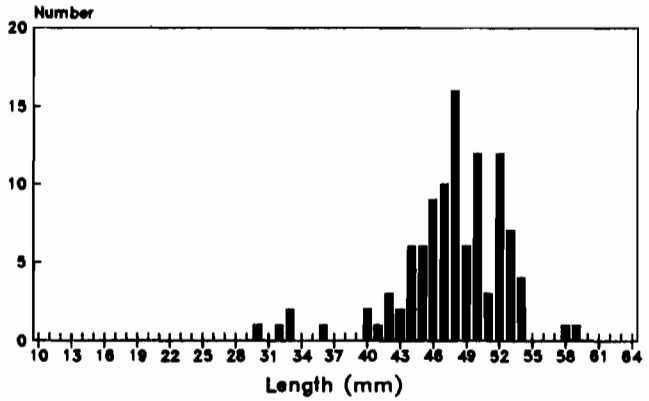
NORMAN MORRISON BAY
Manila Clams



ARDMILLAN BAY
Manila Clams



ORMIDALE HARBOUR
Manila Clams



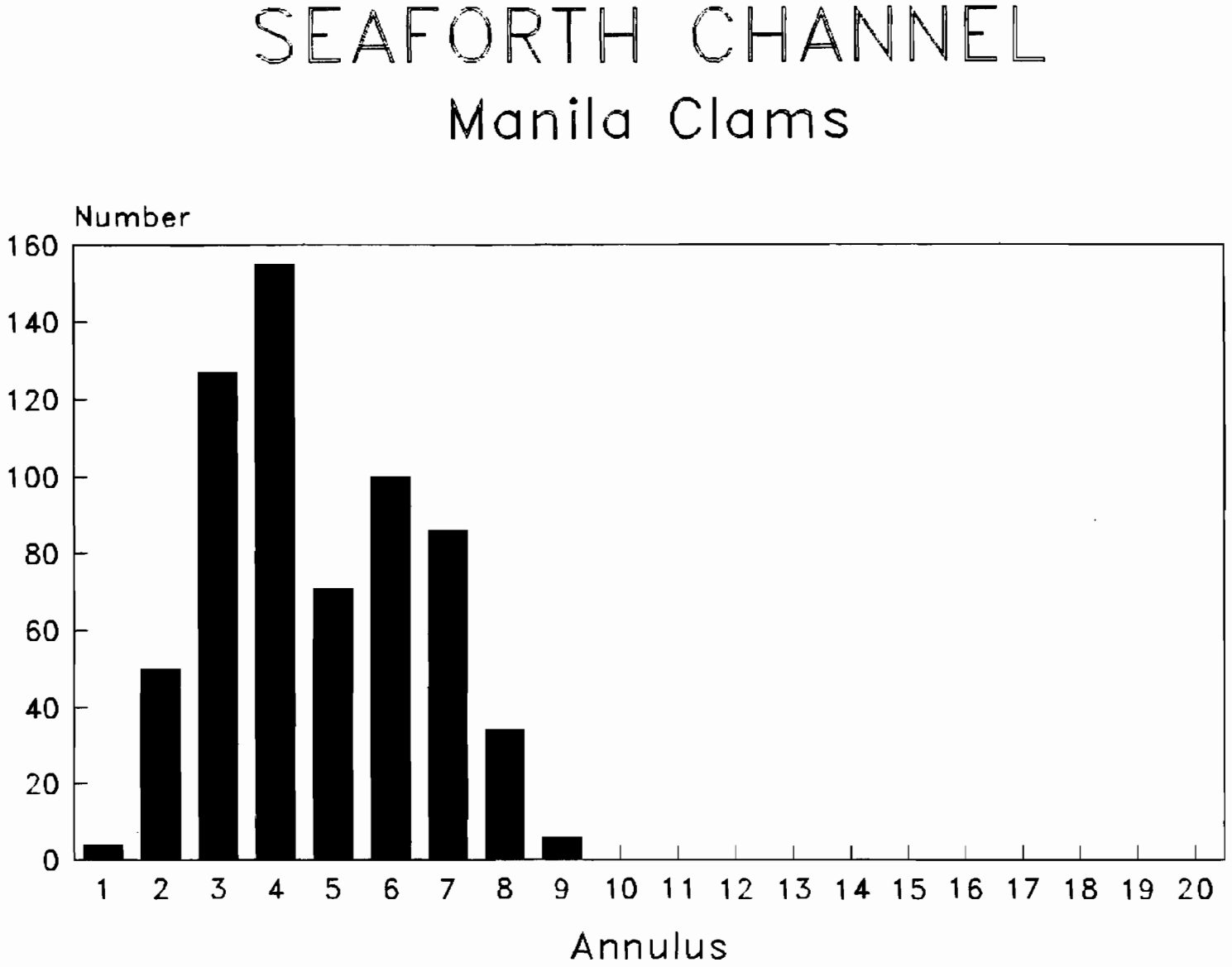


Fig. 50. Age frequency distribution of manila clams sampled in the Seaforth Channel-Raymond Passage area, June 26, 1990.

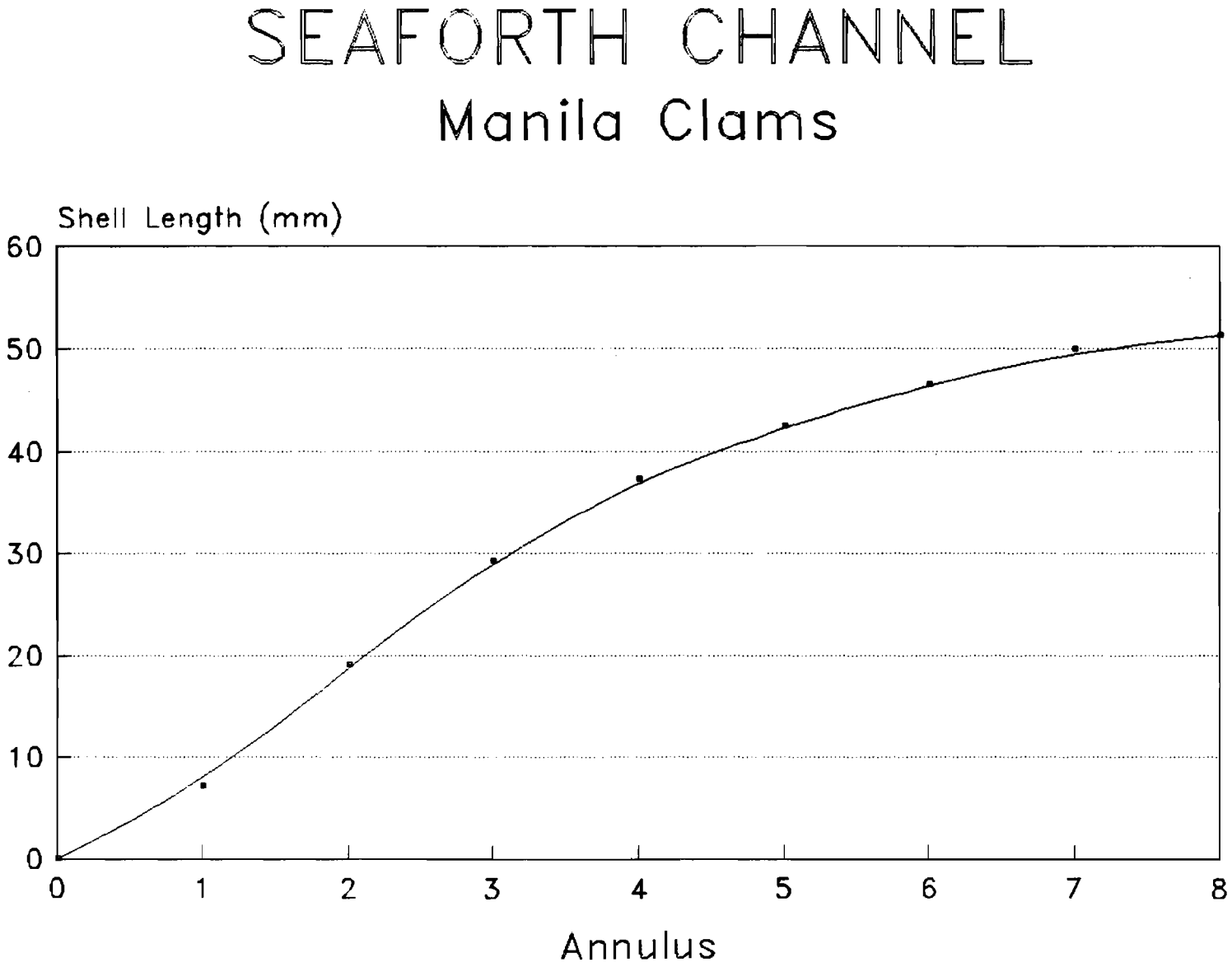


Fig. 51. Growth rate of manila clams sampled in the Seaforth Channel-Raymond Passage area, June 26, 1990.

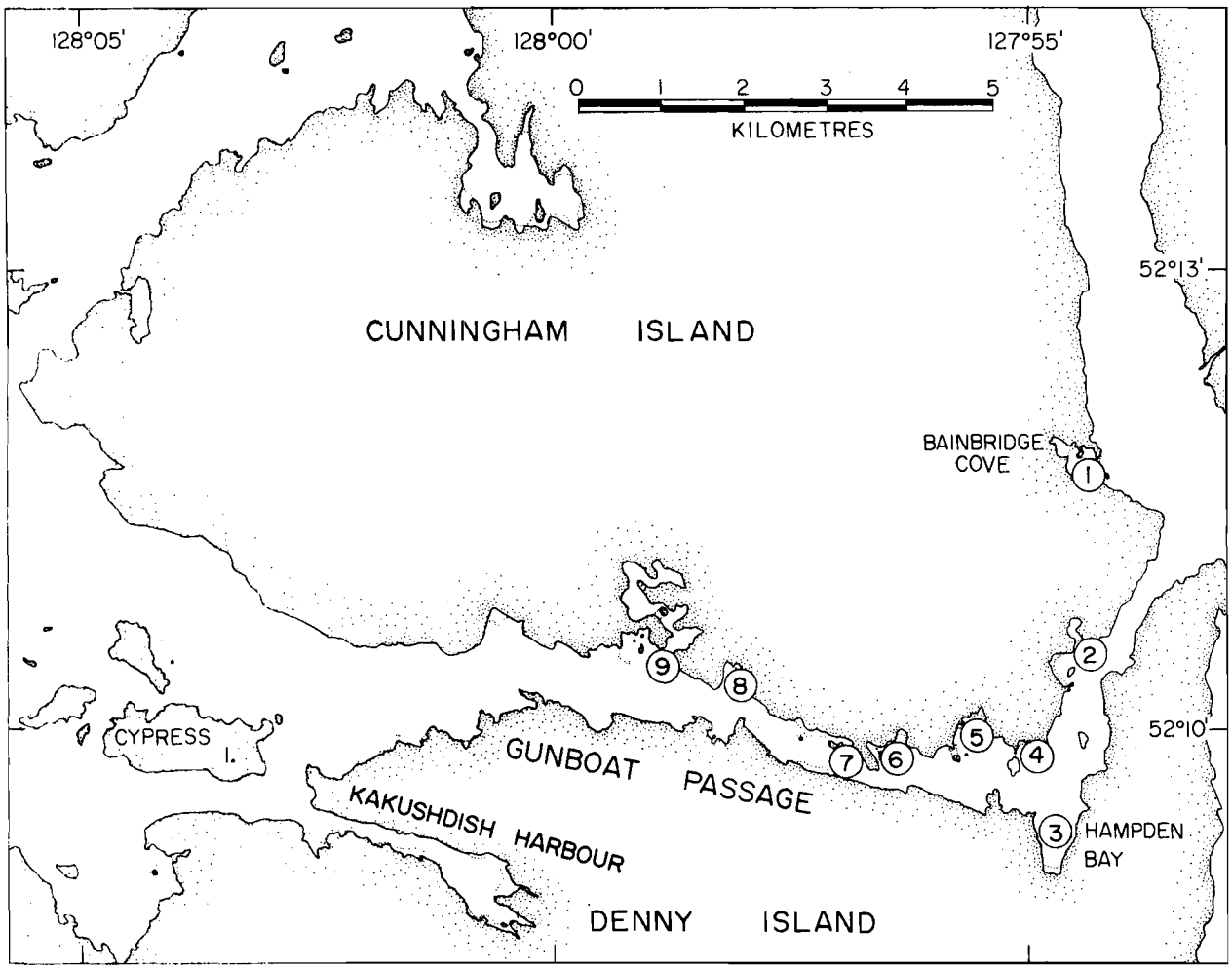


Fig. 52. Map of the Gunboat Passage area showing the location of nine beaches surveyed there, June 27, 1990.