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EXPLORATORY INTERTIDAL BIVALVE SURVEYS IN BRITISH COLUMBIA - 2000 AND 2001

by

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Results of exploratory intertidal clam surveys carried out in 2000 and 2001 to assess populations of commercially important clams on selected beaches in British Columbia (B.C.) are presented. These surveys were a continuation of exploratory clam surveys begun in 1990 to assess intertidal clam resources in the North and Central Coasts and include exploratory surveys in the South Coast to map dispersal of the exotic varnish clam, *Nuttallia obscurata*. Distribution of the Olympia oyster, *Ostrea conchaphila*, was also recorded.

Manila clams, *Venerupis philippinarum*, are distributed from southern B.C. to the head of Laredo Inlet (52°58'N). They support commercial fisheries in the area around Bella Bella, and were found in Fish Egg and Briggs Inlets and Fisher Channel. However, they were not found in adjacent areas such as Princess Royal and Dean Channels.

Varnish clams were found in Clayoquot Sound and Cameleon Harbour in the South Coast, but were not found at any beaches examined in the North Coast or on northwest Vancouver Island.

Olympia oysters were found in Clayoquot Sound, Klaskino Inlet and Fish Egg Inlet. Although the species is broadly distributed from Panama to at least northern B.C. and possibly Southeast Alaska, specific habitat requirements result in abundant populations appearing only in certain distinct localities.

Most beaches in B.C. with suitable clam habitat support populations of littleneck clams, *Protothaca staminea*, butter clams, *Saxidomus gigantea*, cockles, *Clinocardium nuttallii*, and various *Macoma* sp. The proportional representation of each species depends on the habitat characteristics (substrate type, exposure, salinity) of each beach.

RÉSUMÉ

Gillespie, G.E., N.F. Bourne, and B. Rusch. 2004. Exploratory intertidal bivalve surveys in British Columbia – 2000 and 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2681: 120 p.

Nous présentons ici les résultats des relevés exploratoires réalisés en 2000 et 2001 pour évaluer l'état des populations d'espèces commercialement importantes de bivalves fouisseurs intertidaux sur certaines plages de Colombie-Britannique. Ces relevés sont le prolongement des travaux exploratoires lancés en 1990 pour évaluer les ressources intertidales de bivalves des côtes Nord et Centrale et incluent des relevés exploratoires effectués sur la côte Sud pour cartographier la dispersion d'une espèce exotique, la nuttallie obscure (*Nuttallia obscurata*). Nous avons également consigné la répartition de l'huître plate pacifique (*Ostrea conchaphila*).

La palourde japonaise (*Venerupis philippinarum*) est distribuée du sud de la Colombie-Britannique à l'entrée du bras Laredo (52°58'N). Elle fait l'objet d'une pêche commerciale aux environs de Bella Bella, et a été observée dans les bras Fish Egg et Briggs et dans le chenal Fisher. Nous ne l'avons cependant pas retrouvée dans des eaux adjacentes comme les chenaux Princess Royal et Dean.

Nous avons trouvé la nuttallie sur la côte Sud dans la baie Clayoquot et le havre Cameleon, mais sur aucune des plages examinées sur la côte Nord ou dans la partie nord-ouest de l'île de Vancouver.

L'huître plate pacifique est présente dans la baie Clayoquot, dans le bras Klaskino et dans le bras Fish Egg. Bien que l'espèce soit largement répandue de Panama jusqu'au nord de la Colombie-Britannique et peut-être jusqu'au sud-est de l'Alaska, ses besoins particuliers en matière d'habitat font que les populations sont abondantes seulement à certains endroits bien précis.

La plupart des plages de Colombie-Britannique présentant un habitat favorable abritent des populations de palourde du Pacifique, *Protothaca staminea*, de palourde jaune, *Saxidomus gigantea*, de coque, *Clinocardium nuttallii*, et de diverses espèces du genre *Macoma*. La représentation proportionnelle de chaque espèce dépend des caractéristiques écologiques (type de substrat, hydrodynamisme, salinité) de chaque plage.

INTRODUCTION

Intertidal clams continue to be an important commercial, recreational and subsistence resource to coastal communities and First Nations in British Columbia (B.C.). Commercial landings since 1951 have fluctuated greatly due to market demand, shifts in market preference, other socio-economic factors and availability (Webb and Hobbs 1997). Prior to 1980, the B.C. intertidal clam fishery was driven by demand for butter clams, *Saxidomus gigantea*, but landings of this species have declined greatly since then because of the high cost of harvesting and processing (Figure 1). Since the late 1970's, commercial intertidal clam fisheries have been driven by demand for Manila clams, *Venerupis philippinarum* (= *Tapes philippinarum* = *Tapes japonica*), with minor landings of littleneck, *Protothaca staminea*, butter and razor clams, *Siliqua patula*. Small quantities of cockles, *Clinocardium nuttallii*, softshell clams, *Mya arenaria*, and horse clams, *Tresus capax* and *T. nuttallii*, were occasionally reported.

Landings of Manilas peaked in 1988 at 3,909 tonnes (t) but decreased since, largely due to reduction of accumulated stocks, management actions and loss of habitat to fecal contamination (Figure 1). Increased Manila clam landings after 1992 include production from depuration fisheries, in which clams are held live in approved facilities until they purge themselves of fecal contamination, and thus reflect production from some beaches which would be inaccessible in the open commercial fishery. Hailed landings for 2000 indicated that landings of Manila clams comprised 89% of the landed weight from the intertidal clam fishery, including the regular fishery, depuration and aboriginal pilot fisheries. Depurated clams represented approximately 25% of the total weight of commercially landed Manila clams (R. Webb, DFO Parksville, pers. comm.).

There have been relatively few clam fisheries in the North Coast area of B.C., Pacific Fishery Management Areas (PFMA) 1-10, since 1963 primarily because of chronic low levels of paralytic shellfish poisoning (PSP) (Quayle 1969a) and the lack of monitoring programs to detect outbreaks of PSP and levels of bacterial contamination. A closely regulated permit system was initiated by DFO to allow harvest of intertidal clams in the North Coast district, but industry showed little interest in such harvest because of economic concerns. Notable exceptions are the ongoing razor clam fishery on Haida Gwaii and a butter clam canning operation in Port Edward in the mid-1980s. With the notable exception of recent razor clam assessments conducted by the Haida Fisheries Program (Jones *et al.* 1998, 2001), little assessment activity was directed towards intertidal clam stocks in the North Coast.

Manila clams were first found in the North Coast area in 1972 and more extensive populations were found on some beaches in the Bella Bella area in 1980 (Bourne 1982). In 1990, a program was initiated to survey intertidal clam stocks in the North Coast area (Bourne and Cawdell 1992), and further surveys were conducted in 1991 (Bourne *et al.* 1994), 1992 and 1993 (Bourne and Heritage 1997), 1994 and 1996 (Heritage *et al.* 1998), 1997 (Gillespie and Bourne 1998) and 1998 (Gillespie and Bourne 2000). Information was gathered on stocks of all commercially important clam species, but the focus of most work was on assessment of Manila clam dispersal and the extent of populations in the North Coast area.

Strong market demand and a decline in Manila clam landings after the peak in 1988 resulted in renewed industry interest in North Coast clam harvests. Exploratory surveys indicated that Manila clam populations in the North Coast area were sufficient to support limited harvest, and presented an economic opportunity for local communities. A pilot fishery agreement was established between DFO and the Heiltsuk First Nation in 1992 to allow commercial harvest of intertidal clams from the Bella Bella area (parts of PFMA 7) (Gillespie *et al.* 1999a; Gillespie *et al.* 2001a). No butter clams have been landed, only a few minor landings of littleneck clams were made, and Manila landings have fluctuated considerably (Figure 2).

The North Coast survey undertaken in 2000 was a continuation of the exploratory survey program, designed to provide information on distribution, general abundance and population characteristics of commercially important intertidal clam species, primarily Manila clams, in the North Coast. Our primary focus in this survey was to look at areas south (Fisher and Dean Channels) and north (Princess Royal Channel) of previous surveys to examine distributions and stock characteristics in areas that border the relatively well-documented populations in the Bella Bella area. Secondary objectives included determining if Olympia oyster (*Ostrea conchaphila*) populations reported by Bourne and Heritage (1997) at Fish Egg Inlet still existed, and whether varnish clams (*Nuttallia obscurata*) had succeeded in entering Johnstone Strait at Cameleon Harbour.

Surveys on the west coast of Vancouver Island were carried out in both 2000 and 2001 (Figure 3). In 2000, surveys were undertaken in Clayoquot Sound to assess Manila clam populations and determine whether varnish clams, which were known to inhabit Barkley Sound (Gillespie *et al.* 1999b), were now established in this area. In 2001, surveys were carried out in Klaskino and Klaskish Inlets primarily to assess Manila clam populations. These inlets are located north of Brooks Peninsula, which has acted as a biological barrier to the northward dispersal of some organisms (Bourne 1982). Observations were made in both inlets to determine whether varnish clams had overcome this barrier and were present in either locality.

SURVEY METHODS

Methods were similar to those used in previous surveys (Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998; Gillespie and Bourne 1998, 2000). Beaches were selected for survey from charts (using area of the intertidal and substrate information), as well as from previous experience, DFO clam atlases (Harbo *et al.* 1997), contract reports (*e.g.*, Cross and Kingzett 1993) and information from Fisheries Officers and local inhabitants. As in previous surveys, time constraints required that we maximize the number of beaches explored during a tide, rather than exhaustively surveying one or two beaches (*fide* Gillespie and Kronlund 1999). Results give general estimates of clam distributions and abundances in surveyed areas, not statistically rigorous stock estimates. It was also decided to intensify work at the head of inlets, since oceanographic conditions in these localities are thought to promote suitable habitats capable of supporting Manila clam populations.

A brief survey was made of each beach visited to assess the presence or absence of intertidal clams and determine the area of the clam-bearing part of the beach prior to sampling.

Clam-bearing areas were estimated by making exploratory scratches (small holes rather than full sample quadrats) to delimit clam distributions. Slope of the beach and substrate type were recorded. The high tide line was surveyed for drift shell of intertidal clams. In addition, large rocks, which are used by birds to drop and break clams, were examined for shell fragments. In the past, evidence of the presence of Manila clam has been determined with these latter assessment methods.

Clam distribution was assessed by digging test scratches. When aggregations of clams were found, quadrats of 0.25 or 1.00 m^2 were dug. Quadrats in the upper portion of the intertidal zone (0.25 m^2 targeting mainly on Manila clams and to a lesser degree on littleneck clams) were dug with a clam scraper to a depth of about 15 cm. Quadrats lower on the beach (1 m^2 targeting mainly on butter clams and to a lesser extent on littleneck clams) were dug with a potato fork to a depth of about 35 cm. When Manila clams were present at very low abundance, quadrat size was expanded until sufficient clams for biological sampling were obtained, or until no more Manilas could be found, and final quadrat size was estimated and recorded. In all cases, the dug substrate was reworked back into the quadrat through the fingers to detect clams missed when the quadrat was initially dug. All dug clams were washed, bagged and labeled for processing. Additional information was gathered on incidental species of invertebrates found on beaches and some specimens were collected to confirm identification.

Total length of each clam (the longest anterior-posterior length, TL) was measured to the nearest mm with vernier calipers. Shell height, from the umbo to the ventral shell margin, was measured for cockles and Olympia oysters. Ages were determined by counting annuli (Quayle and Bourne 1972). Length/height and age frequency distributions were determined and graphed. Length/height at annulus was measured for a representative sample of littlenecks, butter, softshell clams and cockles. Mean length/height at annulus and standard deviations were calculated and graphed. This provided length/height and age distribution and growth rate information for these species in each area surveyed.

Surface water temperature at a depth of 10 cm was recorded with a standard hand-held thermometer during the summer surveys in the North Coast. Samples of Manila clam gonads were collected at five locations: Fish Egg Inlet, Codville Lagoon, Briggs Inlet, Laredo Inlet and Cameleon Harbour. Tissues were preserved in Davidson's solution, blocked in paraffin, sectioned at 5 μm, stained with haematoxylin-eosin and examined microscopically to determine the stage of gonadal development after the method of Holland and Chew (1974).

RESULTS

Forty-two beaches were surveyed in ten areas: seven beaches in Clayoquot Sound; four beaches in Fish Egg Inlet; two beaches in Dean Channel; six beaches in Fisher Channel; five beaches in Briggs Inlet; seven beaches in Princess Royal Channel; three beaches in Laredo Inlet; one beach in Cameleon Harbour; three beaches in Klaskish Inlet and four beaches in Klaskino Inlet (Table 1, Figure 3, Figure 4).

WEST COAST VANCOUVER ISLAND – 2000

CLAYOQUOT SOUND

Clayoquot Sound is an important Manila clam harvesting area. Annual landings for Statistical Area 24 have ranged from 29.6 to 109.5 t between 1995 and 2002, with an average of 71.6 t landed annually (R. Webb, DFO Parksville, pers. comm.). Previous intertidal clam survey information has been collected for the Clayoquot Sound area in DFO surveys; for two beaches in 1980 by Bourne and Farlinger (1982), for selected beaches between 1980 and 1987 (Adkins and Harbo 1991) and between 1989 and 1991[1]. None of these surveys reported the presence of varnish clams. Naturalist and public reports indicate that varnish clams have been present in Barkley Sound since 1997, but the species was not reported from Clayoquot Sound.

The purpose of the 2000 survey was to opportunistically collect biological data for Manila clams on selected beaches and determine whether varnish clams were present in Clayoquot Sound. Incidental observations were made of other intertidal clam species. No quadrats were dug to quantitatively assess densities, but samples were collected to document size and age composition and growth of Manila clams from seven beaches in the Cypress Bay, Fortune Channel, and Warn Bay areas on April 6 and 7, 2000 (Figure 5).

Beaches that support clam populations in Clayoquot Sound are generally low slope beaches with mixed gravel/sand/silt substrates. Typically, these beaches are at the heads of inlets or in protected bays and are often associated with creeks or small rivers. The upper margin of most beaches is either bedrock or scattered boulders and usually supports thick stands of rockweed, *Fucus distichus*. Large estuarine beaches are typically of low slope until they drop off quickly at their seaward margin. Beaches in protected bays are often silty along their lower margins and support patches of eelgrass, *Zostera marina*.

Cypress Bay

Cypress Bay is a large bay that opens southward west of the mouth of Bedwell Sound and northeast of the confluence of Maurus Channel and Calmus Passage. There is a very large beach behind River Island at the mouth of the Cypre River and smaller beaches in various embayments along the margins of the bay.

We surveyed two smaller beaches. Beach 1 is located on the northeast edge of the Cypre River estuary and beach 2 is in a small unnamed embayment in north Cypress Bay (Figure 5). Cross and Kingzett (1993) found no evidence of varnish clams when these beaches were surveyed in 1992 (their beach numbers C-041 and C-039, respectively). They observed butter, littleneck, Manila clams on both beaches and horse clams, cockle shell and large numbers of moonsnails, *Euspira lewisii*, on beach 2. Neither beach was indexed by Harbo *et al.* (1997).

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[1] Heizer, S.R. unpubl. manuscr. West coast of Vancouver Island intertidal clam surveys, Areas 23 to 27 – 1989 to 1992. PSARC Working Paper I92-05: 114 p.

Beach 1 was primarily gravel and cobble substrate. The beach supported populations of littleneck and butter clams and a large population of striped dogwinkle, *Nucella emarginata*. One portion of the beach was soft sand and supported a small population of softshell clams at upper tide levels and a sparse population of cockles at lower tide levels. We encountered only a few Manila clams, and very few dead Manila shells. No live varnish clams or dead varnish shell were encountered.

Beach 2 was fairly large, approximately 2 ha, with sand predominating on the upper beach and gravel and cobble on the lower beach. The substrate was softer near three creek channels that crossed the beach, tending to be a silt layer over sand. The upper beach supported a sparse population of softshell clams, and the lower beach small populations of butter and littleneck clams. Large Manila shell was common on the beach, but the few live Manilas that were encountered were considerably smaller. Manila densities were low, and no sample was taken. A single large varnish clam shell was found high on the beach during the April 5 visit, but a half-hour search of the beach did not produce any more shell or live varnish clams. The beach was re-visited on April 7, and live varnish clams were found in soft sand substrate at about the half-tide level. We dug a total area of 2 m^2, and collected 43 live varnish clams.

Dawley Passage

Dawley Passage is a narrow pass that separates Vancouver Island from Meares Island and connects the eastern end of Browning Passage and the southern end of Fortune Channel (Figure 5). Beach 3 is at the head of an unnamed bay on the eastern side of Dawley Passage. Harbo *et* al. (1997) indexed this beach as number 265, and estimated the total intertidal area at 2.20 ha. Cross and Kingzett (1993) examined this beach (their number C-014) and rated its suitability for aquaculture as good.

The clam-bearing portion of the beach was small, less than one ha, and the substrate was predominantly wet, spongy gravel and sand. The upper beach was mostly rocky substrate, with a thick cover of rockweed. The beach supported reasonable densities of littleneck and butter clams along the lower margin and lower densities of Manila clams at mid-intertidal heights. No live varnish clams or dead varnish shell were encountered.

Heelboom Bay

Heelboom Bay is a small bay on Meares Island, the western side of Fortune Channel, north of Dawley Passage (Figure 5). Beach 4 is at the head of Heelboom Bay. The beach had a First Nations guardian's cabin and a sign that proclaims the area Meares Tribal Park. Cross and Kingzett (1993) did not report any clam species encountered when they surveyed this beach (their beach C-016). Harbo *et al.* (1997) indexed this beach as number 747, and estimated the total intertidal area at 3.29 ha.

The beach was dominated by a large creek channel, with some gravel flats on the cabin side. The substrate was progressively softer (more mud and silt) at lower tidal elevations, with eelgrass present along the lower margin. The creek channel had some butter and littleneck clams, and Manilas were present in packed gravel substrate on the steep sides of the channel. There were small patches of Manilas and littlenecks on the gravel flat in front of the cabin. No live varnish clams or dead varnish shell were seen.

Mosquito Harbour

Mosquito Harbour is a small shallow inlet that runs northwest from Fortune Channel on Meares Island (Figure 5). Beach 5 is the large beach that extends across the head of Mosquito Harbour. Cross and Kingzett (1993) split this beach into two portions; the smaller east side (their beach C-019) and the larger west side (C-020). Both were described as good clam beaches, but the report did not contain information about clam species or shells encountered.

The lower margin of the beach supported reasonable populations of littleneck and butter clams. Olympia oysters were abundant in eelgrass beds and present at low densities on the open beach. The beach supported high densities of large Manila clams in sand and gravel substrates and loose sand/gravel/shell berms. No live varnish clams or varnish shells were encountered.

The beach showed evidence of considerable commercial digging and we found one vexar sack of clams on the beach. Most of the clams were dead, except for approximately one-third of them which were still alive, those individuals located on the underside of the sack.

Warn Bay

Warn Bay extends northward from the confluence of Fortune Channel and Matlset Narrows (Figure 5). There are a number of small pocket beaches along the eastern and western shores of the inlet and a large beach at the head. We explored the large beach at the head of the inlet and one pocket beach on the western shore. Cross and Kingzett (1993) described both these beaches (their beach numbers C-029 and C-031, respectively) as good clam beaches, but did not describe any clam species or shells encountered. Their photograph of the substrate on C-029 (our beach 6) shows some Manila shell present on the surface. Harbo *et al.* (1997) did not include the beach at the head of the inlet in their clam beach atlas, but indexed the pocket beach as number 270 and estimated the total intertidal area as 4.19 ha.

Beach 6 is a large beach at the head of Warn Bay. The beach was divided into two unequal halves by Bulson Creek. We explored the larger, western half. The substrate was primarily sand with increasing amounts of gravel and cobble close to the stream channel. The gravelly areas supported sparse populations of littleneck and Manila clams; Manilas were collected over a fairly large area to measure biological parameters. Some areas had a covering of silt over sand, and broad areas of the beach were covered with shallow standing water. We searched the large sandy flat for one half-hour, and found only one dead varnish shell (24 mm TL) and one live varnish clam (38 mm TL). Continued digging in the area where the live clam was found did not produce any other clams. The sandy flats of the beach were relatively barren, with only sparsely scattered dead shell, mostly of littleneck clams but including occasional butter and cockle shell fragments.

Beach 7 is a pocket beach on the northwestern shore of Warn Bay (Figure 5). The beach was relatively small; we estimated the clam-bearing area available at that tidal height at approximately one ha. The beach had patches of sand and gravel substrate mixed with large rocks. The beach supported good densities of clams in suitable habitat. One test hole contained large specimens of Manila, butter, littleneck and softshell clams. This beach could not be adequately explored because of time constraints due to the rising tide.

Bivalve Populations

The surveys in Clayoquot Sound were carried out opportunistically as an adjunct to other invertebrate assessment work. Because of time constraints, quadrat samples were not taken to develop quantitative estimates of density and clam populations were described in qualitative terms. Beaches with gravel substrate types (beaches 2-5 and 7) supported littleneck and butter clams at reasonable densities, and varying densities of Manila clams. Softer substrates (sand or silt) supported softshell clams at higher tidal elevations (beaches 1 and 2) or cockles low on the beach (beach 1). The large sand flat at the head of Warn Bay (beach 6) was surprisingly devoid of clams; possibly the beach is too exposed to storm effects from the long open fetch of Fortune Channel and Warn Bay, or there are negative effects from scouring or freshwater exposure during freshet episodes from Bulson Creek.

Manila Clams: Manila clams were equally distributed between clams smaller and larger than legal size, 38 mm TL, at Heelboom Bay (Figure 6) but most were above legal size at Dawley Passage (Figure 7), Mosquito Harbour (Figure 8) and Warn Bay (Figure 9). Most clams were 4-6 years of age at Dawley Passage (Figure 7), four years of age at Heelboom Bay (Figure 6), five years of age at Mosquito Harbour (Figure 8) and 4-7 years of age at Warn Bay (Figure 9). Few clams younger than 3 years were found except at Warn Bay.

Growth of Manila clams from Dawley Passage slowed after formation of the third annulus (approximately 2.5 years of age), and the declining limb of the growth curve is due to poor growth (stunting) in several clams in the sample (Figure 10). The oldest clam in the sample (10 years old) was only 42 mm TL. Growth of clams from Heelboom Bay declined after 3.5 years of age, and size appeared to reach an asymptote not much over 40 mm TL (Figure 11). Clams from Mosquito Harbour exhibited relatively rapid growth to sizes >50 mm TL, with little evidence of growth tapering off until after six years of age (Figure 12). Clams from Warn Bay experienced slower growth after 2.5 years of age and did not grow much larger than 40 mm TL (Figure 13). Growth rates indicated that 4-4.5 years were required to attain legal size at all four beaches.

Varnish Clams: Varnish clams were found on one of two beaches examined in Cypress Bay and one of two beaches examined in Warn Bay. Varnish clams from Cypress Bay ranged in size from 21-45 mm TL; over 70% of the clams measured were ≥38 mm TL (Figure 14).

Growth rates estimated from length frequency modes (Gillespie *et al.* 1999b) suggest that varnish clams have been in Clayoquot Sound for at least four to five years.

Olympia Oysters: Olympia oysters were found only in Mosquito Harbour.

NORTH COAST - 2000

FISH EGG INLET

An exploratory intertidal clam survey was carried out in Fish Egg Inlet in 1993 (Bourne and Heritage 1997). Minor populations of Manila clams were found in the area at that time and also limited populations of Olympia oysters on beaches in Oyster Bay at the head of the inlet. The purpose of the present survey was to re-assess Manila clam populations in the inlet and undertake a more thorough assessment of Olympia oyster populations. Four beaches were surveyed in Fish Egg Inlet in 2000 that correspond to beaches 5, 7, 8, and 10 in the 1993 survey (Figure 15).

Oyster Bay

Beach 1 is at the head of Oyster Bay (Figure 15). This beach was relatively small, approximately 1 ha, and was sharply divided by a deep stream channel (Table 2). The channel banks were sand and gravel, covered by a thin layer of filamentous algae. The upper intertidal was steeply sloped, primarily boulders and bedrock covered by rockweed, bay mussels (*Mytilus trossulus*) and barnacles. We did not dig survey quadrats, as the clams were too sparsely distributed, but found some dead shell of Manilas and softshells. Olympia oysters were abundant on the sides and undersides of rocks in the lower intertidal. Many oysters attached to the underside of rocks were dead shell, most live oysters were situated near margins and on sides of rocks. There were a few live singles living loose on the substrate.

Beach 2 is a small embayment on the eastern shore of Oyster Bay, behind a small unnamed island (Figure 15). The substrate was soft sand and silt with some cover of algal mat. The upper margin of the beach was boulders with rockweed, mussel and barnacle cover, the lower margin of the beach had small areas of eelgrass. The most commonly occurring dead shell was *Macoma nasuta*, with some butter, littleneck and softshell present. There were few live clams and these were sparsely distributed; no sample quadrats were dug. Test scratches produced one small Manila and low numbers of butter, softshell, littleneck and cockle. Olympia oysters were present, but not as abundant as at beach 1; oysters were once again under rocks near the low tide line.

Head of Fish Egg Inlet

Beach 3 is at the head of Fish Egg Inlet (Table 2; Figure 15). The beach was of moderate size, possibly 2 ha, although some of this area was under a stream channel. The substrate was sand and gravel overlain with a thick layer of silt, covered by algal mat. There were eelgrass beds on the lower margin of the beach; the upper margin was rocks covered in rockweed, mussels and barnacles. We collected cockles, Manilas and littlenecks on the surface of the substrate, under algal cover. Some softshells were dug near a large sand berm that looked to be the result of excavation by heavy machinery. Olympia oysters were present in low abundance under rocks near the stream channel at lower elevations.

Inner Fish Egg Inlet

Beach 4 is a small saddle beach between two islands in Inner Fish Egg Inlet (Figure 15). The substrate was a loose mixture of shell and sand over large rocks and boulders, particularly at the top of the saddle. There were large numbers of dead shells at the top of the saddle, primarily butter, Manila, littleneck, softshell and macomas. Three $0.25m^2$ quadrats were dug; one on the lower beach on the southern side, one near the peak of the saddle, and one lower on the northern side.

Bivalve Populations

Results of assessments of bivalve populations in Fish Egg Inlet in 2000 were similar to those found in 1993 (Bourne and Heritage 1997). The limited habitat in the Inlet does not permit extensive populations of any species. Clams were sparsely distributed on beaches 1-3, therefore no quadrat samples were dug. Clams collected from scratches on beaches 2 and 3 and quadrats from beach 4 were pooled for biological sampling.

Manila Clams: Limited habitat in the inlet undoubtedly restricts Manila clam abundance; *e.g.*, the substrate of beach 3 is unsuitable for Manila clams because it is too soft. Manila clams were sparsely distributed on beaches 1-3; no quadrats were dug, but densities were estimated at «1 clam m^{-2}. Manila clams were found in all three samples taken at beach 4 where density ranged from 8-112 clams m^{-2} (Table 3). Most Manila clams (90%) were above the legal size of 38 mm TL (Figure 16). Size ranged from 25-61 mm TL and age from 2-10, most were 3-8 years. The age frequency distribution was spread fairly evenly over a number of age classes indicating a period of regular recruitment; however, size distribution and a lack of 1- to 3-year olds indicated that limited recruitment has occurred in recent years. Growth was rapid and they attained a size of 38 mm TL in about 3.5 years (Figure 17).

Samples of Manila clam gonads from this area showed four females were ripe, five males and one female were partially spent and two males were spent showing that gonadal development and spawning was occurring in the inlet (Table 4). This is not surprising since the surface water temperature recorded during this survey was 18°C, similar to what was recorded in the previous survey in 1993 (Bourne and Heritage 1997).

Manila clam populations in Fish Egg Inlet are too small to support commercial harvest.

Littleneck Clams: Littleneck clams were the most common bivalve found in Fish Egg Inlet and density in the three plots dug on beach 4 ranged from 64-256 clams m^{-2} (Table 3). Size ranged from 19-52 mm TL with a strong mode around legal size and a nearly even split of clams above (49%) and under the 38 mm TL size limit (Figure 18). The age frequency distribution ranged from age classes 1-11 and had a strong mode around age classes 6-9 (Figure 18).

Butter Clams: Butter clams were not seen at beach 1 and few were dug on beaches 2 and 3; five clams and one clam, respectively. Density on beach 4 ranged from 116-192 clams m^{-2} (Table 3). The biological sample consisted of six clams from beaches 2 and 3 and 105 clams from beach 4. Size ranged from 26-71 mm TL with most clams (79%) measuring less than the 63 mm TL size limit (Figure 19). The age frequency distribution ranged from 2-18 years, with strong contributions from year classes 3-12 (Figure 19). Growth was relatively slow with the few clams that achieve legal size taking 9-10 years (Figure 20).

Cockles: Cockles were sparsely distributed on all four beaches. Forty cockles were collected from the surface of beach 3; the biological sample consisted of these clams as well as one from beach 2 and two from beach 4. Height frequency distribution ranged from 32-66 mm (Figure 21). Age frequency distribution ranged from 2-8 years, with most clams aged 4-5 years (Figure 21). Cockles grew relatively rapidly until five years of age, after which growth slowed; cockles attained a shell height of 50 mm in about 4.5 years (Figure 22).

Olympia Oysters: The Olympia oyster population documented by Bourne and Heritage (1997) continues to exist. Distribution of the oysters was extremely clumped on individual rocks in appropriate habitats, thus no means were available to estimate meaningful densities or total abundance. Height frequency ranged from 18-63 mm with most oyster (78%) measuring between 39-51 mm shell height (Figure 23). Three of the 50 oysters sampled contained early-stage (white) larvae.

Varnish Clams: No live varnish clams or varnish clam shell were found in Fish Egg Inlet.

Other Species: Density of clams on beach 4 ranged from 4-84 m^{-2} for softshells and 12-44 m^{-2} for *Macoma inquinata* (Table 3). Dead shells of *Macoma nasuta* were found on beaches 2 and 3.

DEAN CHANNEL

Dean Channel is a long, narrow fjord that extends northward from 52°10'N at the northern end of Fisher Channel to 52°53'N, a total distance of about 85 km. Like many inlets in the North Coast, it is steep-sided with few intertidal beaches; most are at the mouths of creeks or rivers and have predominantly soft muddy substrates. Previous surveys found Manila clams in the Fitz Hugh Channel area (Bourne *et al.* 1994, Bourne and Heritage 1997, Heritage *et al.* 1998) and Manila populations to the west of Fisher Channel are well documented (Bourne and Cawdell 1992; Bourne *et al.* 1994; Heritage *et al.* 1998; Gillespie *et al.* 1999a, 2001a). We wanted to determine if Manila clams had dispersed farther northward to the upper end of Dean Channel.

We intended to explore the estuary of the Dean River, but strong onshore winds prevented landing. Two other areas were sampled; Kimsquit Bay, just north of the mouth of the Dean River and the beach at the mouth of the Kimsquit River (Figure 24).

Kimsquit Bay

We briefly explored the shoreline near the village site of Kimsquit. The beach was sand over cobble, with a thick algal mat and continuous freshwater runoff. Digging was very difficult due to the hard-packed substrate, and the only clams recovered from several scratches were *Macoma balthica.*

Kimsquit River Estuary

We explored the estuary of the Kimsquit River, at the northern terminus of Dean Channel. The estuary was large, >10 ha, with a grassy meadow above the beach and a steep dropoff on the lower margin. There were several active stream channels, and areas in and around these were scoured cobble and gravel. Most of the rest of the beach was sand, often with a thick layer of silt over it. In some areas, the substrate was anoxic, with high levels of decomposing wood fibre and other organic matter. The smell of hydrogen sulphide was quite apparent when these substrates were disturbed. No dead shell was observed, and the only molluscs seen on the beach were *Macoma balthica.*

Bivalve Populations

We did not find significant populations of bivalves in Upper Dean Channel. The only bivalves collected were small numbers of sparsely scattered *Macoma balthica.*

FISHER CHANNEL

Fisher Channel opens into Fitz Hugh Sound in the south and Dean Channel and Cousins Inlet in the north. Lama and Gunboat Passages and Johnson Channel connect Fisher Channel to Seaforth Channel and the main areas that support the Heiltsuk clam fishery near Bella Bella. Evans Inlet opens onto the eastern side of Fisher Channel opposite Denny Island, south of the mouth of Johnson Channel and Gunboat Passage and north of the mouth of Lama Passage (Figure 25). Codville Lagoon opens onto the eastern side of Fisher Channel in Lagoon Bay, opposite the mouth of Lama Passage (Figure 25).

Numerous clam beaches have been explored to the west (Bourne and Cawdell 1992, Bourne *et al.* 1994, Heritage *et al.* 1998) and south (Bourne *et al.* 1994, Bourne and Heritage 1997, Heritage *et al.* 1998) of Fisher Channel. Manila clam populations large enough to support commercial fisheries are well documented west of Fisher Channel (Gillespie *et al.* 1999a, 2001a), but are not as abundant in Fish Egg, Rivers and Smith Inlets and Kwakshua Channel.

We explored beaches in two areas of Fisher Channel; three beaches were examined in Evans Inlet and three in Codville Lagoon (Figure 25).

Evans Inlet

Area of the three beaches in Evans Inlet ranged from about 1-2 ha and the slope was low (Table 2). The substrate was typical of many beaches in the North Coast. The upper part and parts of the sides were mostly rock and cobble interspersed with patches of sand-gravel frequently covered with rock weed and dense populations of barnacles and blue mussels. The lower part of the beaches was mostly sand and gravel. The amount of suitable clam habitat varied from beach to beach.

Codville Lagoon

The three beaches examined in Codville lagoon were all small and ranged in size from <1.0 to 2 ha (Table 2). Substrate was similar to beaches in Evans Inlet, but the lower reaches of these beaches had a gravel and sand substrate and lacked the silt found in Evans Inlet.

Bivalve Populations

Some of the beaches in this part of Fisher Channel were extensive enough to support reasonable populations of bivalves.

Manila Clams: Manila clams were found in both Evans Inlet and Codville Lagoon, but were more abundant in the former area, possibly because of better habitat. At Evans Inlet density ranged from 0-96 clams m^{-2} and in Codville Lagoon from 0-20 clams m^{-2} (Table 3). In Evans Inlet size ranged from 21-47 mm TL, 66% were larger than the legal size and there was an even distribution of ages from 2-7 (Figure 26). In Codville Lagoon most were 43-57 mm TL, 96% were larger than legal size and most clams were 6 and 7 years in age (Figure 27); size and age distribution indicated restricted recruitment in recent years.

Growth was slower in Evans Inlet than in Codville Lagoon, requiring about 5 years to reach a size of 38 mm TL in the former area and 4 years in the latter area (Figure 28 and Figure 29). This difference may be due to sampling bias rather than real differences in environmental parameters between the two areas.

Examination of gonads from a pooled sample of Manila clams from both areas showed 2 males and 3 females were ripe, 1 male and 4 females were partially spent and 1 male was spent (Table 4). Water temperatures recorded at Evans Inlet were 13.5°C and at Codville Lagoon

14°C. Despite these low water temperatures gonadal development was occurring in Manila clams in this area.

Littleneck Clams: Littleneck clams were the most common bivalve found at both locations. At Evans Inlet density ranged from 0-492 clams m^{-2} and at Codville Lagoon from 0-404 clams m^{-2} (Table 3). Size distribution was similar at both locations and most littlenecks were below the legal size, 79% at Evans Inlet and 95% at Codville Lagoon. At Evans Inlet size ranged from 17-46 mm TL, most were 4-6 years of age (Figure 30) and at Codville Lagoon size ranged from 14-43 mm TL, most were 3-5 years of age (Figure 31).

Butter Clams: Butter clams occurred in both locations, but were much more abundant at Codville Lagoon. At Evans Inlet density ranged from 0-76 clams m^{-2} and in Codville Lagoon from 0-244 clams m^{-2} (Table 3). At both areas there was a preponderance of clams smaller than the 63 mm TL legal size, 61% at Evans Inlet and 93% at Codville Lagoon, indicating good recruitment in recent years. At Evans Inlet size ranged from 23-75 mm TL with a spread in ages from 2-10 (Figure 32); at Codville Lagoon size ranged from 14-73 mm TL with age distribution from 1-13, but with a preponderance of 3-5 years olds (Figure 33).

Growth was faster in Evans Inlet than in Codville Lagoon, requiring approximately 9 years to attain the legal size in the former area (Figure 34) compared with approximately 11 years in the latter area (Figure 35). Again this difference may be due to slight differences in sampling technique rather than to a real difference in growth rate between the two areas.

Cockles: Cockle density ranged from 0-32 m^{-2} at Evans Inlet and 0-16 m^{-2} at Codville Lagoon (Table 3). At Evans Inlet shell height of cockles ranged from 31-69 mm and most were 3 and 4 years of age (Figure 36); at Codville Lagoon they ranged in size from 21-71 mm and most were 2, 4 and 5 years of age (Figure 37). Growth was similar in both areas; cockles attained a shell height of 60 mm in about 6 years (Figure 38 and Figure 39).

Olympia Oysters: No live Olympia oysters or Olympia oyster shell were found in Fisher Channel.

Varnish Clams: No live varnish clams or varnish clam shell were found in Fisher Channel.

Other Bivalve Species: Softshell clams and *Macoma inquinata* were found in varying densities at both locations (Table 3). Softshell clams were much more abundant at Evans Inlet (0-156 clams m^{-2}) compared to Codville Lagoon (0-48 clams m^{-2}), which may be due to sampling bias rather than to real differences in population density between the two areas. At Evans Inlet size ranged from 21-79 mm TL (Figure 40) and in Codville Lagoon from 36-86 mm TL (Figure 41).

BRIGGS INLET

Briggs Inlet extends northward from Return Channel for about 19 km (Figure 42). In previous surveys in 1991, 1994 and 1996 areas around Briggs Inlet, Spiller Channel, Bullock Channel and Return Channel were surveyed (Bourne *et al.* 1994; Heritage *et al.* 1998), but no sampling was undertaken in Briggs Inlet. The present survey was intended to complete sampling of the area with an assessment of clam populations in Briggs Inlet.

Like other channels in the area, Briggs Inlet is steep sided with limited intertidal beaches. Most intertidal beaches are small and tend to have considerable rock. Five beaches were surveyed, three at the northern end of the inlet and two about half way along the west side of the inlet (Figure 42). Strong tidal currents and shallow draught at the narrow opening at the mouth prevented access to the lagoon at the head of the inlet.

The five beaches ranged in area from 1-2 ha (Table 2). The three beaches at the head of the inlet had low slopes, but at the other two beaches the slope was moderate (beach 4) to steep (beach 5). There was considerable rock and cobble on all five beaches. Beaches 4 and 5 were mostly rock or cobble with some hard sand interspersed between these areas; there was little suitable clam habitat at either beach. At beaches 1-3 there were more sand-gravel areas between the rocks, particularly at the lower beach levels, that was suitable clam habitat.

Bivalve Populations

Bivalve populations in Briggs Inlet were sparse because of the limited habitat available. Sampling was confined to beaches 1 and 2 at the head of the inlet because there was too little suitable habitat at beaches 4 and 5.

Manila Clams: Manila clams were not found in any of the sample quadrats dug in Briggs Inlet (Table 3), and estimated densities were extremely low. Ten Manilas were collected from beach 1 and one each from beaches 2 and 3; these were pooled for a biological sample. All were large, above legal size, and ranged from 39-59 mm TL and in age from 4-7 years (Figure 43). Growth was rapid and they attained a size of 38 mm TL in about 3.5 years (Figure 44). Low densities and truncated size and age distributions all indicate that recruitment has been poor in recent years.

The presence of Manila clams in Briggs Inlet is not surprising since they were found in other surrounding areas in previous surveys (Bourne *et al.* 1994; Heritage *et al.* 1998). It is surprising they were not more abundant, but this may be due to the lack of suitable habitat particularly in the mid intertidal zone.

Although the surface water temperature was only 13°C, gonadal development and limited spawning was occurring in Manila clams in Briggs Inlet as seen by examination of sections of gonads. Three males and six females were ripe and one male and one female were partially spent (Table 4).

Littleneck Clams: As in other North Coast areas, littleneck clams were the most common bivalve found in Briggs Inlet. Density ranged from 88-204 clams m^{-2} (Table 3) and most (76%) were larger than the legal size (Figure 45). Size ranged from 18-54 mm TL and most were 7 and 8 years of age. The presence of sublegal-sized, younger clams indicated some recruitment in recent years, but most of the population was larger, older clams.

Butter Clams: Butter clams were found at both beaches 1 and 2 in densities from 28-112 clams m^{-2} (Table 3). They were almost equally divided between legal (47%) and sublegal size (53%). Size of butter clams ranged from 27-83 mm TL and age from 2-14 years; but most were 10-12 years of age (Figure 46).

Growth was faster in clams from beach 1 compared to beach 2; the former attained the legal size in about 8 years, while the latter rarely reached legal size at ages up to 14 years (Figure 47). The observed difference in growth rate between the two beaches may be due to sampling bias rather than to a real environmental difference between the two areas.

Cockles: One cockle was found in plots at beach 1, and 39 were collected from beach 3. These clams were pooled for a biological sample. Most were large; shell height ranged from 53-95 mm and most were 4-6 years of age (Figure 48). Growth was fairly rapid and they attained a shell height of 60 mm in about 3.5 years (Figure 49).

Olympia Oysters: No live Olympia oysters or Olympia oyster shell were found in Briggs Inlet.

Varnish Clams: No live varnish clams or varnish clam shell were found in Briggs Inlet.

Other Bivalve Species: *Macoma inquinata* and softshell clams were found at low densities in plots at beach 1 (Table 3). One Pacific gaper (horse clam), *Tresus nuttallii*, was dug on beach 3.

PRINCESS ROYAL CHANNEL

Princess Royal Channel is a narrow, steep sided channel that is a major thoroughfare for boat traffic traveling north and south in B.C. It extends northwestward from the junction of Tolmie Channel and Hiekish Narrows (~52°53'N) to Whale Channel (~53°19'N), a total distance of approximately 61 km. Maximum width of the channel is about 2 km. Because of the steep sided nature of the channel there are few clam beaches along the shores.

The Princess Royal Channel area had never been surveyed for clam populations. In a previous survey, Manila clams were found at the north end of Finlayson Channel and in Sheep Passage at the southern end of Princess Royal Channel (Gillespie and Bourne 2000). It was of interest to determine if Manila clams had dispersed farther northward in Princess Royal Channel as well as to assess populations of other species. Four areas were surveyed: Swanson Bay, Khutze Inlet, Marmot Cove and Scow Bay (Figure 50). Time was limited and since it was desirous to survey as much of the area as possible only a limited amount of time was spent on each beach.

Swanson Bay

The beach in Swanson Bay was about 2.5 ha in area and had a low slope. Most of the beach was cobble interspersed with hard packed sand (Table 2). There was more suitable sandy clam habitat at the lower margin of the beach. One sample plot was dug here. This beach supported large populations of whelks, *Nucella emarginata* and *Nucella canaliculata.*

Khutze Inlet

Three beaches were sampled in Khutze Inlet, two at the upper part of the inlet and one near the mouth (Figure 50). Area of the beaches varied from about 1 ha to slightly less than 10 ha (Table 2). Slope at beach 3 was low, moderate at beach 2 and steep at beach 4. Most of the beaches were rock and cobble with interspersed packed sand. At the lower margins there were some sandy areas and soft silt. Most of the beaches were poor clam habitat and no sample plots were dug.

Marmot Cove

Two beaches were sampled in the Marmot Cove area: beach 5 just outside the cove was less than 1 ha in area and beach 6 inside the cove was about 5 ha in area (Table 2). Slope was steep for beach 5 and moderate for beach 6. The substrate of beach 5 was mostly sand with boulders and loose gravel along the margin. At beach 6 much of the substrate was small rock and gravel, the lower reaches were gravel with sand. A plot was dug on each beach. A rocky area on beach 5 supported abundant leafy hornmouth snails, *Ceratostoma inornata*, furrowed rock crab, *Cancer branneri*, and blackclawed crestleg crab, *Lophopanopeus bellus*.

Scow Bay

A beach near the head of Scow Bay was sampled. It was about 2.5 ha in area with a low slope (Table 2). The substrate was mostly rock and cobble with some sand and silt at the lower margin. No sample plots were dug on this beach, but a biological sample of cockles was collected from a broad area of the beach.

Bivalve Populations

Manila Clams: No live Manila clams or dead shells were found on any of the seven beaches. Manila clams have not dispersed this far north at least via this route. This is not surprising since water temperatures in Khutze Inlet were 11°C and 8°C, too low to permit larval development and also too low to permit gonadal development.

Littleneck Clams: Littleneck clams were common in sample plots and density ranged from 20-296 clams m^{-2} (Table 3). Abundant dead shell was found on other beaches visited indicating they are a common bivalve throughout the area.

There was a wide distribution of size and ages in sampled littlenecks from Marmot Cove. Size ranged from 12-55 mm TL and about half were sublegal (47%) and half legal size (53%) (Figure 51). Age distribution was fairly broad from 1-12 years, although most littlenecks were 3-5 years old (Figure 51). Growth was modest and littlenecks attained a size of 38 mm TL in approximately 5 years (Figure 52).

Butter Clams: Butter clams were found in most plots and density ranged from 0-40 clams m^{-2} (Table 3). Abundant dead shell was found on other beaches visited indicating butter clams were a common bivalve throughout the area.

There were differences in size and age distribution of butter clams sampled in Swanson Bay and Marmot Cove. At Swanson Bay butter clams were large and ranged in size from 62-90 mm TL and in age from 9-17 years (Figure 53) and virtually all (89%) were above legal size. At Marmot Cove there was a much wider distribution in size and age; size ranged from 20-88 mm TL and age from 2-16 years (Figure 54) and an even split of clams larger (47%) and smaller (53%) than the 63 mm TL legal size. This might indicate that recruitment has been relatively poor in Swanson Bay, but the small sample size (9 clams) does not inspire much confidence in such a statement. Growth of butter clams was slow at both Swanson Bay and Marmot Cove; they attained a size of 63 mm TL in about 9 years at the former area and about 10 years at the latter area (Figure 55).

Cockles: Cockles were widely dispersed at low densities in Scow Bay (beach 7); although no quadrats were dug, a biological sample of 27 cockles was collected from a broad area of the beach. The cockles were large and ranged in shell height from 61-83 mm and in age from 4-9 years (Figure 56). Growth of these cockles was modest and they attained a shell height of 60 mm in about 4 years (Figure 57).

Olympia Oysters: No live Olympia oysters or Olympia oyster shell were found on beaches visited in Princess Royal Channel.

Varnish Clams: No live varnish clams or varnish shell were found on beaches visited in Princess Royal Channel.

Other Bivalve Species: Several *Macoma inquinata* were found in sample plots from beaches 1 and 6 (Table 3) and shell was recorded from beaches 1, 4 and 5. *Macoma balthica* shell was seen on beach 2. Softshell clams were not found in sample plots, but this may be an artifact of sample placement as dead softshell shell was found on beaches 2 and 5. One fat gaper (horse clam), *Tresus capax*, was dug on beach 6 and two Arctic hiatella, *Hiatella arctica*, were dug from a quadrat on beach 6.

LAREDO INLET

Laredo Inlet opens into Laredo Sound and terminates 32 km north behind Brew Island. The inlet is narrow and steep sided, with few clam beaches. There is an extensive clam beach at the head of the inlet, in the Arnoup Creek estuary (Figure 58).

The beach at the mouth of Arnoup Creek was briefly examined in 1998 (Gillespie and Bourne 2000). That survey found nine live Manila clams ranging from 13-48 mm TL. This was the northernmost known naturally-occurring population of Manila clams in British Columbia (52°58'N).

Three beaches were examined during this survey: one on the inner estuary of Arnoup Creek, one on the outer margin of the estuary and one in the small bay to the east at the mouth of Brew Creek (Figure 58).

The inner Arnoup Creek estuary was approximately 3 ha in area, with a sand and gravel substrate crossed by numerous creek channels. The lower portion of the estuary supported low densities of Manila and littleneck clams and the upper portion supported softshell clams.

The beach on the outer part of the Arnoup Creek estuary was approximately 6 ha in size with a sand and silt substrate and a large eelgrass bed on the lower margin. There was a small sand/gravel bank (<1 ha) near the outlet from the upper estuary.

The beach at the mouth of Brew Creek was relatively small (< 1 ha) with a hard packed sand and silt substrate on the lower beach and cobble in packed sand on the upper beach. Several scratches were made but few clams, only a few stunted littlenecks, were found. No quadrats were dug.

Bivalve Populations

Manila Clams: Manila clam densities ranged from 0-36 clams m^{-2} on beach 1 and from 0-20 clams m^{-2} in the gravel bank on beach 2 (Table 3). There was a wide size and age distribution of the pooled sample of Manila clams from Laredo Inlet (Figure 59). Size ranged from 16-51 mm TL and age from 2-8 years; most were 3-5 years old. Most of the clams (73%) were less than 38 mm TL. Growth was slow and it required approximately 5 years for Manila clams to grow to 38 mm TL (Figure 60).

Although surface water temperature was only 14°C, gonadal development was occurring in Manila clams in Laredo Inlet. Eight males and two females were ripe and two males were partially spent (Table 4).

Littleneck Clams: Littleneck clam densities ranged from 0-12 clams m^{-2} on beaches 1 and 2 (Table 3). Most littlenecks (62%) were less than the 38 mm TL legal size limit, although the sample size was small and collected relatively high on beach. The number of clams collected from the plots was too small to construct meaningful size or age distributions.

The survey in Laredo Inlet was designed to assess Manila clams populations and determine if varnish clams were present. Few littleneck clams were found in the plots, which is not surprising since sampling occurred outside the zone of abundance of this species. Dead shells were observed at lower intertidal levels indicating this species is present, possibly at moderate densities at lower tidal elevations on beaches in the area.

Butter Clams: No butter clams were found in the quadrats sampled in Laredo Inlet (Table 3). There was butter clam shell seen on the lower margins of beaches 1 and 2, which indicates that butters are present at lower tidal elevations on these beaches.

Cockles: Cockles were not present in quadrats dug on beach 1 or the gravel berm on beach 2, but were sparsely distributed on the sandy portion of beach 2. Cockle density was 20 clams m^{-2} in the single quadrat dug there. Size distribution of cockles was wide ranging from 22-60 mm shell height, and ages ranged from 1-5 years, most being 3 years old (Figure 61). Growth of cockles was slow and it required about 4 years to attain a shell height of 50 mm (Figure 62).

Olympia Oysters: No live Olympia oysters or Olympia oyster shell were found on beaches visited in Princess Royal Channel.

Varnish Clams: No live varnish clams or dead shell were found on the three beaches examined in Laredo Inlet.

Other Bivalve Species: Softshell clams were found in some plots at beaches 1 and 2. Softshell clam density ranged from 0-76 clams m^{-2}, and there was a wide size distribution from 16-79 mm TL (Figure 63). One *Macoma nasuta* was dug on beach 2.

JOHNSTONE STRAIT - 2000

CAMELEON HARBOUR

Cameleon Harbour, on Sonora Island, opens onto Nodales Channel via Burgess Passage (Figure 64). Clam beaches extend around the entire perimeter of the harbour, divided to some extent by rock outcrops and streams. Part of the beach lies within Thurston Bay Marine Park.

The beach at the head of Cameleon Inlet was visited in 1991 (Bourne *et al.* 1994) and surveyed in 1993 and 1994 (Bourne and Heritage 1997; Heritage *et al.* 1998). Previous surveys did not find varnish clams. This survey was conducted on a relatively poor tide that provided little time or beach exposure to examine most species. Our objectives were to collect gonad samples from Manila clams and determine if varnish clams had become established in the harbour.

Bivalve Populations

Manila Clams: Due to restraints of time and tide, most of the beach area inhabited by Manila clams was inaccessible. We did not dig formal quadrats for Manila clams; we collected 11 Manila clams from exploratory scratches to examine gonadal condition. Histological sections showed that males were mostly ripe or partially spent and females were mostly spent or partially spent (Table 4).

Varnish Clams: Varnish clams were found to be relatively abundant in loose sand in the upper intertidal zone. Densities in five quadrats ranged from 4-85 varnish clams m^{-2} (Table 3). Size distribution ranged from 18-50 mm TL and was roughly bimodal (Figure 65). A small mode present between 17-28 mm TL likely indicates recent recruitment to the population, and a larger mode between 30–50 mm TL likely represents several year classes. Growth rates estimated from length frequency analyses by Gillespie *et al.* (1999b) suggest that varnish clams have been in the harbour for at least five years.

Other Species: The tide level at time of sampling precluded examination of potential habitat for other bivalve species. Previous surveys reported Manila, littleneck, butter, softshell and *Macoma* clams.

WEST COAST VANCOUVER ISLAND - 2001

KLASKISH INLET

Klaskish Inlet is a small inlet located at the northern headland of Brooks Peninsula that opens into Brooks Bay. The area is completely inaccessible by land and access by small boat is difficult, as exposed ocean water must be crossed to enter the inlet. Three large beaches in this area were identified as having clam stocks that may have been accessed previously in the commercial fishery. The inlet has been closed to commercial fishing since 1990 (R. Webb, DFO Parksville, pers. comm.).

Three beaches were sampled in this survey, Klaskish Anchorage, Shields Cove and the beach at the head of Klaskish Inlet (Figure 66). The beach in Klaskish Basin was briefly examined, but any available clam habitat was largely inaccessible due to the incoming tide.

Klaskish Anchorage

Although relatively large, the majority of this beach was poor clam habitat. The slope was low and the upper intertidal region consisted of large rock and coarse gravel. Some good clam habitat existed on the south end and in small patches elsewhere, but the majority of the clam-bearing ground was at the north end where fine gravel and mud substrate occurred. Only about 10% of this beach contained clams, covering an area of approximately 1-2 ha. The remainder of the beach had areas of clay silt, mud and fine gravel/mud substrates. Eel grass beds extended sporadically along the beach in muddy and silty areas, and could be seen beyond the water's edge (Table 2).

The northern third of this beach directly fronts an Indian Reserve and the entire beach is part of Books Peninsula Provincial Park. The beach was indexed by Harbo *et al.* (1997) as beach 352, with the total intertidal area estimated at 11.8 ha.

Quadrats were dug at five locations, four from the north end and one sample from the small patch of clam ground at the southern end of the beach.

Shields Cove

Harbo *et al.* (1997) called this beach Shields Cove as it is located at the base of Shields Cone. It was indexed in their clam atlas as beach 353, and total intertidal area was estimated to be 12.0 ha. The beach is located at the mouth of an unnamed river flowing into Klaskish Inlet just south of the entrance to Klaskish Basin. Only the north and south sections of this beach were assessed due to the inability to land on the intertidal area between the river channels, which appeared to consist of large gravel and boulders, and was not likely to have large clam populations due to scouring by shifting river channels.

The northern section of the beach had a moderate slope with good clam habitat located behind two large rocks exposed at all tide levels. A small area, approximately 1 ha, of sand/mud and fine gravel substrate supported reasonable clam populations. The remainder of the beach was fine to coarse broken gravel without mud or sand. This entire area was moderately exposed and would at times experience indirect ocean swell. Three samples were taken at this location when the tide level was approximately 1 m above chart datum. Higher densities of clams may have been located lower on this beach as live clams could be seen on the surface of the substrate not exposed at this tide level.

The southern section of beach consisted of fine gravel and mud, with deep mud in the extreme south of the bay. Clams were found in approximately 1 ha of this region, representing about half of the beach between the river channel and the head of the bay. Two samples were taken from this area.

Both sections of this beach showed signs of recent winter kill (in the last 2-3 years) indicated by piles of shell at the high intertidal, which were not heavily weathered or broken (Bower *et al.* 1986, Bower 1992). Dead shell was also commonly encountered in the substrate when quadrats were dug.

Klaskish Basin

This beach was not sampled due to difficult access at low water. The beach was walked at about half tide, but the extent of good clam habitat was difficult to determine, as much of the beach was covered by the incoming tide. Evidence of Manila, littleneck and butter clam populations was found in the form of broken shell dropped by birds on the rocks above the intertidal. Shell was also observed on the substrate from the boat while trying to land.

The beach had a very gradual slope with flats at the mouth of the Klaskish River extending for considerable distance. The river flowed along the east shore and the substrate in this area was large gravel and boulders. The west shore of the head of the basin appeared to be gravel/mud and may be good clam habitat. Harbo *et al.* (1997) indexed this beach as beach 351, and estimated the total intertidal area at 9.8 ha. We estimated that approximately 1 to 2 ha of this area was potentially good clam habitat.

Bivalve Populations

Manila Clams: Manila clam density ranged from 0-64 clams m^{-2} on beach 1 and from 0-80 clams m^{-2} on beach 2 (Table 3). Size frequency of Manila clams sampled from Klaskish Inlet ranged from 24-51 mm TL with a mode at approximately 36 mm TL (Figure 67). Approximately 40% of Manilas in the sample were of legal size. Age frequency of Manilas ranged from 2-11 years with most clams 3-4 years old (Figure 67). This distribution suggests consistent recent recruitment, as 2 year-olds might be under-represented and 1 year-olds would not be expected to be collected from hand-dug quadrats. Growth was somewhat slow, requiring 4-5 years to attain legal size (Figure 68).

Littleneck Clams: Littleneck clam density ranged from 40-124 clams m^{-2} on beach 1 and from 4-96 clams m^{-2} on beach 2 (Table 3). Size frequency of littlenecks ranged from 10-52 mm TL with potential modes near 25 and 37 mm TL (Figure 69). Nearly three-quarters of littlenecks sampled were <38 mm TL, which is not unexpected when littleneck samples are taken from relatively high tidal elevations. Age frequency distribution of littlenecks ranged from 1-13 years with potential modes at 2-3, 7 and 10 years of age (Figure 69). This distribution suggests relatively consistent recruitment, or at least reasonably frequent episodes of successful recruitment.

Olympia Oysters: No live Olympia oysters or dead shell were found in Klaskish Inlet.

Varnish Clams: No varnish clams or dead varnish shell were found in Klaskish Inlet.

Other Species: Butter clams were not common at the tidal heights sampled on these surveys; they were present at densities from 0-4 clams m^{-2} on beach 1 and not encountered on beach 2 (Table 3). Softshell clams were present at densities ranging from 0-16 clams m^{-2} on beach 1 and from 0-8 clams m^{-2} on beach 2. *Macoma* sp. and cockles were not seen on beach 1 and were present at densities between 0-4 clams m^{-2} on beach 2.

KLASKINO INLET

Klaskino Inlet is a small inlet located approximately half way between the head of Brooks Peninsula and the mouth of Quatsino Sound. The inlet is bounded by a narrow, shallow entrance, opening to a moderately deep, 1.2 km wide inlet extending for approximately 3.3 km before entering another narrows leading to the head of the inlet. There is no major river present in the inlet and all fresh water enters through several small creeks. Several small beaches are present in the inlet with the majority of the intertidal area near the head. Klaskino Anchorage, a large beach near the mouth of the inlet, was not examined on this survey. All beaches in this area have been identified as clam beaches previously harvested in either commercial or recreational fisheries (Harbo *et al.* 1997). The inlet has been closed to commercial fishing since 1990 (R. Webb, DFO Parksville, pers. comm.).

The area is accessible by an active logging road, which runs just inland of the shore around the entire inlet. Active logging was observed along the southern side of the inlet and several loaded logging trucks were observed traveling along the road on the north shore. All beaches in the area could be accessed from the existing road.

The largest beach at the head of the inlet was sampled; three other beaches were only briefly examined due to time constraints (Figure 70).

Head of Klaskino Inlet (Northeast)

Beach 1 is the largest beach at the head of Klaskino Inlet, with potential clam habitat of approximately 2-3 ha, approximately 1.5 ha of which was considered good clam habitat. Harbo *et al.* (1997) indexed this as beach 362 and estimated the total intertidal area at 6.4 ha. The beach was moderately sloped, with the total distance between the high and low tide marks approximately 70-90 meters. Substrate was fine broken gravel mixed with mud producing a firm substrate that was very easy to dig. Four samples were taken (Table 2).

This beach also had a large population of Olympia oysters, which were present in the low intertidal and covered much of the beach. Olympia oysters were not directly sampled on this beach, as most of the population was underwater.

South Side of Klaskino Inlet (Southwest)

Beach 2 is a small beach with approximately 1 ha of potential clam habitat, located west of the narrows at the head of Klaskino Inlet. Harbo *et al.* (1997) indexed this beach as beach 359 and estimated the total intertidal area at 2.3 ha. There was a small creek running across the center of the beach. The slope was moderate with a steep drop off just below the low tide mark. Substrate was fine broken gravel/mud over the entire beach except along the creek where the substrate was coarse to fine gravel. The beach was exceptional clam habitat, and densities of clams were comparable, and possibly greater than that of beach 1, the only sampled beach on this survey. Olympia oysters were present in high densities in the lower intertidal.

South Side of Klaskino Inlet (Southeast)

Beach 3 is a small beach on the south shore of the head of the inlet. Harbo *et al.* (1997) indexed this as beach 361 and estimated the total intertidal area at 0.7 ha. We estimated potential clam habitat at <0.5 ha. The beach was moderate to steeply sloped with a substrate consisting of fine gravel/mud in the lower intertidal and coarse gravel in the upper region. Significant numbers of Manila and littleneck clams were present in the lower area of the intertidal. Significant numbers of Olympia oysters were also present low on the intertidal zone.

North Side of Klaskino Inlet (Northwest)

Beach 4 is a very small beach immediately west of the large beach at the head of the inlet, which was not indexed by Harbo *et al.* (1997). The beach was steeply sloped, having a fine gravel substrate. Total potential clam habitat was considerably less than 0.5 ha. Clams were present but sparsely distributed; Olympia oysters were present at low density.

Bivalve Populations

Manila Clams: Manila clam density ranged from 92–276 clams m^{-2} (Table 3). There was a relatively even split of legal and sublegal sized clams, with 55% of the sample made up of legals. Size frequency ranged from 12-53 mm TL, with modes near 20, 30 and 40-48 mm TL (Figure 71). Age frequency was from 1-11 years of age with strong contributions of 2 and 3 year-olds and a broad mode of clams 7-10 years of age (Figure 71). Growth was somewhat slow, requiring 4-5 years to attain legal size (Figure 72).

Littleneck Clams: Littleneck clam density ranged from 8-220 clams m^{-2} (Table 3). Most littlenecks in the sample (88%) were less than legal size. Size frequency ranged from 6-42 mm TL, but limited data prevented detection of possible modes (Figure 73). Age frequency ranged from 1-10 years, with strong contributions from 1 and 2 year-olds and a broad mode from 5-9 years of age (Figure 73).

Cockles: Two cockles were found in quadrat samples; density ranged from 0-4 cockles m^{-2} (Table 3).

Olympia Oysters: Olympia oysters were present on all beaches examined, and at high densities on beaches 1 and 2.

Varnish Clams: Nor live varnish clams or varnish clam shell were found.

Other Species: *Macoma* sp. were found at low densities between 0-4 clams m^{-2} (Table 3). Softshells were somewhat more abundant, with densities between 4-24 clams m^{-2}. No butter clams or butter clam shell were found.

DISCUSSION

These surveys increase our knowledge of the distribution and state of bivalve populations in B.C., particularly those of Manila clams.

MANILA CLAMS

A small Manila clam population continues to exist in Fish Egg Inlet. Limited successful breeding is occurring in this population as shown by results of gonad sections and size distribution. Although small clams were found, their numbers were low, suggesting the population is merely maintaining itself and not expanding. Suitable habitat is also limited and the population is much too small to support commercial harvesting.

In the Fisher and Dean Channel areas results of the survey showed that Manila clams have spread throughout Fisher Channel, but were absent from beaches examined in upper Dean Channel. The occurrence of Manila clams in Fisher Channel was not unexpected since they occur in the Fitz Hugh Channel area and it is not a long distance for larvae to have travelled northward this far. The population is modest and it is questionable whether it is sufficient to be of interest to the industry. The lack of Manila clams in upper Dean Channel may be a result of lack of suitable habitat, as both butter and littleneck clams were absent from the beaches examined.

The occurrence of Manila clams in Briggs Inlet again was not unexpected since they have occurred in the surrounding area and one would expect that larvae have been dispersed into this area.

The absence of Manila clams in Princess Royal Channel shows that Manila clams have not dispersed northward from the southern end of this channel in the Sheep Passage-Finnlayson Channel area where they were found in a previous survey (Gillespie and Bourne 2000). There is little intertidal clam habitat in Princess Royal Channel, but there are some excellent areas supporting large populations of butters and littlenecks, and these areas would support Manila clams if conditions for larval transport into the area existed. Oceanographic conditions probably do not permit survival of larvae that may be carried northward via this channel. Sampling in the present survey occurred in the northern part of Princess Royal Channel. Surveys of any intertidal beaches in the southern part of this Channel in future surveys would determine if Manila clams have at least dispersed into the southern part of this area.

Results of sampling at the northern end of Laredo Inlet were of particular interest. Small numbers of Manila clams were found there in a previous survey (Gillespie and Bourne 2000), but a flooding tide prevented extensive sampling to determine the extent of this population. The present survey undertook a thorough investigation of this area. There is extensive habitat for Manila clams in this location but the population appears to be limited and maximum density was 36 clams m^{-2}. Most clams (75%) were smaller than the legal size. This is partly due to slow growth; it required 5 years to attain the legal size (Figure 60), indicating the population may be stunted. However, 2 and 3 year-olds were abundant indicating good recruitment in recent years.

It is obvious that the population is maintaining itself, but it is too small to be of interest to industry for commercial harvest.

This population of Manila clams is the northernmost in B.C., and perhaps in the world. A substantial natural population is established in the U.K. at Poole Harbour in England (50°45'N), and is harvested commercially (Morgan 2003; B. Spencer, pers. comm.). Manila clams are farmed in Ireland but to date they have not reproduced naturally (D. Kelly, pers. comm.). It would be interesting to undertake an in-depth study of this farthest northern population of this subtropical species to determine what oceanographic conditions permit it to exist and to follow it through several years to determine its viability.

Samples of gonads taken in all five locations during the survey showed that Manila clams were either ripe, partially spent or spent showing that spawning is occurring in all areas where they occur, even at the most northern location at the head of Laredo Inlet. Mann (1979) showed that a temperature of 15°C was required to permit gonadal development and spawning. Such temperatures have been recorded in many protected bays in northern B.C. waters. Size and age distributions of populations of Manila clams also indicate that successful breeding is occurring. Whether sufficient degree-days are occurring every year to permit successful gonadal development and spawning is unknown, but sufficient breeding is occurring to maintain populations.

VARNISH CLAMS

This report documents the first records of varnish clams in Cameleon Harbour and Clayoqout Sound and indicates that they have continued dispersal northward along both coasts of Vancouver Island from previous records in Barkley Sound and the Strait of Georgia (Gillespie *et al.* 1999b, 2001b). Additional records of dead shell imply that varnish clams have dispersed as far north as Checlset Bay (50°07'N, 127°37'W) on the west coast of Vancouver Island and Toba Inlet (50°29'N, 124°24'W) and Salmon Bay (50°24'N, 125°58'W), although evidence of established populations in these areas is lacking (Gillespie *et al.* 2001b). The rate of expansion suggests that varnish clams may soon be found in the North Coast; future survey effort should be directed at the northwest coast of Vancouver Island, Johnstone and Queen Charlotte Straits as well as mainland inlets north of Vancouver Island.

The size frequency of varnish clams in both Clayoquot Sound and Cameleon Harbour suggests that they have been in these locations for several years, when compared with preliminary growth rates from length frequency analyses (Gillespie *et al.* 1999b). That they had not been reported previously may be due to the remoteness of the areas in which they were found or to the distribution of varnish clams higher on the beach than commercially sought species. Populations in both areas were small, which probably decreased the likelihood of detection by casual observation.

Varnish clams have a number of biological characteristics that contribute to their fishery potential, including low mortality rates during storage and shipping and high density populations on beaches where they have become well-established (Gillespie *et al.* 2001b). Despite these characteristics, fishery interest in the South Coast has been limited for two reasons: 1) processors have not been able to establish strong markets, and 2) diggers are discouraged by prices significantly lower then those offered for Manila clams. Continued study is warranted, however, as market conditions may change and information on biological and population dynamics characteristics of varnish clams will be required to assist in rational management of the species should a fishery develop.

Studies should also continue to document the rate and route(s) of dispersal of this exotic species as it's range continues to expand northward in B.C. It will be particularly interesting to determine whether varnish clams become established more rapidly, take similar dispersal routes and eventually disperse further northward than Manila clams did after introduction in the 1930s (Quayle 1964; Bourne 1982).

OLYMPIA OYSTERS

The Olympia oyster was a common bivalve in the southern part of the Province and supported a commercial harvest industry for many years (Quayle 1988). It has a wide distribution on the west coast of North America; Coan *et al.* (2000) state it occurs from Sitka, Alaska, Lat. 57°1'N to Panama, Lat 9° N, although the northern limit is based on a record by Dall (1914) that is somewhat suspect (Gillespie 1999). Paul and Feder (1976) reported Olympia oysters from southeast Alaska, but not in dense aggregations, nor were specific locations reported. Quayle (1988) reported them at Campbell Island and in many inlets in the Bella Bella area. Other authors have not reported populations north of Campbell Island (Quayle 1969b) and the Bardswell Group (Elsey 1933). Summaries of Olympia oyster distribution and biology are given by Baker (1995) and Gillespie (1999).

The present survey confirmed the continued existence of the small population in Fish Egg Inlet reported by Bourne and Heritage (1997), but they were only found in Oyster Bay at the head of the inlet. This bay was obviously named Oyster Bay by early surveyors because of the presence of Olympia oysters, so the population has existed for many years. It is not a large population and from recent information does not appear to have increased in size in recent years; it is a small population that continues to exist.

It would be of interest to know the extent of Olympia oyster populations north of the Bella Bella area. Hopkins (1937) stated Olympia oysters require an ambient water temperature of at least 12.5°C to reproduce, but reproduction occurs more commonly at temperatures of 14-16°C (Strathman 1987). These temperatures are similar to those required for successful breeding of Manila clams (Mann 1979). Future surveys in the North Coast area should include careful observations for Olympia oyster populations so that its distribution in B.C. can be accurately determined.

Extensive populations of Olympia oysters were found in Klaskino Inlet but none in Klaskish Inlet. This may have been due to lack of good habitat or the fact that sampling in the latter inlet was not undertaken low enough on the intertidal area. Modest populations of Olympia oysters are known to occur in several inlets on the west coast of Vancouver island

(Quayle 1988) and periodically enquiries are received about possible commercial harvest of these populations. Commercial harvest of these populations should be discouraged. The populations have probably accumulated over a period of many years and they would be quickly eradicated by commercial harvest (Gillespie 1999). It could take years for the populations to recover as has been the case elsewhere. The populations should be left for occasional recreational harvest and for future studies.

Care should be taken to prevent transfer from these isolated populations to the Strait of Georgia and *vice versa*. Bower *et al.* (1997) have shown that Olympia oysters in the Strait of Georgia are infected with Denman Island disease and this may be a contributing reason that populations in the Strait of Georgia area have not recovered to historic levels. Presumably populations in Klaskino Inlet and in the North Coast are not infected with this disease but could suffer heavy mortalities if it spread to these areas. These isolated populations could be important in future transmission studies and hence they should not become infected.

BUTTER CLAMS

These surveys were not designed to assess butter clam populations, but a few plots were dug specifically to assess butter clam populations in the North Coast. Results of this limited sampling along with incidental observations and observations of dead shell on beaches indicate that butter clams are abundant in suitable habitat in the lower third of many intertidal beaches in B.C. Size distribution shows there has been good recruitment in recent years in most localities.

Growth is now well documented from survey work and other sources and it requires 5-9 years for butter clams to attain the legal size limit of 63 mm TL shell length. Growth rate depends on position on the intertidal beach and geographic location; it is generally slower in the northern areas of B.C. (Quayle and Bourne 1972). Some samples from exploratory surveys do not reflect optimal growth rates because only the portion of the population that overlaps littleneck and Manila clam distributions is sampled. What proportion is sampled incidentally depends on the degree of overlap of the species distributions and the area of beach that is exposed for sampling. Samples from surveys early or late in the tidal cycle will not be representative of butter clam populations on those beaches.

Populations of butter clams in the North Coast are sufficient to support commercial harvest that could be as large as 2,500-3,000 t annually. However, development of a butter clam fishery will depend on economics and under present conditions harvest and processing of this species in B.C. is not economically viable except for limited niche markets. One cannery in Nanaimo does process a limited amount for a specialty market and total production from the South Coast (primarily from Seal Island in the Strait of Georgia and Johnstone and Queen Charlotte Straits) has averaged 272 t annually between 1970 and 2001. Whether these markets can be expanded is unknown.

In the meantime, efforts should continue in future surveys to continue gathering information on butter clams throughout the Province so that if a fishery develops information will be present to assist in management of the resource.

LITTLENECK CLAMS

As was the situation for butter clams, the present surveys were not designed to sample littleneck clams, although they frequently appeared in samples because their habitat range often overlaps that of Manila clams.

Littleneck clams are probably the most abundant intertidal bivalve in B.C. They are found literally on all beaches where suitable habitat exists, from protected to exposed areas. They can occur in high densities, upwards of 500 clams m^{-2} (Bourne and Cawdell 1992, Bourne *et al.* 1994, Heritage *et al.* 1998, Gillespie and Bourne 2000, this study). Results from the many samples taken during this and other surveys shows there is a wide range in size and age distribution indicating that recruitment is relatively consistent.

There are large populations of littleneck clams along the B.C. coast that could be exploited commercially; potential landings could be about 2,000 t annually. In previous years there was a moderate fishery for this species and they are relished by First Nations. At present landings are small, an average of 233 t annually between 1970 and 2001. The problem is that the market has little interest in this species. Although the present principal market for intertidal clams is steamer clams, it does not want littlenecks. The market claims that this species has a shorter shelf life than Manila clams and that when steamed the soft parts do not separate from the shell as readily as Manila clams.

Until economically viable markets for littlenecks are found the aim in future surveys should be similar as for butter clams (discussed above). Effort should continue to collect information on littlenecks so that when a fishery does develop information will exist to assist in proper management of the fishery.

OTHER SPECIES

As in other years, information was gathered on *Macoma*, softshell clam and cockle populations during the present survey. None of these species are harvested commercially at present in B.C., but the last two are used to some extent in recreational and First Nations food fisheries. Neither species could support targeted fisheries under present conditions but they could be harvested along with other species in any fishery. As was the case with butter and littleneck clams, information on these species should continue to be collected in future surveys so that information is available to manage these resources should a commercial fishery develop.

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Table 1. Location of beaches sampled during exploratory intertidal clam surveys in British Columbia, 2000 and 2001.

Location	# Beaches	Date
Clayoquot Sound	7	April 5-7, 2000
Fish Egg Inlet	4	June 29, 2000
Dean Channel	2	June 30, 2000
Fisher Channel	6	July 1, 2000
Briggs Inlet	5	July 2, 2000
Princess Royal Channel	7	July 3, 2000
Laredo Inlet	3	July 4, 2000
Cameleon Harbour	1	July 12, 2000
Klaskish Inlet	3	February 18-19, 2001
Klaskino Inlet	4	February 20, 2001

Table 2. Physical description of beaches and number of quadrats dug on beaches visited during exploratory intertidal clam surveys in British Columbia, 2000 and 2001.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Clayoquot Sound		
1	0.04	0	low	Primarily gravel and cobble with small sandy area in center.	Estuary of Cypre River, Cypress Bay. Live butter, littleneck, softshell, cockle and horse clams.
2	2.0	1	low	Primarily sand and gravel with large cobble and silt near creek channels.	Cypress Bay. Live butter, littleneck, Manila, softshell, cockle, horse and varnish clams. Burrowing shrimp abundant.
3	0.8	0	low	Soft, wet sand and gravel substrate.	Dawley Pass, Fortune Channel. Live butter, littleneck Manila and softshells.
4	1.0	0	low	Primarily sand and gravel with covering of silt near creek channel.	Heelboom Bay. Live butter, littleneck, Manila and cockles.
5	2.0	0	low	Gravel and sand with some gravel berms, some rocky areas and silty areas near creek channels.	Head of Mosquito Harbour. Live butter, littleneck, Manila, softshell, cockle and Olympia oyster.
6	>10	0	low	Wet sand, gravel and cobble beach, some silty areas, some standing water over sand.	Bulson Creek Estuary, Warn Bay. Live butter, littleneck, Manila, softshell and varnish clams.
7	1.0	0	low	Gravel and cobble beach with numerous large rocks and some sandy areas.	West side of Warn Bay. Live butter, littleneck, Manila and sofshells.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Fish Egg Inlet	
1	<1.0	0	mod.	Channel banks sand/gravel covered by thin layer of filamentous algae; upper intertidal steeply sloped boulders and bedrock covered by rockweed, bay mussels and barnacles.	Head of Oyster Bay. Water temperature 18°C. Some Manila and softshell clams, Olympia oysters relatively abundant.
2	<1.0	0	low	Soft sand/silt, some cover of algal mat; eelgrass at lower margin of beach, boulders with rockweed, mussels and barnacles above.	East side of Oyster Bay. Water temperature 18°C. Shell of *Macoma nasuta*, butter, littleneck and softshell clams. Live Manila, butter, softshell, littleneck, cockle and Olympia oyster.
3	2.0	0	low	Sand/gravel overlain with thick layer of silt, covered by algal mat, some large rocks at lower tidal margin.	Head (east end) of Fish Egg Inlet. Water temperature 18°C. Live Manila, littleneck and cockles on surface, some softshell and butter clams and Olympia oysters. Shell of *Macoma nasuta*.
4	<1.0	3	mod.	Shell/sand, some large rock and boulders underneath, particularly at top of saddle.	Saddle beach between two small islands on the northwestern shore of Fish Egg Inlet. High densities of butter, littleneck and *Macoma inquinata*. Abundant dead shell at top of saddle (butter, Manila, littleneck, softshell, *Macoma* sp.).

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Dean Channel	
1	<1.0	0	mod.	Sand over cobble, thick algal mat, continuous freshwater runoff.	Northwest of Dean River estuary. Few bivalves, only *Macoma balthica*.
2	>10	0	low	Sand, often with thick layer of silt. Several stream channels, areas around which were scoured cobble and gravel. Many areas of anoxic substrate with high levels of decomposing wood debris and other organic matter (hydrogen sulfide odor when disturbed). Grassy meadow on upper margin of beach, steep dropoff on seaward edge.	Kimsquit River estuary. Water temperature in mid-channel 12°C. Few bivalves, only *Macoma balthica*.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Fisher Channel	
1	2.0	2	low	Upper beach rock, cobble covered in rockweed, mussels and barnacles. Lower beach sand and silt.	Head (southeast side) of Evans Inlet. Live butter, littleneck, softshell and cockles, shell of Manila clams. Water temperature 13.5°C.
2	1.0	3	low	Sand and silt on lower beach, upper margin rock and cobble with rockweed, mussels and barnacles. Small stream channel.	Head (northeast side) of Evans Inlet. Live butter, littleneck, Manila, softshell, cockle and *Macoma inquinata.*
3	1.5	3	low	Sand and silt on lower beach, upper beach gravel, cobble and rock.	North side of Evans Inlet, west of Boot Island. Live Live butter, littleneck, Manila, softshell, cockle and *Macoma inquinata.*

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
			Fisher Channel (cont'd.)		
4	2.0	5	low	Sand, gravel and shell on lower beach, upper margin cobble and rock.	Head of southern arm of Codville Lagoon. Live butter, littleneck, cockle and *Macoma inquinata.* Some Manila shell found, but no live Manilas. Some softshells high on beach.
5	1.0	1	low	Upper margin rock and cobble with rockweed, barnacle and mussel cover. Lower beach gravel and sand.	Head of northeastern arm of Codville Lagoon, behind Codville Island. Live butter, littleneck, Manila, softshell, cockle and *Macoma inquinata.* Large Manilas near creek.
6	<1.0	2	low	Upper intertidal rocks and cobble, rockweed, barnacles and mussels.	Head of northwestern arm of Codville Lagoon. Water temperature 14°C. Live butter, littleneck, Manila and *Macoma inquinata.* Very small patch of gravelly habitat adjacent to creek, found live Manilas there.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Briggs Inlet	
1	1.0	2	low	Upper intertidal rock and cobble with rockweed, barnacles and mussels, some small sandy areas. Lower beach sand and gravel covered with thick mat of filamentous algae.	Western shore, upper Briggs Inlet. Live butter, littleneck, softshell, cockle, *Macoma inquinata*, and one *Tresus nuttallii*. Some *Tresus* shell.
2	<1.0	1	low	Upper beach rock and cobble with rockweed, barnacles and mussels. Small creek in upper intertidal above fish weir. Lower beach sand and gravel.	Eastern shore near narrows at head of Briggs Inlet. Live butter, littleneck and Manila clams.
3	2.0	0	low	Lower beach firm sand with patchy cover of filamentous green algae. Numerous horse clam shows and cockles sparsely scattered on and just under surface. Upper beach above creek channel rock and cobble with cover of rockweed, barnacles and mussels.	Western shore opposite narrows at head of Briggs Inlet. Live cockle, horse and Manila clams. Sand lance, *Ammodytes hexapterus*, in substrate of creek channel.
4	1.0	0	mod.	Primarily rock and cobble with sand packed between.	Emily Bay. Live butter, littleneck and cockle on lower beach.
5	<1.0	0	high	Steep cobble beach, rockweed, barnacle and mussel cover. Very little clam habitat.	South of Emily Bay. Water temperature 13°C. Low densities of live butter and littleneck clams

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Princess Royal Channel	
1	2.5	1	low	Most of beach hard packed cobble and sand. Small areas of sandy substrate on lower margin of intertidal.	Swanson Bay. Live butter, littleneck cockle, horse and *Macoma inquinata*. Shell of butter clam and *M. inquinata* most abundant, some littleneck, cockle and horse clam shells.
2	2.5	0	mod.	Lower margin sand, most of beach rock and cobble with packed sand.	Lower Khutze Inlet, inside Green Reef. Water temperature 11°C. Few live clams found, some shell of littleneck, butter, cockle, horse, softshell and *M. balthica*.
3	>10	0	low	Lower margin silt and mud, some sandy areas with eelgrass. Steep dropoff at lower margin. Substrate too soft to explore, did not go ashore.	Khutze River estuary. Water temperature 8°C.
4	<1.0	0	high	Mostly rock and cobble with rockweed, mussel and barnacle cover. Some sand and silt at lower margin.	Upper Khutze Inlet. Several horse clam shows visible. Some *M. inquinata*, horse clam and cockle shells, very few littleneck and butter shells.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Princess Royal Channel (cont'd.)	
5	<1.0	1	high	Sand substrate. Lower margin of beach forested with plumose tube worms sticking up ~30 cm from the sand.	Outside Marmot Cove. Very few clams on beach, shells of butter, horse, littleneck and *M. inquinata*. Live littleneck and cockle. Eastern margin had boulders and large loose rock cover.
6	5.0	2	mod./ low	Saddle beach was small rock and gravel substrate, with thick growth of *Laminaria* and *Gigartina* on the lower margin. Approximately 3.0 ha of beach on saddle between mainland and large island, 2.0 ha of beach in cove. Lower beach and estuary gravel and sand.	Marmot Cove. Live butter, littleneck, cockle and *Macoma inquinata.* Shells of softshell and horse clams.
7	2.5	0	low	Upper beach cobble and rock with rockweed, mussel and barnacle cover, lower beach sand and silt, some sparse algal cover. Large stream channel down center of beach.	Scow Bay, Klekane Inlet. Live cockles, sparse cockle and horse clam shell.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Laredo Inlet	
1	3.0	12	low	Sand and gravel with numerous creek channels. Outer edges rock, cobble or grassy meadow.	Upper Arnoup creek estuary. Live littleneck, Manila and softshells.
2	6.0	5	low	Sand and silt, small gravel bank at outlet of upper estuary. Eelgrass on lower margin.	Lower Arnoup Creek estuary. Water temperature 14°C. Live littleneck, Manila, softshell, cockle and *Macoma nasuta*.
3	<1.0	0	low	Lower beach packed sand with silt cover, upper beach cobble in sand with rockweed cover.	Brew Creek estuary. Few live clams or shell, only stunted littlenecks.
				Cameleon Harbour	
1	<1.0	5	low	Lower beach sand and gravel, upper beach had several berms of soft sand. Upper margin of beach rock and cobble with rockweed cover.	Head of Cameleon Harbour. Live Manilas on middle of beach, live varnishes in sand berms on upper beach.

Table 2. continued.

Beach No.	Area (ha)	No. of Quadrats	Slope	Substrate	Remarks
				Klaskish Inlet	
1	>10	5	low	Upper beach large rock and coarse gravel, lower beach largely clay, silt and mud. Some areas (approx. 1-2 ha) of sand and gravel substrate able to support clam populations. Some eelgrass beds low on beach.	Klaskish Anchorage. Live butter, littleneck, Manila and softshells.
2	>10	5	mod./ low	Northern end coarse gravel with areas of mixed gravel/sand that supported clam populations (approx. 1ha), southern end gravel and mud. Center between stream channels boulders and gravel, not suitable clam habitat.	Shields Cove. Live littleneck, Manila, softshell, cockle and *Macoma* sp.
3	10	0	low	Boulders and large gravel near river, rest of beach gravel and mud.	Klaskish Basin. Shell of butter, littleneck and Manila clams on rocks above high tide line.

Table 2. continued.

			Klaskino Inlet		
1	2.5	4	mod.	Fine gravel and mud.	Head of Klaskino Inlet (northeast). Live littleneck, Manila, softshell, cockle, *Macoma* sp. and Olympia oysters.
2	2.0	0	mod.	Fine gravel and mud with coarse gravel near stream channel.	South side of Klaskino Inlet near head (southwest). Live littleneck, Manila, softshells and Olympia oysters.
3	<1.0	0	mod./ high	Upper beach coarse gravel, lower beach fine gravel and mud.	South side of Klaskino Inlet, opposite beach 1 (southeast). Live littleneck, Manila and softshells and Olympia oysters.
4	<1.0	0	high	Fine gravel.	North side of Klaskino Inlet, adjacent to beach 1 (northwest). Live littleneck, Manila, softshell, cockle, *Macoma* sp. and Olympia oysters.

Table 3. Clam densities (clams m^{-2}) by species from exploratory intertidal clam surveys in British Columbia, 2000 and 2001.

		Butter		Littleneck		Manila					
Beach	Quadrat	Legal	Sublegal	Legal	Sublegal	Legal	Sublegal	Macoma	Softshell	Cockle	Varnish
					Fish Egg Inlet						
4	1	0.0	192.0	100.0	156.0	96.0	16.0	36.0	84.0	8.0	0.0
	2	72.0	64.0	44.0	20.0	16.0	0.0	12.0	8.0	0.0	0.0
	3	20.0	96.0	80.0	120.0	4.0	4.0	44.0	4.0	0.0	0.0
					Fisher Channel						
1	1	4.0	0.0	8.0	4.0	0.0	0.0	0.0	0.0	8.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.0	0.0	0.0
2	1	0.0	0.0	24.0	36.0	60.0	48.0	0.0	4.0	32.0	0.0
	2	0.0	8.0	0.0	40.0	8.0	0.0	12.0	0.0	0.0	0.0
	3	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0
3	1	32.0	44.0	4.0	76.0	0.0	0.0	20.0	0.0	8.0	0.0
	2	0.0	4.0	12.0	292.0	0.0	0.0	0.0	156.0	0.0	0.0
	3	0.0	4.0	84.0	408.0	4.0	0.0	0.0	40.0	0.0	0.0
4	1	4.0	240.0	8.0	64.0	0.0	0.0	48.0	0.0	12.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0
	3	28.0	176.0	8.0	36.0	0.0	0.0	4.0	0.0	16.0	0.0
	4	4.0	68.0	8.0	172.0	0.0	0.0	4.0	0.0	0.0	0.0
	5	0.0	0.0	0.0	104.0	0.0	0.0	0.0	16.0	4.0	0.0
5	1	0.0	0.0	0.0	0.0	1.3	0.1	0.5	0.7	0.0	0.0
6	1	0.0	28.0	4.0	400.0	12.0	0.0	0.0	0.0	4.0	0.0
	2	0.0	8.0	16.0	352.0	20.0	0.0	12.0	0.0	0.0	0.0
					Briggs Inlet						
1	1	16.0	12.0	52.0	36.0	0.0	0.0	16.0	0.0	4.0	0.0
	2	0.0	0.0	124.0	12.0	0.0	0.0	0.0	12.0	0.0	0.0
2	1	48.0	64.0	160.0	44.0	0.0	0.0	0.0	0.0	0.0	0.0
					Princess Royal Channel						
1	1	4.0	4.0	8.0	12.0	0.0	0.0	8.0	0.0	0.0	0.0
5	1	0.0	0.0	44.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0
6	1	8.0	28.0	128.0	168.0	0.0	0.0	44.0	0.0	8.0	0.0
	2	36.0	4.0	60.0	76.0	0.0	0.0	12.0	0.0	0.0	0.0

Table 3. continued.

Beach	Quadrat	Butter Legal	Butter Sublegal	Littleneck Legal	Littleneck Sublegal	Manila Legal	Manila Sublegal	Macoma	Softshell	Cockle	Varnish
					Laredo Inlet						
1	1	0.0	0.0	0.0	12.0	16.0	16.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.8	2.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	4.0	28.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	0.0	0.0	4.0	32.0	0.0	0.0	0.0	0.0
	6	0.0	0.0	0.0	0.0	1.7	7.7	0.0	0.0	0.0	0.0
	7	0.0	0.0	4.0	8.0	8.0	24.0	0.0	0.0	0.0	0.0
	8	0.0	0.0	1.3	0.0	1.3	16.0	0.0	0.0	0.0	0.0
	9	0.0	0.0	0.0	12.0	0.0	0.0	0.0	16.0	0.0	0.0
	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0	0.0	0.0
	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0
	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.0	0.0	0.0
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0
	2	0.0	0.0	0.0	4.0	0.0	8.0	0.0	4.0	0.0	0.0
	3	0.0	0.0	0.0	0.0	0.8	1.0	0.0	0.0	0.0	0.0
	4	0.0	0.0	0.0	0.0	8.0	12.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	4.0	8.0	0.0	0.0	4.0	0.0	0.0	0.0
					Cameleon Harbour						
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2
	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0
	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	84.8
	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.5
					Klaskish Inlet						
1	1	0.0	0.0	28.0	28.0	0.0	0.0	0.0	4.0	0.0	0.0
	2	0.0	0.0	24.0	16.0	8.0	8.0	0.0	16.0	0.0	0.0
	3	0.0	4.0	12.0	28.0	16.0	28.0	0.0	16.0	0.0	0.0
	4	0.0	0.0	36.0	88.0	24.0	24.0	0.0	0.0	0.0	0.0
	5	0.0	0.0	28.0	96.0	36.0	28.0	0.0	0.0	0.0	0.0
2	1	0.0	0.0	0.0	4.0	12.0	20.0	0.0	0.0	0.0	0.0
	2	0.0	0.0	4.0	84.0	8.0	32.0	0.0	0.0	0.0	0.0
	3	0.0	0.0	0.0	76.0	20.0	60.0	0.0	8.0	0.0	0.0
	4	0.0	0.0	12.0	24.0	16.0	20.0	4.0	4.0	4.0	0.0
	5	0.0	0.0	32.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
					Klaskino Inlet						
1	1	0.0	0.0	4.0	20.0	96.0	76.0	4.0	16.0	4.0	0.0
	2	0.0	0.0	0.0	8.0	100.0	176.0	0.0	24.0	0.0	0.0
	3	0.0	0.0	24.0	196.0	56.0	36.0	0.0	4.0	0.0	0.0
	4	0.0	0.0	0.0	76.0	160.0	52.0	4.0	20.0	4.0	0.0

Table 4. Stages of gonadal development in Manila clams sampled during intertidal clam surveys in British Columbia, June-July 2000.

Date	Stage of Development				
	Early Active	Late Active	Ripe	Partially Spent	Spent
			Fish Egg Inlet		
June 29	0 M 0 F	0 M 0 F	0 M 4 F	5 M 1 F	2 M 0 F
			Fisher Channel		
July 1	0 M 0 F	0 M 0 F	2 M 3 F	1 M 4 F	1 M 0 F
			Briggs Inlet		
July 2	0 M 0 F	0 M 0 F	3 M 6 F	1 M 1 F	0 M 0 F
			Laredo Inlet		
July 4	0 M 0 F	0 M 0 F	8 M 2 F	2 M 0 F	0 M 0 F
			Cameleon Harbour		
July 12	0 M 0 F	0 M 0 F	5 M 0 F	1 M 1 F	0 M 4 F

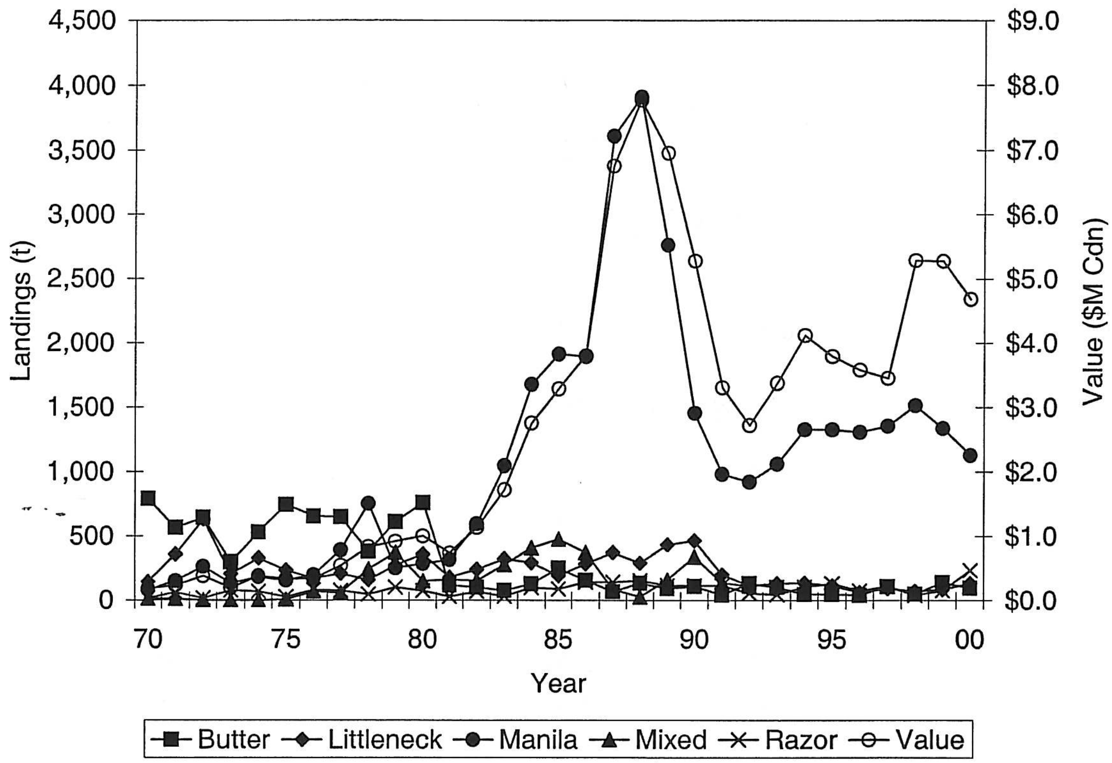


Figure 1. Landings (t) and value ($Can) of intertidal clams from British Columbia commercial fisheries, 1970-2000.

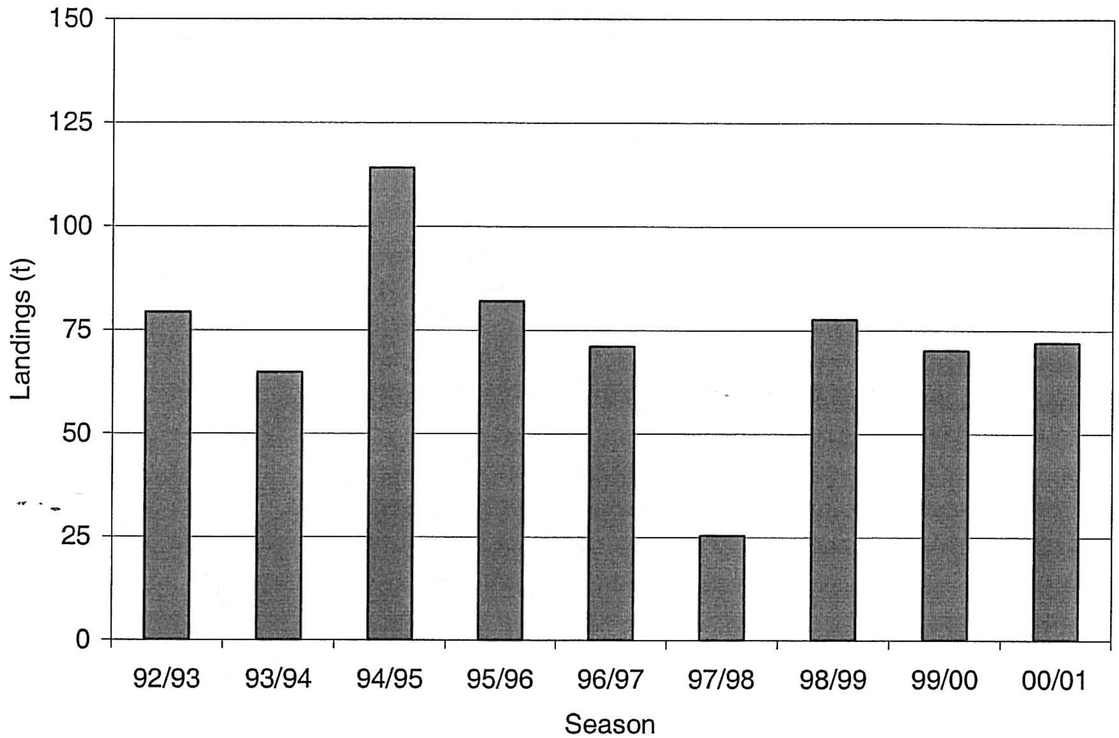


Figure 2. Landings of Manila clams (t) from the Heiltsuk First Nation's clam fishery in Pacific Fisheries Management Area 7, 1992/1993 to 2000/2001 seasons.

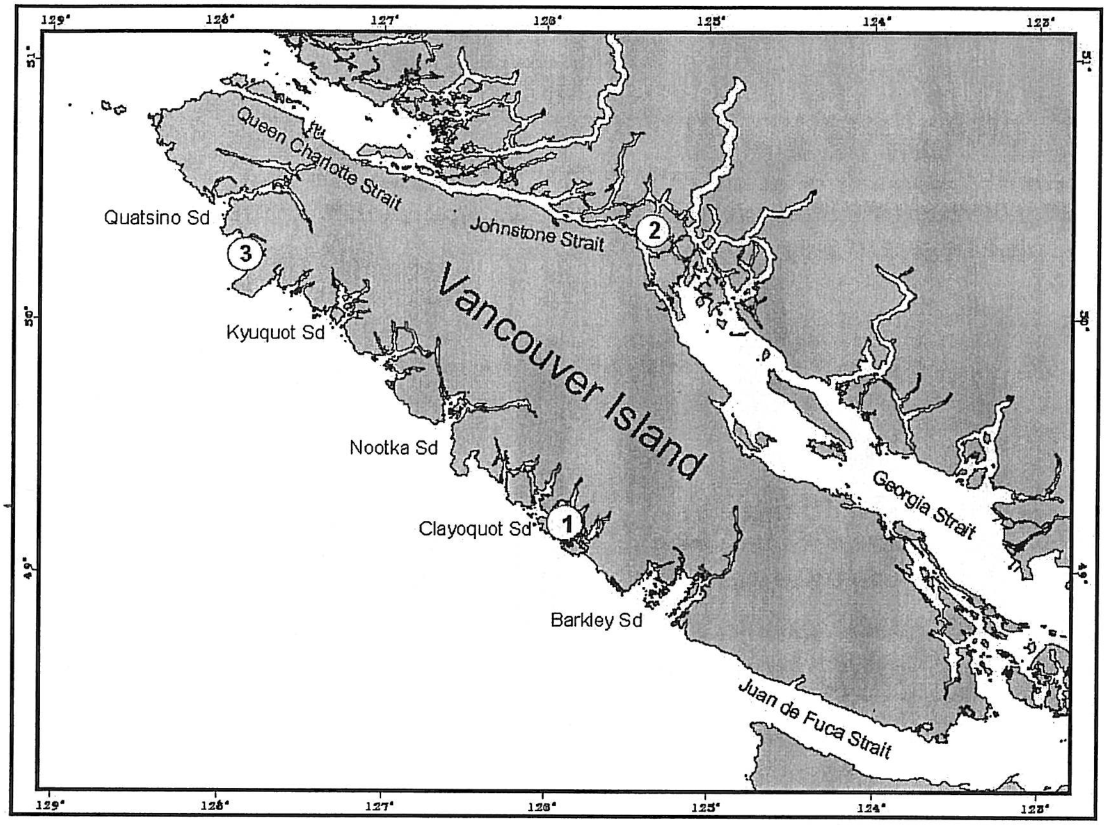


Figure 3. General locations of exploratory clam surveys in southern British Columbia in 2000 and 2001.

Legend: 1 – Clayoquot Sound; 2 – Cameleon Harbour; 3 – Klaskino and Klaskish Inlets.

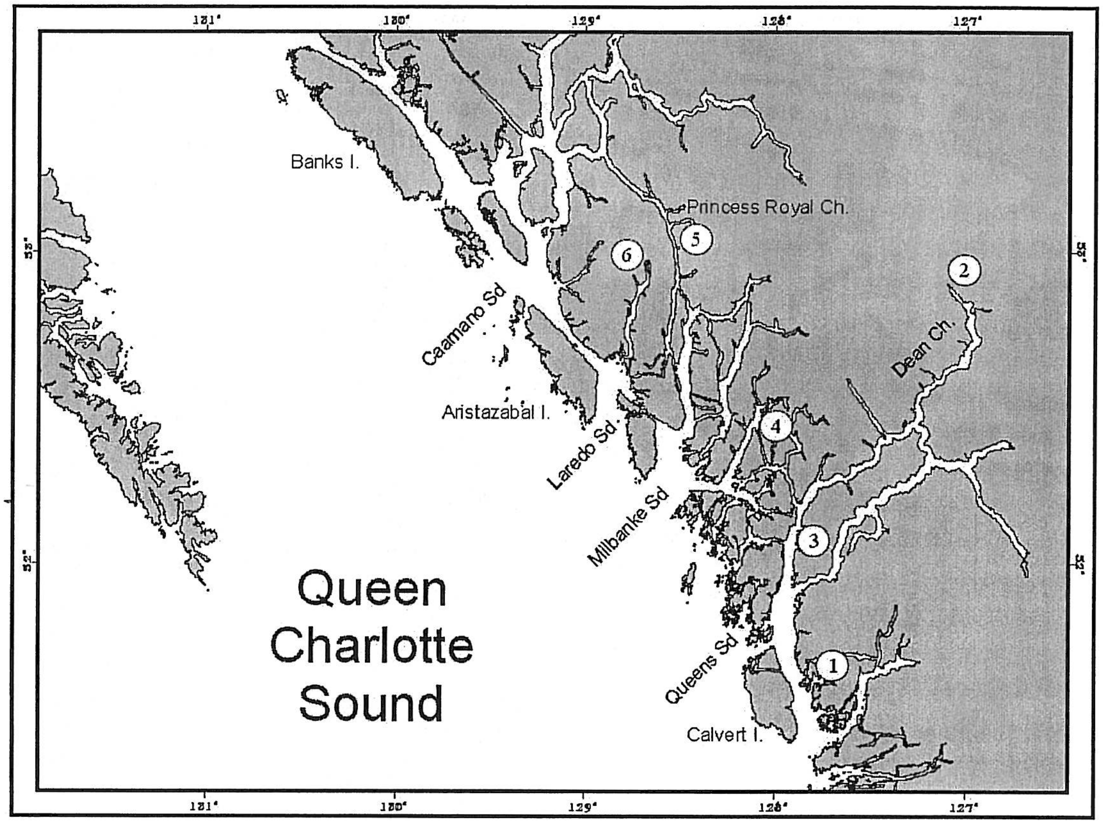


Figure 4. General locations of exploratory clam surveys in northern British Columbia in 2000.

Legend: 1 – Fish Egg Inlet; 2 – Dean Channel; 3 – Fisher Channel; 4 – Briggs Inlet; 5 – Princess Royal Channel; 6 – Laredo Inlet.

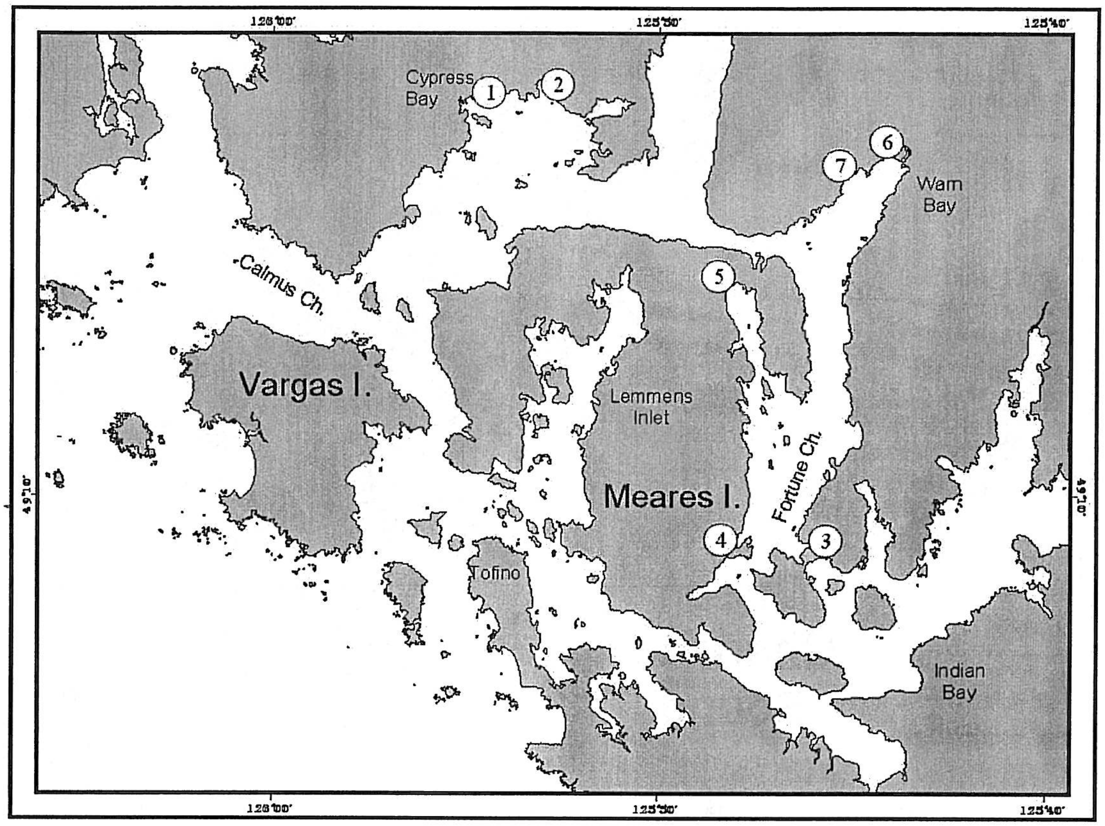


Figure 5. Locations of beaches surveyed in Clayoquot Sound, April 5-7, 2000.

Legend: 1 – Cypre River estuary; 2 – Cypress Bay; 3 – Dawley Pass; 4 – Heelboom Bay; 5 – Mosquito Harbour; 6 – Bulson Creek estuary; 7 – West Side of Warn Bay.

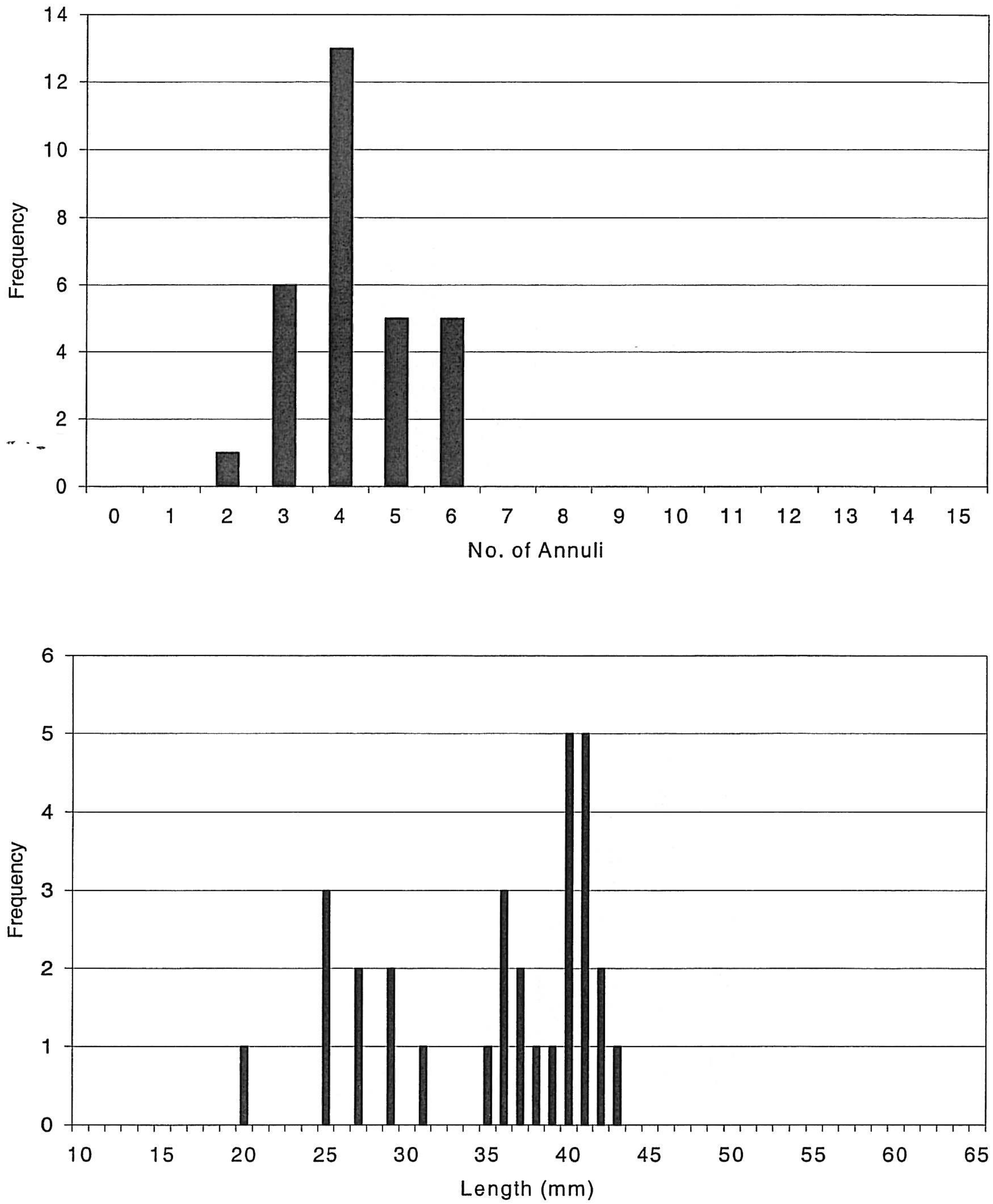


Figure 6. Length (top) and age (bottom) frequency distributions of Manila clams collected in Heelboom Bay, Clayoquot Sound, April 6, 2000.

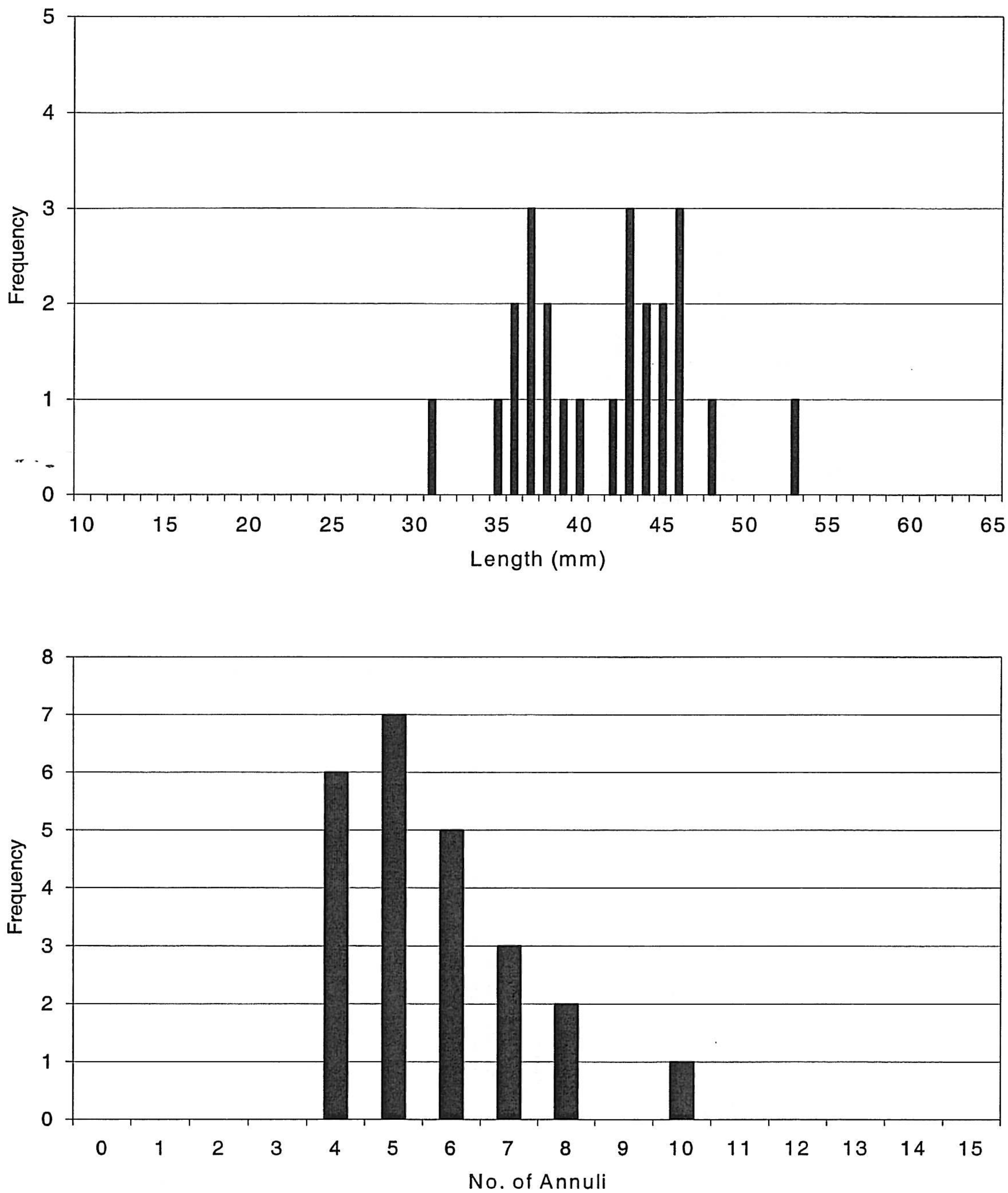
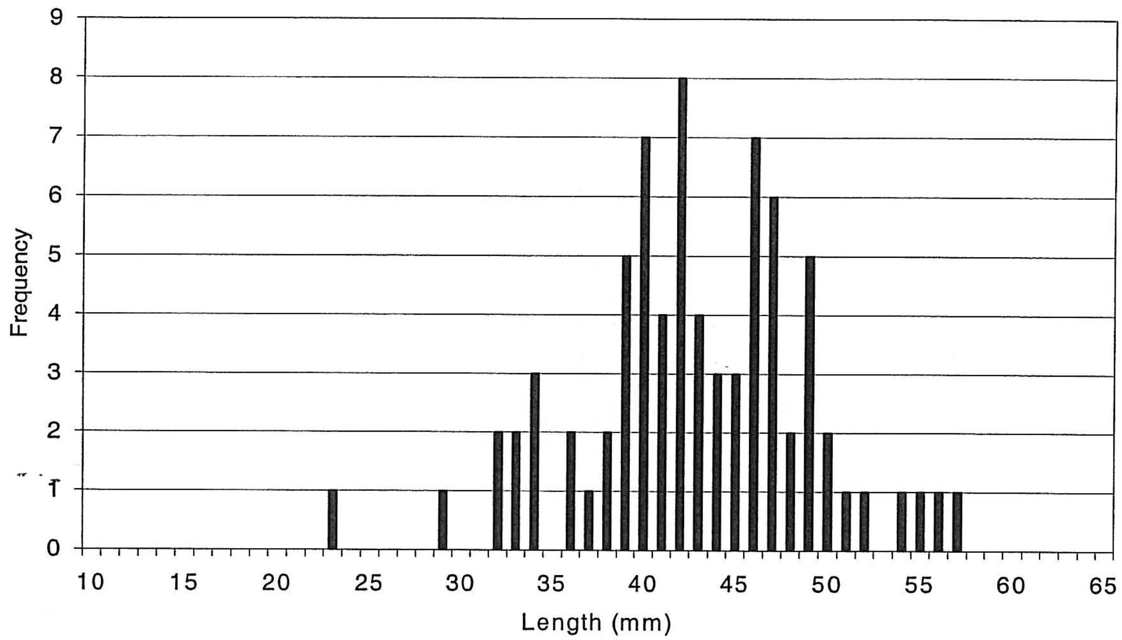


Figure 7. Length (top) and age (bottom) frequency distributions of Manila clams collected in Dawley Passage, Clayoquot Sound, April 6, 2000.



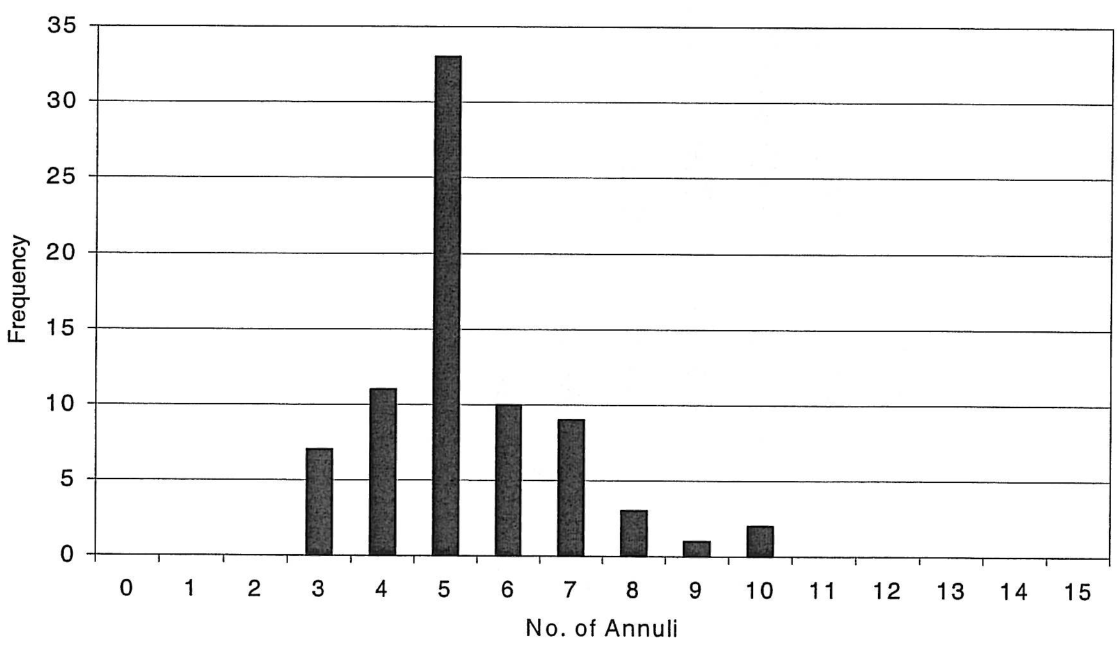


Figure 8. Length (top) and age (bottom) frequency distributions of Manila clams collected in Mosquito Harbour, Clayoquot Sound, April 6, 2000.

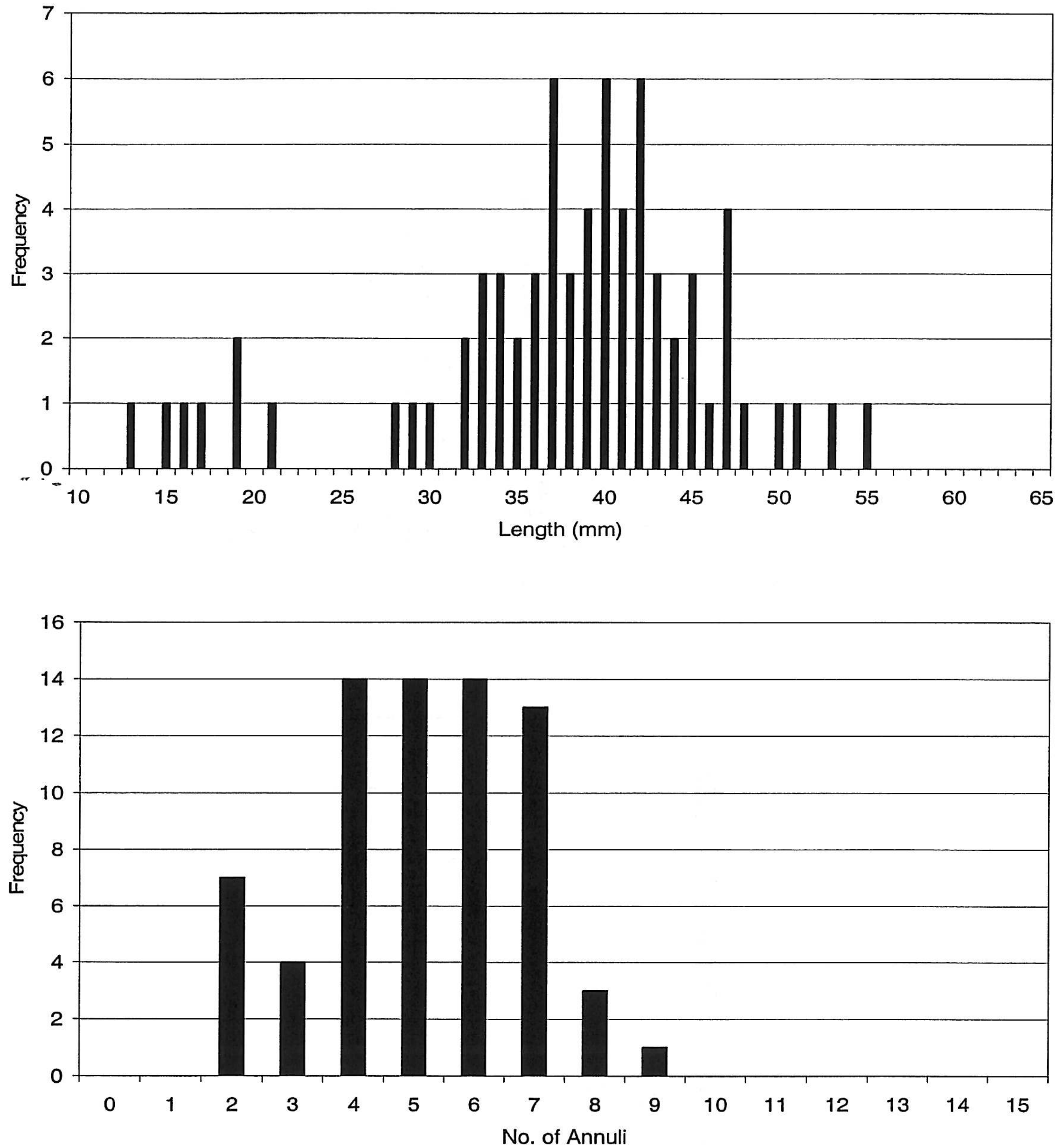


Figure 9. Length (top) and age (bottom) frequency distributions of Manila clams collected in Warn Bay, Clayoquot Sound, April 7, 2000.

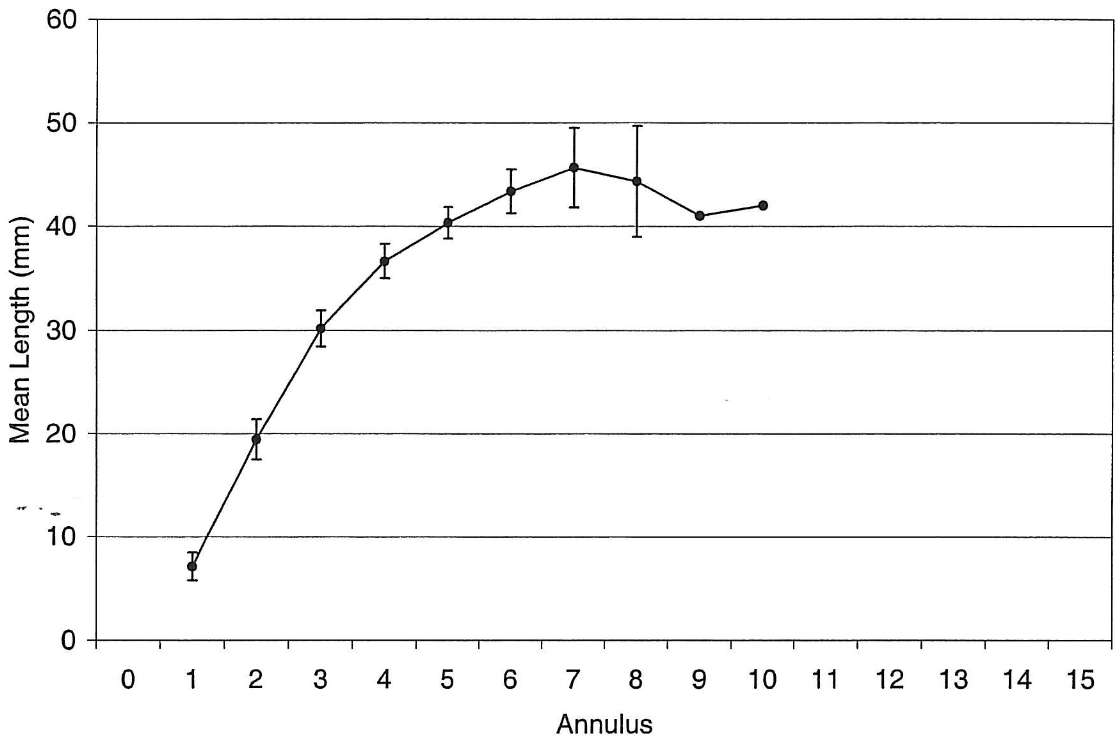


Figure 10. Mean length-at-annulus (mm) of Manila clams collected in Dawley Passage, Clayoquot Sound, April 6, 2000.

Error bars are 95% confidence intervals.

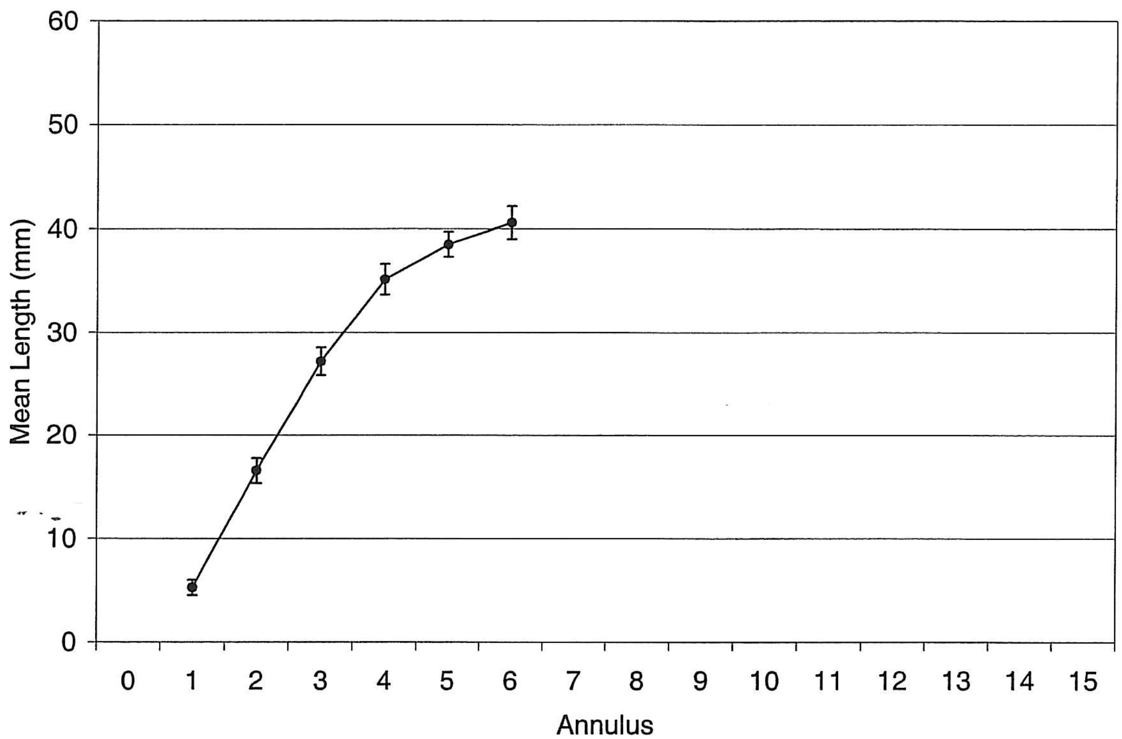


Figure 11. Mean length-at-annulus (mm) of Manila clams collected in Heelboom Bay, Clayoquot Sound, April 6, 2000.

Error bars are 95% confidence intervals.

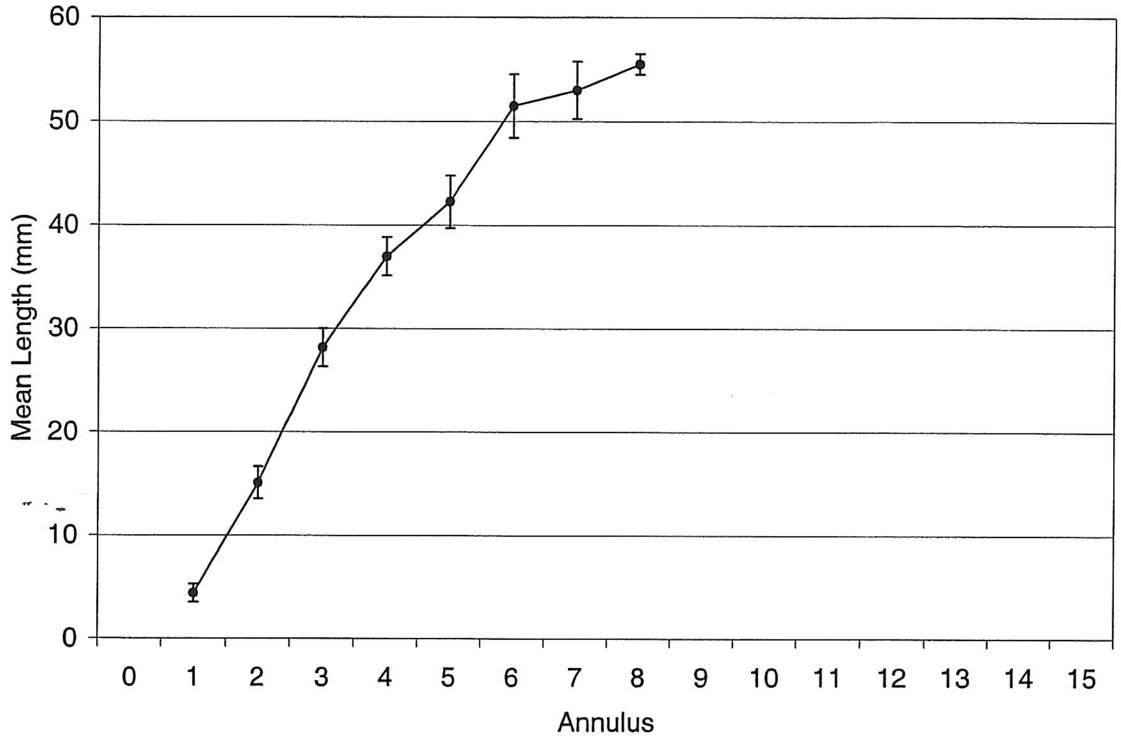


Figure 12. Mean length-at-annulus (mm) of Manila clams collected in Mosquito Harbour, Clayoquot Sound, April 6, 2000.

Error bars are 95% confidence intervals.

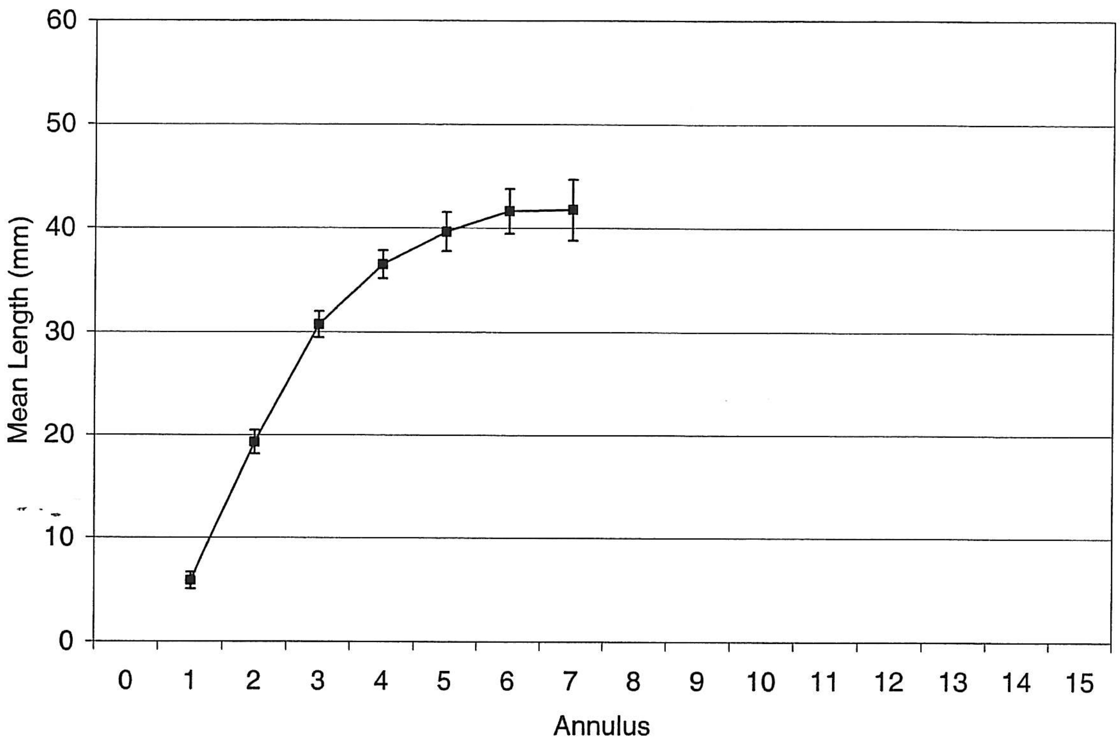


Figure 13. Mean length-at-annulus (mm) for Manila clams collected in Warn Bay, Clayoquot Sound, April 7, 2000.

Error bars are 95% confidence intervals.

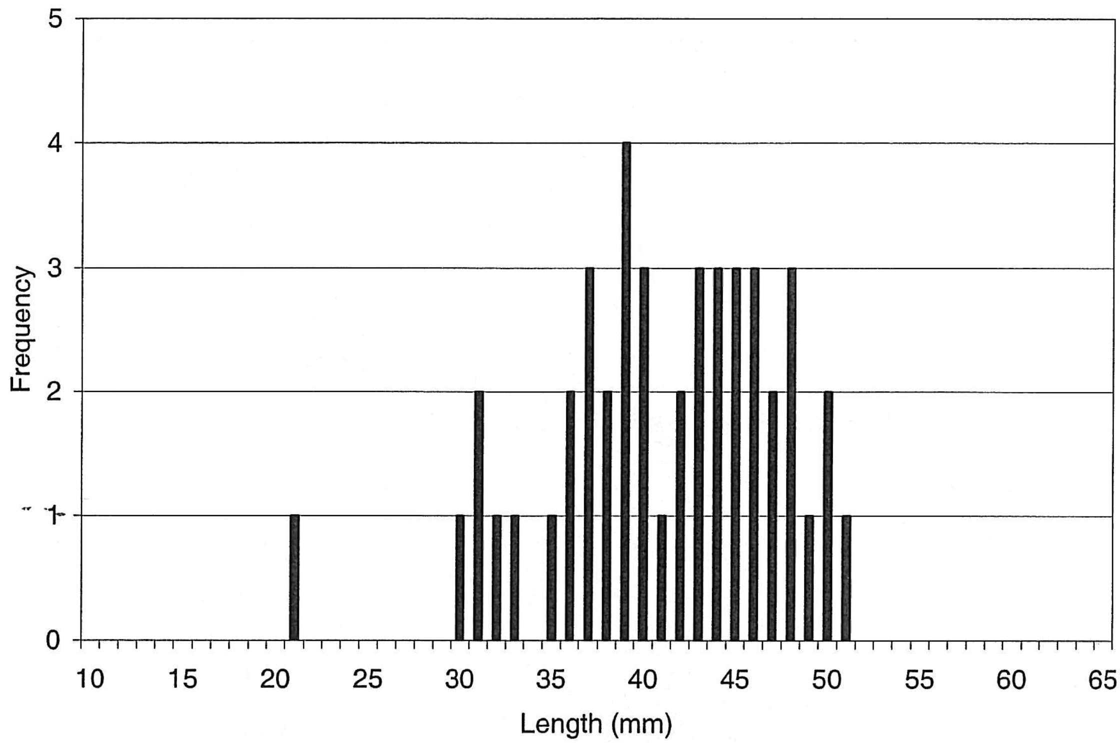


Figure 14. Length frequency distribution of varnish clams collected in Cypress Bay, Clayoquot Sound, April 7, 2000.

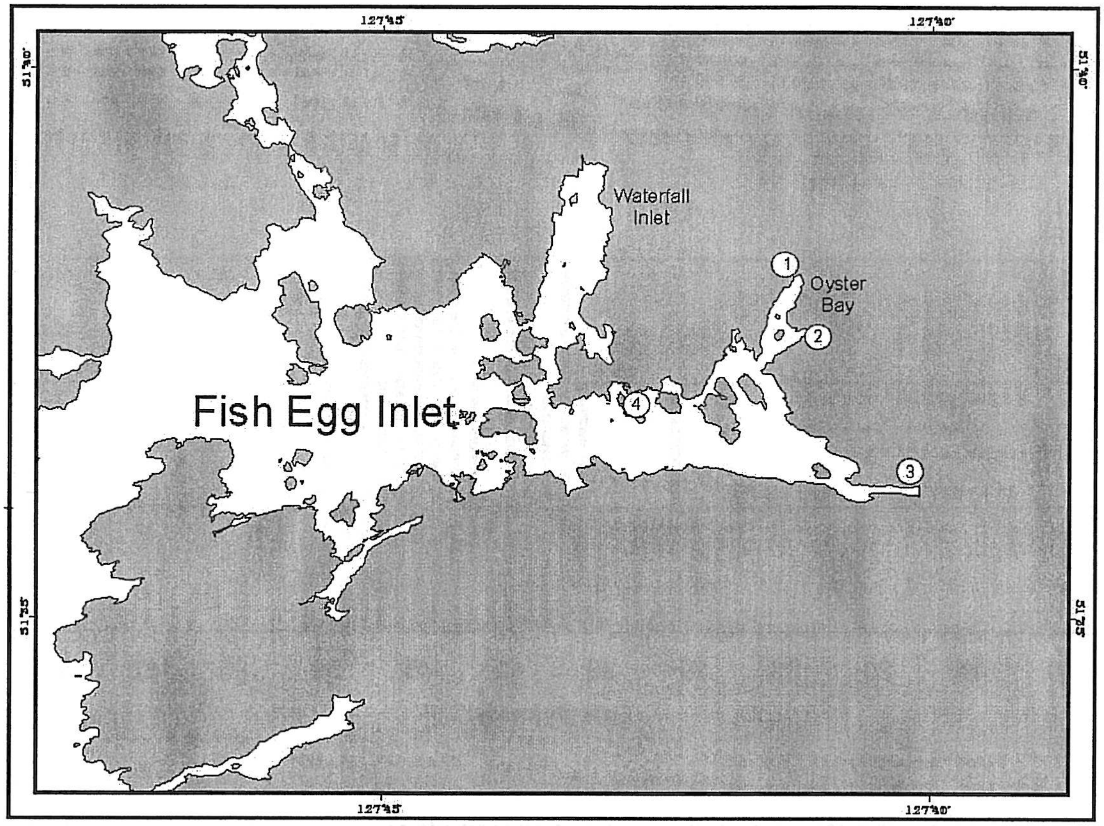


Figure 15. Location of beaches surveyed in Fish Egg Inlet, June 29, 2000.

Legend: 1 – Head of Oyster Bay; 2 – East Side of Oyster Bay; 3 – Head of Fish Egg Inlet; 4 – Inner Fish Egg Inlet.

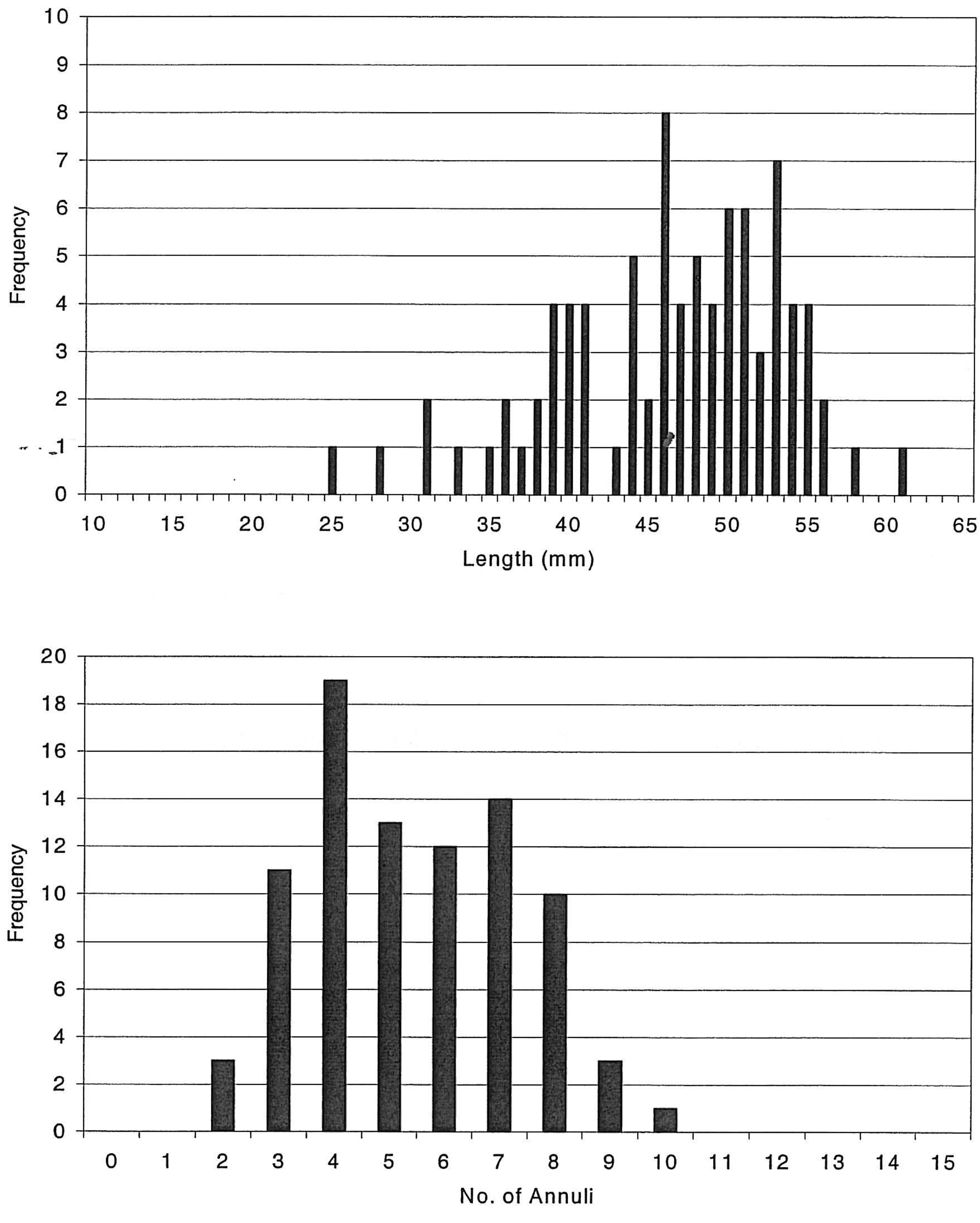


Figure 16. Length (top) and age (bottom) frequency distributions of Manila clams collected in Fish Egg Inlet, June 29, 2000.

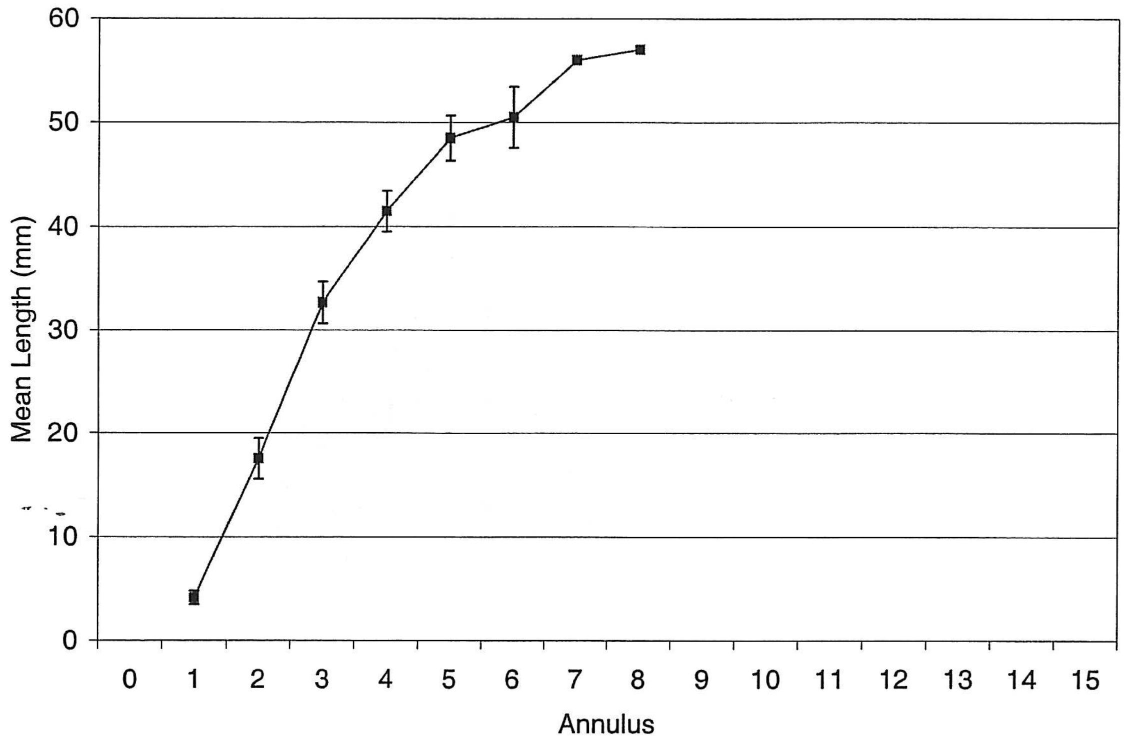
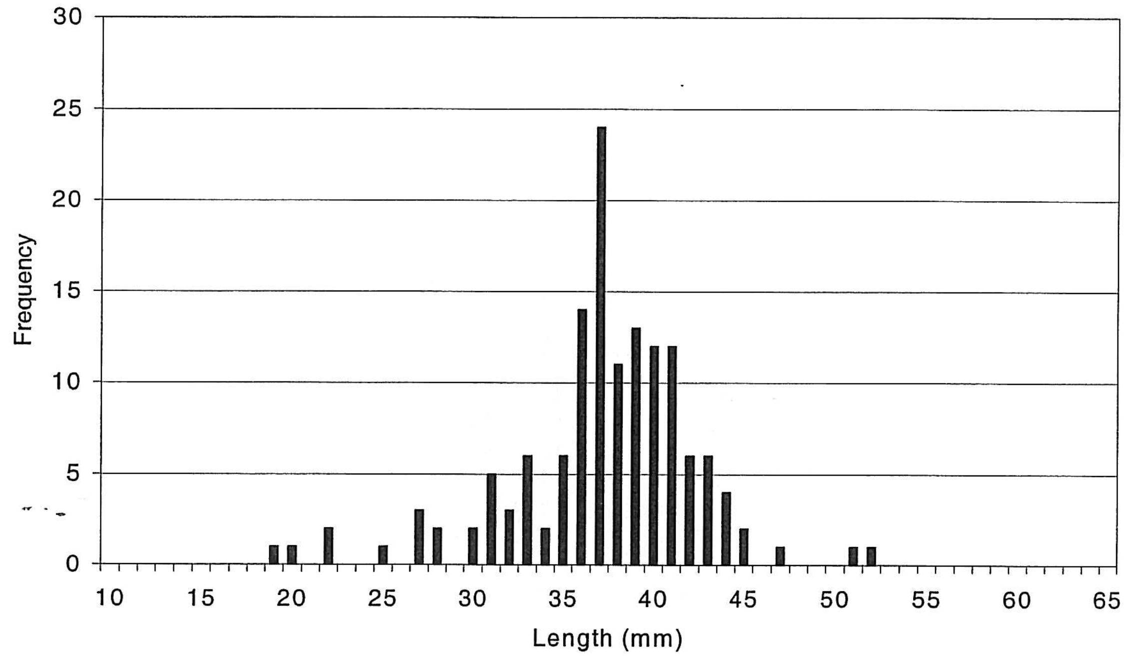


Figure 17. Mean length-at-annulus (mm) for Manila clams collected in Fish Egg Inlet, June 29, 2000.

Error bars are 95% confidence intervals.



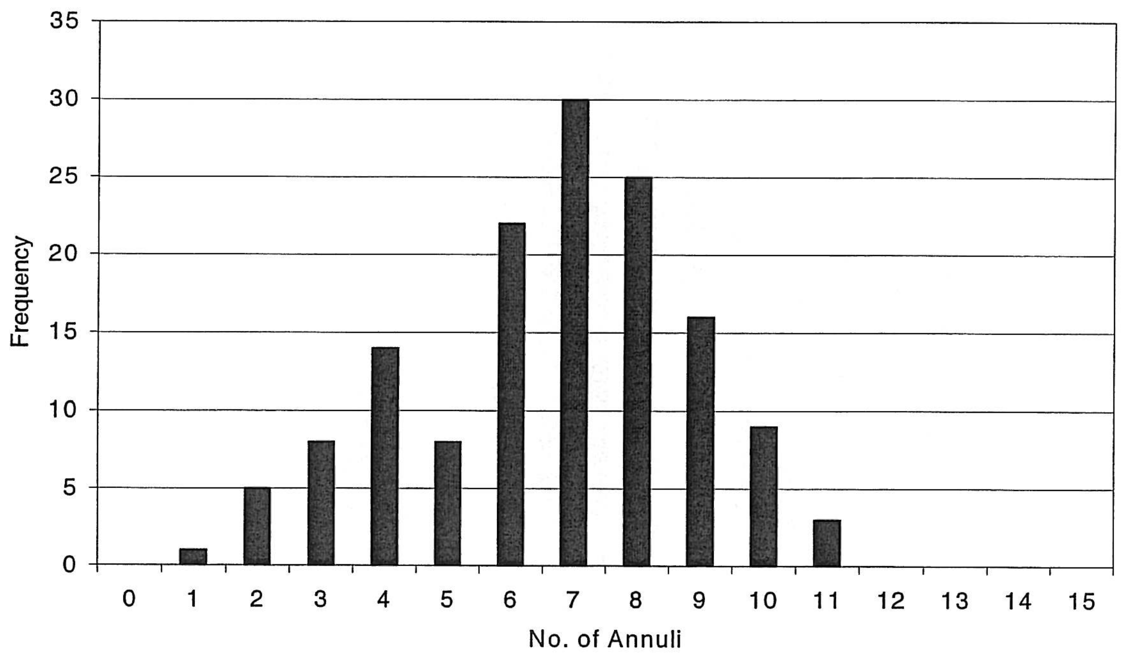


Figure 18. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Fish Egg Inlet, June 29, 2000.

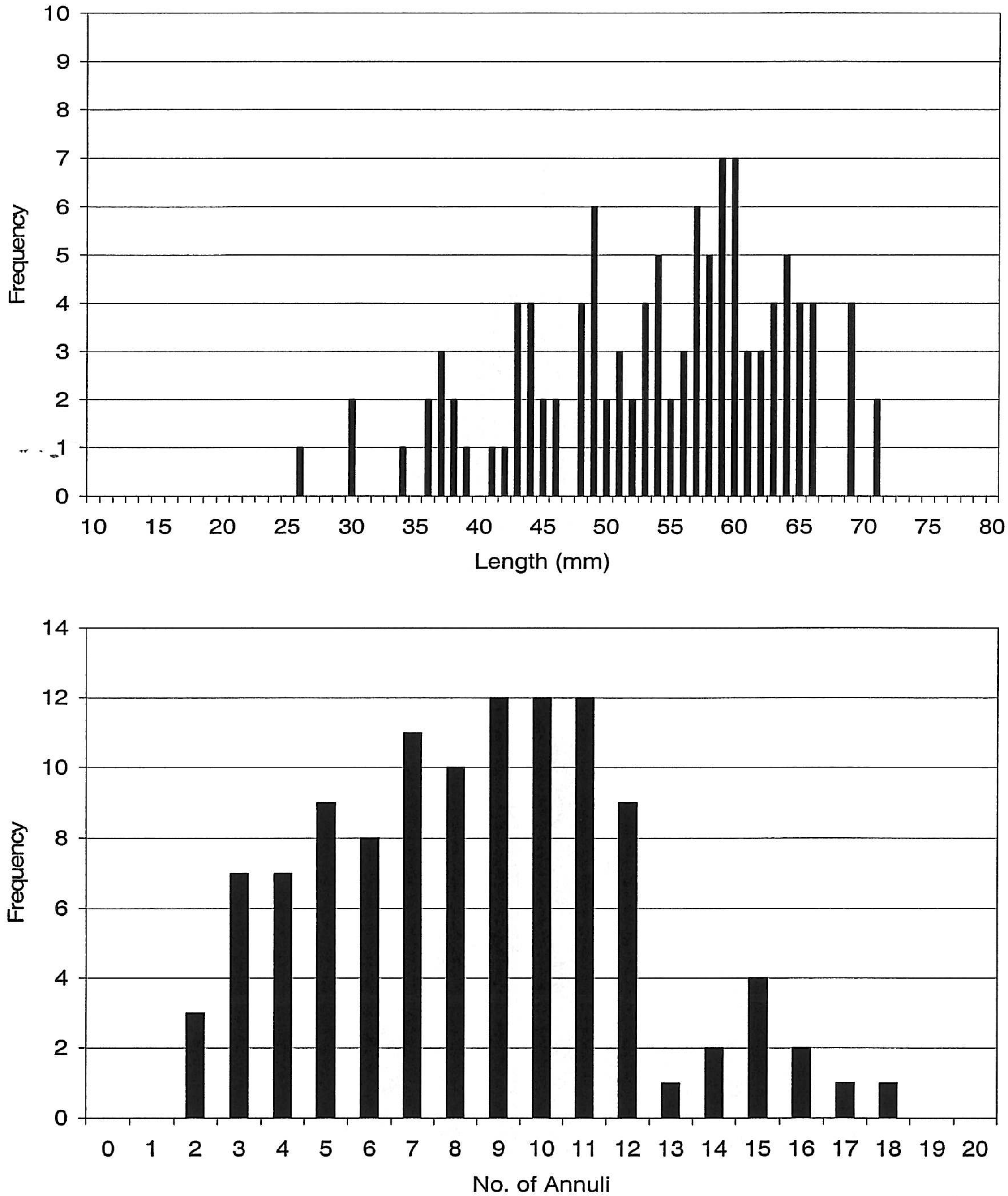


Figure 19. Length (top) and age (bottom) frequency distributions of butter clams collected in Fish Egg Inlet, June 29, 2000.

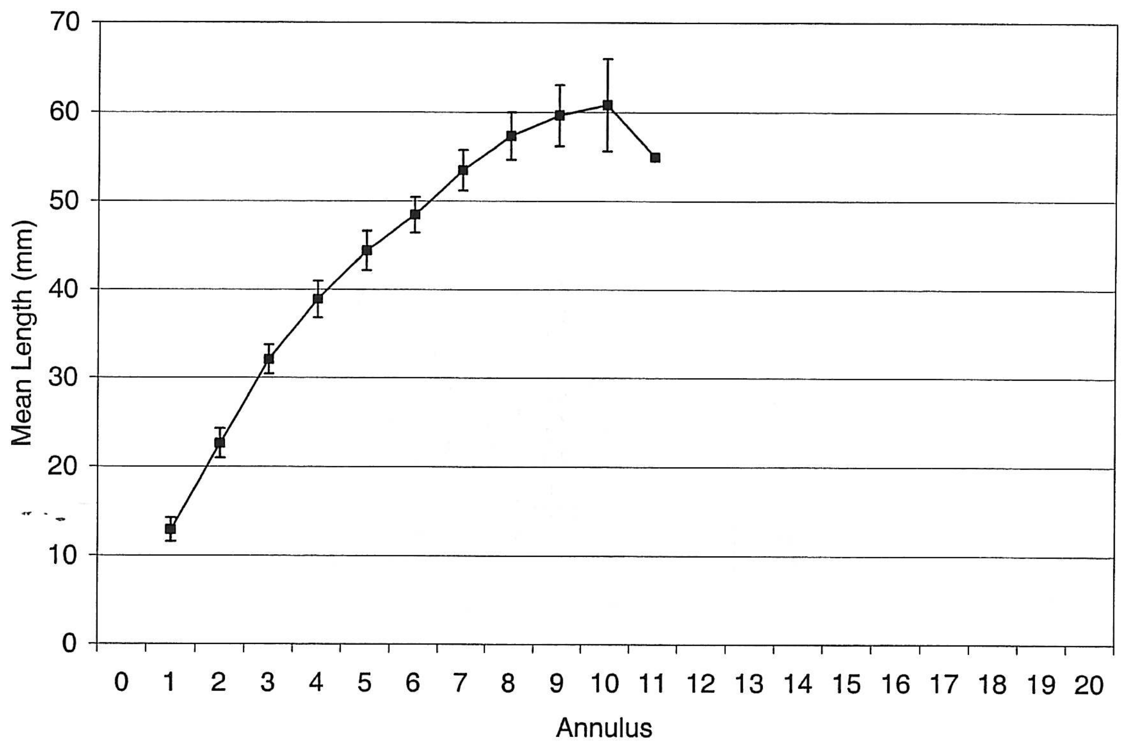
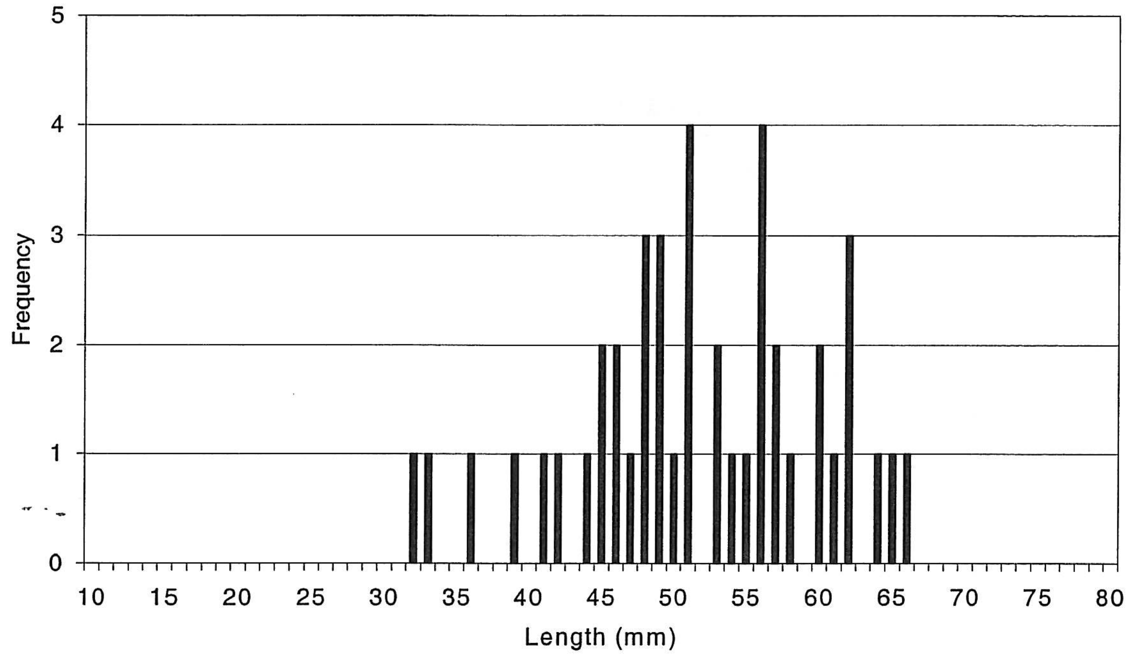


Figure 20. Mean length-at-annulus (mm) for butter clams collected in Fish Egg Inlet, June 29, 2000.

Error bars are 95% confidence intervals.



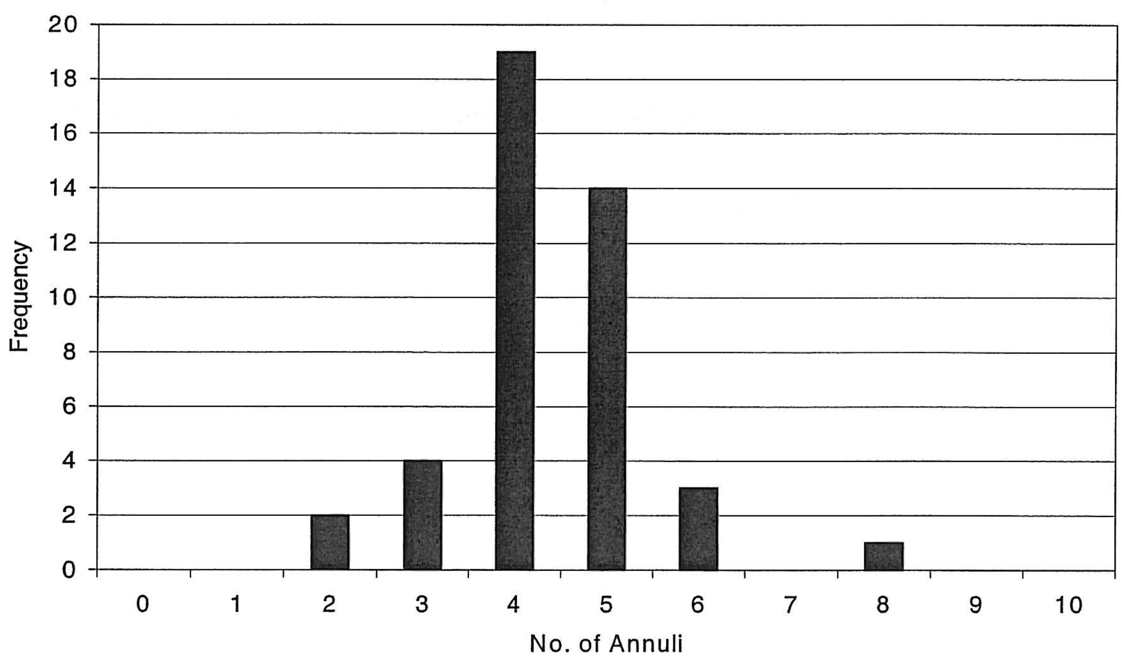


Figure 21. Height (top) and age (bottom) frequency distributions of cockles collected in Fish Egg Inlet, June 29, 2000.

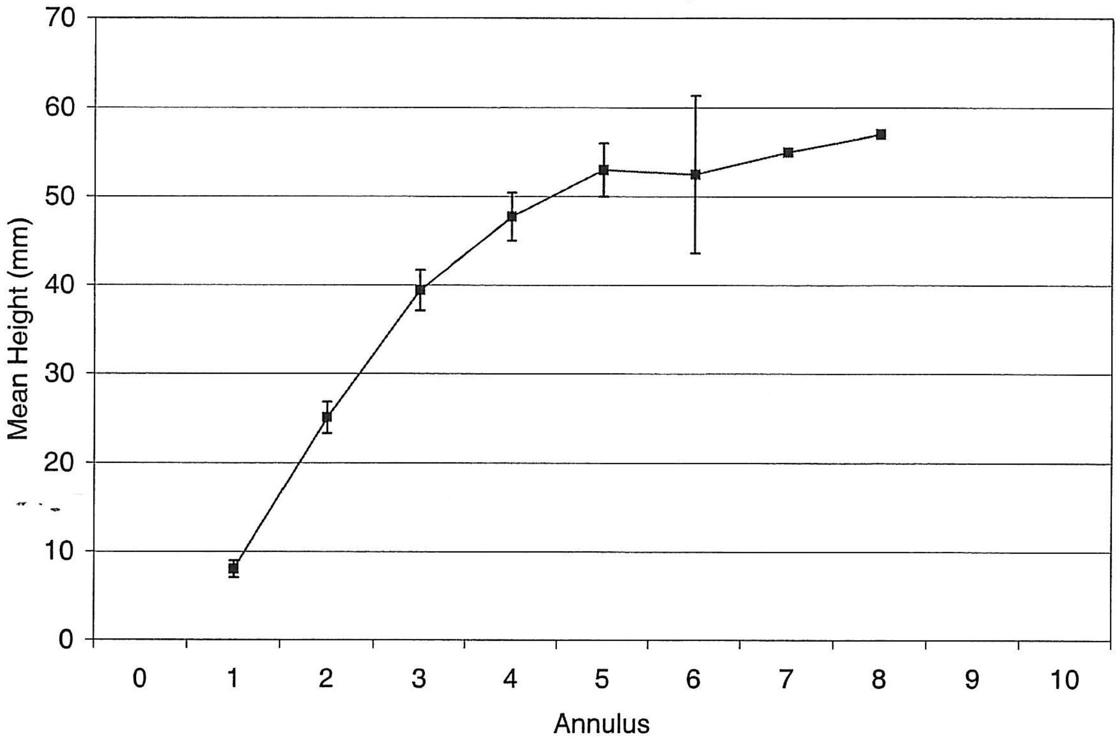


Figure 22. Mean height-at-annulus (mm) for cockles collected in Fish Egg Inlet, June 29, 2000.

Error bars are 95% confidence intervals.

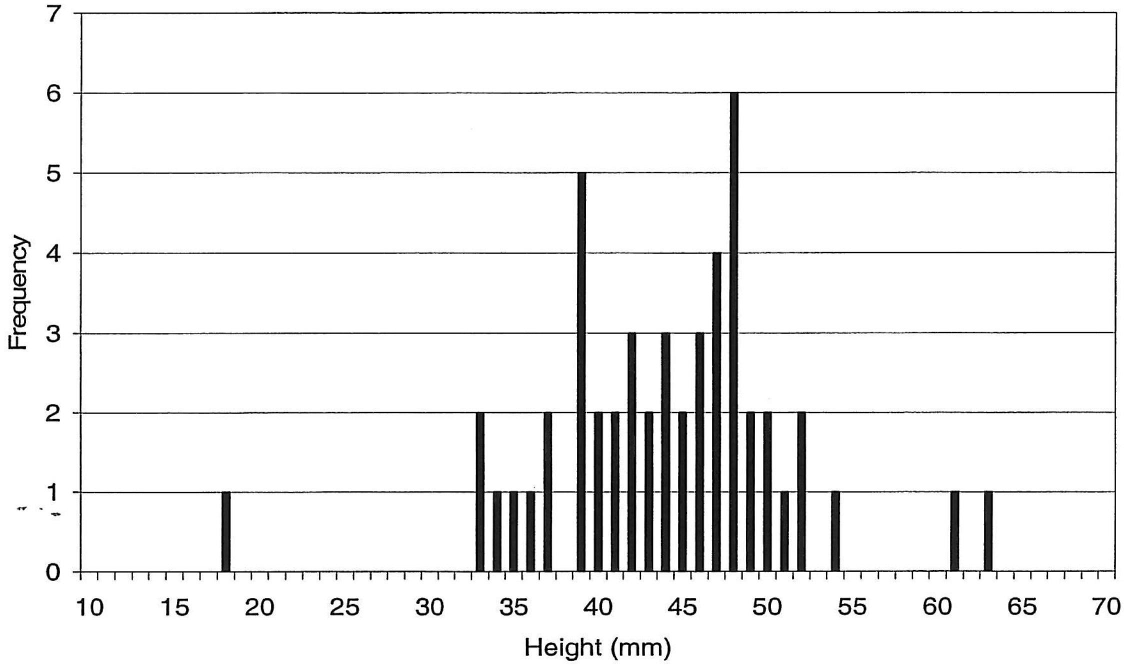


Figure 23. Height frequency distribution of Olympia oysters collected in Fish Egg Inlet, June 29, 2000.

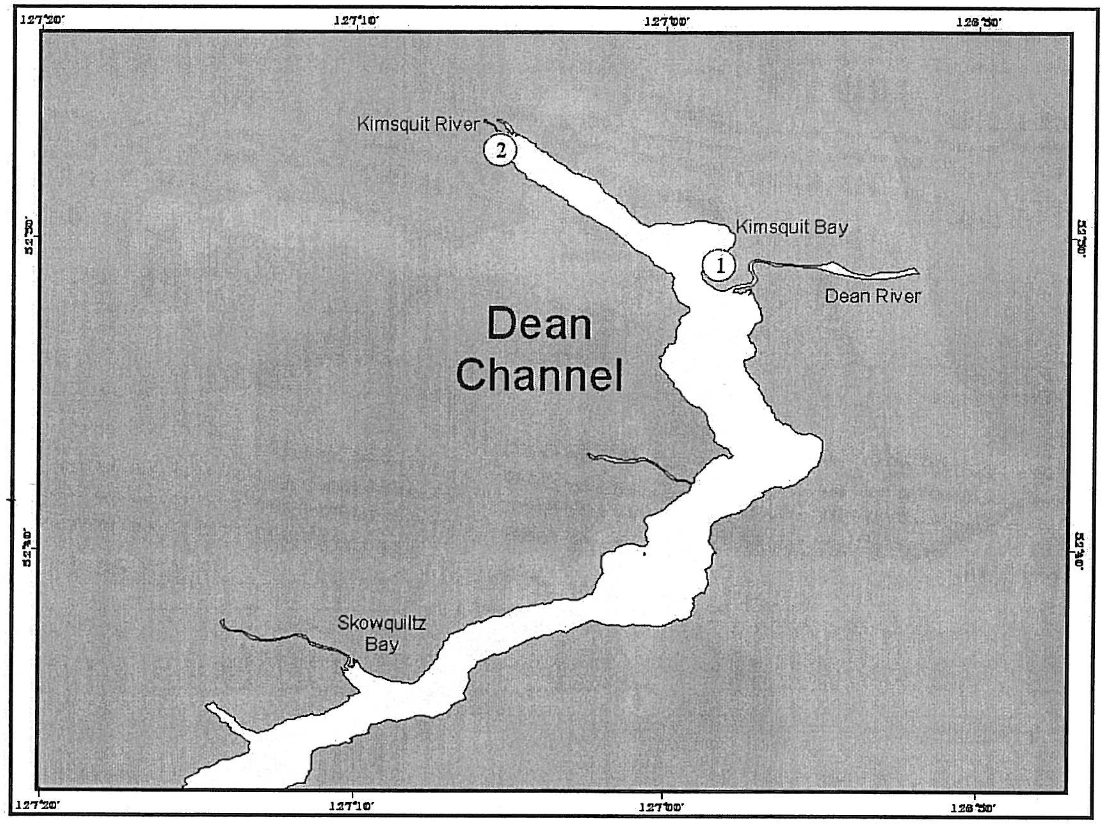


Figure 24. Location of beaches surveyed in Dean Channel, June 30, 2000.

Legend: 1 – Kimsquit Bay; 2 – Kimsquit River Estuary.

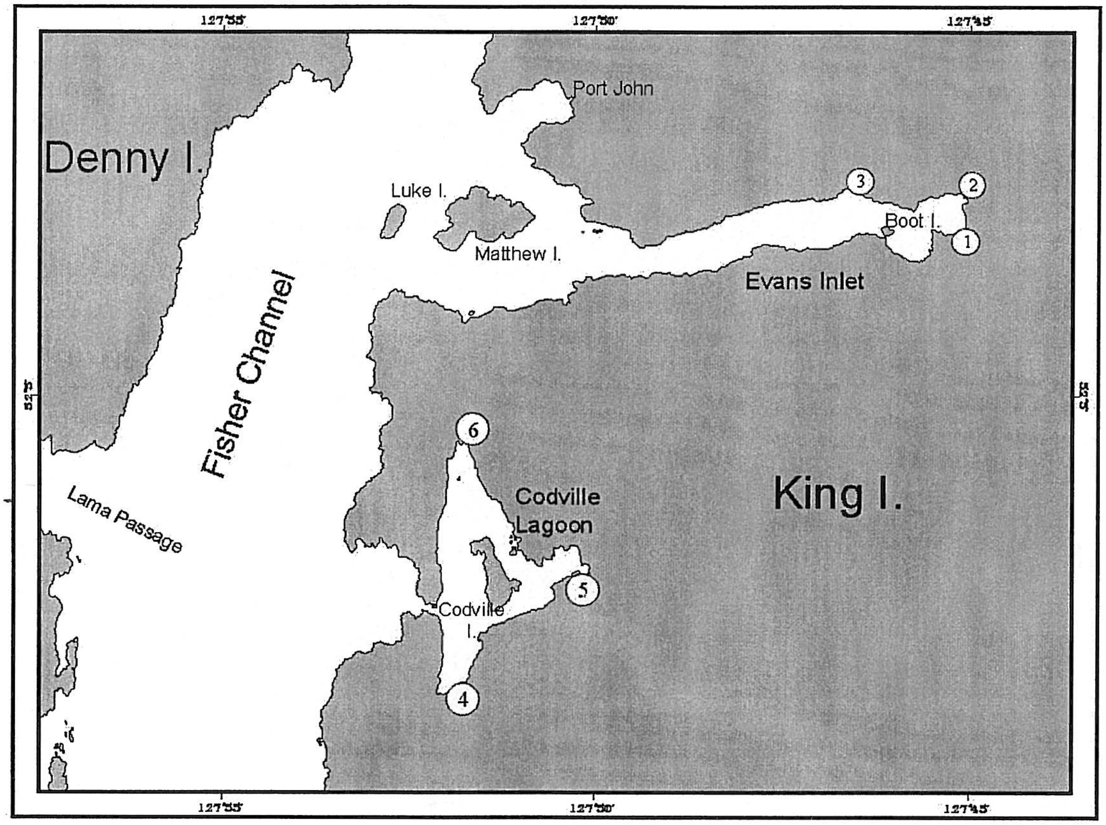
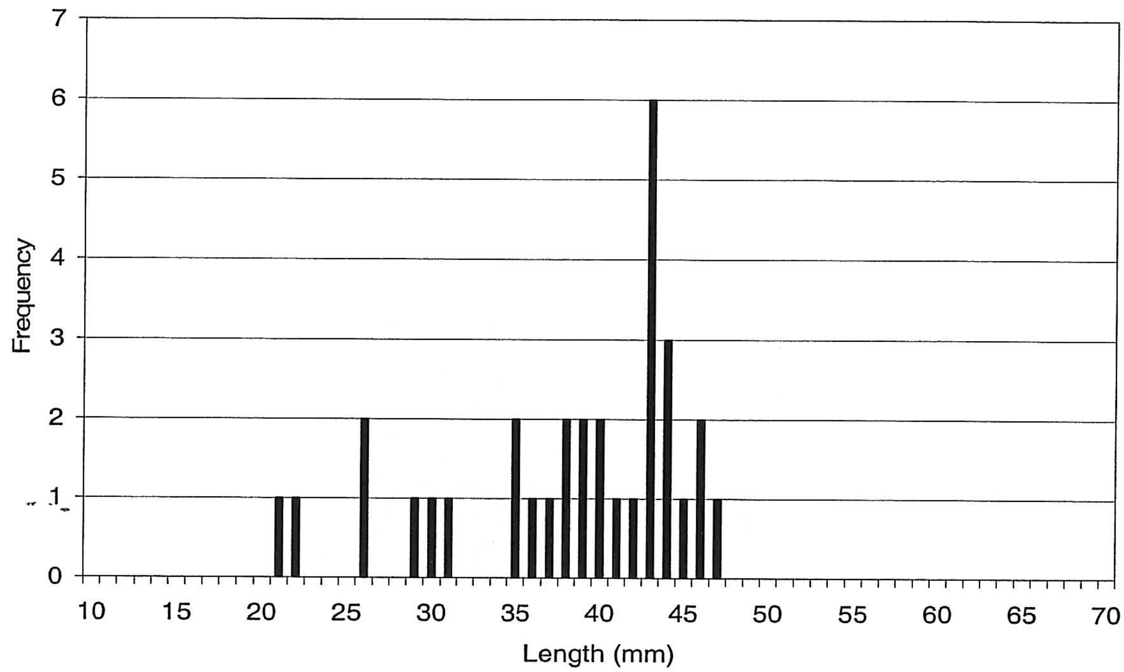


Figure 25. Locations of beaches surveyed in Fisher Channel, July 1, 2000.

Legend: 1 – Southeast Evans Inlet; 2 – Northeast Evans Inlet; 3 – North Side of Evans Inlet; 4 – Southern Codville Lagoon; 5 – Northeastern Codville Lagoon; 6 – Northwestern Codville Lagoon.



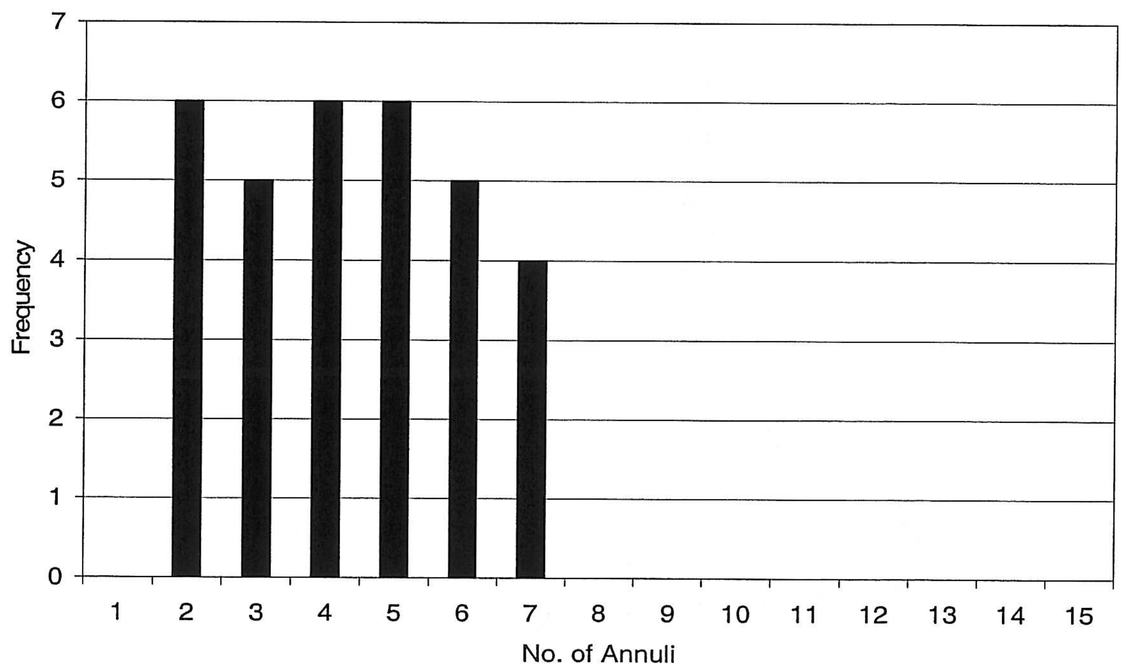
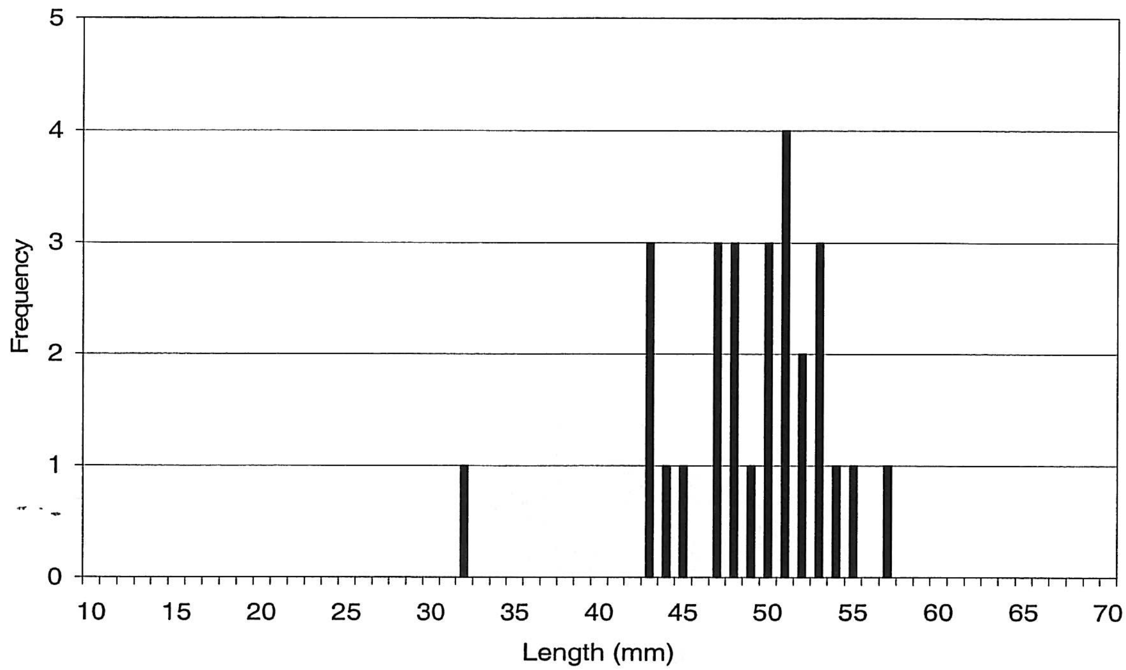


Figure 26. Length (top) and age (bottom) frequency distributions of Manila clams collected in Evans Inlet, Fisher Channel, July 1, 2000.



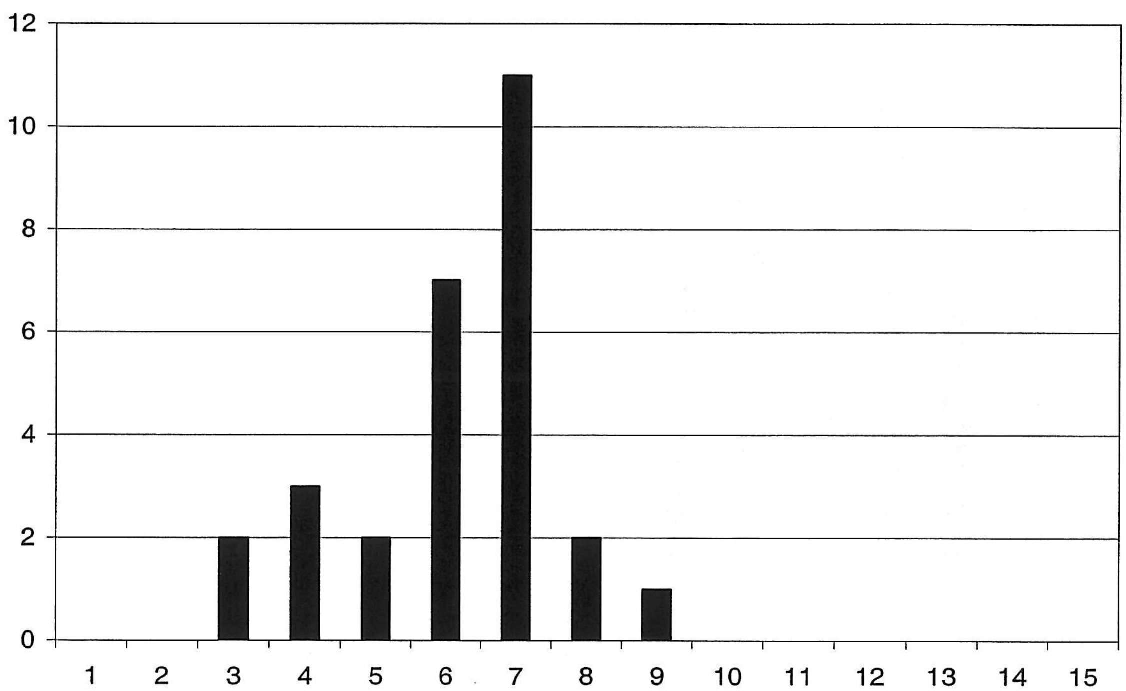


Figure 27. Length (top) and age (bottom) frequency distributions of Manila clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

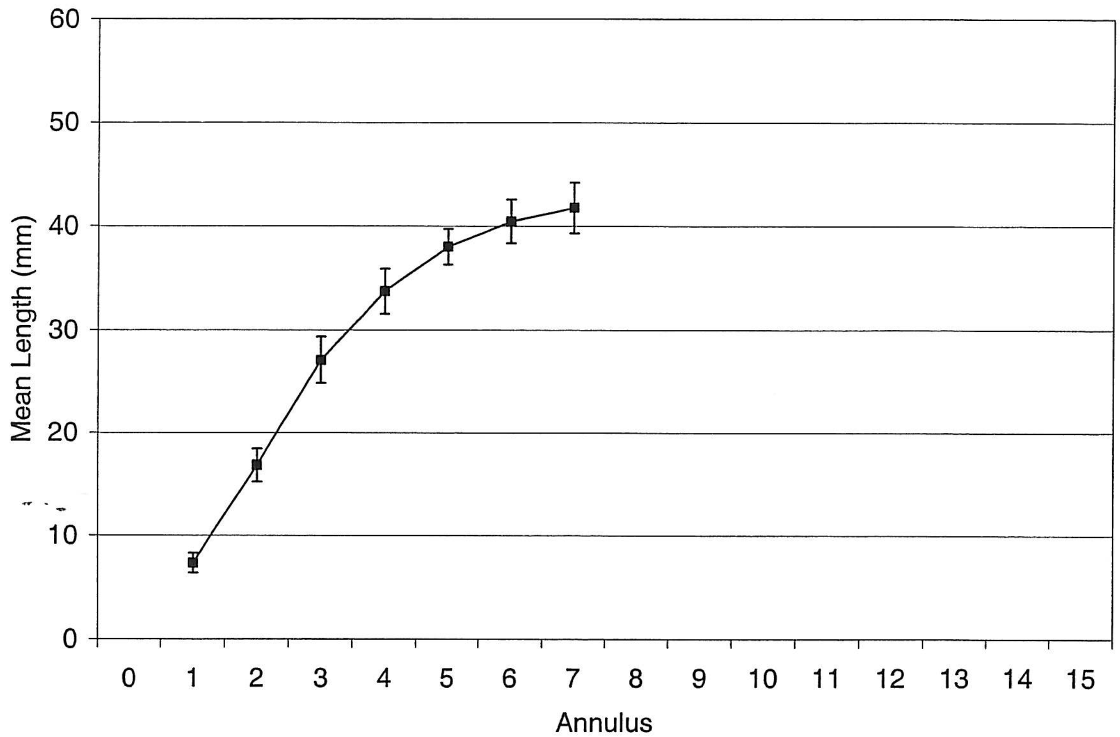


Figure 28. Mean length-at-annulus (mm) for Manila clams collected in Evans Inlet, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

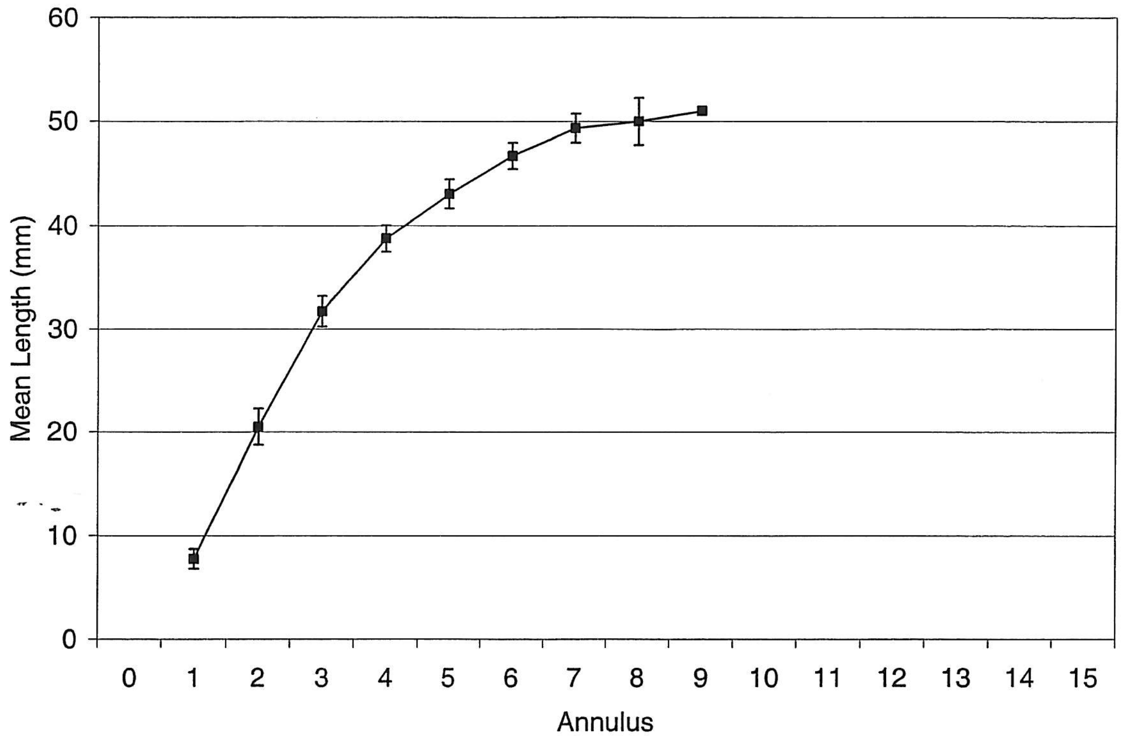


Figure 29. Mean length-at-annulus (mm) for Manila clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

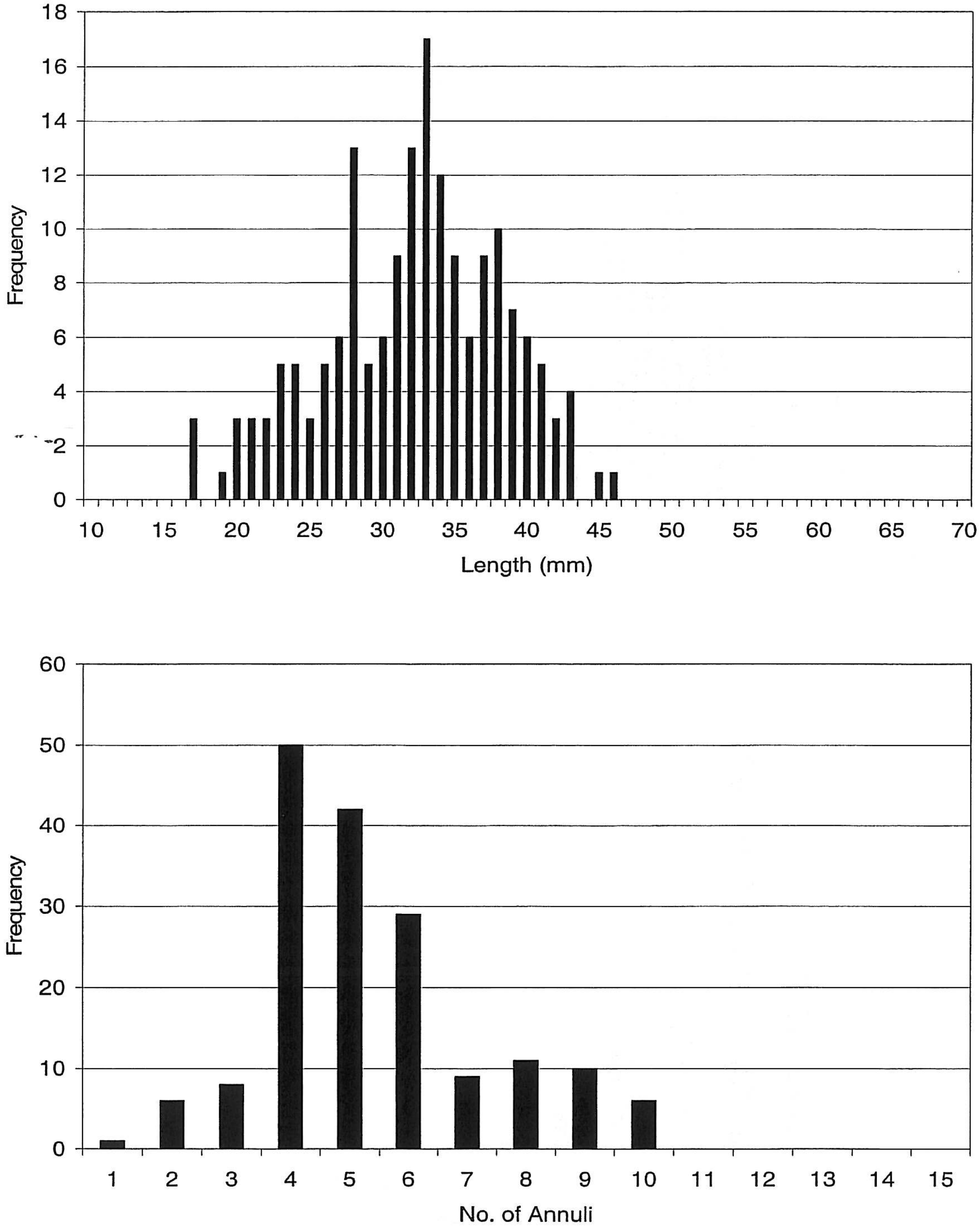
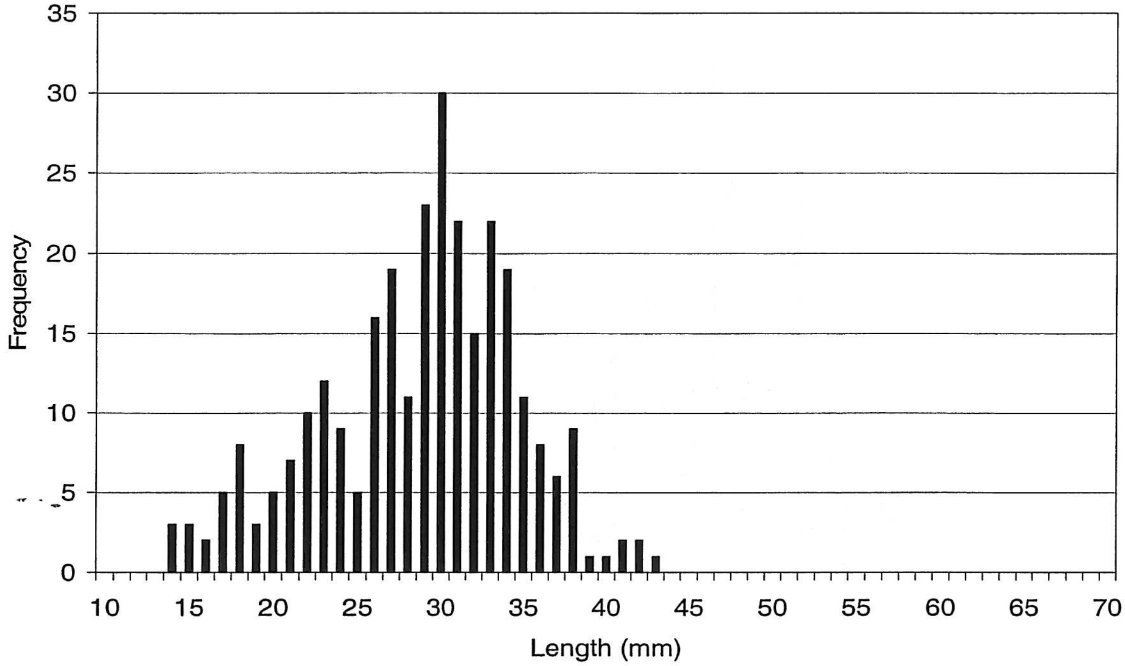


Figure 30. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Evans Inlet, Fisher Channel, July 1, 2000.



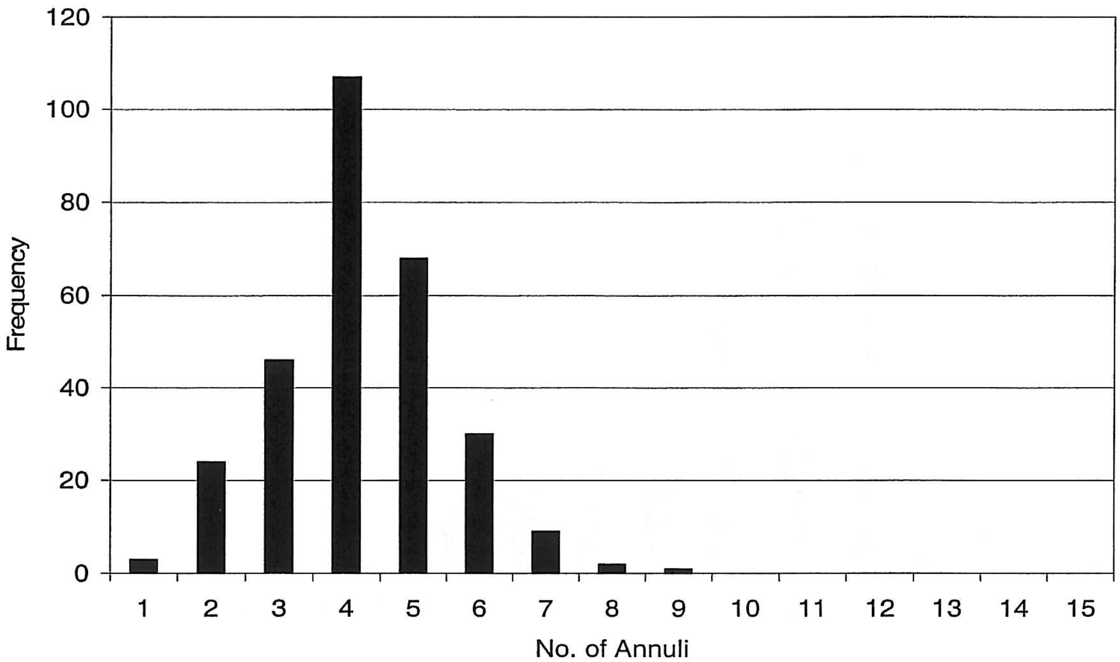


Figure 31. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

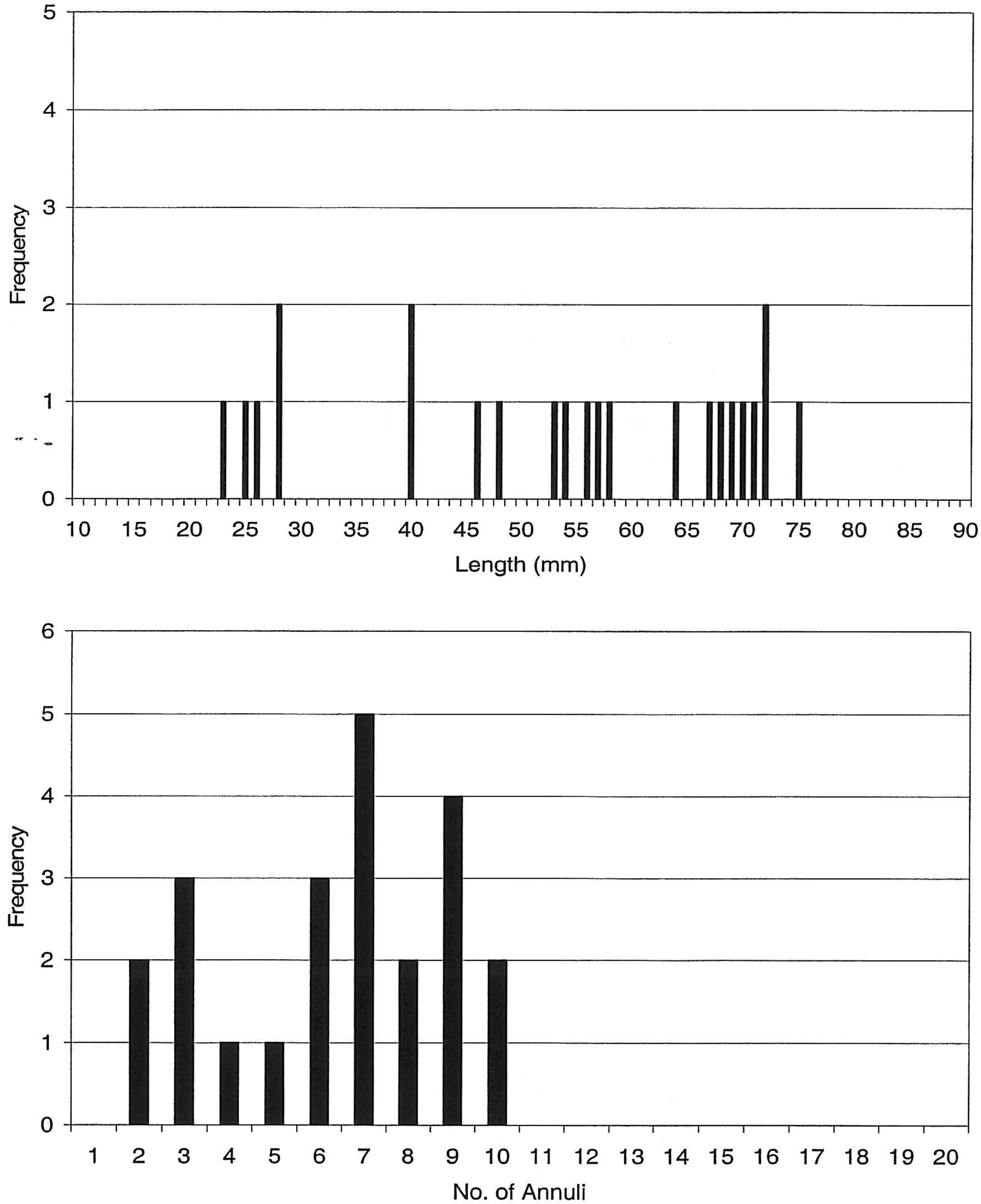
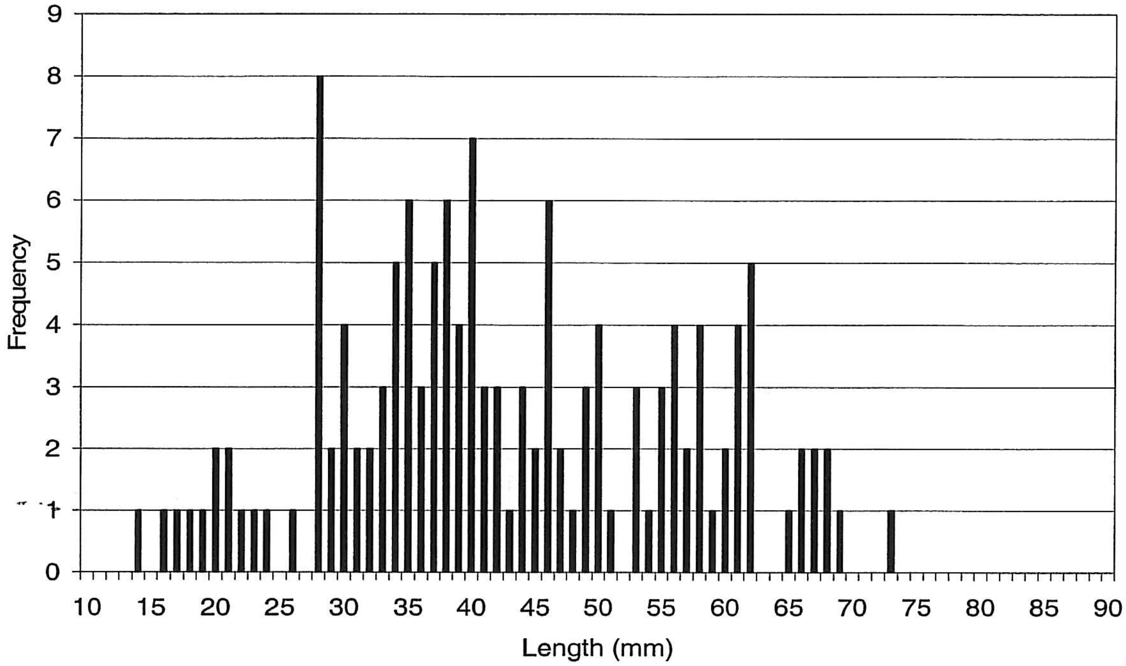


Figure 32. Length (top) and age (bottom) frequency distributions of butter clams collected in Evans Inlet, Fisher Channel, July 1, 2000.



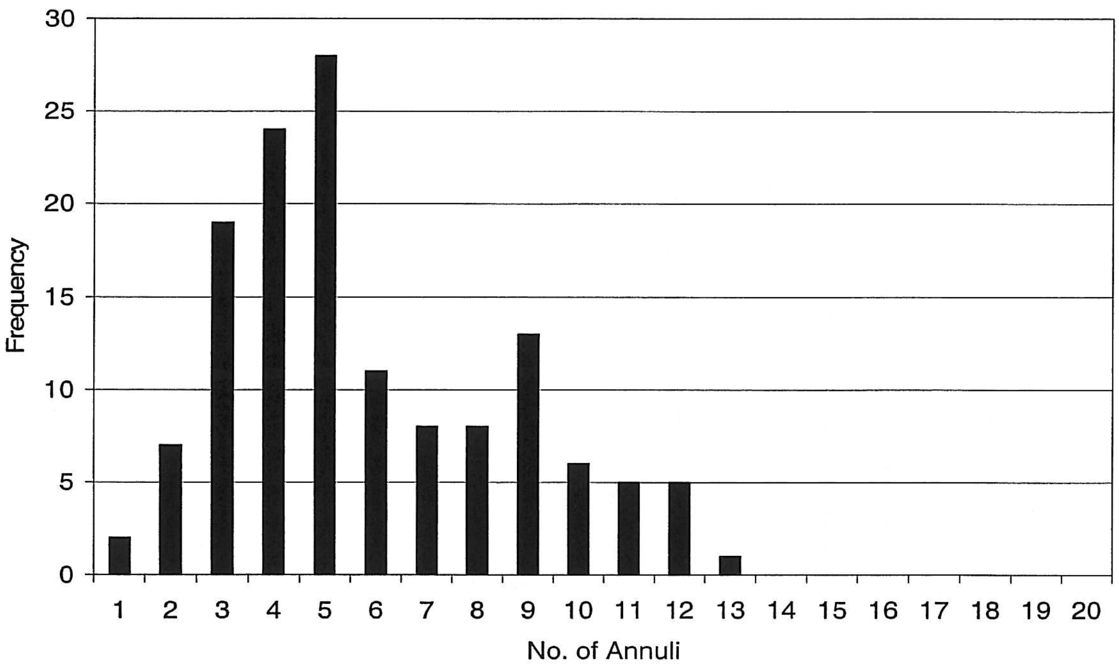


Figure 33. Length (top) and age (bottom) frequency distributions of butter clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

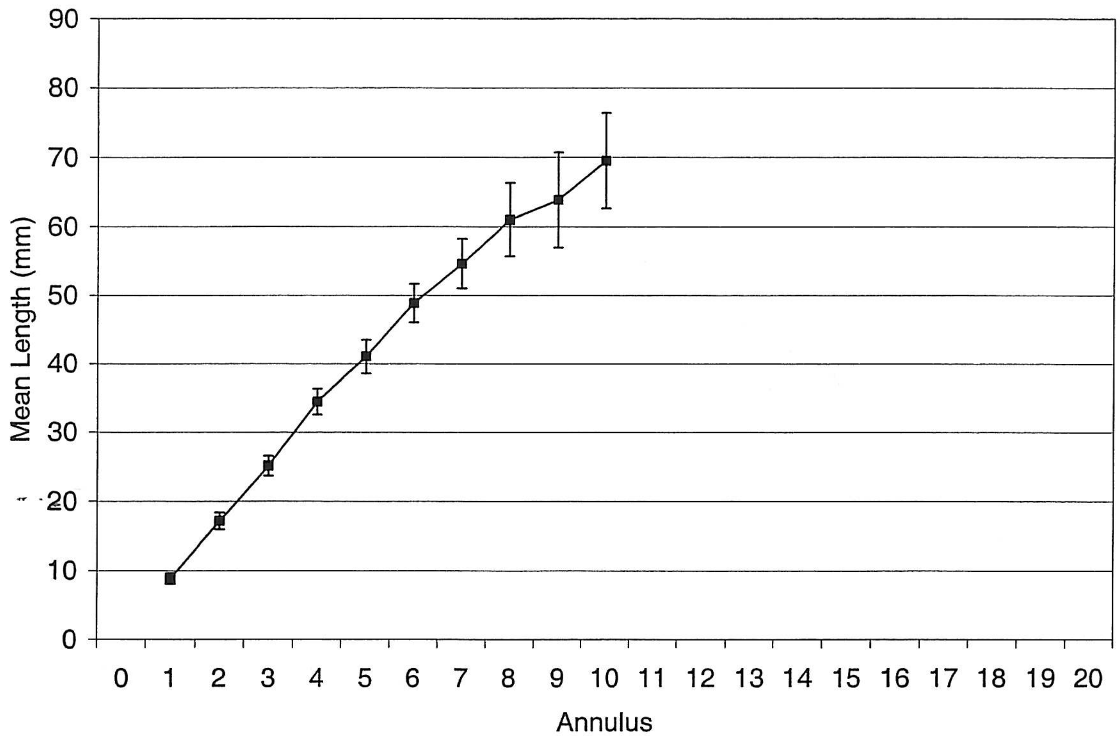


Figure 34. Mean length-at-annulus (mm) for butter clams collected in Evans Inlet, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

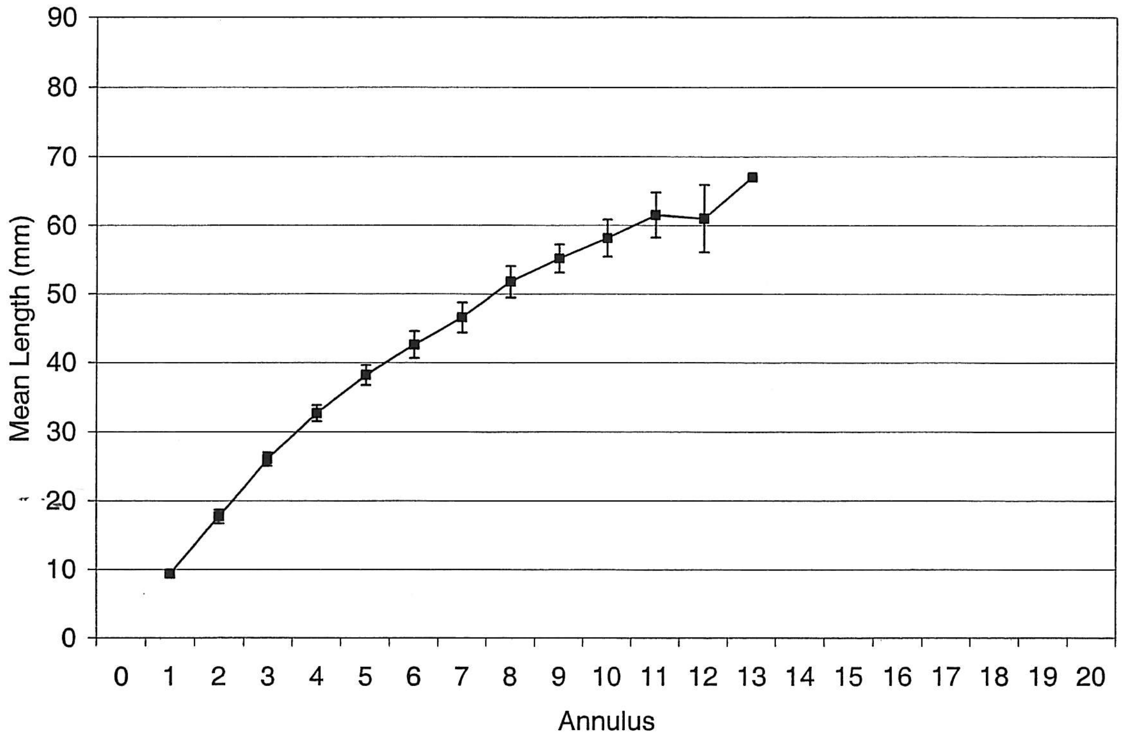


Figure 35. Mean length-at-annulus (mm) for butter clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

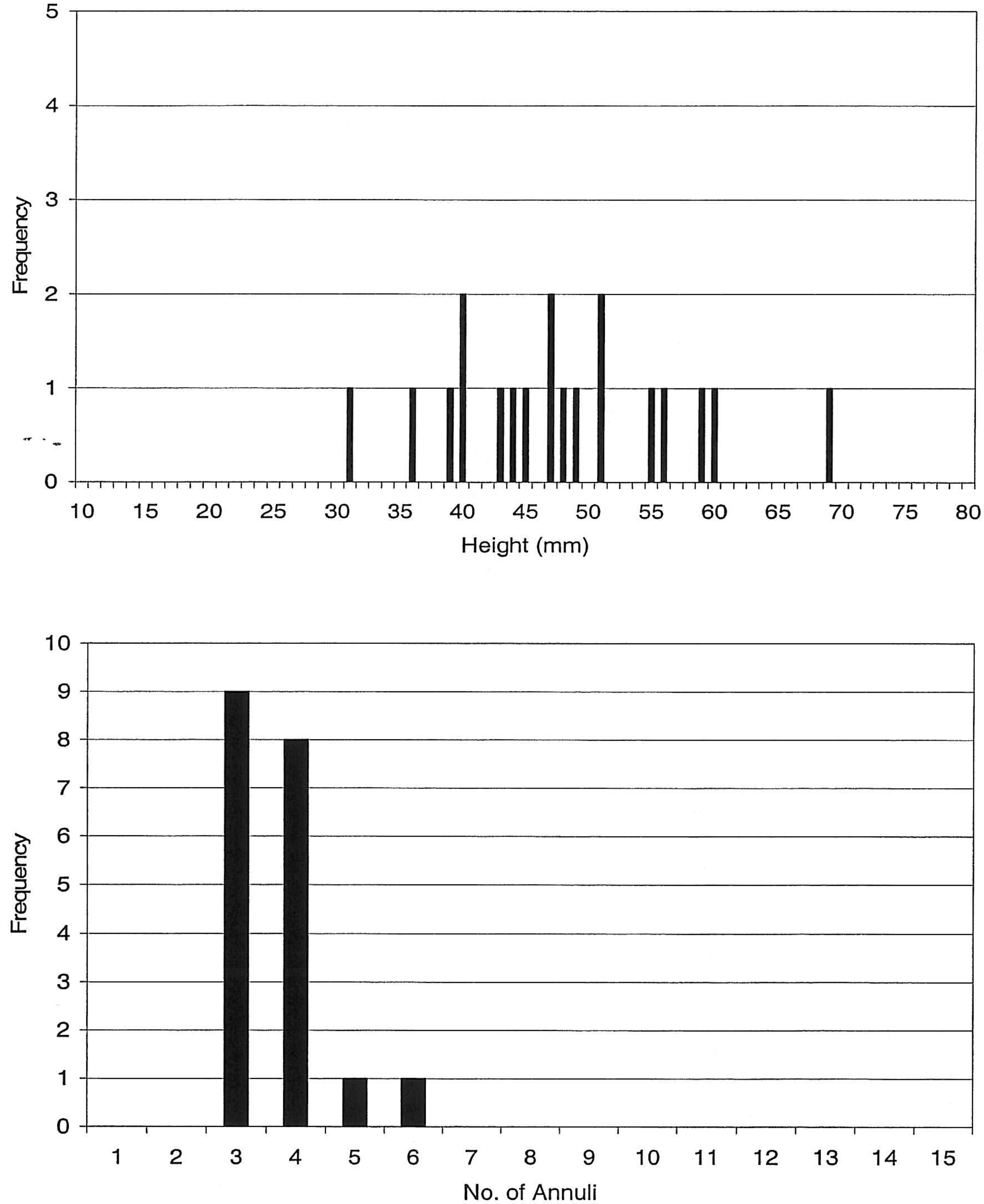
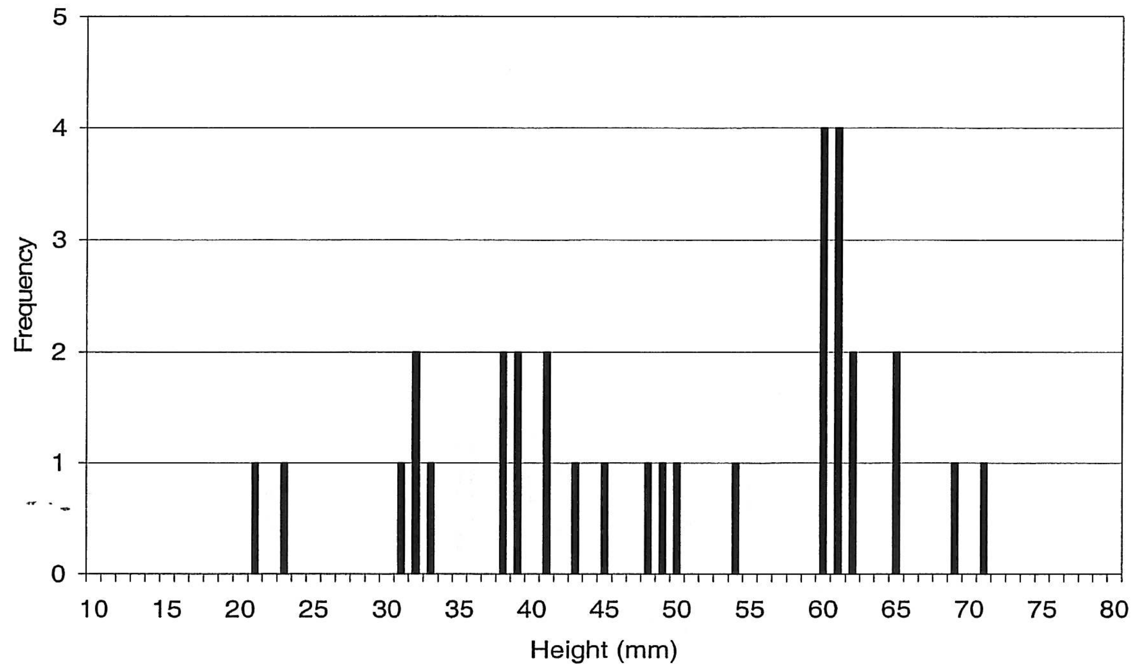


Figure 36. Height (top) and age (bottom) frequency distributions of cockles collected in Evans Inlet, Fisher Channel, July 1, 2000.



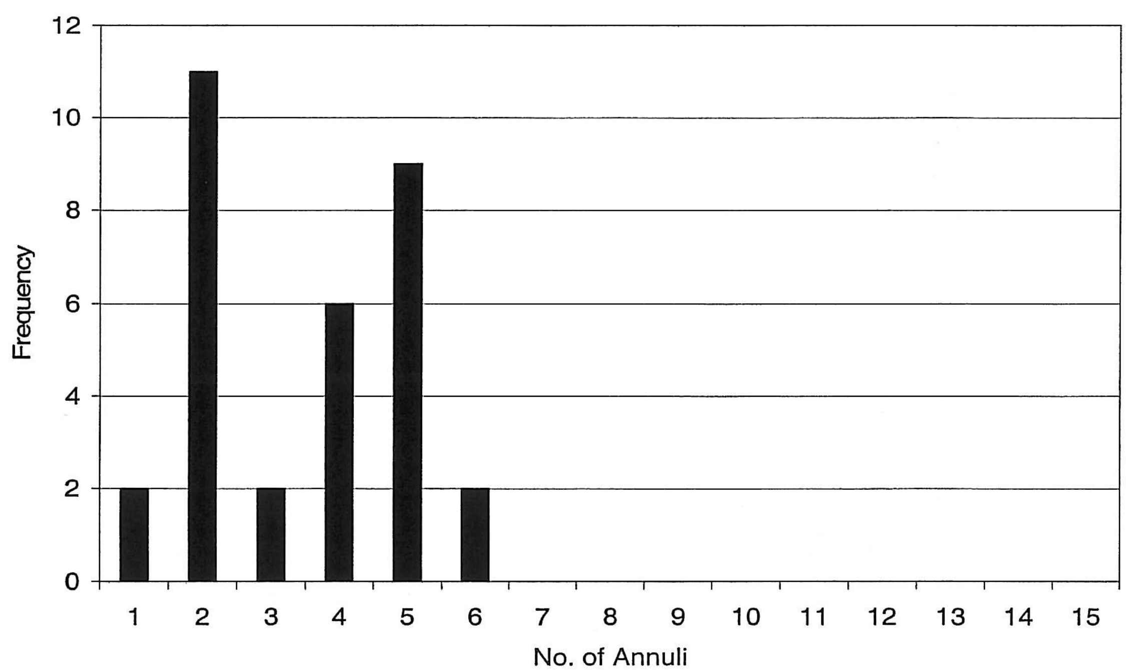


Figure 37. Height (top) and age (bottom) frequency distributions of cockles collected in Codville Lagoon, Fisher Channel, July 1, 2000.

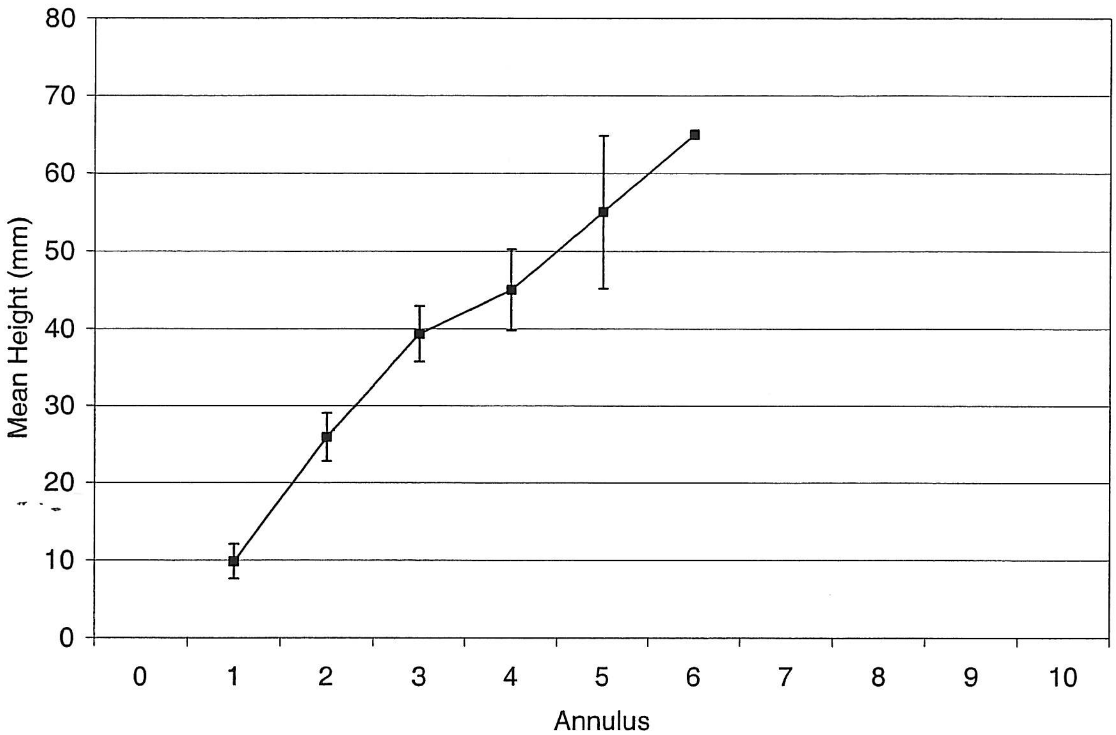


Figure 38. Mean height-at-annulus (mm) for cockles collected in Evans Inlet, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

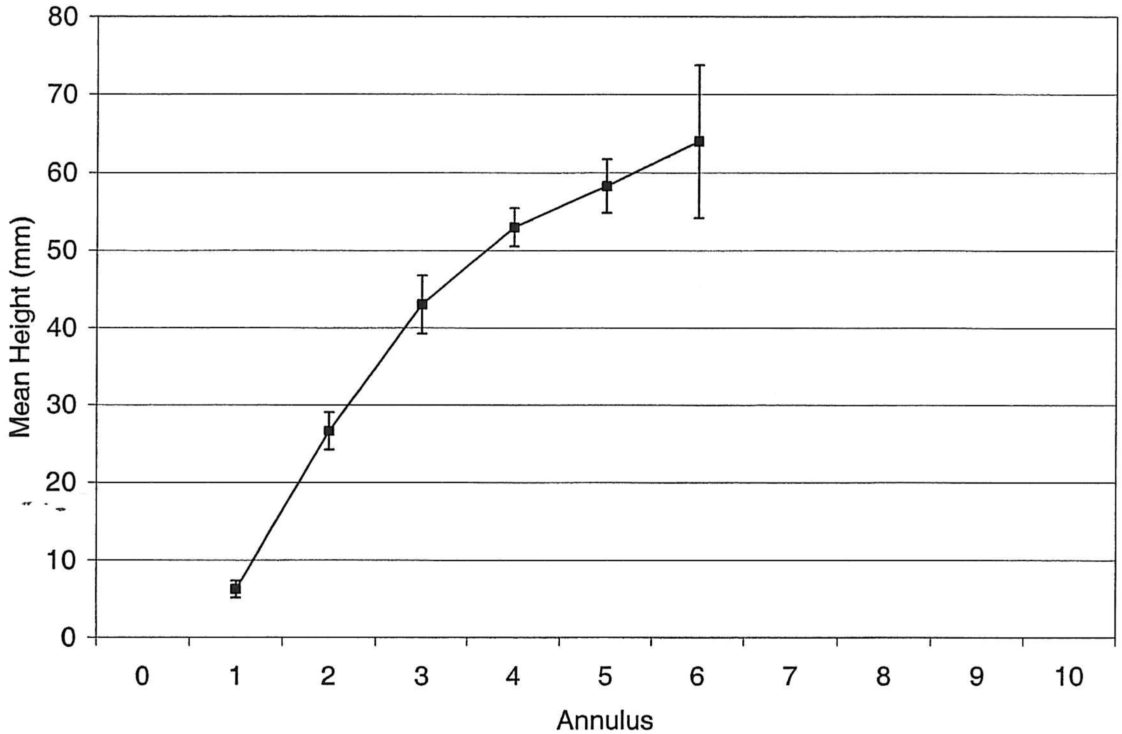


Figure 39. Mean height-at-annulus (mm) for cockles collected in Codville Lagoon, Fisher Channel, July 1, 2000.

Error bars are 95% confidence intervals.

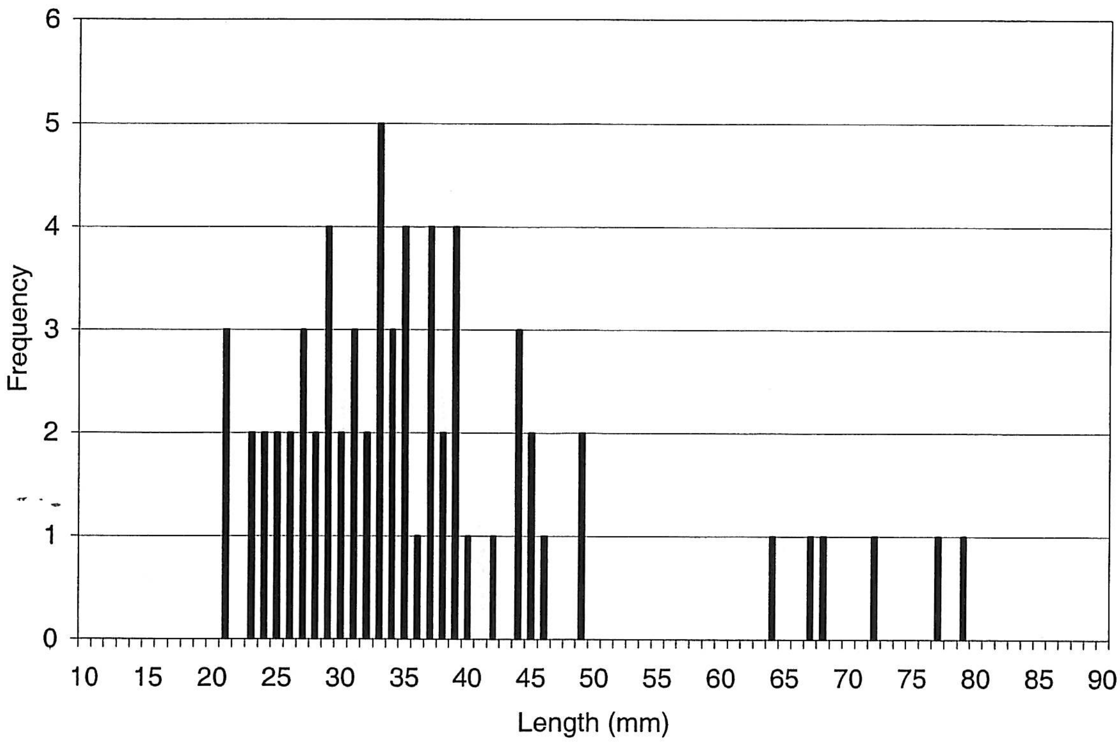


Figure 40. Length frequency distribution of softshell clams collected in Evans Inlet, Fisher Channel, July 1, 2000.

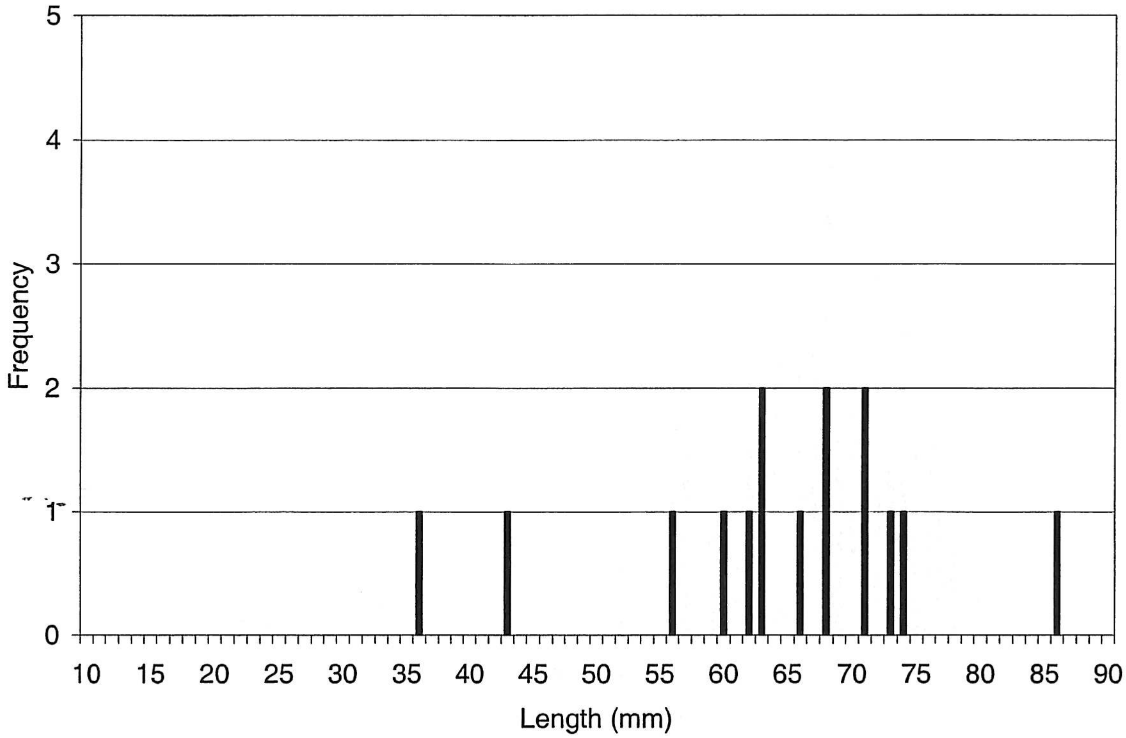


Figure 41. Length frequency distribution of softshell clams collected in Codville Lagoon, Fisher Channel, July 1, 2000.

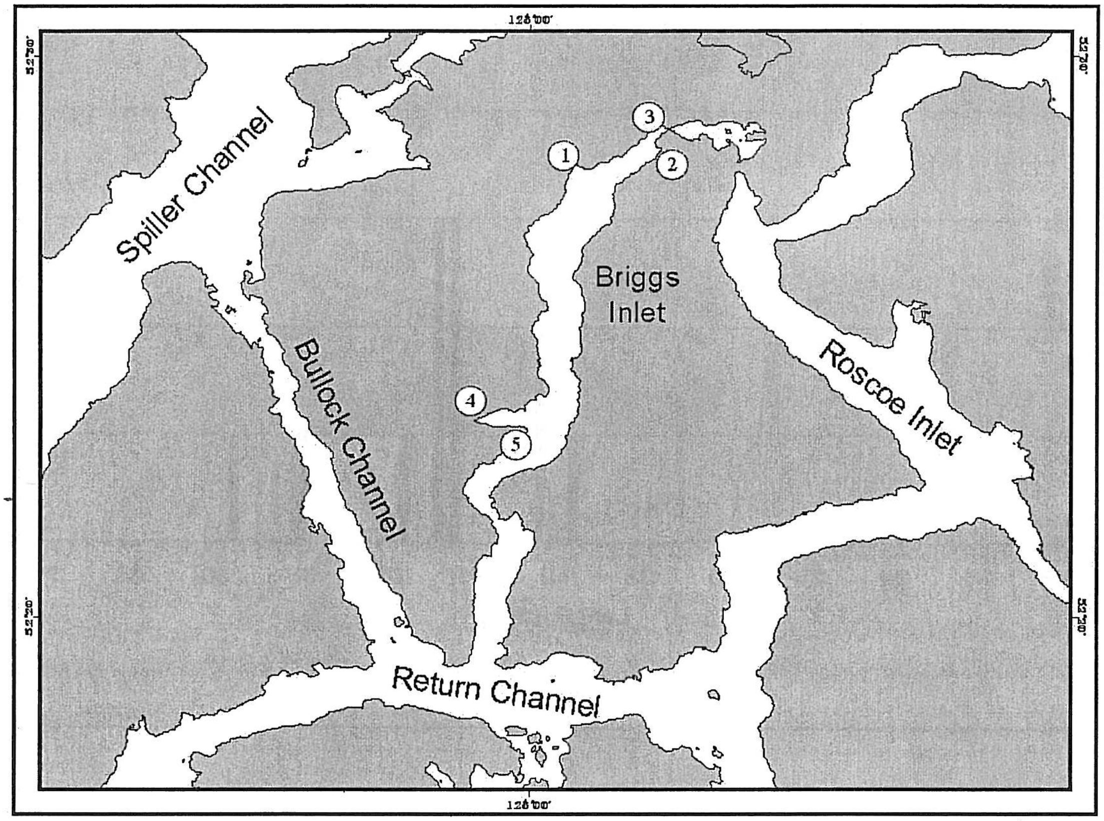


Figure 42. Location of beaches surveyed in Briggs Inlet, July 2, 2000.

Legend: 1 – Western Shore of Upper Briggs Inlet; 2 – Eastern Shore of Upper Briggs Inlet; 3 – Head of Briggs Inlet; 4 – Emily Bay; 5 – South of Emily Bay.

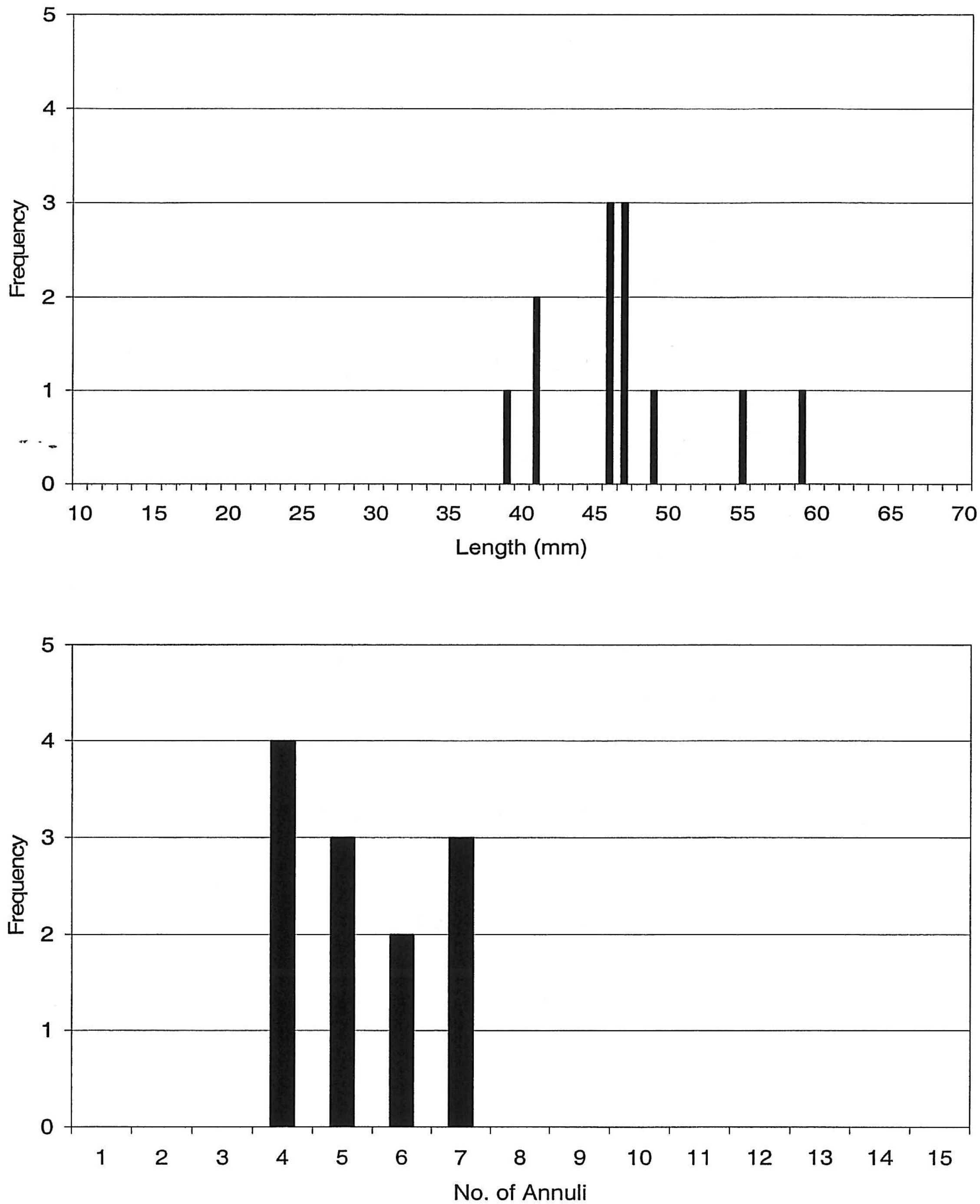


Figure 43. Length (top) and age (bottom) frequency distributions of Manila clams collected in Briggs Inlet, July 2, 2000.

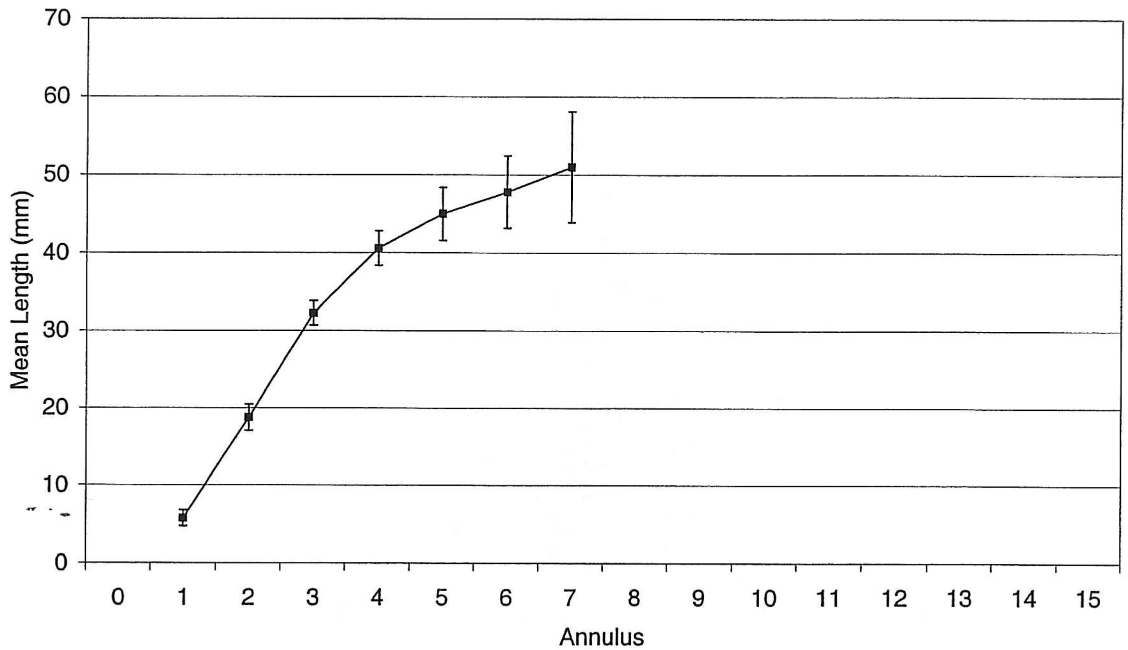


Figure 44. Mean length-at-annulus of Manila clams collected in Briggs Inlet, July 2, 2000. Error bars are 95% confidence intervals.

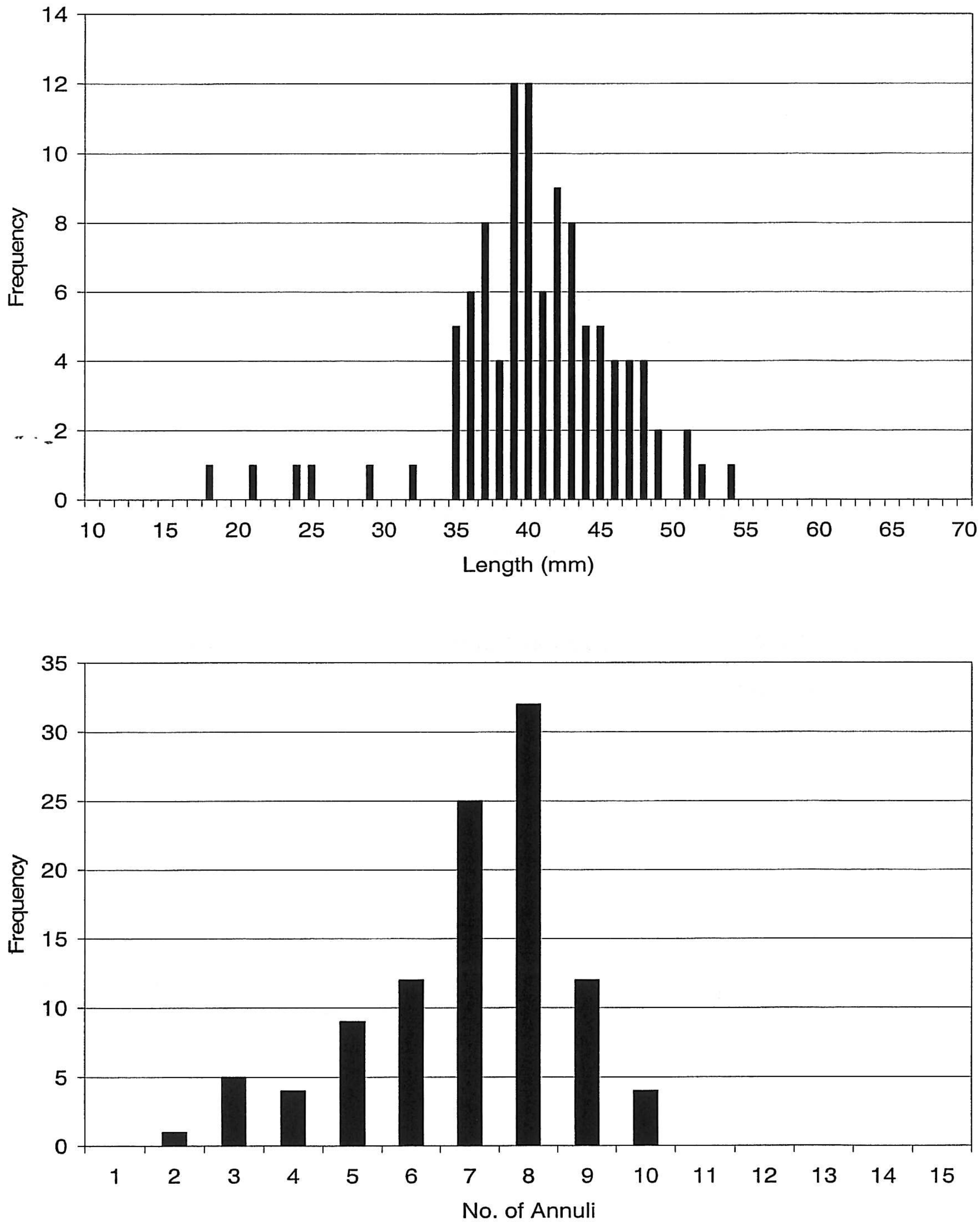


Figure 45. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Briggs Inlet, July 2, 2000.

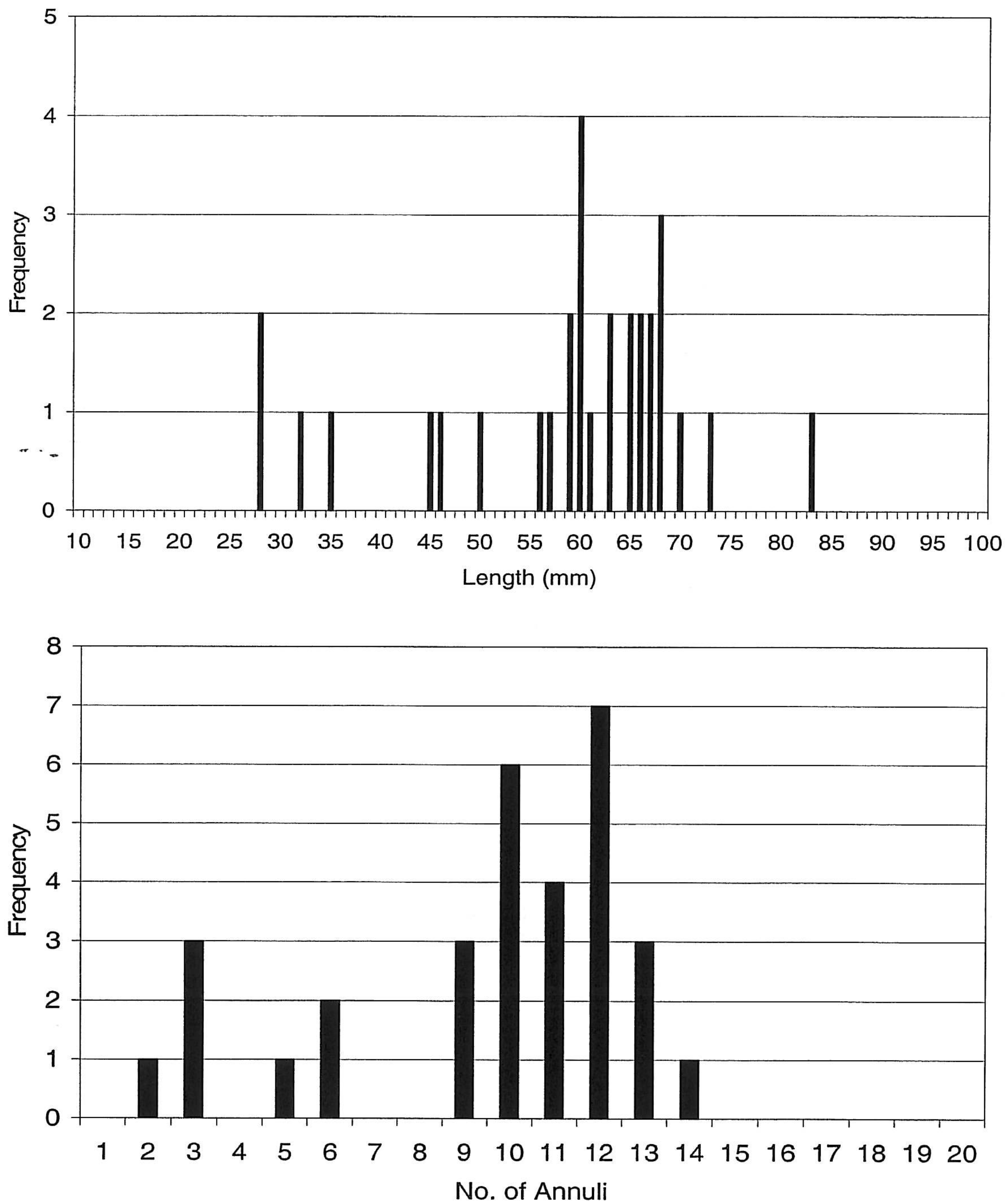


Figure 46. Length (top) and age (bottom) frequency distributions of butter clams collected in Briggs Inlet, July 2, 2000.

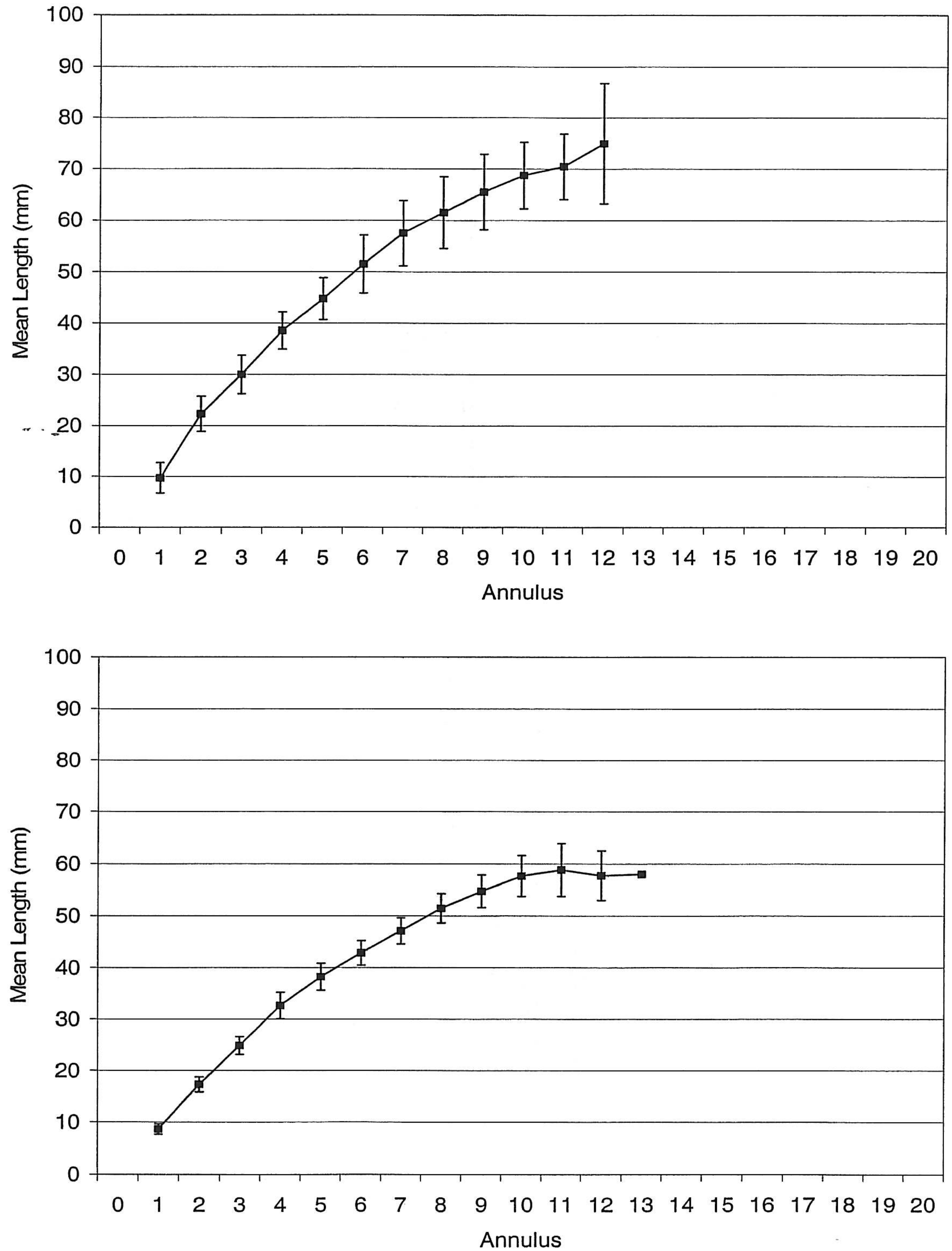
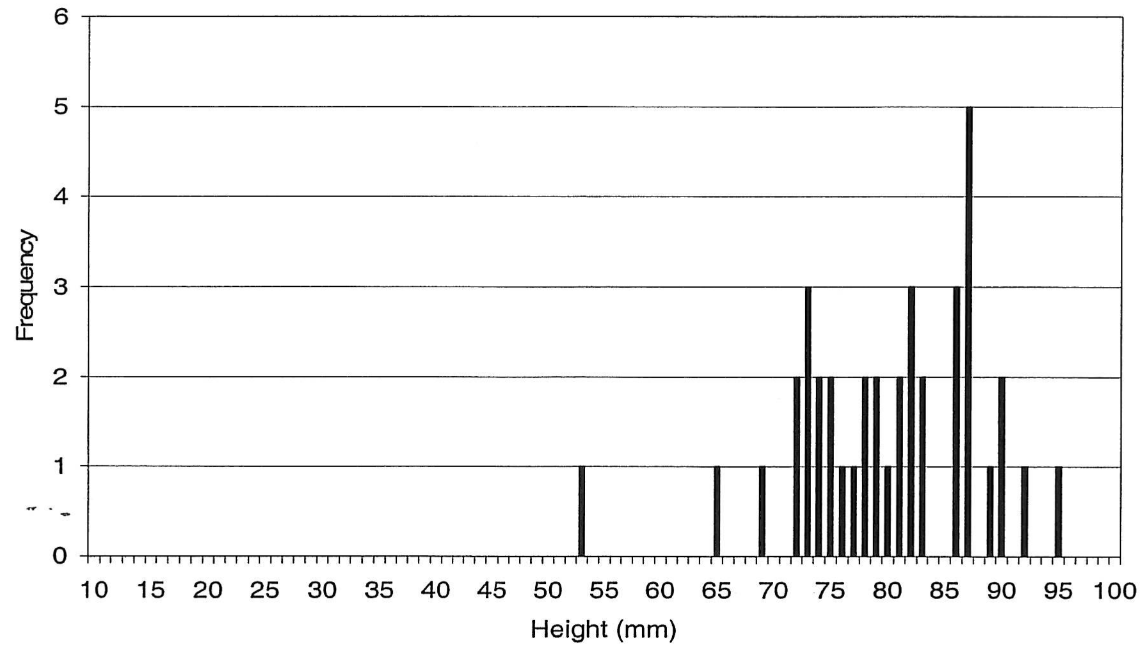


Figure 47. Mean length-at-annulus of butter clams collected from beach 1 (top) and beach 2 (bottom) in Briggs Inlet, July 2, 2000.

Error bars are 95% confidence intervals.



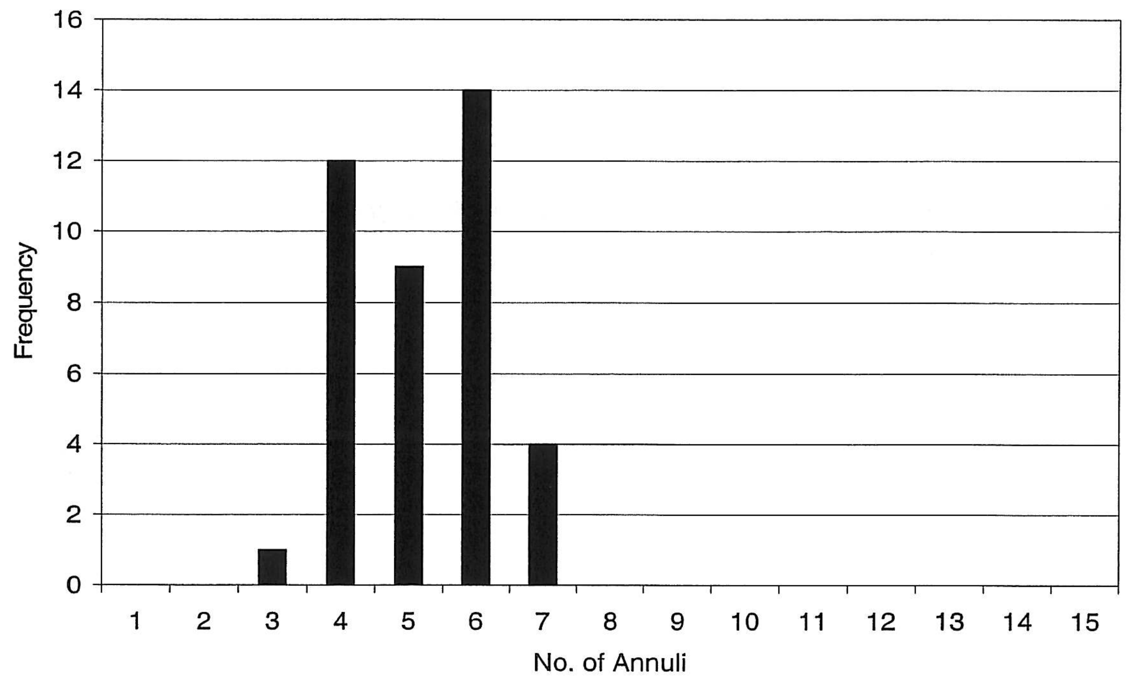


Figure 48. Height (top) and age (bottom) frequency distributions of cockles collected in Briggs Inlet, July 2, 2000.

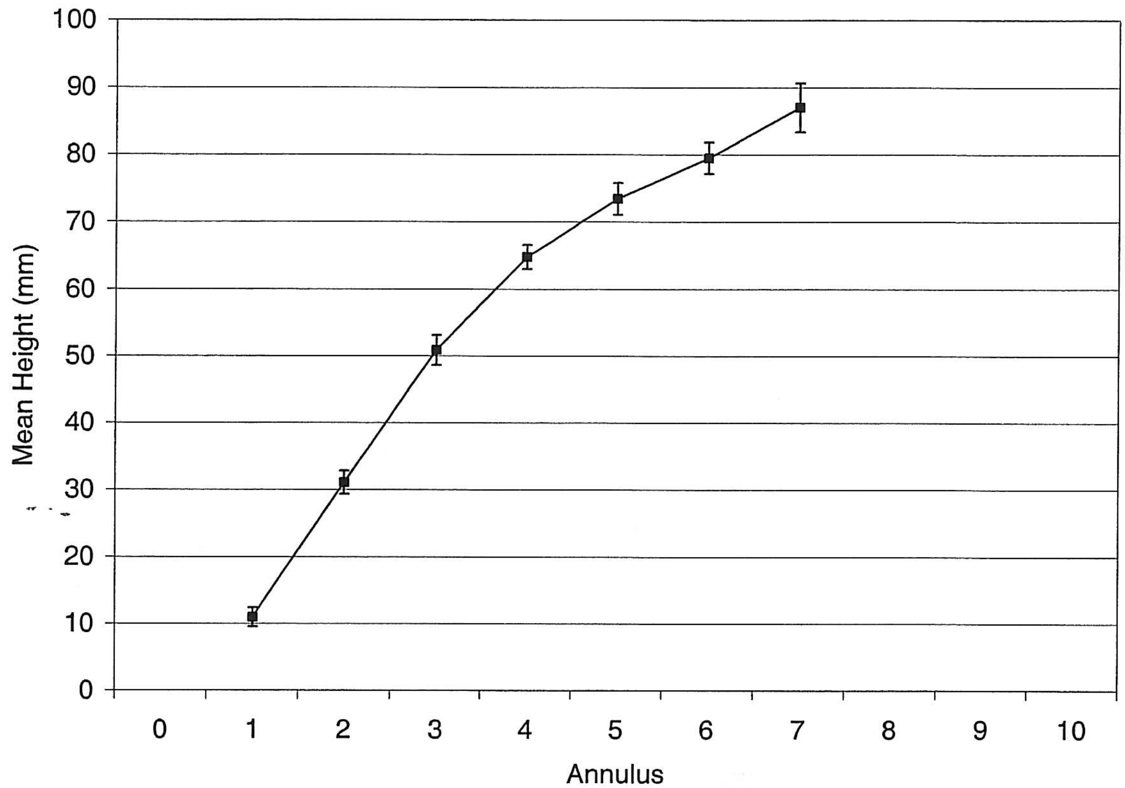


Figure 49. Mean height-at-annulus of cockles collected in Briggs Inlet, July 2, 2000. Error bars are 95% confidence intervals.

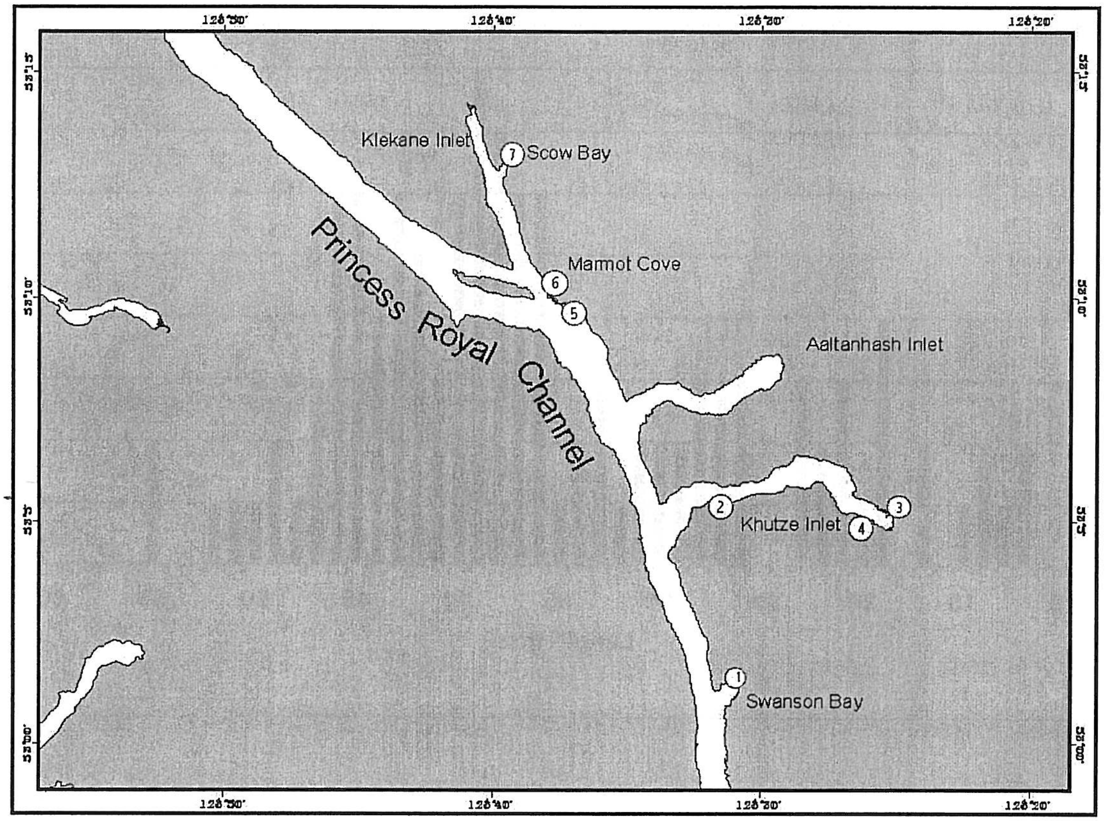
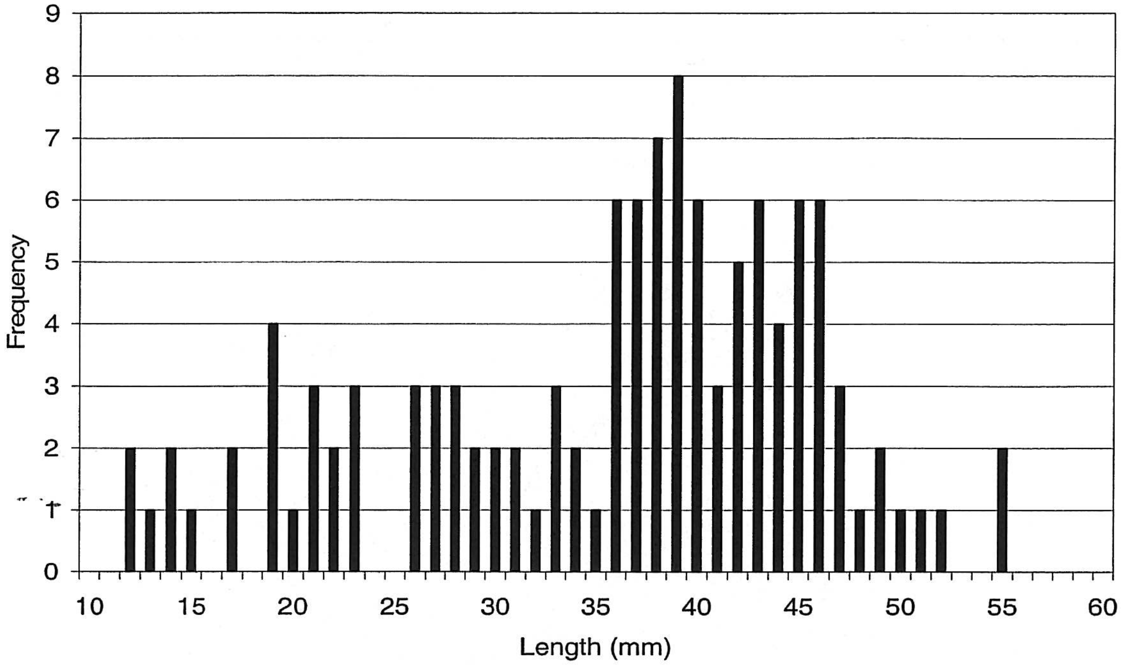


Figure 50. General locations of areas surveyed in Princess Royal Channel, July 3, 2000.

Legend: 1 – Swanson Bay; 2 – Lower Khutze Inlet; 3 – Khutze River estuary; 4 – Upper Khutze Inlet; 5 – Outside Marmot Cove; 6 – Marmot Cove; 7 – Scow Bay.



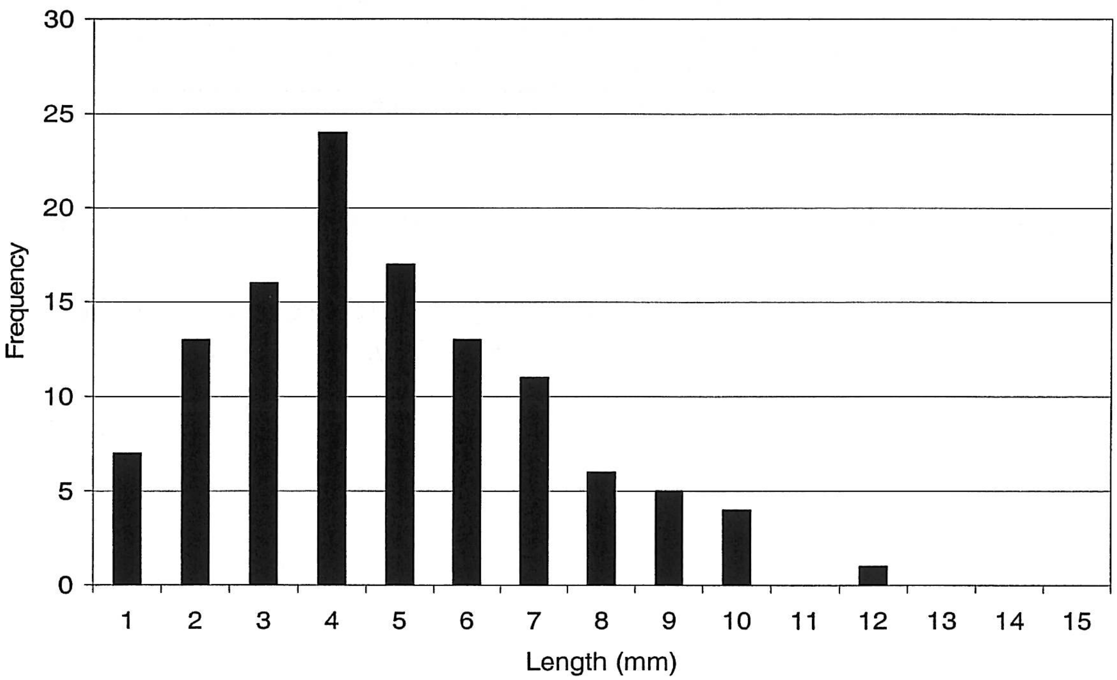


Figure 51. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Marmot Cove. Princess Royal Channel, July 3, 2000.

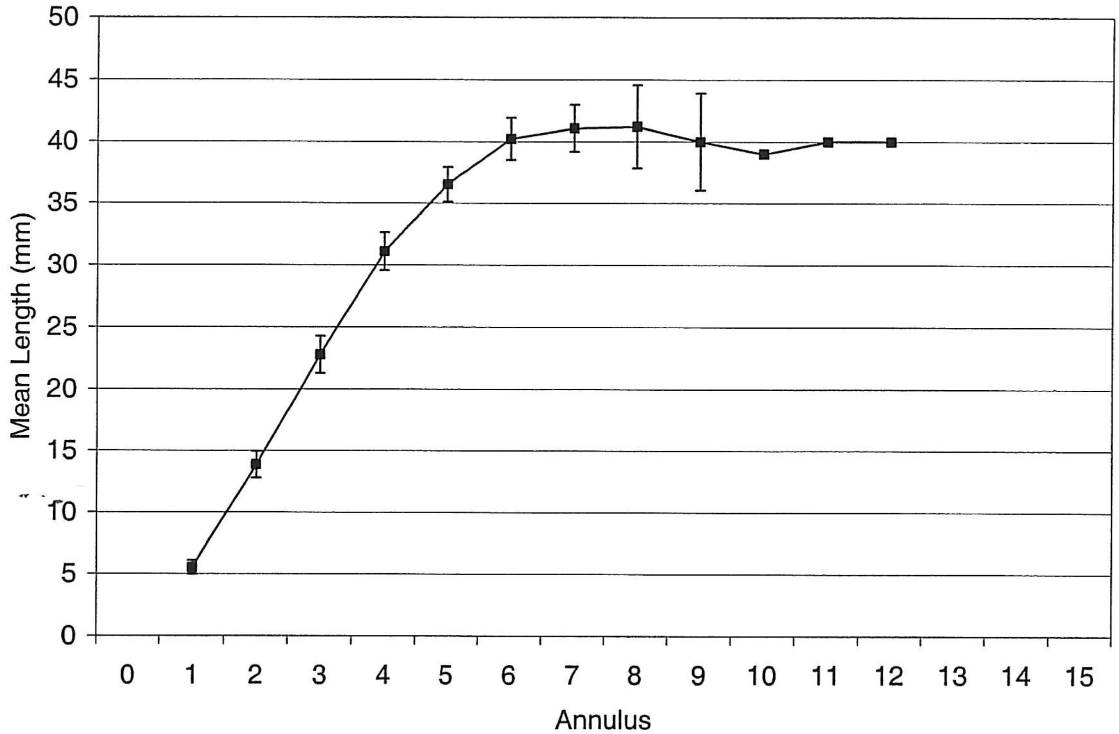
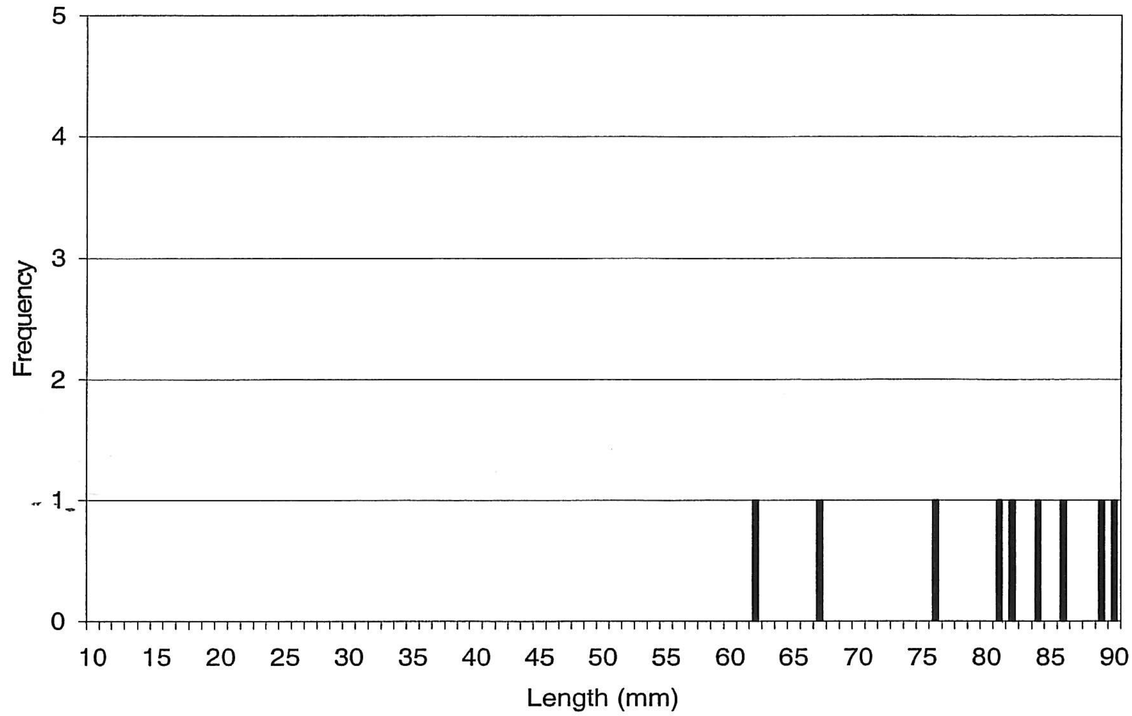


Figure 52. Mean length-at-annulus (mm) for littleneck clams collected in Marmot Cove, Princess Royal Channel, July 3, 2000.

Error bars are 95% confidence intervals.



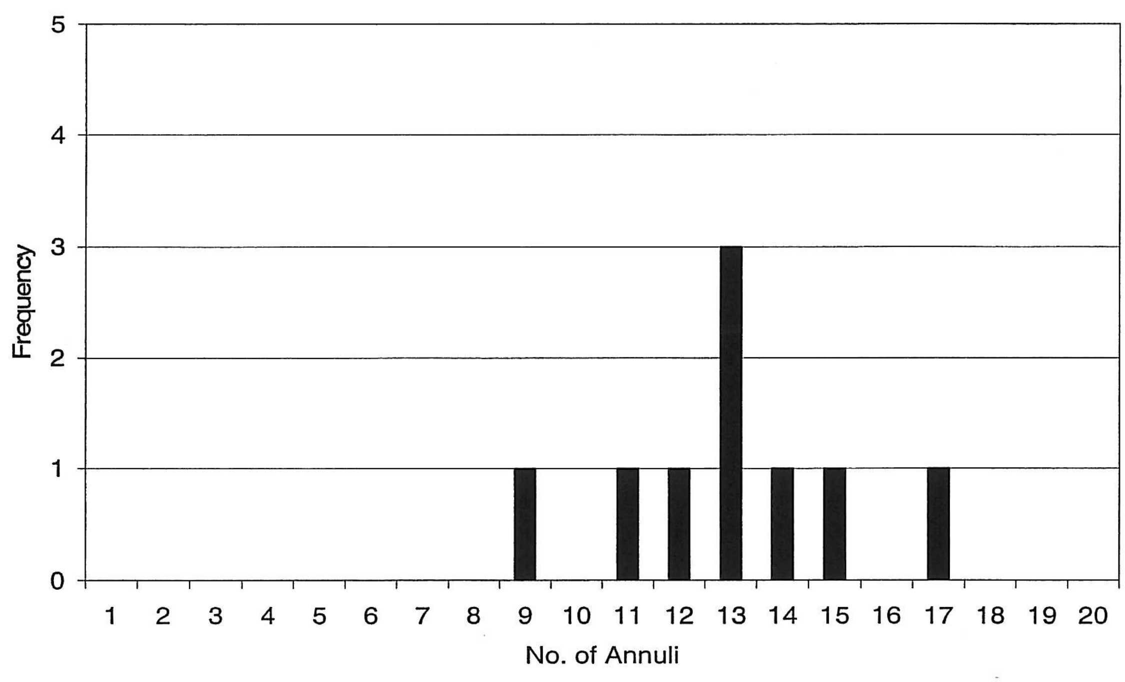
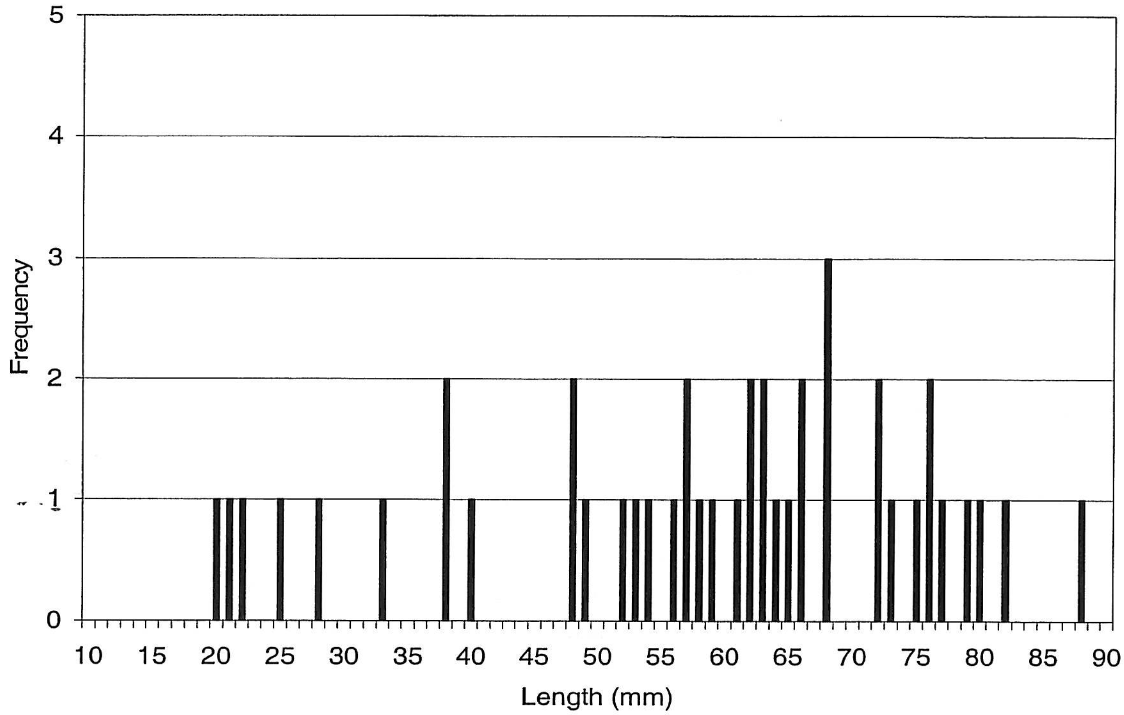


Figure 53. Length (top) and age (bottom) frequency distributions of butter clams collected in Swanson Bay, Princess Royal Channel, July 3, 2000.



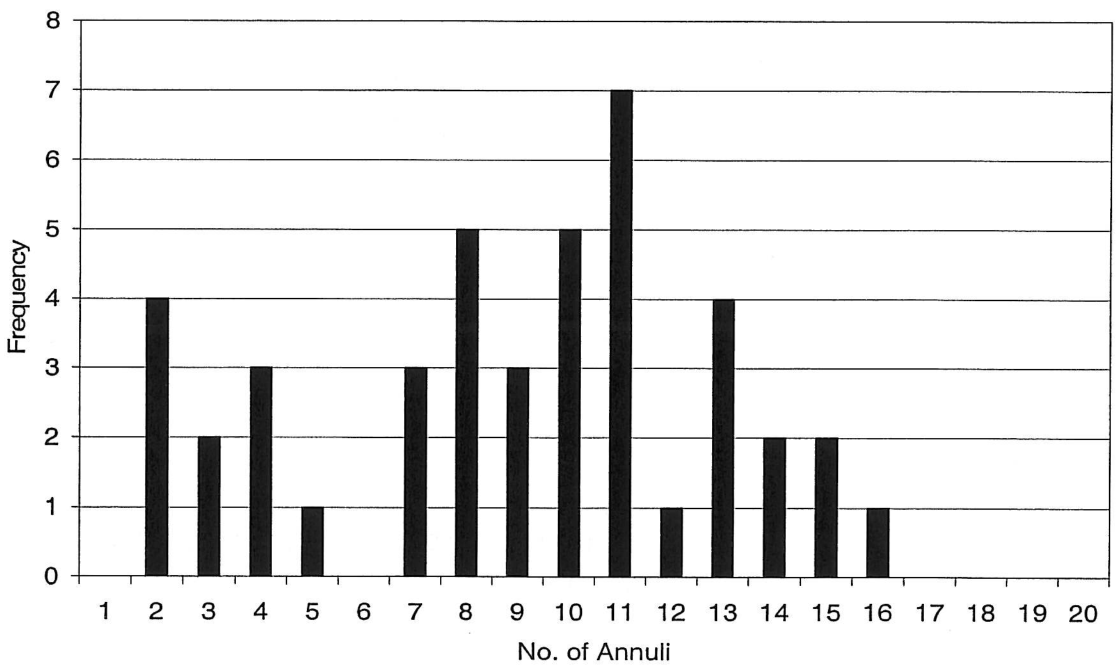
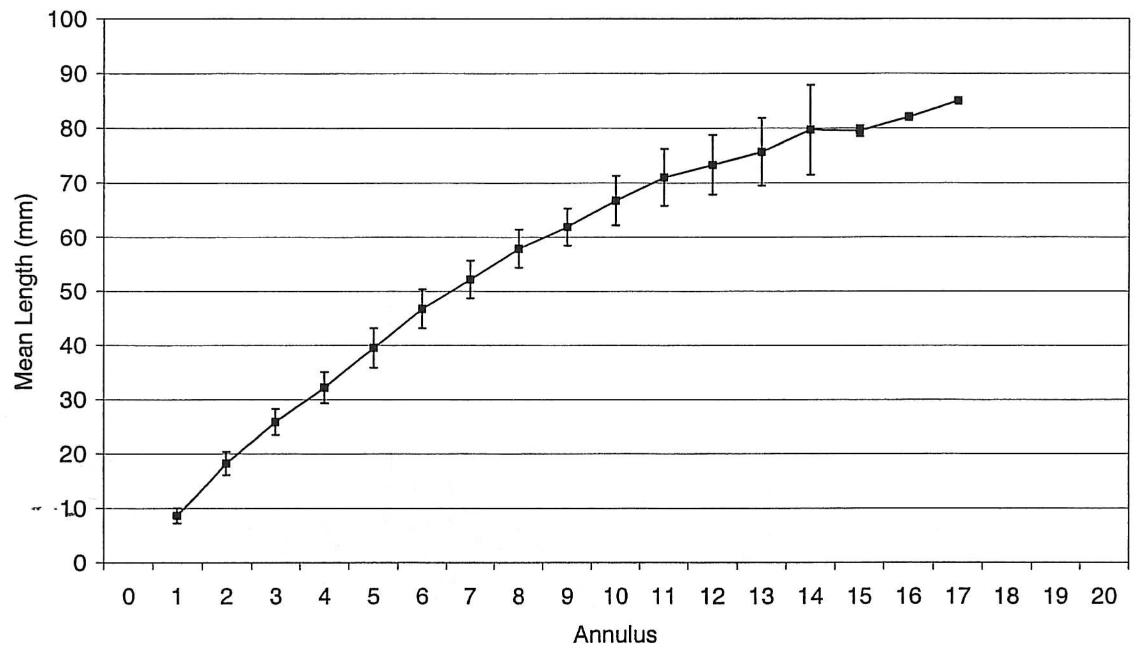


Figure 54. Length (top) and age (bottom) frequency distributions of butter clams collected in Marmot Cove, Princess royal Channel, July 3, 2000.



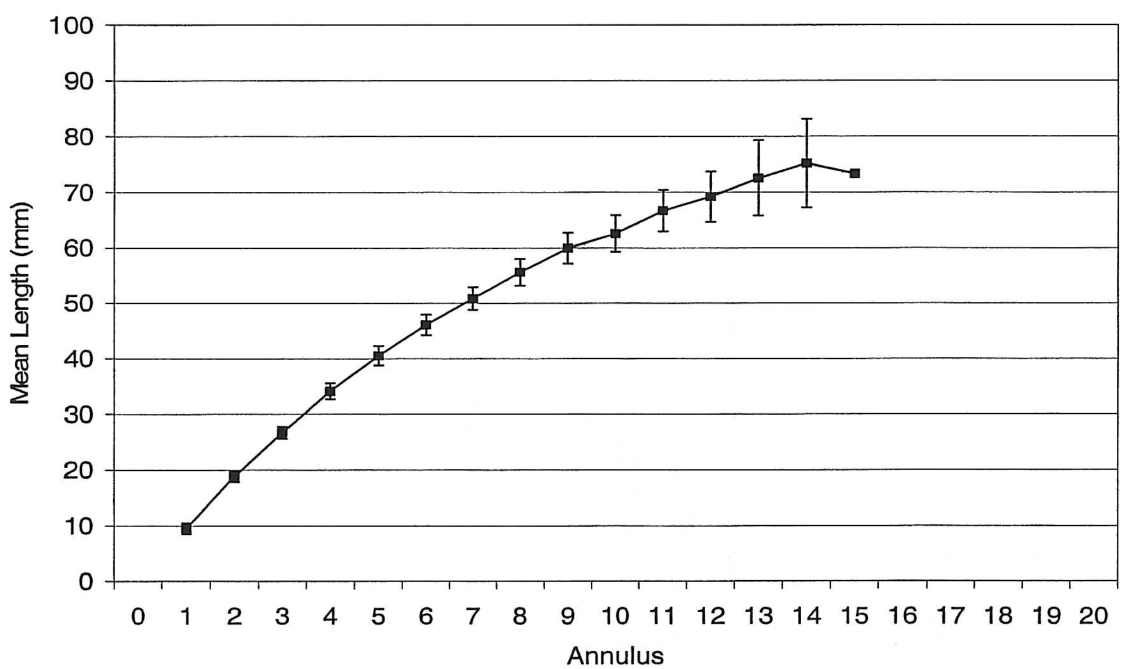
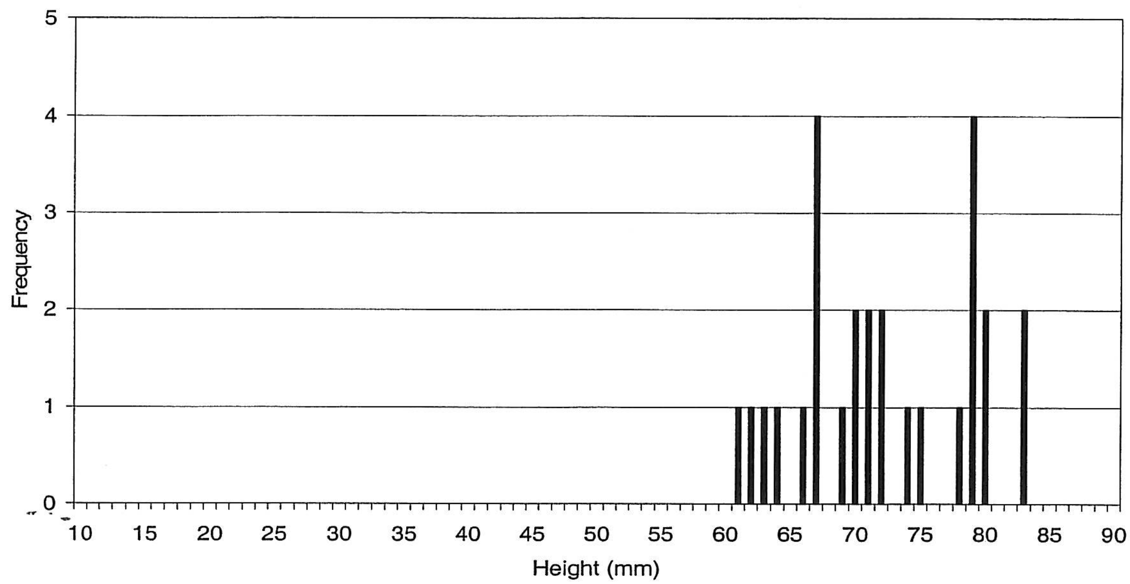


Figure 55. Mean length-at-annulus of butter clams collected in Swanson Bay (top) and Marmot Cove (bottom), Princess Royal Channel, July 3, 2000.

Error bars are 95% confidence intervals.



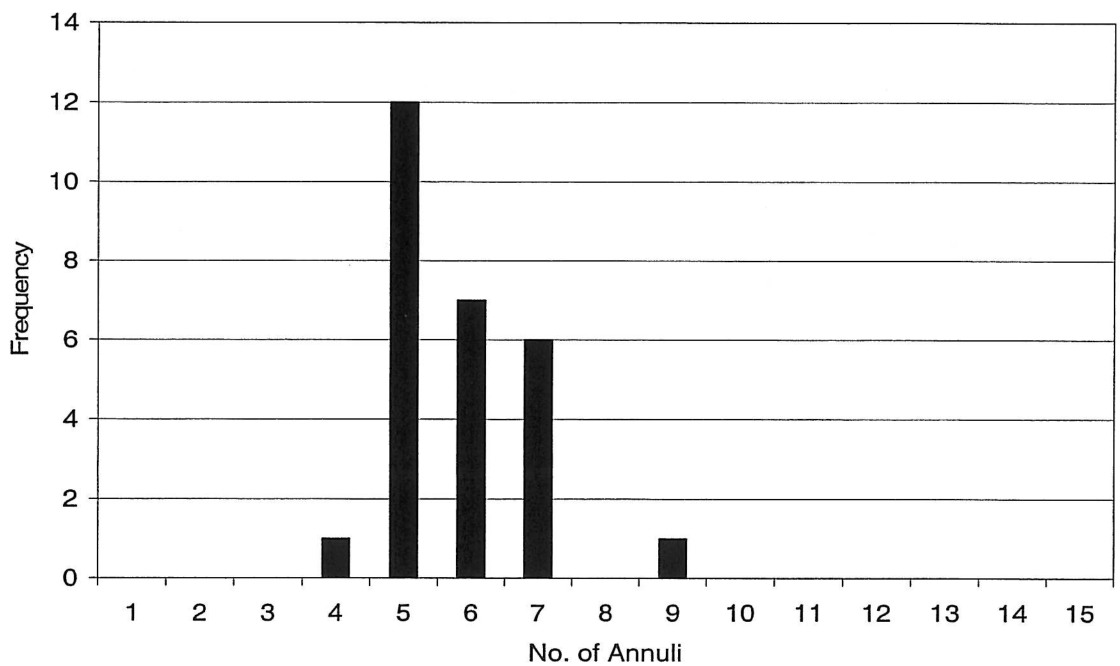


Figure 56. Height (top) and age (bottom) frequency distributions of cockles collected in Scow Bay, Klekane Inlet, Princess Royal Channel, July 3, 2000.

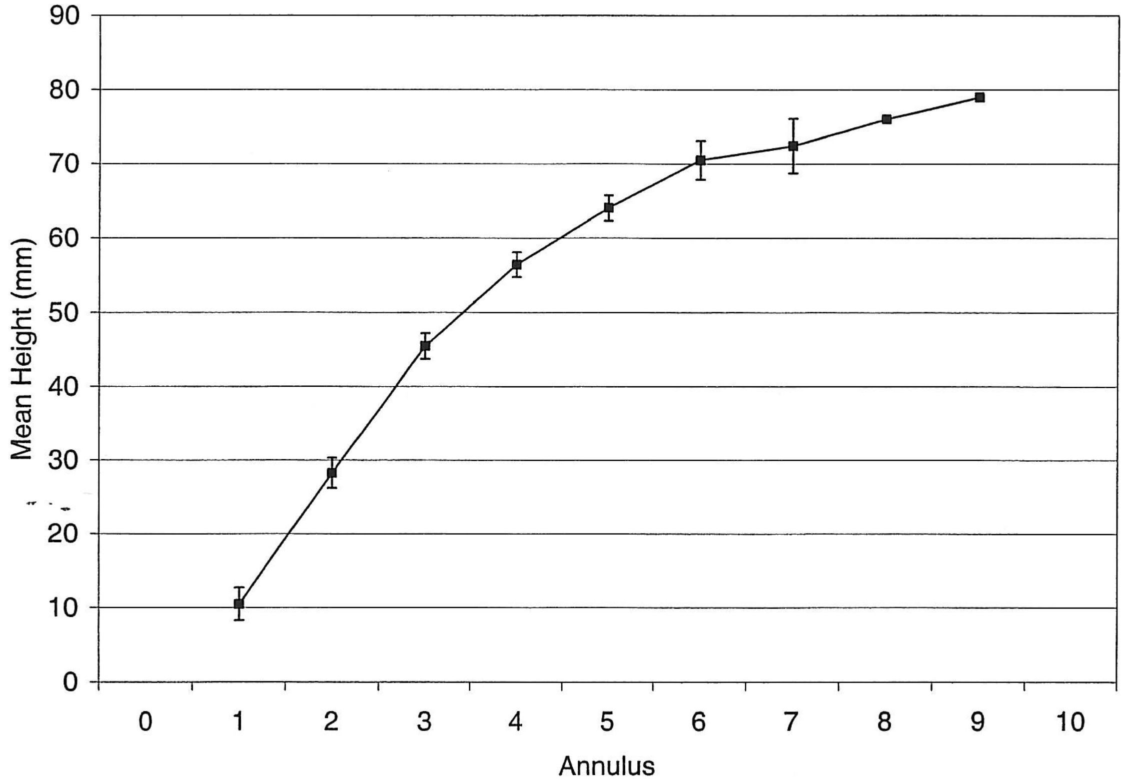


Figure 57. Mean height-at-annulus (mm) for cockles collected in Scow Bay, Klekane Inlet, Princess Royal Channel, July 3, 2000.

Error bars are 95% confidence intervals.

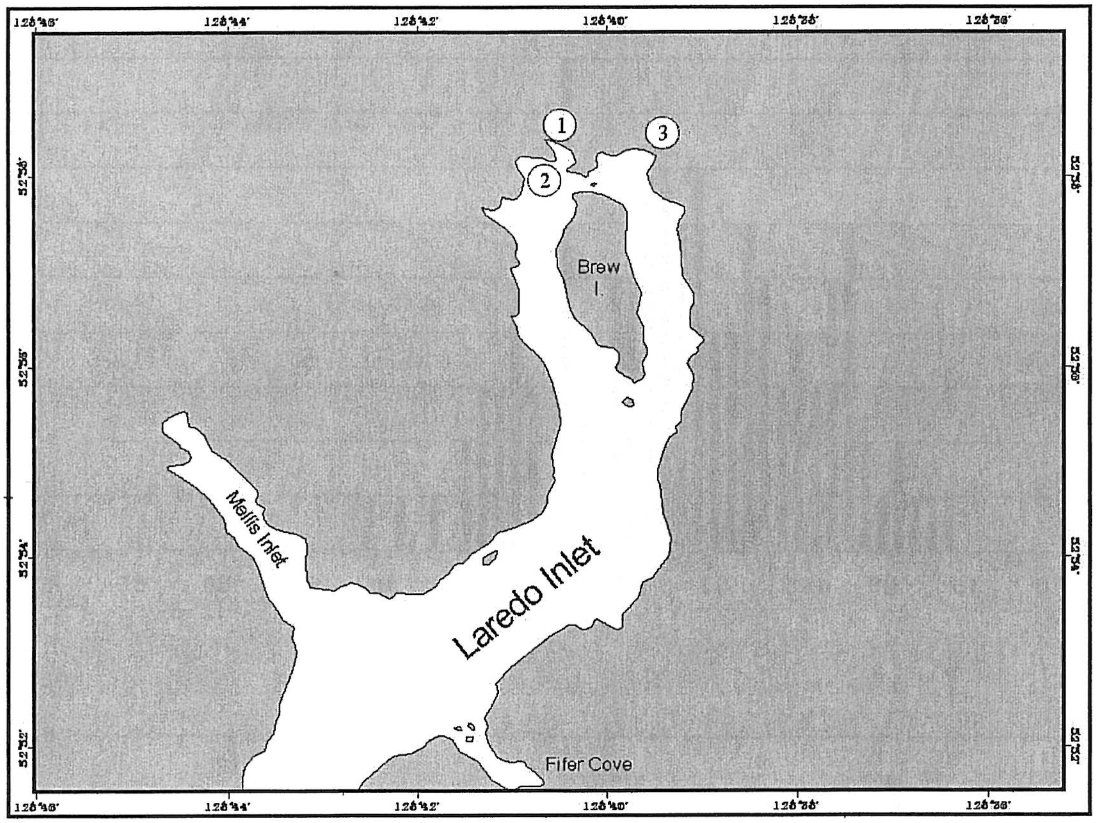


Figure 58. Location of beaches surveyed in Laredo Inlet, July 4, 2000.

Legend: 1 – Inner Arnoup Creek estuary; 2 – Outer Arnoup Creek estuary; 3 – Brew Creek estuary.

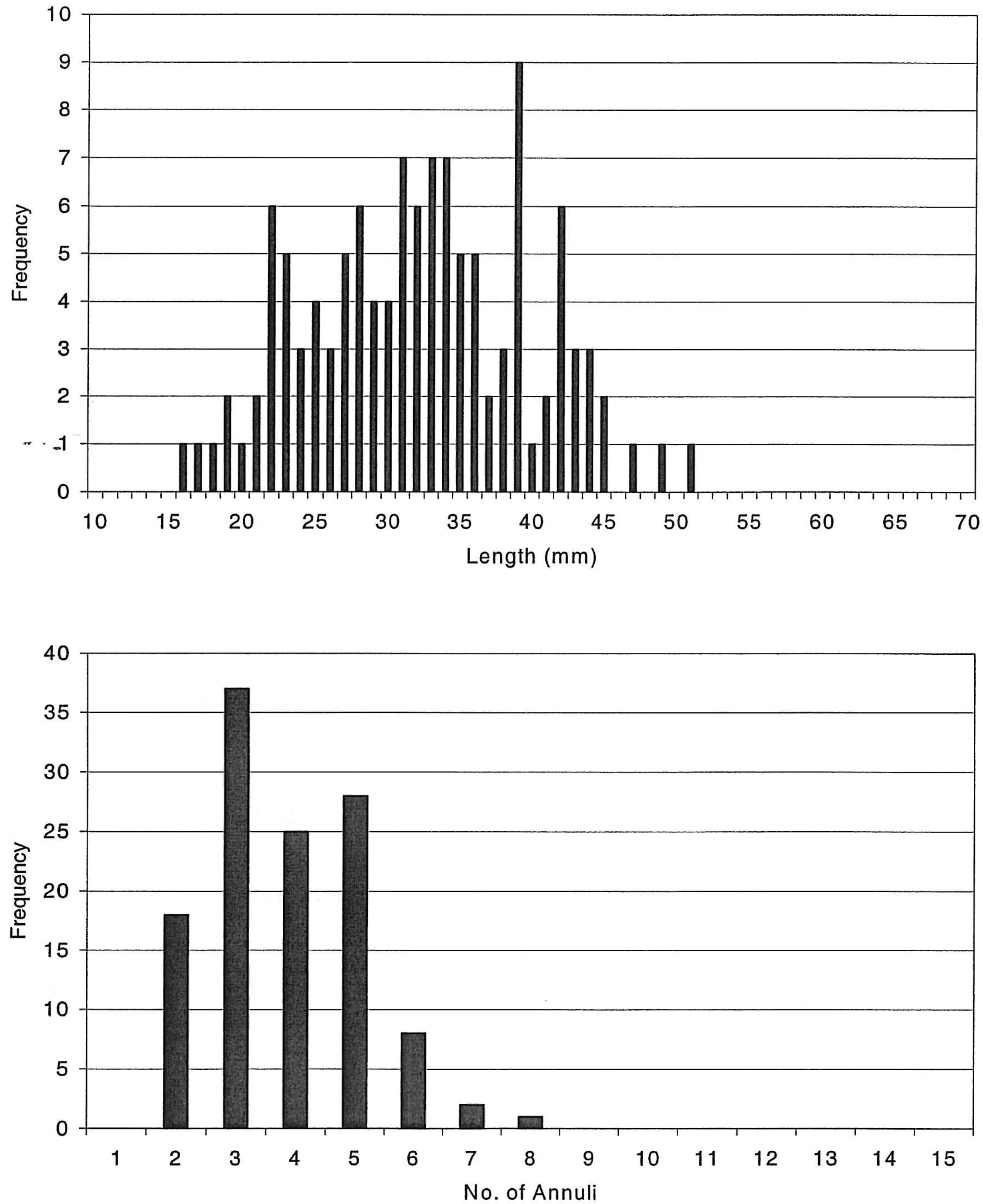


Figure 59. Length (top) and age (bottom) frequency distributions of Manila clams collected in Laredo Inlet, July 4, 2000.

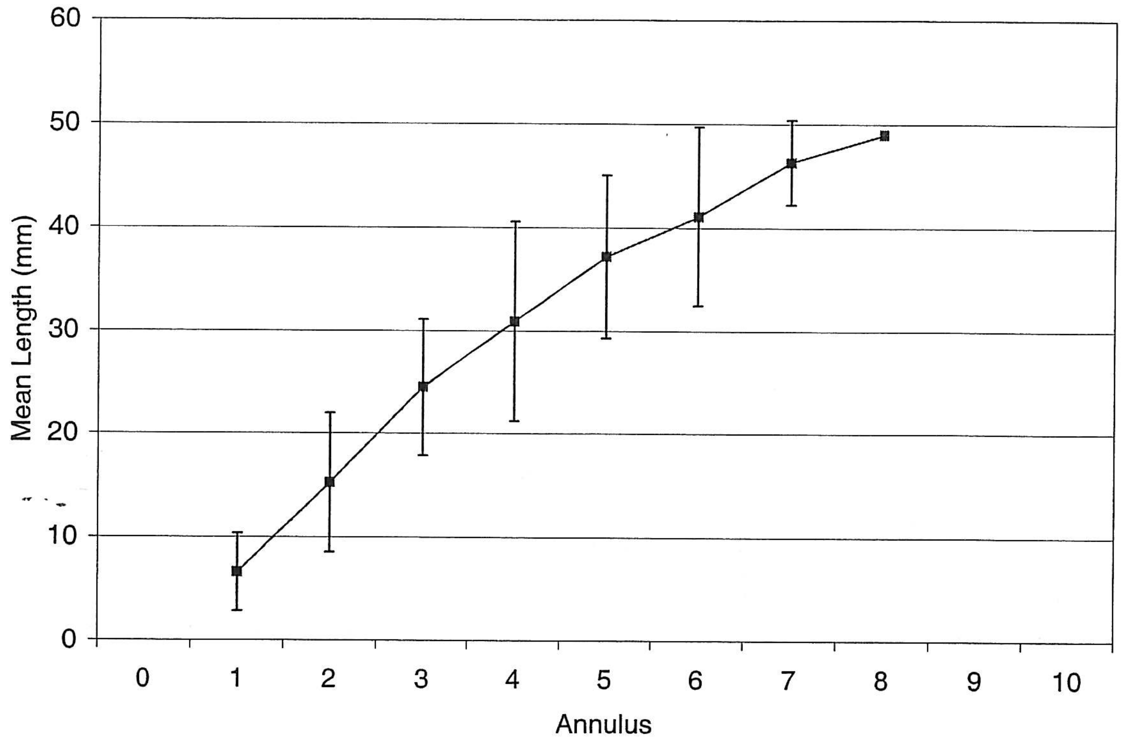
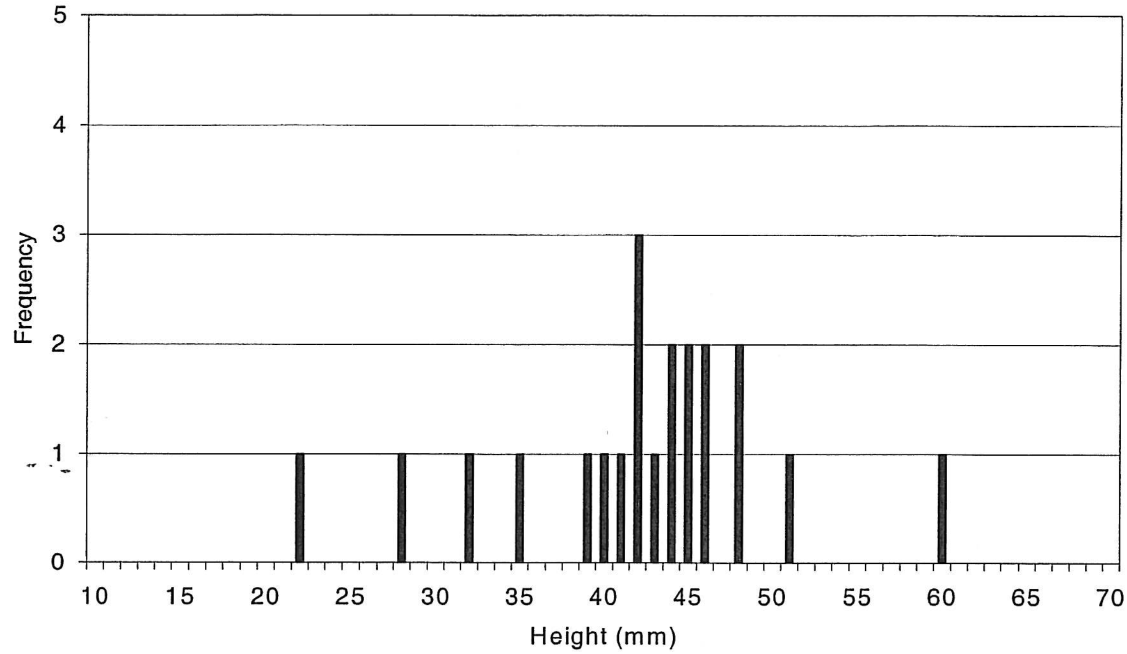


Figure 60. Mean length-at-annulus (mm) of Manila clams collected in Laredo Inlet, July 2, 2000.

Error bars are 95% confidence intervals.



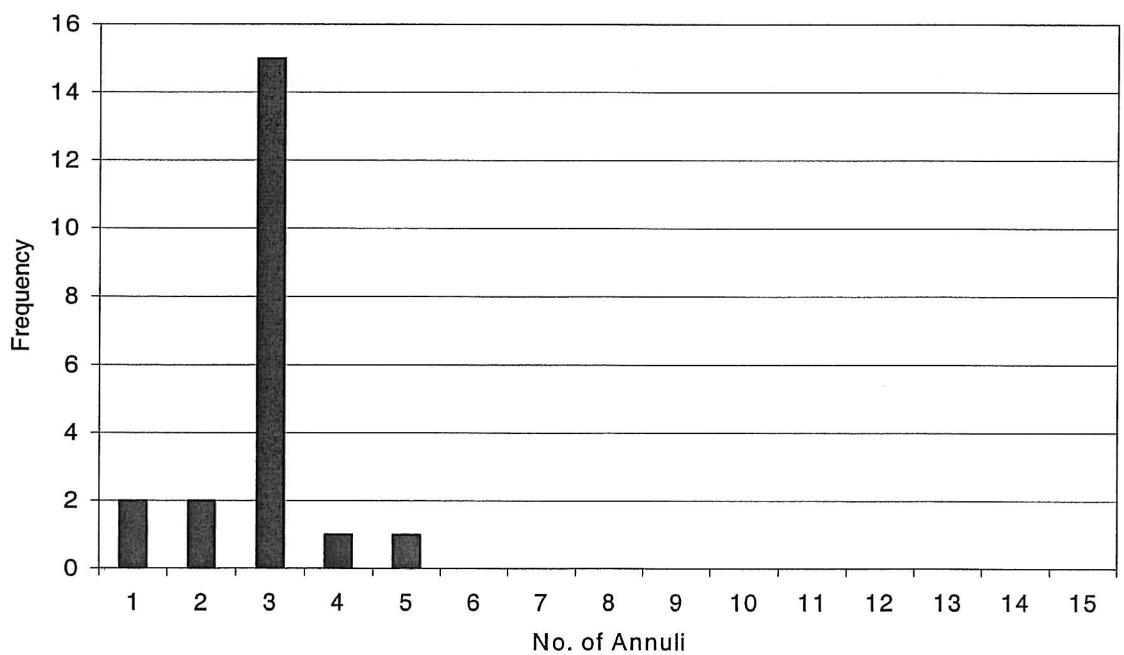


Figure 61. Height (top) and age (bottom) frequency distributions of cockles collected in Laredo Inlet, July 4, 2000.

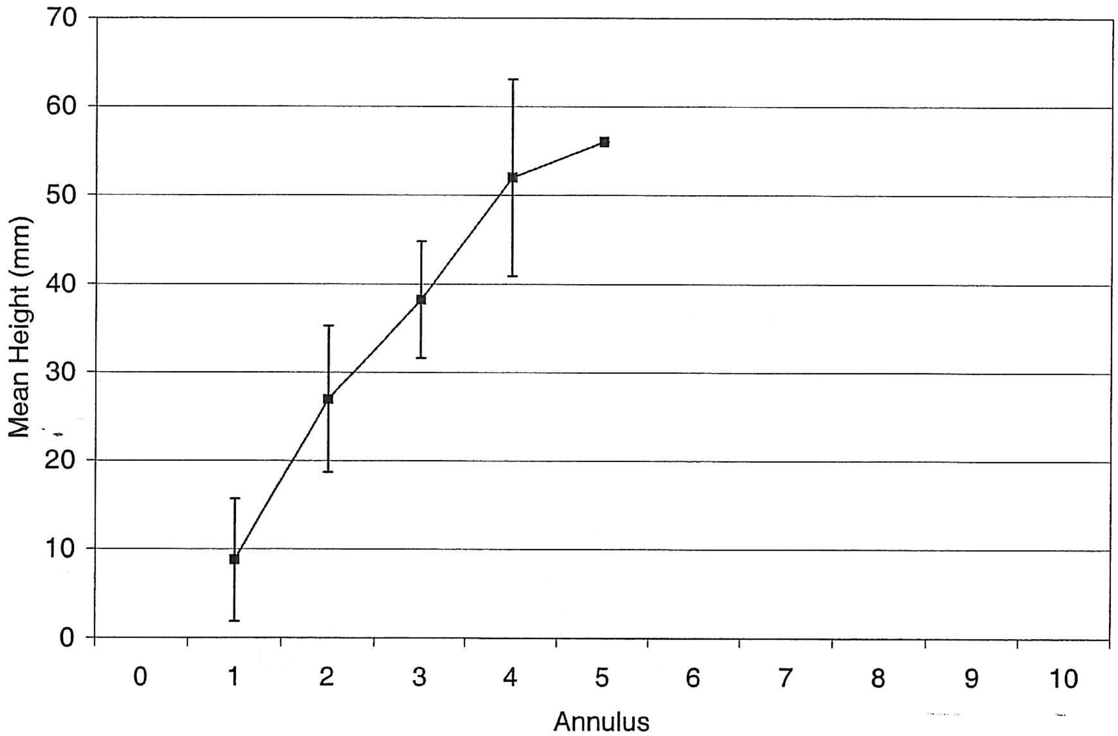


Figure 62. Mean height-at-annulus of cockles collected in Laredo Inlet, July 4, 2000. Error bars are 95% confidence intervals.

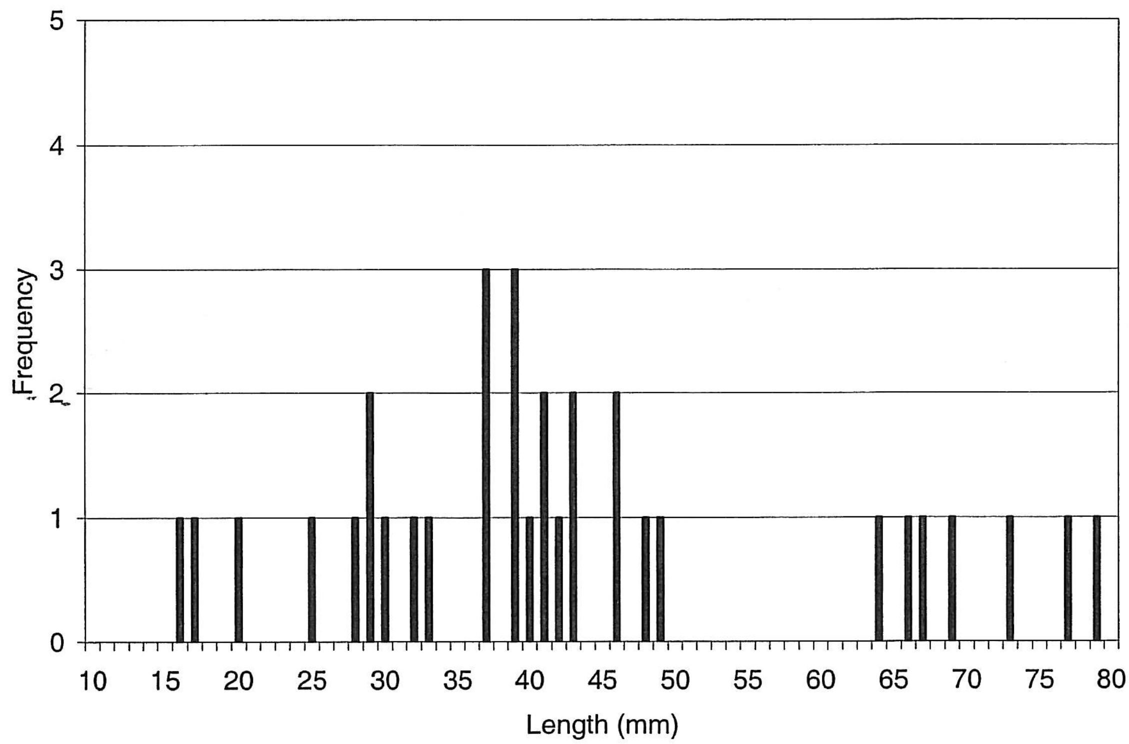


Figure 63. Length frequency distribution of softshell clams collected in Laredo Inlet, July 4, 2000.

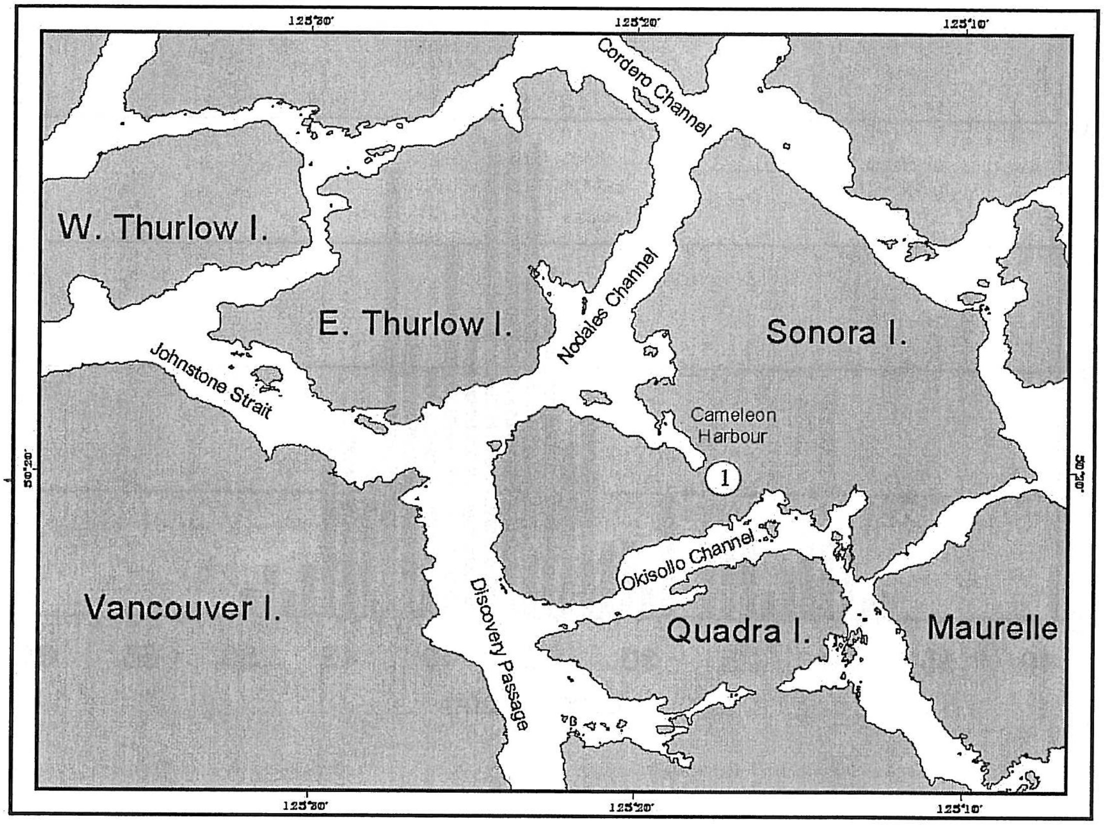


Figure 64. Location of beach surveyed in Cameleon Harbour, July 12, 2000.

Legend: 1 – Head of Cameleon Harbour.

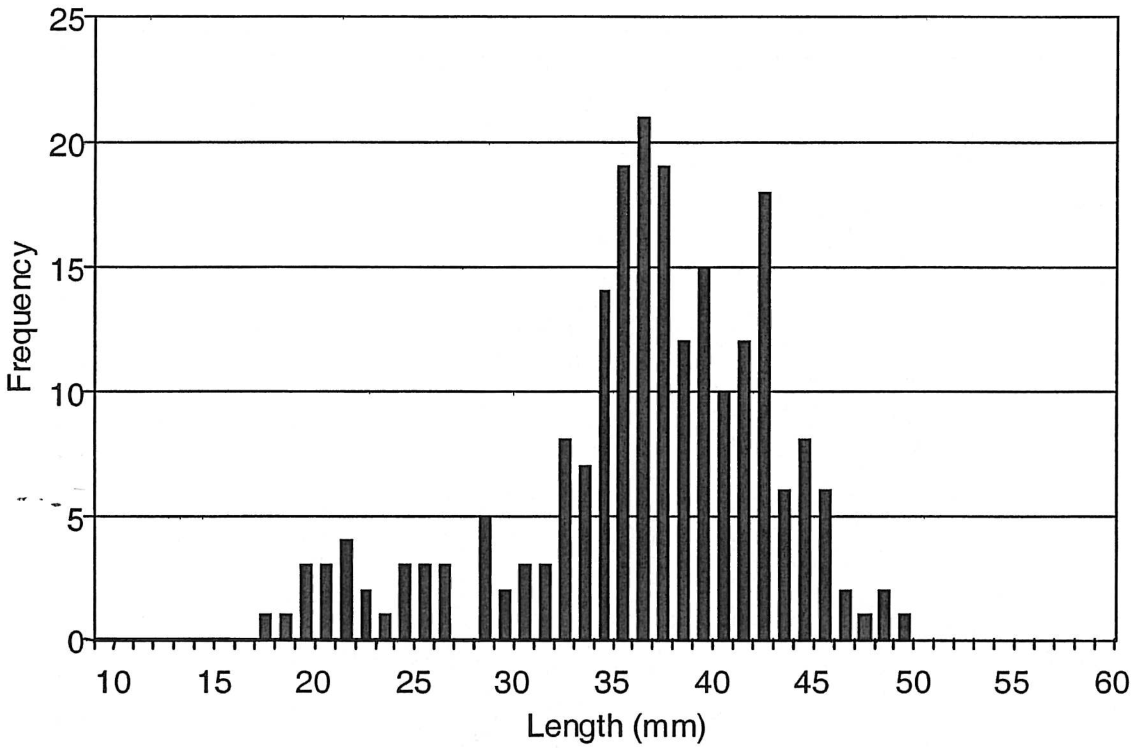


Figure 65. Length frequency distribution of varnish clams collected in Cameleon Harbour, July 12, 2000.

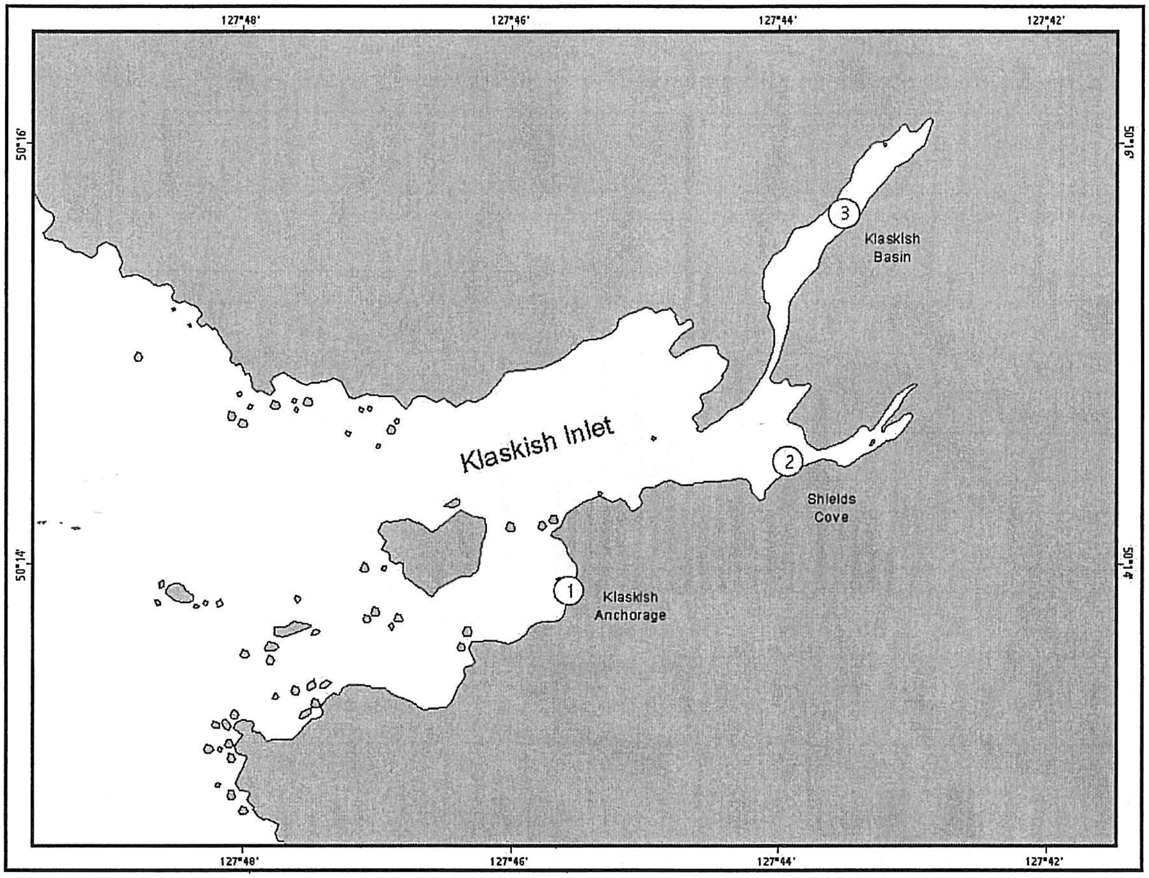
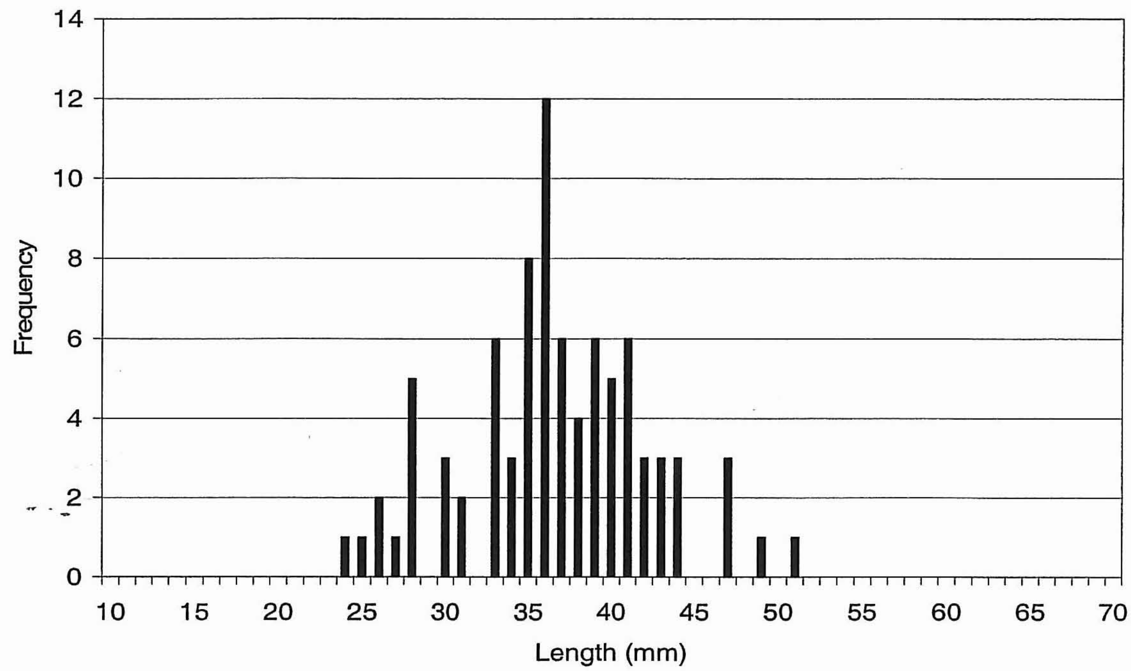


Figure 66. Location of beaches surveyed in Klaskish Inlet, February 18-19, 2001.

Legend: 1 – Klaskish Anchorage; 2 – Shields Cove; 3 – Klaskish Basin.



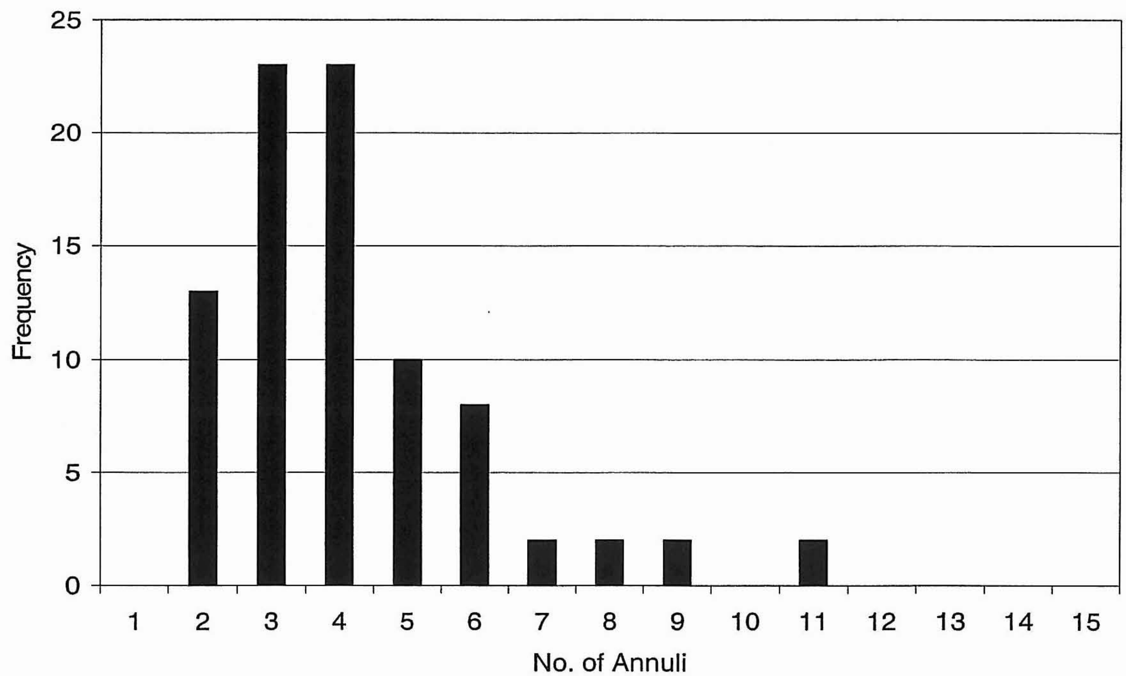


Figure 67. Length (top) and age (bottom) frequency distributions of Manila clams collected in Klaskish Inlet, February 18-19, 2001.

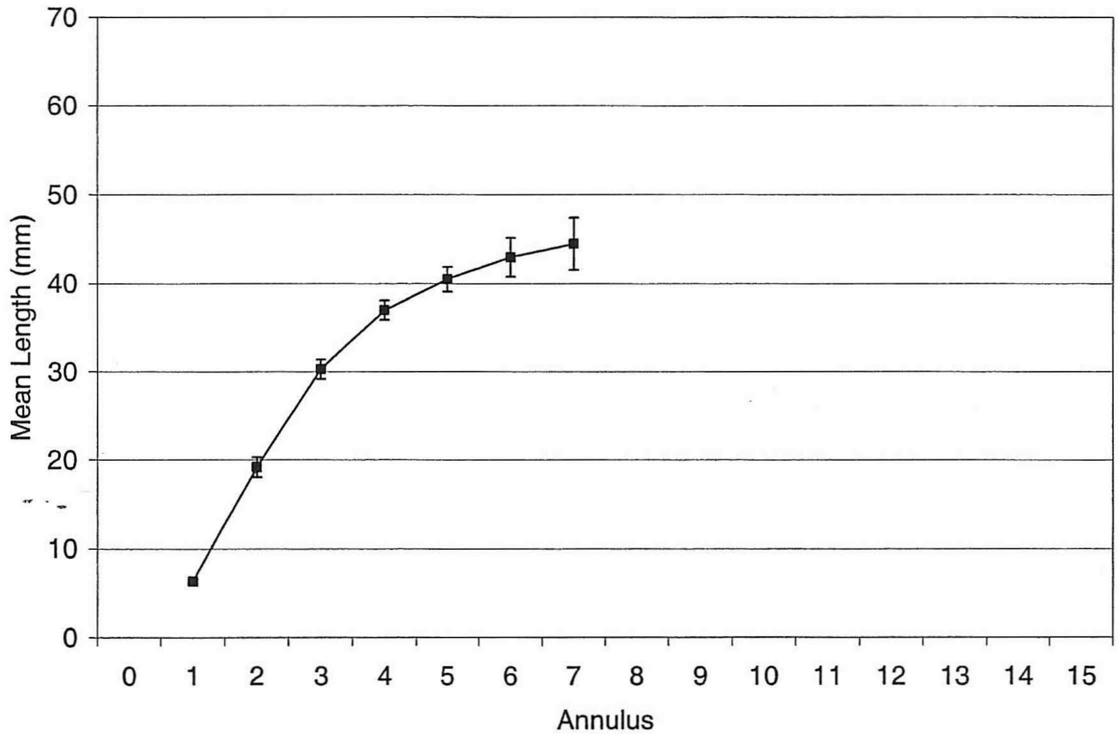
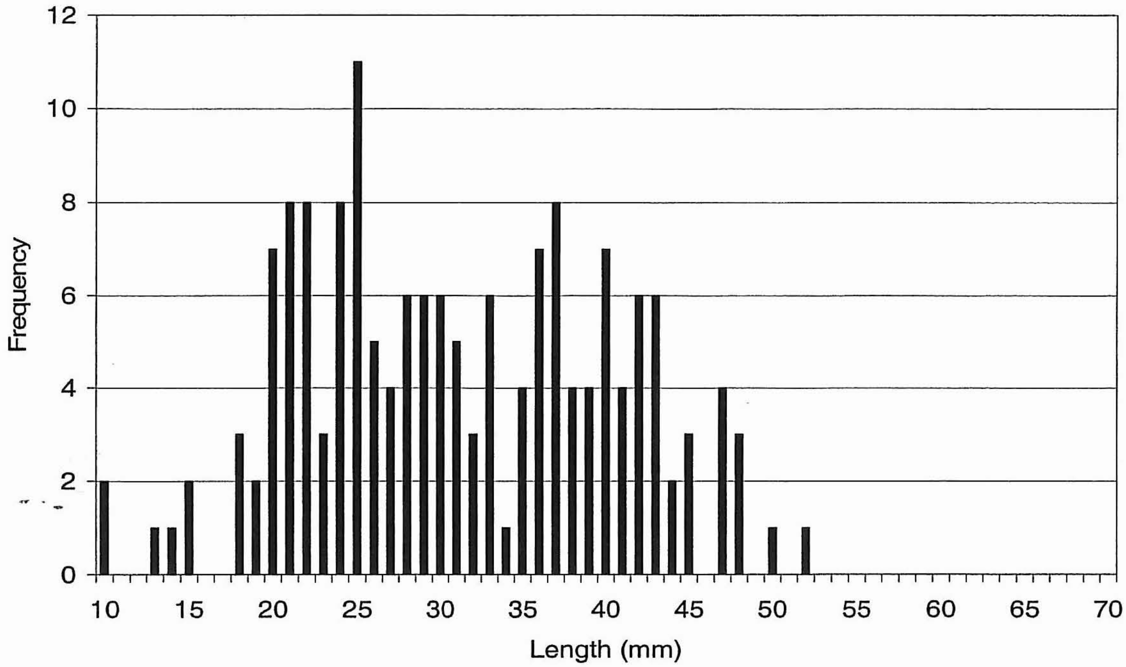


Figure 68. Mean length-at-annulus of Manila clams collected in Klaskish Inlet, February 18-19, 2001.

Error bars are 95% confidence intervals.



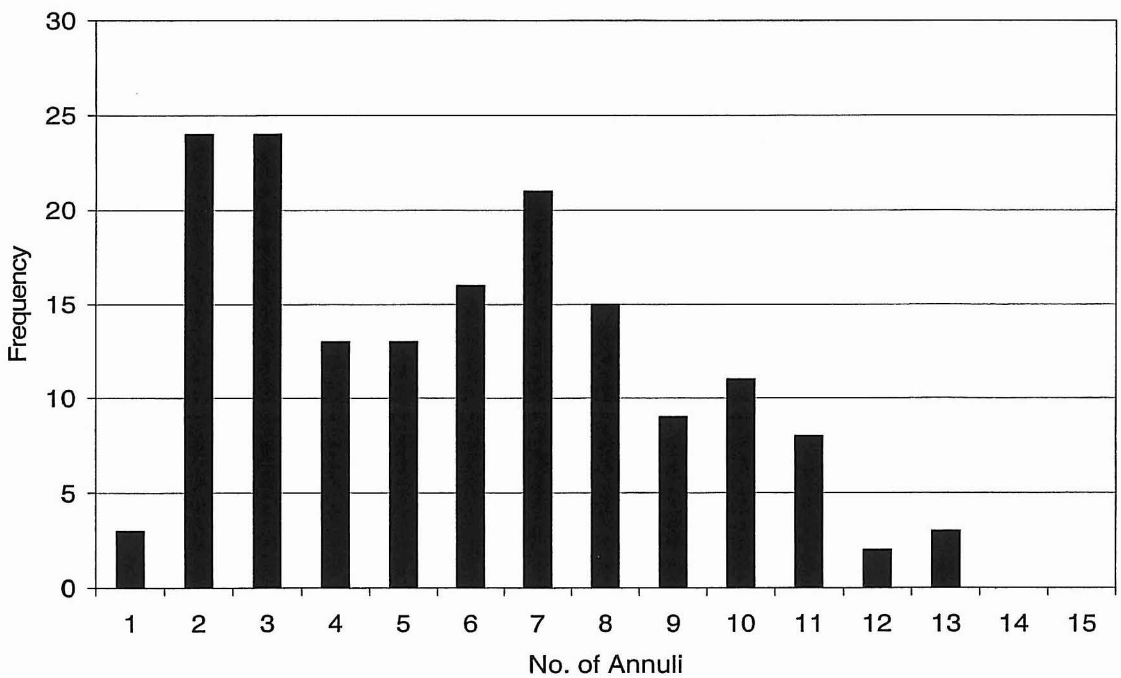


Figure 69. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Klaskish Inlet, February 18-19, 2001.

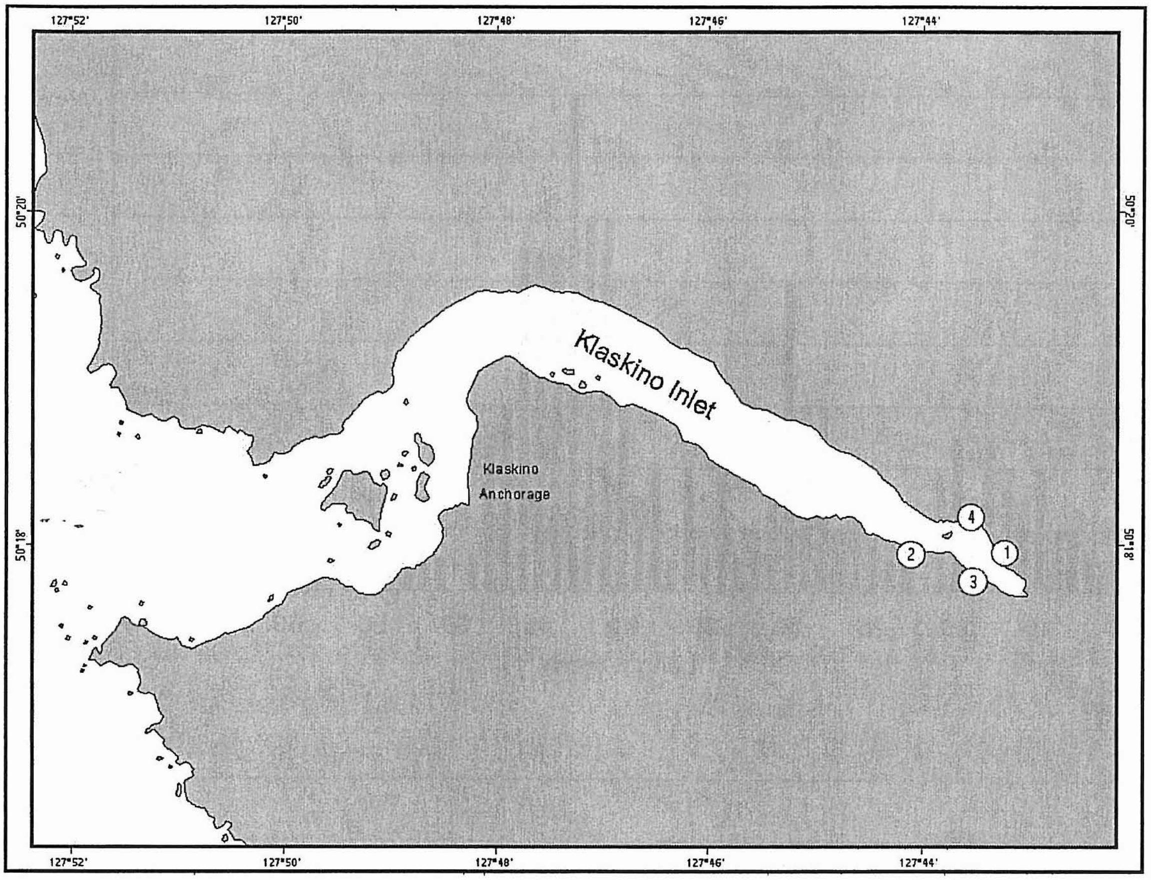


Figure 70. Location of beaches surveyed in Klaskino Inlet, February 20, 2001.

Legend: 1 – Northeast Klaskino Inlet; 2 – Southwest Klaskino Inlet; 3 – Southeast Klaskino Inlet; 4 – Northwest Klaskino Inlet.

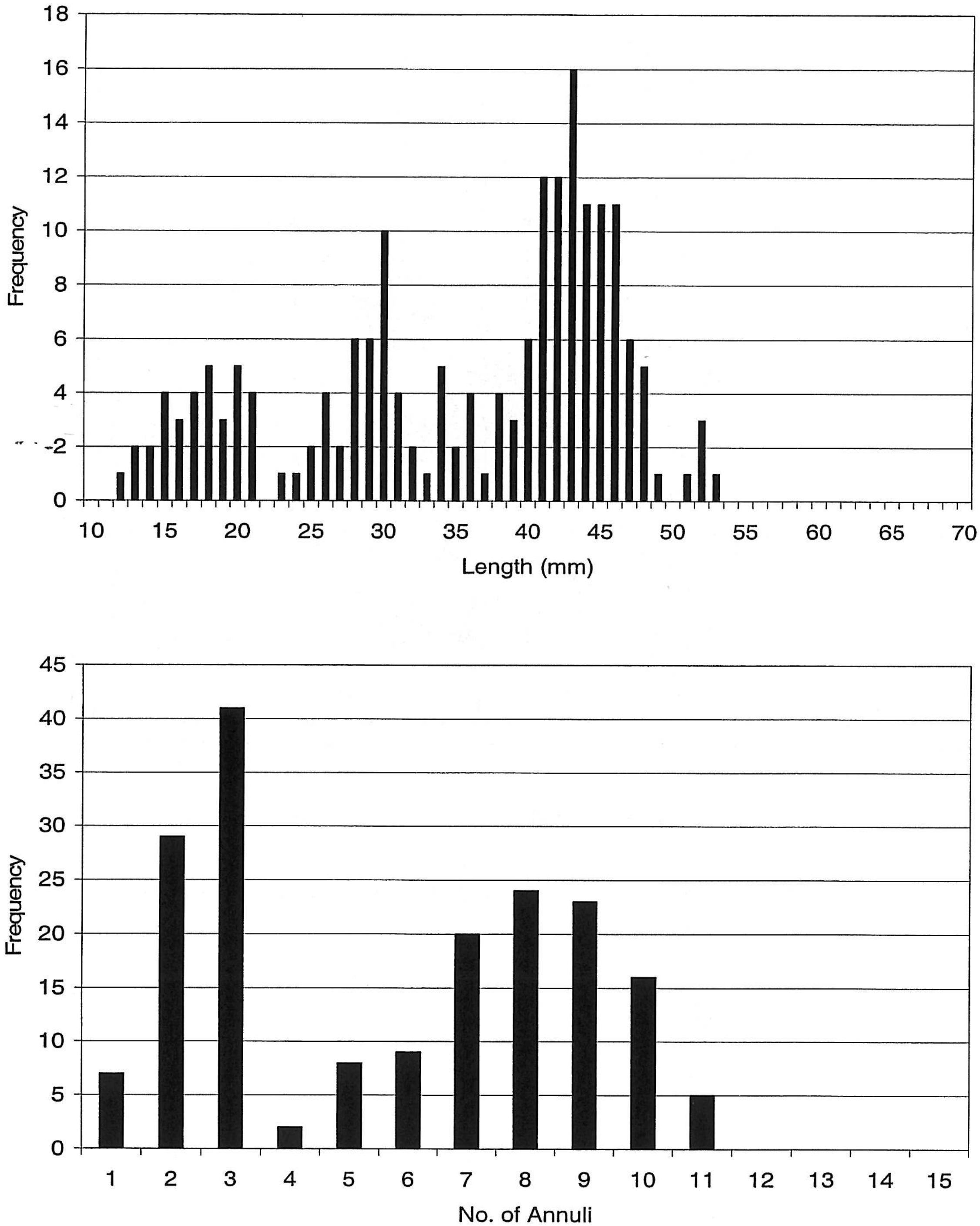


Figure 71. Length (top) and age (bottom) frequency distributions of Manila clams collected in Klaskino Inlet, February 20, 2001.

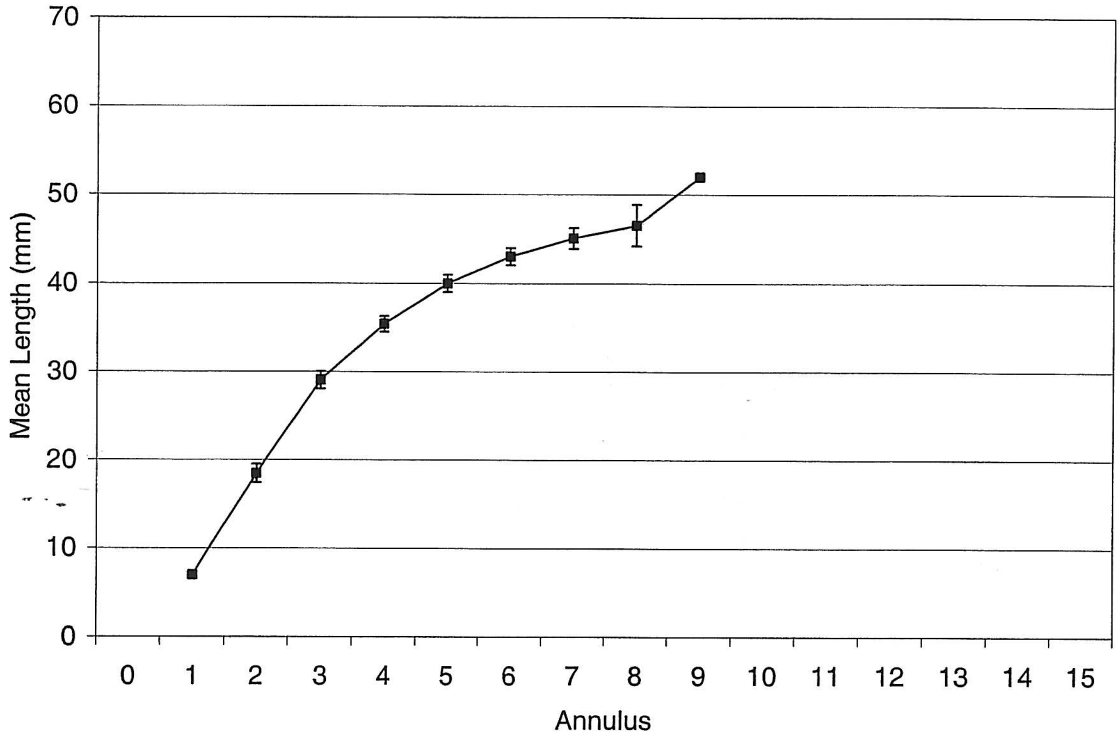


Figure 72. Mean length-at-annulus of Manila clams collected in Klaskino Inlet, February 20, 2001.

Error bars are 95% confidence intervals.

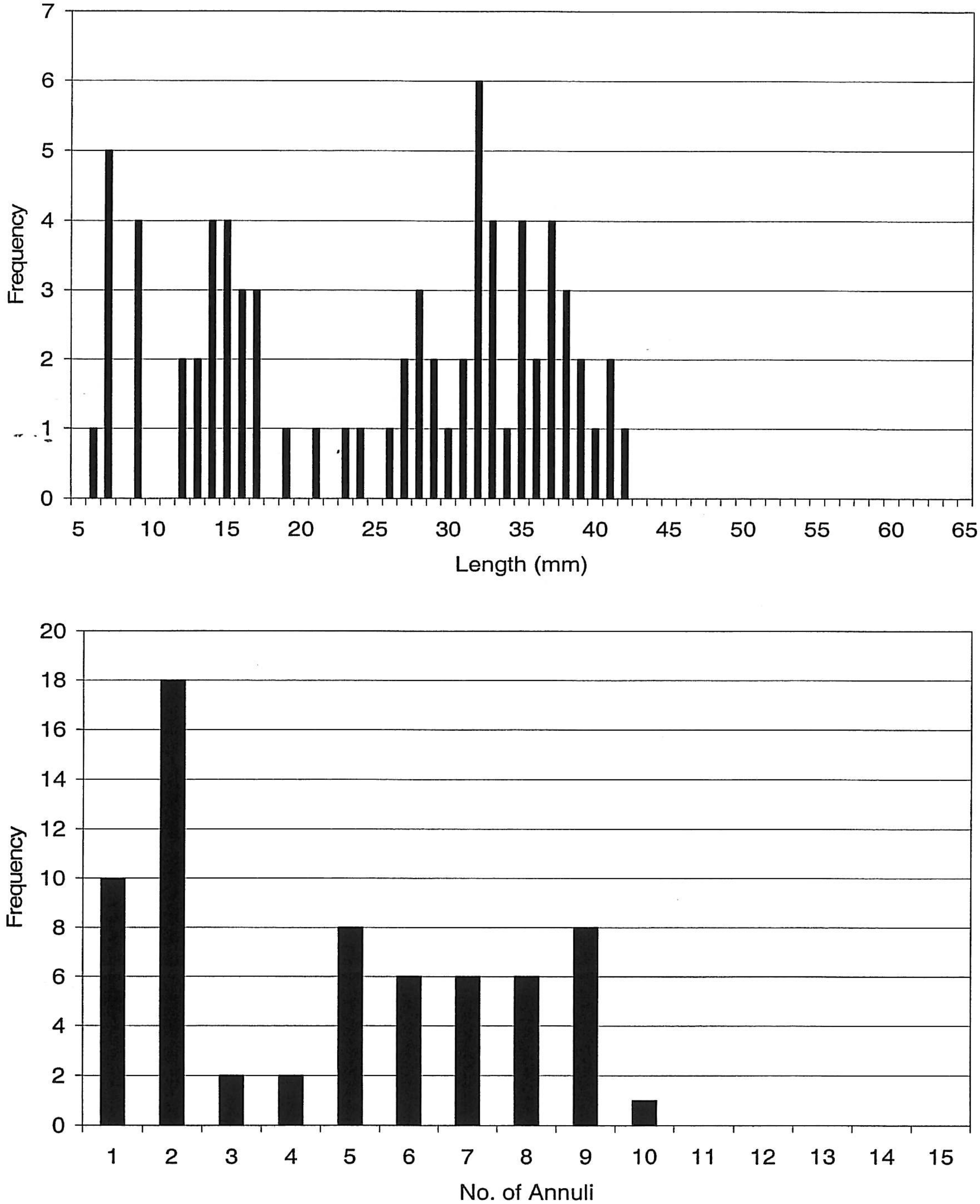


Figure 73. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Klaskino Inlet, February 20, 2001.