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EXPLORATORY INTERTIDAL BIVALVE SURVEYS IN BRITISH COLUMBIA - 2002

by

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ABSTRACT

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Results of exploratory intertidal clam surveys carried out in 2002 to assess populations of commercially important clams, exotic varnish clams, *Nuttallia obscurata*, and native Olympia oysters, *Ostrea conchaphila*, on selected beaches in British Columbia (B.C.) are presented. These surveys were a continuation of exploratory clam surveys initiated in 1990 to assess intertidal clam resources in the North and Central Coasts. These surveys were expanded to include exploratory work in the South Coast to map varnish clam dispersal and distribution of native Olympia oysters.

Manila clams, *Venerupis philippinarum*, were found at low densities in Johnstone and Queen Charlotte Straits and Sunderland Channel. One live clam and some dead shells indicated that the species was present in Seymour and Belize Inlets, but at very low population levels. Manila clams were common on most beaches on the west coast of Vancouver Island, with lower densities recorded in Tofino Inlet and north of Brooks Peninsula.

Varnish clams were confirmed from Salmon Bay in Johnstone Strait, and were found in Barkley, Clayoquot and Kyuquot Sounds and Ououkinsh and Nasparti Inlets on the west coast of Vancouver Island. None were found north of Brooks Peninsula.

Significant populations of Olympia oysters were recorded from Klaskino and Amai Inlets and Port Eliza. Results of the 2002 surveys, as well as previously documented surveys, indicate that extensive populations of Olympia oysters remain relatively rare in B.C.

Most beaches with suitable substrate supported populations of native clam species, including littleneck clams, *Protothaca staminea*, butter clams, *Saxidomus gigantea*, cockles, *Clinocardium nuttallii*, and various *Macoma* species. Relative abundance of each species depended upon the habitat characteristics (tidal elevation, substrate type, exposure, salinity) of individual beaches.

RÉSUMÉ

Gillespie, G.E. and N.F. Bourne. 2005. Exploratory intertidal bivalve surveys in British Columbia – 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2733: xi + 199 p.

Nous présentons ici les résultats des relevés exploratoires réalisés en 2002 pour évaluer l'état des populations d'espèces commercialement importantes de bivalves fouisseurs intertidaux – palourdes, nuttallies obscures (*Nuttallia obscurata*) et huîtres plates du Pacifique (*Ostrea conchaphila*), sur certaines plages de Colombie-Britannique. Ces relevés prolongent les 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) et la distribution de l'huître plate du Pacifique.

La Palourde japonaise (*Venerupis philippinarum*) a été observée en faible densité dans les détroits de Johnstone et de la Reine-Charlotte et dans le passage Sunderlande. La présence d'une palourde vivante et de quelques coquilles vides indique que l'espèce est présente dans les inlets Seymour et Belize, mais à de très faibles niveaux démographiques. Les palourdes japonaises se sont avérées abondantes sur la plupart des plages de la côte ouest de l'île de Vancouver, les densités les plus faibles ayant été observées dans l'inlet Tofino et au nord de la péninsule Brooks.

Nous avons confirmé la présence de la Nuttallie dans la baie Salmon, dans le détroit de Johnstone, dans les baies Barkley, Clayoquot et Kyuquot et dans les inlets Ououkinsh et Nasparti sur la côte ouest de l'île de Vancouver. Aucune nuttallie n'a été trouvé au nord de la péninsule Brooks.

Des populations importantes d'huîtres plates du Pacifique ont été observées dans les inlets Klaskino et Amai et à Port Eliza. Les résultats des relevés de 2002 ainsi que les données recueillies lors de relevés antérieurs indiquent les populations importantes d'huîtres plates du Pacifique restent relativement rares en Colombie-Britannique.

La plupart des plages comportant un substrat adéquat abritent des populations de bivalves indigènes, notamment des palourde du Pacifique, de *Protothaca staminea*, de palourdes jaunes, de *Saxidomus gigantea*, de coques, de *Clinocardium nuttallii* et de diverses espèce du genre *Macoma*. L'abondance relative de chaque espèce dépend des caractéristiques de l'habitat (hauteur de la marée, type de substrat, exposition, salinité) disponible sur chacune des plages.

INTRODUCTION

The present survey is one of a series initiated in 1990 to assess intertidal bivalve resources in British Columbia (B.C.)(Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998; Gillespie and Bourne 1998, 2000, 2005; Gillespie *et al.* 2004). Initially, these surveys concentrated on studies of the dispersal and extent of populations of Manila clams[1] in the coastal waters of northern B.C., as this species has dominated commercial clam landings in B.C. since the 1980's (Figure 1). As a result of these surveys, a commercial fishery for Manila clams was developed in the Bella Bella area (Pacific Fisheries Management Area [PFMA] 7) in 1992, which continues with annual landings ranging from 25-115 t (Gillespie *et al.* 1999a, 2001a; Figure 2).

In recent years these surveys have been expanded to include other regions of B.C., including Johnstone and Queen Charlotte Straits, the west coast of Vancouver Island and the Queen Charlotte Islands. Survey objectives were also expanded to include assessment of species that are utilized in commercial, recreational or First Nations harvests, or have potential to be utilized. These include butter, littleneck and horse clams, cockles, softshells and a number of species of macomas.

Recent effort has also been directed at documenting the dispersal and establishment of viable populations of the exotic varnish clam in B.C. This species was unintentionally introduced into southern B.C. in the in the late 1980's, and has rapidly spread northward (Gillespie *et al.* 1999b, 2001b).

We were also interested in collecting information on the native Olympia oyster, which is listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and under the Species at Risk Act (SARA) as a species of Special Concern (COSEWIC 2004).

The present survey explored beaches at several sites in Johnstone and Queen Charlotte Straits and on the west coast of Vancouver Island (Figure 3). The surveys revisited some sites previously surveyed and explored new sites. The primary objectives of these surveys were gather information on the distribution and biological characteristics of populations of Manila clams, varnish clams and Olympia oysters. Information on other bivalves and other invertebraes was collected opportunistically.

METHODS

Methods used in the surveys have changed little since they began in 1990 and have been described previously (Bourne and Cawdell 1992; Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998; Gillespie and Bourne 1998, 2000; Gillespie *et al.* 2004). Beaches were selected for survey from charts, as well as from previous experience, DFO clam atlases (Harbo *et al.* 1997a,b), contract reports (Cross and Kingzett 1993; Cross *et al.* 1995; Kingzett *et al.*

[1] Common and scientific names for all species recorded are in Appendix 1.

1995a,b), information from Fisheries Officers and local inhabitants and from requests by industry. A guiding principal in this work has been to maximize the number of beaches explored during a tide, rather than survey one or two beaches in detail (*fide* Gillespie and Kronlund 1999). Results of these surveys give estimates of clam distribution and abundance in surveyed areas and not statistically rigorous stock estimates.

The exact location of each beach was determined from charts and by GPS. 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 areas were estimated by digging exploratory holes to delimit clam distribution. Slope of the beach and substrate type were recorded. The high tide line was surveyed for drift shell of intertidal clams and 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 clams 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 m^2 or 1.00 m^2 were dug. Quadrats in the upper portion of the intertidal zone (0.25m^2 targeting mainly Manila clams and to a lesser extent 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 butter clams and to a lesser extent 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 Manila clams 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 for further identification.

Total length of each clam (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. 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 Manila, littlenecks, butter, softshells and cockles. 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 20 cm was recorded with a standard hand-held thermometer in each area. A five minute surface plankton tow using a 40 cm diameter frame and 70 μm mesh was made in most areas to determine the presence of any bivalve larvae.

RESULTS

A total of 58 beaches was surveyed in 13 locations in the South and Central Coasts of B.C. (Table 1, Figure 3).

Clayoquot Sound

Clayoquot Sound is a large system of inlets and channels on the southwest coast of Vancouver Island. Shores near the mouth, where the sound is open to the Pacific Ocean, are typically rocky or wave-swept sand beaches. Neither would support populations of hardshell clams, although the latter can support razor clams, *Siliqua patula*. Further up the inlets there are pocket beaches formed in bays, in the lee of points or islets, or at the mouth of streams. If these beaches have substrates of mixed sand, gravel, mud and/or shell, they can be ideal for hardshell clams.

Between April 16-18, 2002, 14 beaches were examined in Clayoquot Sound: three beaches in Gunner Inlet, Island Cove, Indian Bay, and Tsapee Narrows in Tofino Inlet; Atleo River and Sharpe Creek estuaries in Millar Channel; Big Whitepine and Little Whitepine Coves in Herbert Inlet; Cypre River estuary and Cypress Bay in Maurus Channel; and Warn Bay and Mosquito Harbour in Fortune Channel (Figure 4).

Description of Beaches

Most of the beaches in Tofino Inlet were small, generally less than 1.5 ha, with mixed gravel and sand substrates (Table 2). The two exceptions were the southernmost beach in Gunner Inlet, which was largely mud, and Tsapee Narrows, which was a packed sand beach. All beaches in Millar and Herbert Channels were gravel and sand substrates and beaches at Atleo River and Big Whitepine Cove were fairly large (3-5 ha). Beaches in Maurus and Fortune Channels were all fairly large, between two and at least 10 ha, and all had mixed gravel and sand substrates. All beaches surveyed in the Clayoquot Sound area were well protected and had low slopes.

Bivalve Populations

Olympia Oysters

Live Olympia oysters were observed sparsely scattered across the beach at Big Whitepine Cove. No Olympia oysters or shell were observed on the other surveyed beaches.

Manila Clams

Live Manila clams were observed on all but two beaches; the beach at the head of Gunner Inlet and Tsapee Narrows, although Manila shell was observed at the latter location (Table 2). Estimated densities were 24-84 clams m^{-2} at the southernmost beach in Gunner Inlet, 23 clams m^{-2} at Island Cove, 0-16 clams m^{-2} at Indian Bay, 0-288 clams m^{-2} at Atleo River, 28-196 clams m^{-2} at Sharpe Creek, 148-400 clams m^{-2} at Big Whitepine Cove, 156-224 clams m^{-2} at Little Whitepine Cove, 0-8 clams m^{-2} at Cypre River, 4 clams m^{-2} at Cypress Bay and 0-252 clams m^{-2} at Warn Bay (Table 3).

Manila clams sampled in Tofino Inlet were predominantly young sublegal clams. Size ranged from 23-38 mm TL in Gunner Inlet and the age frequency distribution was dominated by three-year-olds (Figure 5). Size at Island Cove ranged from 22-45 mm TL, with virtually all clams sampled being sublegal, and the age frequency distribution was dominated by four-year-olds (Figure 6). Indian Bay Manila clams ranged from 25-42 mm TL with only one legal size clam in the sample, and the age frequency distribution was dominated by three- and four-year-olds (Figure 7). Size and age at Atleo River ranged from 11-51 mm TL and 1-7 years, respectively, with a significant contribution by young age classes indicating regular recent recruitment (Figure 8). Size ranged from 23-48 mm TL and age from 3-9 years at Sharpe Creek, where the dominant age class was four years (Figure 9). At Big Whitepine Cove, size and age ranged from 9-55 mm TL and 1-9 years respectively, and the most abundant age classes were five and six (Figure 10). Size and age ranged from 27-48 mm TL and 3-10 years respectively at Little Whitepine Cove, with ages five and six dominating the frequency distribution (Figure 11). Size ranged from 9-49 mm TL and age from 1-9 years in Warn Bay (Figure 12).

Varnish Clams

Live varnish clams were observed at low densities at Indian Bay (17 clams m^{-2}), Cypre River (5-44 clams m^{-2}), Cypress Bay (28 clams m^{-2}) and Warn Bay (0-1 clams m^{-2})(Table 3).

Size at Indian Bay ranged from 35-55 mm TL (Figure 13) and from 20-48 mm TL at Cypre River (Figure 14).

Littleneck Clams

Live littlenecks were observed at all beaches except those in Tofino Inlet (Gunner Inlet, Island Cove, Indian Bay and Tsapee Narrows)(Table 2). Some littleneck shell was observed at Tsapee Narrows. Densities ranged from 0-228 clams m^{-2} at Atleo River, 48-316 clams m^{-2} at Sharpe Creek, 0-40 clams m^{-2} at Big Whitepine Cove, 0-4 clams m^{-2} at Little Whitepine Cove, 4 clams m^{-2} at Cypress Bay and 0-28 clams m^{-2} at Warn Bay (Table 3).

Size and age ranged from 11-51 mm TL and 1-10 years at Atleo River, with greatest contribution by younger age classes (2-4 years)(Figure 15). Size ranged from 19-50 mm TL at Sharpe Creek and age from 3-10 years with the frequency distribution dominated by moderately old age classes, 4-7 years (Figure 16). Size ranged from 17-49 mm TL and age from 2-7 years in Big Whitepine Cove (Figure 17).

Butter Clams

No legal size butter clams were observed in samples from any of the beaches surveyed in Clayoquot Sound. A single butter clam was found in quadrats at Indian Island, and densities ranged from 0-44 clams m^{-2} at Atleo River, 0-196 clams m^{-2} at Sharpe Creek, and 0-4 clams m^{-2} in both Big Whitepine Cove and Warn Bay (Table 3). Live butter clams and butter shell were observed at the Cypre River estuary and in Cypress Bay, respectively (Table 2).

Size and age ranged from 14-59 mm TL and 1-7 years respectively at Atleo River (Figure 18). Size and age ranged from 9-61 mm TL and 1-10 years respectively at Sharpe Creek with strong contribution in the age frequency distribution from three-and four-year old clams (Figure 19). Size and age ranged from 20-56 mm TL and 2-8 years in Big Whitepine Cove (Figure 20).

Other Species

Live Baltic macomas were collected at densities of 0-77.8 clams m^{-2} at the head of Gunner Inlet, 0-0.3 clams m^{-2} at Indian Bay, 0-24 clams m^{-2} at Atleo River, 0-8 clams m^{-2} in Little Whitepine Cove, 0-28 clams m^{-2} at the Cypre River estuary and 4 clams m^{-2} in Cypress Bay (Table 3) and were observed at Gunner Inet 2, Gunner Inlet 3 and Island Cove (Table 2). Live pointed macomas were collected at densities of 0-16 clams m^{-2} at Atleo River, 8-92 clams m^{-2} at Sharpe Creek and 0-44 clams m^{-2} in Big Whitepine Cove (Table 3). Shell of bentnose macoma were observed at Tsapee Narrows (Table 2).

Live softshells were collected at densities of 32-1,625 clams m^{-2} at the head of Gunner Inlet, 60-84 clams m^{-2} at Gunner Inlet 3, 0-18 clams m^{-2} at Indian Bay, 0-56 clams m^{-2} at Atleo River, 0-8 clams m^{-2} at Sharpe Creek, 0-32 clams m^{-2} in Big Whitepine Cove, 4 clams m^{-2} in Little Whitepine Cove, 0-28 clams m^{-2} at the Cypre River estuary and 28 clams m^{-2} in Cypress Bay (Table 3). Live softshells were also observed at Gunner Inlet 2 and Island Cove (Table 2). Size and age ranged from 17-62 mm TL and 1-7 years at the head of Gunner Inlet (Figure 21), 30-72 mm TL and 2-10 years at Gunner Inlet 2 (Figure 22), 14-77 mm TL and 1-8 years in Indian Bay (Figure 23), 13-76 mm TL and 1-5 years at Atleo River (Figure 24) and 16-87 mm TL and 1-9 years in Big Whitepine Cove (Figure 25).

Live cockles were collected at densities of 0-0.7 clams m^{-2} in Indian Bay (Table 3). Cockle shell was observed at Tsapee Narrows, Sharpe Creek, Big Whitepine Cove, Cypress Bay and Warn Bay (Table 2).

Horse clam (*T. capax*) shell was reported from Tsapee Narrows and Atleo River (Table 2). Pacific oysters or their shells were observed on all beaches in Gunner Inlet, Island Cove, Atleo River and Big Whitepine Cove.

Other Observations

No plankton tows or water temperatures were collected due to the time of year the surveys were carried out. April temperatures have little significance for clams that spawn in the summer or fall, and few larvae of the primary species of interest would be in the water column.

Johnstone Strait

Johnstone Strait extends approximately 87 km along the northern shore of Vancouver Island from Chatham Point to Blinkhorn Peninsula. The surrounding terrain is mountainous, and the shores generally steep except where large stream systems empty into the strait.

The Johnstone Strait area has supported limited commercial harvest of intertidal clams in past years, mostly for littleneck clams (Quayle and Bourne 1972; Webb 2002, 2004). The area has been of interest in determination of the route of northward dispersal of Manila clams in B.C. Originally it was believed that Manila clams could not be dispersed north of the Discovery Passage-Yuculta Rapids area at the northern end of the Strait of Georgia because of cold water temperatures (Quayle and Bourne 1972; Bourne 1982). It was postulated that the minor populations of Manila clams that were found in the Johnstone Strait area during intertidal clam surveys resulted from settlement of larvae that were transported down the strait from the north. This assumption has proven to be false from results of intertidal clam surveys that have been undertaken since 1990 (Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998; Gillespie *et al.* 2004). In 1991, a population of Manila clams was found in Cameleon Harbour, just north of the Discovery Passage area, which was undoubtedly established by larvae that drifted northward from the Strait of Georgia (Bourne *et al.* 1994). This population has been assessed on other occasions (Bourne and Heritage 1997; Heritage *et al.* 1998; Gillespie *et al.* 2004) and has proven to be extensive; indeed it has supported limited commercial harvest (R. Webb, DFO Parksville, pers. comm.). Other small populations of Manila clams have been found in other parts of Johnstone Strait, specifically Port Harvey and Port Neville (Bourne and Heritage 1997; Heritage *et al.* 1998).

A more thorough survey of the Johnstone Strait area was warranted to assess clam populations in the general area, and in particular to determine the extent of Manila and varnish clam populations. Between June 23-25, 2002, investigations were undertaken in the middle part of the strait at Salmon Bay, a small beach to the south of Salmon Bay and H'Kusam Bay (Table 2, Figure 26). Sunderland Channel, which runs north from Johnstone Strait, was also explored, including surveys of beaches in Forward and Topaze Harbours. Survey activity was curtailed to a limited extent because of boat problems.

Description of Beaches

Three of the beaches surveyed were very large: the Salmon River estuary in Salmon Bay and the extensive beaches at the head of Topaze and Forward Harbours (Table 2). Salmon Bay was primarily gravel with some sand and silt cover, and Topaze and Forward Harbours were sand and silt on the lower reaches with gravel on the upper levels. The beach at H'Kusam Bay was small, less than 1 ha, primarily silt and sand on the lower portion and packed gravel and cobbles on the upper portion. The beach South of Salmon Bay had only a small patch of gravel completely surrounded by bedrock.

Bivalve Populations

Manila Clams

Manila clams were found on the small beach south of Salmon Bay and in both Topaze and Forward Harbours. Maximum density was highest in Topaze Harbour at 120 clams m^{-2}, although their distribution was extremely limited and they were only collected in one of six quadrats dug (Table 3). Density ranged from 0-16 clams m^{-2} South of Salmon Bay and was extremely low in Forward Harbour, 0-4 clams m^{-2}, with only a single sublegal Manila found in the three quadrats dug. No live Manila clams or dead shell were found in Salmon or H'Kusam Bays.

Although only a small proportion of Manila clams collected south of Salmon Bay were of legal size (38 mm TL), most were six years of age or older (Figure 27). While a larger proportion of the sample from Topaze Harbour was of legal size, none were greater than 44 mm TL and the age distribution peaked at 7-8 years (Figure 28). Growth was very slow, with legal size attained at approximately nine years of age south of Salmon Bay and 6-8 years of age in Topaze Harbour (Figure 29). Dead shell collected in Forward Harbour showed somewhat more rapid growth, with five years required to reach legal size (Figure 30).

Varnish Clams

An important find was the presence of varnish clams in Salmon Bay. They were scattered at extremely low densities across large areas of the beach, and the maximum density encountered (when enough were present to warrant a quadrat) was 17.9 clams m^{-2} (Table 3). No evidence of varnish clams was found on the other four beaches surveyed. Most varnish clams at Salmon Bay were small, shell length ranged from 8-20 mm, and were young, 1 and 2 years old (Figure 31). A growth rate was calculated from live animals and dead shell; varnish clams at this beach required about 4 years to attain a shell length of 30 mm (Figure 32).

Littleneck Clams

Littleneck clams were collected from South of Salmon Bay, and were abundant in both Topaze and Forward Harbours. Densities South of Salmon Bay were 0-28 clams m^{-2}, and all clams collected were sublegals (Table 3). Densities in Topaze and Forward Harbours were 0-88 clams m^{-2} and 64-128 clams m^{-2}, respectively. No evidence of littleneck clams was found in Salmon Bay, but some dead shell was observed in H'Kusam Bay.

Size distribution in Topaze Harbour ranged from 19-63 mm TL and age distribution from 2-12 years with age classes five, six and eight most abundant (Figure 33). Size distribution in Forward Harbour ranged from 18-60 mm TL with most animals above legal size, and age distribution ranged from 2-10 years with age classes five, seven and eight most abundant (Figure 34). Growth was reasonable in both locations with approxiamtely five years required to attain legal size (Figure 35).

Butter Clams

Butter clams were not abundant in the quadrat samples, although these are generally dug at beach elevations above those that support greatest densities of butter clams. Butter clam densities were 0-12 clams m^{-2} at both South of Salmon Bay and Forward Harbour, and 0-24 clams m^{-2} in Topaze Harbour (Table 3). No evidence of butter clams was found in Salmon or H'Kusam Bays. Size and age distributions from Topaze Harbour ranged from 25-92 mm TL and 1-17 years, respectively (Figure 36). Sample size was too small to determine meaningful modes, but most clams were above legal size. Growth was reasonable with approximately seven years required to attain legal size (Figure 37).

Other Species

Most of the substrate in Salmon Bay was not suitable for bivalves, and no live clams other than varnish clams were collected. Shells of Baltic, pointed and white sand macomas were observed, as were very rare occurrences of shells of cockles and softshells (Table 2). Live pointed macomas were collected at all beaches surveyed except Salmon Bay, and were the only species collected alive at H'Kusam Bay, where they attained a density of 156 clams m^{-2} (Table 3). Bentnose macomas were collected live from South of Salmon Bay and Forward and Topaze Harbours, and dead shell was observed at H'Kusam Bay.

Live softshells were collected at low densities at South of Salmon Bay (0-4 clams m^{-2}), Topaze Harbour (0-4 clams m^{-2}) and Forward Harbour (0-8 clams m^{-2})(Table 3). Size distribution of softshells at Forward Harbour ranged from 68-116 mm TL, and age from 5-10 years with age class nine most abundant (Figure 38). Growth was rapid and they achieved 50 mm TL in about three years (Figure 39).

Live cockles were found at low densities in Topaze Harbour (0-12 clams m^{-2}) and Forward Harbour (0-4 clams m^{-2})(Table 3). Cockle shell was rarely observed in Salmon Bay, and no evidence of cockles was found South of Salmon Bay or in H'Kusam Bay (Table 2). Height frequency distribution ranged from 42-85 mm and age distribution from 2-9 years with age class five most abundant (Figure 40). Growth was relatively rapid with a shell height of 50 mm achieved in 3-4 years (Figure 41).

Other Observations

A plankton tow taken in Forward Harbour contained mainly flocculent algae and some small zooplankton (including rotifers). Very few bivalve larvae were seen; straight-hinge mussels and early umbone stages of an unidentified bivalve species were observed.

West Side of Gilford Island

The west side of Gilford Island region has been an important harvesting area for butter and littleneck clams for many years (Quayle and Bourne 1972, Webb 2002, 2004). Some intertidal beaches in the area have been surveyed previously (Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998). The purpose of the present survey was to re-assess some areas and in particular determine if Manila clams had become more abundant in the area and whether varnish clams had dispersed into this region.

Four beaches were surveyed on June 27, 2002. These included Viner Sound, a beach in the Burdwood Group, Deep Harbour and Shoal Harbour (Table 2, Figure 42). The last three beaches had been sampled on previous surveys (Bourne *et al.* 1994).

Description of Beaches

Beaches examined ranged in size from very large in Viner Sound and Shoal Harbour to a small pocket at Deep Harbour, or small saddle beaches between rocky headlands in the Burdwood Group (Table 2). Substrate on the larger beaches was primarily mud and sand, with some gravelly areas or embedded rock. Substrate on the smaller beaches were primarily sand and shell.

Bivalve Populations

Manila Clams

No live Manila clams were found in any quadrats dug on these beaches (Table 3). Although we were unable to access the majority of the beach area in Viner Sound due to the state of the tide, a search of the upper beach margin produced several dead Manila shells, and five live Manila clams and several dead shells were collected from scratches and surface searches in Deep Harbour. These were used to calculate growth rates for these beaches. Growth was slow and it required approximately 4.5 years to attain legal size on both beaches (Figure 43).

Varnish Clams

No evidence of varnish clams, either live animals or dead shell, was found in the Gilford Island area.

Littleneck Clams

There is a long history of littleneck clam harvest in the West Gilford Island area (Quayle and Bourne 1972). They were common on the three beaches that were sampled in the present survey where densities ranged from 24 clams m^{-2} at Deep Harbour to 132 clams m^{-2} in Shoal Harbour and 148-268 clams m^{-2} in the Burdwood Group (Table 3). In the Burdwood Group there was a wide range in shell length from 20-53 mm TL and in ages from 2-10 with modes at five and eight years (Figure 44). At Deep Harbour shell length ranged from 14-46 mm TL and age from 2-10, although most were seven years of age and older (Figure 45). In Shoal Harbour shell length ranged from 23-44 mm and age from 3-9 with a strong mode also at 7 years (Figure 46). Growth was similar at the three locations, requiring about 5 years to attain a shell length of 38 mm (Figure 47 and Figure 48).

Butter Clams

Butter clams are common in the West Gilford Island area and were found on the three latter beaches where densities ranged from 44 clams m^{-2} at Deep Harbour to 60 clams m^{-2} at Shoal Harbour and 96-316 clams m^{-2} in the Burdwood Group (Table 3). Butter clam shell was conspicuously absent from the beach in Viner Sound.

There was a wide distribution of sizes and ages at the three locations. At the Burdwood Group there was a bimodal distribution of shell lengths ranging from 30-92 mm TL with modes at 43 and 81 mm TL and ages from 2-17, with a strong mode of four year olds indicating good recruitment in recent years (Figure 49). At Deep Harbour shell length ranged from 16-80 mm TL and age from 2-14 years, although most were seven years of age and older (Figure 50). At Shoal Harbour shell length ranged from 44-81 mm TL and age from 4-11 years (Figure 51). Growth was similar at the three locations, it required about 7.5-8 years to attain a shell length of 63 mm (Figure 52 and Figure 53).

Other Species

Live horse clams (*T. capax*) were collected at low densities from the Burdwood Group (12 clams m^{-2}) and Shoal Harbour (4 clams m^{-2})(Table 3).

Live pointed macomas were collected from the Burdwood Group and Deep Harbour, and pointed macoma shell was observed in Shoal Harbour (Table 2). Densities were 8-28 clams m^{-2} in the Burdwood Group and 4 clams m^{-2} in Deep Harbour (Table 3). Shell of bentnose macoma was observed in Viner Sound.

No live softshells were collected form any of the four beaches, but softshell shells were observed in Viner Sound (Table 2).

Live cockles were collected at low densities from the Burdwood Group (0-8 clams m^{-2}) and Deep Harbour (10 clams m^{-2})(Table 3). Cockle shell was observed at Shoal Harbour, but not in Viner Sound.

One truncated softshell was found in the Burdwood Group. Bedrock outcrops and some of the larger shells on this beach were covered in large thatched barnacles.

<u>Other Observations</u>

A plankton tow made in Viner Sound contained large amounts of flocculent phytoplankton, diatoms and desmids. No bivalve larvae were detected; they were either absent or caught up in the flocculent material. Water temperature in Viner Sound was 11°C.

Kingome Inlet

Kingcome Inlet runs northwest from Sutlej Channel for approximately 15 km then splits with Wakeman Sound extending northeast for 11 km and Kingcome Inlet continuing west for approximately 20 km.

Beaches in the Kingcome Inlet-Wakeman Sound areas had never been assessed for intertidal clam populations and hence the reason for the present survey. It was also unknown if Manila clams and varnish clams had dispersed into the area. Three beaches (Anchorage Cove, Charles Creek and Belleisle Inlet) were sampled on June 28, 2002 (Figure 54). Attempts to explore the estuaries of the Kingcome and Wakeman Rivers were unsuccessful due to extremely soft substrate and poor water clarity, which made approaches to these beaches hazardous.

Descriptions of Beaches

Beaches surveyed in Kingcome Inlet ranged from an extremely small pocket beaches in Anchorage Cove and Belleisle Inlet to a moderately large beach at the mouth of Charles Creek (Table 2). The beach at Charles Creek was soft sand and silt, as were the lower reaches of the beach in Anchorage Cove. The beach in Belleisle Inlet had a firmer sand and gravel substrate. The estuaries of both the Kingcome and Wakeman Rivers are extensive, but have extremely soft mud and silt substrates.

Bivalve Populations

No evidence of Manila, varnish, littleneck or butter clams, either live or dead shell, was found in the Kingcome Inlet area.

Although no live bivalves were collected in Anchoage Cove, shells of Baltic and bentnose macomas were observed (Table 2). Live Baltic macomas were observed at Charles Creek, and Baltic macoma shell was observed in Belleisle Inlet.

Softshells were the most common bivalve found, and they were only found on the beaches at Charles Creek and Belleisle Inlet. Samples were collected by digging individual shows. At Charles Creek shell length ranged from 66-109 mm TL and age from 3-12 years, although most were older than seven years (Figure 55). In Belleisle Inlet the sample was small but shell length ranged from 30-68 mm TL and age from 2-6 with a mode at five years (Figure 56). Growth was moderate and it required 4-5 years to attain a shell length of 60 mm (Figure 57).

Although no live cockles were observed in the Kingcome Inlet area, some dead cockle shell was found in Belleisle Inlet (Table 2).

Other Observations

Water temperature at Anchorage Cove was 8°C. The waters of the inlet were extremely silty, likely the result of glacial water outflows from the two major rivers on the inlet system.

Broughton Strait

Broughton Strait runs along the northeastern coast of Vancouver Island from Johnstone Strait to Queen Charlotte Strait. The area had not been surveyed previously and it was not known if Manila or varnish clams had dispersed this far north through Johnstone Strait. On June 29, 2002, two beaches were surveyed in Broughton Strait: the beach to the west of the Cluxewe River estuary and the estuary of the Nimpkish River (Figure 58).

Descriptions of Beaches

The two beaches surveyed were very different (Table 2). The beach at Cluxewe was a moderate size beach adjacent to the main estuary of the Cluxewe River. The substrate was primarily sand and gravel with an eelgrass bed on the lower margin. The beach at Nimpkish was the main estuary of the river; the substrate was rock and cobble embedded in sand near the river with increasing amounts of packed sand further from the area of river runoff.

Bivalve Populations

Manila and Varnish Clams

No evidence of Manila or varnish clams, either live animals or dead shell, was found in Broughton Strait.

Littleneck Clams

Littleneck clams were uncommon in the area. Densities ranged from 0-6 clams m^{-2} at Cluxewe (Table 3) and they were not observed at Nimpkish (Table 2).

Butter Clams

Butter clams were abundant in the lower part of the beach at Cluxewe with densities that ranged from 12-60 clams m^{-2} (Table 3). There was a wide range in size and age from 29-80 mm TL and from 3-15 years suggesting there has been reasonable recruitment in recent years (Figure 59). Growth was moderately slow and it required about 8 years to attain a shell length of 63 mm (Figure 60).

Other Species

Live horse clams were found at low densities of 0-2 clams m^{-2} at Cluxewe (Table 3). Live pointed macomas were found at densities of 0-24 clams m^{-2} at Cluxewe and a few live pointed macomas were observed at Nimpkish. Cockles densities were 0-10 clams m^{-2} at Cluxewe. No evidence of softshells was found at either location.

Other Observations

A plankton tow taken off Nimpkish was largely chain-forming diatoms, large single diatoms, desmids and large quantities of zooplankton. Very few bivalve larvae were seen, only a few mussel larvae. Water temperature at both beaches was 12°C.

Seymour and Belize Inlets

Seymour and Belize Inlets are extensive bodies of protected water that extend north and westward from the northeastern part of Queen Charlotte Strait. The area has been considered for floating culture of bivalves but it had never been surveyed for intertidal bivalve populations. Entrance to the complex is narrow and hence there is a limited exchange of water every tidal cycle. It was felt that the complex would have a semi enclosed circulation that would tend to retain planktonic larvae. If temperatures were sufficient and Manila clam larvae settled in the area a population could develop in the complex that might be of interest to industry.

The shore of most of the inlets is steep sloped and there is little beach area, in fact, most of the intertidal area is rock cliff. Intertidal beach area probably comprises less than 1% of the total intertidal area in the complex. Unfortunately, the survey was undertaken during a cycle of neap tides hence parts of some beaches were submerged when surveyed and the intertidal area of each beach could only be roughly estimated.

An extensive survey was undertaken by small boat at the western end of Seymour Inlet in Whelakis and McKinnon Lagoons. There was an active logging operation in Whelakis Lagoon. There was little intertidal beach area in these lagoons and we did not go ashore to sample because the habitat was soft mud and unsuitable for bivalves.

Between June 30 and July 3, 2002, seven beaches were surveyed in the Seymour/Belize Inlet area: the head of Seymour Inlet; Chief Nollis Bay in Alison Sound; Nugent Creek; a beach on the south side of Nugent Sound; and three beaches at the head of Nugent Sound, near the entry to Schwartzenberg Lagoon (Figure 61). A second beach at the head of Alison Sound was visited. The substrate was primarily rocks and boulders with only a small patch of sand/gravel substrate. No evidence of live bivalves or shell was found.

Description of Beaches

All of the beaches surveyed were small, generally less than 0.5 ha (Table 2). The substrate on most beaches was primarily sand with varying proportions of mud and gravel, although the last beach examined at the head of Nugent Sound had only a soft mud substrate. The beach in Chief Nollis Bay had significant amounts of wood debris underlying the sand substrate.

Bivalve Populations

Manila Clams

Manila clams were rare on beaches surveyed in the system. One live Manila clam and 15 dead shells were collected at Nugent Creek, and shells were observed at the beach on the south side of Nugent Sound and one beach at the head of Nugent Sound (Table 2). The live animal and shells were measured to estimate growth rate; growth was rapid with only 3-3.5 years required to attain a size of 38 mm TL (Figure 62).

Varnish Clams

No evidence of varnish clams was found in the Seymour/Belize area.

Littleneck Clams

No live littleneck clams were collected in the system, primarily because poor tides precluded surveys of intertidal elevations that would support this species. Littleneck shell was abundant in Nugent Sound, implying that the species could be found on more favourable tides.

Butter Clams

As with littleneck clams, no live butter clams were collected during surveys in Seymour and Belize Inlets but shell was abundant in Nugent Sound, implying tht the species was commonly present.

Other Species

No live horse clams were observed, but *T. capax* shell was observed at Nugent Creek (Table 2). Live Baltic and pointed macomas were collected in Chief Nollis Bay, and shells were observed at the head of Seymour Inlet, and on most beaches in Nugent Sound. No live cockles were collected, but shells were observed throughout Nugent Sound.

Softshells were observed, either as live animals or shells, at all beaches surveyed in Seymour and Belize Inlets (Table 2). Dead shell collected at the head of Seymour Inlet was measured to estimate a growth rate; approximately 4.5 years was required to attain a size of 60 mm TL (Figure 63). Live softshells collected from an extensive area in Chief Nollis Bay by digging individual shows were measured to estimate growth; these clams required approximately four years to reach 60 mm TL (Figure 64). These clams were exceptionally soft-shelled and brittle, easily fracturing and crumbling when extracted from the substrate. Live softshells collected from the south side of Nugent Sound were measured; growth was reasonable with five years required to attain 60 mm TL (Figure 65). These shells were sturdier than those collected in Chief Nollis Bay.

Other Observations

Water temperature at the head of Nugent Inlet was 16°C.

Winter Harbour

Bourne (1982) reported that Manila clams were first found in the Winter Harbour area circa 1966. He postulated that larval drift from these populations could have established Manila clam populations in the Central Coast and Queen Charlotte Strait.

Bourne and Heritage (1997) conducted exploratory surveys on beaches in Quatsino Sound and Holberg Inlet in 1993. They surveyed 13 beaches between Koprino Harbour and Quatsino Narrows, and five beaches in Holberg Inlet. They found Manila clams only at the beach in Kultus Cove, and speculated that commercial landings reported from Quatsino Sound in the mid- to late-1980s may have come from beaches near Winter Harbour.

Two beaches at the head of Winter Harbour were explored on July 6, 2002 (Figure 66). Tides on this morning were not ideal, dropping to only 1.3 m at 04:45.

Description of Beaches

Both beaches were primarily sand and gravel substrates with gravel dominating the upper elevations and sand and silt on the lower margins. The lower margin of the beach at the head of Winter Harbour supported beds of eelgrass.

Bivalve Populations

Manila Clams

Manila clams were present on both beaches. Denities ranged from 2-32 clams m^{-2} at the head of the harbour and from 44-132 clams m^{-2} at Denad Creek (Table 3). At the head of Winter Harbour, size ranged from 18-44 mm TL with a mode near 40 mm TL and age from 2-6 years with a mode at four to five years of age (Figure 67). Size ranged from 8-60 mm TL at Denad Creek, and age from 1-8 years with a strong mode at five years of age (Figure 68). Growth was slow with 4-4.5 years required to reach 38 mm TL (Figure 69).

Varnish Clams

No evidence of live varnish clams or dead shells was found on either beach in Winter Harbour.

Littleneck Clams

Littleneck clams were present on both beaches, with densities of 0-20 clams m^{-2} at the head of the harbour and 8-72 clams m^{-2} at Denad Creek (Table 3). At the head of Winter Harbour, size ranged from 19-47 mm TL and age from 2-8 years with a strong mode at four years of age (Figure 70). Size ranged from 26-51 mm TL at Denad Creek, and age from 3-9 years with a mode at six years of age (Figure 71). Although the sample size was small, growth was slow at the head of the harbour with 5.5-6 years required to reach legal size (38 mm TL)(Figure 72). Growth was also somewhat slow at Denad Creek with 4.5-5.5 years required to reach 38 mm TL. Both the low densities and poor growth rates could be due to the tidal elevations sampled, which were above those normally supporting the main body of littleneck clam populations.

Butter Clams

Butter clams were not commonly encountered on these beaches, certainly because the state of the tide did not allow exploration of tidal elevations that should support the greatest number of butter clams. Densities from quadrats dug on the upper beach ranged from 0-8 clams m^{-2} at the head of the harbour and from 0-20 clams m^{-2} at Denad Creek (Table 3). Although sample sizes were small, size ranged from 17-65 mm TL and age from 2-9 years at the head of the harbour (Figure 73) and from 44-64 mm TL and 5-11 years at Denad Creek (Figure 74). As with littleneck clams, growth was poor with more than nine years required to reach legal size (63 mm TL) at the head of the harbour and more than 11 years required to reach legal size at Denad Creek (Figure 75).

Other Species

Pointed macomas were found in quadrats at the head of the beach with density ranging from 0-36 clams m^{-2} (Table 3). No live macomas or shell were observed at Denad Creek.

Softshells were collected at low densities from both beaches; density ranged from 0-8 clams m^{-2} on each beach (Table 3).

Although no live cockles were collected, cockle shell was noted on the beach at the head of Winter Harbour.

Other Observations

Moonsnails were present on both beaches, and were particularly abundant at Denad Creek (Table 2). Ghost shrimp were common at the head of Winter Harbour, and dogwinkles were common at Denad Creek.

A plankton tow taken in Winter Harbour contained mainly chain-forming algae (including diatoms), large single diatoms and desmids, with some zooplankton. Three bivalve larvae were seen, all early-stage mussels. There were also large quantities of unidentified eggs. Water temperature at Denad Creek was 13°C.

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 runs approximately 4 km from mouth to head, is generally steep sided with relatively few beaches concentrated at the head. The area was surveyed in 2001 and significant populations of Manila and littleneck clams sampled (Gillespie *et al.* 2004). These surveys also noted large populations of Olympia oysters on most beaches. Three beaches were surveyed at the head of Klaskino Inlet on July 7, 2002 (Figure 76). The first two were surveyed in 2001, the last had not been visited by us before. Only the first beach, Northeast Klaskino, could be sampled in detail, as poor tidal conditions forced only cursory exploration of the other two beaches.

Description of Beaches

All three beaches were of moderate size and had areas of sand and gravel substrate suitable for clam habitat (Table 2). The upper margins of all beaches were either increasingly rocky substrates, or more steeply sloped than the middle tidal elevations.

Bivalve Populations

Olympia Oysters

Live Olympia oysters were noted on all three beaches. Densities of live oysters on Northeast Klaskino ranged from 0-867 oysters m^{-2} with a mean density of 109.26 oysters m^{-2} (Table 4). Density of dead shells in the same samples ranged from 0-144 shells m^{-2} with a mean density of 13.62 shells m^{-2}. Shell height frequency distribution ranged from 17-55 mm (Figure 77). Of 97 oysters sampled, five were in the white larvae stage and one in the black larvae stage.

Manila Clams

Live Manila clams were observed on all three beaches. Densities at Northeast Klaskino ranged from 92-252 clams m^{-2} (Table 3). Size on Northeast Klaskino ranged from 17-59 mm TL with a strong mode around 46 mm TL and age ranged from 1-9 years with a strong mode at age six (Figure 78). Growth was rapid with less than 3.5 years required to achieve 38 mm TL (Figure 79).

Varnish Clams

No evidence of varnish clams, either live animals or shells, was found in Klaskino Inlet.

Littleneck Clams

Live littleneck clams were observed on all three beaches. Densities on Northeast Klaskino ranged from 128-308 clams m^{-2} (Table 3). Size ranged from 10-49 mm TL on Northeast Klaskino and age ranged from 1-9 years with modes at four and six years (Figure 80).

Butter Clams

No live butter clams were collected from Klaskino Inlet, likely due to the poor state of tides on the day the beaches were surveyed. Butter shell was observed at Northeast Klaskino, indicating that this species is present at lower tidal elevations on this beach (Table 2).

Other Species

Although no live horse clams were observed in Klaskino Inlet, shell of both the fat and Pacific horse clam species were observed on Northeast Klaskino (Table 2). Live softshells were observed on two of the three beaches with densities at Northeast Klaskino ranging from 0-4 clams m^{-2} (Table 3).

Other Observations

Moonsnails were common on all three beaches and dogwinkles and dire whelks were also observed (Table 2).

A plankton tow taken in Klaskino contained mainly chain-forming diatoms and some *Noctiluca*. Only a few early umbone larvae of an unidentified bivalve species were seen. Water temperature was 16°C.

Nasparti Inlet

Nasparti Inlet is immediately south of Brooks Peninsula. Varnish clam shell had been reported from the area and we wished to assess Manila clam and Olympia oyster populations in the area.

Two beaches were surveyed in the Nasparti Inlet area on July 8, 2002 (Figure 81). These were the large beach at the head of the inlet and the beach at Jackobson Point, just outside the inlet on the eastern shore of Brooks Peninsula.

Description of Beaches

The two beaches differed considerably in their physical characteristics (Table 2). The beach at the head of Nasparti Inlet was the large estuary of the Nasparti River and was open to wind and waves funneling up the inlet. The substrate was primarily gravel and rocky beach with some sandy areas. The beach at Jackobson Point was behind a protected anchorage with a clean sand substrate and some gravel and wood debris near a small creek.

Bivalve Populations

Manila Clams

Manila clams were collected at relatively low densities from both beaches; densities ranged from 0-40 clams m^{-2} at the head of the inlet and from 0-32 clams m^{-2} at Jackobson Point (Table 3). Size at the head of the inlet ranged from 29-46 mm TL and all clams were four to six years of age (Figure 82). Size at Jackobson Point ranged from 14-47 mm TL and age from 1-6 years, though most clams were four years old (Figure 83). Estimation of growth rate indicated that 3.5-4 years required to attain 38 mm TL at both sites (Figure 84).

Varnish Clams

No evidence of varnish clams was found at the head of the inlet. Varnish clam densities ranged from 0-97 clams m^{-2} at Jackobson Point, and dead shell was common (Table 3). Size ranged from 22-66 mm TL with most clams greater than 50 mm TL and age from 2-8 with a strong mode at 5-6 years (Figure 85). Growth was relatively rapid with 38 mm TL achieved at approximately 3.5 years (Figure 86).

Littleneck Clams

Littleneck clams were common at the head of Nasparti Inlet where densities ranged from 12-120 clams m^{-2} (Table 3). They were not common at Jackobson Point where densities ranged from 0-16 clams m^{-2} and all clams were less than legal size. At the head of the inlet, size ranged from 17-46 mm TL and age from 3-8 years with most clams being four and five years old (Figure 87).

Butter Clams

One live butter clam was collected from quadrats dug at the head of the inlet, and butter clam shell was also observed there (Table 2). Live butter clams were observed at Jackobson Point, although none were collected from quadrats dug there.

Other Species

No live horse clams were collected, but shell of both species was observed at Jackobson Point (Table 2).

Live bentnose macoma were collected at Jackobson Point with densities ranging from 0-108 clams m^{-2} (Table 3). No macomas or shell were observed at the head of the inlet.

Live softshells were collected at the head of the inlet with densities ranging from 0-8 clams m^{-2} (Table 3). We also noted a large bed of softshells in sandy substrate high in the intertidal at the head of the inlet. Live softshells were collected at Jackobson Point with densities ranging from 0-8 clams m^{-2}.

Live cockles were collected at Jackobson Point and shell was observed at the head of the inlet (Table 2).

Other Observations

Plankton tows were taken in Nasparti Inlet and near Jackobsen Point. Both samples were primarily chain-forming diatoms. The Nasparti sample had more zooplankton, including ostracods. Both samples had very few bivalve larvae; some late-stage *Mya* larvae from Nasparti and a few early-stage mussel larvae in each sample. Water temperatures were 14°C at the head of the inlet and 16°C at Jackobson Point.

Ououkinsh Inlet

On July 9, 2002, seven beaches were surveyed in and around Ououkinsh Inlet (Figure 88). These included two beaches in Gay Passage, two beaches on the Acous Peninsula, Battle Bay, the estuary of the Power River, and the large beach at the head of the inlet.

Description of Beaches

Most beaches in the area were small pocket beaches 0.5 ha in area or less (Table 2). The two exceptions were a moderately large beach on the south side of Acous Peninsula and the large beach at the head of Ououkinsh Inlet. Substrate on protected beaches, *e.g.*, the pocket beach in Gay Passage, was largely mud. High energy beaches open to the main inlet and Checleset Bay were either hard-packed sand (west side of Acous Peninsula) or clean gravel with sandy or muddy areas (Battle Bay). Other beaches were varying proportions of gravel and sand with larger cobble and rock at the upper margin.

Bivalve Populations

Olympia Oysters

A single live Olympia oyster was found at the beach on the south side of Acous Peninsula and a single small shell was found at Battle Bay (Table 2). No other shell was observed, and there was no evidence that Olympia oysters were present on other beaches in the area.

Manila Clams

Live Manila clams or dead shell were found on all beaches except the exposed beaches on the west side of Acous Peninsula and Battle Bay, neither of which supported significant clam populations (Table 2). No Manila clams were collected in quadrats dug in Gay Passage, but densities ranged from 0-8 clams m^{-2} on the south side of Acous Peninsula, 112-292 clams m^{-2} at Power River and 40-252 clams m^{-2} at the head of the inlet (Table 2). Size ranged from 20-46 mm TL and age from 2-10 years with modes at three and six years of age at Power River (Figure 89). Size ranged from 16-45 mm TL and age from 2-8 years at the head of the inlet (Figure 90). Growth was relatively slow with legal size achieved in 5.5 years at Power River and 4.5 years at the head of the inlet (Figure 91).

Varnish Clams

Live varnish clams were collected from the beach on the main channel in Gay Passage at densities ranging from 36-108 clams m^{-2}, and from the south side of Acous Peninsula at densities between 0-12 clams m^{-2} (Table 3). Size ranged from 19-60 mm TL in Gay Passage, and age from 1-7 years with a strong mode at three years of age (Figure 92). Growth was rapid; approximately 3.5 years was required to reach 38 mm TL (Figure 93).

Littleneck Clams

Live littleneck clams were observed on all beaches except the west side of Acous Peninsula and Battle Bay (Table 2). Densities ranged from 16-36 clams m^{-2} in Gay Passage, from 0-16 clams m^{-2} on the south side of Acous Peninsula, from 0-64 clams m^{-2} at Power River and 4-88 clams m^{-2} at the head of the inlet (Table 3). There was a broad range of sizes in Gay Passage, shell length ranged from 11-52 mm TL and age from 1-8 years (Figure 94). At Power River, size ranged from 25-41 mm TL and age from 3-7 years (Figure 95). Size ranged from 15-45 mm TL at the head of the inlet, and age from 2-8 years (Figure 96). Growth was slow with legal size achieved in 5.5 and 6.5 years in Gay Passage and at Power River, respectively (Figure 97) and at least 5.5 years required at the head of the inlet, where some individuals were still less than 38 mm TL at eight years of age (Figure 98).

Butter Clams

Live butter clams were observed at the beach on the main channel in Gay Passage, where densities ranged from 20-52 clams m^{-2} (Table 3), and shells were observed on both beaches in Gay Passage, the south side of Acous Peninsula and at the head of the inlet (Table 2). Size ranged from 11-60 mm TL in Gay Passage and age from 1-7 years (Figure 99). Growth was poor, as all clams were less than legal size, even those five and seven years old (Figure 100).

Other Species

Live fat horse clams were collected from the beach on the main channel in Gay Passage (Table 2) where densities ranged form 0-72 clams m^{-2} (Table 3). Shells of fat horse clams were observed on the south side of Acous Peninsula and at the head of the inlet, and shells of both fat and Pacific horse clams were observed on the beach on the main channel of Gay Passage.

Live pointed macomas were found at low densities, 0-4 clams m^{-2}, at the head of Ououkinsh Inlet (Table 3). Shell of bentnose macoma was observed on the pocket beach off Gay Passage (Table 2). No macoma species were reported as live or dead shells from any of the other beaches surveyed in the area.

Live softshells were collected at low densitites from the south side of Acous Peninsula (0-16 clams m^{-2}) and the head of the inlet (0-8 clams m^{-2})(Table 3). Live softshells were also observed on the pocket beach off Gay Passage, and a small bed of live softshells was observed in the creek estuary above the beach at Battle Bay (Table 2). Shells were observed at Power River. Growth was slow with approximately 5 years required to achieve a size of 50 mm TL (Figure 101).

Cockles were uncommon in the area; only a few shells were observed at Battle Bay (Table 2).

A few heavily worn shells of several species, green false-jingles, hooked surfclam, blue and California mussels, were observed at Battle Bay (Table 2).

Other Observations

There was evidence of sea otters using intertidal clams as a food source in the area. The beach on the main channel in Gay Passage had several large, distinct holes surrounded by sediment and shells; it appeared that otters had dug individual horse clams, possibly gripping an exposed siphon and clearing the substrate from around the clam while it was submerged at high tide. The beach on the southern shore of Acous Peninsula had numerous holes dug by otters, even high in the intertidal where only softshells, Manila, littleneck and varnish clams were available.

A plankton tow taken in Ououkinsh Inlet contained primarily chain-forming algae and diatoms. There were very few bivalve larvae, only a few early-stage mussels. Water temperatures were 14°C at Acous Peninsula and 15°C at the head of Ououkinsh Inlet.

Kyuquot Sound

On July 10, 2002, six beaches were surveyed in Kyuquot Sound (Figure 102). These included two in Cachalot Inlet, the beach fronting the abandoned whaling station at the mouth of Cachalot Inlet, and three beaches in Amai Inlet.

Description of Beaches

Each inlet had a large estuarine beach at the head, although substrates differed slightly on each (Table 2). The estuary at the head of Cachalot Inlet was primarily sand over wood debris and anoxic mud with some areas sand and gravel in the mid-intertidal. The estuary at the head of Amai Inlet was primarily large gravel berms with areas of gravel and embedded rock near the creek channel. The beach at the whaling station was more exposed and the substrate was largely cobble and rock embedded in sand. Beaches on the southern sides of the inlets were fairly rocky with areas of gravel and sand. The small pocket beach at the mouth of Amai Inlet was rocky in the upper intertidal, gradually shifting through gravel to softer sand and mud at the lower margin.

Bivalve Populations

Olympia Oysters

Live Olympia oysters were collected from the small beach on the south side of Cachalot Inlet, at Amai Creek at the head of the inlet and a particularly dense bed of oysters on the beach on the south side of Amai Inlet (Table 2). Densities on the latter ranged from 0-891 oysters m^{-2}, while density of dead shell ranged from 0-530 shells m^{-2} (Table 4). Height frequency distribution of Olympia oysters on this beach ranged from 21-61 mm (Figure 103). None of the oysters sampled were carrying larvae.

Manila Clams

Live Manila clams were found on all beaches except at the head of Amai Inlet, where only dead shells were observed (Table 2). Densities ranged from 348-500 clams m^{-2} on the south side of Cachalot Inlet and from 0-128 clams m^{-2} at the head of the inlet (Table 3). In Amai Inlet, densisties ranged from 88-420 clams m^{-2} on the small beach on the south side of the inlet and from 36-288 clams m^{-2} in the small cove by the mouth of the inlet. Size on the south side of Cachalot Inlet ranged from 22-50 mm TL and age from 3-7 years (Figure 104). Size at the whaling station ranged from 16-50 mm TL and age from 2-6 years (Figure 105). In Amai Inlet, size ranged from 22-51 mm TL and age from 2-7 years on the south side of the inlet (Figure 106) and the cove at the mouth of the inlet (Figure 107); dominant age classes were 3-4 on the south side and 4-5 in the cove. Growth was similar in both inlets, with 3.5 years required to achieve legal size (Figure 108).

Varnish Clams

Live varnish clams were observed at low densities on the beaches on the south sides of Cachalot and Amai Inlets, where densities ranged from 0-4 and 0-12 clams m^{-2}, respectively (Table 3). Varnish shell was also observed on the large beach at the head of Cachalot Inlet (Table 2). Growth was rapid with approximately 3.5 years required to reach 38 mm TL (Figure 109).

Littleneck Clams

Live littleneck clams were observed on all beaches except the head of Amai Inlet, where only dead shell was found (Table 2). Densities were 24-36 clams m^{-2} on the south side of Cachalot Inlet, 4-92 clams m^{-2} at the whaling station, 0-196 clams m^{-2} on the south side of Amai Inlet and 20-196 clams m^{-2} in the small cove at the mouth of Amai Inlet (Table 3). Size ranged from 21-44 mm TL and age from 1-6 years on the south side of Cachalot Inlet (Figure 110) and from 12-56 mm TL and 1-10 years at the whaling station (Figure 111). Size ranged from 16-51 mm TL and age from 2-8 years on the south side of Amai Inlet (Figure 112) and from 17-46 mm TL and 2-8 years in the cove at the mouth of Amai Inlet (Figure 113). Growth was relatively slow with 4.5 and 5.5 years required to reach legal size in Cachalot and Amai Inlets, respectively (Figure 114).

Butter Clams

Live butter clams were collected at the whaling station (0-29 clams m^{-2}) and the cove at the mouth of Amai Inlet (0-16 clams m^{-2})(Table 3). Butter shell was observed at all beaches except the beach on the south side of Cachalot Inlet (Table 2). Butter clams collected in Cachalot Inlet ranged in size from 20-85 mm TL and age from 2-15 years (Figure 115). Growth was poor with 8.5 years required to reach legal size in Cachalot Inlet, and with no legal size clams found in Amai Inlet, even after eight years of growth (Figure 116).

Other Species

One live fat horse clam was collected from quadrats dug at the whaling station (Table 3), and horse clam shell was observed on the south side of Amai Inlet (Table 2).

Live Baltic macomas were collected on the south side of Cachalot Inlet (0-4 clams m^{-2}) and the south side of Amai Inlet (0-24 clams m^{-2})(Table 3). Live pointed macomas were collected at the whaling station (0-12 clams m^{-2}) and in the cove at the mouth of Amai Inlet (0-8 clams m^{-2}). Shell of bentnose macoma was observed at the head of Amai Inlet (Table 2).

Live softshells were collected on the south side of Cachalot Inlet (32 clams m^{-2}), the south side of Amai Inlet (8-28 clams m^{-2}) and in the cove at the mouth of Amai Inlet (0-8 clams m^{-2})(Table 3). Dead softshells were observed on all other beaches in the area (Table 2). Although sample sizes were small, size ranged from 18-59 mm TL and age from 2-6 years in Cachalot Inlet (Figure 117), and from 15-70 mm TL and 1-5 years in Amai Inlet (Figure 118). Growth was slow with softshells not achieving 60 mm TL after six years in Cachalot Inlet and requiring 4.5 years to reach 60 mm TL in Amai Inlet (Figure 119).

No live cockles were found on the beaches surveyed, but cockle shell was observed at the whaling station and the head of both inlets (Table 2).

Other Observations

Plankton tows taken in Cachalot and Amai Inlets contained some chain-forming diatoms and very few bivalve larvae. Both contained various stages of mussel larvae (from straight hinge to eyed stages) and some clam larvae, including littleneck clam larvae from Amai Inlet and *Mya*, littleneck clam and other unidentified bivalve larvae from Cachalot Inlet. Water temperatures were 14°C in Cachalot Inlet and 17°C in Amai Inlet.

Esperanza Inlet

On July 11, 2002, three beaches were surveyed in Esperanza Inlet: two beaches in Port Eliza and the beach at Garden Point (Figure 120).

Description of Beaches

The two beaches in Port Eliza had very different substrates (Table 2). The small beach on the west side of the inlet was primarily gravel with embedded rock, while the large beach at the head of the inlet was gravel and sand over wood debris and anoxic mud. The beach at Garden Point had a large sand and gravel berm on the west end, while most of the rest of the beach was gravel with some patches of sand.

Bivalve Populations

Olympia Oysters

Live Olympia oysters were found on both beaches in Port Eliza, but were not present at Garden Point (Table 2). Densities of live oysters ranged from 0-1,203 oysters m^{-2} with a mean density of 360.14 oysters m^{-2}, while densities of dead shell ranged from 0-1,348 shells m^{-2} with a mean density of 280.80 shells m^{-2} (Table 4). Shell heights ranged from 27-50 mm with a broad mode centered around 37 mm (Figure 121). Two of 100 oysters sampled were in the white larvae stage and one in the black larvae stage.

Manila Clams

Live Manila clams were collected at the head of Port Eliza and at Garden Point, but only dead shells were observed on the west side of Port Eliza (Table 2). Densities ranged from 12-84 clams m^{-2} at the head of Port Eliza and from 0-60 clams m^{-2} at Garden Point (Table 3). Size ranged from 21-57 mm TL and age from 2-9 years in Port Eliza (Figure 122), and from 17-44 mm TL and 2-5 years at Garden Point (Figure 123). Growth was extremely rapid in Port Eliza, with legal size achieved in approximately three years (Figure 124).

Varnish Clams

Live varnish clams were collected at the head of Port Eliza and at Garden Point, at densities ranging from 0-20 and 0-160 clams m^{-2}, respectively (Table 3). No evidence of varnish clams was found on the beach on the west side of Port Eliza. Varnish clams in Port Eliza were small (12-33 mm TL) and young (1-3 years)(Figure 125), while Garden Point supported larger and older clams (Figure 126). Growth was moderate at Garden Point with approximately 3.5 years required to reach 38 mm TL (Figure 127).

Littleneck Clams

Live littleneck clams were found at the head of Port Eliza and at Garden Point, but only dead shell was found on the west side of Port Eliza (Table 2). Densities ranged from 0-12 clams m^{-2} in Port Eliza and from 0-34 clams m^{-2} at Garden Point (Table 3). Although the sample was small, a broad range of sizes (12-64 mm TL) and ages (1-9 years) was represented at Garden Point (Figure 128). Growth was rapid with approximately three years required to reach legal size (Figure 129).

Butter Clams

Live butter clams were only collected at Garden Point, and no shells were seen in Port Eliza (Table 2). All of the live butter clams were collected from the first quadrat dug at Garden Point, where density was estimated at 110 clams m^{-2} (Table 3). A broad range of sizes (13-88 mm TL) and ages (1-13 years) was contained in the sample (Figure 130). Growth was relatively slow with approximately 6.5 years required to attain legal size (Figure 131).

Other Species

Live horse clams of both species were collected from one quadrat at Garden Point, where density was estimated to be 76 clams m^{-2} (Table 3). No horse clam shell was observed in Port Eliza. A broad range of size from 15-145 mm TL was contained in the sample (Figure 132).

Live bentnose macomas were collected at the head of Port Eliza at densities of 0-32 clams m^{-2} (Table 3). Live pointed macomas were collected at Garden Point at densities of 0-114 clams m^{-2} (Table 3).

Live softshells were collected at low densities from the head of Port Eliza (0-8 clams m^{-2}) and Garden Point (0-24 clams m^{-2})(Table 3). Size ranged from 13-61 mm TL and age from 1-5 years (Figure 133). Growth was slow with no clams reaching 60 mm TL after 4.5 years (Figure 134).

Cockles were only observed at Garden Point, where density ranged from 0-38 clams m^{-2} (Table 3). Shell heights ranged from 22-61 mm and age from 1-4 years (Figure 135).

Other Observations

A plankton tow taken in Port Eliza contained some phytoplankton and zooplankton (including rotifers). There were few bivalve larvae, mostly mussels in the late straight-hinge stage and a few early-umbone larvae from unidentified clams. Water temperature in Port Eliza was 15°C.

Toquart Bay

Three beaches were surveyed in Toquart Bay, Barkley Sound, on July 12, 2002 (Figure 136). These were the beach at the mouth of Lucky Creek, the beach on the west side of Hillier Island, and the large beach at the mouth of the Maggie River.

Description of Beaches

The beach at Lucky Creek was small, and the area exposed on the survey was dominated by oysters, with little suitable clam habitat. The beach on the east side of Hillier Island was a moderately large beach, most of which was gravel substrate, ideal for clams. The Maggie River estuary is a portion of a large beach that extends down the west side of Macoah Passage. Much of this beach is scoured cobbles in a packed sand and gravel substrate, but patches of suitable clam habitat are present.

Bivalve Populations

Olympia Oysters

The beach at Hillier Island was known to support significant populations of Olympia oysters, as oysters had been collected there in the late 1990s. This survey discovered large numbers of dead shells on the lower portion of the beach, but few live Olympia oysters, indicating significant mortality in recent years.

The upper area of the beach at Lucky Creek was densely populated by large Pacific oysters. Olympia oysters and dead Olympia shell were present at much lower densities. Because of extremely high densities of Pacific oysters, no attempt could be made to estimate Olympia oyster densities. Height frequency distribution at Lucky Creek ranged between 27-47 mm with a peak between 35-38 mm (Figure 137).

Manila Clams

Live Manila clams were collected from Hillier Island and Maggie River, and shells were present at Lucky Creek. Manila clam densities were extremely high at Hillier Island, 388-412 clams m^{-2}, and less so at Maggie River, 0-104 clams m^{-2} (Table 3). Most of the Manila clams sampled at Hillier Island and all of the Manila clams collected at Maggie River were less than legal size (Figure 138 and Figure 139, respectively). Age distributions at both locations were dominated by young clams, primarily age classes 2-4.

Varnish Clams

Varnish clam densities ranged between 68-76 clams m^{-2} at Hillier Island and 176-456 clams m^{-2} at Maggie River (Table 3). No evidence of varnish clams was found at Lucky Creek. Length distribution of varnish clams at Hillier Island ranged between 13-40 mm TL with a peak at approximately 25 mm TL, and age distribution ranged from 1-5 years with a peak at age class three (Figure 140). Length distribution at Maggie River ranged from 16-42 mm TL with a peak at approxiamtely 31-32 mm TL, and age distribution ranged from 1-5 with a peak at age class three (Figure 141). Estimated growth rate from Maggie River showed that it required three years to achieve 30 mm TL (Figure 142).

Littleneck Clams

A small number of stunted littleneck clams were observed at Hillier Island and shell was found at Lucky Creek. No evidence of littleneck clams was found at Maggie River.

Butter Clams

A few shells of butter clams were observed at Lucky Creek and Hillier Island. No evidence of butter clams was found at Maggie River.

Other Species

Softshell density ranged from 12-36 clams m^{-2} at Maggie River; no evidence of softshells was found at Lucky Creek or Hillier Island (Table 3). Length distribution ranged from 13-43 mm TL with most clams <21 mm TL, and age distribution was from 1-3 years with age class one most abundant (Figure 143).

Some dead Pacific oyster shells at Lucky Creek harboured kellyclams and Arctic hiatella.

Other Observations

A plankton sample from near Lucky Creek contained some zooplankton and a considerable amount of bivalve larvae. About half were mussel larvae from straight-hinge to eyed stages; the rest were *Mya*, littleneck clam, Olympia oysters and shipworm. No Manila clam larvae were identified.

DISCUSSION

As in previous years, results of the present survey have increased our knowledge of intertidal bivalve populations in British Columbia. It is our hope that the extensive information accumulated from these surveys will provide a solid biological basis for management policies for present fisheries or expansion of fisheries and aquaculture into new areas or involving new species.

Manila Clams

The presence of Manila clams on the beach south of Salmon Bay marks a relatively rare record of the species from Johnstone Strait *sensu stricto.* Extensive beach surveys in areas west of Johnstone Strait indicated that Manila clams were regularly found on beaches from Desolation Sound north and west through Toba and Bute Inlets to Phillips Arm and Nodales Channel (Blyth *et al.* 1997a). Blyth *et al.* (1997a) only reported Manila clams from two locations west of Phillips Arm: one beach on West Thurlow Island in Chancellor Channel and two beaches in Blenkinsop Bay near Port Neville. Bourne and Heritage (1997) and Heritage *et al.* (1998) reported small populations of Manila clams in Port Harvey and Port Neville. All of these areas are relatively protected bays or channels north of Johnstone Strait. However, these were obviously stunted populations that probably resulted from larvae settling from other areas; populations were not extensive and may not maintain themselves over the long term.

Dead shell was found in Sunderland Channel, but live Manila clams were not common. The only significant population was found in a small area of firm gravel-sand substrate high on the beach in Topaze Harbour. Growth was slow and it is unlikely that this population is self sustaining. Previously documented populations in Johnstone Strait certainly were not large enough to support commercial fisheries at that time, nor are the populations found near Salmon Bay and in Topaze Harbour.

Results from the present survey in Queen Charlotte Strait were similar to those of previous surveys (Bourne *et al.* 1994; Bourne and Heritage 1997; Heritage *et al.* 1998). Manila clams remain very scarce in the area, with only a few live Manila clams collected in Deep Harbour and some dead shell observed in Viner Sound; no evidence of Manila clams was found in either Kingcome Inlet or Broughton Strait. Whether there is sufficient local stock in the area to maintain this limited population or whether it survives from settlement of larvae produced elsewhere is unknown. Growth is relatively slow and successful breeding probably does not occur regularly because of cold water temperatures. Manila clams require 13-14°C for gonadal development and spawning occurs if temperatures exceed 15°C (Obah 1959; Mann 1979). Water temperatures taken in July near Gilford Island, in Kingcome Inlet and Broughton Strait were all too low to promote spawning (Table 2).

Only one live Manila clam was found in the Seymour-Belize Inlet complex, but dead shell was found on other beaches. It appears the species has been present in the area for at least ten years. These populations may be maintained by larvae produced elsewhere that have settled in the complex, but if a self sustaining population has been established it is too small to attract commercial interest. Water temperatures in the inlet complex were sufficient to permit gonadal development, spawning and larval development of Manila clams, but a significant population has not developed.

Manila clam densities were low in Tofino Inlet, and size and age structure were dominated by small, young clams, indicating that survival may be low although recruitment may be fairly regular. This may be because of substrate characteristics or lower salinity in the upper reaches of the inlet.

Elsewhere on protected beaches on the west coast of Vancouver Island south of Brooks Peninsula densities are higher and age and size structure indicate reasonable recruitment. Habitat surveys on the west coast of Vancouver Island reported Manila clams to be present on 106 of 152 beaches in Barkley Sound (Blyth *et al.* 1997b), 33 of 118 beaches in Clayoquot Sound (Cross and Kingzett 1993), 57 of 123 beaches in Nootka Sound (Kingzett *et al.* 1995a), 15 of 49 beaches in Kyuquot Sound (Kingzett *et al.* 1995b) and 36 of 53 beaches in Checlset Bay (Blyth *et al.* 2004). These data, coupled with regular records of commercial fishery production (Webb 2002, 2004), indicate that Manila clams are well established along the west coast of Vancouver Island.

Manila clam populations were present in both Winter Harbour and Klaskino Inlet. Previous surveys of these areas indicated that Manila clams were abundant in only a few localities (Heritage and Bourne 1997, Gillespie *et al.* 2004). Habitat surveys of 90 beaches in Quatsino Sound resulted in reports of Manila clams on only three beaches (Cross *et al.* 1995). One of these was in Winter Harbour and two in Holberg Inlet. Shells of "commercial hardshell clams" were reported from an additional beach in each of these locations as well as two beaches between Koprino Harbour and Drake Island; although not explicitly stated, these reports may include Manila clams. Manila clams are present at fewer suitable locations and at generally lower densities than from areas south of Brooks Peninsula.

Varnish Clams

Varnish clams continue to disperse westward through Johnstone Strait, and are now confirmed to have reached Salmon Bay. The lack of larger, older clams in the population indicates that this population is likely the result of larvae transported from elsewhere, and we are uncertain whether this population can be maintained in the absence of transport of larvae from further south or east. Previous surveys indicated that varnish clams had established a population at Cameleon Harbour (Gillespie *et al.* 2004) and dead shell records indicated that they were present in Salmon Bay (Gillespie *et al.* 2001b). No evidence of varnish clams was found further west and north in the Gilford Island, Kingcome Inlet, Broughton Strait and Seymour-Belize Inlet areas.

Varnish clams continue to become more established on the west coast of Vancouver Island. We found varnish clams on two of three beaches surveyed in Barkley Sound, four of 14 beaches in Clayoquot Sound, two of three beaches in Esperanza Inlet, three of six beaches in Kyuquot Sound, two of seven beaches in Ououkinsh Inlet and one of two beaches in Nasparti Inlet (Table 2). Extensive habitat surveys on the west coast of Vancouver Island did not document the presence of varnish clams, implying that establishment has been a relatively recent phenomenon (Cross and Kingzett 1993; Cross *et al.* 1995; Kingzett *et al.* 1995a, 1995b; Blyth *et* *al.* 1997b, 2004). None were found in Klaskino Inlet or Winter Harbour, suggesting that Brooks Peninsula may be a barrier to northward dispersal of larvae.

Olympia Oysters

We found significant populations of Olympia oysters on the west coast of Vancouver Island in Klaskino Inlet, Kyuquot Sound and Esperanza Inlet. Sparse populations or evidence of presence were observed in Clayoquot Sound and Ououkinsh Inlet. No evidence of Olympia oysters was found on beaches surveyed in Johnstone and Queen Charlotte Straits, Kingcome Inlet, Seymour/Belize Inlets, Winter Harbour or Nasparti Inlet.

Extensive beach surveys of Nootka and Kyuquot Sounds reported Olympia oysters from only three locations (Kingzett *et al.* 1995a, b). They were reported from six beaches on the northwestern side and western end of Port Eliza, two beaches in Tlupana Inlet and two beaches in Amai Inlet (the latter correspond to beaches 4 and 5 in Kyuquot Sound in this study). Beach surveys conducted in Quatsino, Clayoquot and Barkley Sounds and Checleset Bay did not document the presence of Olympia oysters[2] in any of those waterways (Cross and Kingzett 1993; Cross *et al.* 1995; Blyth *et al.* 1997b, 2004).

British Columbia likely represents the northern limit of distribution of Olympia oysters, and extensive populations (*i.e.*, oyster reefs) are relatively rare in B.C. (Gillespie 1999). Extensive populations may only develop after decades or centuries, and these populations are not resistant to commercial harvest. The populations documented in Klaskino Inlet, Amai Inlet and Port Eliza deserve special protection, particularly as the species is on the Special Concern list of COSEWIC (COSEWIC 2004).

Littleneck Clams

As was noted in previous survey documents, littleneck clam populations may be under-estimated by the methods used in exploratory surveys, and may be the most abundant intertidal bivalve in B.C. (Gillespie *et al.* 2004). They were recorded on most beaches examined, with the exception of Tofino Inlet, Salmon Bay, Kingcome Inlet, Nimpkish, Seymour/Belize Inlets, the west side of Acous Peninsula, Battle Bay, the head of Amai Inlet and Maggie River. Most of these beaches are not particularly suited to littleneck clams due to substrate, exposure or decreased salinity. Size and age composition on beaches where they were present generally indicated regular recruitment, though growth was relatively slow in Ououkinsh and Kyuquot Inlets and Winter Harbour.

Market preference still continues to determine fishery potential for littleneck clams. The primary market in B.C. is for Manila clams, which are abundant in the South Coast (close to processors and markets), have a higher meat recovery and separate from the shell more readily

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[2] Blyth *et al.* (1997b, 2004) indicated whether "oysters" as a generic were present or absent, but did not differentiate between Pacific and Olympia oysters. Because these surveys were done to assess aquaculture potential of the beaches we assume that these records document the species of interest to aquaculturists, the Pacific oyster.

after steaming. Development of clam fisheries in areas of the Central and North Coast where Manila clams are not common will require development or strengthening of markets for littleneck and butter clams.

Butter Clams

As with littleneck clams, the methods used in exploratory surveys are not ideal for determining abundance or biological characteristics of butter clam populations. However, they do provide a minimum estimate of the extent of butter clam populations. Evidence of butter clam populations was found on six of 14 beaches in Clayoquot Sound, three of five beaches in Johnstone Strait, three of four beaches near Gilford Island, one of two beaches in Broughton Strait, four of seven beaches in Seymour and Belize Inlets, both beaches in Winter Harbour, one of three beaches in Klaskino Inlet, one of two beaches in Nasparti Inlet, four of seven beaches in Ououkinsh Inlet, five of six beaches in Kyuquot Sound, one of three beaches in Esperanza Inlet and two of three beaches in Toquart Bay.

Growth was generally slow (relative to the Strait of Georgia; Quayle and Bourne 1972) with seven to eight years required to reach legal size in Johnstone and Broughton Straits, Gilford Island, Ououkinsh and Esperanza Inlets and Kyuquot Sound, and extremely slow in Winter Harbour with at least nine years required to reach legal size. Some of these results are attributable to latitudinal effects, but some (Winter Harbour) may be due to the tidal levels available for sampling and variation in growth on individual beaches. There are signs of recent recruitment (previous 1-5 years) of butter clams in Johnstone and Broughton Straits, Winter Harbour, Ououkinsh and Esperanza Inlets and Kyuquot Sound.

There were considerable landings of butter clams from the Central and North Coasts historically, and current surveys indicate that growth and recruitment are sufficient to support harvest at the current time. However, costs of harvest, processing and transport of butter clam products from more remote locations continue to limit economic viability. The present surveys provide some information to assist managers but more intensive assessment programs would be beneficial should fisheries develop in the near future.

Other Species

As in previous years, this survey focused mainly on collecting data on butter, littleneck and Manila clam resources. However, information on other species is accumulating and results of this survey contribute to this general knowledge. Collection of information for these species should continue in future surveys so that information is available to manage these resources should a fishery develop, to address biodiversity and invasive species questions and for Species At Risk concerns.

Horse clams, mainly *T. capax*, are a common bivalve in the lower third of many intertidal beaches in northern B.C. Results of our survey work do little more than establish the presence or absence of the species. Although there is probably an extensive horse clam resource in the North

Coast and portions of these populations would be available to intertidal harvest, a fishery has not developed.

Cockles are present on many beaches in the north coast, particularly in the lower half of beaches in soft substrate. Results of the present and past surveys report the presence or absence of the species and give some estimate of the extent of populations, as well as estimating growth rates. The species has no commercial value in B.C. and even if dense extensive populations existed, it is doubtful industry would have any interest in harvesting them. However, they do have particular significance to First Nations as a food species, especially in the North Coast (Baxter *et al.*, in press).

Softshells are another abundant bivalve on many beaches in the North Coast. The species is highly prized on the Atlantic coast of Canada and supports a valuable fishery there, but it has never been accepted in B.C. although it is used to a limited extent in the recreational fishery. Small commercial harvests occurred in the past in the state of Washington, as well as recreational fisheries in Oregon and California (Schink *et al.* 1983). It is doubtful if populations of soft-shell clams could support a targeted commercial fishery in B.C. even if suitable economic conditions prevailed, but it could be harvested along with other species. Growth has been assessed in many areas and it generally takes three to five years to attain a shell length of 50 mm.

Plankton Tows

No plankton tows were made in Clayoquot Sound because few bivalve larvae would be present during the sampling period (April). Other than mussels, few bivalve larvae were observed in other areas of the coast. The lack of larvae in other areas is due in part to tows being made in June and July. Extensive spawning of many bivalves may not have occurred by that time. Another reason for the lack of larvae was that heavy phytoplankton blooms were occurring in most areas that plugged the plankton net. Larvae may have been caught up in the phytoplankton mass and could not be sorted out for observation.

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Table 1. Location of beaches sampled during exploratory intertidal bivalve surveys in British Columbia, 2002.

Location	Number of Beaches	Date
Clayoquot Sound	14	April 16-18
Johnstone Strait	5	June 23-24
Gilford Island	4	June 27
Kingcome Inlet	3	June 28
Broughton Strait	2	June 29
Seymour and Belize Inlets	4	June 30-July 3
Winter Harbour	2	July 6
Klaskino Inlet	3	July 7
Nasparti Inlet	2	July 8
Ououkinsh Inlet	7	July 9
Kyuquot Sound	6	July 10
Esperanza Inlet	3	July 11
Toquart Bay	3	July 12

Table 2. Physical description of beaches and number of quadrats dug on beaches visited during exploratory intertidal bivalve surveys in British Columbia, 2002.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Clayoquot Sound	
1	0.3	Low	Gravel/sand with cobbles on upper beach, mud on lower beach. Relatively little eelgrass on lower margin.	Gunner Inlet 1 (49°10.21'N, 125°44.57'W). Narrow beach, somewhat broader at creek mouths. Live softshell and Baltic macoma collected. Some live blue mussel and Pacific oyster present, mud shrimp abundant in lower beach.
2	<0.1	Low	Gravel/sand strip around mouth of small creek.	Gunner Inlet 2 (49°09.14'N, 125°44.63'W). Small numbers of live softshell and Baltic macoma, three live Manila clams found. Large, dead Pacific oyster shell abundant.
3	<0.1	Low	Sand/mud with much of beach soft mud.	Gunner Inlet 3 (49°08.96'N, 125°44.63'W). Live softshell, Manila clam and Baltic macoma collected, few large Pacific oysters observed. Patches of blue mussel on surface. Lower beach very soft, mud shrimp abundant.
4	<0.1	Low	Sand/gravel surrounded by rocks and bedrock. One creek channel.	Island Cove (49°08.92'N, 125°45.51'W). Tiny beach at head of Island Cove. Live Manila clam, softshell and Baltic macoma collected, one dead Pacific oyster shell observed.
5	1.3	Low/ High	Gravel/sand on high slope portion of beach, sand/gravel on low slope portion. Upper margin of beach gravel/cobble. Two creek channels cross beach, two sections separated by bedrock outcrop.	Indian Bay (49°06.82'N, 125°43.18'W). Live varnish, Manila and butter clams, softshell, cockle and Baltic macoma collected. Few clams on high slope portion of beach, quadrats dug in low slope area between creek channels. Varnish clams deep in gravel under sand. Upper margin of beach covered with rockweed and blue mussels.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Clayoquot Sound (continued)	
6	1.5	Low	Packed sand, eelgrass at low tide margin.	Tsapee Narrows (49°07.65'N, 125°48.77'W). Shell of Manila, littleneck, butter and horse (*T. capax*) clams, cockle and bentnose macoma collected. Tide relatively high, no live clams found on beach.
7	3.0	Low	Gravel/sand with rocks in upper intertidal.	Atleo River (49°22.12'N, 126°03.66'W). Live Manila, littleneck and butter clams, softshell and Baltic and pointed macomas collected. Shell of butter, littleneck, Manila and horse clam (*T. capax*) observed. Some Pacific oyster shell on beach. Live dogwinkles common on lower beach.
8	1.5	Low	Gravel/sand with rocks in upper intertidal.	Sharpe Creek (49°22.87'N, 126°04.09'W). Live Manila, littleneck and butter clams, softshell and pointed macoma collected. Large Manila clams under mussel cover. Shell of Manila, littleneck and butter clams and cockles observed. Gravel banks at mid-tide covered with layer of blue mussels.
9	5.0	Low	Gravel/sand with coarse gravel and rocks near river channel. Eelgrass at low tide margin.	Big Whitepine Cove (49°18.10'N, 125°57.02'W). Live Manila, littleneck and butter clams, softshell and pointed macoma collected. Live Pacific oysters observed on beach, live Olympia oysters sparsely scattered low on beach. Shell of Manila and littleneck clams, cockle and moonsnail observed.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Clayoquot Sound (continued)	
10	1.5	Low	Gravel/sand with rocky upper margin and eelgrass at low tide line. One creek channel across beach.	Little Whitepine Cove (49°17.79'N, 125°58.04'W). Live Manila and littleneck clams, softshell and Baltic macoma collected. Sparse cover of blue mussels over beach surface. Shell of Manila and littleneck clams and softshell observed.
11	8.0	Low	Sand/gravel; upper areas of estuary rock.	Cypre River Estuary (49°16.21'N, 125°54.76'W). Large beach adjacent to River Island. Live varnish and Manila clams, softshell and Baltic macoma collected, some live butter and littleneck clams observed on lower beach. Dogwinkles and dire whelks common, some moonsnail shell observed. Rockweed and barnacle cover on upper beach.
12	2.0	Low	Primarily sand/gravel with large cobble and silty areas near stream channels. Eelgrass on lower margin.	Cypress Bay (49°16.93'N, 125°52.89'W). Live varnish, Manila and littleneck clams, softshell and Baltic macoma collected. Cockle and butter clam shell observed.
13	>10	Low	Wet sand/gravel and cobble beach. Some silty areas and areas of standing water.	Warn Bay (49°15.37'N, 125°43.81'W). Live butter, littleneck, Manila and varnish clams collected, some cockle shell observed. Upper beach had heavy barnacle set, sparse blue mussels.
14	2.0	Low	Gravel/sand with some gravel berms, rocky and silty areas near stream channels.	Mosquito Harbour (49°13.51'N, 125°48.13'W). Beach nearly covered by rising tide. Live Manila clams found, some littleneck shell observed.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
				Johnstone Strait
1	8.0	Low	Gravel with some sand/silt cover.	Salmon Bay (50°23.43'N, 125°57.28'W). Relatively few clams, only a small number of live varnish clams found. Shell of Baltic, pointed and white sand macomas observed, cockles and softshell shells rarely observed.
2	<0.1	Low	Small gravel patch between bedrock outcrops.	South of Salmon Bay (50°23.37'N, 125°56.08'W). Live Manila, littleneck and butter clams, softshell, pointed and bentnose macomas collected.
3	0.8	Low	Lower beach silt/sand with sparse eelgrass cover, upper beach gravel and cobbles.	H'Kusam Bay (50°23.21'N, 125°5.52'W). Live pointed macomas collected. Littleneck clam, cockle and bentnose macoma shell observed.
4	~20	Low	Lower beach sand/silt with large eelgrass bed, upper beach gravel.	Topaze Harbour (50°31.56'N, 125°43.67'W). Extensive beach around head of harbour. Live littleneck, butter and Manila clams, softshell, cockle and pointed and bentnose macomas collected. Shell of butter, littleneck and Manila clams, cockle and bentnose macoma observed. Heavy barnacle cover.
5	~25	Low	Lower beach sand/mud, upper beach had patches of gravel.	Forward Harbour (50°29.29'N, 125°42.32'W). Live littleneck, butter and Manila clams, cockle, softshell and pointed and bentnose macomas collected. Heavy sets of barnacles and mussels.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			West Side of Gilford Island	
1	n/a	Low	Mud.	Viner Sound (50°47.20'N, 126°22.70'W). Extensive beach, but area could not be estimated due to tide height. No live clams collected, shell of Manila and littleneck clams, softshell and bentnose macoma observed. Water temperature was 11°C.
2	0.1	Mod.	Shell/sand substrate with abundant dead shell.	Burdwood Group (50°47.65'N, 126°28.90'W). Live butter, littleneck and horse (*T. capax*) clams, cockle and pointed macoma collected. Shell of butter, littleneck and horse (*T. capax*) clams, horsemussel and pointed macoma observed. Some algal cover, heavy set of barnacles, kelp below lower margin.
3	0.2	Low	Sand/shell with some embedded rock.	Deep Harbour (50°47.75'N, 126°34.30'W). Live butter and littleneck clams, cockle and pointed macoma collected. Five live Manila clams collected from scratches. Shell of butter and littleneck clams abundant, cockle shell also observed.
4	5.5	Low	Mud/sand on west end, east end entirely mud near old log sort.	Shoal Harbour (50°43.85'N, 126°29.25'W). Live butter, littleneck and horse (*T. capax*) clams collected. Shell of butter and littleneck clams, cockle and pointed macoma observed.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Kingcome Inlet	
1	<0.1	Low	Lower beach soft silt, upper beach cobbles and rock.	Anchorage Cove (50°54.31'N, 126°11.88'W). Very small pocket beach. Very little shell on surface, only Baltic and bentnose macomas observed. No live clams found. Sparse barnacle and rockweed cover. Water temperature was 8°C.
2	2.0	Low	Broad estuary of sand with silt covering.	Charles Creek (50°56.13'N, 126°21.45'W). Live softshell and Baltic macoma collected. No other species observed.
3	0.5	Low	Sand/gravel with embedded rock, some areas of rock and wood debris.	Belleisle Inlet (50°53.63'N, 126°24.19'W). Beach behind small island. Live softshells collected by digging individual shows. Shell of softshell, cockle and Baltic macoma observed. Solid substrate covered in rockweed, barnacles and blue mussels.
			Broughton Strait	
1	3.5	Low/ Mod.	Lower beach sand/gravel with sparse algal cover and eelgrass at lower margin, upper beach moderately sloped gravel berm.	Cluxewe River Estuary (50°36.95'N, 127°11.77'W). Live butter, littleneck and horse (*T. capax*) clams, cockle and pointed macomas collected. Water temperature was 12°C.
2	>10	Low	Rock and cobble in packed sand near river, packed sand over rest of beach.	Nimpkish River Estuary (50°34.04'N, 126°57.98'W). Live pointed macoma collected, very little shell on surface, few cockles and pointed macomas. Water temperature was 12°C.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Seymour and Belize Inlets	
1	0.5	Low	Sand/mud with small areas of sand/gravel.	Head of Seymour Inlet (51°11.05'N, 126°40.00'W). No live bivalves found. Shell of softshell, Baltic and pointed macomas and blue mussel present.
2	0.5	Low	Sand/gravel over wood debris.	Chief Nollis Bay, Alison Sound (51°11.10'N, 127°05.65'W). Live softshell, Baltic and pointed macomas collected.
3	<0.1	Low	Sand/gravel with some rocky areas.	Nugent Creek (51°05.05'N, 127°23.10'W). One live Manila clam collected. Butter and littleneck shell abundant, shell of cockle, horse (*T. capax*) and macoma present.
4	<0.1	Low	Sand/gravel with some rocky areas.	South side of Nugent Sound (51°05.15'N, 127°16.90'W). Live softshells collected. Littleneck and butter shell abundant; shell of cockle, pointed macoma and Manila clam found.
5	<0.1	Low	Mud/sand/gravel with some rocky areas.	Head of Nugent Sound 1 (near mouth of Schwartzenberg Lagoon)(51°04.90'N, 127°11.80'W). No live bivalves found. Shell of softshell, littleneck and butter clams and cockle observed.
6	<0.1	Low	Soft mud/sand/gravel.	Head of Nugent Sound 2 (opposite mouth of Schwartzenberg Lagoon)(51°05.55'N, 127°12.10'W). No live bivalves collected. Shell of Manila, butter and littleneck clams, softshell and cockle observed.
7	<0.1	Low	Soft mud.	Head of Nugent Sound 3 (opposite mouth of Schwartzenberg Lagoon)(51°05.62'N, 127°11.60'W). Substrate too soft to explore beach. Water temperature was 16°C.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Winter Harbour	
1	n/a	Low	Gravel plateau above silt/sand beach. Eelgrass on lower margin.	Head of Winter Harbour (50°32.13'N, 127°59.10'W). Extensive beach, only 1-2 ha exposed on poor tide. Live Manila, littleneck and butter clams, softshell and pointed macoma collected. Cockle, blue mussel and moonsnail shell observed. Ghost shrimp abundant.
2	n/a	Low	Sand/shell/gravel.	Denad Creek (50°31.84'N, 128°00.57'W). Extensive beach, only 2 ha exposed on poor tide. Live Manila, littleneck and butter clams and softshell collected. Moonsnails and dogwinkles common. Blue mussel and barnacle cover. Water temperature was 13°C.
			Klaskino Inlet	
1	3.0	Low	Gravel/shell with embedded rock on upper beach.	Northeast Klaskino Inlet (50°17.92'N, 127°43.42'W). Live Manila and littleneck clams, softshell, blue mussel and Olympia oyster collected. Butter and horse clam shell (*T. capax* and *T. nuttallii*) also present. Moonsnails and dogwinkles common, dire whelks also observed.
2	2.5	Low	Gravel/sand with rockweed and algal cover on mid- to upper beach, eelgrass on lower margin.	Southeast Klaskino Inlet (50°17.70'N, 127°43.20'W). Live Manila and littleneck clams, softshell and Olympia oyster observed. Moonsnails common, red rock and graceful crabs observed.
3	1.0	Low/ Mod.	Gravel/sand with relatively steep upper slope.	Southwest Klaskino Inlet (50°18.09'N, 127°43.98'W). Beach rapidly covered by incoming tide. No samples taken, live Manila and littleneck clams and Olympia oyster observed. Moonsnails and giant pink starfish present in low intertidal. Water temperature was 16°C.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
				Nasparti Inlet
1	~10	Low	Gravel and rock beach with some sandy areas. Green algal cover in sandy areas.	Head of Nasparti Inlet (50°11.19'N, 127°36.99'W). Live butter, littleneck and Manila clams and softshell collected. Some butter clam and cockle shell observed. Large softshell bed in sandy area of upper intertidal. Barnacle and blue mussel cover. Water temperature was 14°C.
2	~20	Low	Clean sand beach with some gravel and wood fiber near creek bed.	Jackobson Point (50°08.39'N, 127°41.61'W). Live varnish, littleneck and Manila clams, bentnose macoma, softshell, cockle collected. Varnish shell abundant, some horse clam shell (*T. capax* and *T. nuttallii*) observed. Water temperature was 16°C.
				Ououkinsh Inlet
1	0.5	Low	Gravel/mud at high tide line, mud with eelgrass at low tide line.	Gay Passage 1 (50°06.34'N, 127°30.51'W). Small pocket beach off main passage. Live Manila and littleneck clams and softshell observed at very low densities; all small and stunted. Shell of Manila, littleneck and butter clams and bentnose macoma observed. No samples taken.
2	<0.1	High	Coarse sand/gravel with eelgrass at lower margin.	Gay Passage 2 (50°06.41'N, 127°31.76'W). Narrow beach on main passage. Live butter, littleneck, horse (*T. capax*) and varnish clams collected. Shell of butter, littleneck, Manila, varnish and horse clams (*T. capax* and *T. nuttallii*) observed. Large otter pits on beach.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Ououkinsh Inlet (continued)	
3	1.0	Low	Gravel/sand with cobbles and rockweed on upper margin, eelgrass and algae on lower margin.	Acous Peninsula 1 (50°06.61'N, 127°35.75'W). Live Manila, littleneck and varnish clams and softshell collected. Live Pacific and one Olympia oyster observed. Shell of Manila, littleneck, butter and horse clam and softshell abundant. Moonsnail and sea stars abundant subtidally. Beach scoured by sea otters; numerous holes in beach. Water temperature was 14°C.
4	0.3	Low	Hard packed sand	Acous Peninsula 2 (50°07.08'N, 127°35.75'W). No live infaunal bivalves or shell observed. Sparse cover of blue mussel and thatched barnacle on rocks.
5	0.5	Mod.	Clean gravel with sand/mud.	Battle Bay (50°07.25'N, 127°35.10'W). High energy beach open to main inlet. No live clams on main beach, small patch of softshells behind main berm in creek estuary. Scattered worn shell of blue and California mussels, false jingle, hooked surfclam, cockle, softshell and one small Olympia oyster.
6	<0.1	Mod.	Rock and cobble with some patches of sand/mud.	Power River Estuary (50°10.59'N, 127°28.55'W). Live littleneck and Manila clams collected. Shell of Manila and littleneck clams, softshell and blue mussel observed.
7	~10	Low	Gravel/sand/mud with scattered cobble, rocks with cover of rockweed near upper margin.	Head of Ououkinsh Inlet (50°11.13'N, 127°26.47'W). Extensive estuary of Ououkinsh River at head of inlet. Live littleneck, Manila and horse (*T. capax*) clams, pointed macoma and softshells collected. Shell of Manila, littleneck and butter clams and softshell observed. Water temperature was 15°C.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Kyuquot Sound	
1	<0.1	Low	Rocky estuary with areas of sand/mud in mid-intertidal, lower intertidal mud with eelgrass.	Cachalot Inlet 1 (49°59.86'N, 127°08.72'W). Live Manila, littleneck and varnish clams, softshell and Baltic macoma collected. Live Pacific and Olympia oysters observed at low densities. Water temperature was 14°C.
2	~10	Low	Most of beach sand over wood debris and anoxic mud, some areas of sand/gravel in mid-intertidal, lower margin soft silt.	Cachalot Inlet 2 (49°59.83'N, 127°07.99'W). Large beach at head of inlet. Live Manila and littleneck clams and blue mussels at low densities. Shell of Manila, littleneck and varnish clams, softshell, butter, cockle and Olympia oyster observed. Dungeness crab and moonsnails common on lower margin.
3	1.5	Low	Primarily cobble and small rock imbedded in sand. Eelgrass, *Sargassum* and other algae at lower margin.	Whaling Station (49°59.95'N, 127°09.64'W). Live butter, littleneck, Manila and horse clams (*T. capax*) and pointed macomas collected. Shell of butter, littleneck, Manila and horse clams, softshell and cockle observed. Heavy cover of blue mussels and barnacles, sparse rockweed on upper margin.
4	2.0	Mod./ High	Beach mostly cobbles; lower third of beach steeper with sand/gravel substrate.	Amai Inlet 1 (50°01.36'N, 127°06.10'W). Strip beach in south shore of inlet. Live littleneck, Manila and varnish clams, softshell and Baltic macomas collected. Dense Olympia oyster bed at East end of beach; large live Pacific oysters very sparsely scattered over beach. Shell of Manila, littleneck, varnish, butter and horse clams, softshell and false-jingle observed. Thick cover of barnacles and blue mussels. Water temperature was 17°C.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Kyuquot Sound (continued)	
5	~10	Low	Large portion of beach gravel berms; portion near creek gravel with imbedded small rock and cobble.	Amai Inlet 2 (50°01.51'N, 127°04.99'W). Large beach at head of inlet, included portion at mouth of Amai Creek. Few live infaunal bivalves observed; Olympia oyster bed near creek. Shell of Manila, littleneck and butter clams, softshell, cockle and bentnose macoma observed. Thick cover of blue mussels and barnacles.
6	0.25	Low	Upper beach gravel and rock, lower portion sand/mud with eelgrass.	Amai Inlet 3 (50°01.25'N, 127°10.55'W). Estuary in unnamed cove on north shore at mouth of inlet. Live butter, littleneck and Manila clams, softshell and pointed macomas collected. Shell of butter, littleneck and Manila clams, softshell, Olympia and Pacific oyster observed.

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Esperanza Inlet	
1	1.5	Low/ Mod.	Gravel with embedded rock. Lower margin drops off quickly to soft substrate and eelgrass. Several creek channels cross beach.	Port Eliza 1 (49°55.94'N, 127°02.73'W). Strip beach on west side of inlet near head. Olympia oysters abundant, few scattered Pacific oysters. Few live infaunal bivalves observed, shell of Manila and littleneck clams present. Moderate cover of acorn barnacles, patches of blue mussel and rockweed. Large purple and sunflower stars on lower beach margin. One live male green crab collected from creek channel. Water temperature was 15°C.
2	~10	Low	Mostly gravel/sand over wood debris and anoxic mud. Grassy meadow on upper margin with patches of rockweed, lower margin dropping off quickly with soft substrate eelgrass and algal cover.	Port Eliza 2 (49°56.31'N, 127°02.91'W). Large estuary at head of inlet. Live Manila, varnish and littleneck clams, softshell and bentnose macoma collected. Few live Olympia oysters present, no Pacific oysters observed. Shell of Manila, littleneck and varnish clams, softshell and Olympia oyster observed.
3	~10	Low	Mixed substrates. Large sand/gravel berm near Garden Point, most of east side of beach gravel, with patches of clean sand.	Garden Point (49°50.94'N, 126°54.04'W). Extensive beach on east side of point. Live butter, horse (*T. capax* and *T. nuttallii*) and littleneck clams, softshell, cockle and pointed macoma collected from berm near point. Manila and varnish clams, softshell and Baltic macomas dug from gravel substrates, varnish clams also found alone in sandy substrates. Blue mussel and acorn barnacle cover in gravel areas

Table 2. continued.

Beach No.	Area (ha)	Slope	Substrate	Remarks
			Toquart Bay	
1	2.0	Low	Very little clam-bearing substrate exposed at this tide level.	Lucky Creek (49°01.59'N, 125°18.37'W). Pacific oysters extremely abundant, Olympia oysters mixed in at lower densities. Small numbers of Manila, littleneck and butter clam shells observed. Sea stars (purple, sunflower, leather, giant pink) common on lower margin of beach. Water temperature was 18°C.
2	1.5	Low	Gravel with increasing cobble and rock on upper margin.	Hillier Island (49°01.92'N, 125°19.49'W). East side of island. Pacific oysters abundant on upper portion of beach, Olympia oysters sparsely scattered on lower portion. Live Manila and varnish clams collected, some stunted live littleneck clams observed. Shell of Olympia oyster abundant on lower portion, shell of varnish, Manila, littleneck and butter clams, pointed and bentnose macoma observed. Moonsnails common on lower margin.
3	~10	Low	Mainly cobble imbedded in sand/gravel.	Maggie River Estuary (48°59.20'N, 125°23.16'W). Extensive estuary on north side of channel. Live Manila and varnish clams and softshell collected. Some live Pacific oyster scattered on beach. Very little shell observed. Heavy cover of acron barnacles on cobble.

Table 3. Clam densities (clams m^{-2}) by species from exploratory intertidal bivalve surveys in British Columbia, 2002.

		Butter		Littleneck		Manila						
Beach	Quadrat	Legal	Sublegal	Legal	Sublegal	Legal	Sublegal	Horse	Macoma	Softshell	Cockle	Varnish
						Clayoquot Sound						
1	1	0	0	0	0	0	0	0	0	192.0	0	0
1	2	0	0	0	0	0	0	0	0	348.0	0	0
1	3	0	0	0	0	0	0	0	0	32.0	0	0
1	4	0	0	0	0	0	0	0	0	232.0	0	0
1	5	0	0	0	0	0	0	0	77.8	311.1	0	0
1	6	0	0	0	0	0	0	0	0	1625.0	0	0
3	1	0	0	0	0	4.0	20.0	0	0	84.0	0	0
3	2	0	0	0	0	8.0	76.0	0	0	60.0	0	0
4	1	0	0	0	0	1.6	21.2	0	0	0	0	0
5	1	0	0	0	0	0	0	0	0	0	0	17.2
5	2	0	0.3	0	0	0.7	15.3	0	0.3	18.0	0.7	1.0
7	1	0	0	0	0	88.0	200.0	0	24.0	20.0	0	0
7	2	0	0	0	4.0	48.0	68.0	0	24.0	32.0	0	0
7	3	0	0	0	20.0	44.0	36.0	0	0	0	0	0
7	4	0	44.0	72.0	156.0	0	0	0	4.0	0	0	0
7	5	0	8.0	32.0	20.0	28.0	40.0	0	0	0	0	0
7	6	0	0	0	0	0	0	0	20.0	56.0	0	0
8	1	0	96.0	4.0	44.0	76.0	120.0	0	8.0	8.0	0	0
8	2	0	196.0	68.0	248.0	28.0	0	0	92.0	0	0	0
9	2	0	4.0	0	0	272.0	68.0	0	8.0	32.0	0	0
9	3	0	0	20.0	8.0	116.0	32.0	0	44.0	4.0	0	0
9	4	0	0	0	28.0	172.0	16.0	0	32.0	0	0	0
9	5	0	0	0	8.0	180.0	120.0	0	0	0	0	0
9	6	0	40.0	4.0	36.0	236.0	164.0	0	20.0	4.0	0	0
10	1	0	0	0	0	184.0	40.0	0	0	4.0	0	0
10	2	0	0	0	4.0	84.0	72.0	0	8.0	4.0	0	0
11	1	0	0	0	0	0	1.0	0	0	4.0	0	5.0
11	2	0	0	0	0	0	0	0	0	0	0	8.0
11	3	0	0	0	0	8.0	0	0	28.0	28.0	0	44.0
12	1	0	0	4.0	0	0	4.0	0	4.0	28.0	0	28.0
13	1	0	4.0	0	0	28.0	48.0	0	0	0	0	0
13	2	0	0	0	28.0	104.0	148.0	0	0	0	0	0
13	3	0	0	0	12.0	28.0	12.0	0	0	0	0	0
13	4	0	0	0	0	0	0	0	0	0	0	1.0
						Johnstone Strait						
1	1	0	0	0	0	0	0	0	0	0	0	17.9
2	1	0	0	0	0	4.0	8.0	0	0	4.0	0	0
2	2	0	0	0	0	0	16.0	0	0	0	0	0
2	3	0	0	0	0	0	8.0	0	0	4.0	0	0
2	4	0	12.0	0	28.0	0	0	0	44.0	0	0	0
3	1	0	0	0	0	0	0	0	156.0	0	0	0
4	1	20.0	4.0	76.0	12.0	0	0	0	52.0	0	12.0	0
4	2	0	0	52.0	12.0	0	0	0	24.0	0	0	0
4	3	0	0	0	0	64.0	56.0	0	0	4.0	0	0
4	4	8.0	0	52.0	0	0	0	0	40.0	0	0	0
4	5	0	0	0	0	0	0	0	0	0	0	0
4	6	0	0	44.0	116.0	0	0	0	56.0	0	0	0
5	1	0	0	12.0	52.0	0	0	0	0	0	0	0
5	2	0	0	36.0	32.0	0	4.0	0	0	8.0	4.0	0
5	3	4.0	8.0	116.0	12.0	0	0	0	68.0	0	4.0	0
						West Side Gilford Island						
2	1	84.0	232.0	128.0	140.0	0	0	12.0	8.0	0	0	0
2	2	72.0	24.0	116.0	32.0	0	0	0	28.0	0	8.0	0
3	1	36.0	8.0	22.0	2.0	0	0	0	4.0	0	10.0	0
4	1	32.0	28.0	96.0	36.0	0	0	4.0	0	0	0	0

Table 3. continued.

Beach	Quadrat	Butter Legal	Butter Sublegal	Littleneck Legal	Littleneck Sublegal	Manila Legal	Manila Sublegal	Horse	Macoma	Softshell	Cockle	Varnish
						Broughton Strait						
1	1	56.0	4.0	0	0	0	0	0	4.0	0	0	0
1	2	10.0	28.0	0	0	0	0	2.0	24.0	0	10.0	0
1	3	4.0	8.0	4.0	2.0	0	0	0	0	0	0	0
1	4	16.0	4.0	0	0	0	0	0	0	0	0	0
						Winter Harbour						
1	1	1.0	3.0	0	0	1.0	1.0	0	14.0	1.0	0	0
1	2	0	0	0	8.0	12.0	12.0	0	0	4.0	0	0
1	3	0	8.0	0	20.0	24.0	8.0	0	0	0	0	0
1	4	0	8.0	2.0	13.0	17.0	12.0	0	9.0	1.0	0	0
1	5	0	0	0	4.0	0	12.0	0	36.0	8.0	0	0
2	1	0	4.0	64.0	8.0	112.0	8.0	0	0	0	0	0
2	2	0	0	12.0	4.0	32.0	12.0	0	0	0	0	0
2	3	0	0	8.0	12.0	32.0	24.0	0	0	0	0	0
2	4	0	0	4.0	4.0	92.0	16.0	0	0	0	0	0
2	5	4.0	16.0	28.0	20.0	84.0	48.0	0	0	8.0	0	0
						Klaskino Inlet						
1	1	0	0	108.0	200.0	76.0	16.0	0	0	4.0	0	0
1	2	0	0	8.0	120.0	228.0	24.0	0	0	0	0	0
						Nasparti Inlet						
1	1	0	0	12.0	36.0	0	16.0	0	0	0	0	0
1	2	0	0	20.0	100.0	20.0	4.0	0	0	0	0	0
1	3	0	4.0	12.0	56.0	28.0	12.0	0	0	8.0	0	0
1	4	0	0	4.0	8.0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0	2.0	0	36.0
2	2	0	0	0	0	4.0	0	0	0	4.0	0	52.0
2	3	0	0	0	0	0	0	0	0	4.0	0	92.0
2	4	0	0	0	0	0	0	0	0	8.0	0	48.0
2	5	0	0	0	0	0	3.3	0	0	0	0	96.7
2	6	0	0	0	16.0	28.0	4.0	0	108.0	0	0	0
2	7	0	0	0	0	0	0	0	8.0	0	8.0	4.0
2	8	0	0	0	0	0	0	0	0	0	0	4.0
2	9	0	0	0	4.0	0	0	0	0	0	0	12.0
						Ououkinsh Inlet						
2	1	0	52.0	0	16.0	0	0	72.0	0	0	0	88.0
2	2	0	20.0	8.0	12.0	0	0	0	0	0	0	36.0
2	3	0	48.0	12.0	44.0	0	0	12.0	0	0	0	108.0
3	1	0	0	0	0	0	0	0	0	12.0	0	0
3	2	0	0	4.0	12.0	0	0	0	0	4.0	0	4.0
3	3	0	0	0	0	0	8.0	0	0	16.0	0	12.0
3	4	0	0	0	0	4.0	0	0	0	0	0	0
6	1	0	0	16.0	48.0	64.0	52.0	0	0	0	0	0
6	2	0	0	8.0	48.0	112.0	180.0	0	0	0	0	0
6	3	0	0	0	0	64.0	48.0	0	0	0	0	0
7	1	0	0	32.0	56.0	128.0	124.0	0	0	0	0	0
7	2	0	0	16.0	28.0	12.0	28.0	0	4.0	8.0	0	0
7	3	0	0	0	4.0	72.0	92.0	4.0	0	4.0	0	0
						Kuyoquot Sound						
1	1	0	0	8.0	28.0	264.0	236.0	0	4.0	32.0	0	0
1	2	0	0	8.0	16.0	244.0	104.0	0	0	32.0	0	4.0
3	1	0	0	8.0	48.0	28.0	44.0	0	0	0	0	0
3	2	16.0	13.0	4.0	0	0	0	1.0	4.0	0	0	0
3	3	0	24.0	48.0	44.0	72.0	56.0	0	12.0	0	0	0
4	1	0	0	36.0	112.0	140.0	280.0	0	0	8.0	0	12.0
4	2	0	0	48.0	148.0	92.0	120.0	0	0	8.0	0	0
4	3	0	0	0	0	60.0	28.0	0	24.0	28.0	0	0
6	1	0	0	4.0	16.0	24.0	12.0	0	0	8.0	0	0
6	2	0	0	32.0	164.0	148.0	140.0	0	4.0	0	0	0
6	3	0	16.0	16.0	80.0	116.0	124.0	0	8.0	8.0	0	0

Table 3. continued.

Beach	Quadrat	Butter Legal	Butter Sublegal	Littleneck Legal	Littleneck Sublegal	Manila Legal	Manila Sublegal	Horse	Macoma	Softshell	Cockle	Varnish
						Esperanza Inlet						
2	1	0	0	8.0	4.0	68.0	16.0	0	0	0	0	0
2	2	0	0	0	0	0	48.0	0	32.0	8.0	0	20.0
2	3	0	0	0	4.0	0	12.0	0	8.0	0	0	20.0
3	1	36.0	74.0	22.0	12.0	0	0	76.0	114.0	2.0	38.0	0
3	2	0	0	0	0	0	0	0	0	0	0	160.0
3	3	0	0	0	0	0	0	0	0	0	0	20.0
3	4	0	0	0	0	0	4.0	0	4.0	8.0	0	80.0
3	5	0	0	0	0	32.0	28.0	0	20.0	16.0	0	12.0
3	6	0	0	0	0	0	20.0	0	12.0	24.0	0	20.0
3	7	0	0	0	0	0	8.0	0	24.0	16.0	0	12.0
						Toquart Bay						
2	1	0	0	0	0	4.0	384.0	0	0	0	0	68.0
2	2	0	0	0	0	12.0	400.0	0	0	0	0	76.0
3	1	0	0	0	0	0	0	0	0	36.0	0	456.0
3	2	0	0	0	0	0	104.0	0	0	12.0	0	176.0

Table 4. Density estimates (oysters m^{-2}) of Olympia oysters from surveys on the west coast of Vancouver Island, July 2002.

Location	Date	# of Samples	# of Live Oysters				# of Dead Shells			
			Mean	95% CI	Max.	Min.	Mean	95% CI	Max.	Min.
Northeast Klaskino Inlet	July 7	76	109.26	35.49	866.48	0.00	13.62	5.47	144.41	0.00
Amai Inlet 1	July 10	27	353.01	94.38	890.55	0.00	155.11	44.64	529.51	0.00
Port Eliza 1	July 11	54	360.14	76.11	1,203.44	0.00	280.80	78.08	1,347.85	0.00

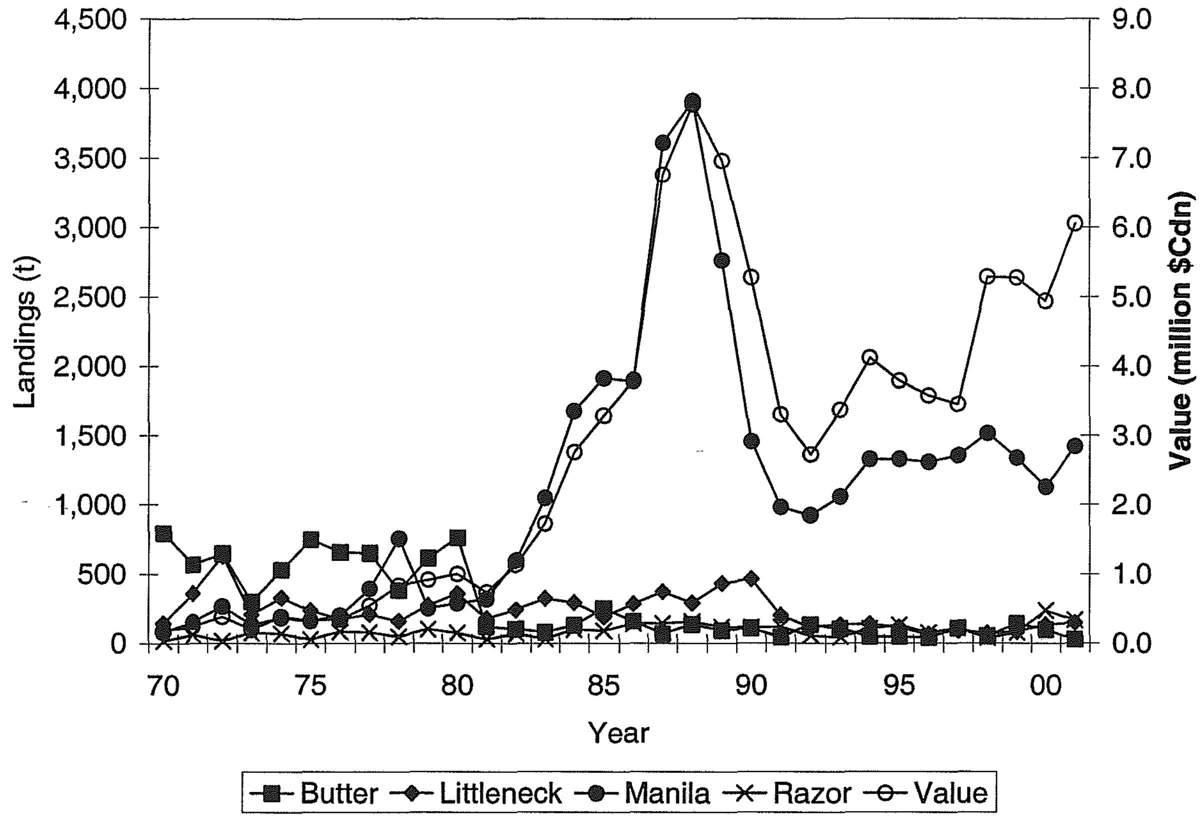


Figure 1. Landings (tonnes) and value ($Cdn) of intertidal clams from British Columbia commercial fisheries, 1970-2001.

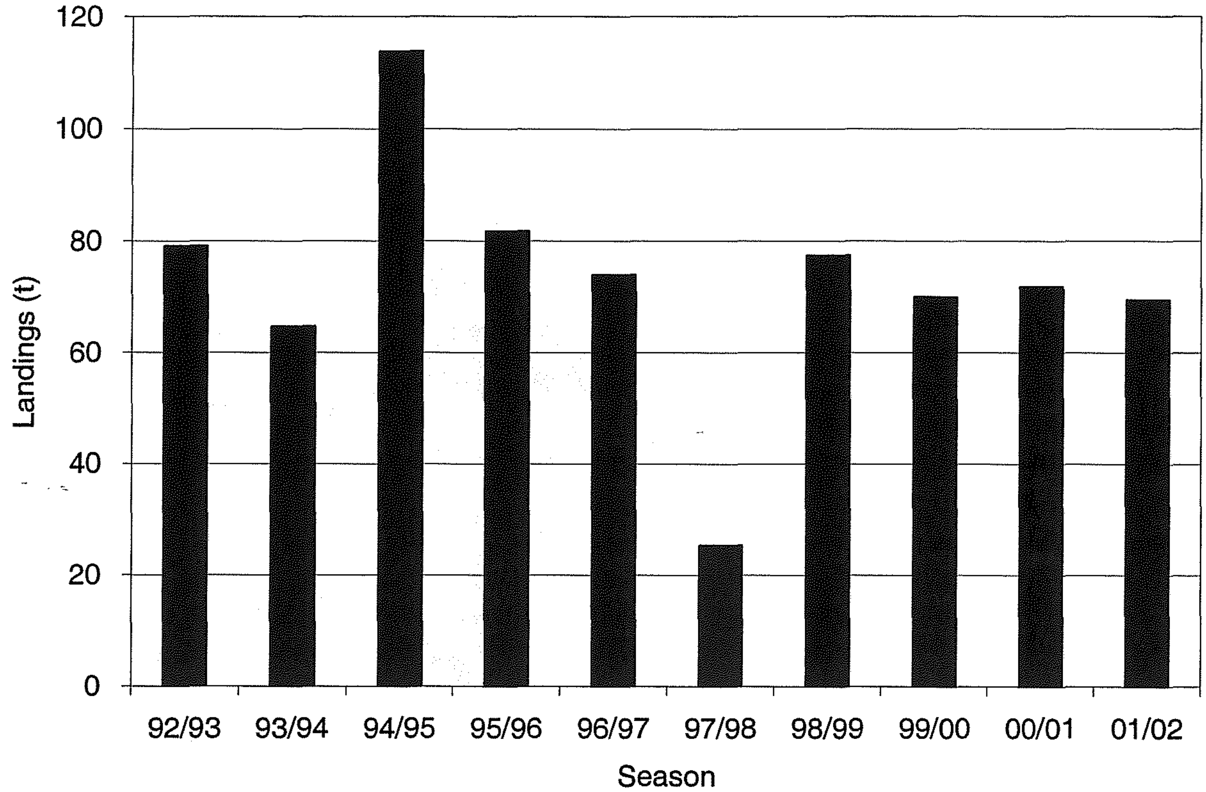


Figure 2. Landings of Manila clams (tonnes) from Pacific Fisheries Management Area 7, 1992/93 to 2001/02 seasons.

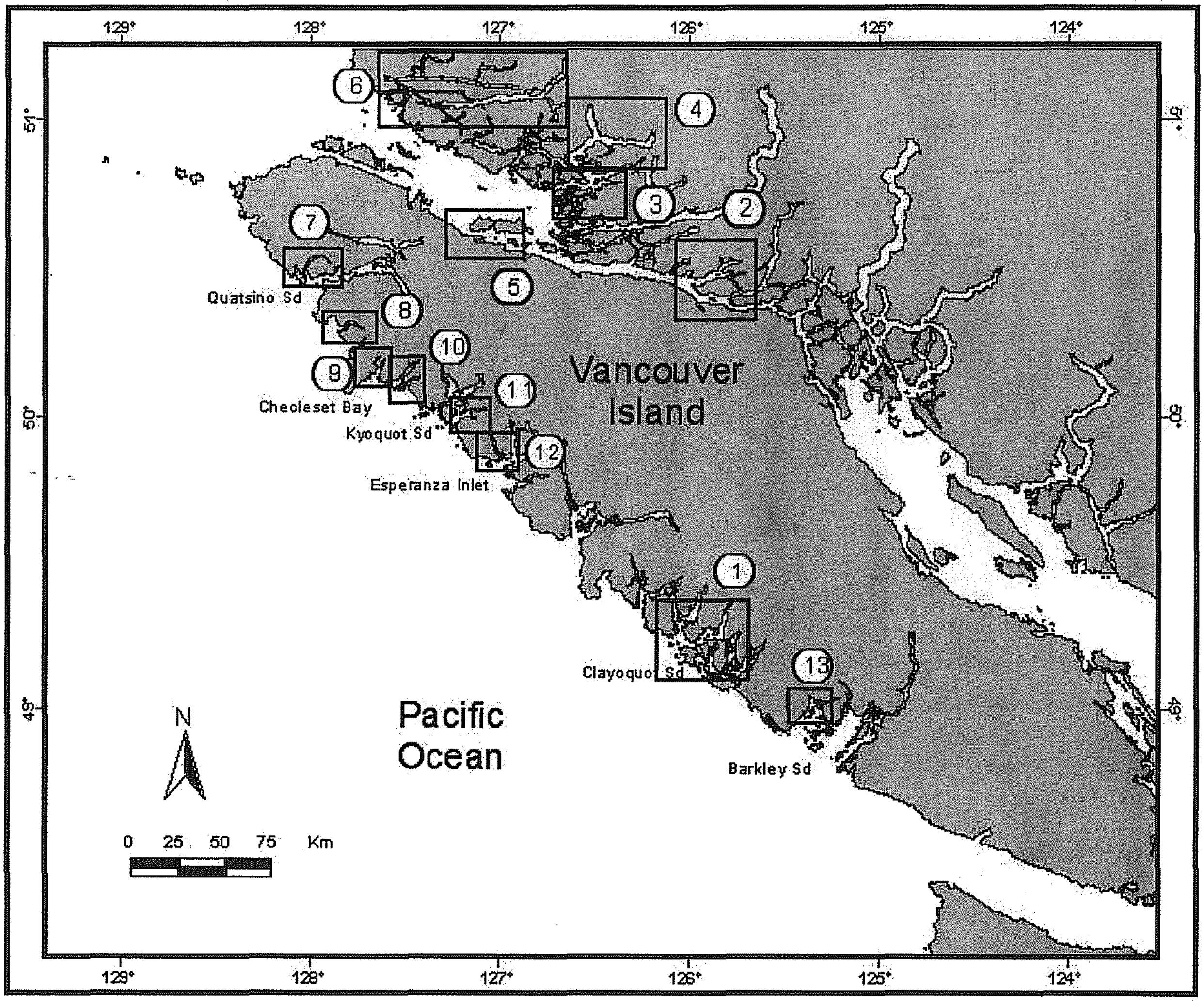


Figure 3. General location of exploratory intertidal bivalve surveys, 2002.

Legend: 1 – Clayoquot Sound; 2 – Johnstone Strait; 3 – Gilford Island; 4 – Kingcome Inlet; 5 – Broughton Strait; 6 - Seymour and Belize Inlets; 7 – Winter Harbour; 8 – Klaskino Inlet; 9 – Nasparti Inlet; 10 – Ououkinsh Inlet; 11 – Kyoquot Sound; 12 – Esperanza Inlet; 13 – Toquart Bay.

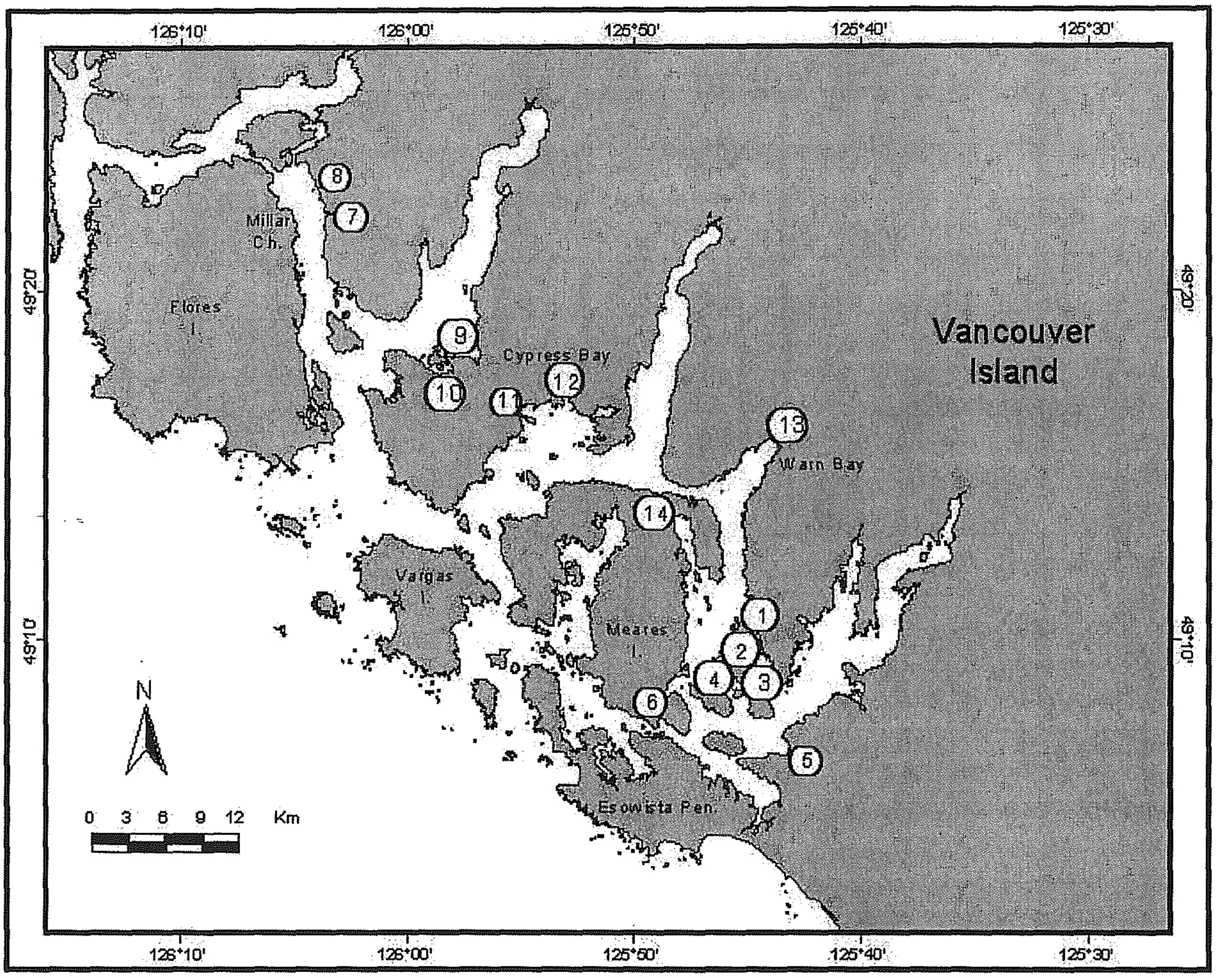
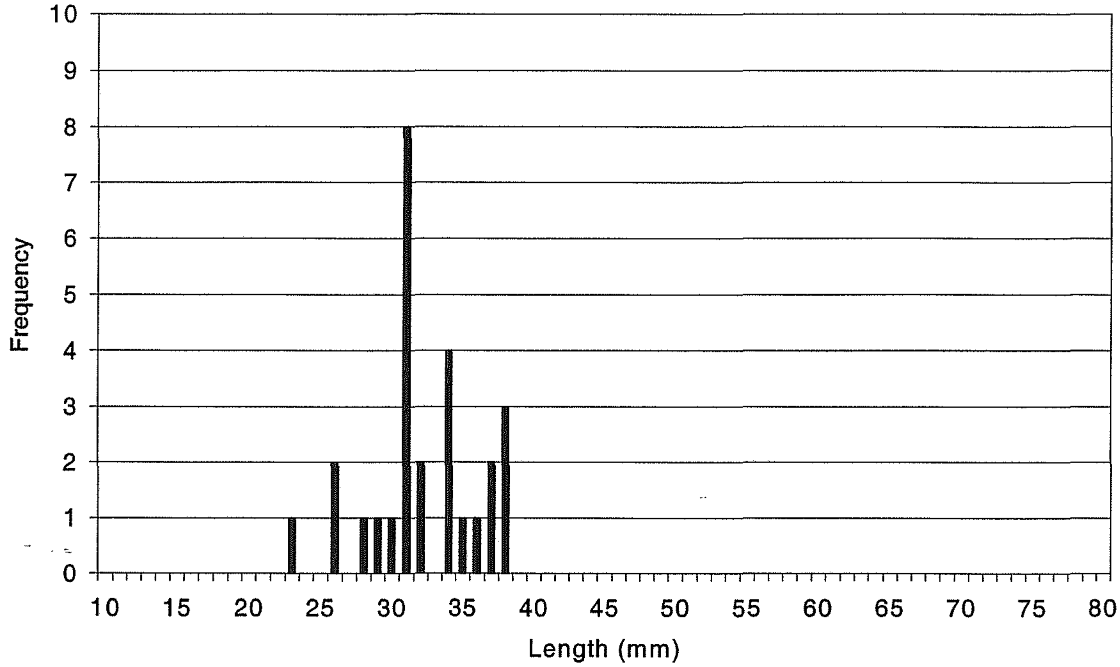


Figure 4. Locations of beaches surveyed in Clayoquot Sound and Millar Channel, April 16-18, 2002.

Legend: 1 – Gunner Inlet 1; 2 – Gunner Inlet 2; 3 – Gunner Inlet 3; 4 – Island Cove; 5 – Indian Bay; 6 – Tsapee Narrows; 7 – Atleo River; 8 – Sharpe Creek; 9 – Big Whitepine Cove; 10 – Little Whitepine Cove; 11 – Cypre River estuary; 12 – Cypress Bay; 13 – Warn Bay; 14 – Mosquito Harbour.



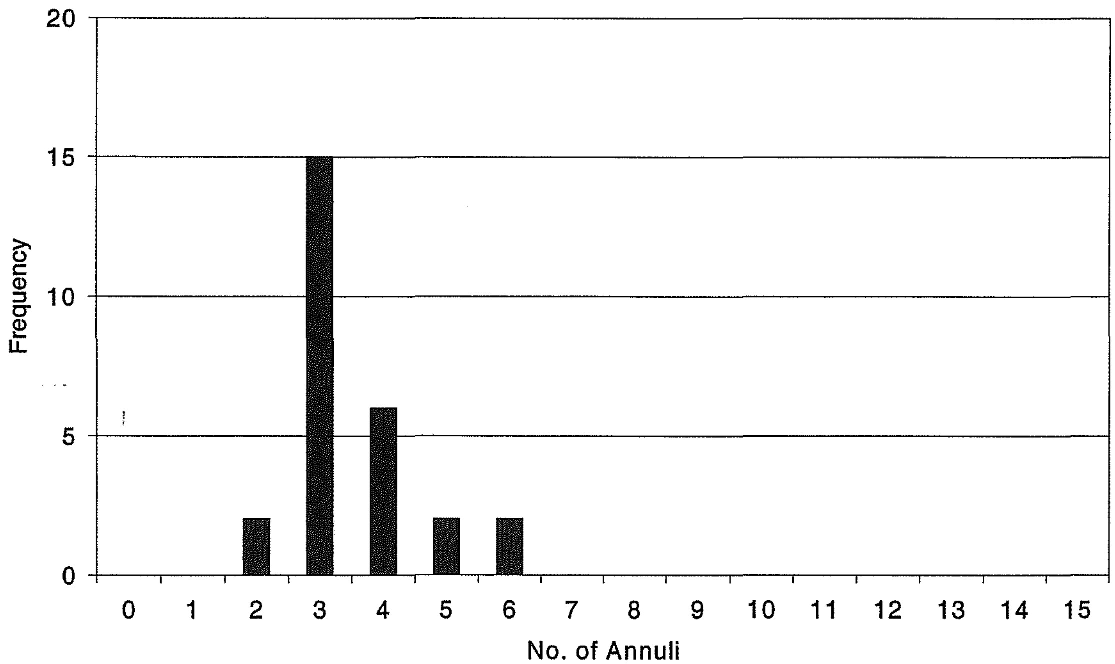
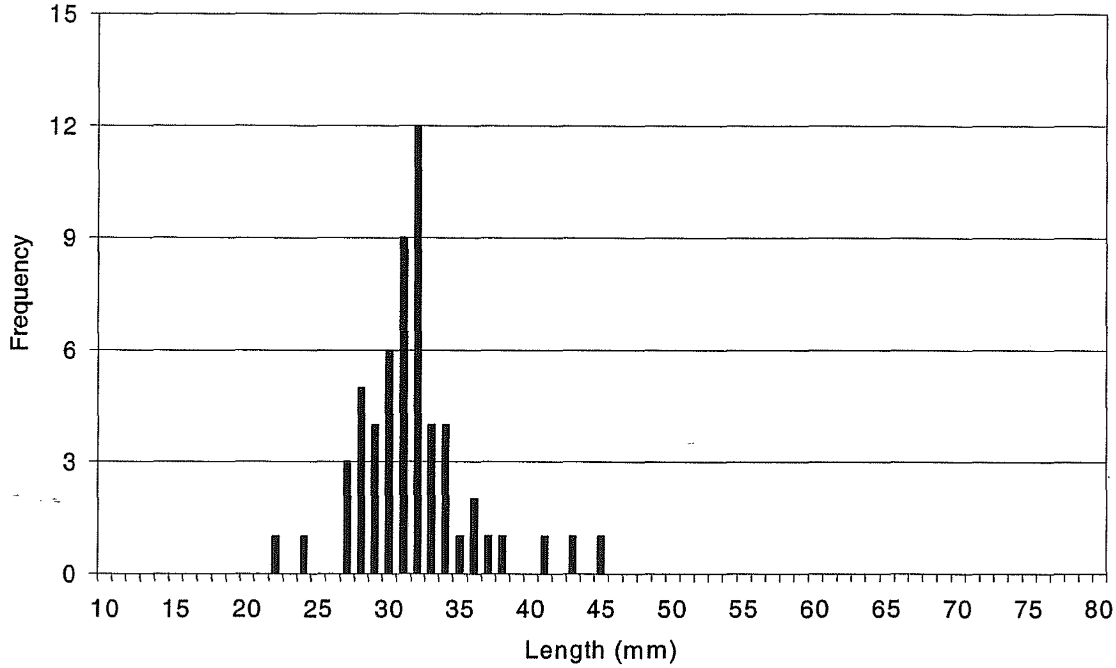


Figure 5. Length (top) and age (bottom) frequency distributions of Manila clams collected at Gunner Inlet 3, Clayoqout Sound, April 16, 2002.



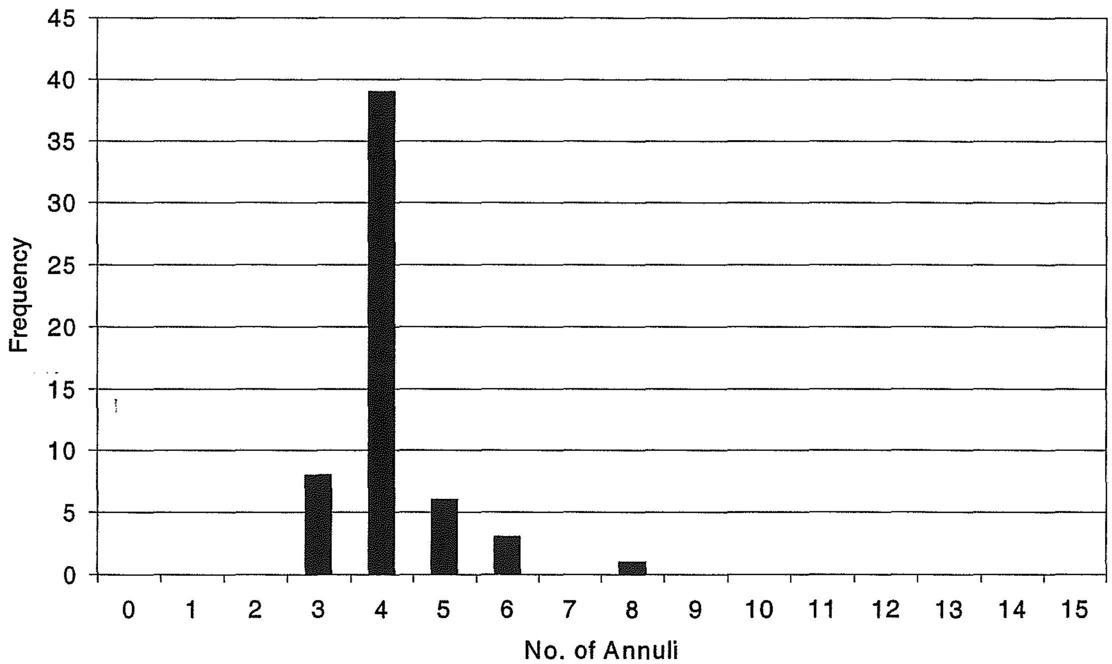
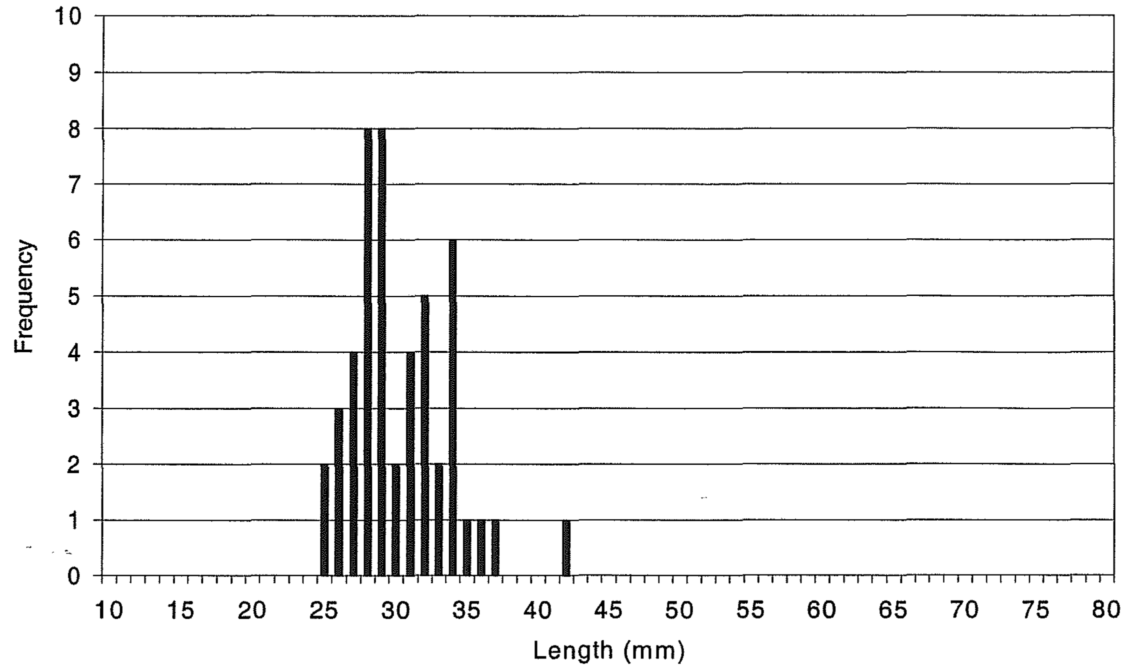


Figure 6. Length (top) and age (bottom) frequency distributions of Manila clams collected in Island Cove, Clayoquot Sound, April 16, 2002.



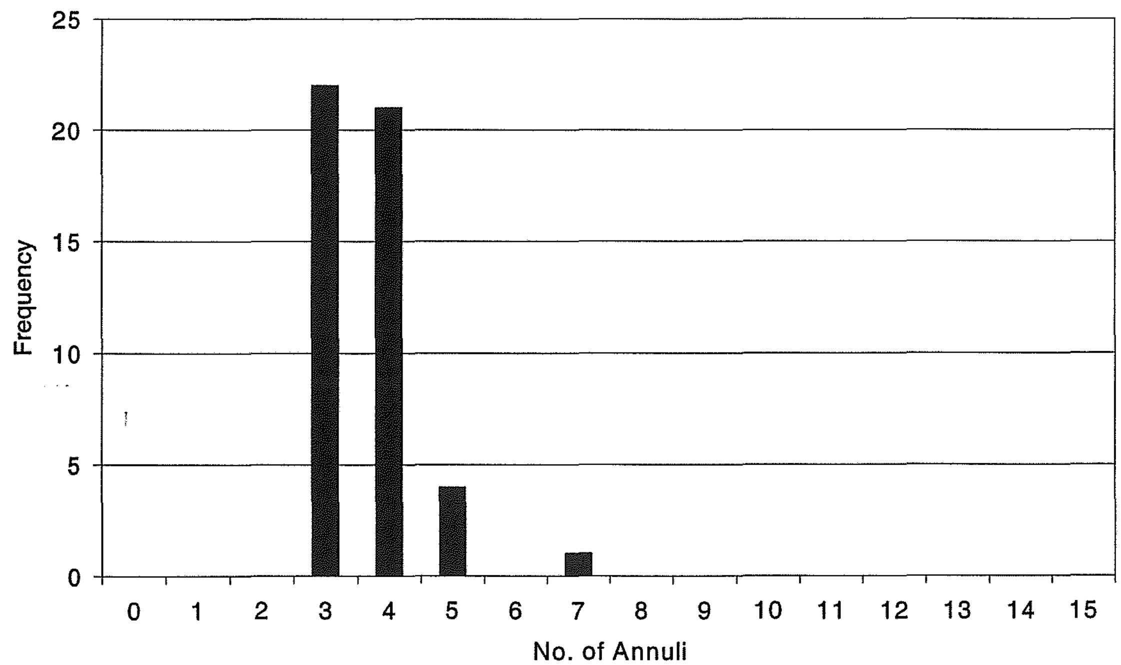


Figure 7. Length (top) and age (bottom) frequency distributions of Manila clams collected in Indian Bay, Clayoquot Sound, April 16, 2002.

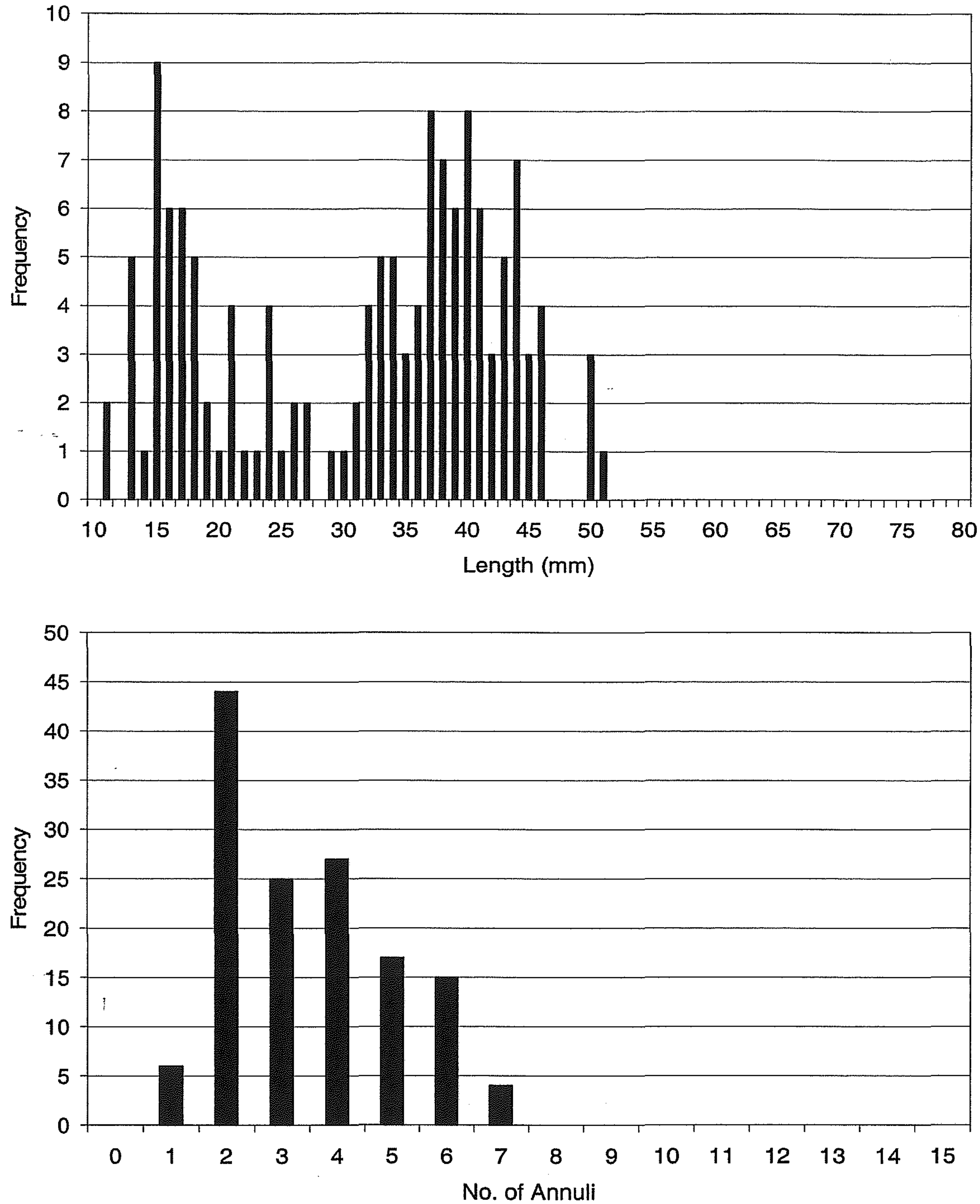


Figure 8. Length (top) and age (bottom) frequency distributions of Manila clams collected at Atleo River, Clayoquot Sound, April 17, 2002.

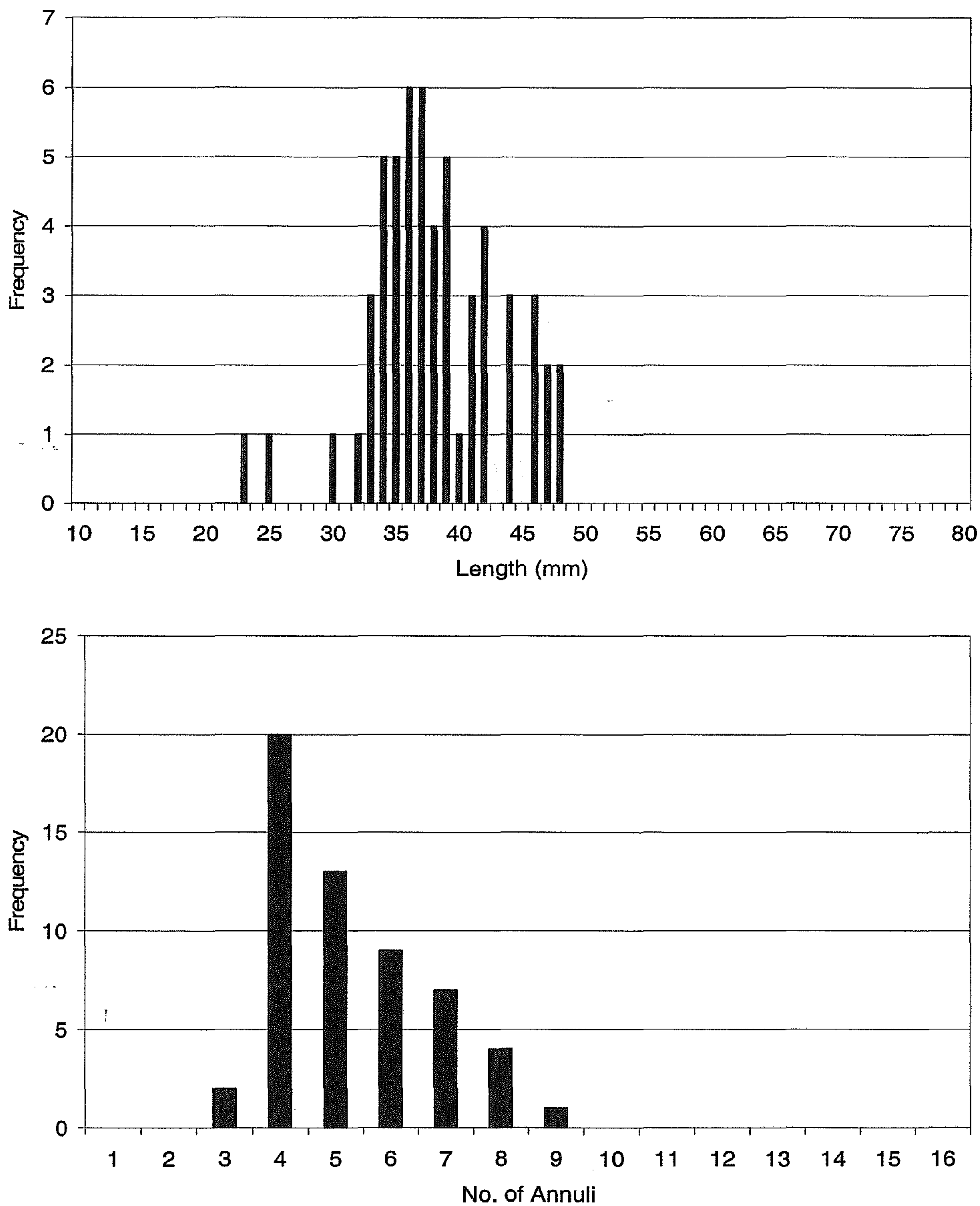


Figure 9. Length (top) and age (bottom) frequency distributions of Manila clams collected at Sharpe Creek, Clayoquot Sound, April 17 , 2002.

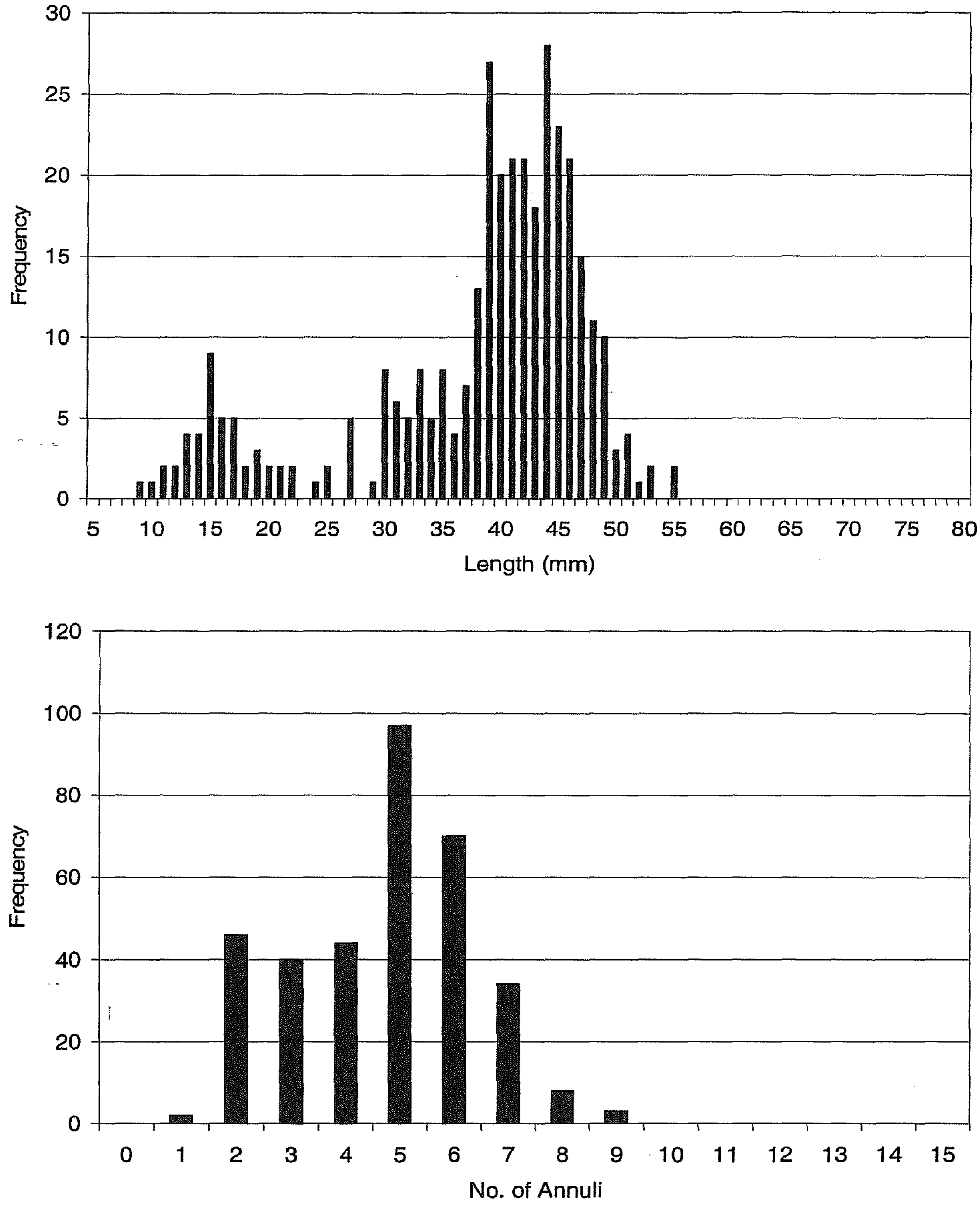


Figure 10. Length (top) and age (bottom) frequency distributions of Manila clams collected in Big Whitepine Cove, Clayoquot Sound, April 17, 2002.

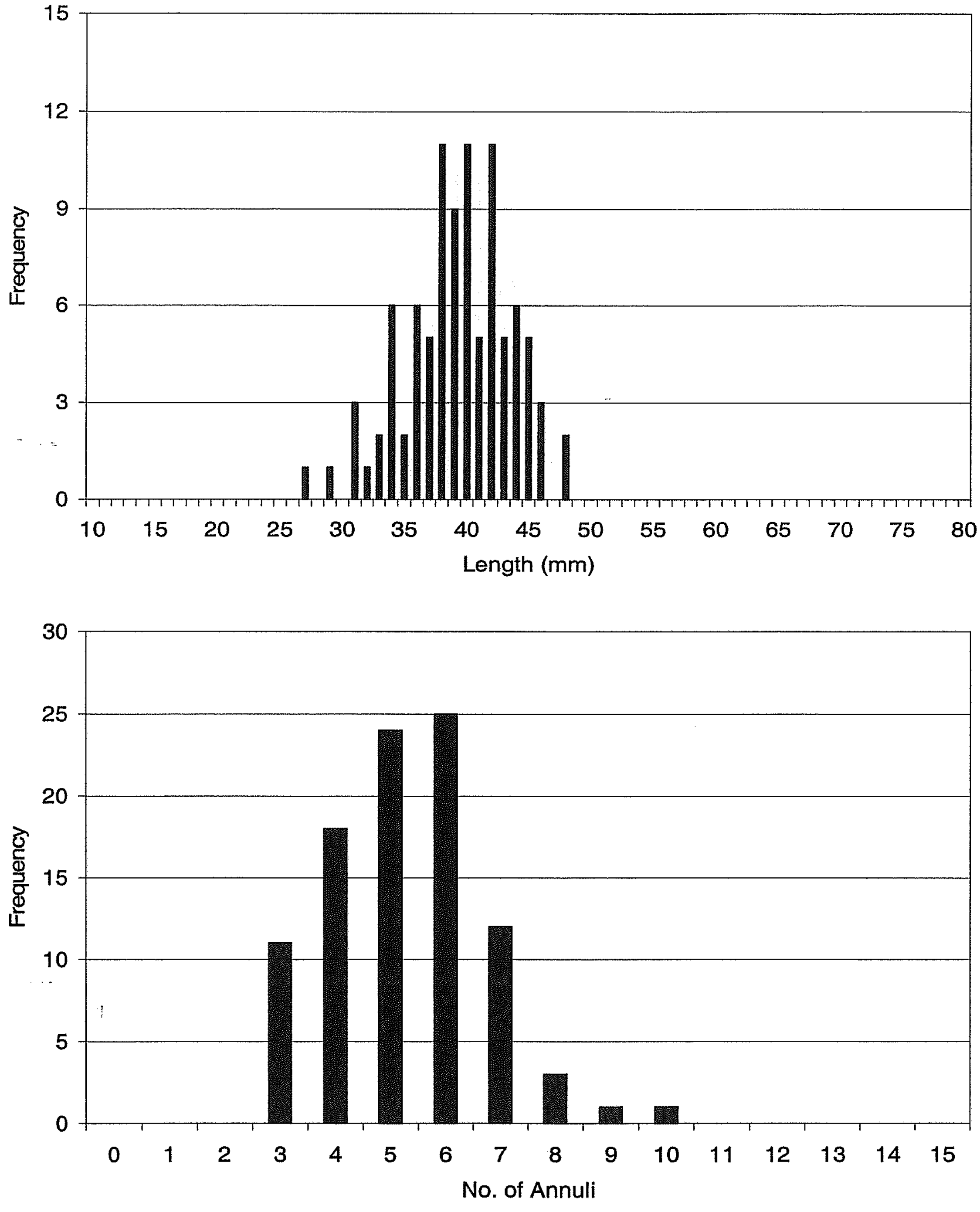


Figure 11. Length (top) and age (bottom) frequency distributions of Manila clams collected in Little Whitepine Cove, Clayoquot Sound, April 17, 2002.

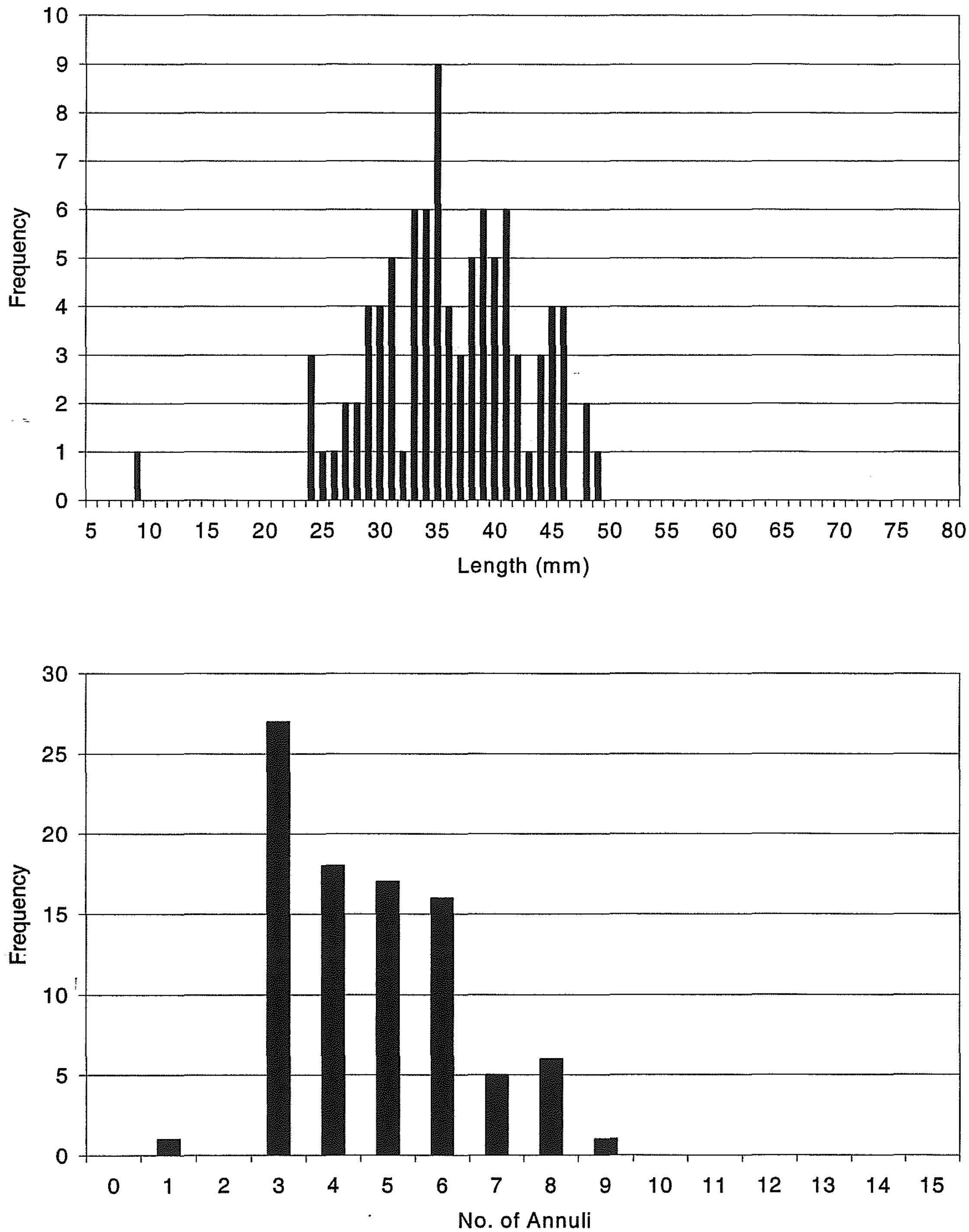


Figure 12. Length (top) and age (bottom) frequency distributions of Manila clams collected in Warn Bay, Clayoquot Sound, April 18, 2002.

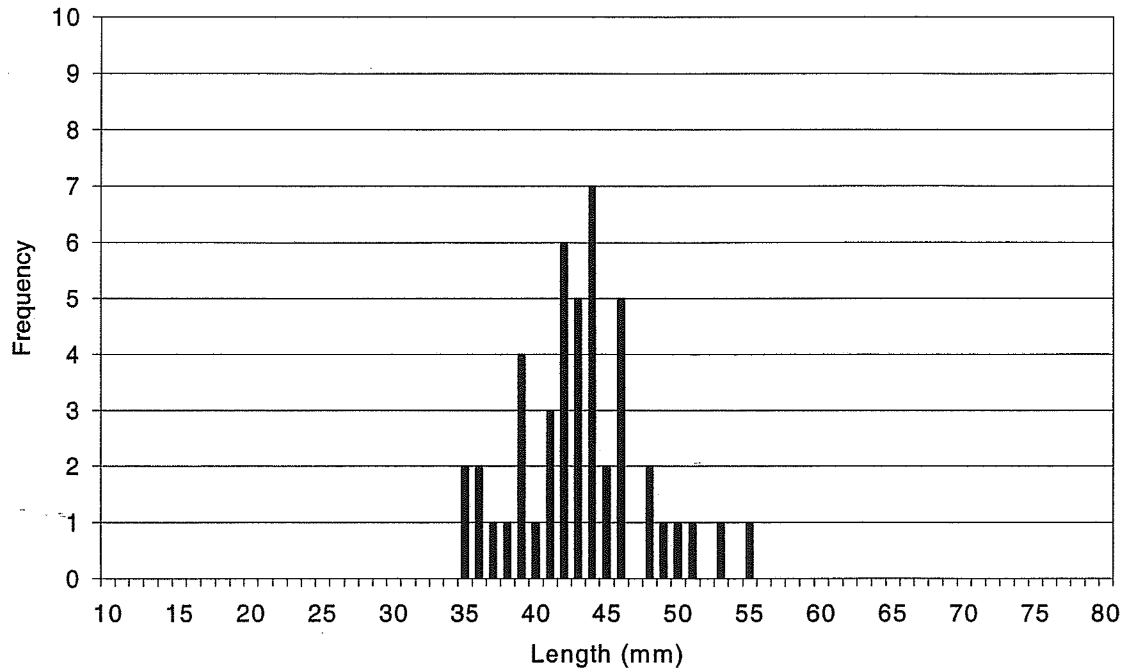


Figure 13. Length frequency distribution of varnish clams collected in Indian Bay, Clayoquot Sound, April 16, 2002.

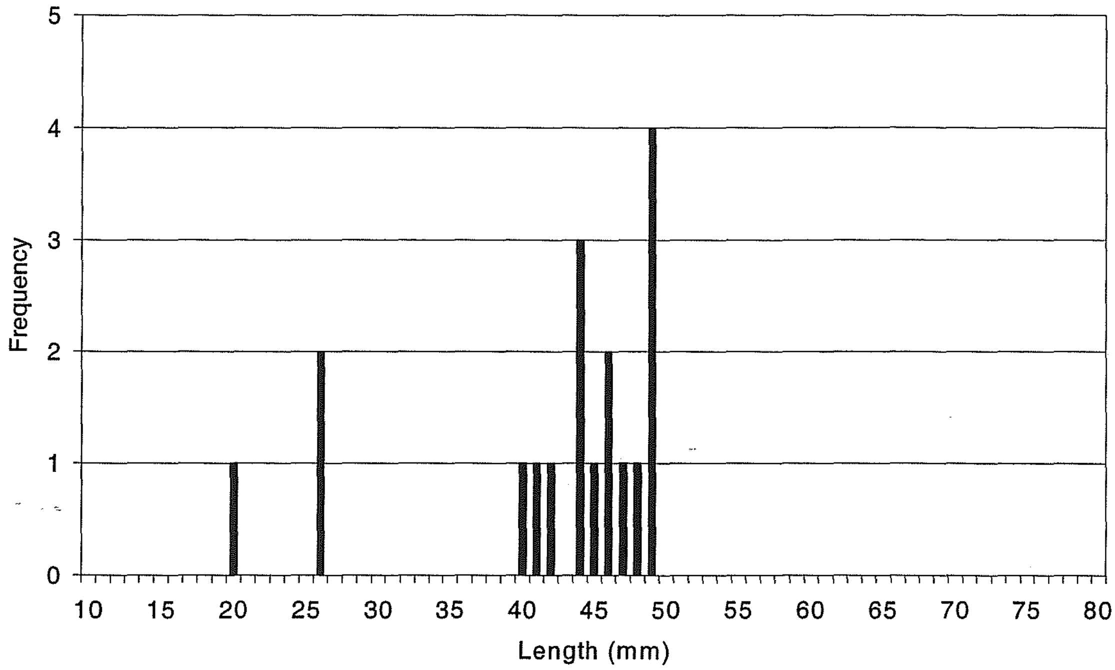


Figure 14. Length frequency distribution of varnish clams collected at the Cypre River estuary, April 18, 2002.

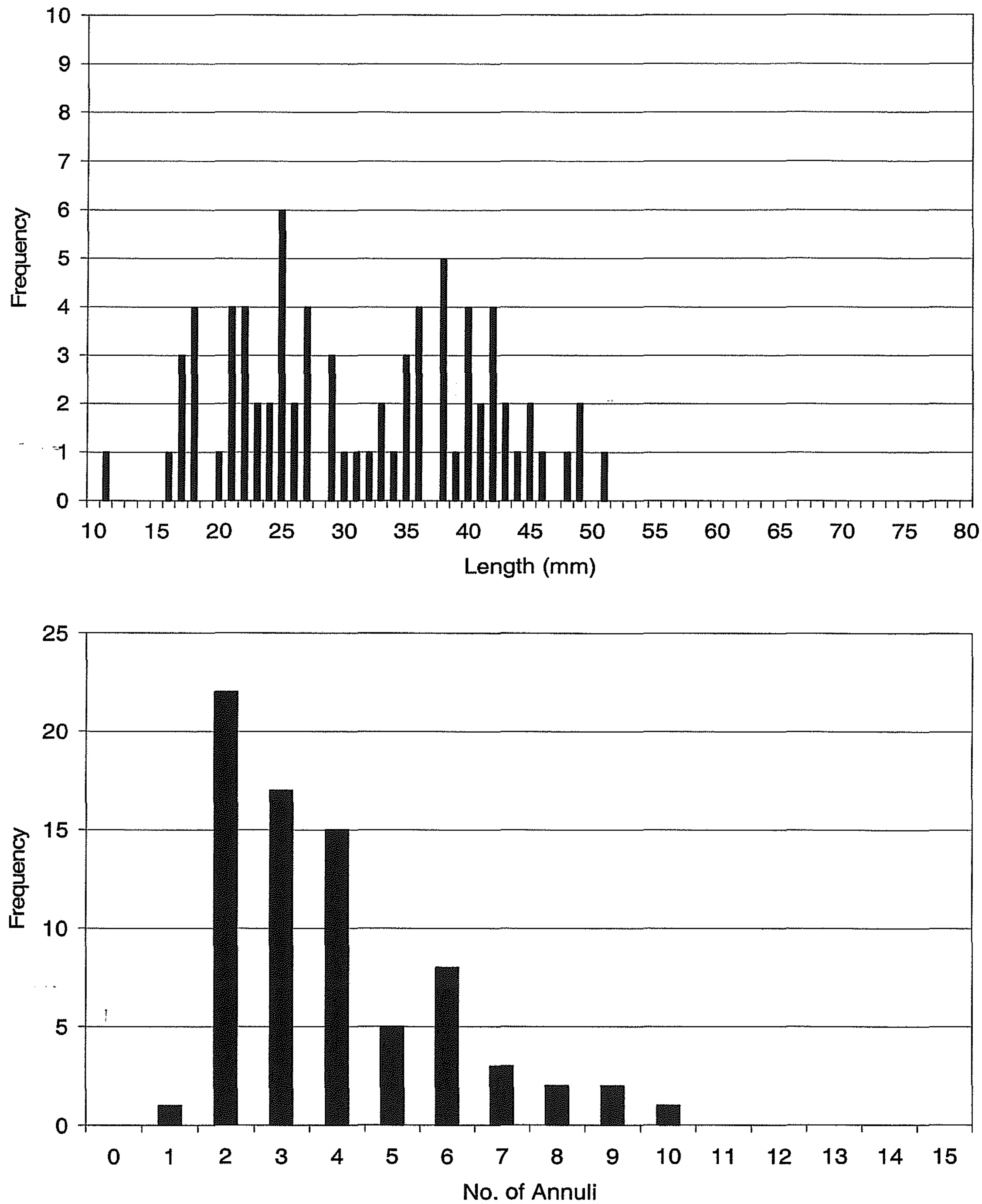


Figure 15. Length (top) and age (bottom) frequency distributions of littleneck clams collected at Atleo River, Clayoquot Sound, April 17, 2002.

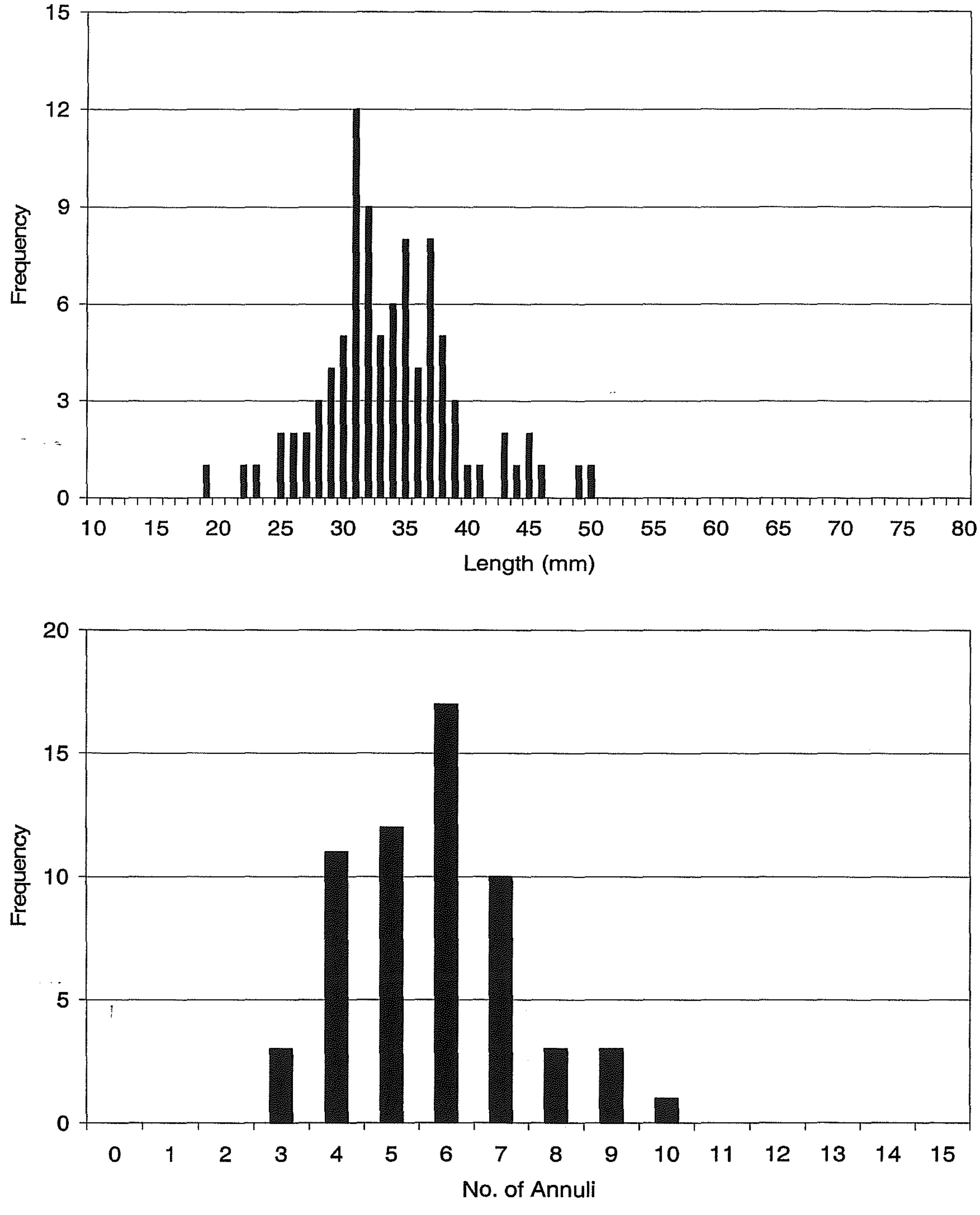


Figure 16. Length (top) and age (bottom) frequency distributions of littleneck clams collected at Sharpe Creek, Clayoquot Sound, April 17, 2002.

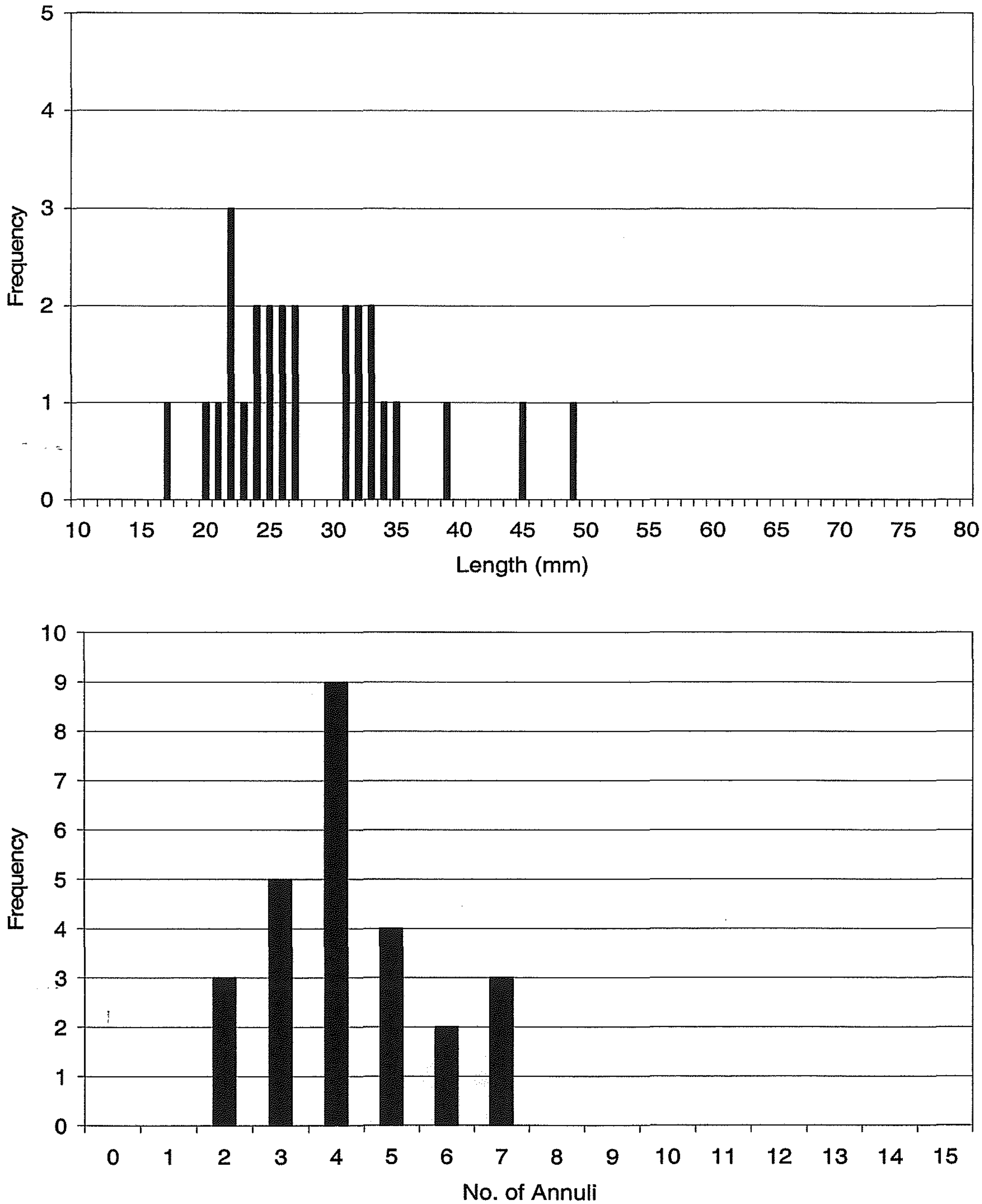


Figure 17. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Big Whitepine Cove, Clayoquot Sound, April 17, 2002.

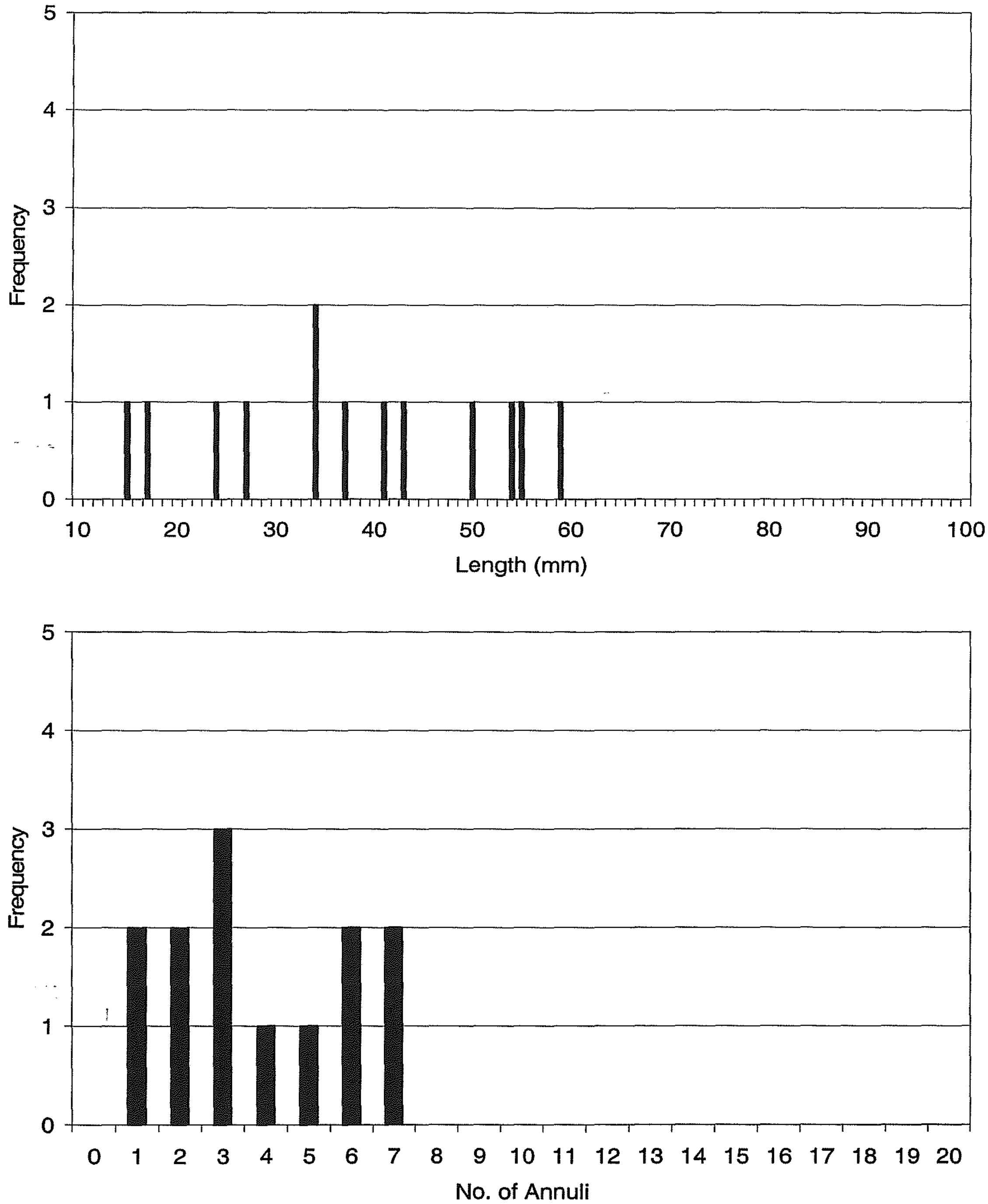


Figure 18. Length (top) and age (bottom) frequency distributions of butter clams collected at Atleo River, Clayoquot Sound, April 17, 2002.

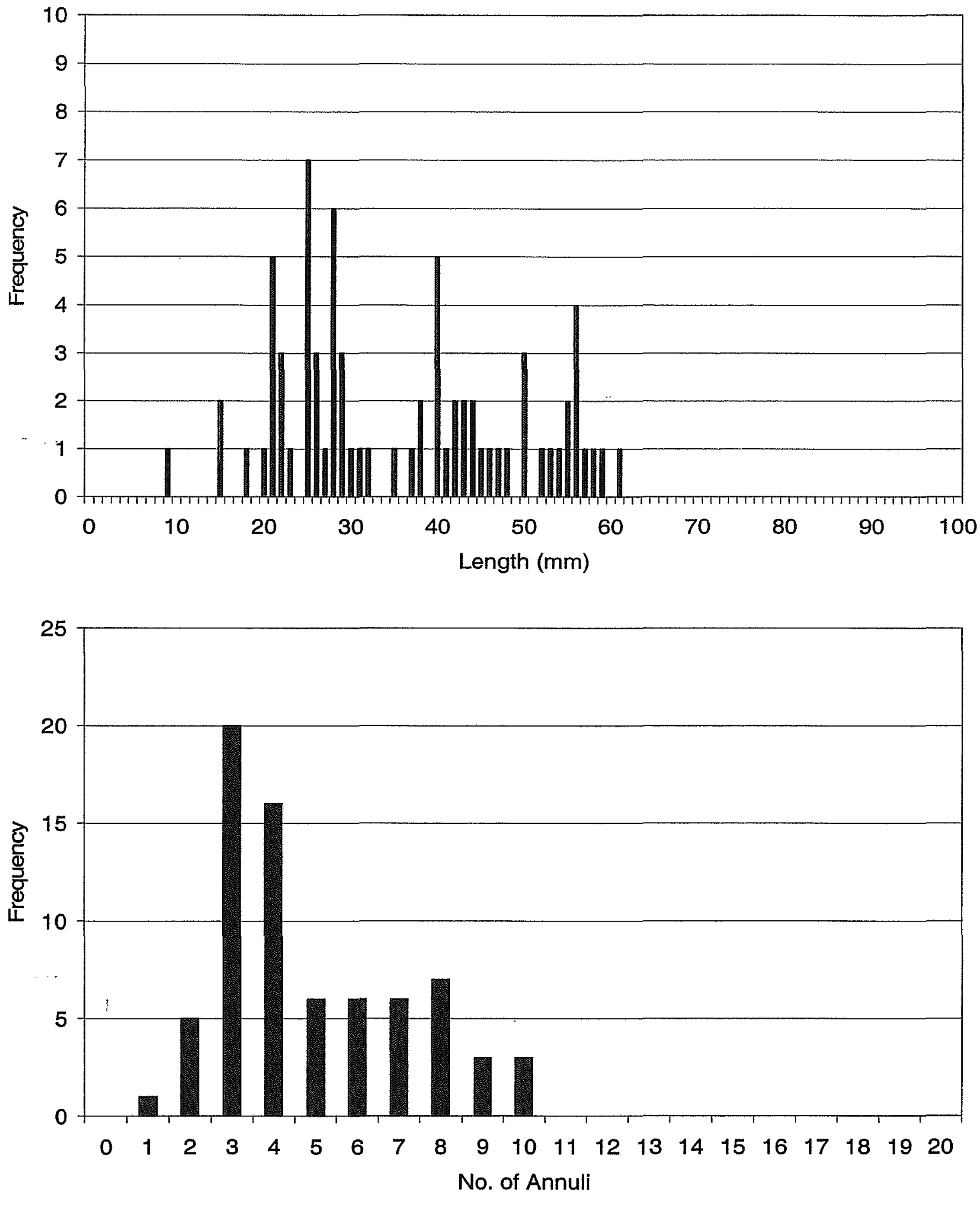
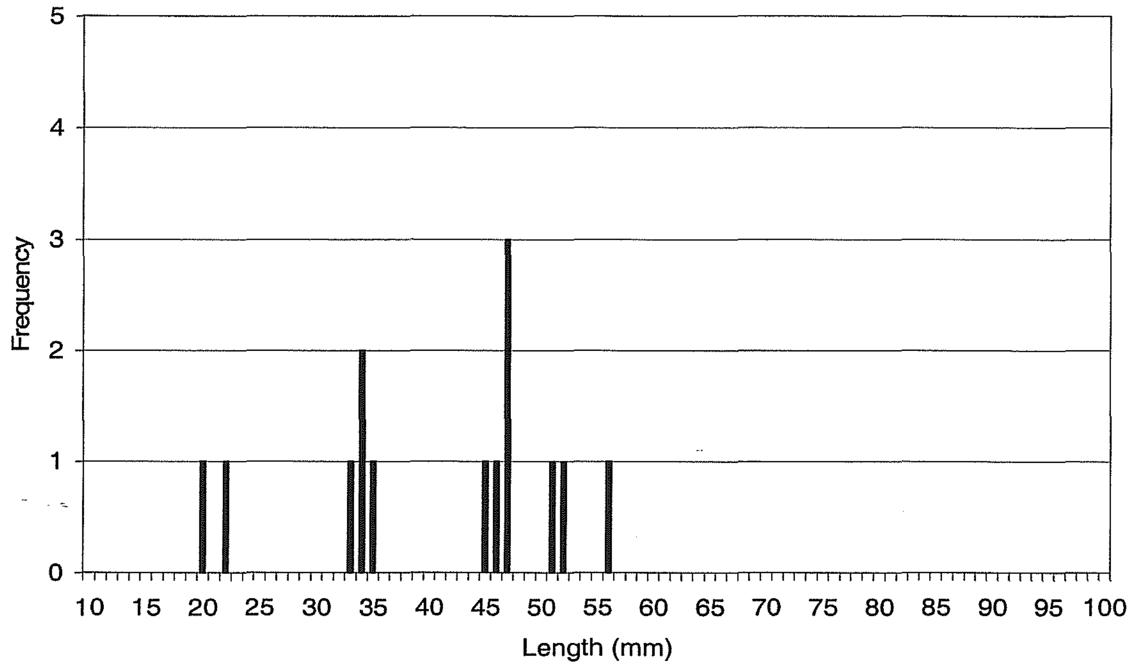


Figure 19. Length (top) and age (bottom) frequency distributions of butter clams collected at Sharpe Creek, Clayoquot Sound, April 17, 2002.



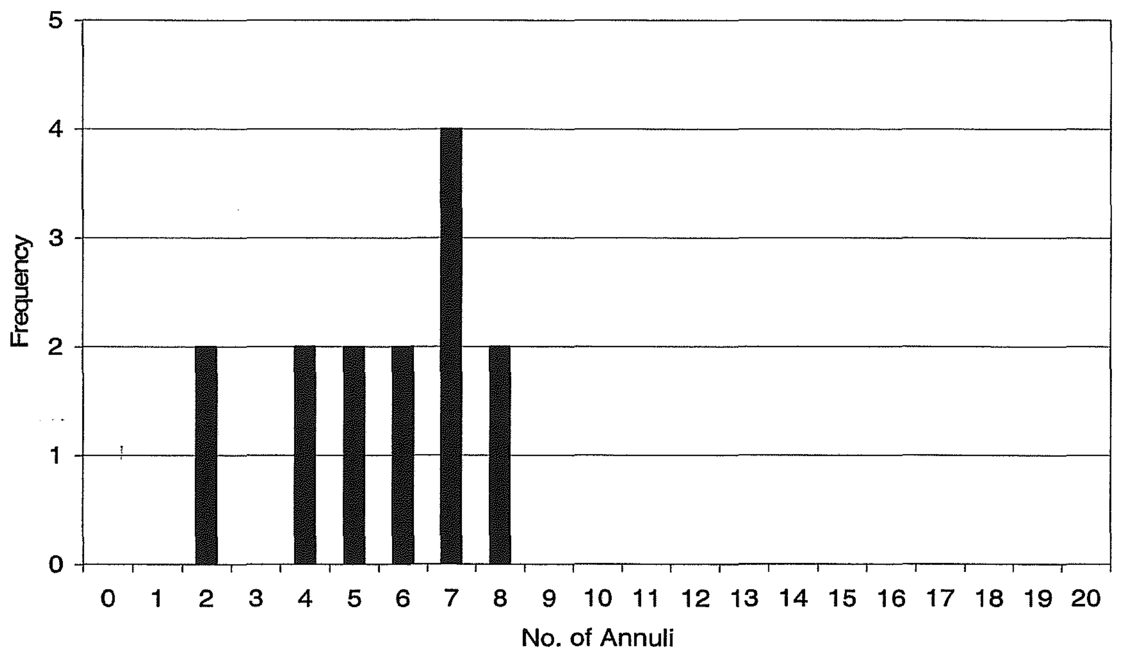


Figure 20. Length (top) and age (bottom) frequency distributions of butter clams collected in Big Whitepine Cove, Clayoquot Sound, April 17, 2002.

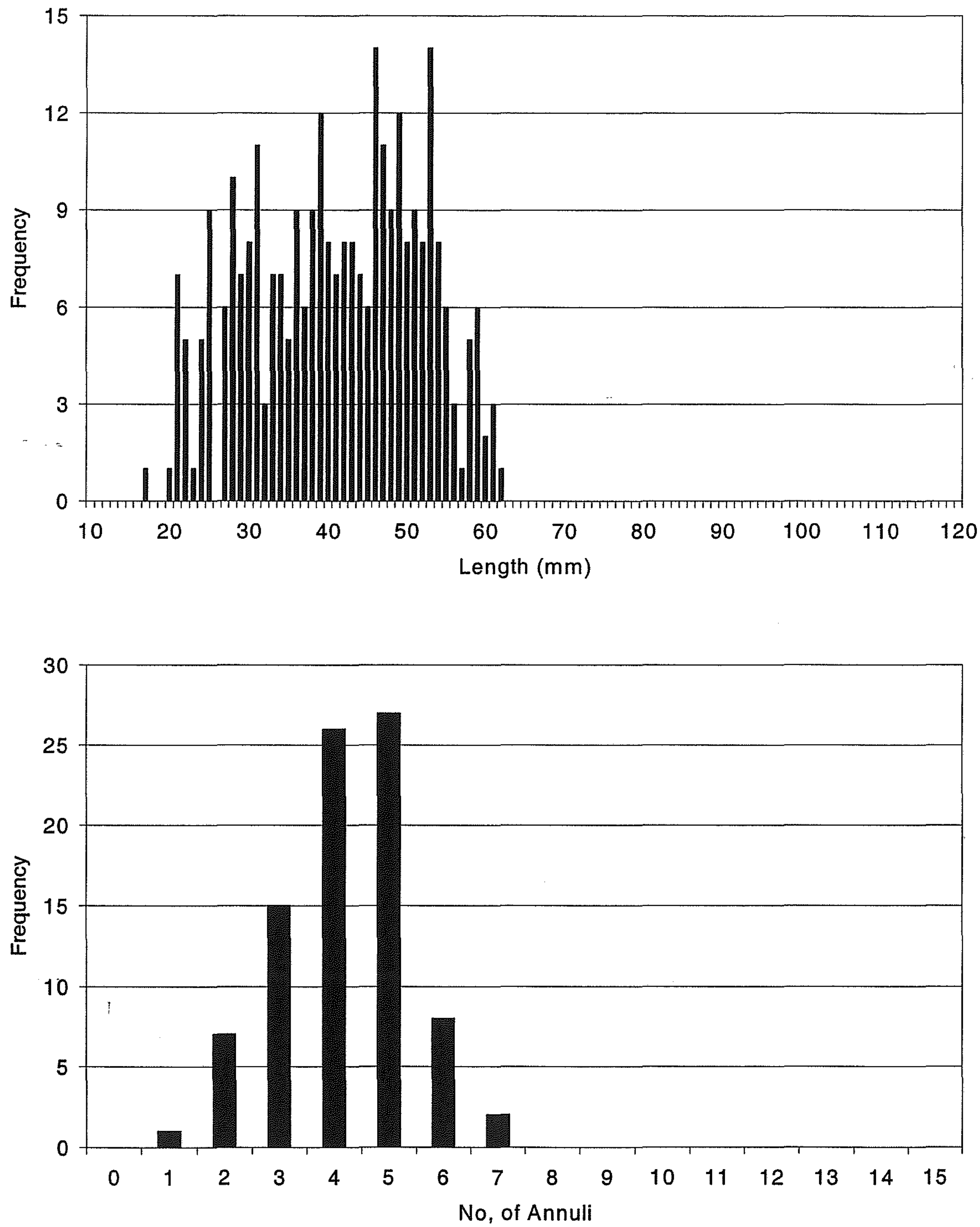
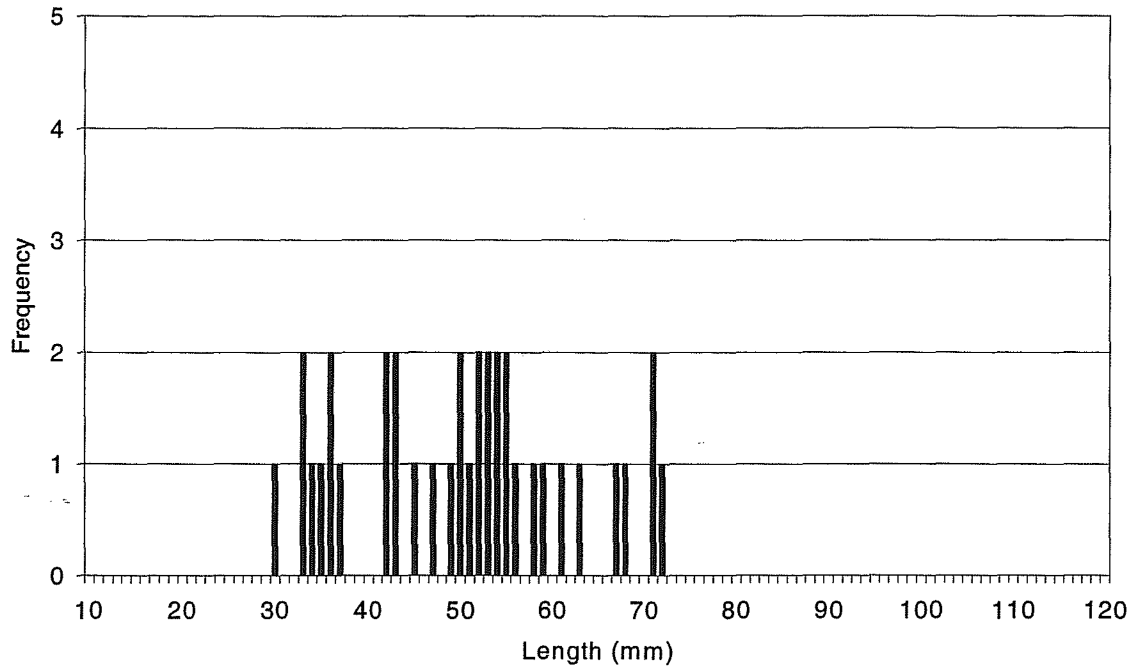


Figure 21. Length (top) and age (bottom) frequency distributions of softshells collected at Gunner Inlet 1, Clayoquot Sound, April 16, 2002.



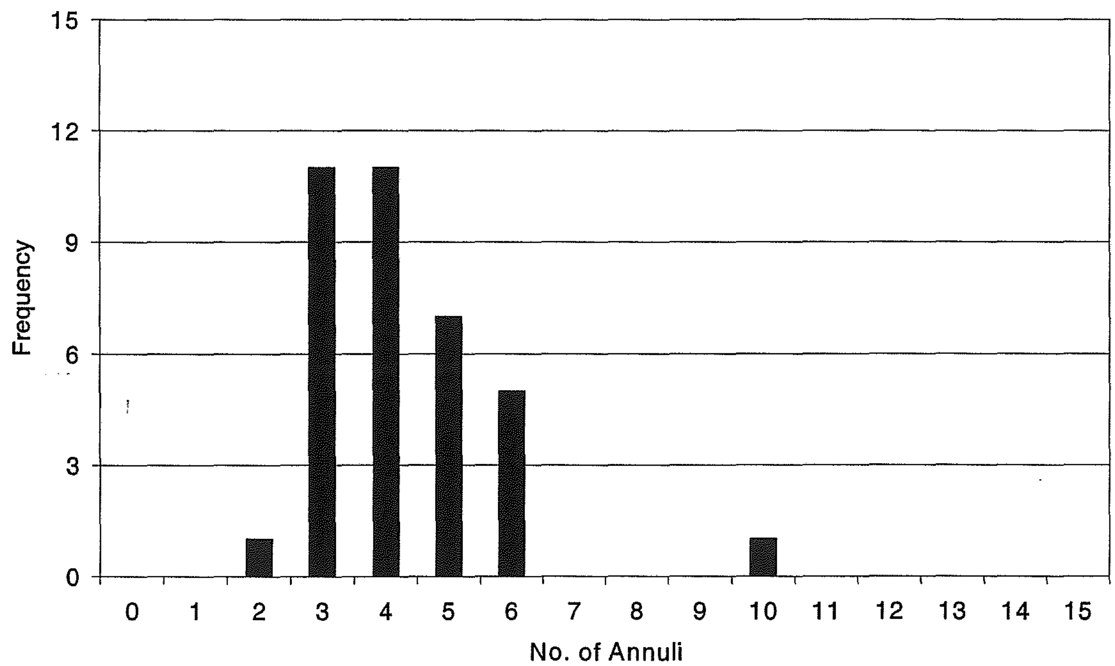
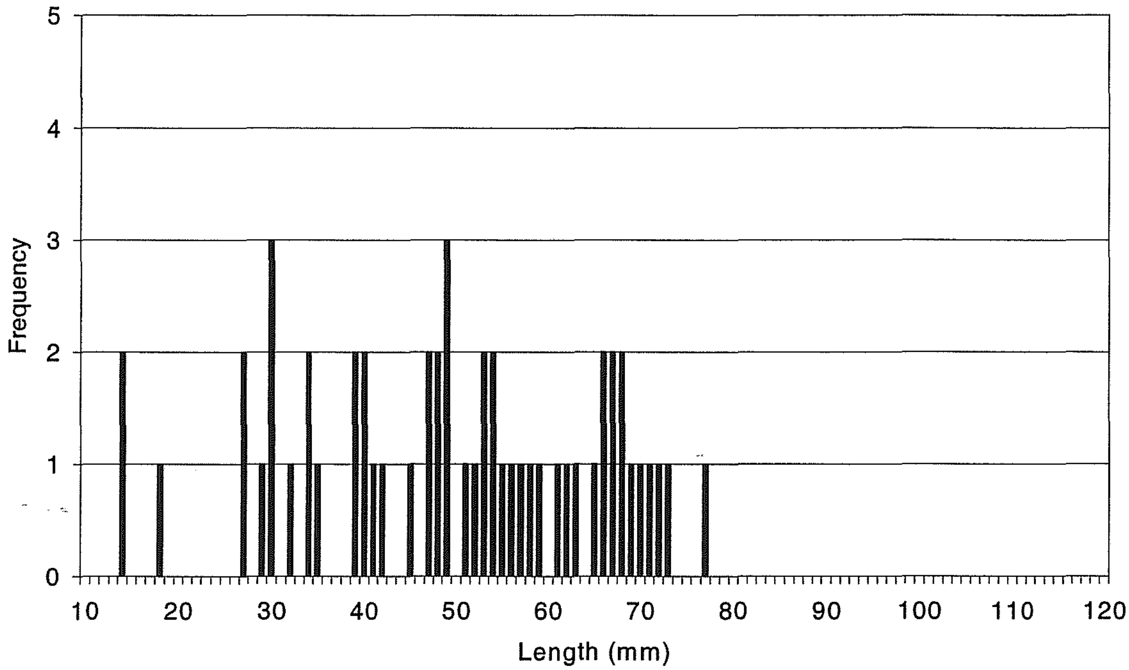


Figure 22. Length (top) and age (bottom) frequency distributions of softshells collected at Gunner Inlet 3, Clayoquot Sound, April 16, 2002.



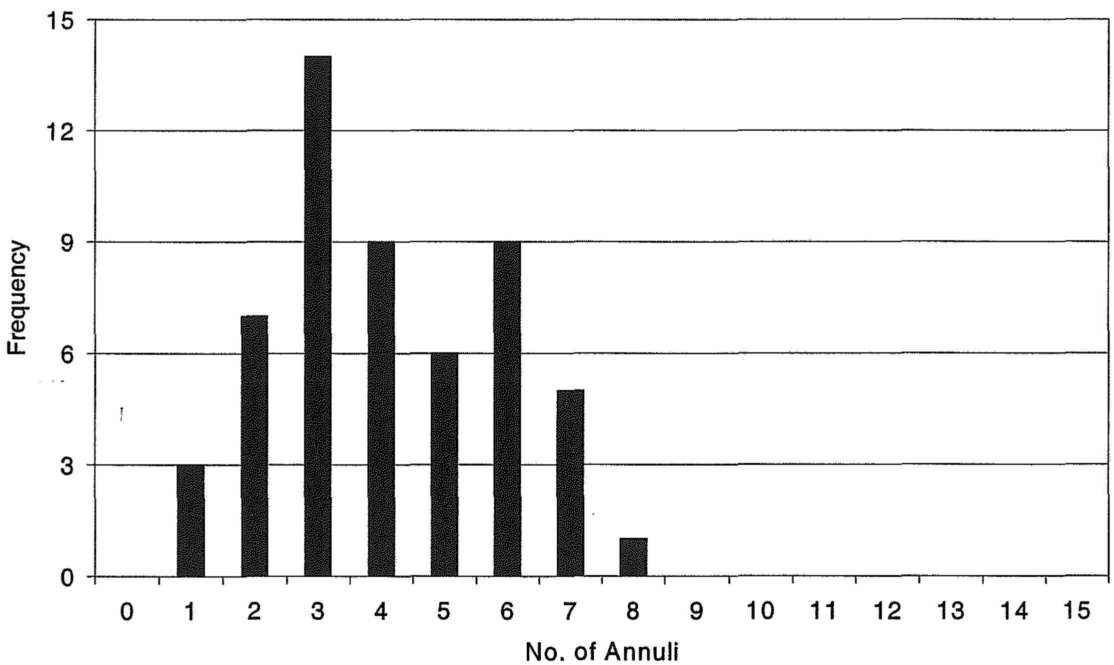


Figure 23. Length (top) and age (bottom) frequency distributions of softshells collected in Indian Bay, Clayoquot Sound, April 16, 2002.

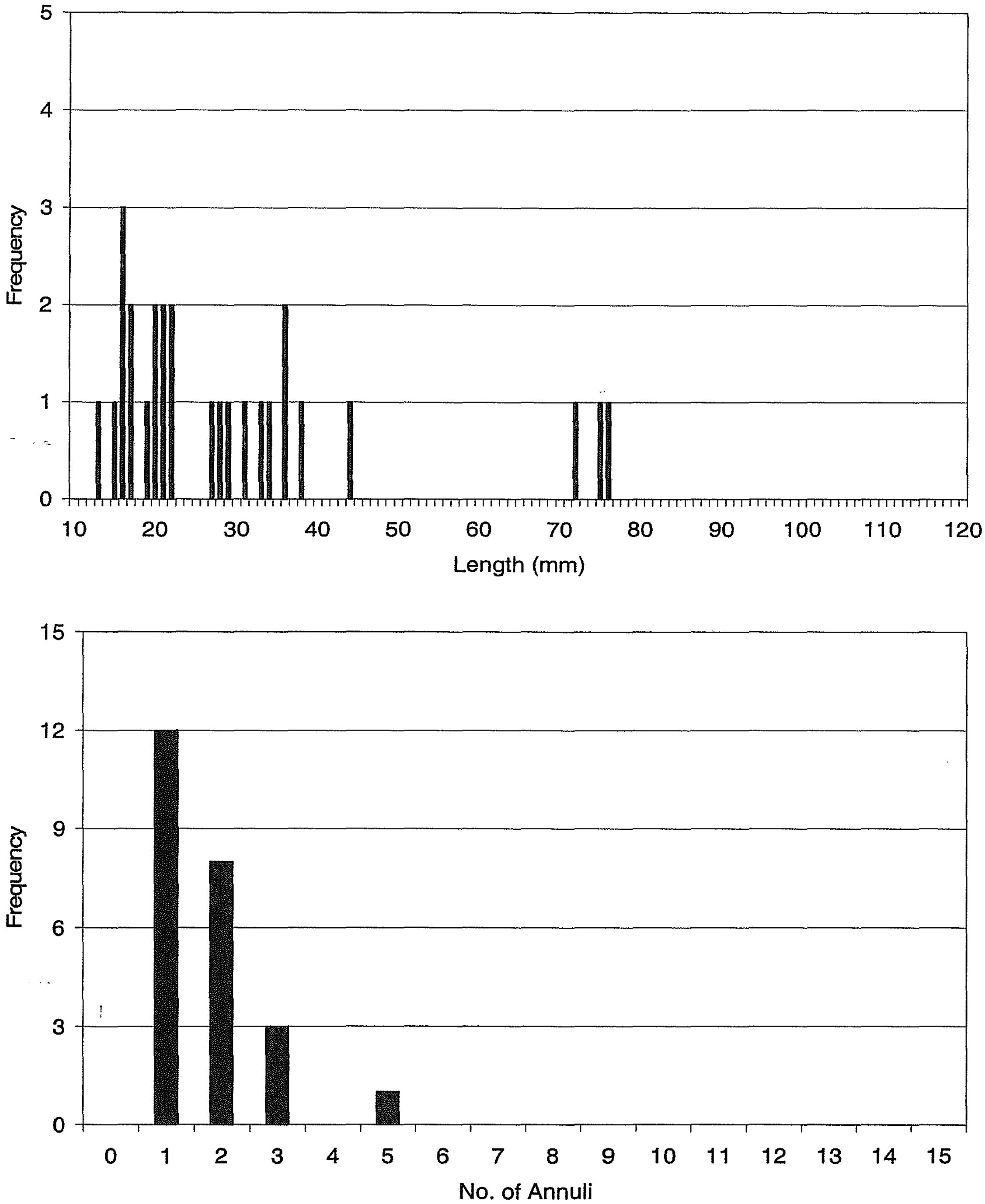


Figure 24. Length (top) and age (bottom) frequency distributions of softshells collected at Atleo River, Clayoquot Sound, April 17, 2002.

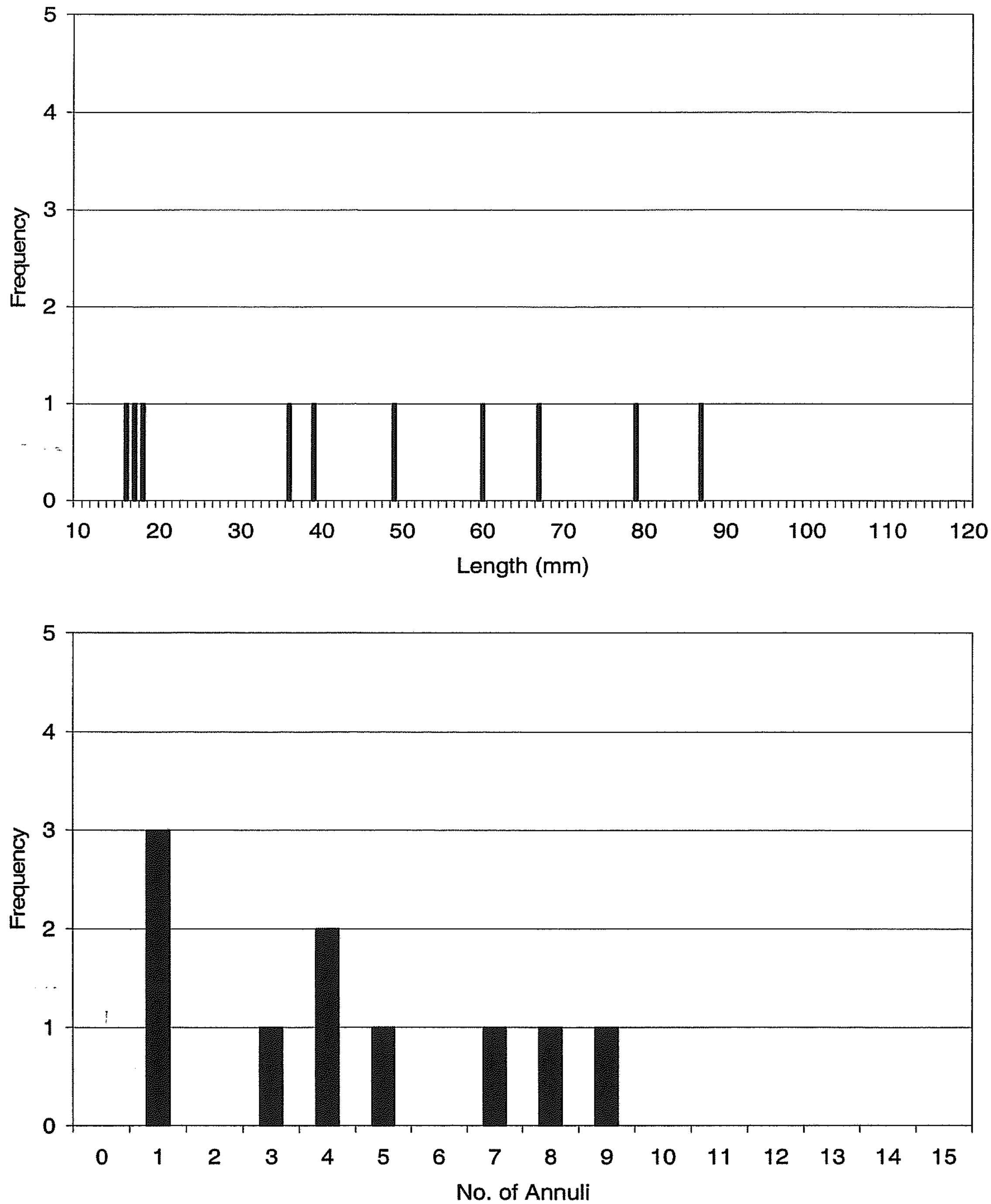


Figure 25. Length (top) and age (bottom) frequency distributions of softshells collected in Big Whitepine Cove, Clayoquot Sound, April 17, 2002.

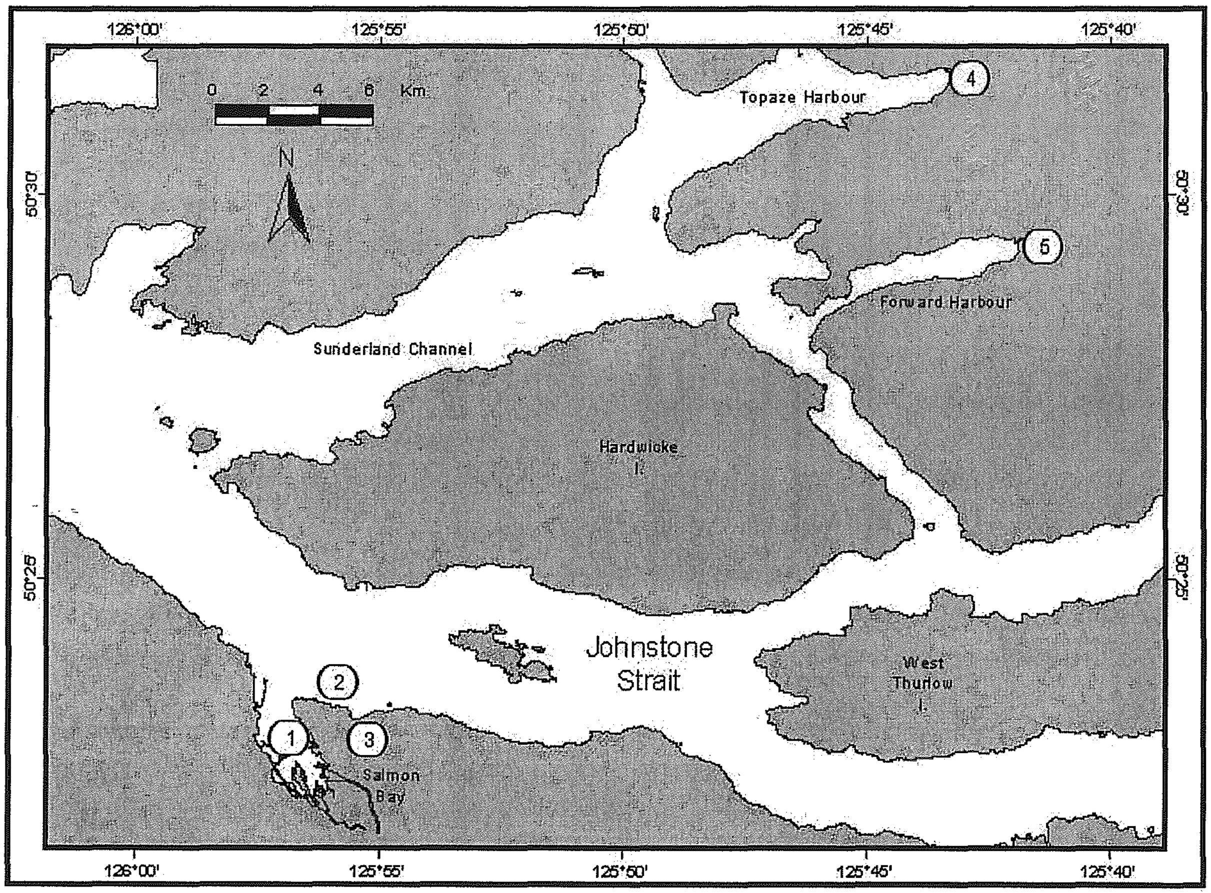


Figure 26. Locations of beaches surveyed in Johnstone Strait and Sunderland Channel, June 23-24, 2002.

Legend: 1 – Salmon Bay; 2 – South of Salmon Bay; 3 – H'Kusum Bay; 4 – Topaze Harbour; 5 – Forward Harbour.

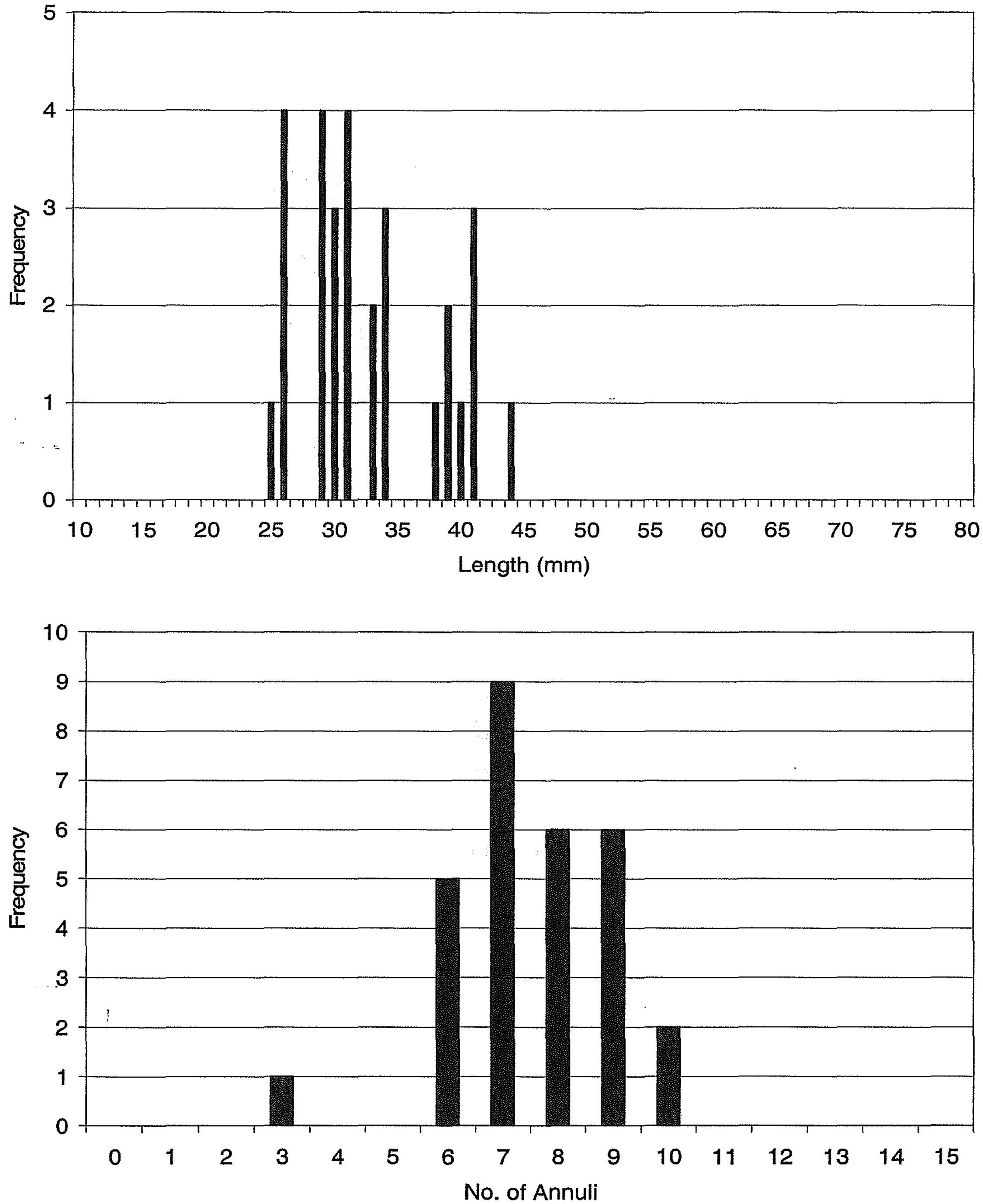


Figure 27. Length (top) and age (bottom) frequency distributions of Manila clams collected at beach 2, south of Salmon Bay, Johnstone Strait, June 23, 2002.

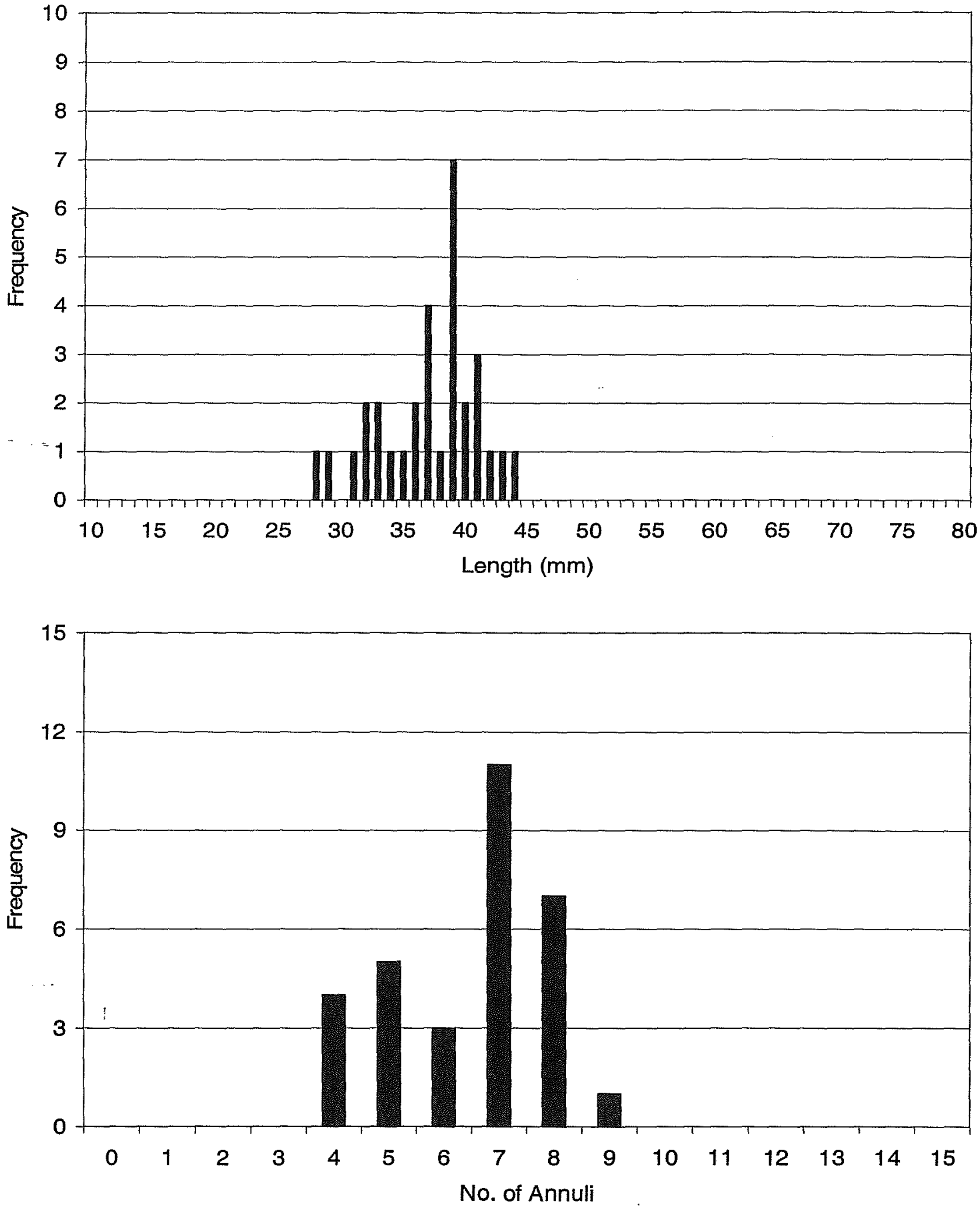
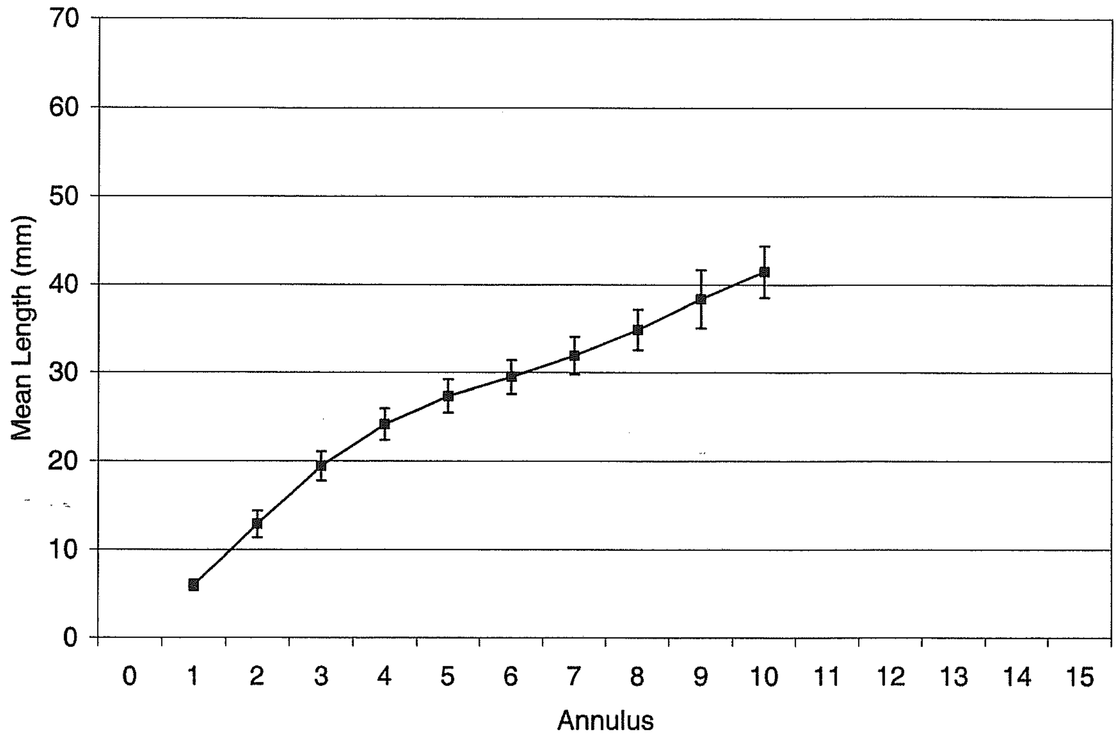


Figure 28. Length (top) and age (bottom) frequency distributions of Manila clams collected in Topaze Harbour, Sunderland Channel, June 24, 2002.



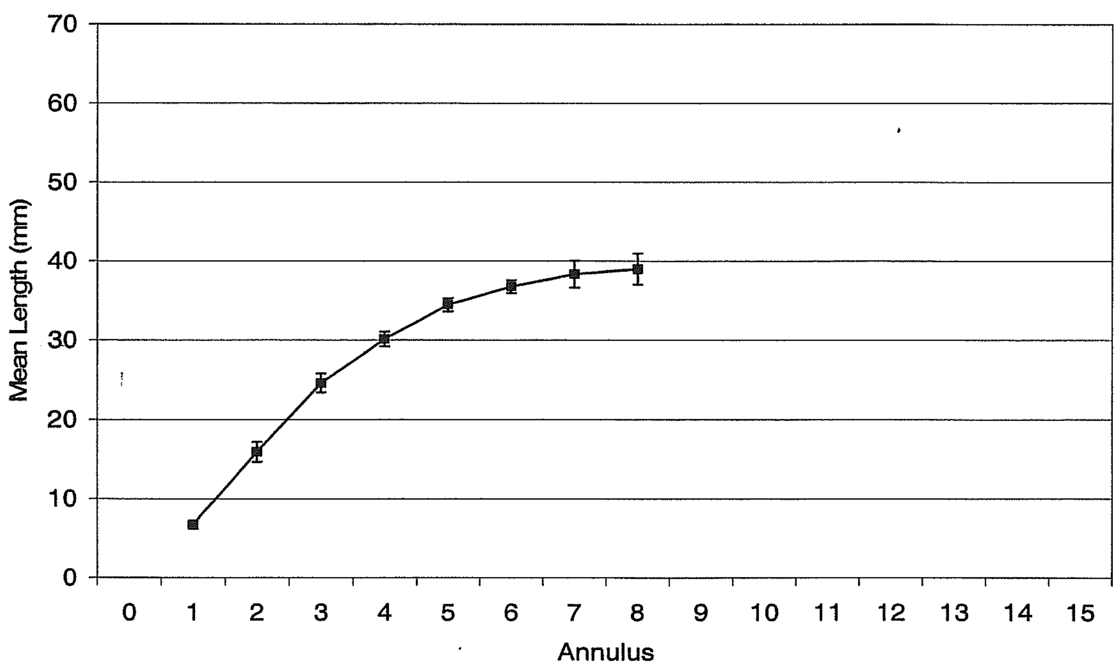


Figure 29. Mean length-at-annulus of Manila clams collected from South of Salmon Bay, Johnstone Strait, and Topaze Harbour, Sunderland Channel, June 23-24, 2002.

Error bars represent 95% confidence intervals.

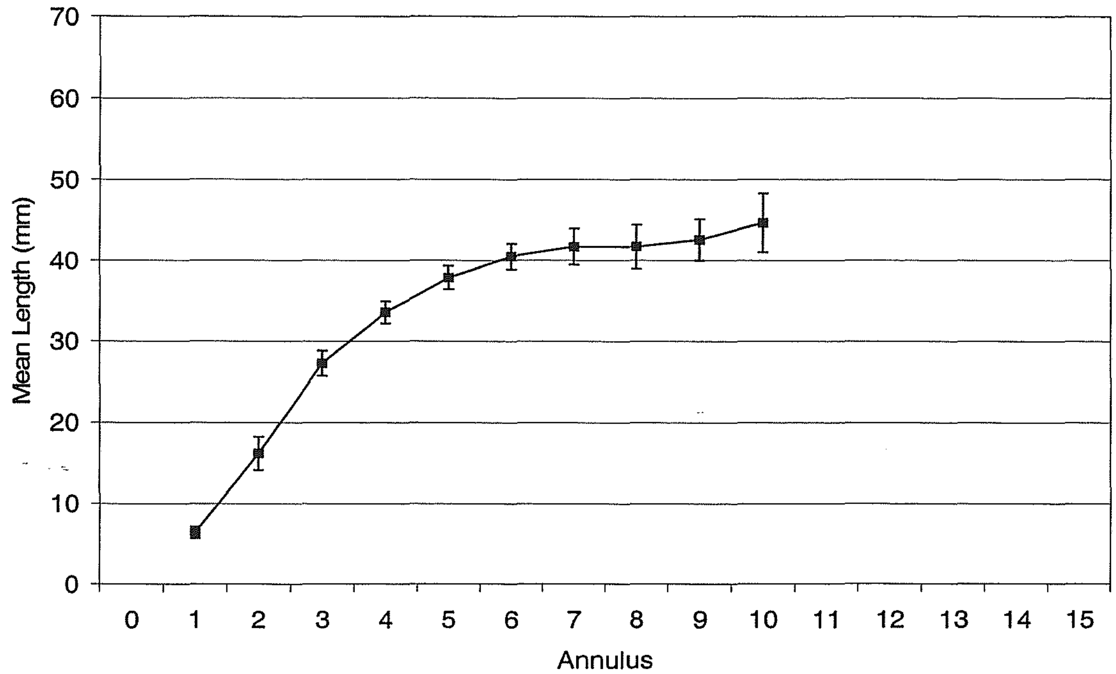
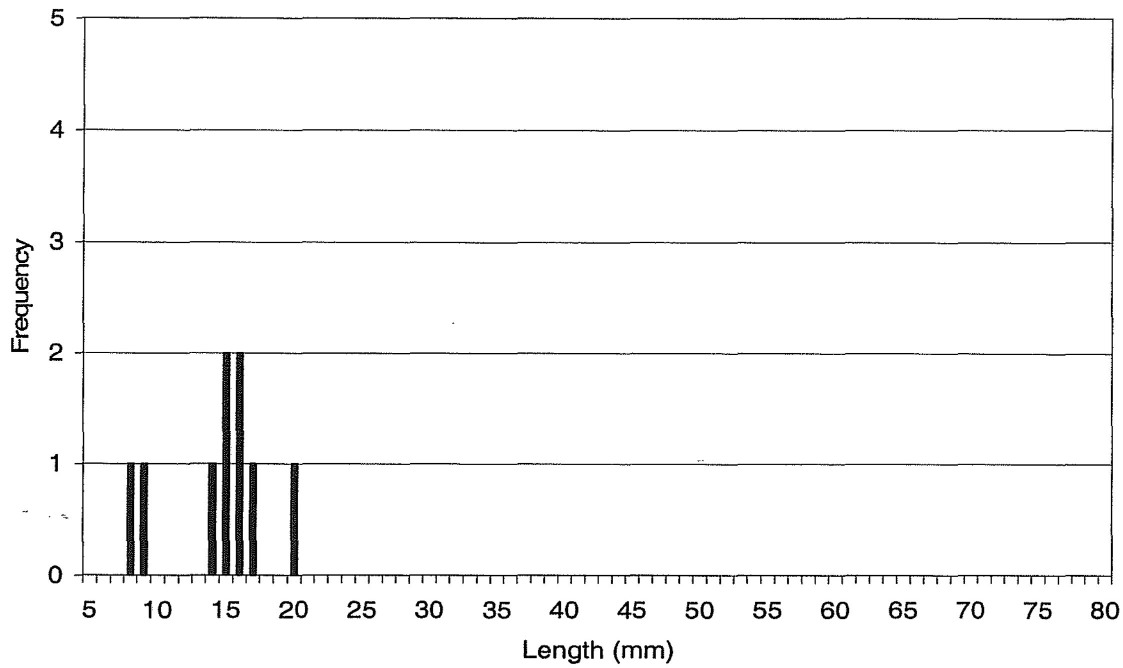


Figure 30. Mean length-at-annulus of Manila clam shells collected in Forward Harbour, Sunderland Channel, June 24, 2002.

Error bars represent 95% confidence intervals.



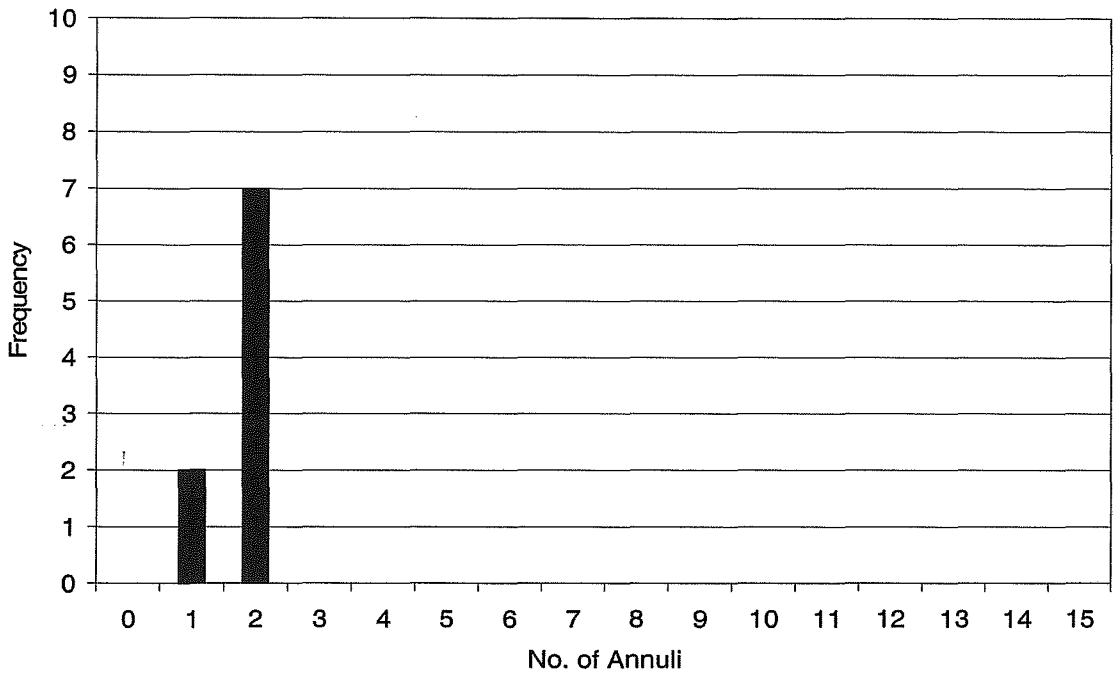


Figure 31. Length (top) and age (bottom) frequency distributions of varnish clams collected at Salmon Bay, Johnstone Strait, June 23, 2002.

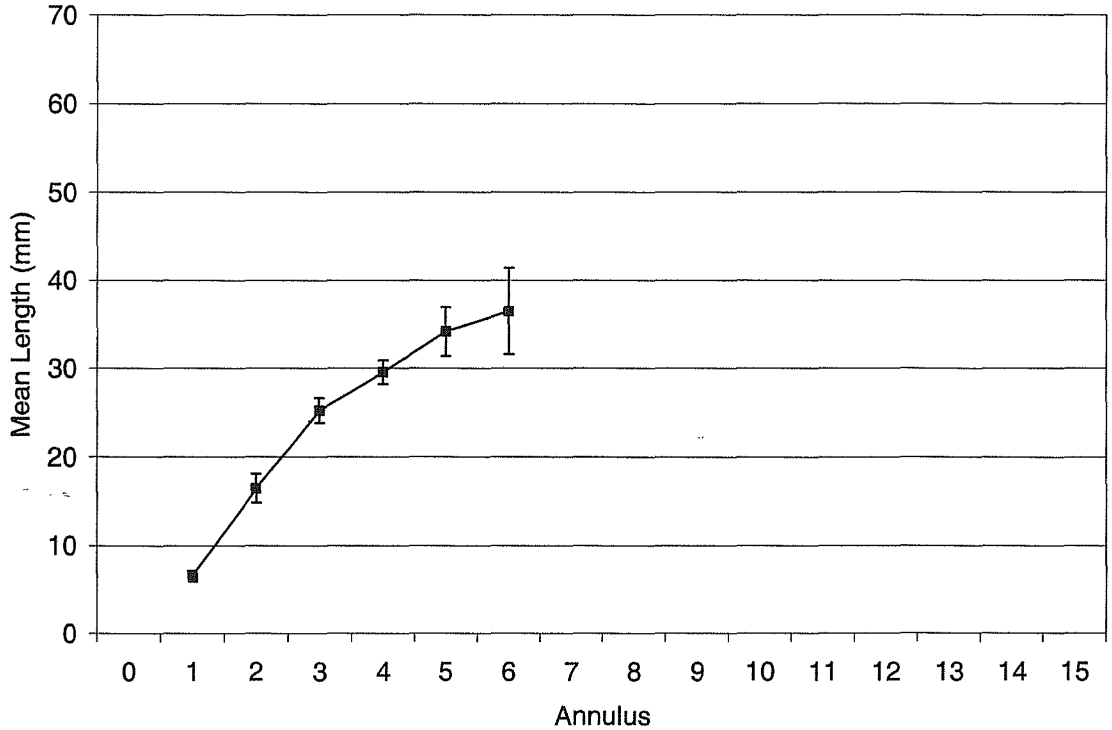
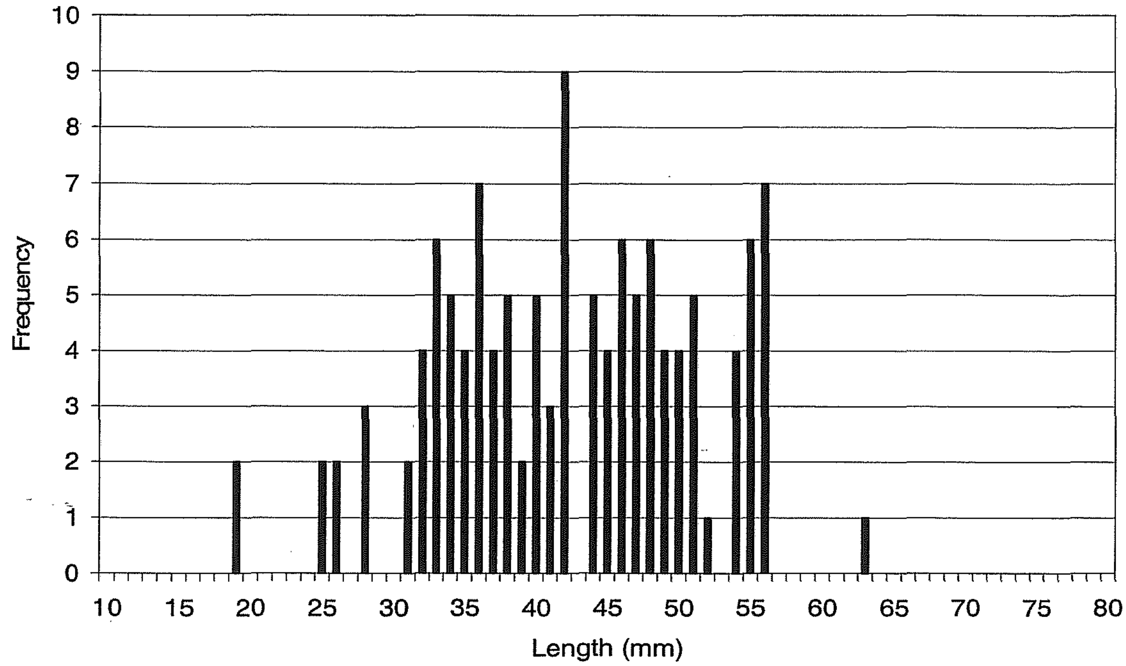


Figure 32. Mean length-at-annulus of dead varnish clam shells collected at Salmon Bay, Johnstone Strait, June 23, 2002.

Error bars represent 95% confidence intervals.



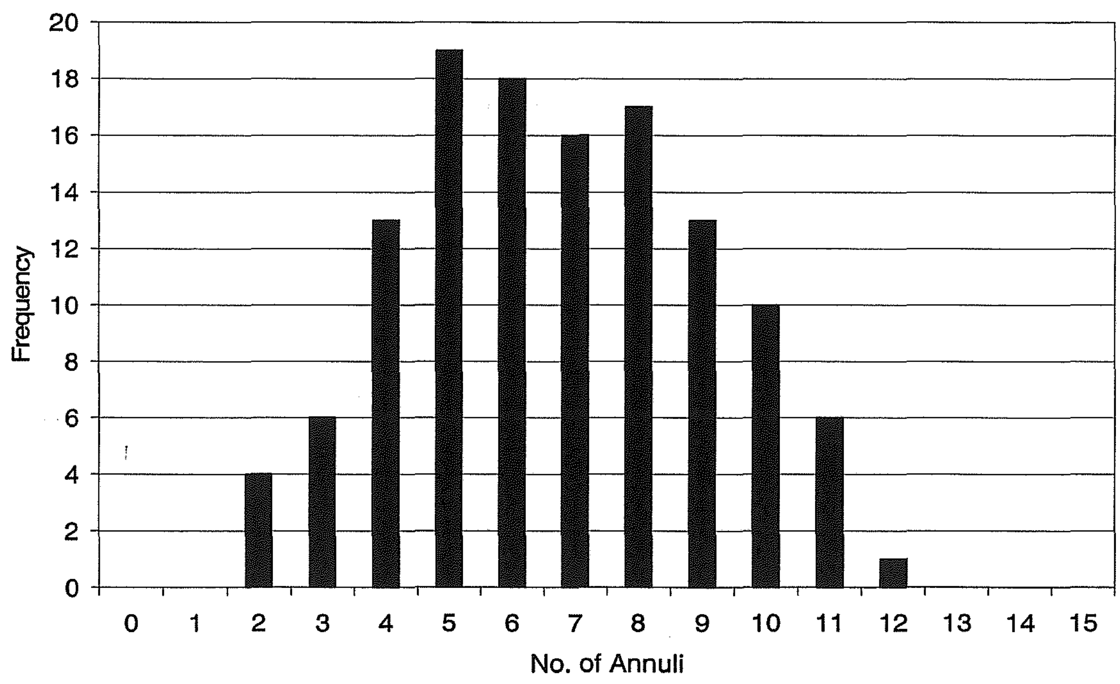
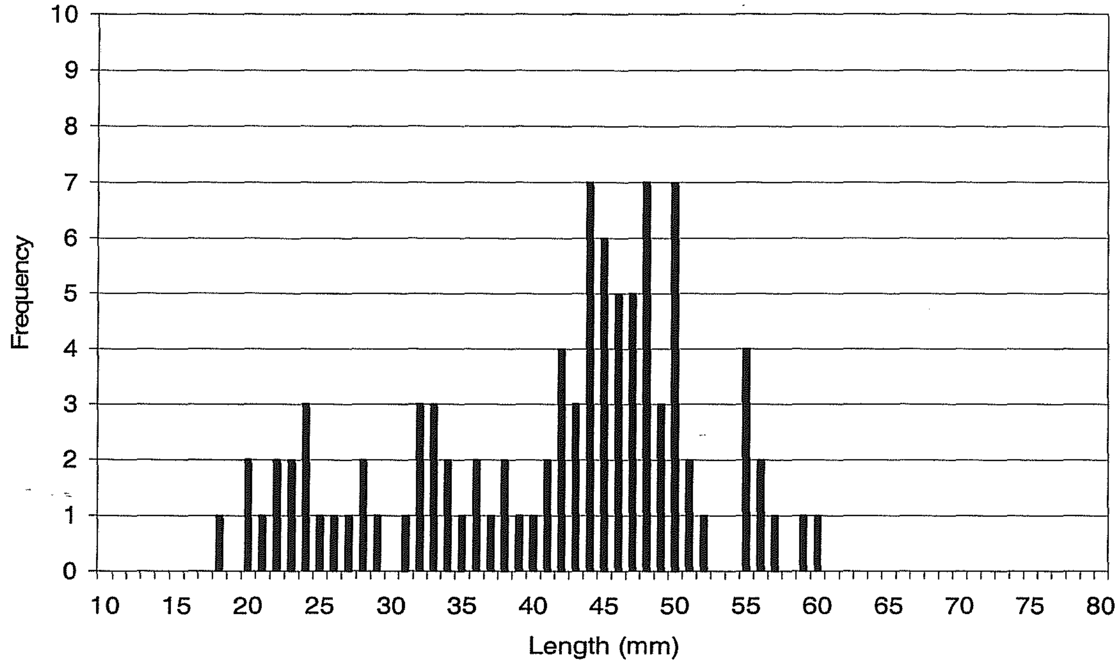


Figure 33. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Topaze Harbour, Sunderland Channel, June 24, 2002.



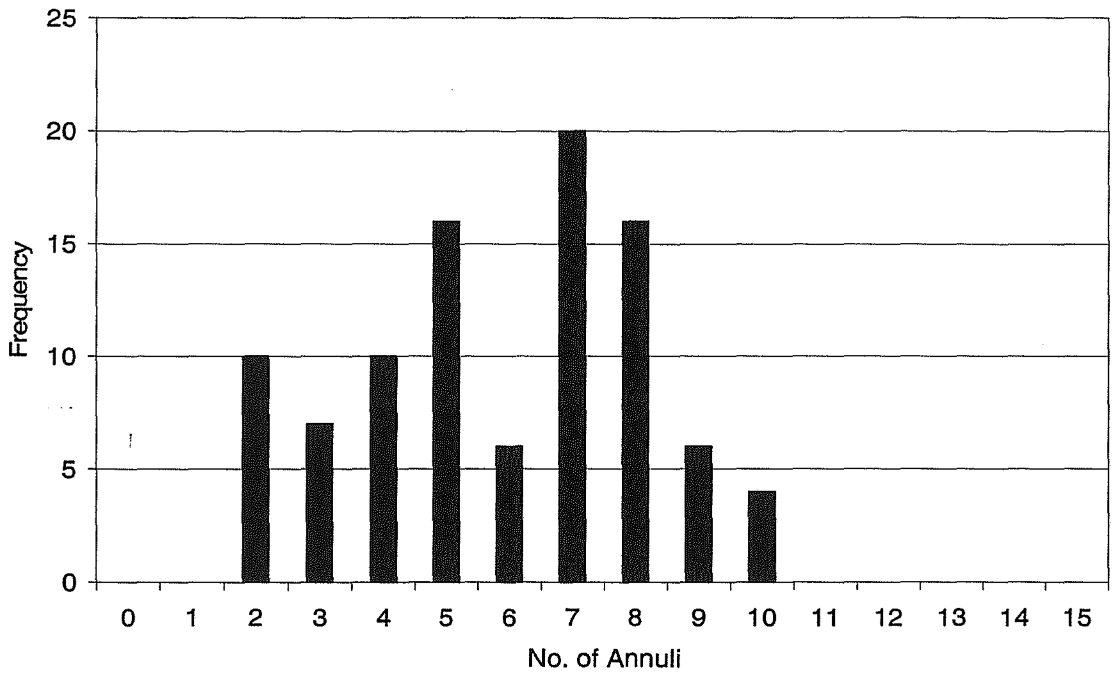
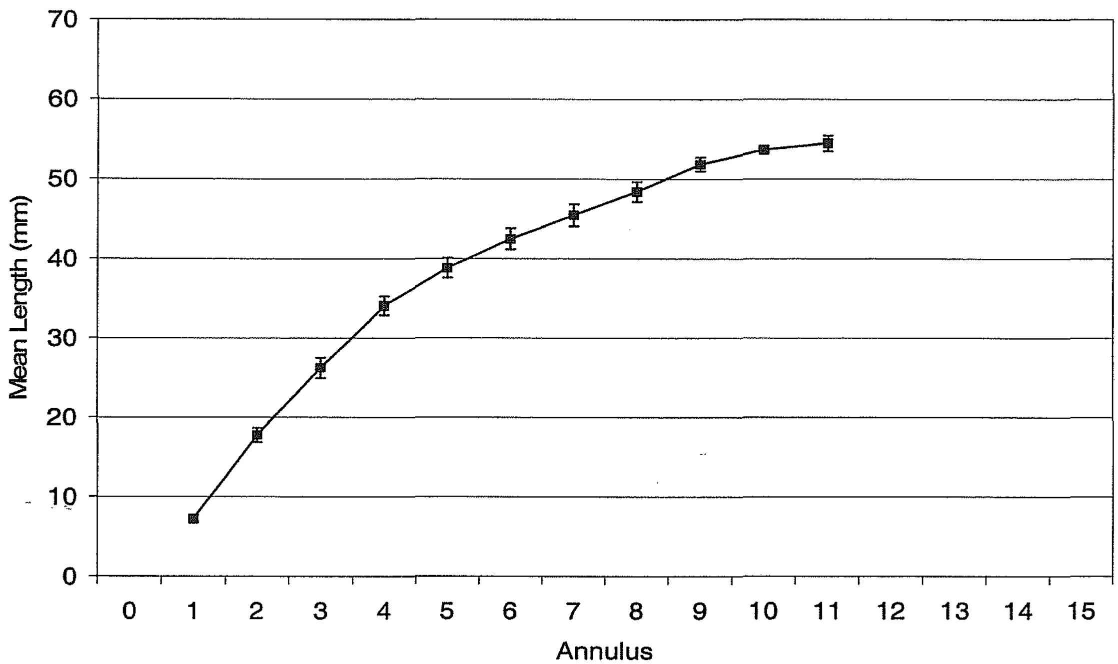


Figure 34. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Forward Harbour, Sunderland Channel, June 24, 2002.



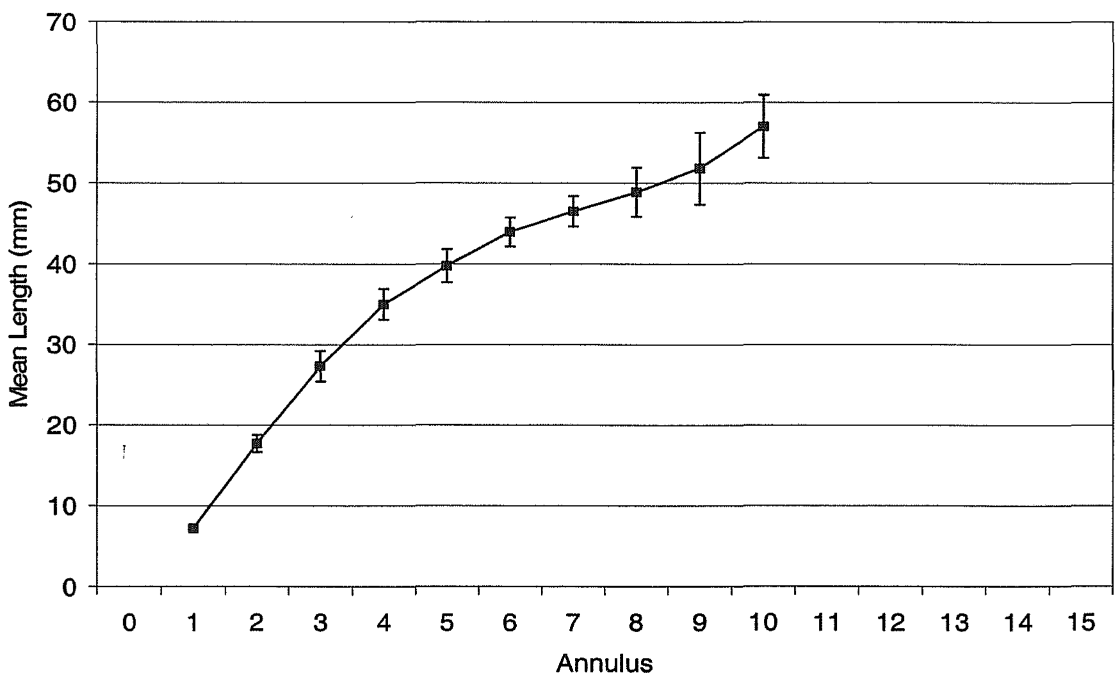


Figure 35. Mean length-at-annulus of littleneck clams collected in Topaze Harbour (top) and Forward Harbour (bottom), Sunderland Channel, June 24, 2002.

Error bars represent 95% confidence intervals.

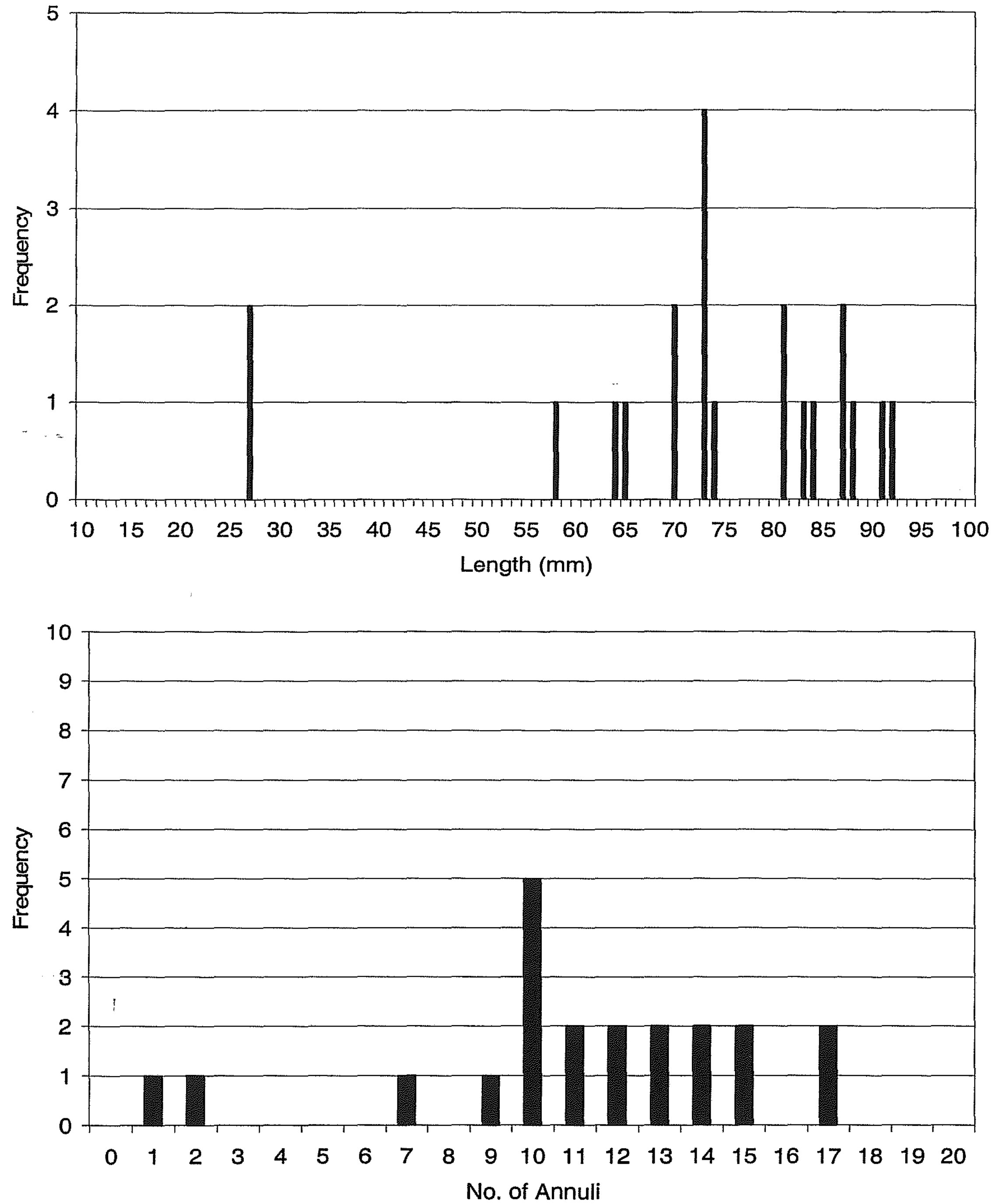


Figure 36. Length (top) and age (bottom) frequency distributions of butter clams collected in Topaze Harbour, Sunderland Channel, June 24, 2002.

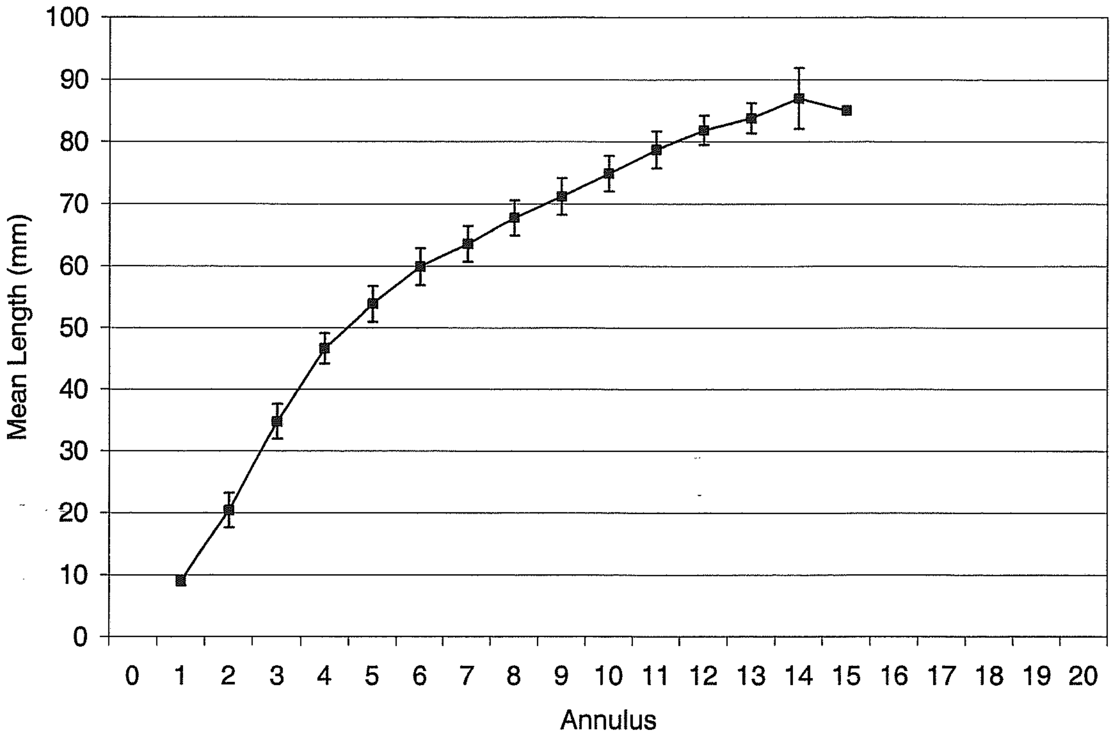
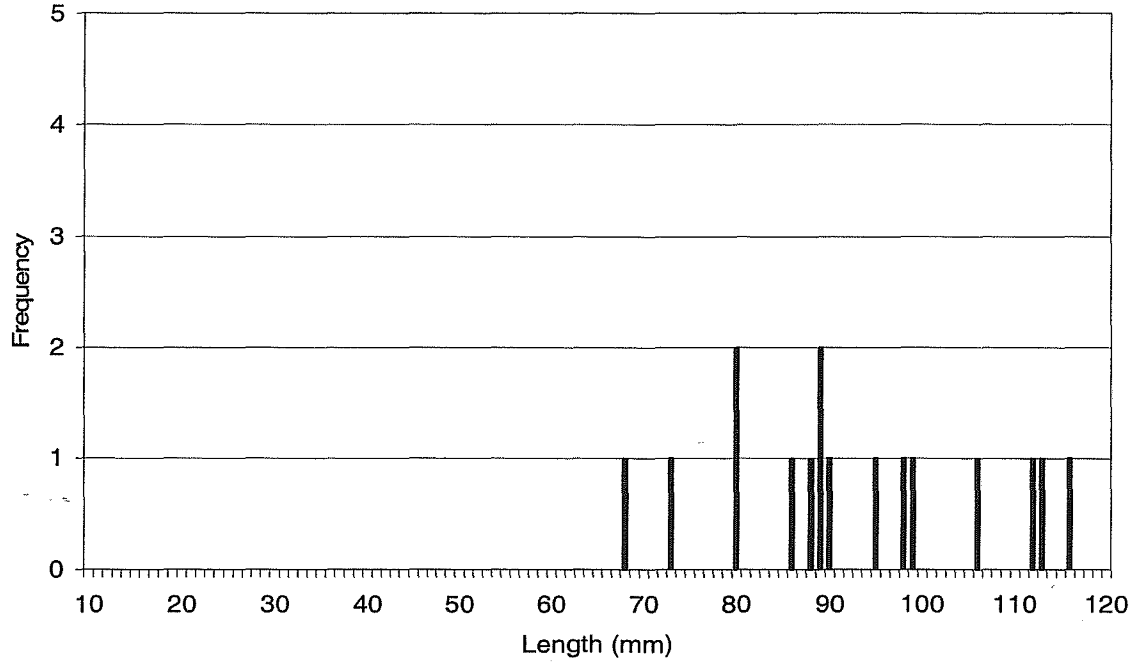


Figure 37. Mean length-at-annulus of butter clams collected in Topaze Harbour, Sunderland Channel, June 24, 2002.

Error bars represent 95% confidence intervals.



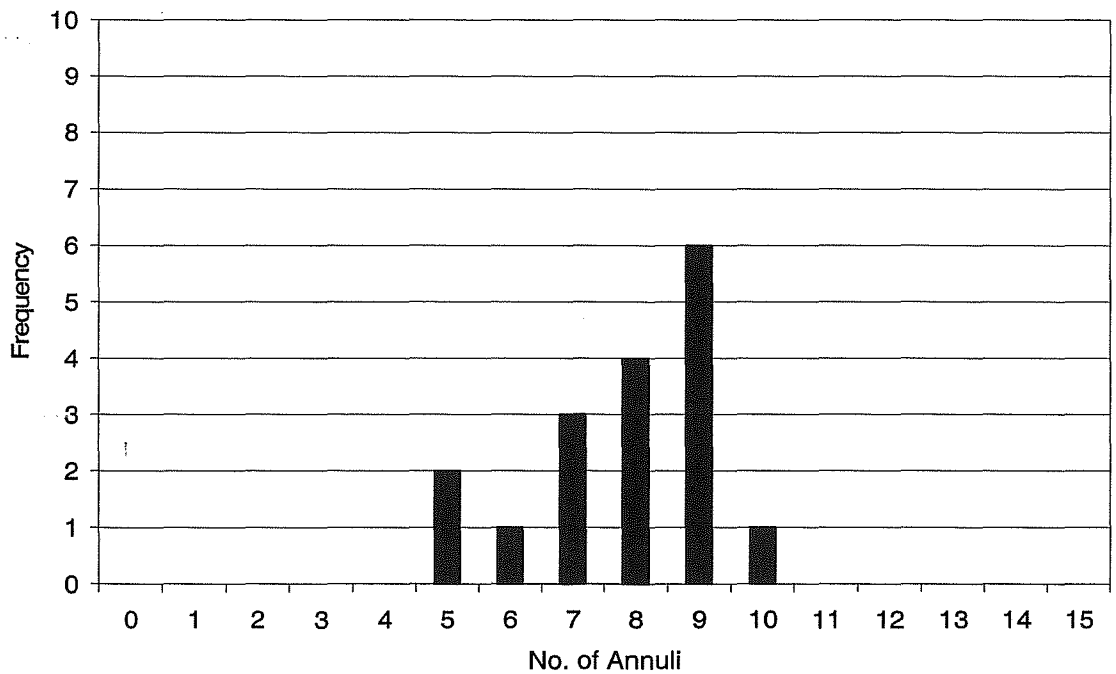


Figure 38. Length (top) and age (bottom) frequency distributions of softshells collected in Forward Harbour, Sunderland Channel, June 24, 2002.

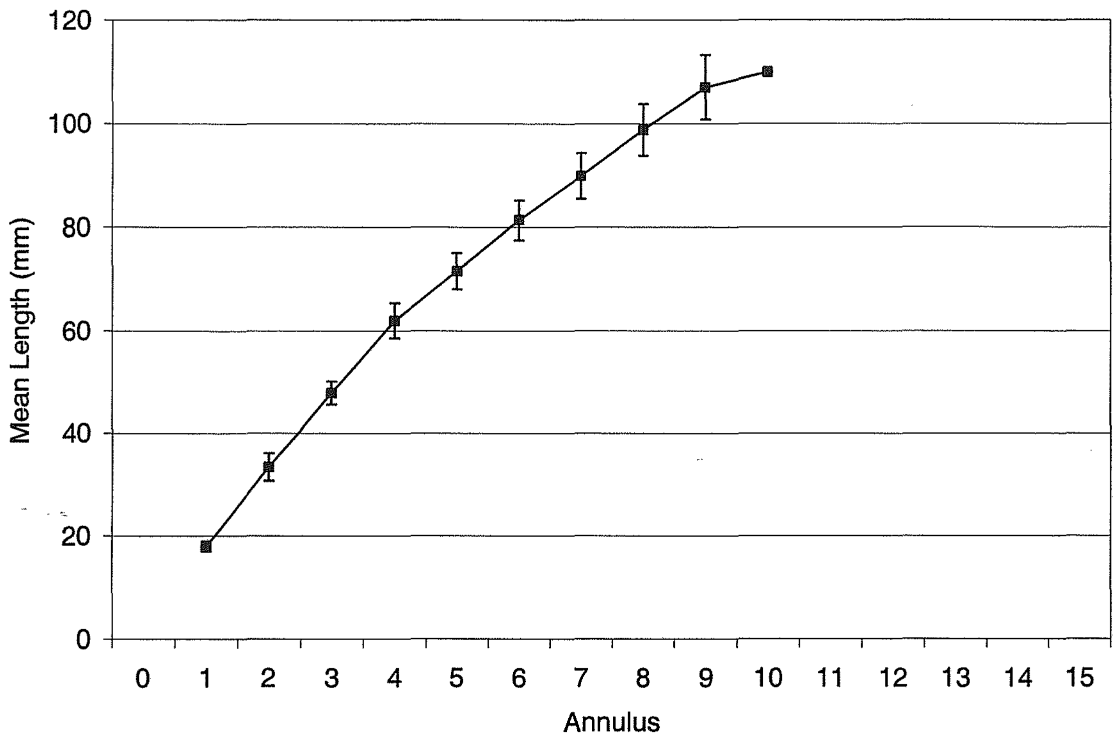


Figure 39. Mean length-at-annulus of softshells collected in Forward Harbour, Sunderland Channel, June 24, 2002.

Error bars represent 95% confidence intervals.

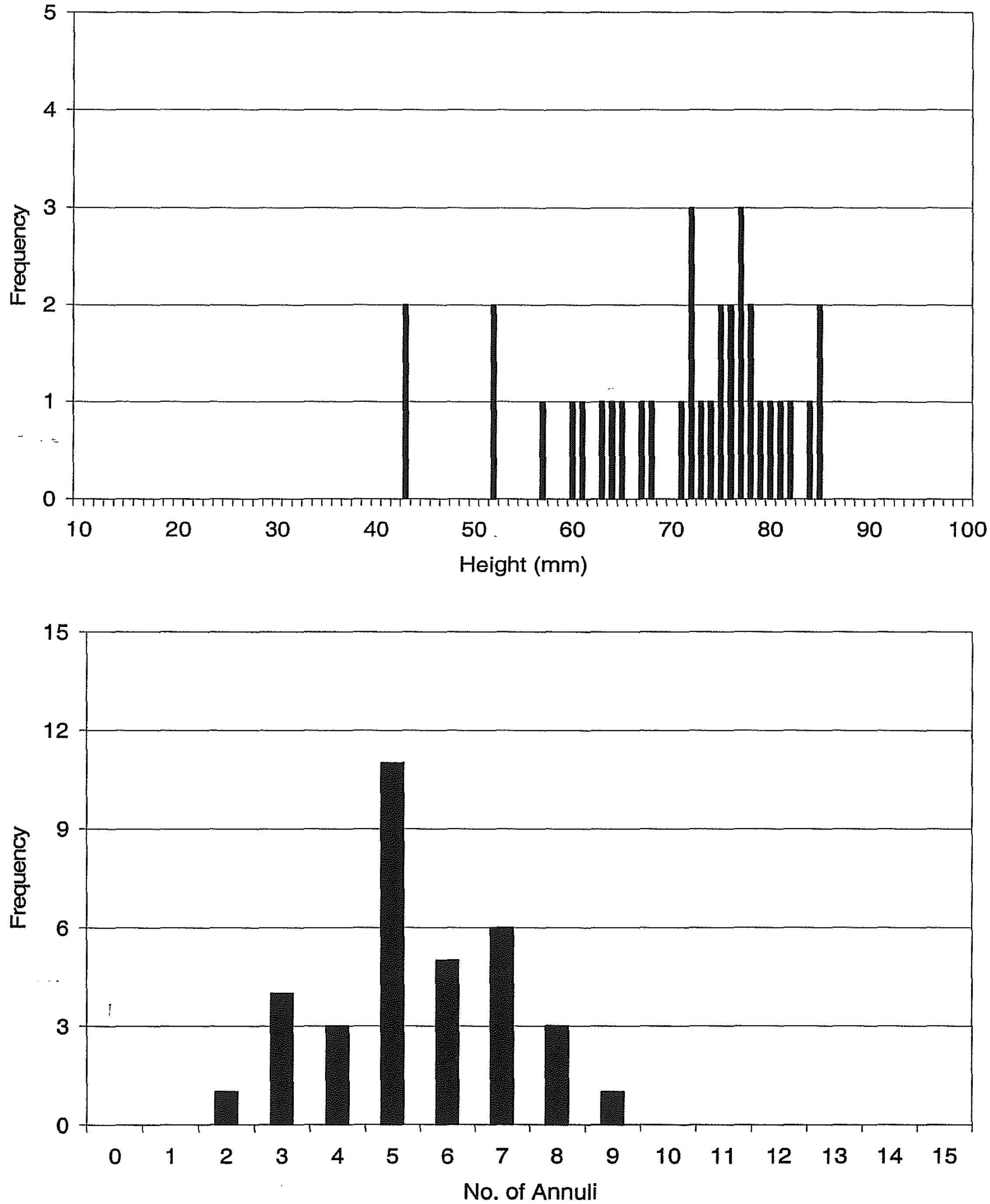


Figure 40. Height (top) and age (bottom) frequency distributions of cockles collected in Forward Harbour, Sunderland Channel, June 24, 2002.

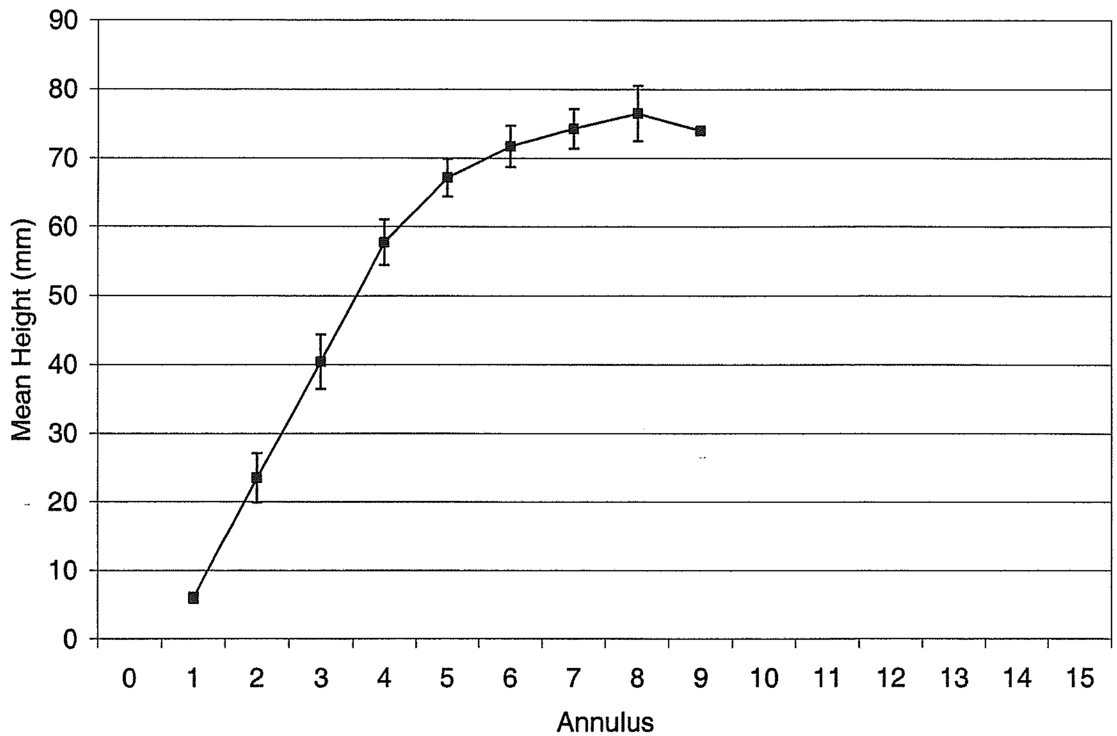


Figure 41. Mean height-at-annulus of cockles collected in Forward Harbour, Sunderland Channel, June 24, 2002.

Error bars represent 95% confidence intervals.

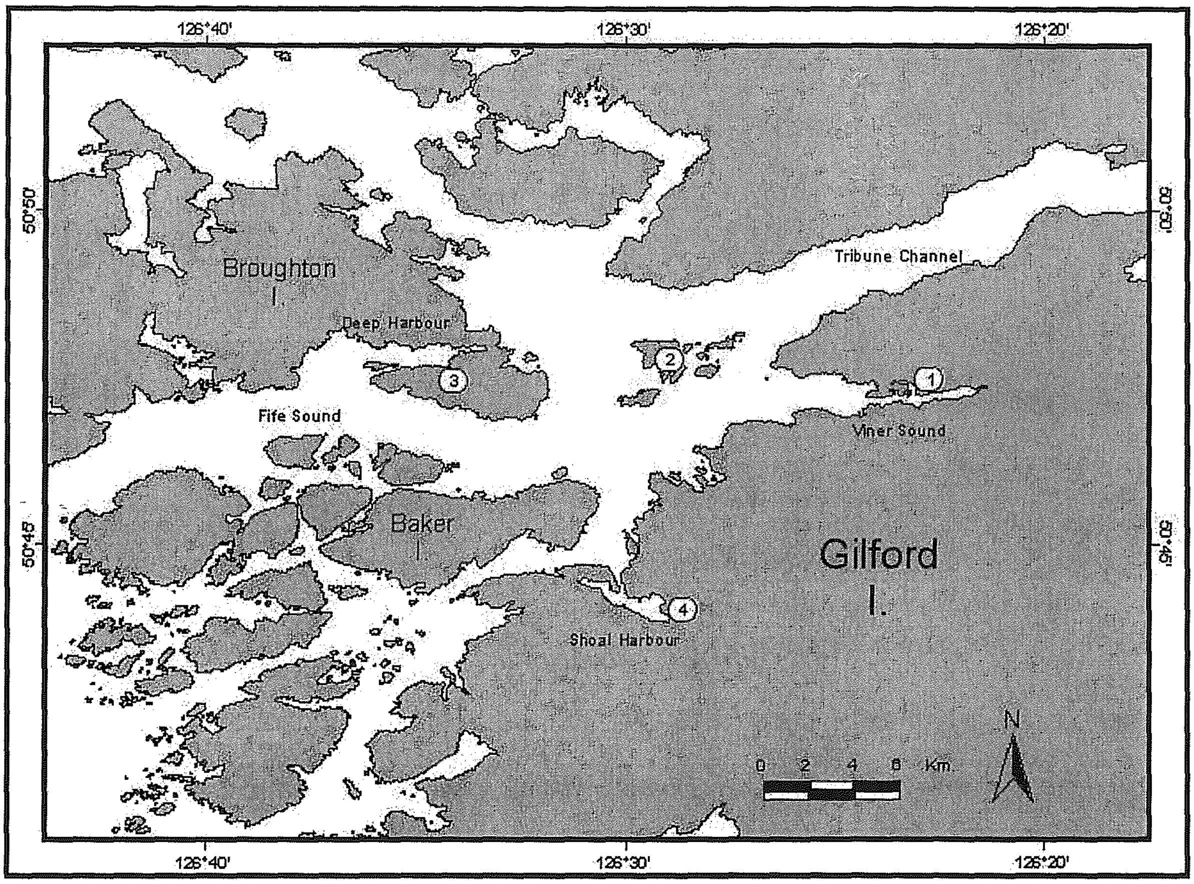


Figure 42. Locations of beaches surveyed near Gilford Island, June 27, 2002.
Legend: 1 – Viner Sound; 2 – Burdwood Group; 3 – Deep Harbour; 4 – Shoal Harbour.

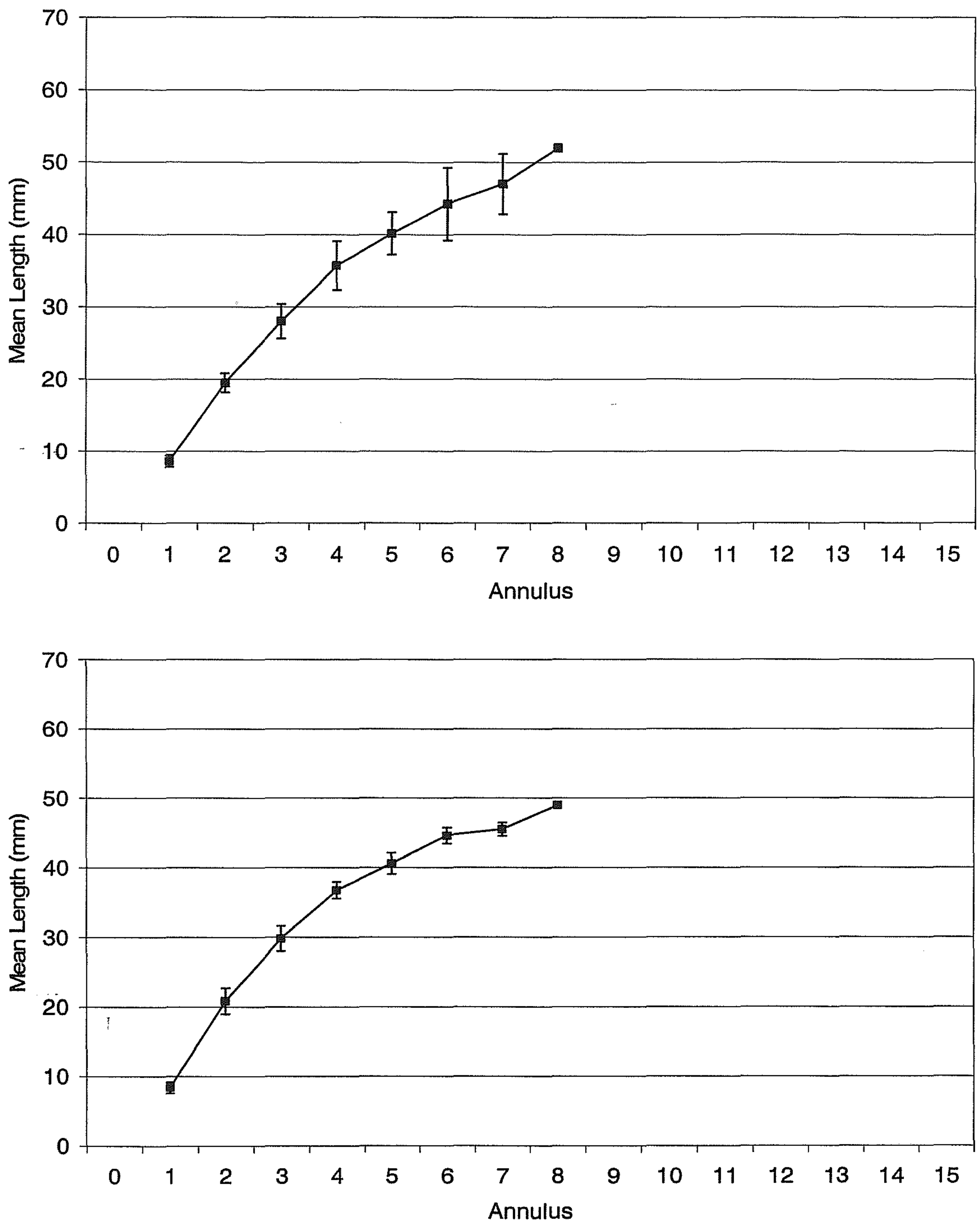


Figure 43. Mean length-at-annulus of Manila clam shells collected in Viner Sound (top) and Deep Harbour (bottom), Gilford Island, June 27, 2002.

Error bars represent 95% confidence intervals.

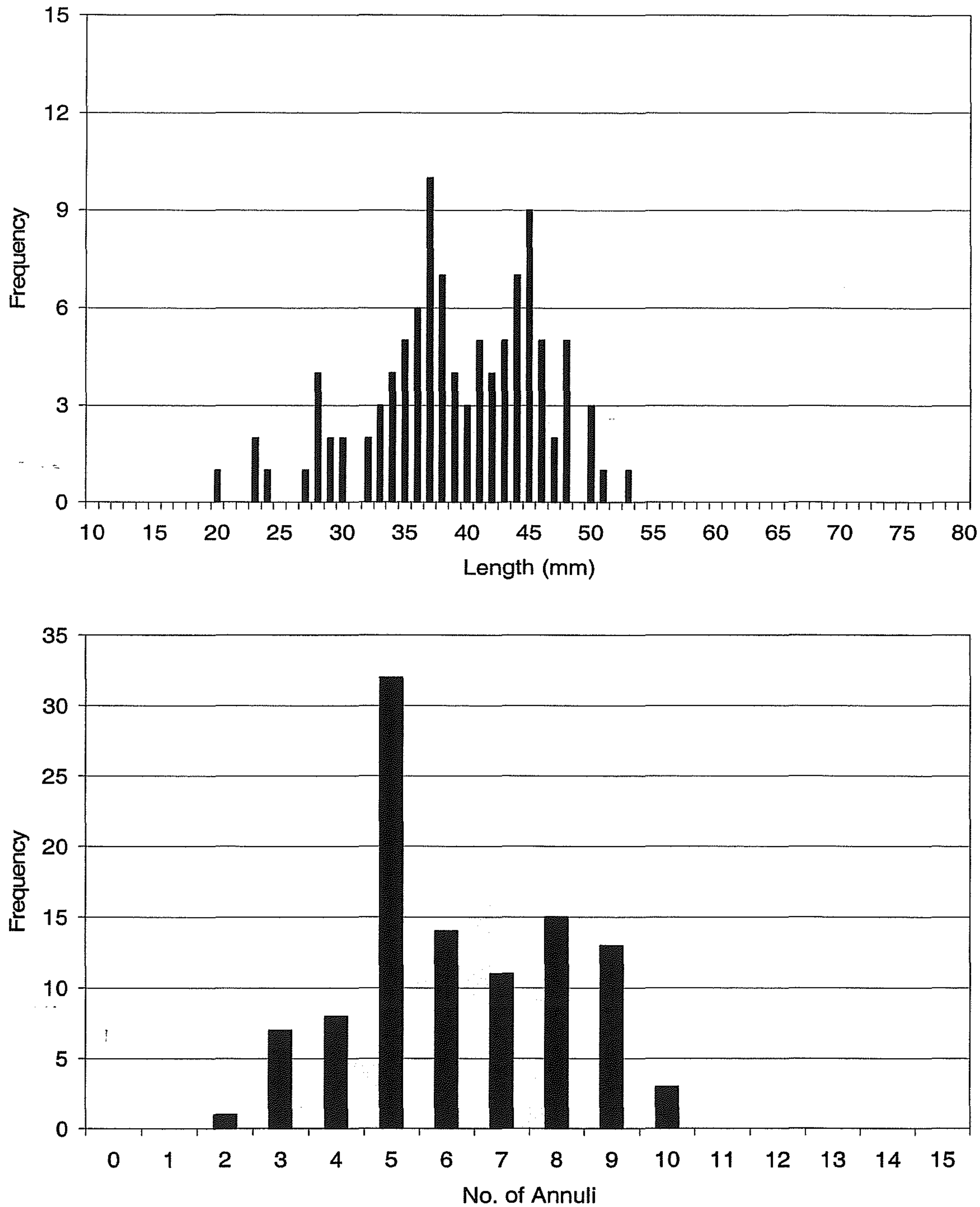


Figure 44. Length (top) and age (bottom) frequency distributions of littleneck clams collected in the Burdwood Group, Gilford Island, June 27, 2002.

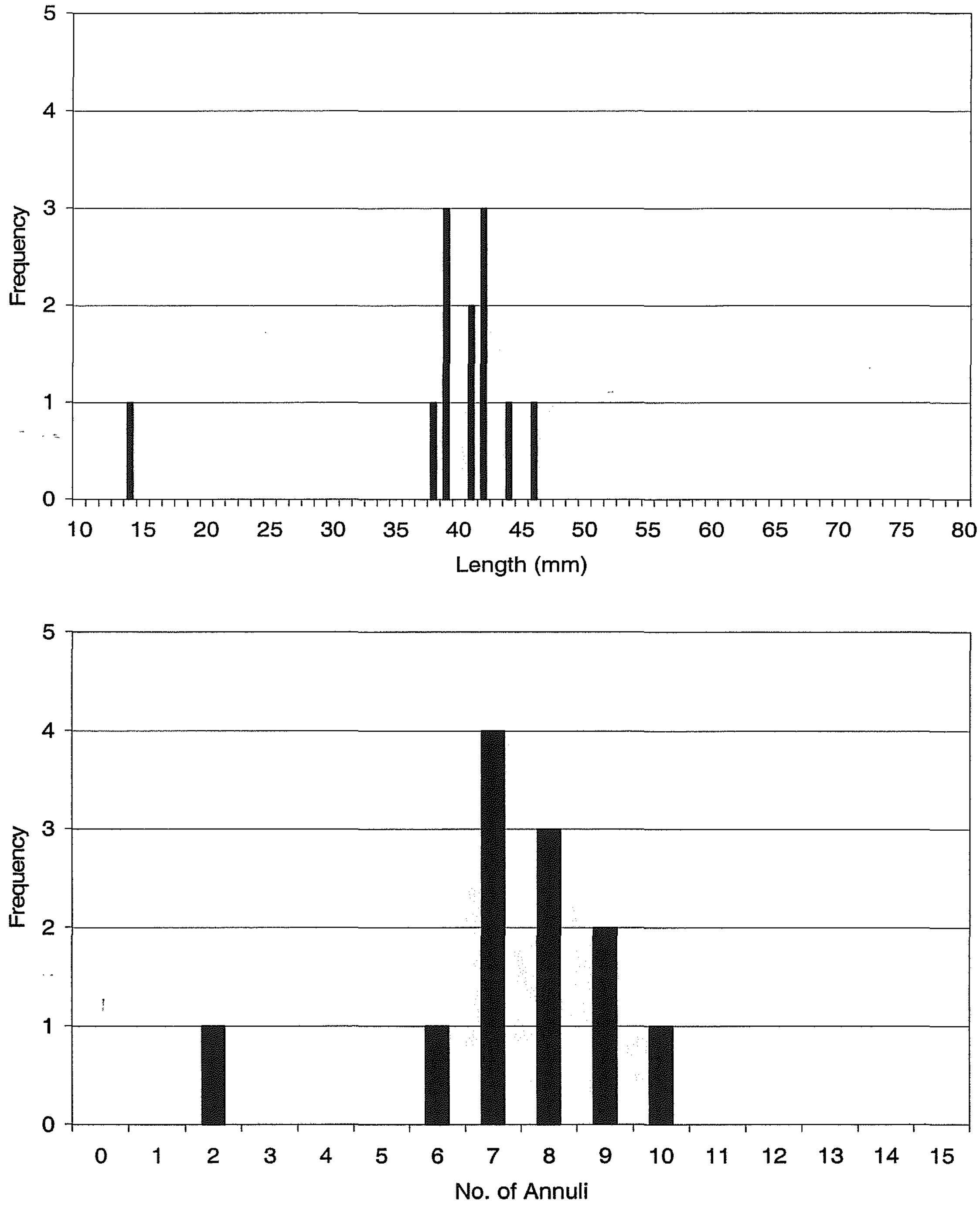


Figure 45. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Deep Harbour, Gilford Island, June 27, 2002.

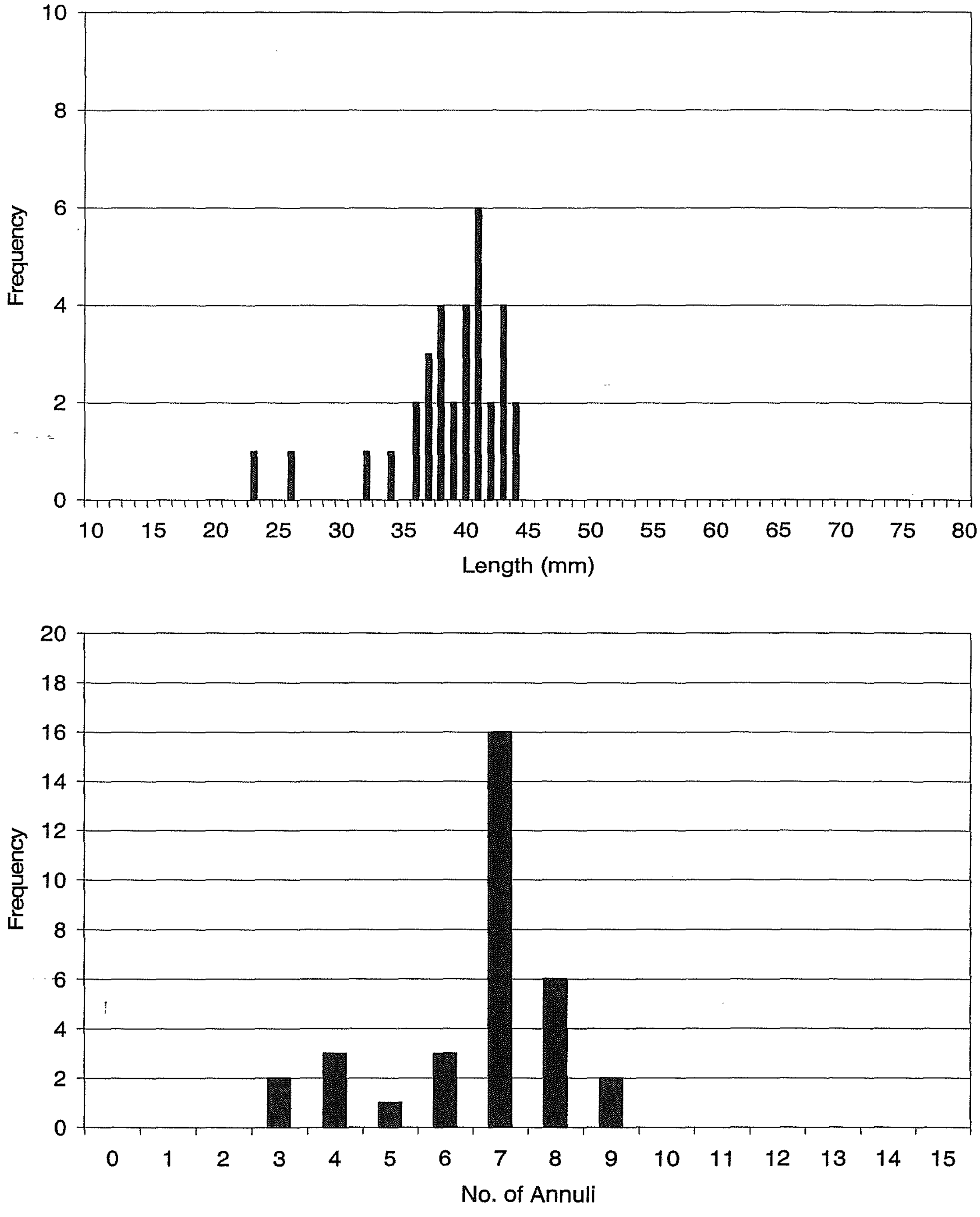


Figure 46. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Shoal Harbour, Gilford Island, June 27, 2002.

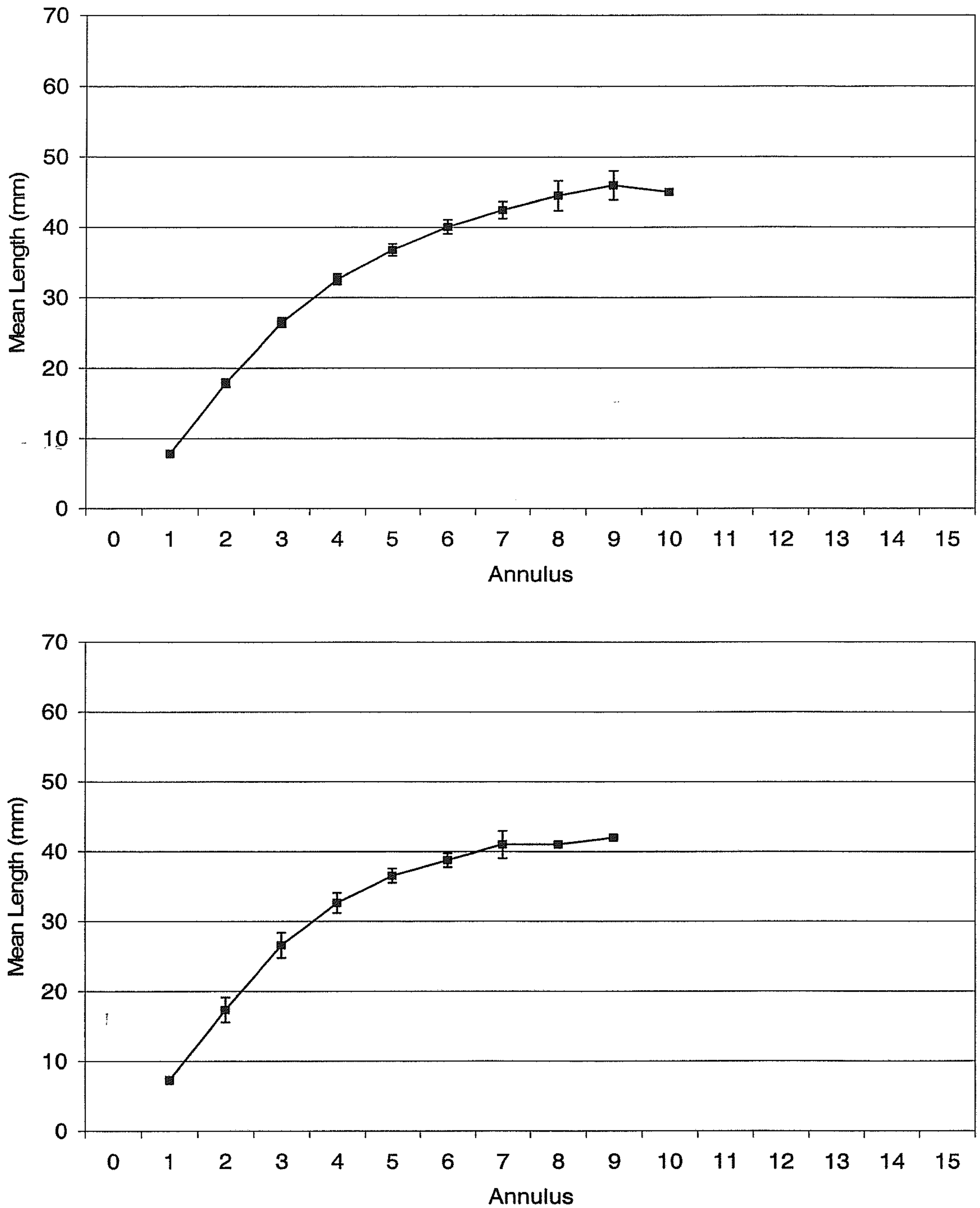


Figure 47. Mean length-at-annulus of littleneck clams collected in the Burdwood Group (top) and Deep Harbour (bottom), Gilford Island, June 27, 2002.

Error bars represent 95% confidence intervals.

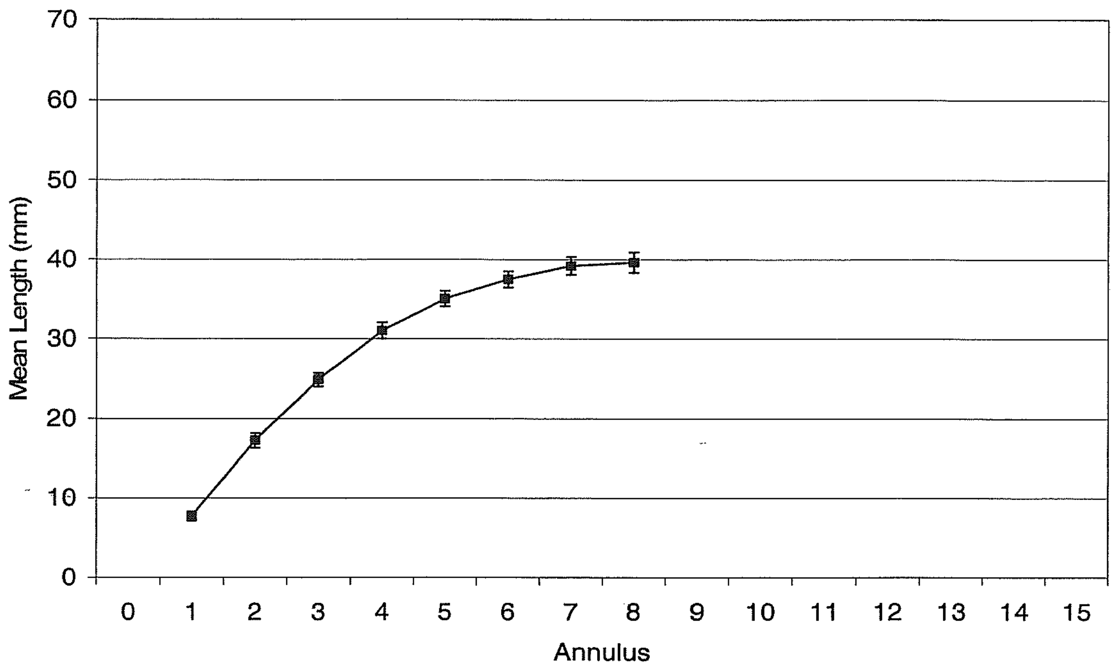
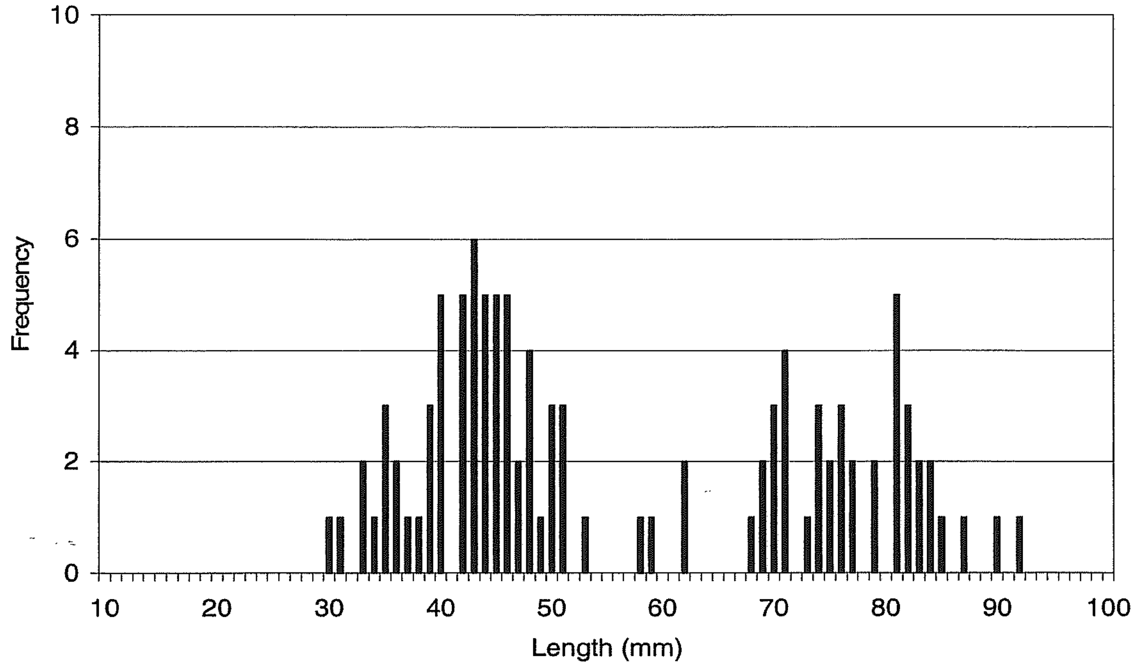


Figure 48. Mean length-at-annulus of littleneck clams collected in Shoal Harbour, Gilford Island, June 27, 2002.

Error bars represent 95% confidence intervals.



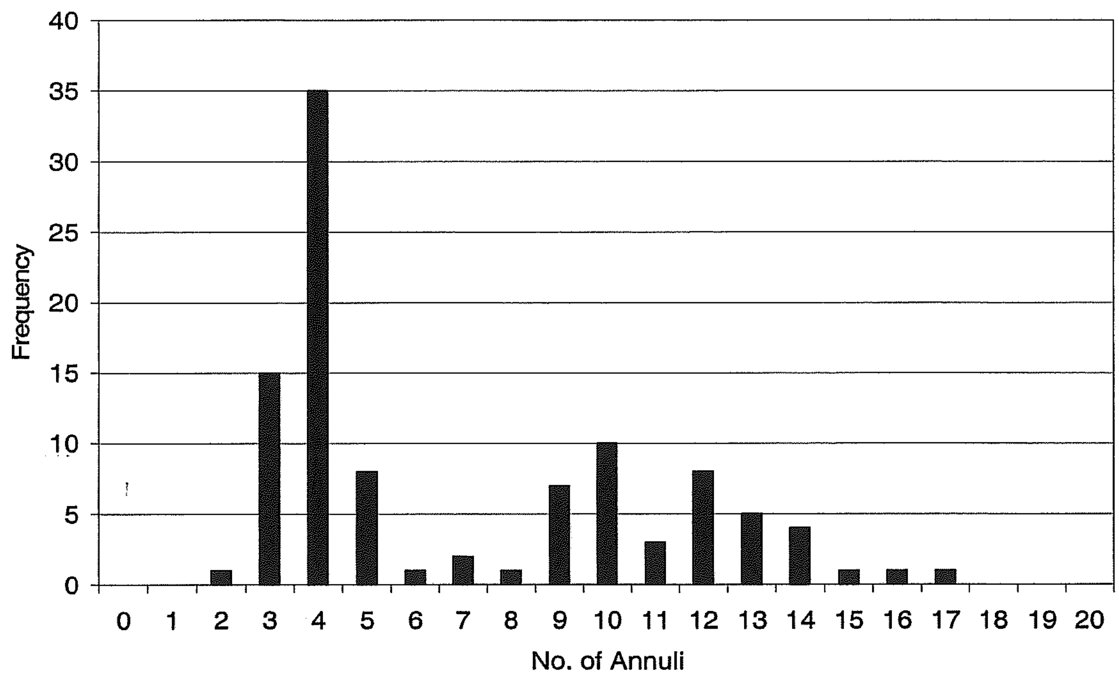


Figure 49. Length (top) and age (bottom) frequency distributions of butter clams collected in the Burdwood Group, Gilford Island, June 27, 2002.

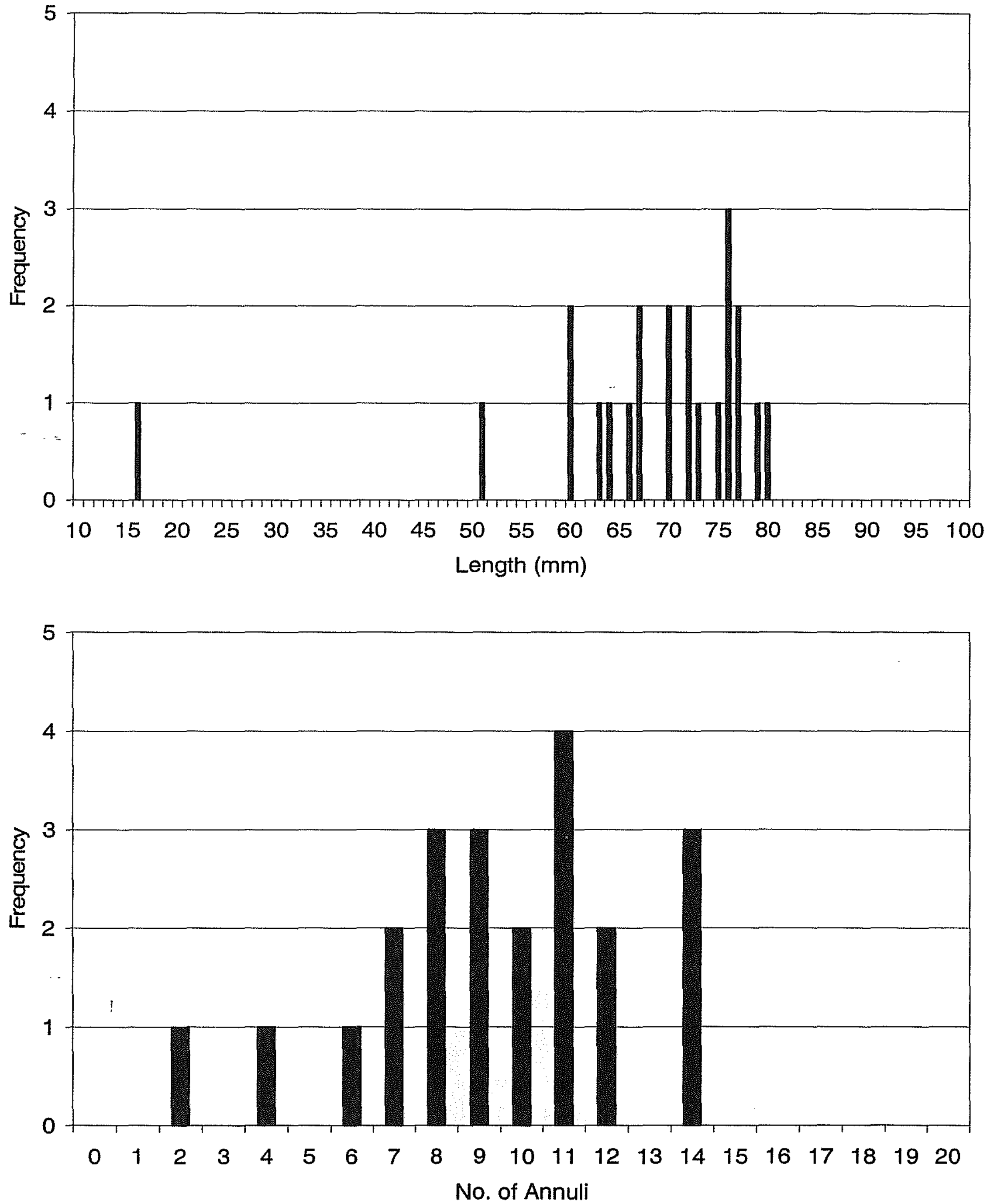


Figure 50. Length (top) and age (bottom) frequency distributions of butter clams collected in Deep Harbour, Gilford Island, June 27, 2002.

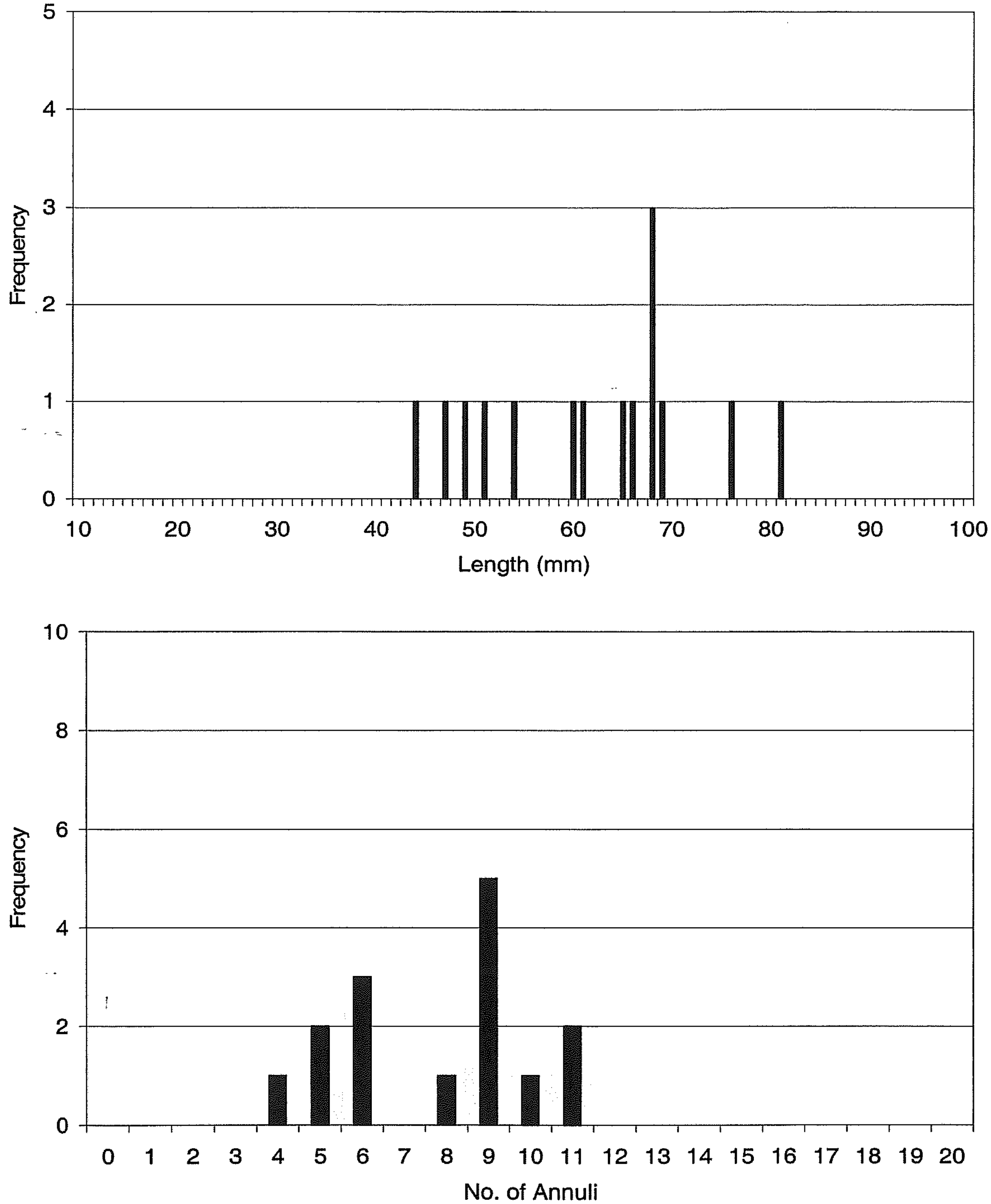


Figure 51. Length (top) and age (bottom) frequency distributions of butter clams collected in Shoal Harbour, Gilford Island, June 27, 2002.

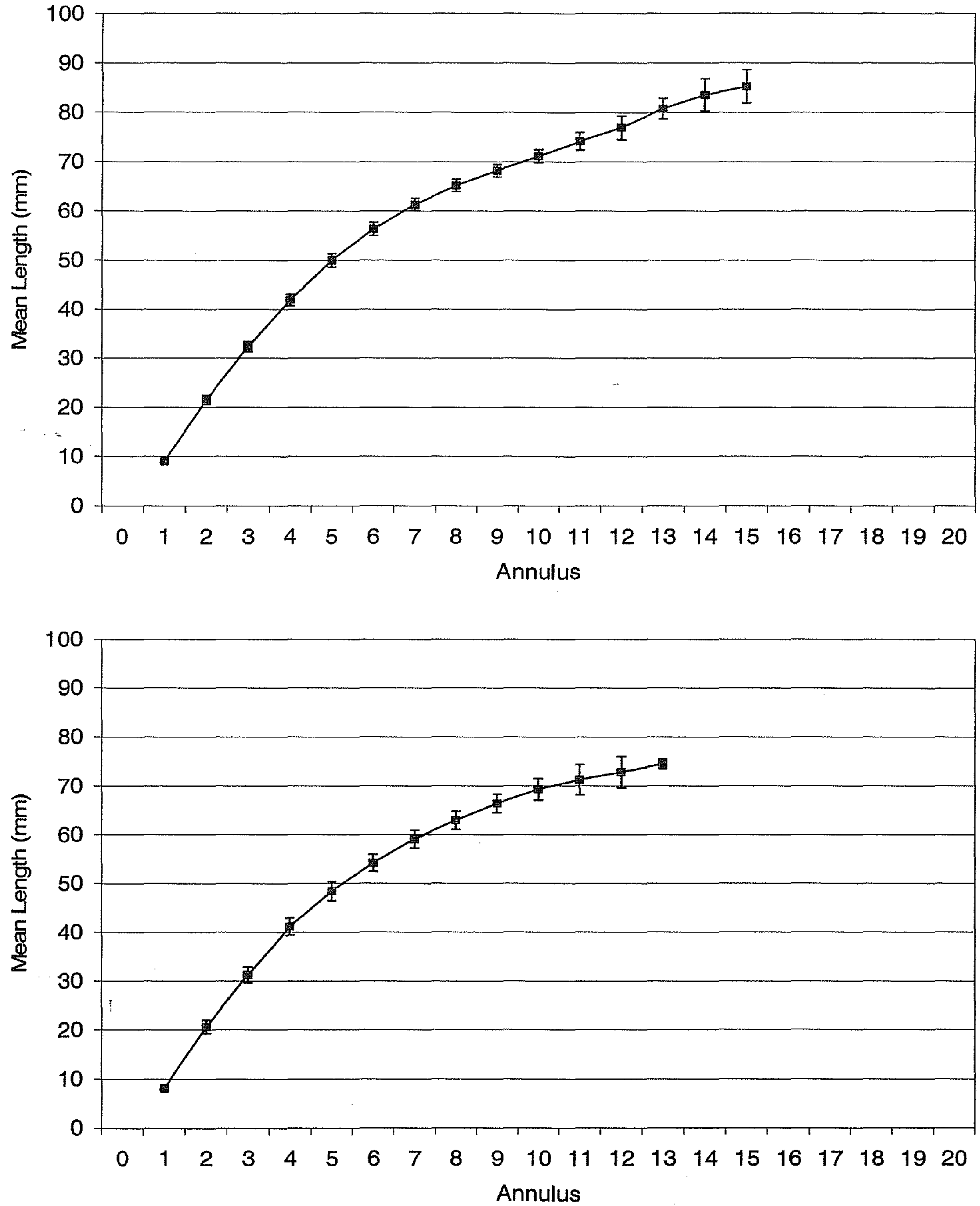


Figure 52. Mean length-at-annulus of butter clams collected in the Burdwood Group (top), and Deep Harbour (bottom), Gilford Island, June 27, 2002.

Error bars represent 95% confidence intervals.

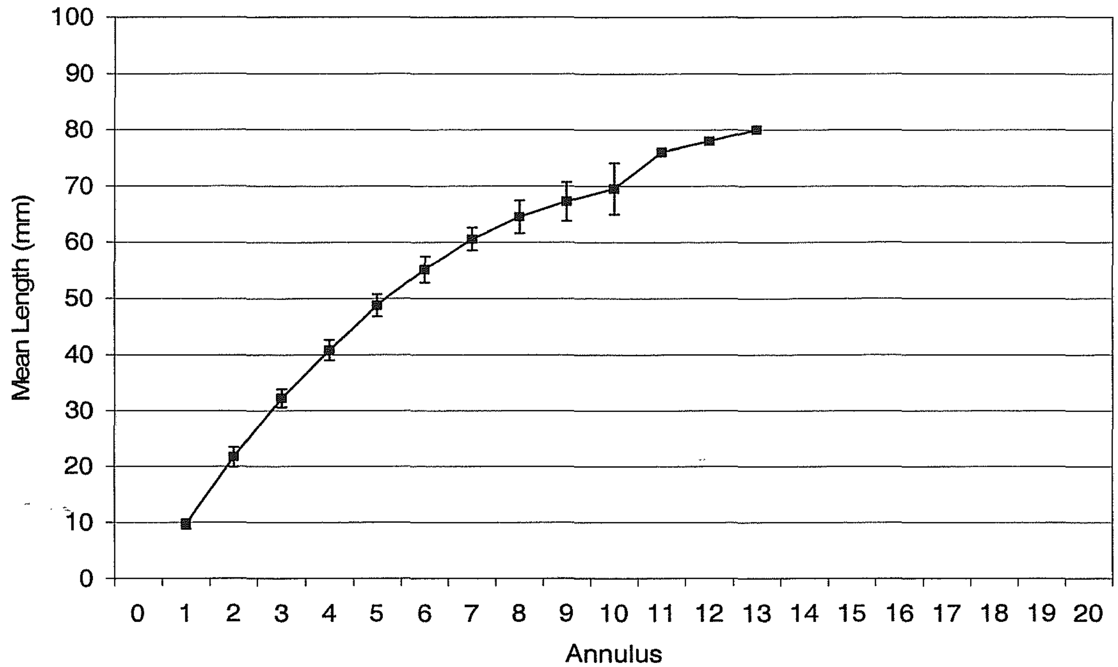


Figure 53. Mean length-at-annulus of butter clams collected in Shoal Harbour, Gilford Island, June 27, 2002.

Error bars represent 95% confidence intervals.

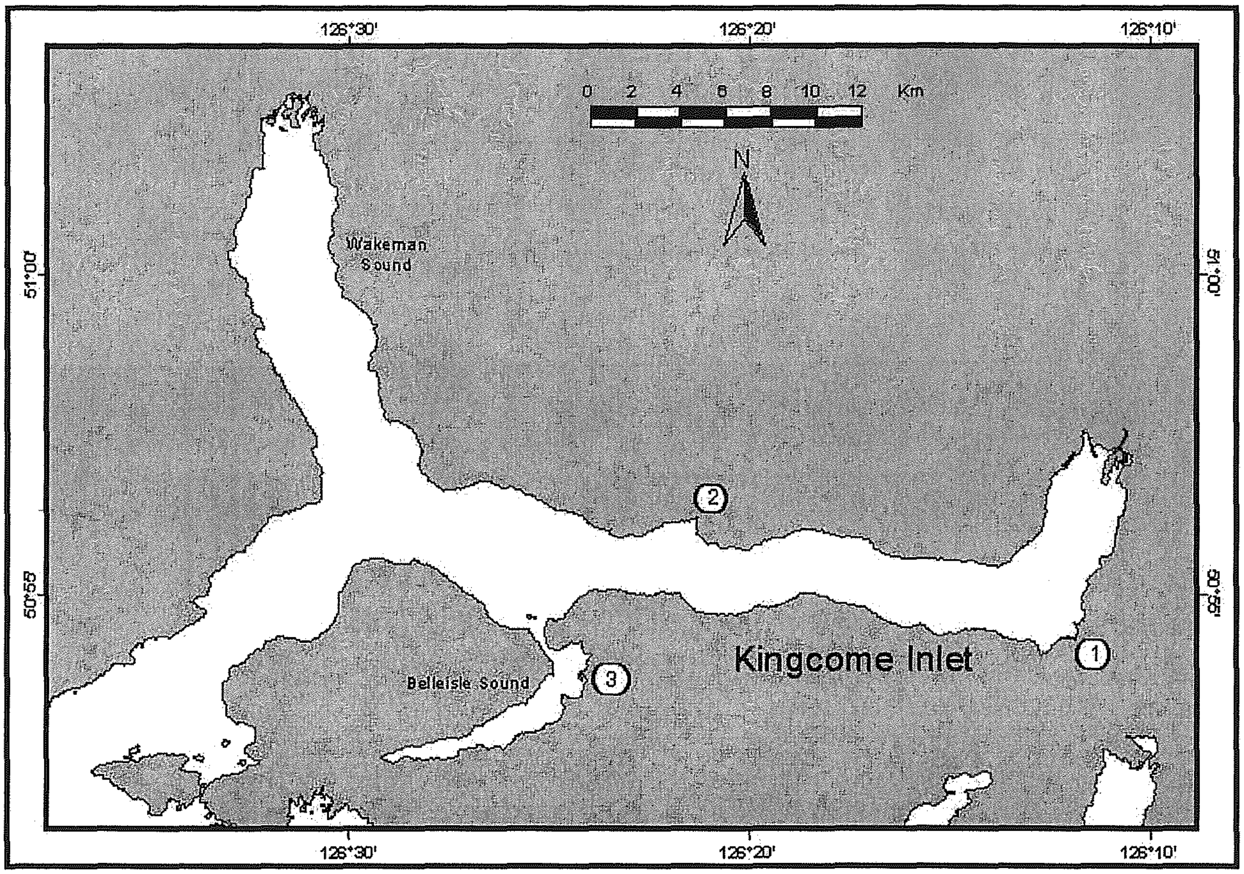


Figure 54. Locations of beaches surveyed in Kingcome Inlet, June 28, 2002.
Legend: 1 – Anchorage Cove; 2 – Charles Creek; 3 – Belleisle Inlet.

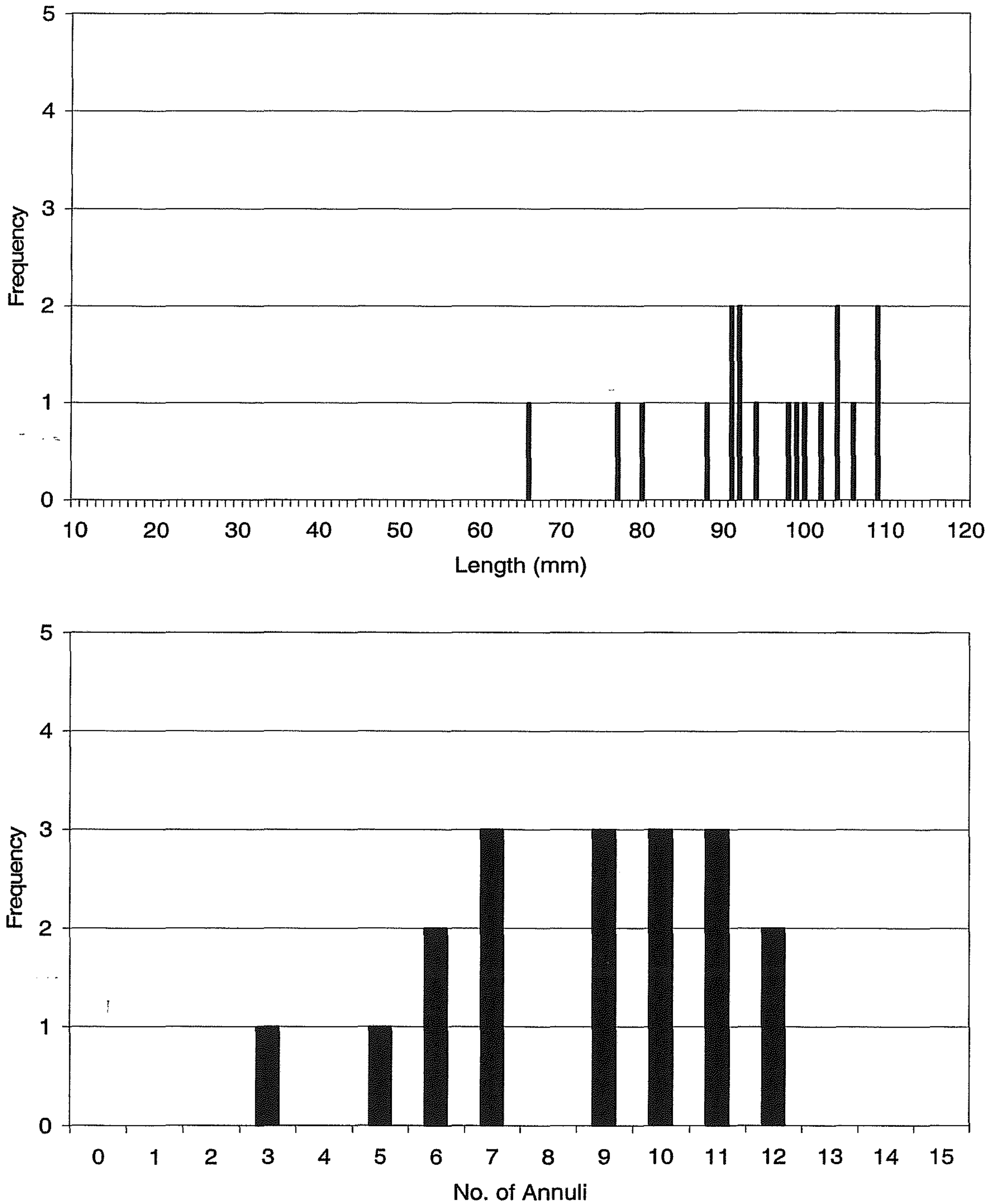


Figure 55. Length (top) and age (bottom) frequency distributions of softshells collected at Charles Creek, Kingcome Inlet, June 28, 2002.

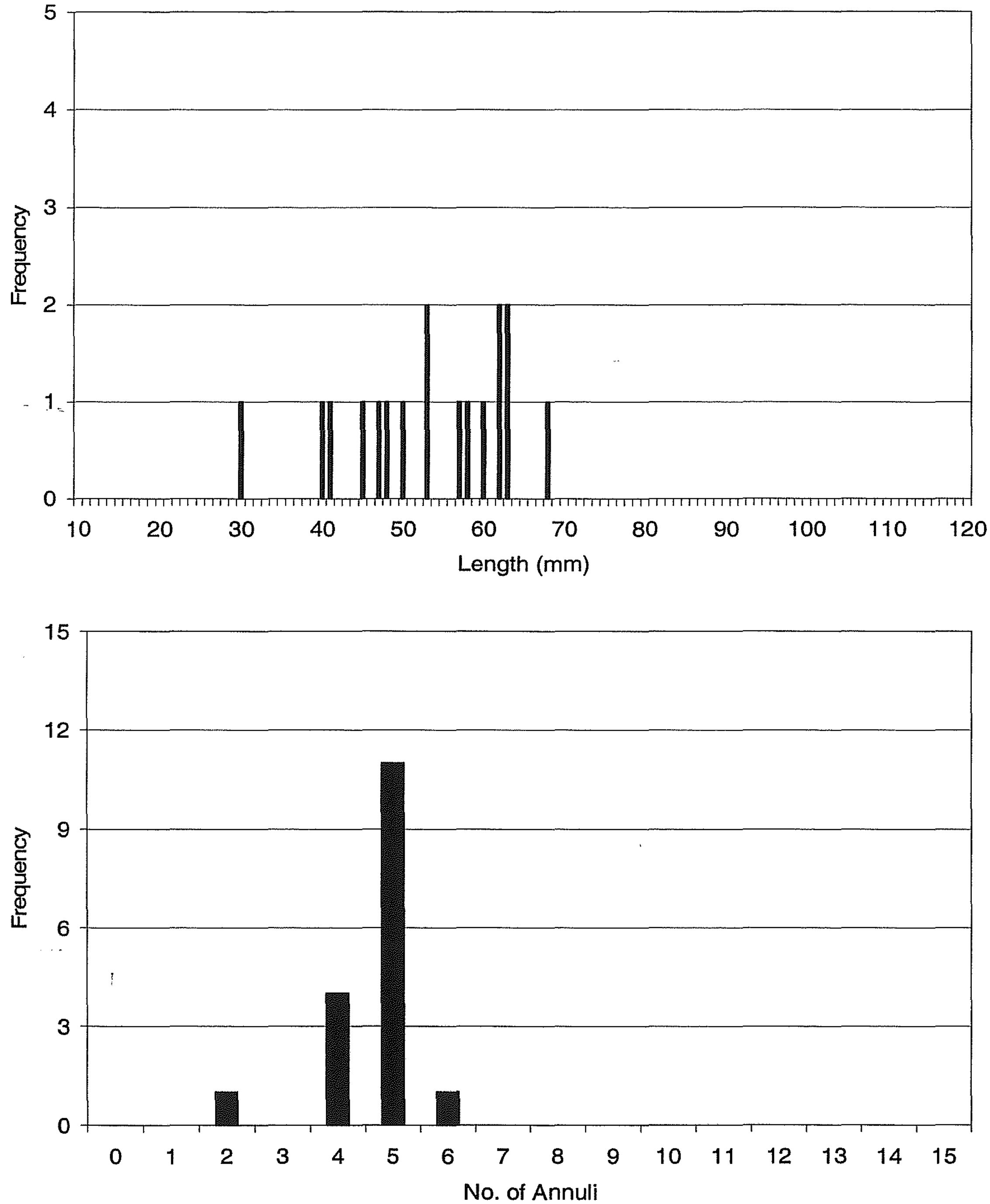


Figure 56. Length (top) and age (bottom) frequency distributions of softshells collected in Belleisle Sound, Kingcome Inlet, June 28, 2002.

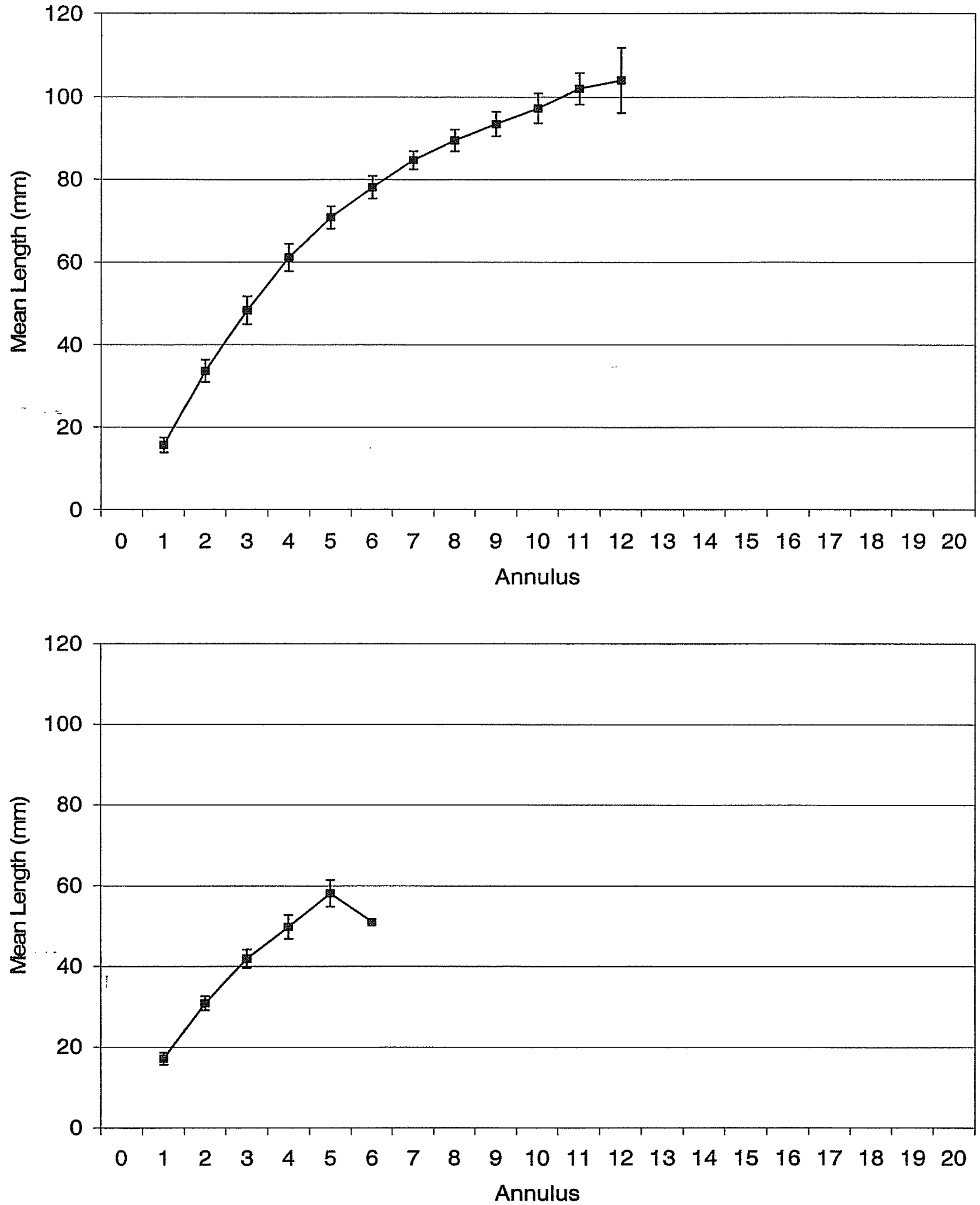


Figure 57. Mean length-at-annulus of softshells collected at Charles Creek (top) and in Belleisle Sound (bottom), Kingcome Inlet, June 28, 2002.

Error bars represent 95% confidence intervals.

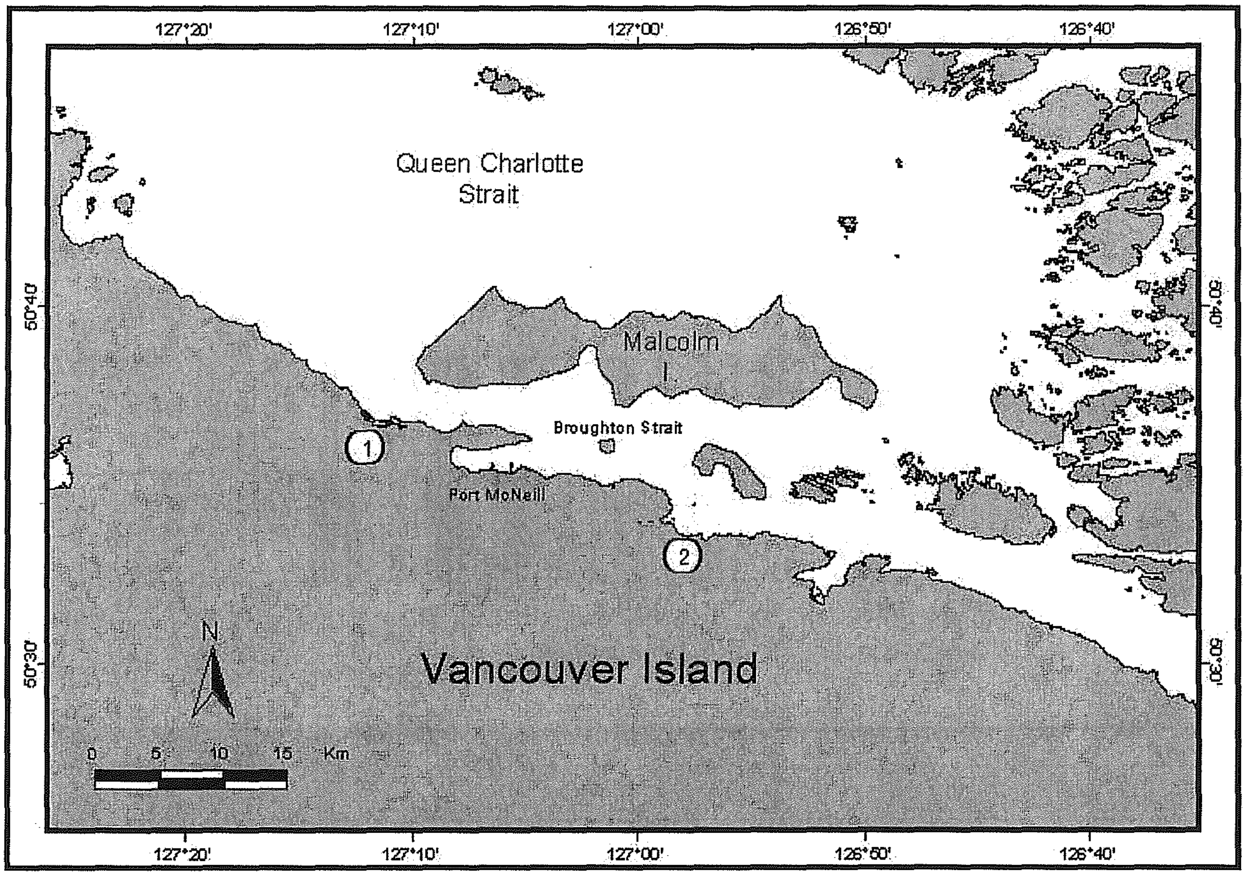


Figure 58. Locations of beaches surveyed in Broughton Strait, June 29, 2002.
Legend: 1 – Cluxewe River estuary; 2 – Nimpkish River estuary.

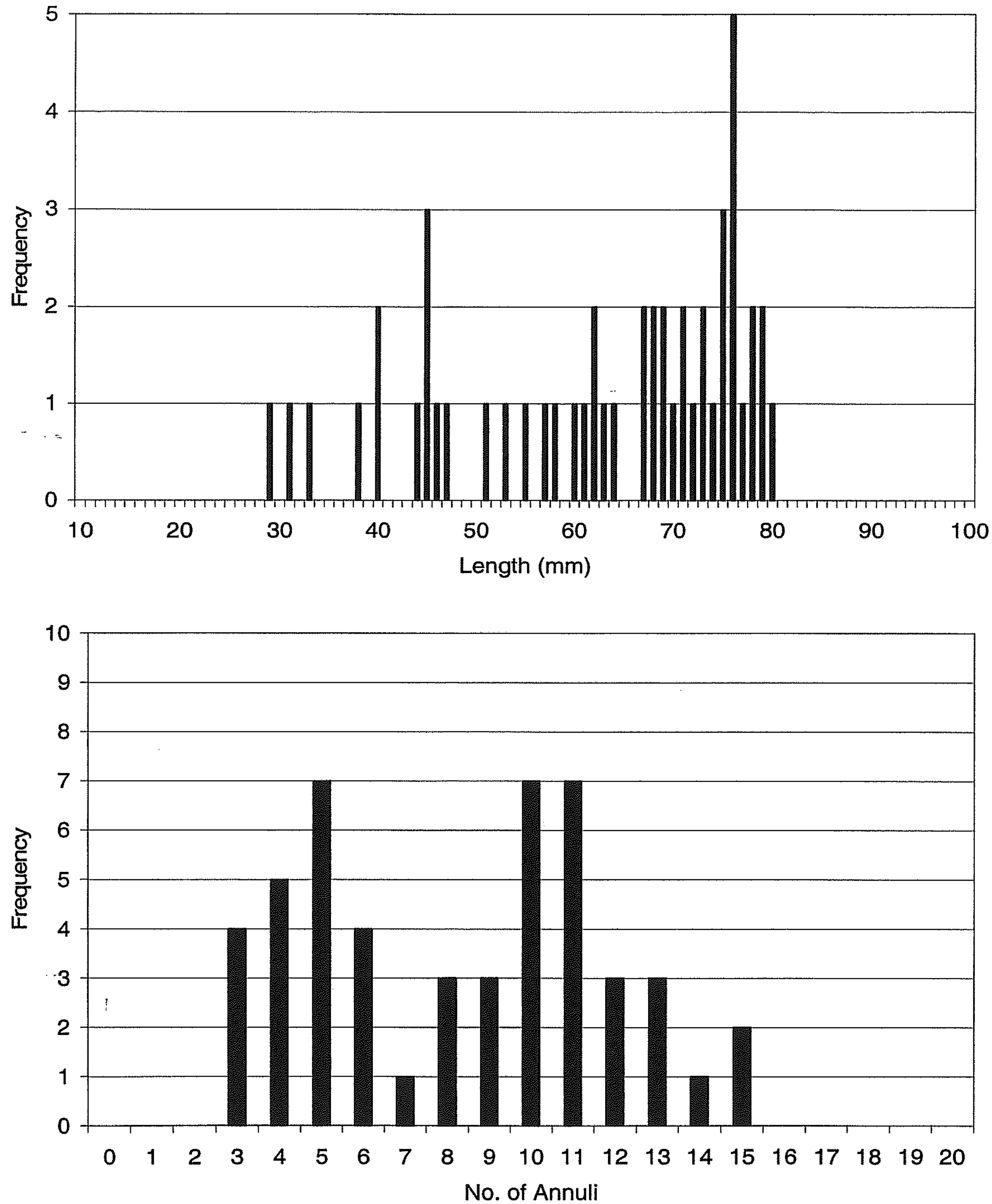


Figure 59. Length (top) and age (bottom) frequency distributions of butter clams collected at the Cluxewe River estuary, Broughton Strait, June 29, 2002.

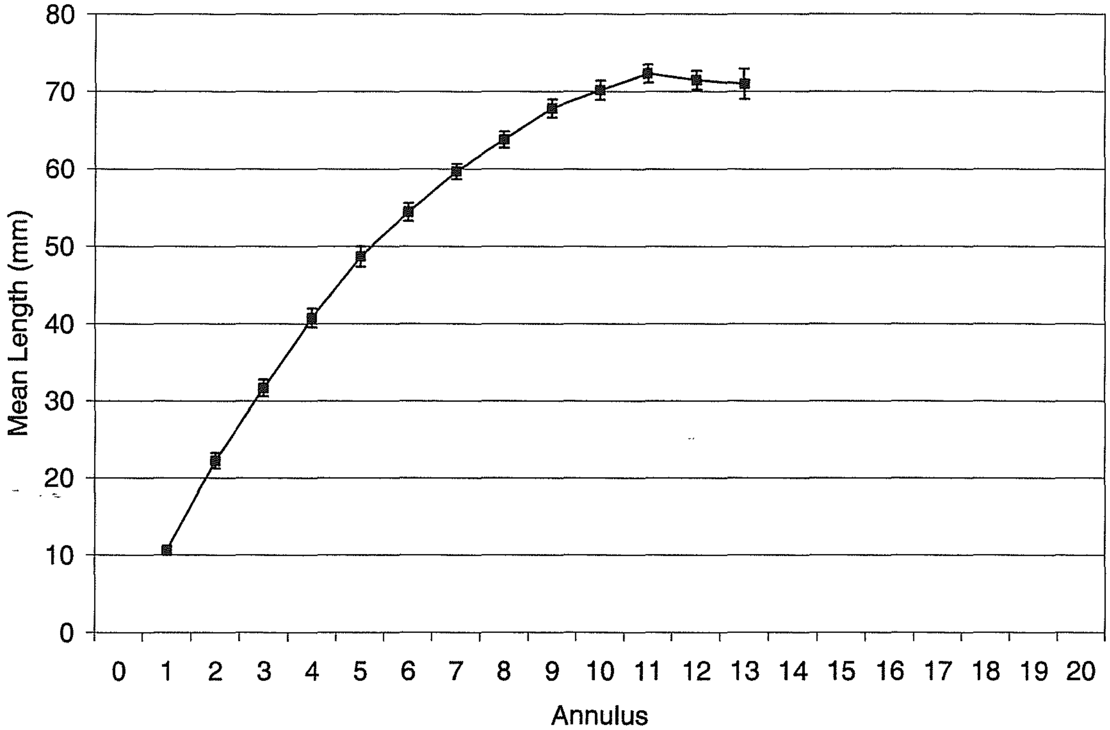


Figure 60. Mean length-at-annulus of butter clams collected at the Cluxewe River estuary, Broughton Strait, June 29, 2002.

Error bars represent 95% confidence intervals.

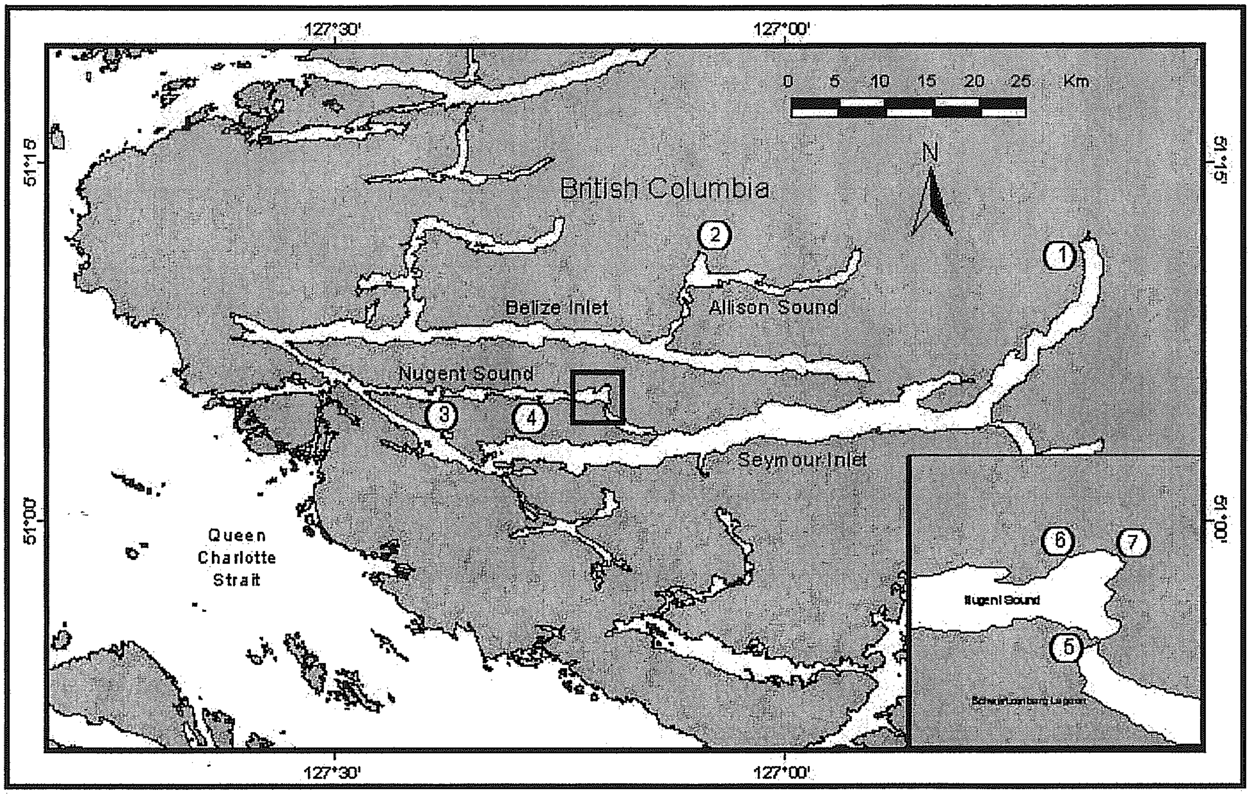


Figure 61. Locations of beaches surveyed in Seymour and Belize Inlets, June 30-July 3, 2002.

Legend: 1 – Head of Seymour Inlet; 2 – Chief Nollis Bay; 3 – Nugent Creek; 4 – South Side of Nugent Sound; 5 – Head of Nugent Sound 1; 6 – Head of Nugent Sound 2; 7 – Head of Nugent Sound 3.

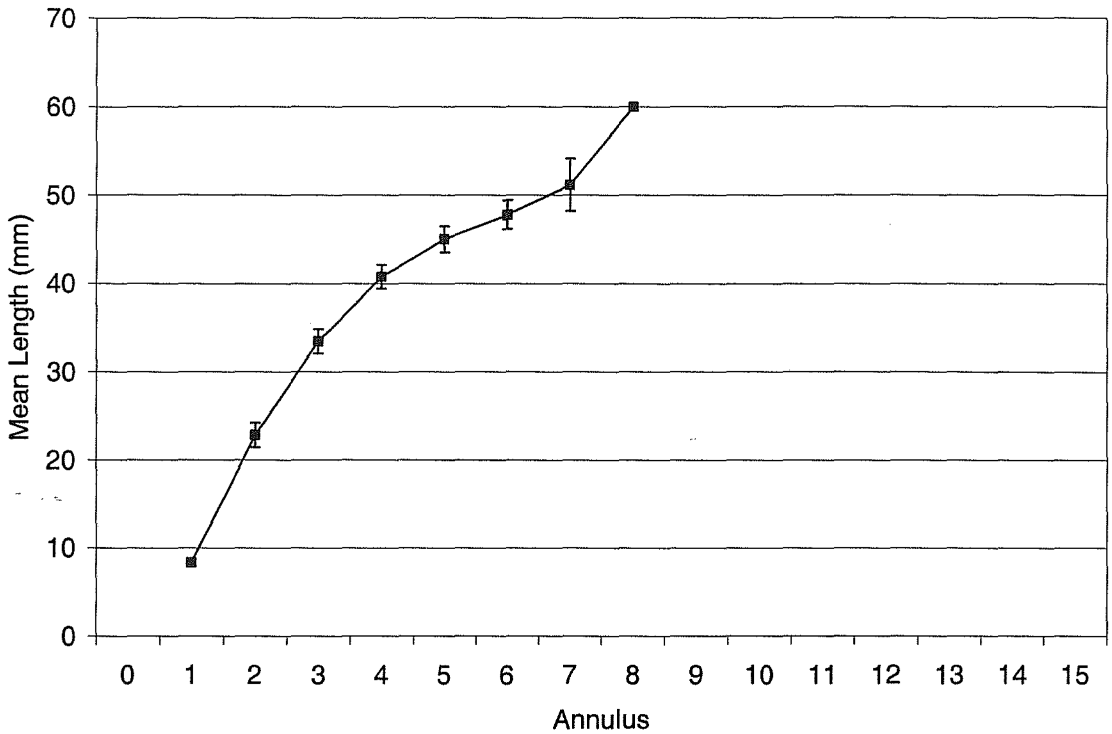


Figure 62. Mean length-at-annulus of Manila clam shells collected in Nugent Sound, July 3, 2002.

Error bars represent 95% confidence intervals.

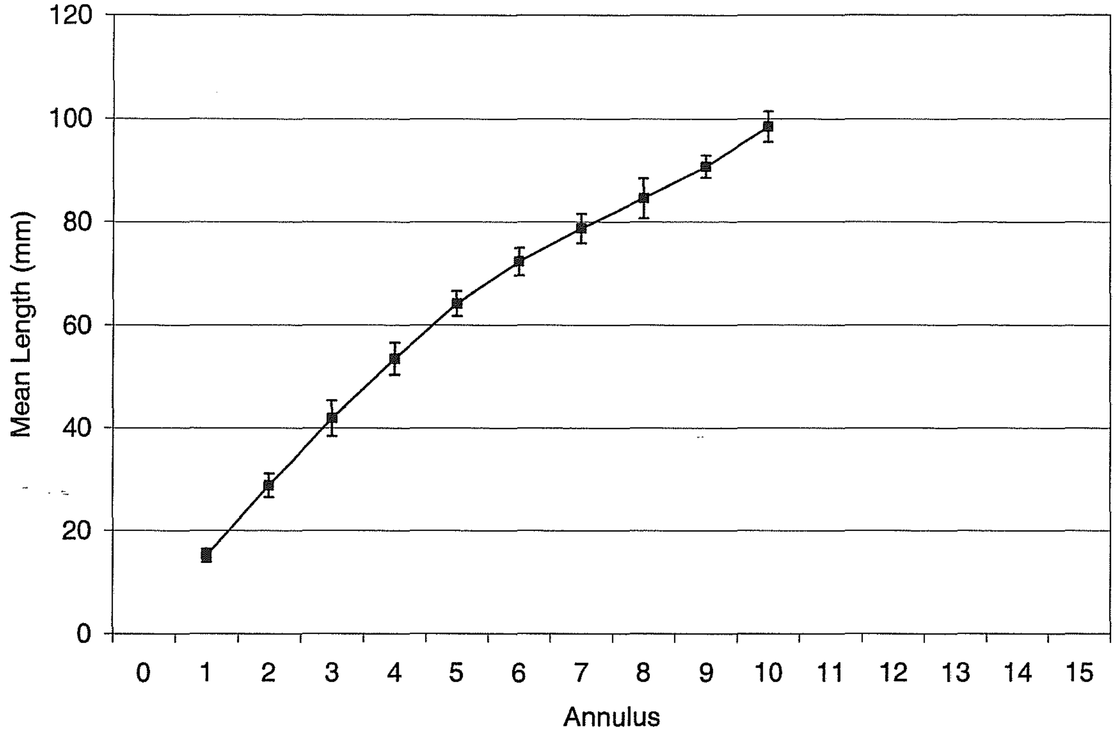


Figure 63. Mean length-at-annulus of softshells (dead shell) collected at the head of Seymour Inlet, June 30, 2002.

Error bars represent 95% confidence intervals.

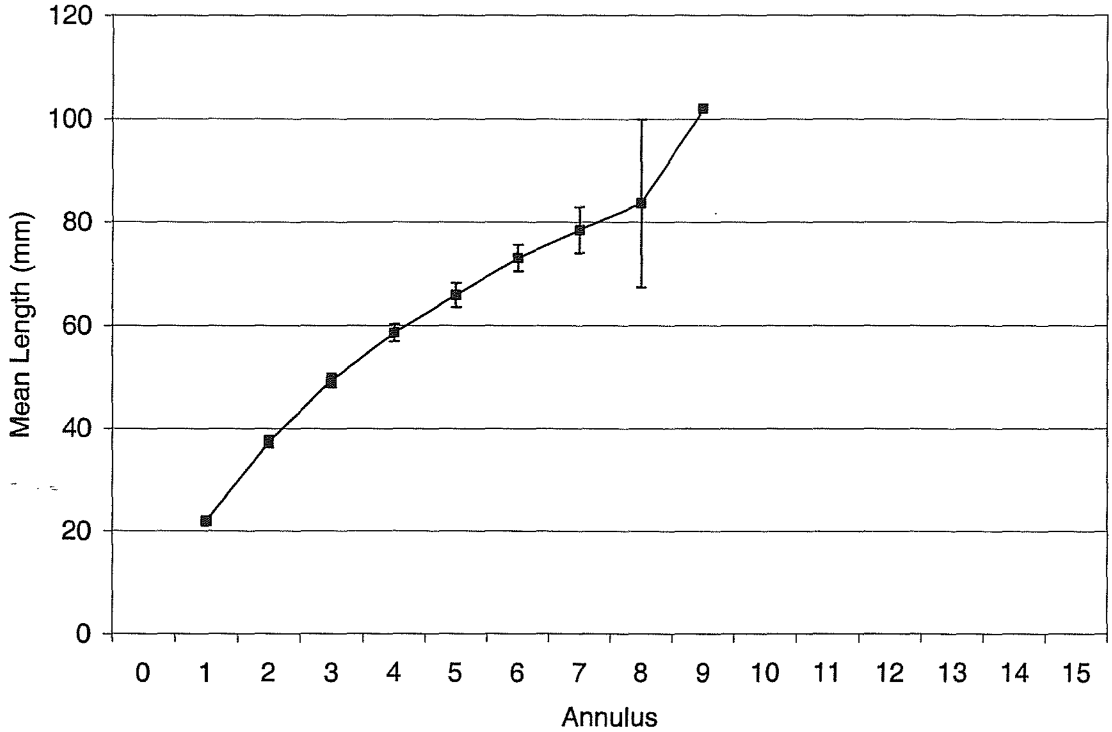


Figure 64. Mean length-at-annulus of softshells collected in Chief Nollis Bay, Allison Sound, July 2, 2002.

Error bars represent 95% confidence intervals.

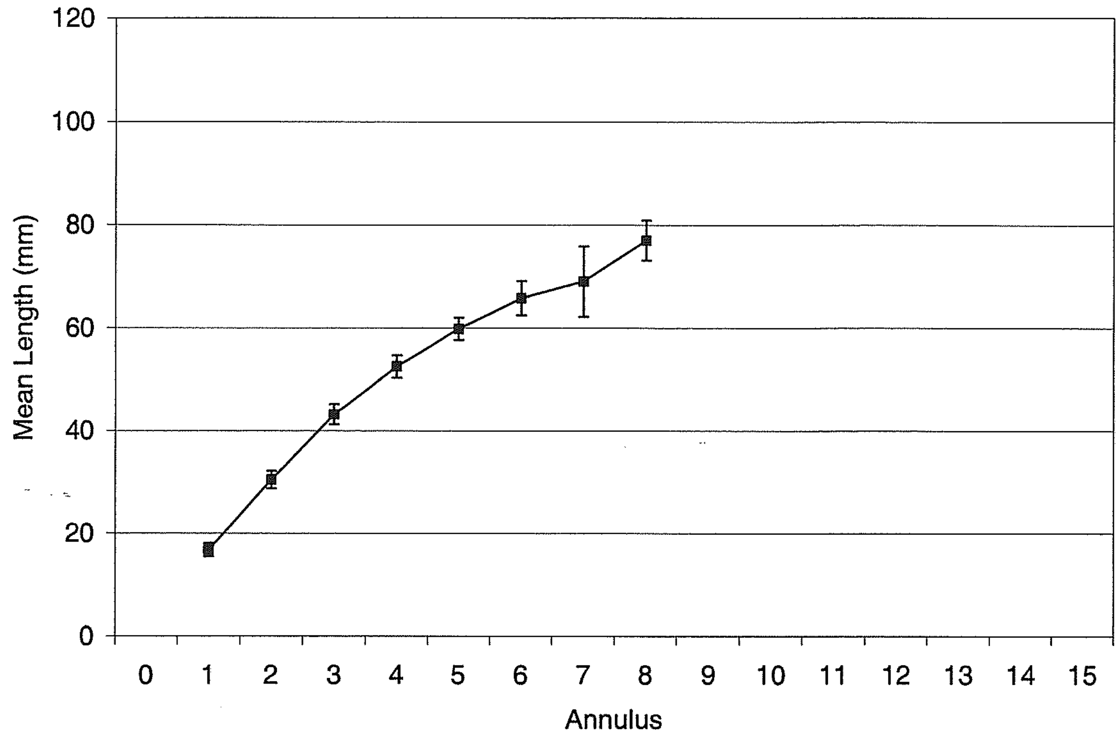


Figure 65. Mean length-at-annulus of softshells collected from the beach on the south side of Nugent Sound, Belize Inlet, July 3, 2002.

Error bars represent 95% confidence intervals.

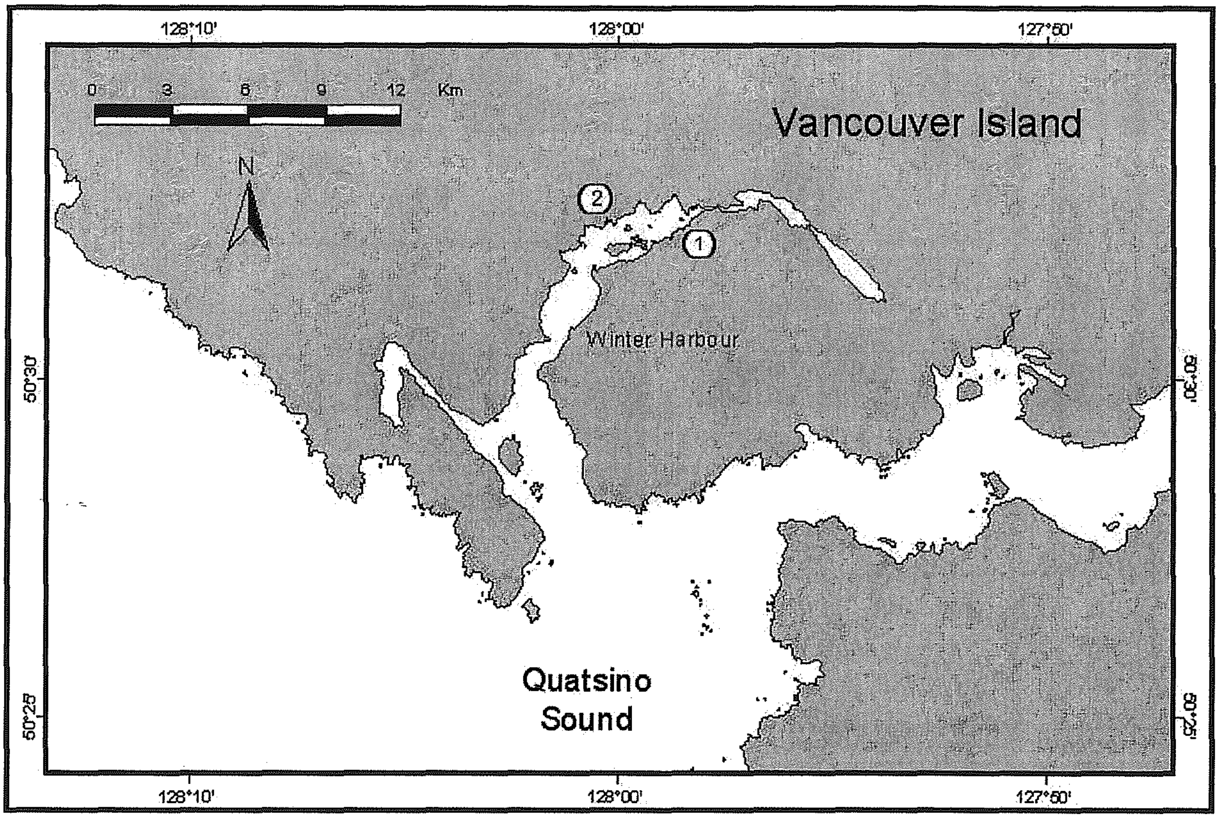


Figure 66. Locations of beaches surveyed in Winter Harbour, July 6, 2002.
Legend: 1 – Head of Winter Harbour; 2 – Denad Creek.

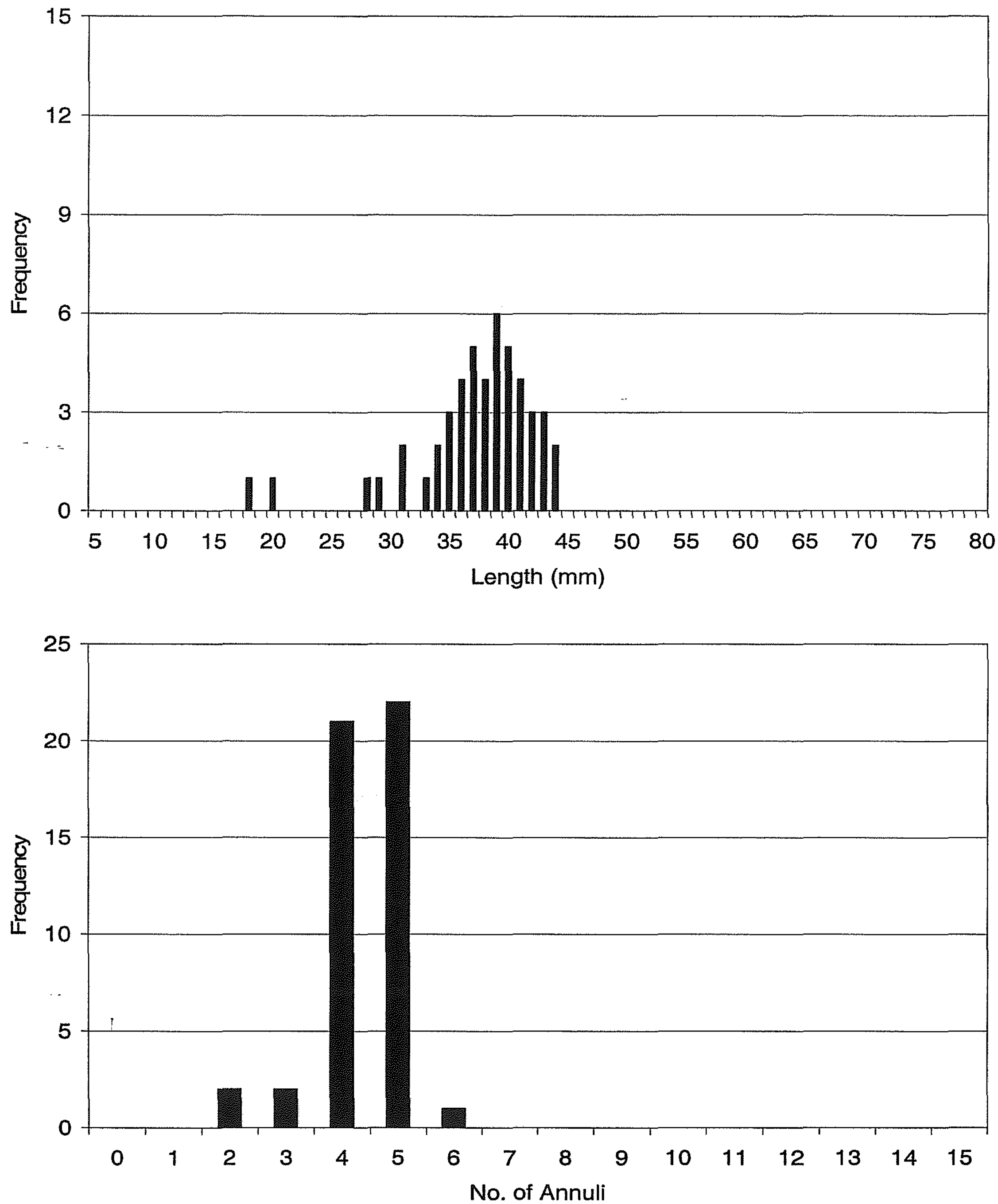


Figure 67. Length (top) and age (bottom) frequency distributions of Manila clams collected at the head of Winter Harbour, July 6, 2002.

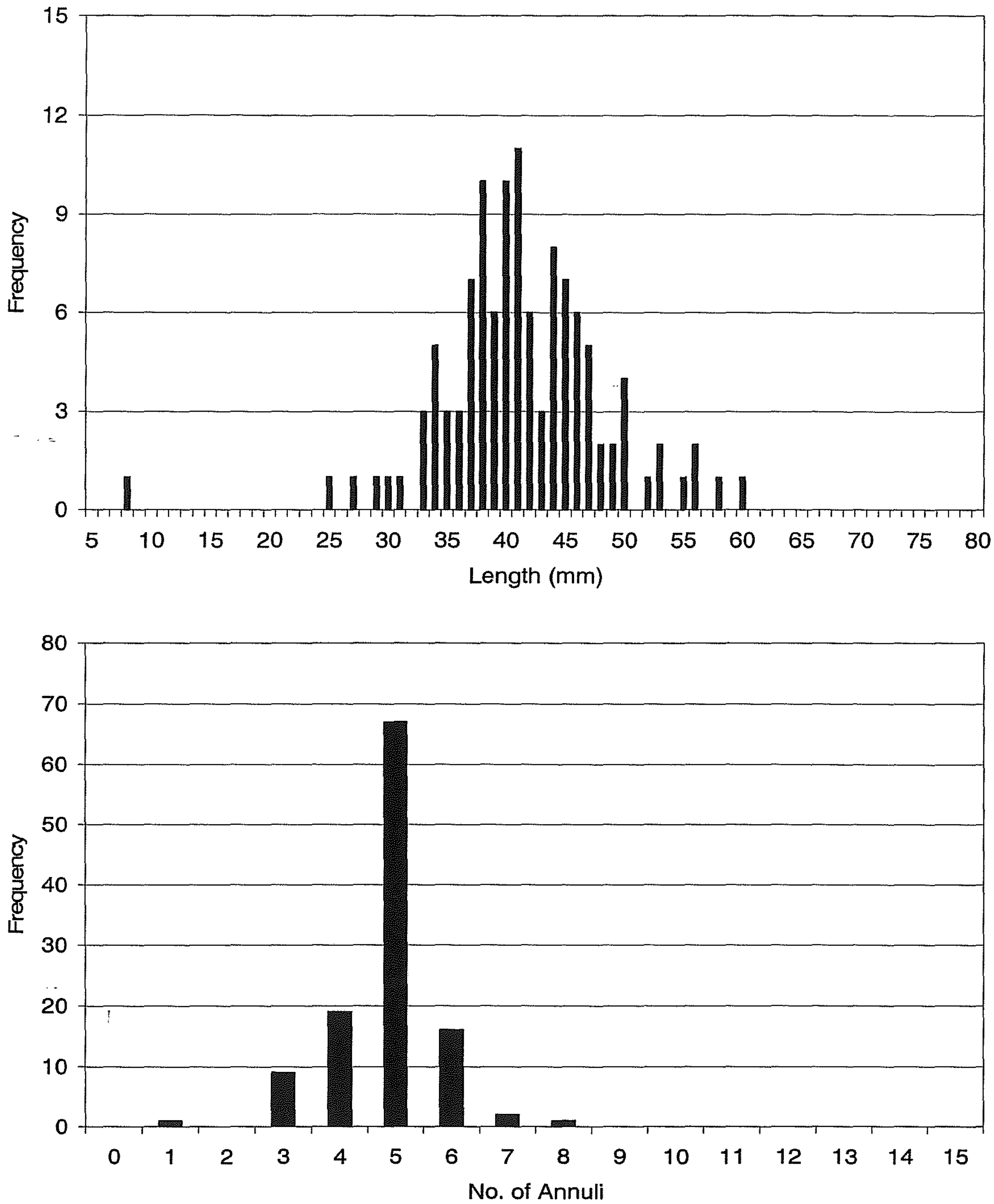
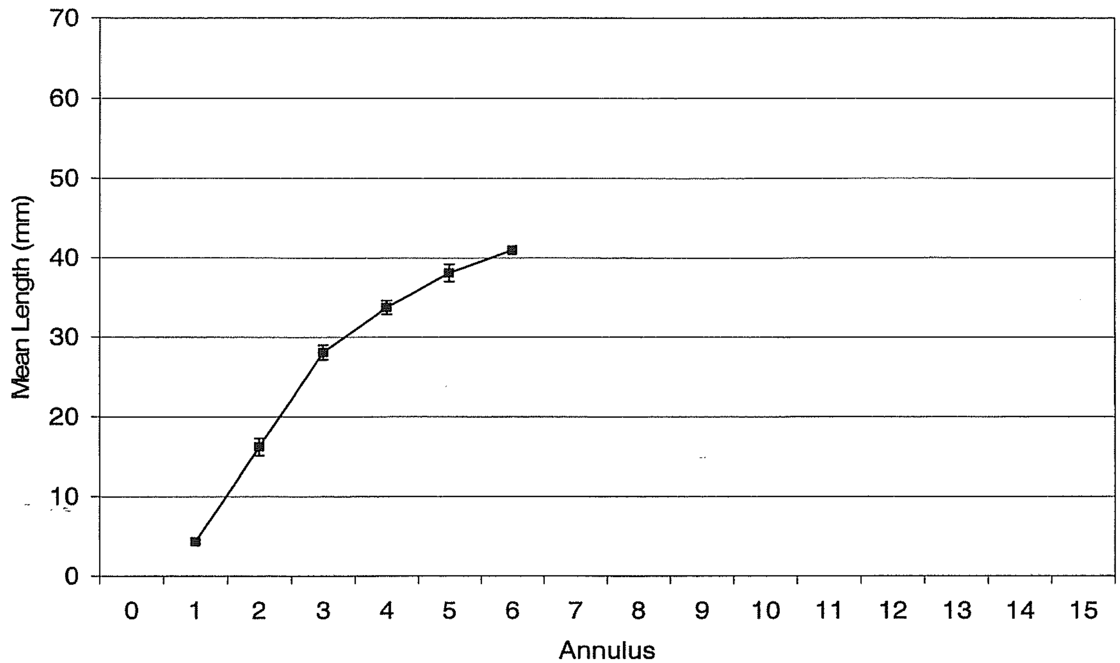


Figure 68. Length (top) and age (bottom) frequency distributions of Manila clams collected at Denad Creek, Winter Harbour, July 6, 2002.



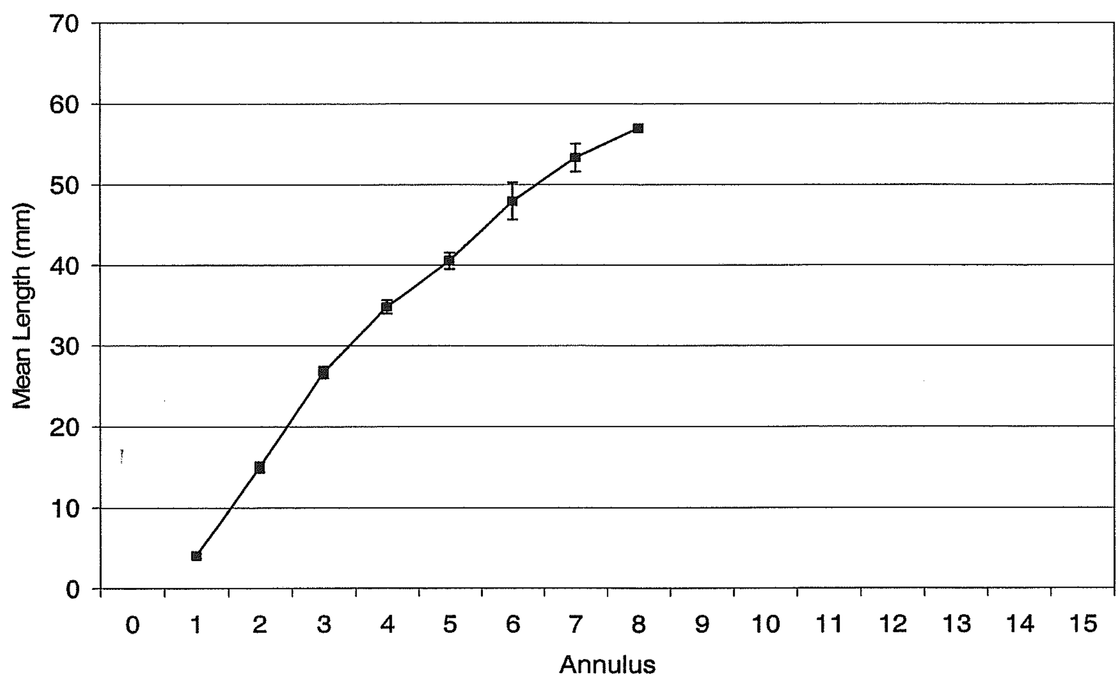
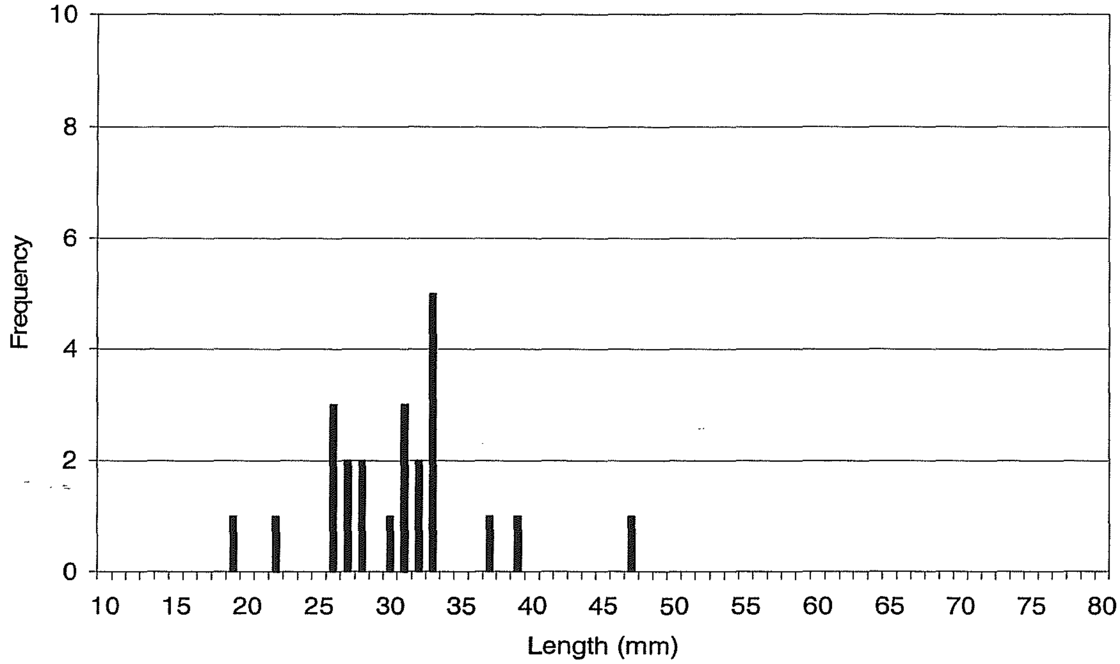


Figure 69. Mean length-at-annulus of Manila clams collected at the head of Winter Harbour (top) and Denad Creek (bottom), Winter Harbour, July 6, 2002.

Error bars represent 95% confidence intervals.



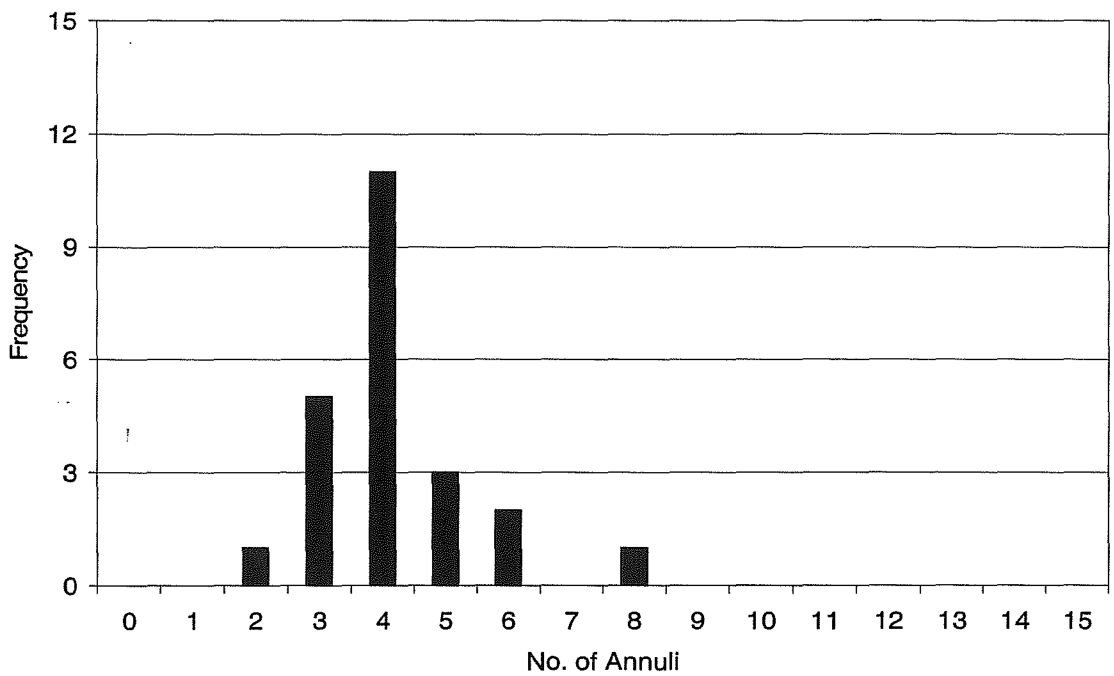


Figure 70. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the head of Winter Harbour, July 6, 2002.

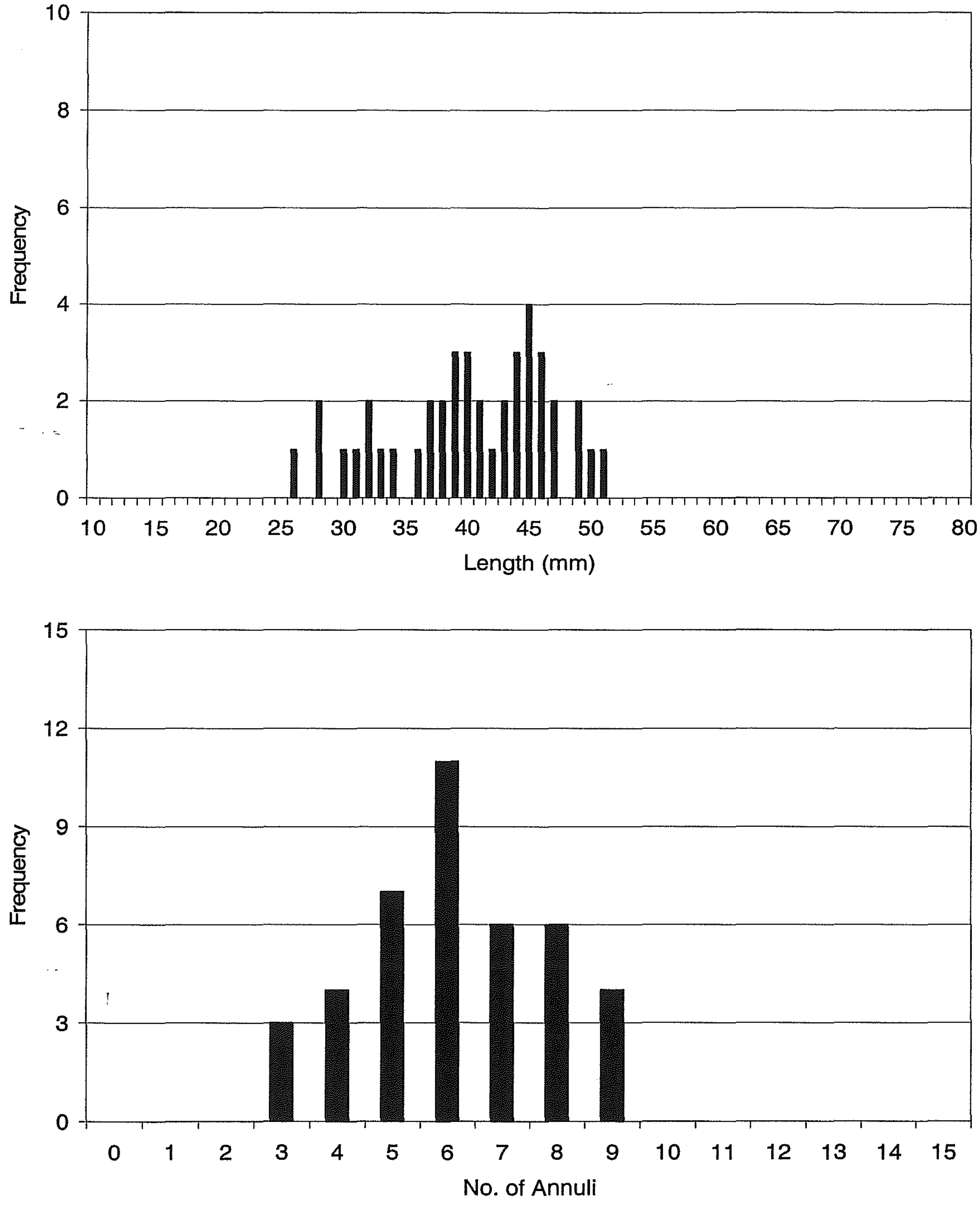


Figure 71. Length (top) and age (bottom) frequency distributions of littleneck clams collected at Denad Creek, Winter Harbour, July 6, 2002.

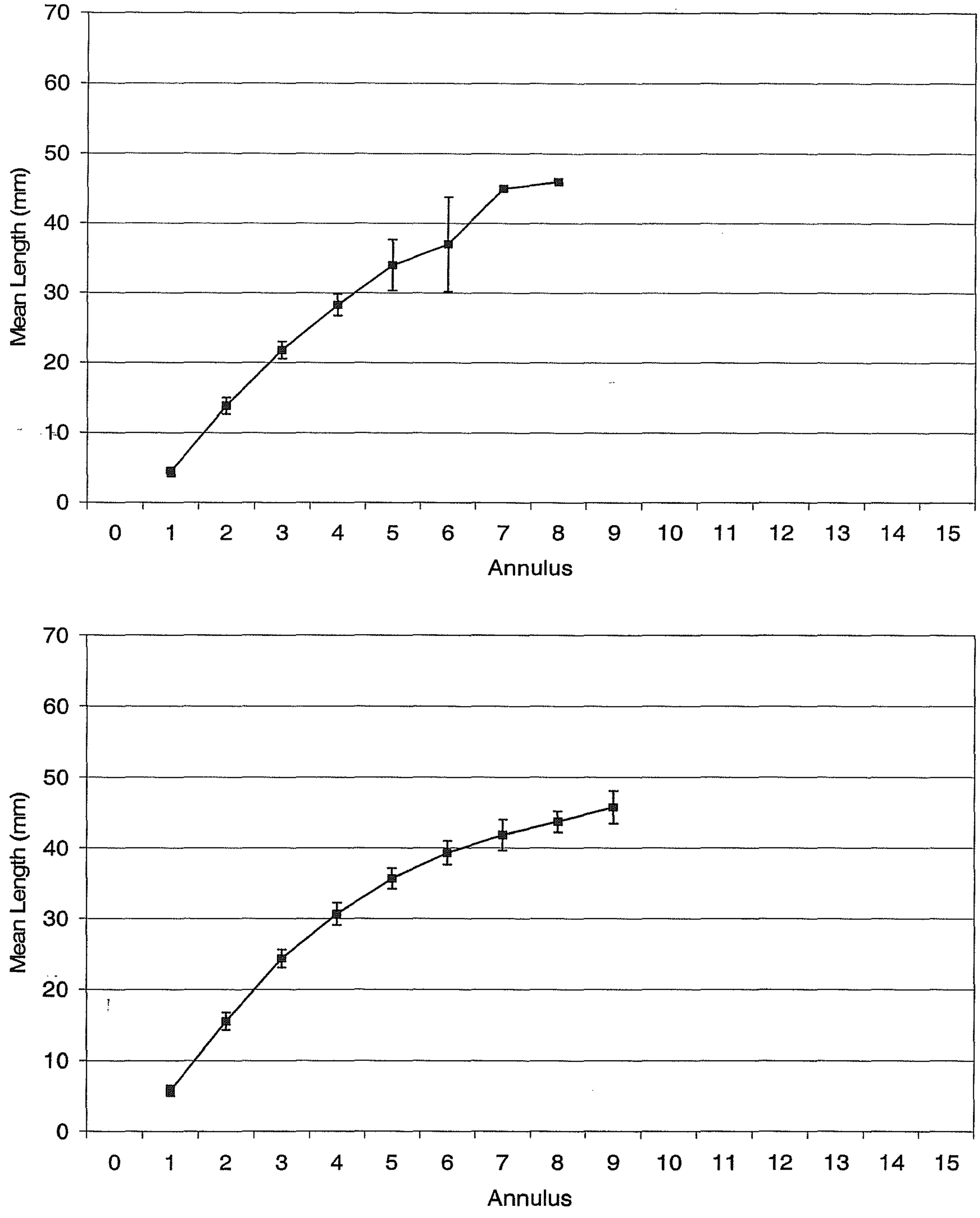


Figure 72. Mean length-at-annulus of littleneck clams collected at the head of the harbour (top) and Denad Creek (bottom), Winter Harbour, July 6, 2002.

Error bars represent 95% confidence intervals.

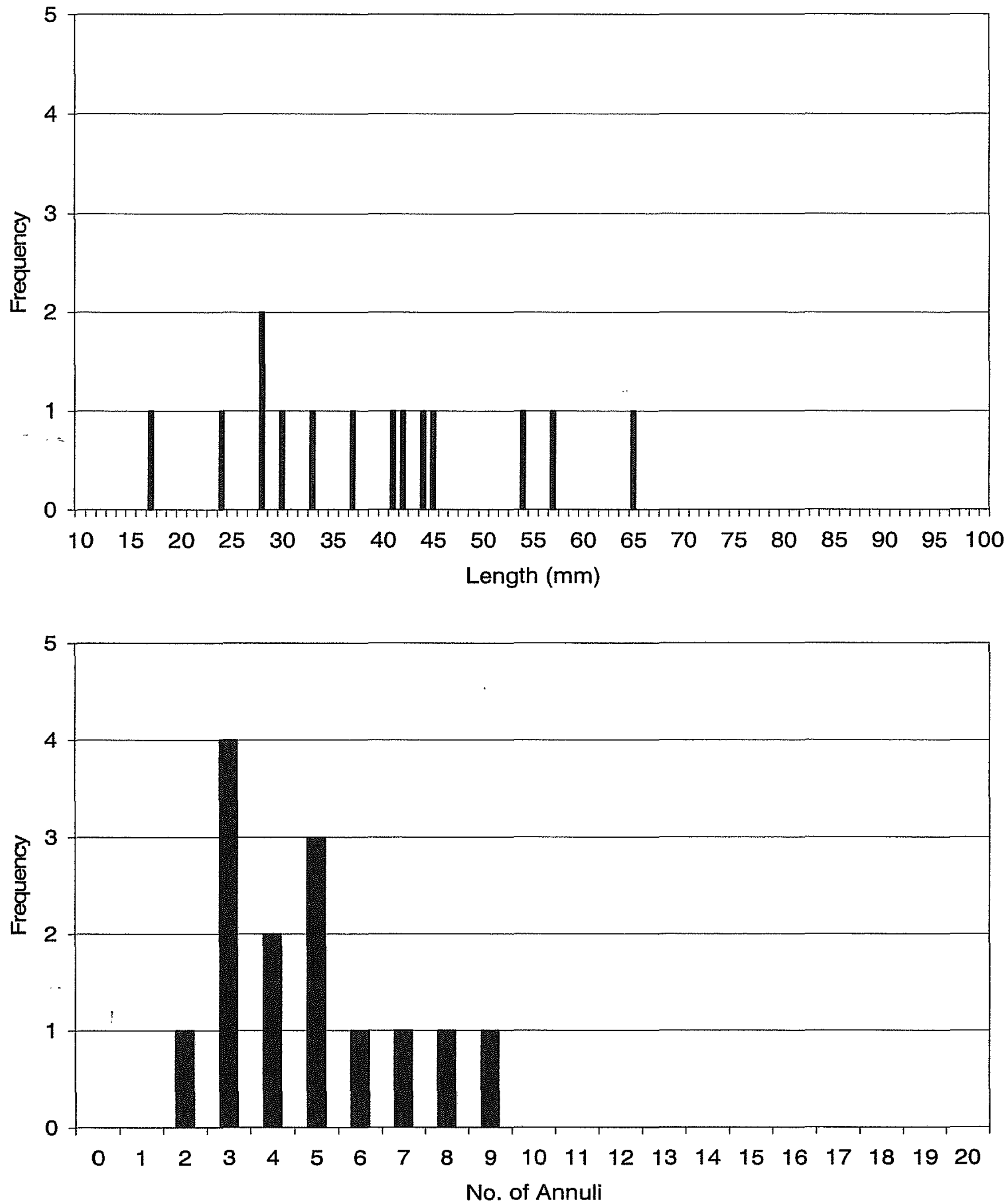


Figure 73. Length (top) and age (bottom) frequency distributions of butter clams collected at the head of Winter Harbour, July 6, 2002.

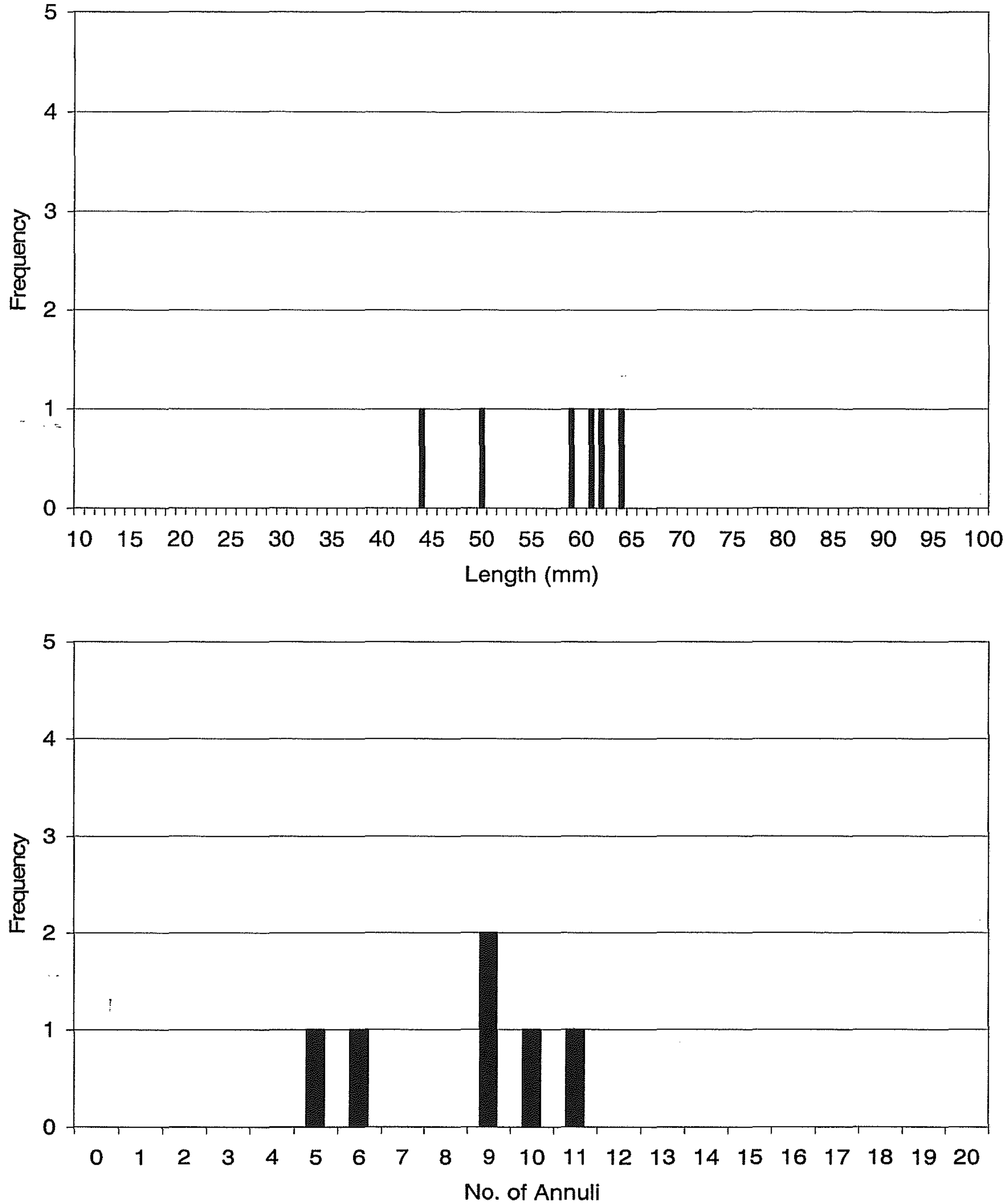


Figure 74. Length (top) and age (bottom) frequency distributions of butter clams collected at Denad Creek, Winter Harbour, July 6, 2002.

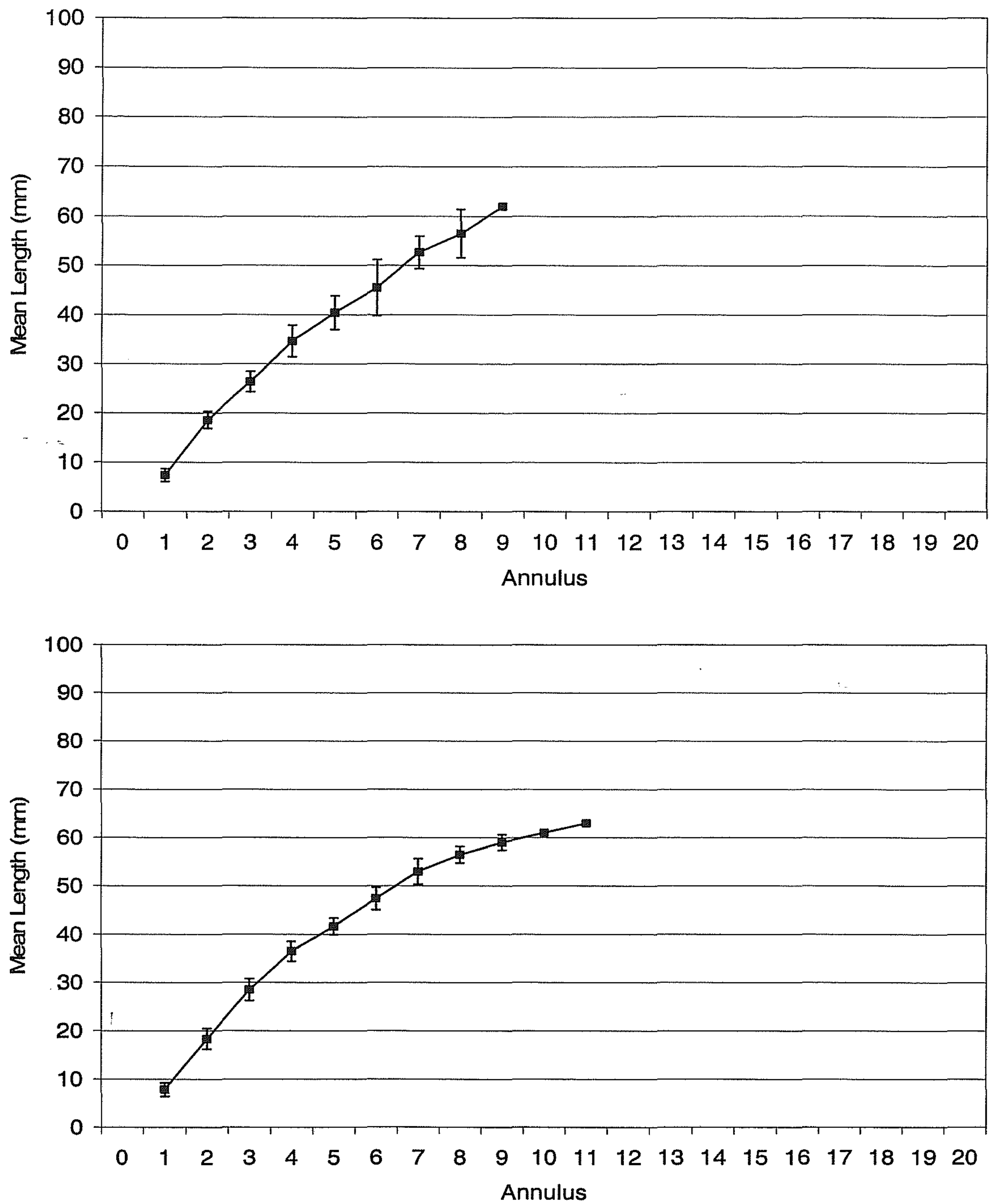


Figure 75. Mean length-at-annulus of butter clams collected at the head of the harbour (top) and Denad Creek (bottom), Winter Harbour, July 6, 2002.

Error bars represent 95% confidence intervals.

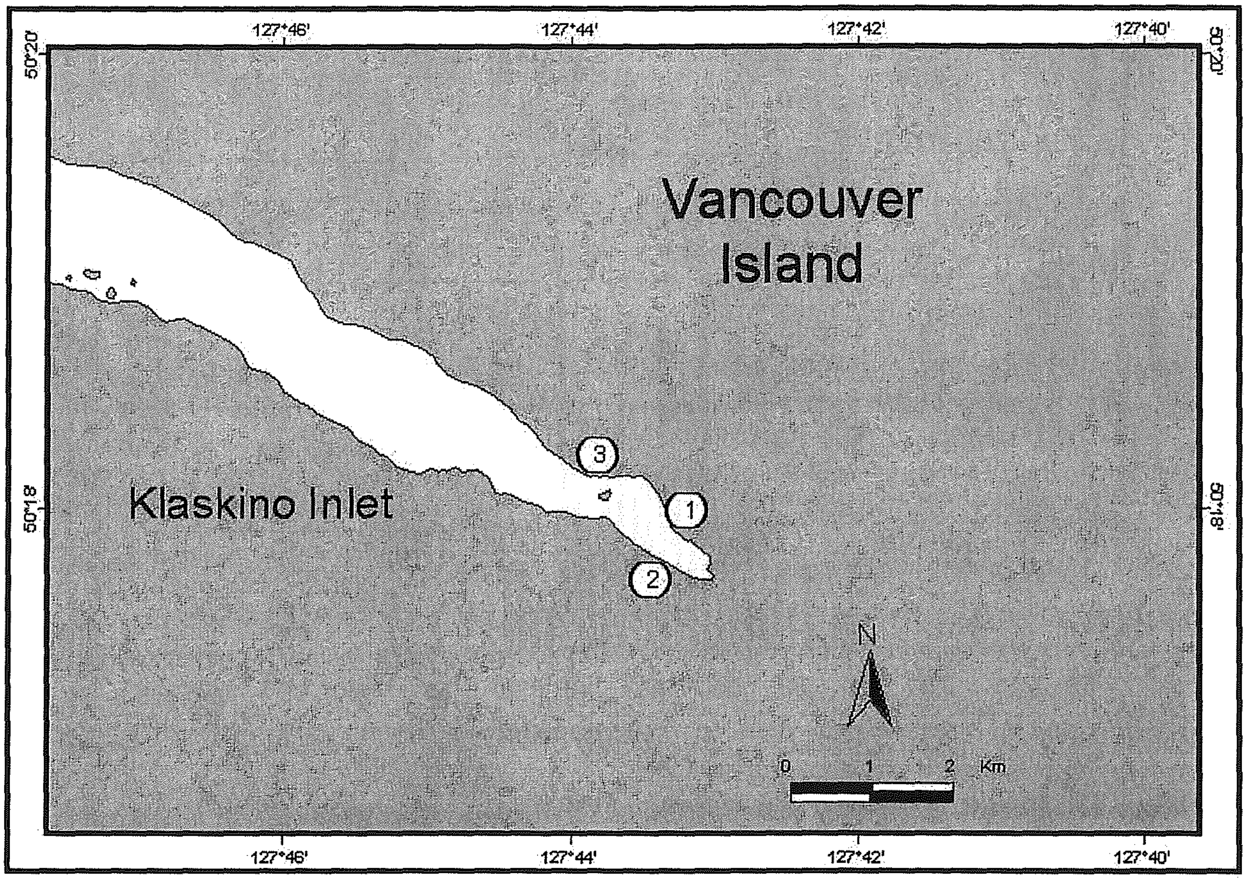


Figure 76. Locations of beaches surveyed in Klaskino Inlet, July 7, 2002.
Legend: 1 – Northeast Klaskino; 2 – Southeast Klaskino; 3 – Northwest Klaskino

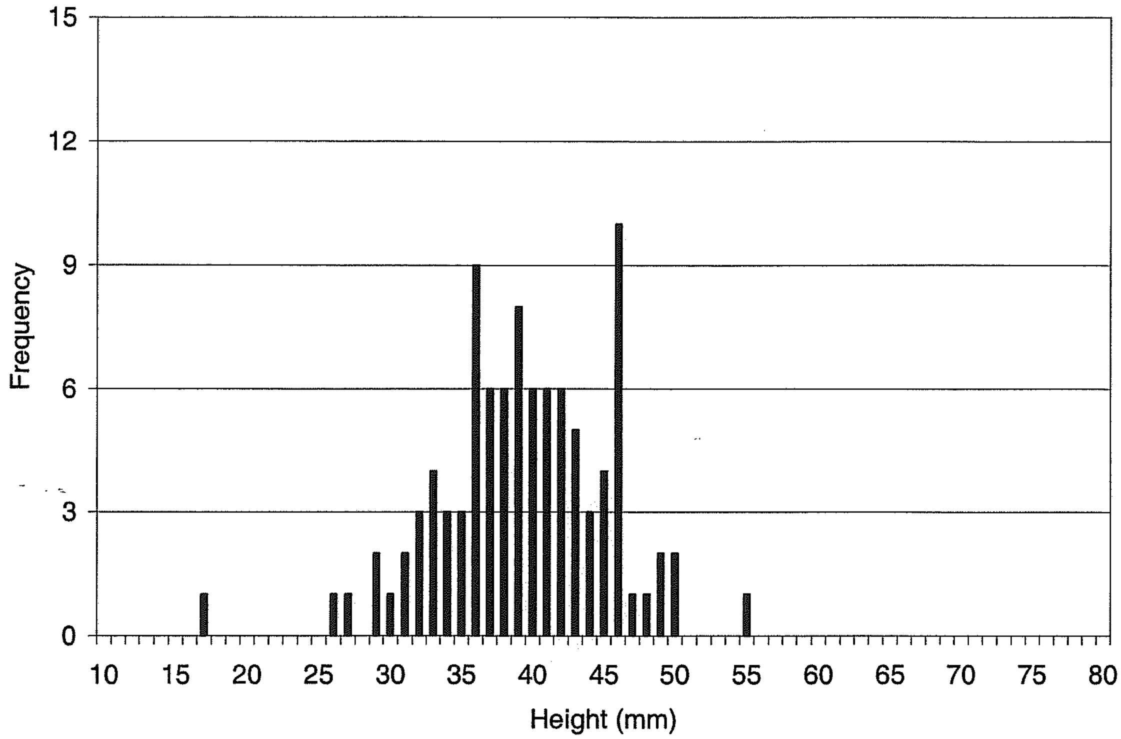
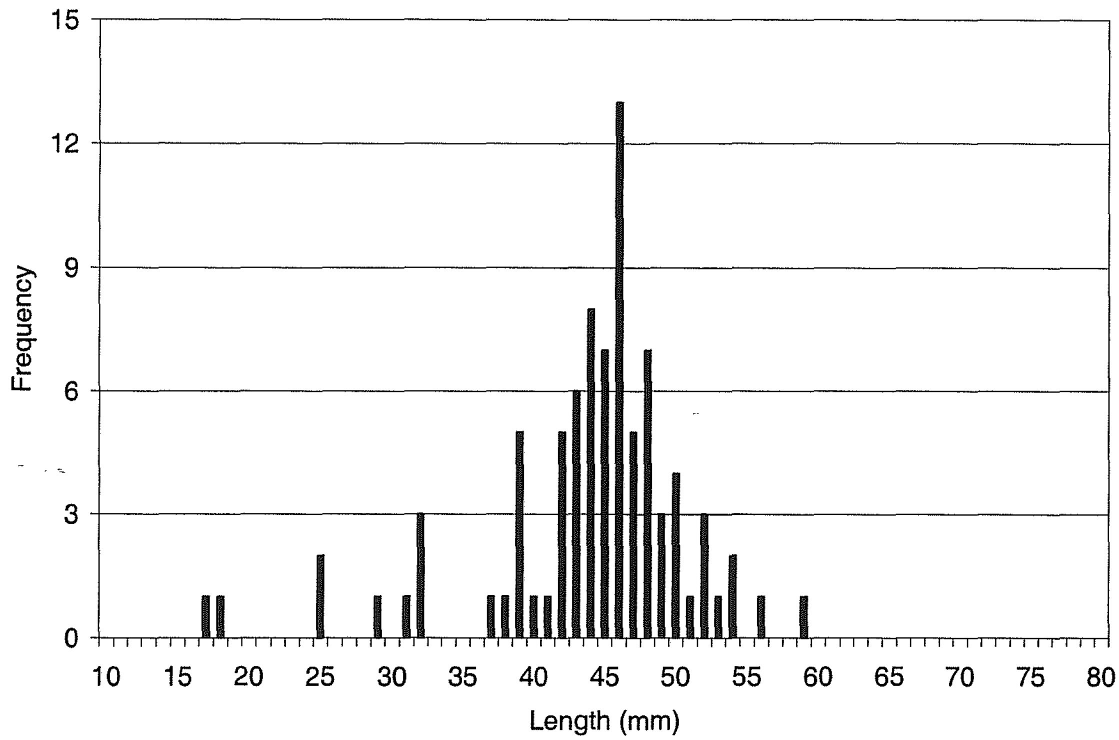


Figure 77. Height frequency distribution of Olympia oysters collected in Klaskino Inlet, July 7, 2002.



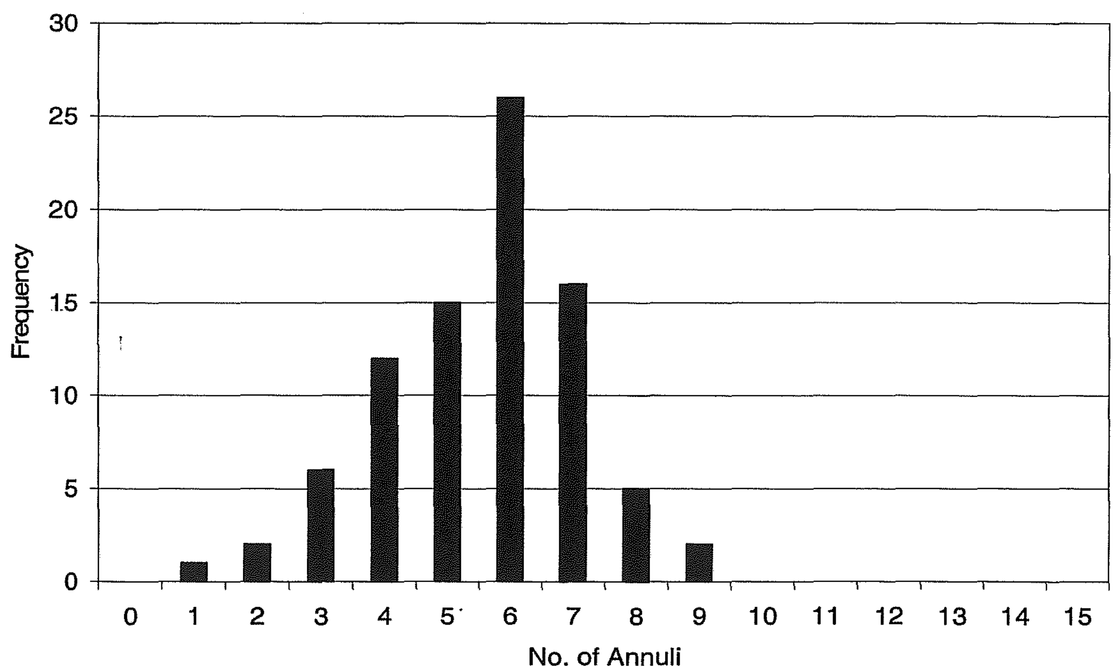


Figure 78. Length (top) and age (bottom) frequency distributions of Manila clams collected in Klaskino Inlet, July 7, 2002.

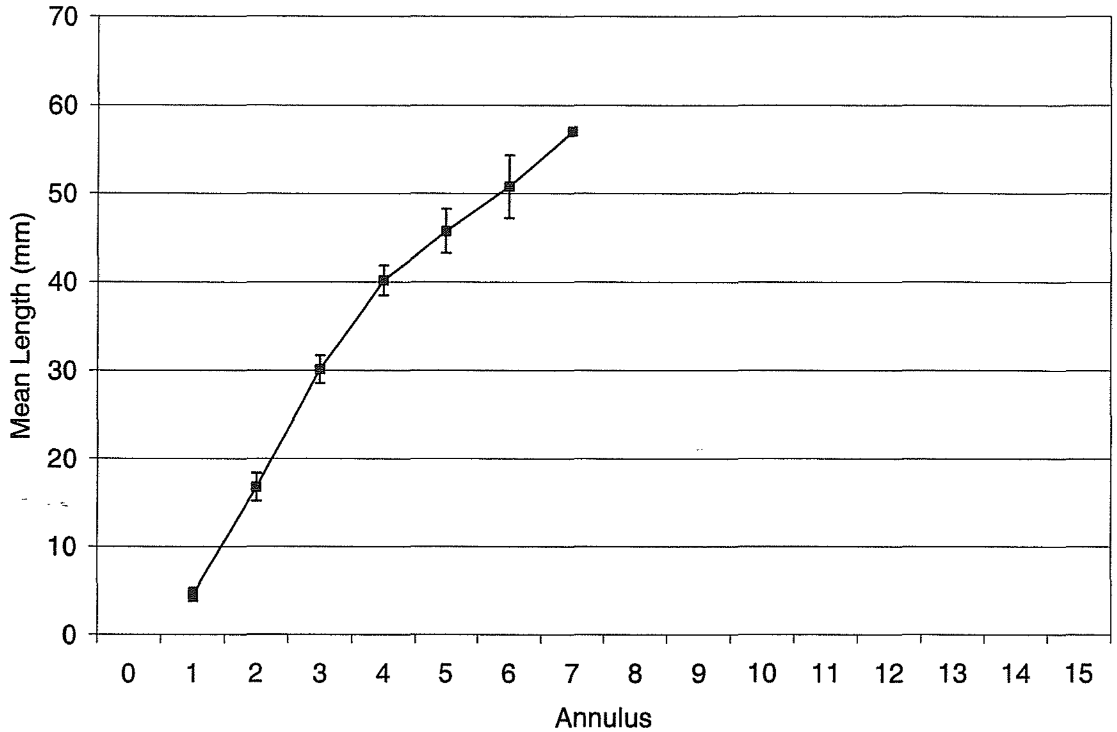
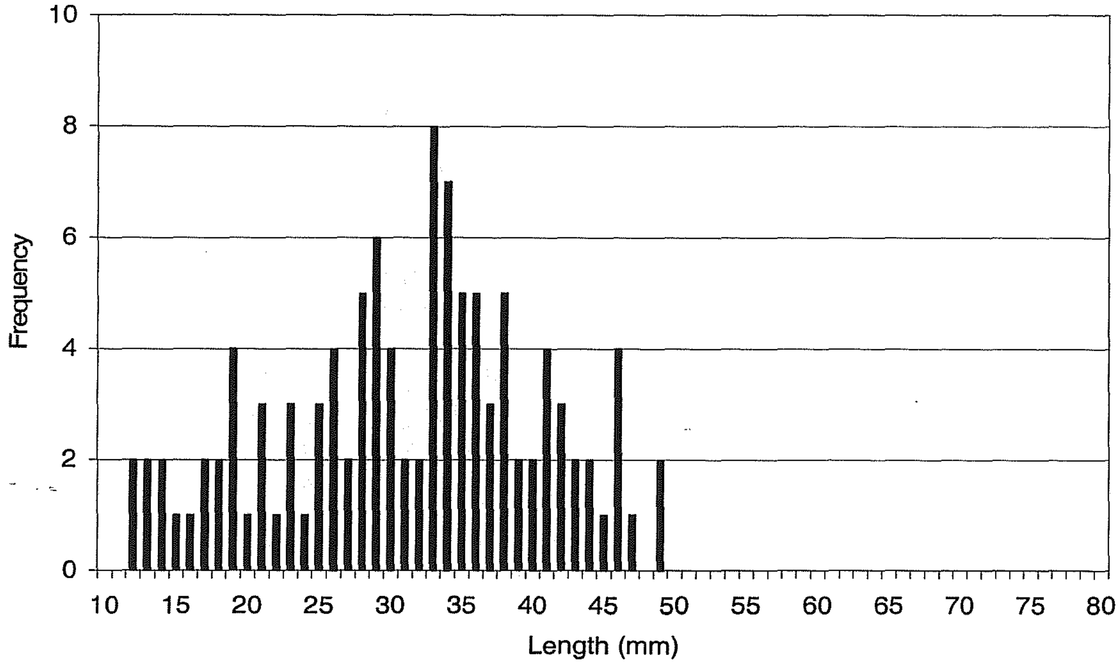


Figure 79. Mean length-at-annulus of Manila clams collected in Klaskino Inlet, July 7, 2002.

Error bars represent 95% confidence intervals.



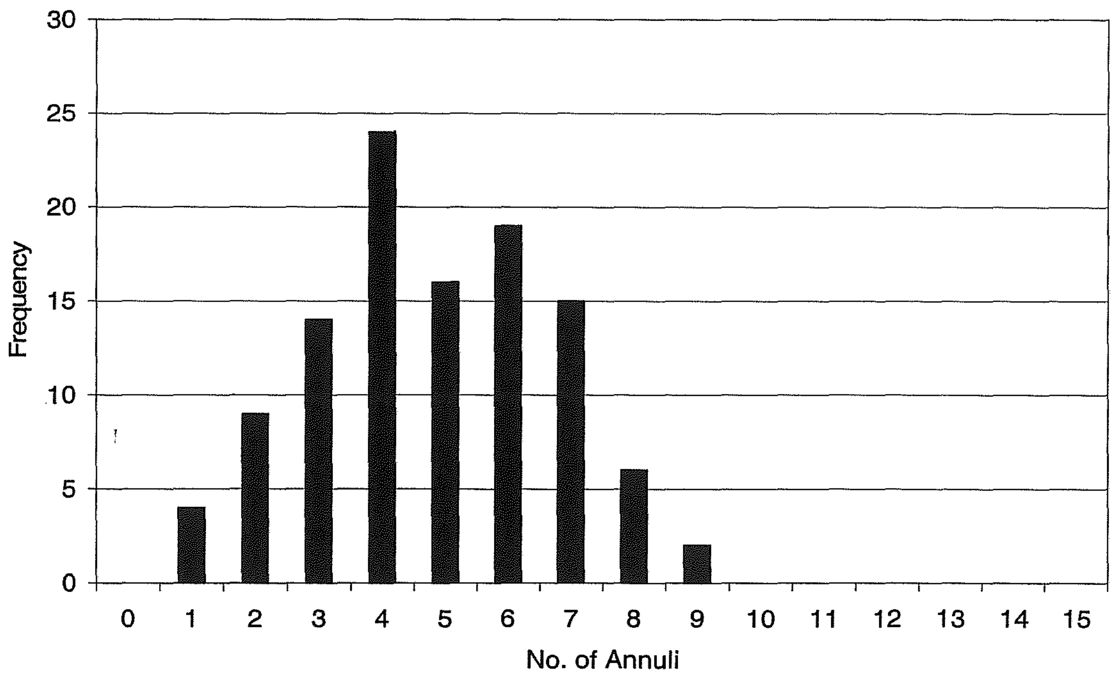


Figure 80. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Klaskino Inlet, July 7, 2002.

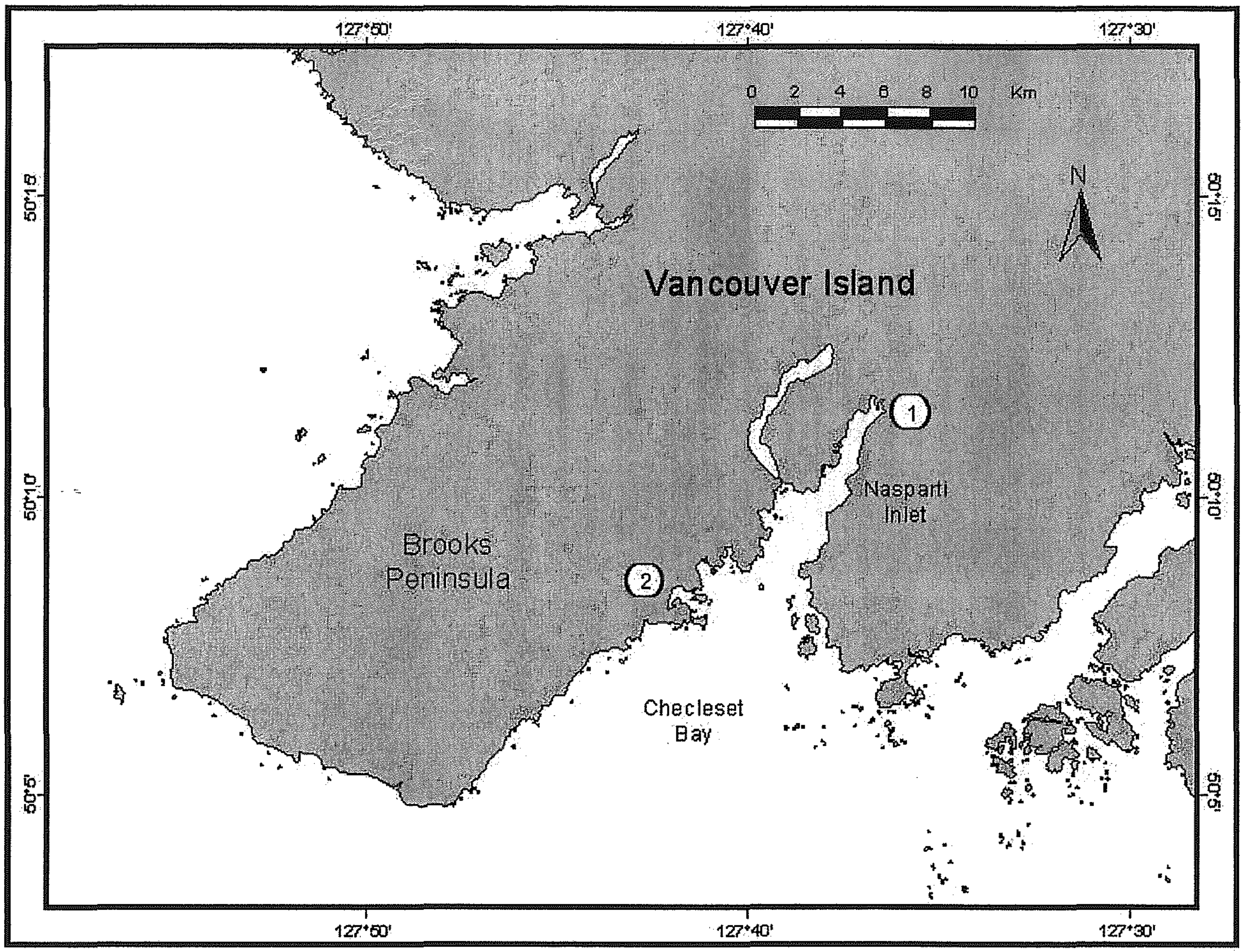


Figure 81. Locations of beaches surveyed in Nasparti Inlet, July 8, 2002.

Legend: 1 – Head of Nasparti Inlet; 2 – Jackobsen Point.

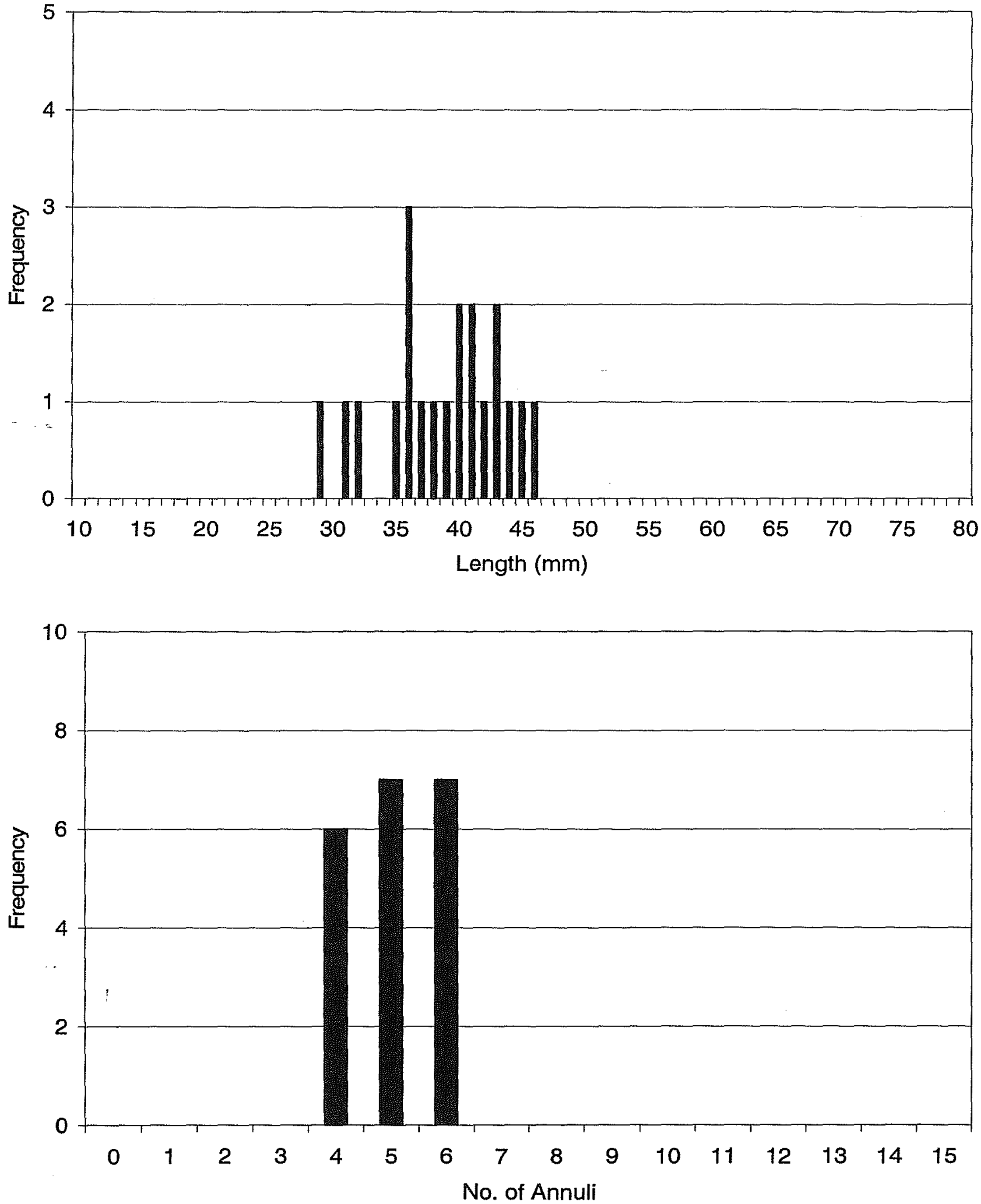
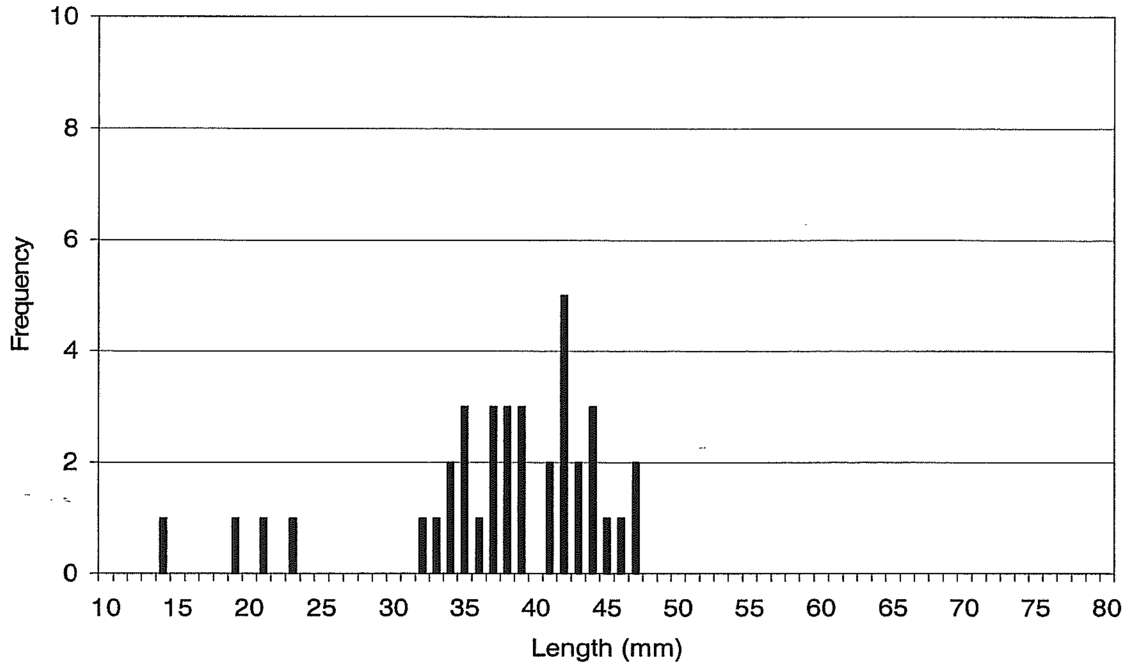


Figure 82. Length (top) and age (bottom) frequency distributions of Manila clams collected at the head of Nasparti Inlet, July 8, 2002.



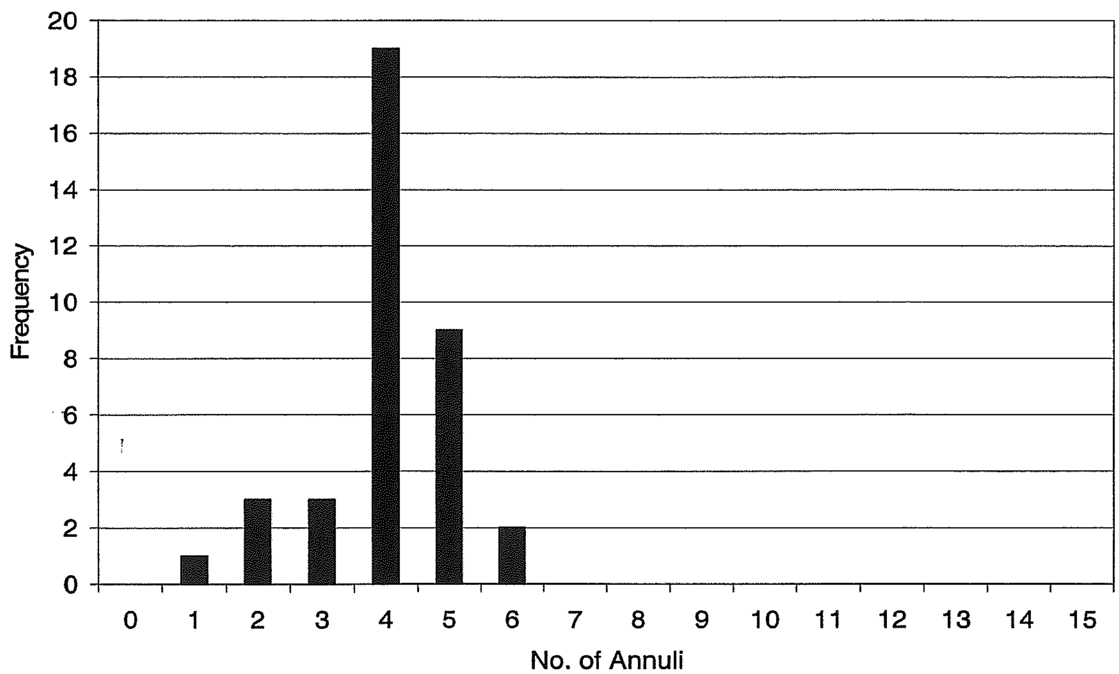
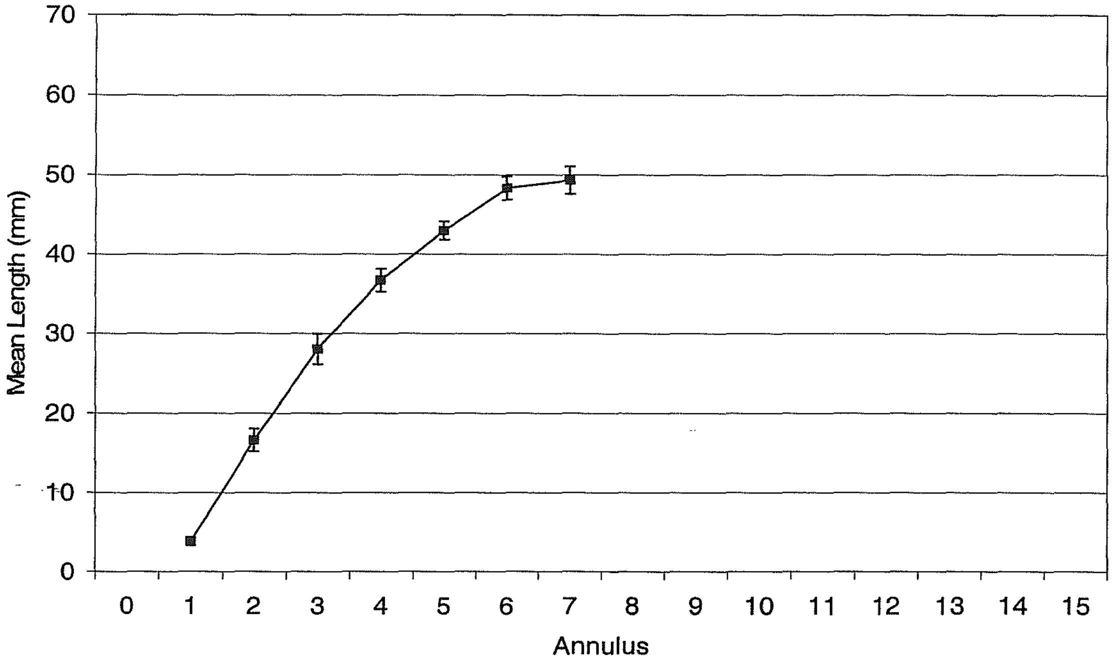


Figure 83. Length (top) and age (bottom) frequency distributions of Manila clams collected at Jackobson Point, Nasparti Inlet, July 8, 2002.



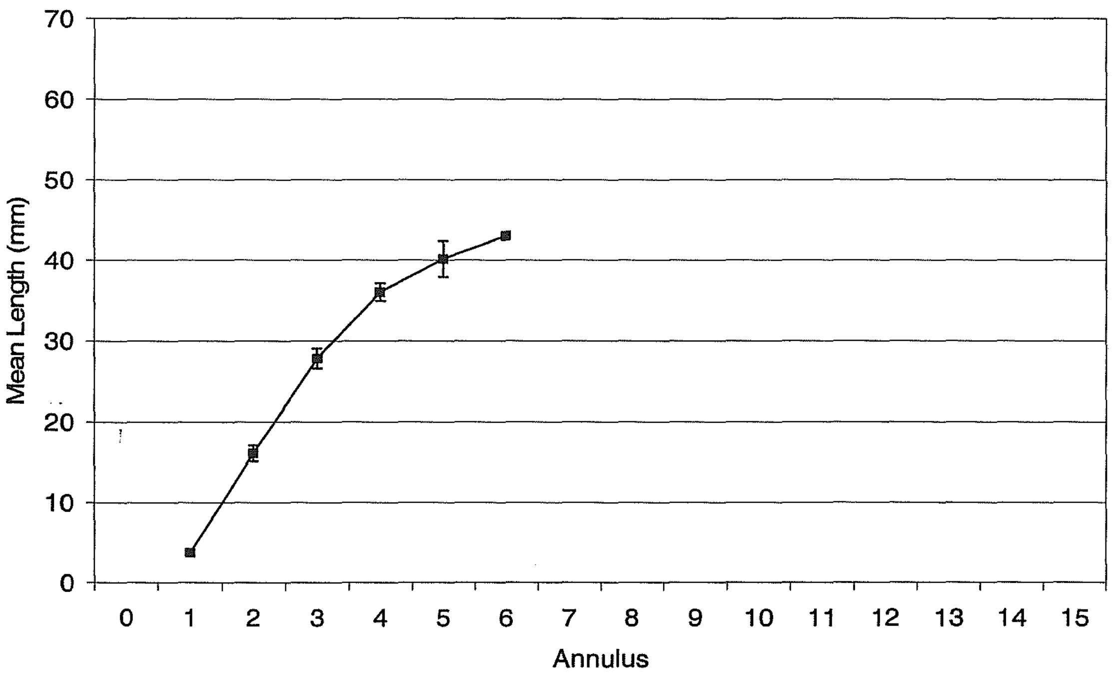


Figure 84. Mean length-at-annulus of Manila clams collected at the head of Nasparti Inlet (top) and at Jackobson Point (bottom), Nasparti Inlet, July 8, 2002.

Error bars represent 95% confidence intervals.

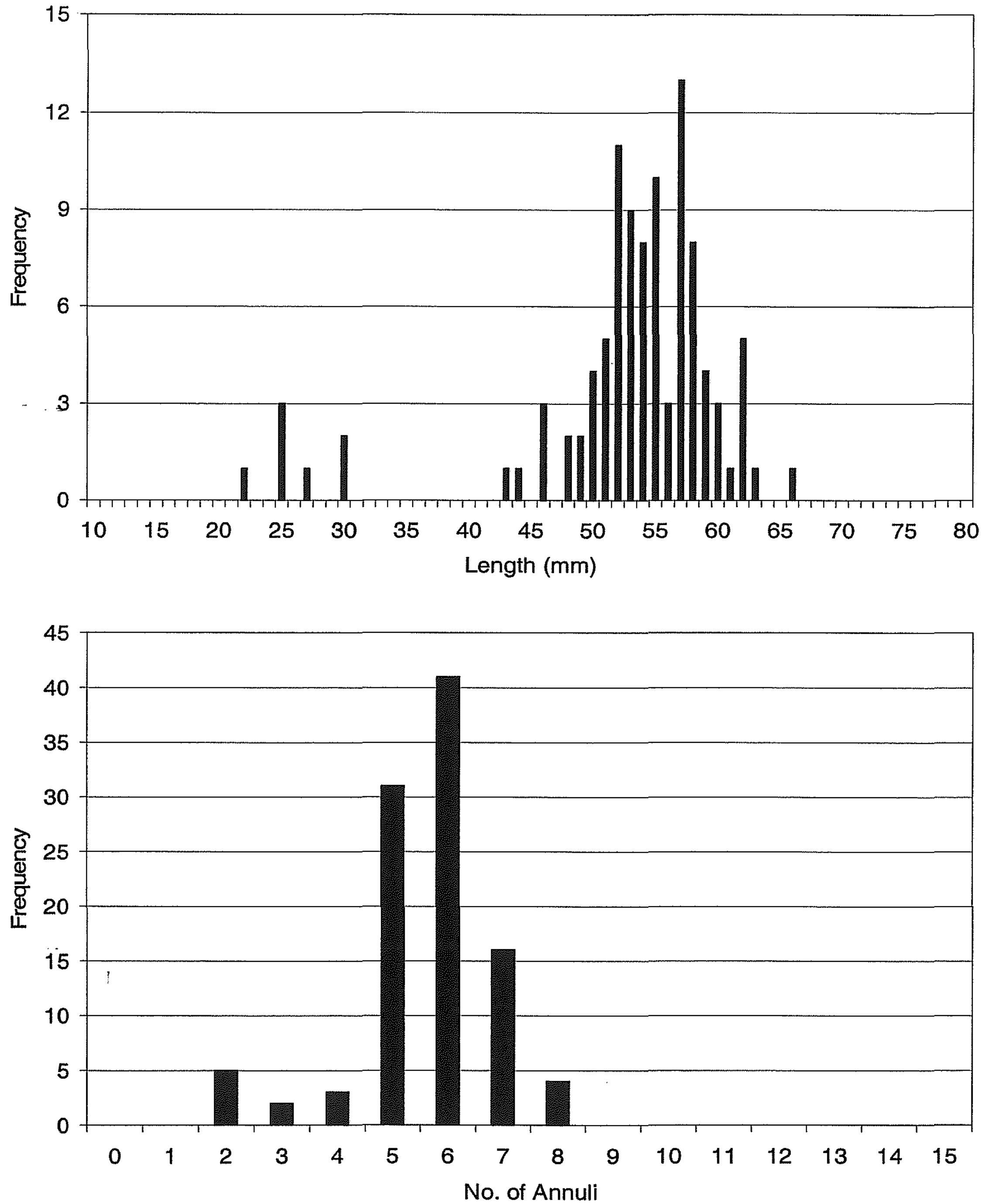


Figure 85. Length (top) and age (bottom) frequency distributions of varnish clams collected at Jackobson Point, Nasparti Inlet, July 8, 2002.

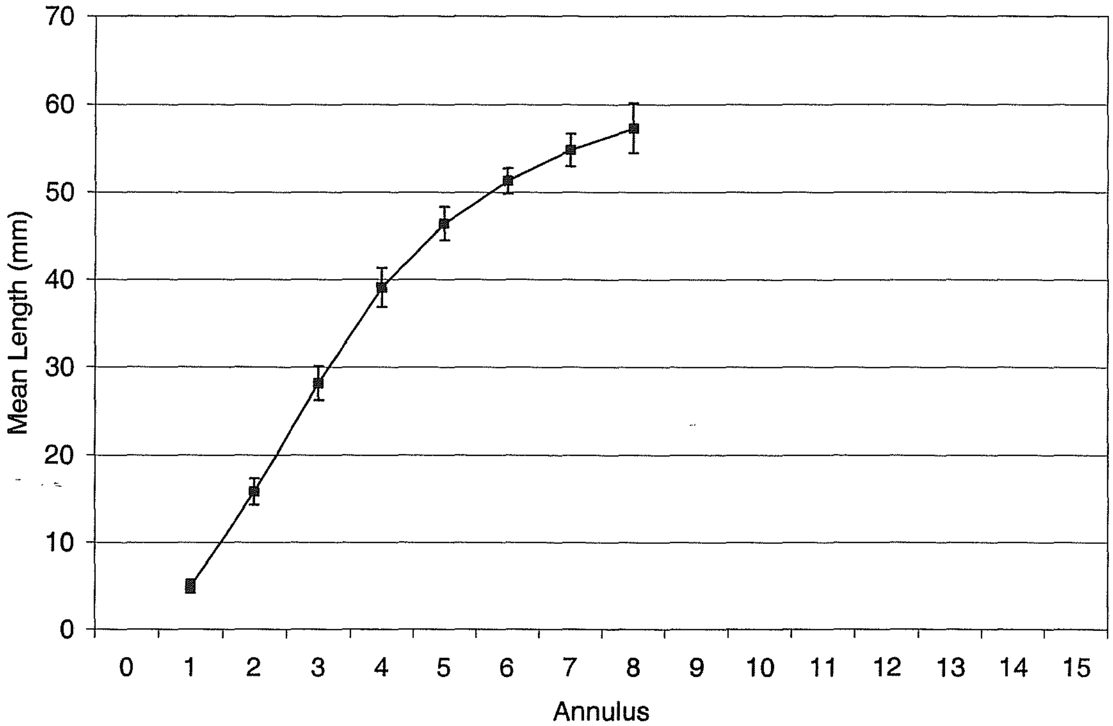


Figure 86. Mean length-at-annulus of varnish clams collected at Jackobson Point, Nasparti Inlet, July 8, 2002.

Error bars represent 95% confidence intervals.

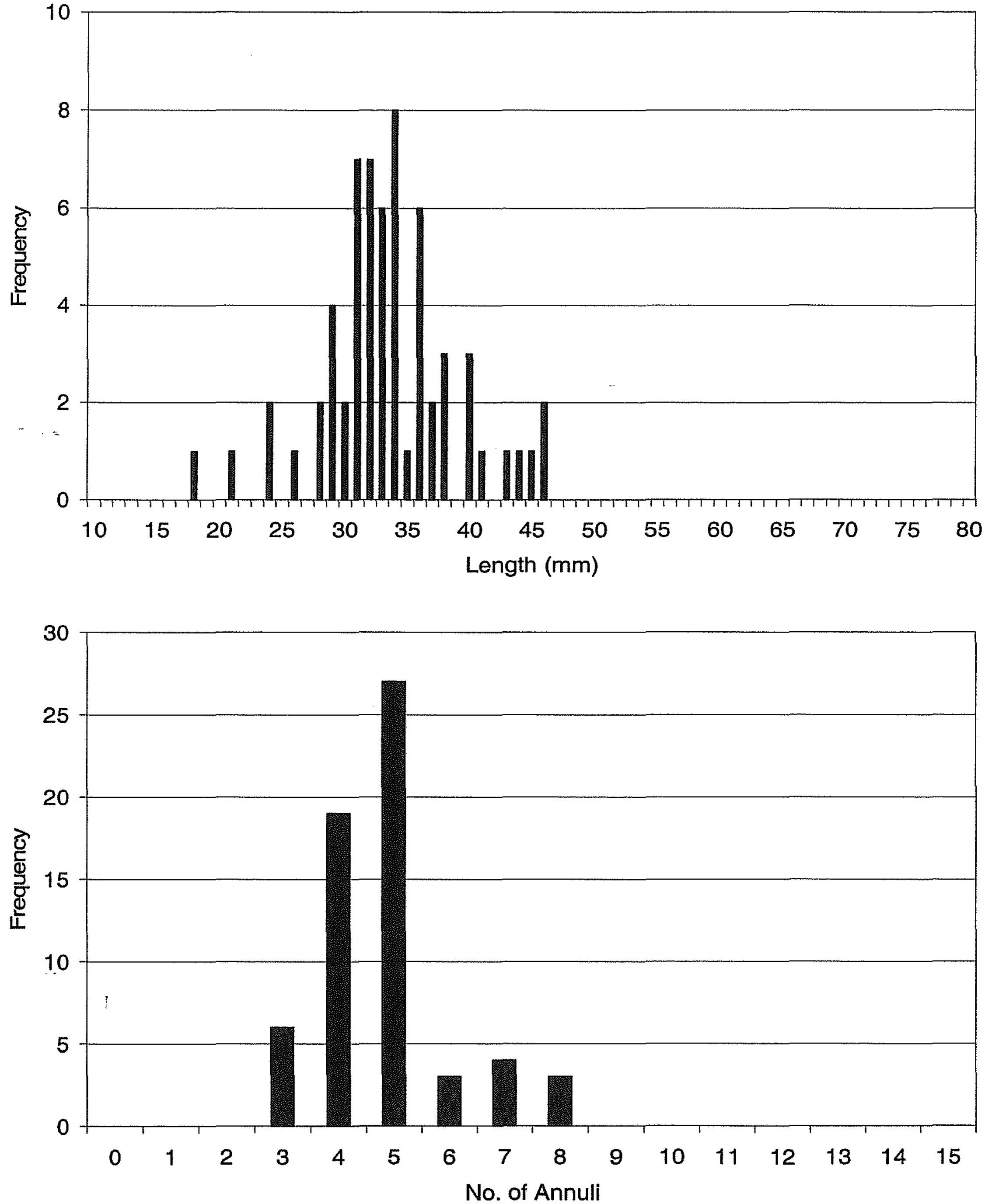


Figure 87. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the head of Nasparti Inlet, July 8, 2002.

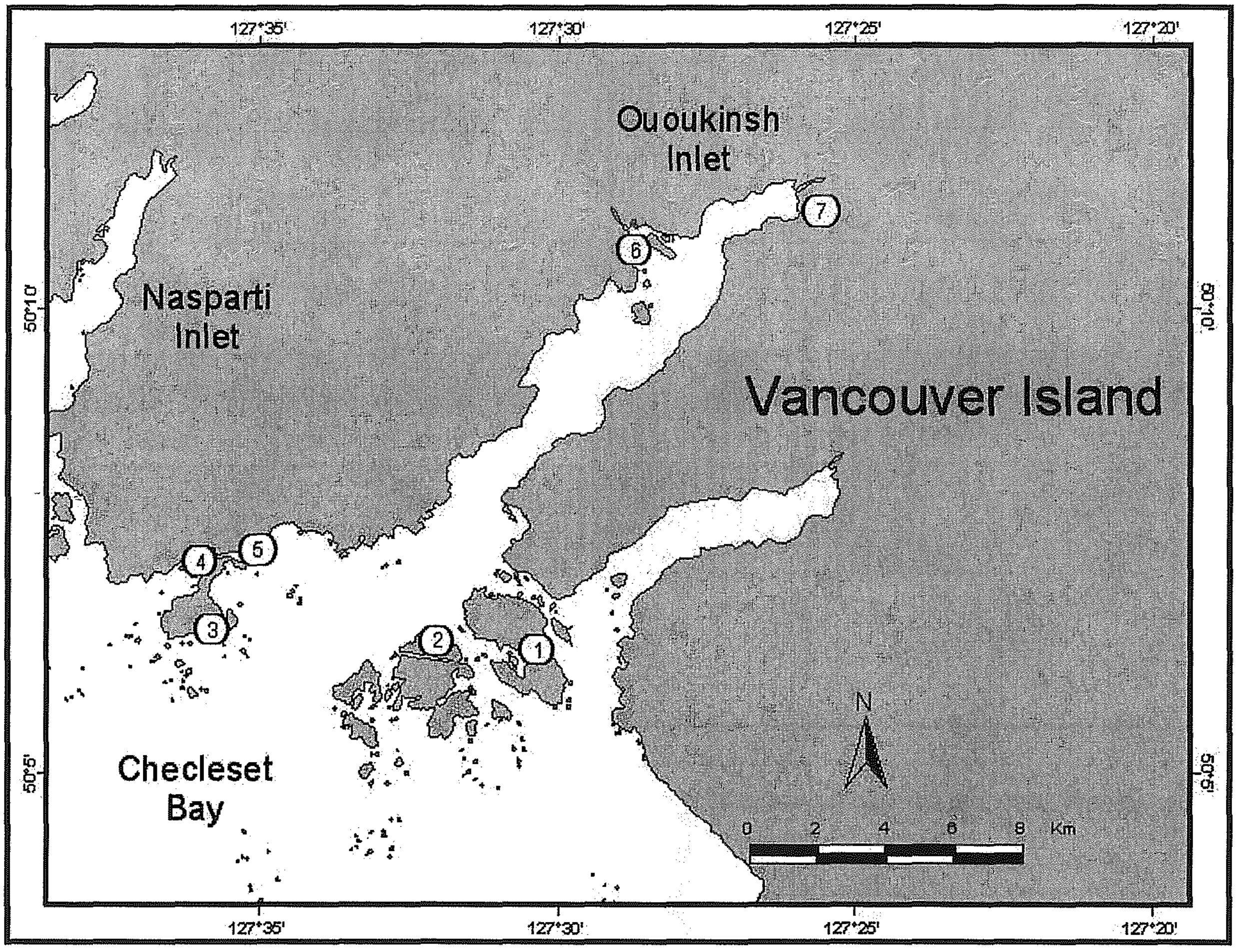
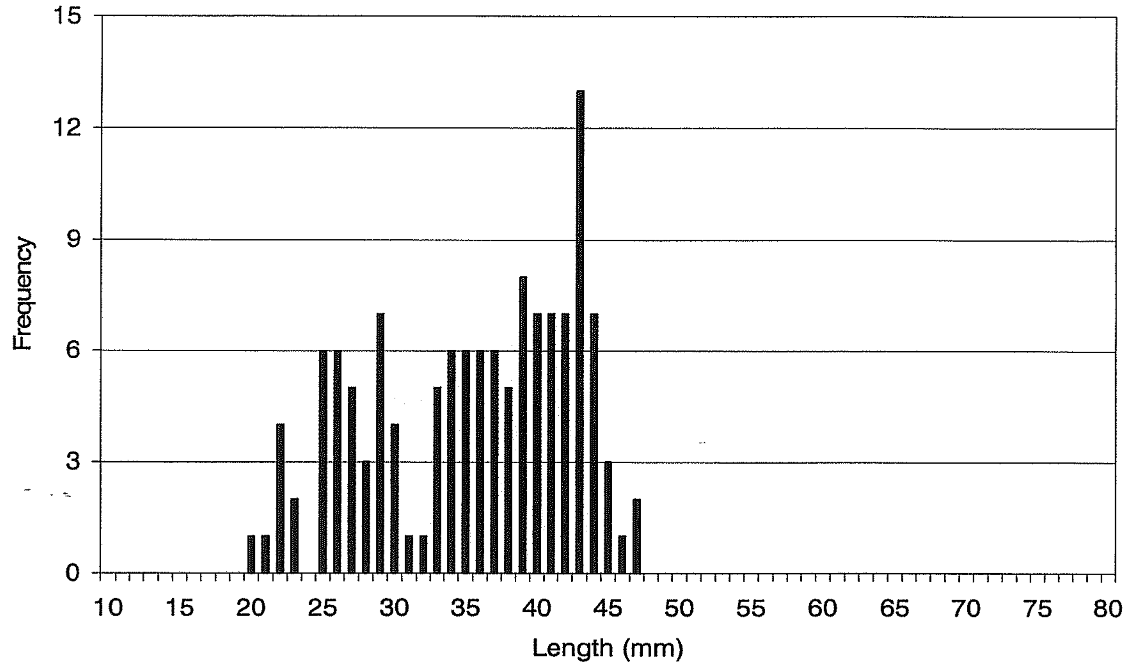


Figure 88. Locations of beaches surveyed in Ououkinsh Inlet, July 9, 2002.

Legend: 1 – Gay Passage 1; 2 – Gay Passage 2; 3 – Acous Peninsula 1; 4 – Acous Peninsula 2; 5 – Battle Bay; 6 – Power River estuary; 7 – Head of Ououkinsh Inlet.



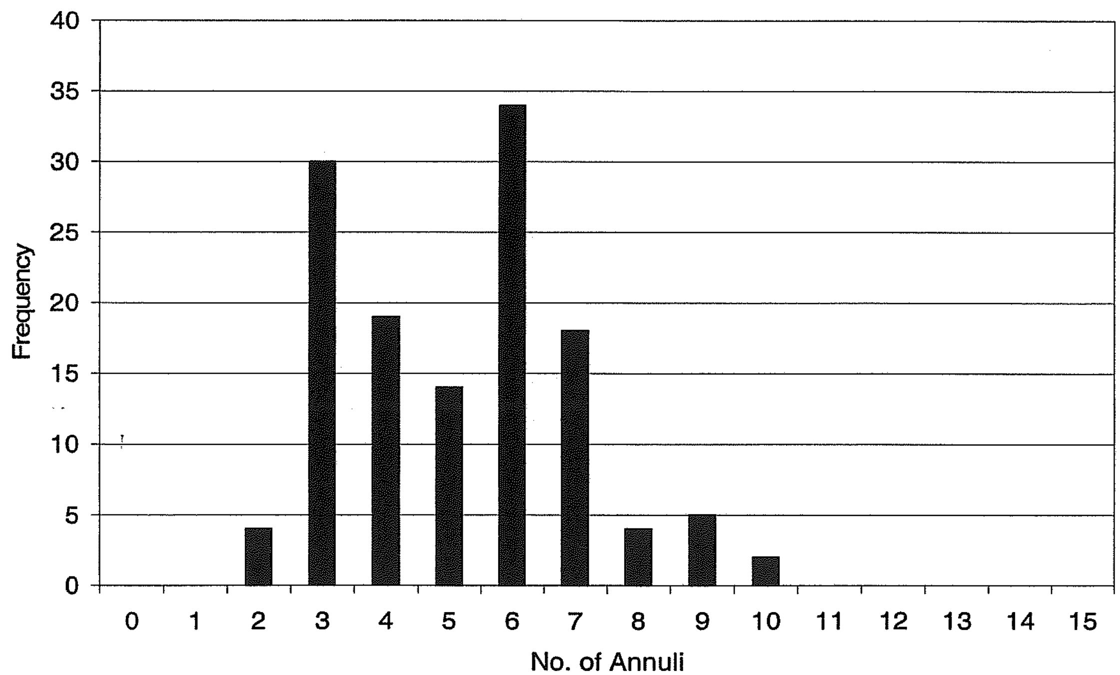


Figure 89. Length (top) and age (bottom) frequency distributions of Manila clams collected at the Power River estuary, Ououkinsh Inlet, July 9, 2002.

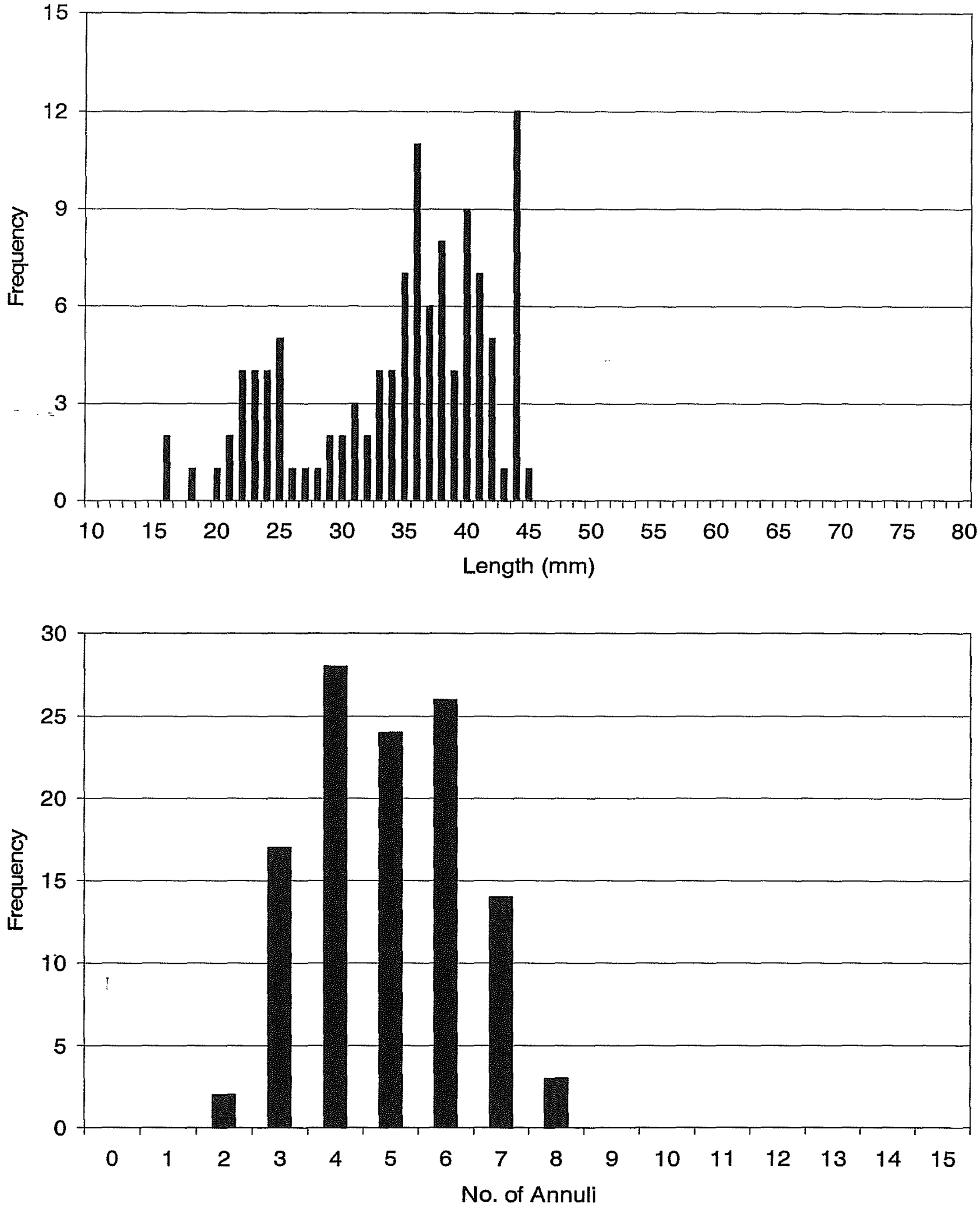


Figure 90. Length (top) and age (bottom) frequency distributions of Manila clams collected at the head of Ououkinsh Inlet, July 9, 2002.

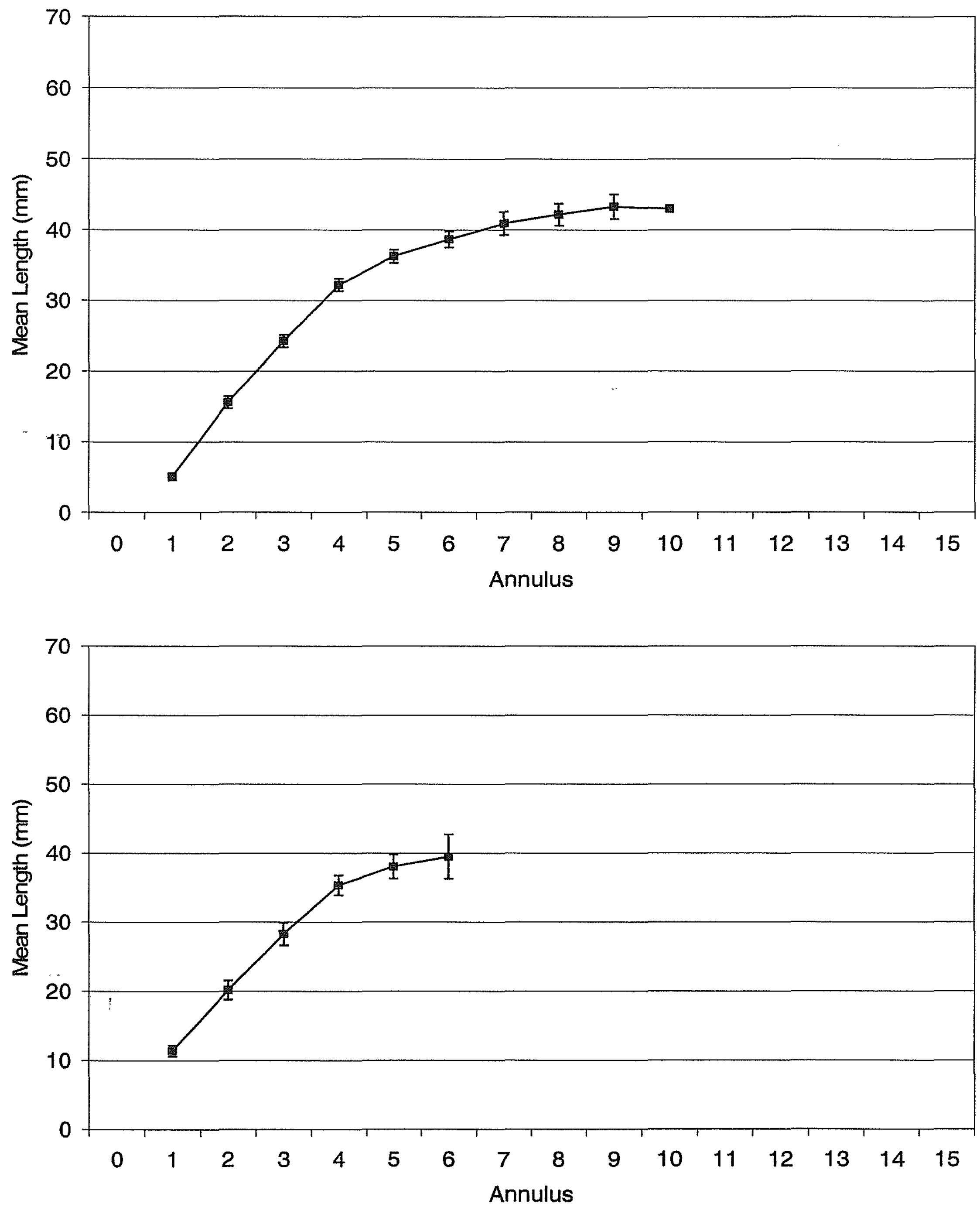


Figure 91. Mean length-at-annulus of Manila clams collected at the Power River estuary (top) and the head of Ououkinsh Inlet (bottom), Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

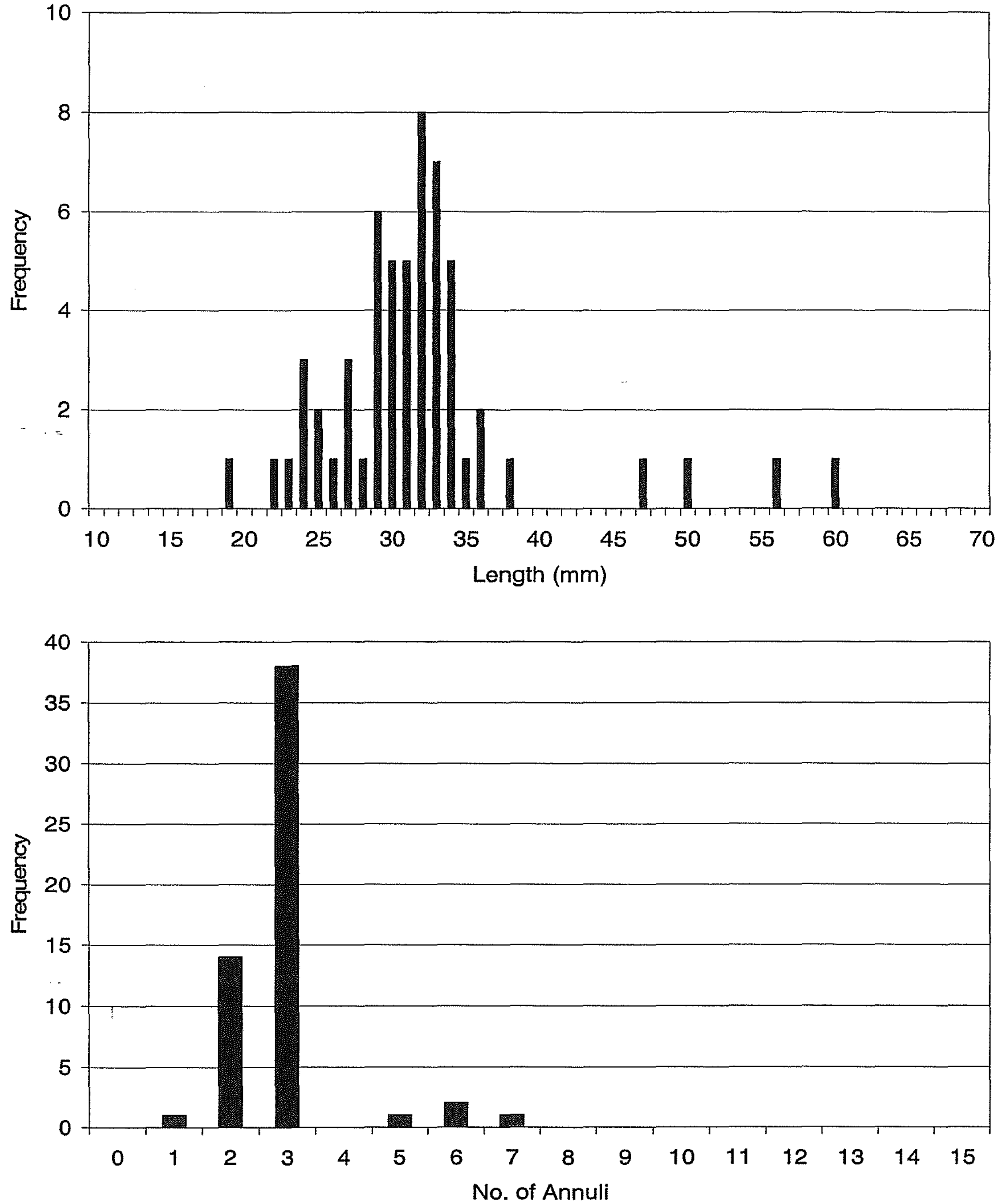


Figure 92. Length (top) and age (bottom) frequency distributions of varnish clams collected in Gay Passage, Ououkinsh Inlet, July 9, 2002.

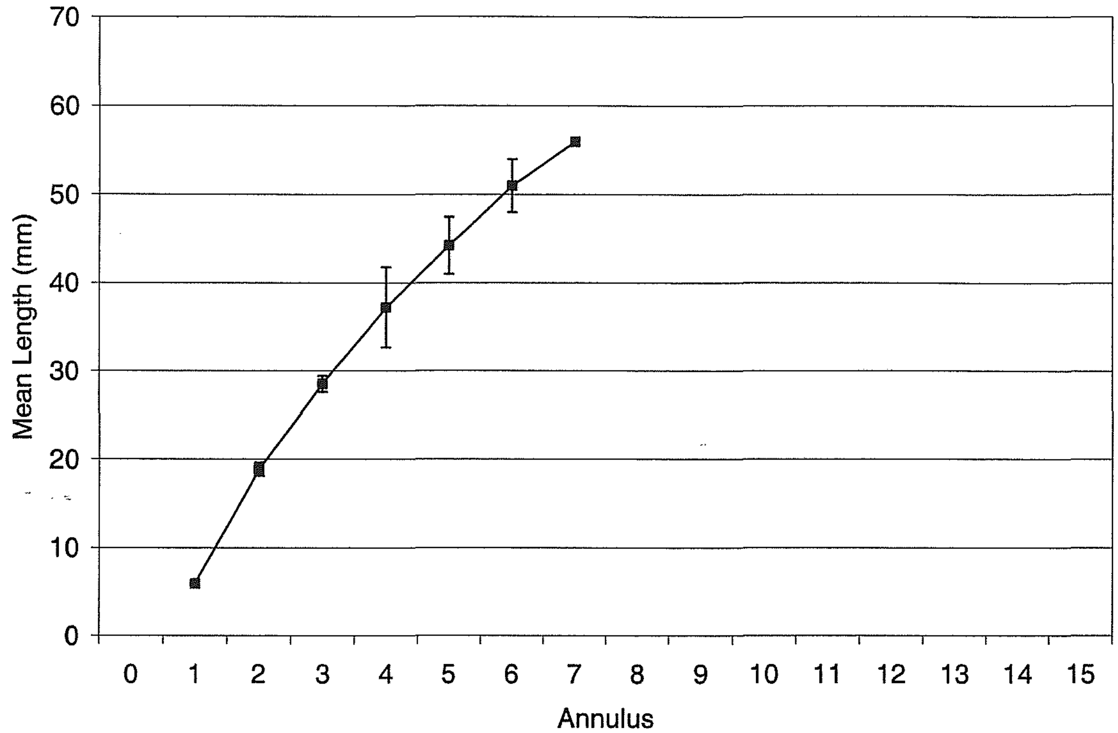


Figure 93. Mean length-at-annulus of varnish clams collected in Gay Passage, Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

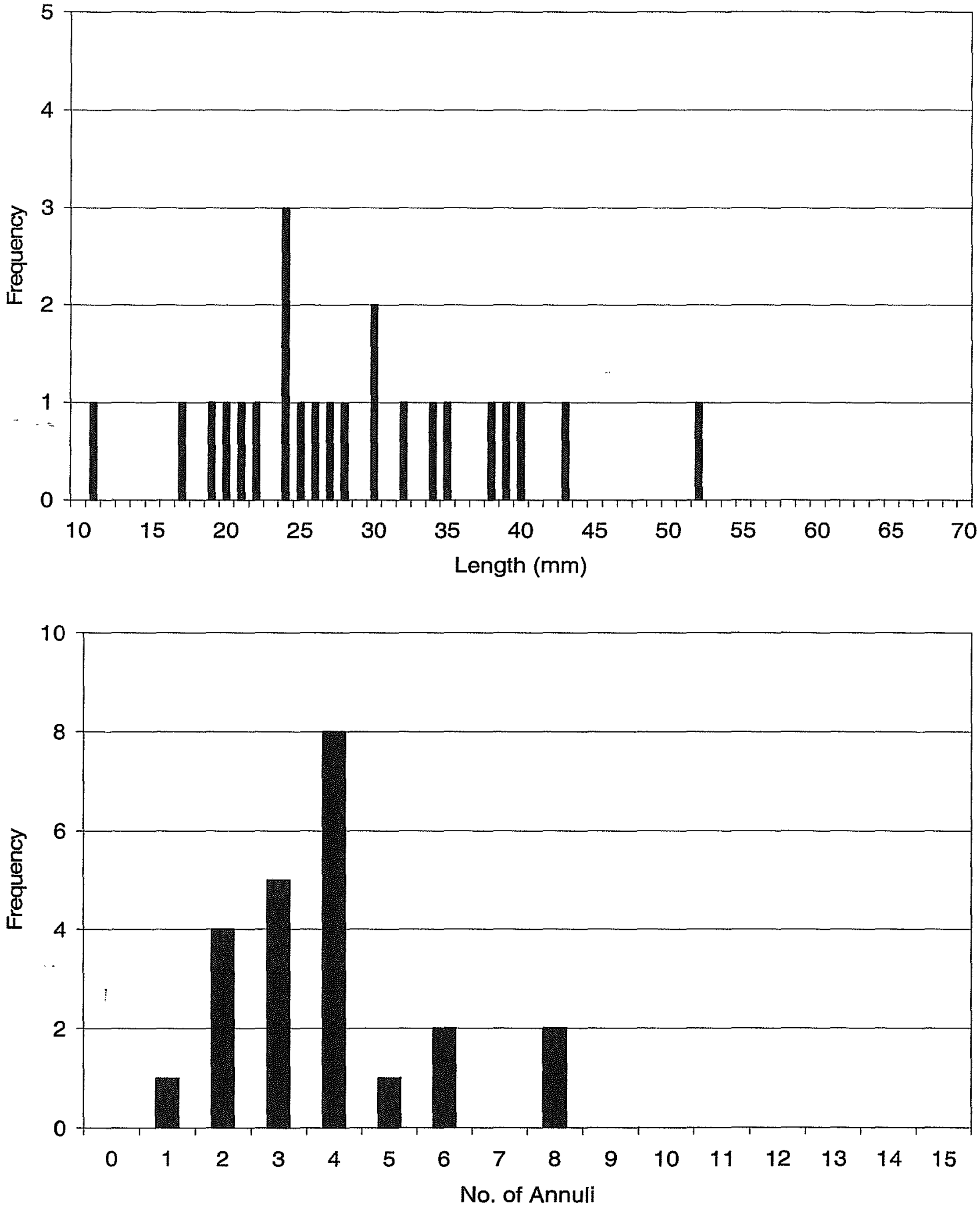
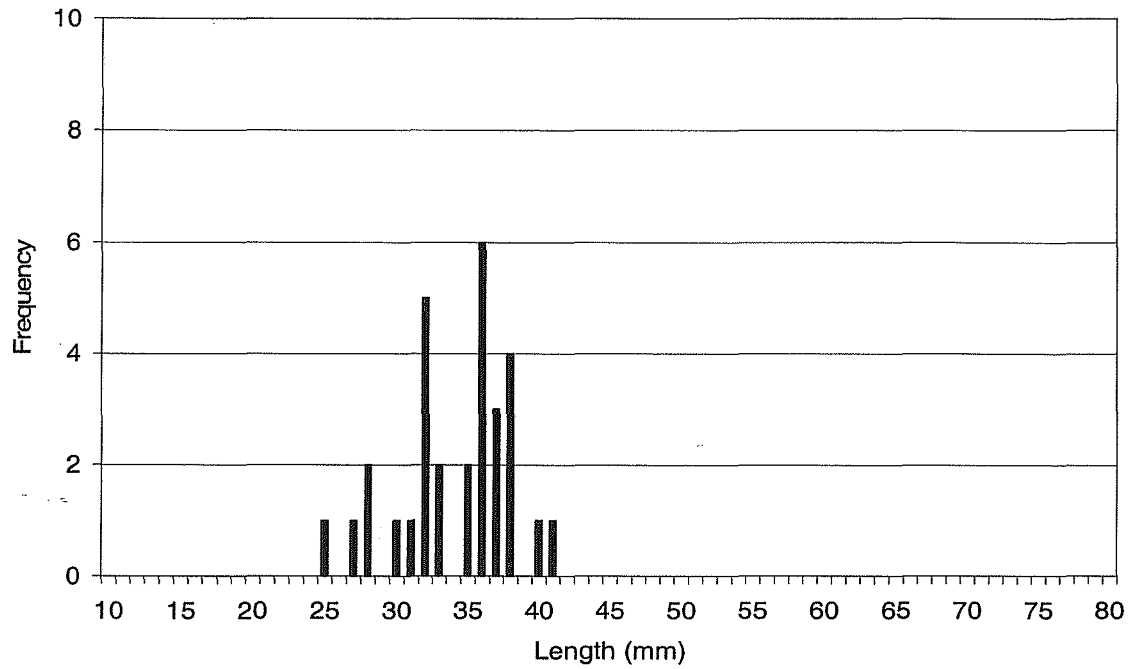


Figure 94. Length (top) and age (bottom) frequency distributions of littleneck clams collected in Gay Passage, Ououkinsh Inlet, July 9, 2002.



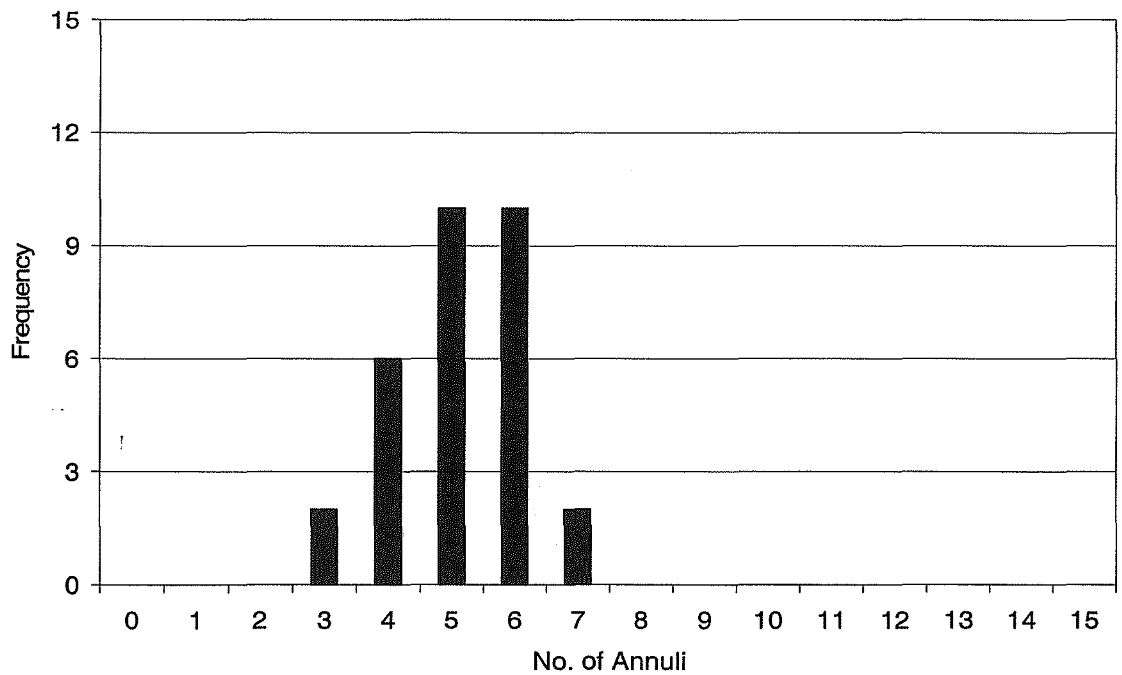


Figure 95. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the Power River estuary, Ououkinsh Inlet, July 9, 2002.

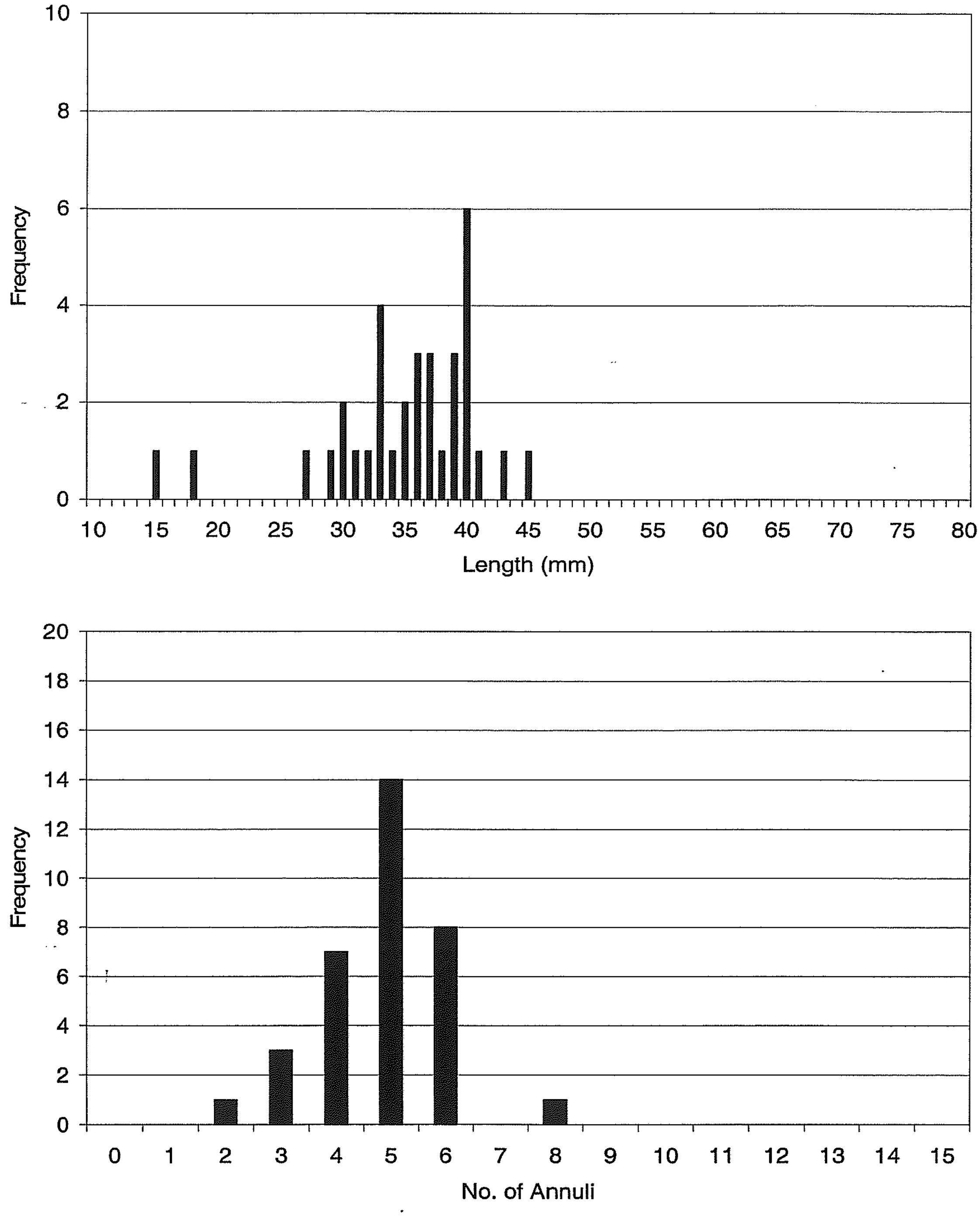
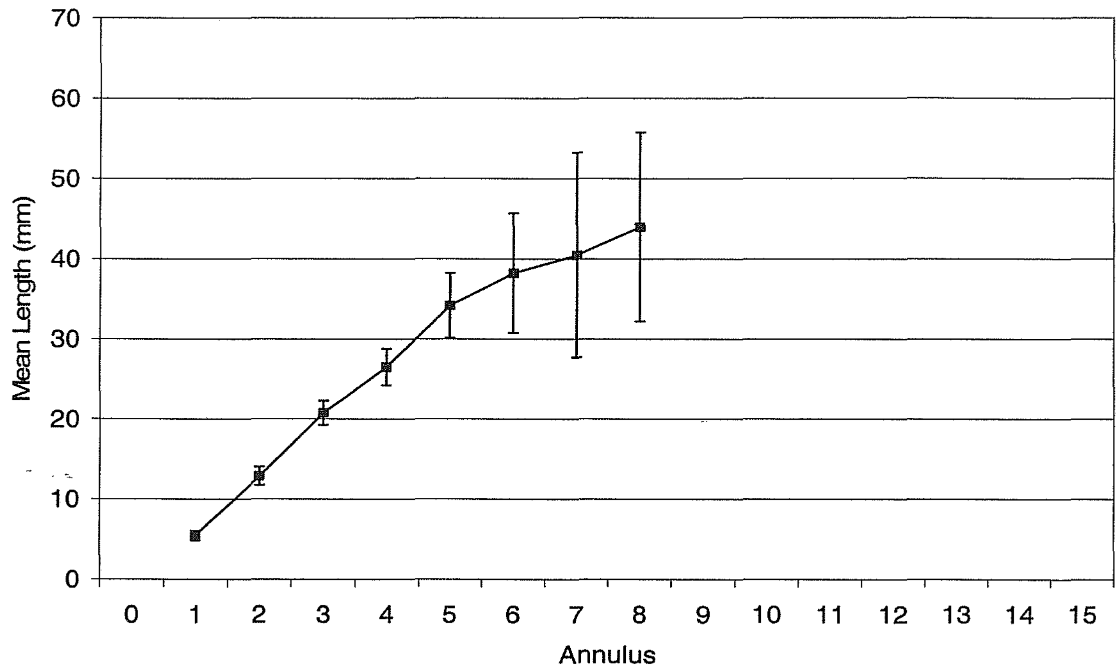


Figure 96. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the head of Ououkinsh Inlet, July 9, 2002.



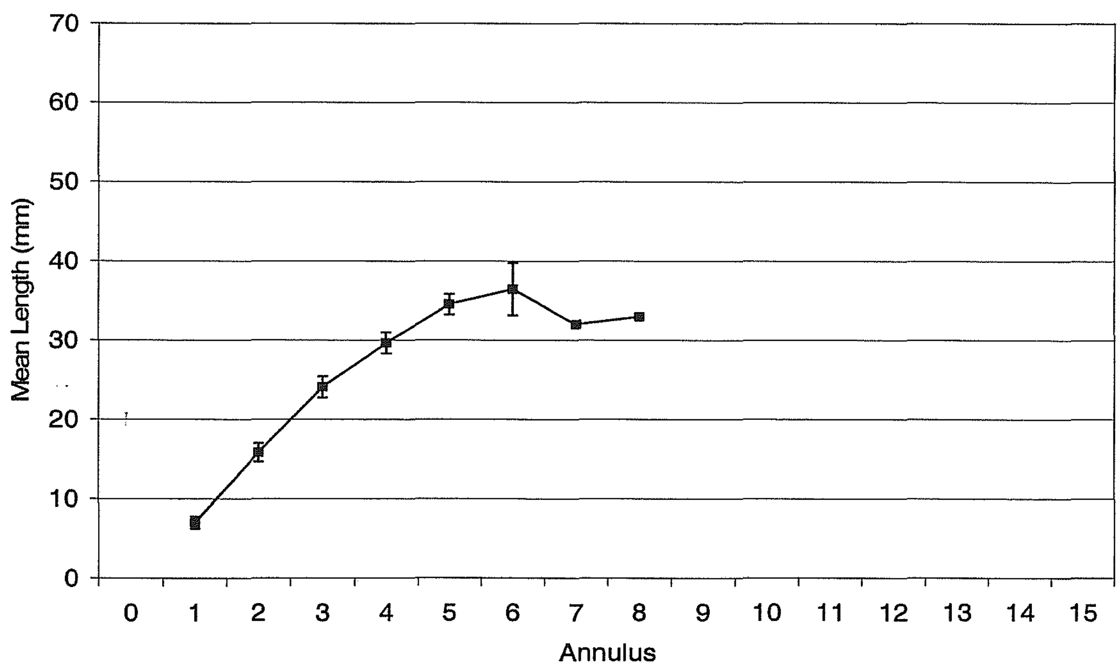


Figure 97. Mean length-at-annulus of littleneck clams collected from Gay Passage (top) and the Power River estuary (bottom), Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

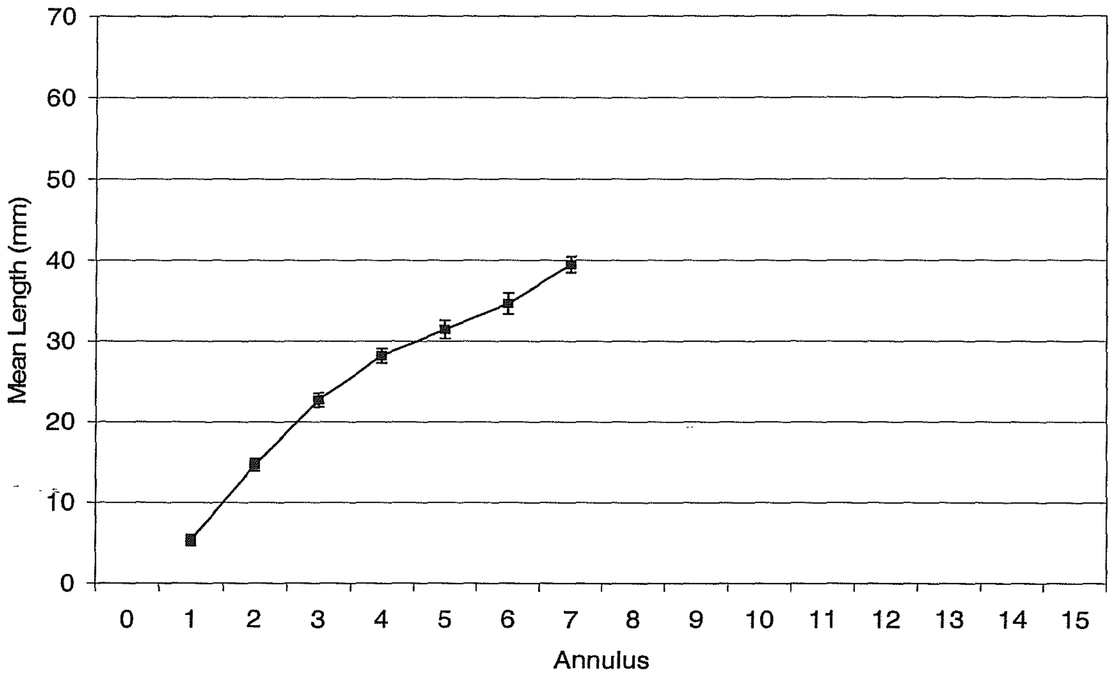


Figure 98. Mean length-at-annulus of littleneck clams collected at the head of Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

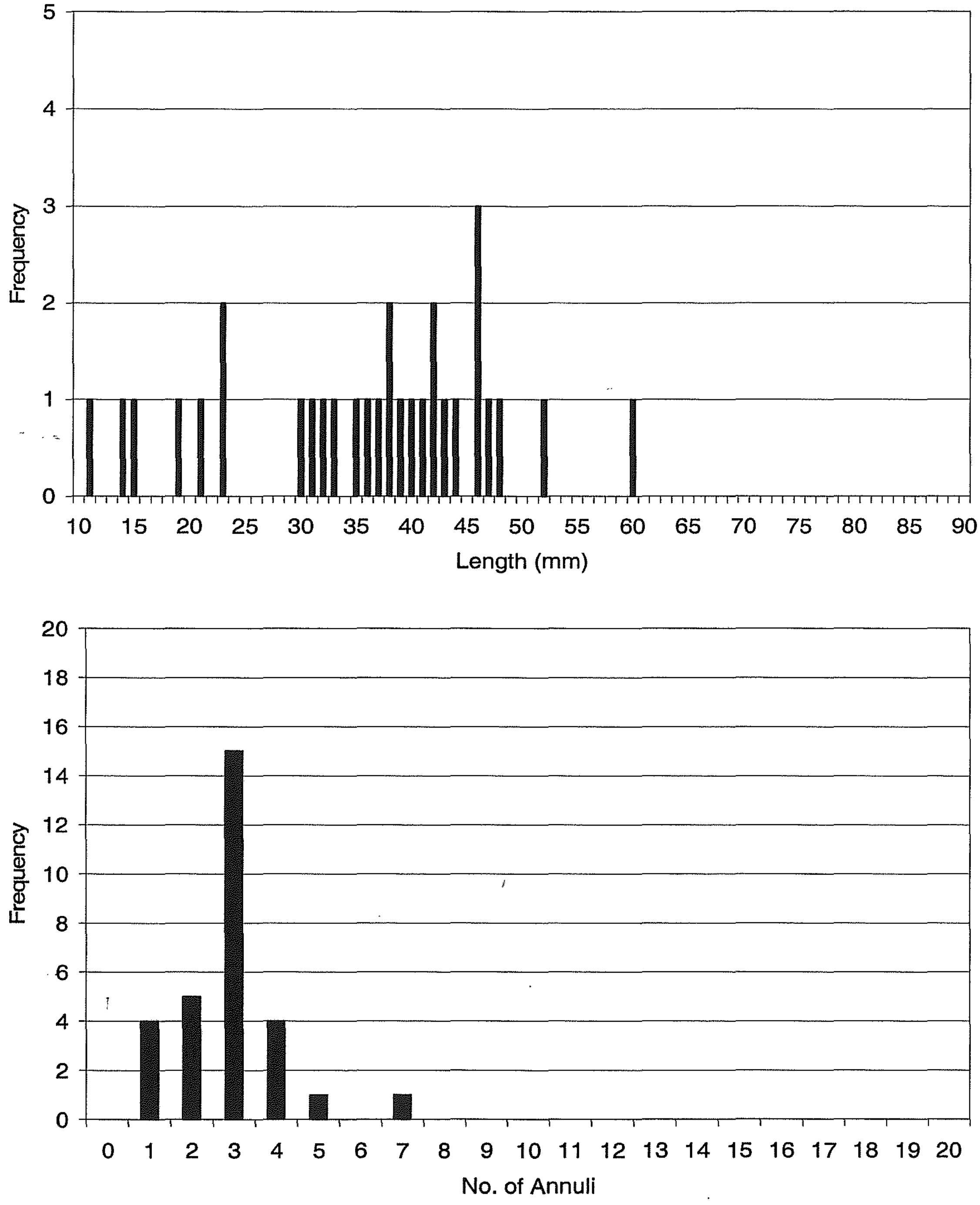


Figure 99. Length (top) and age (bottom) frequency distributions of butter clams collected in Gay Passage, Ououkinsh Inlet, July 9, 2002.

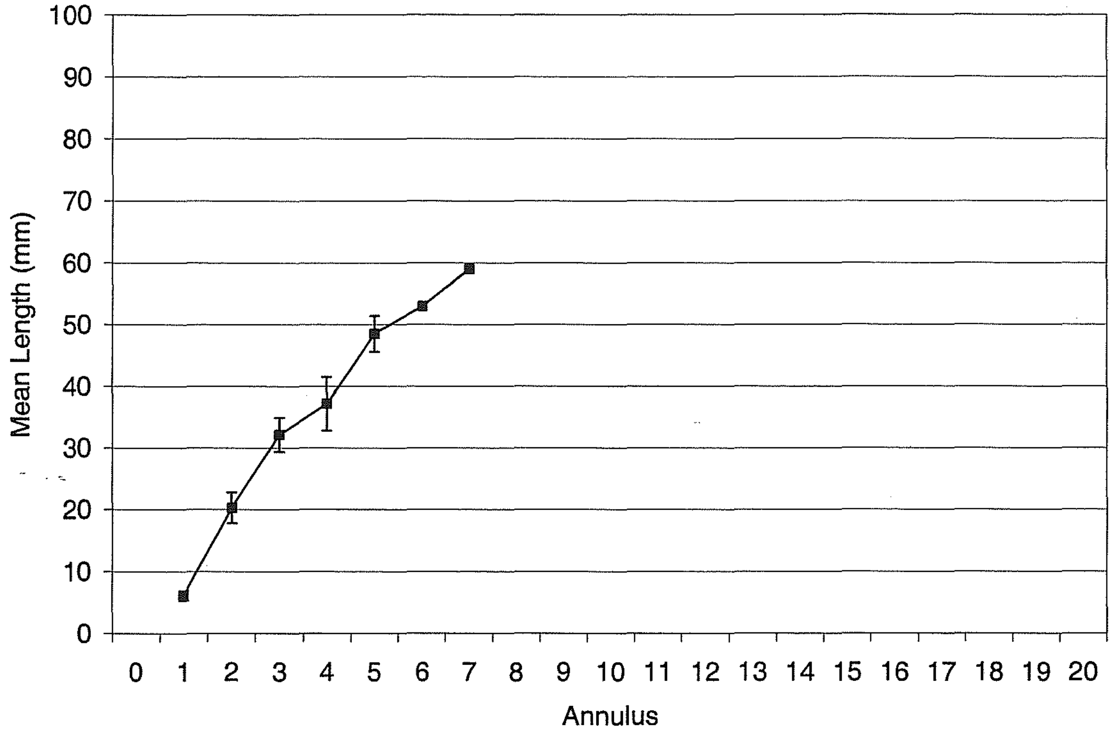


Figure 100. Mean length-at-annulus of butter clams collected in Gay Passage, Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

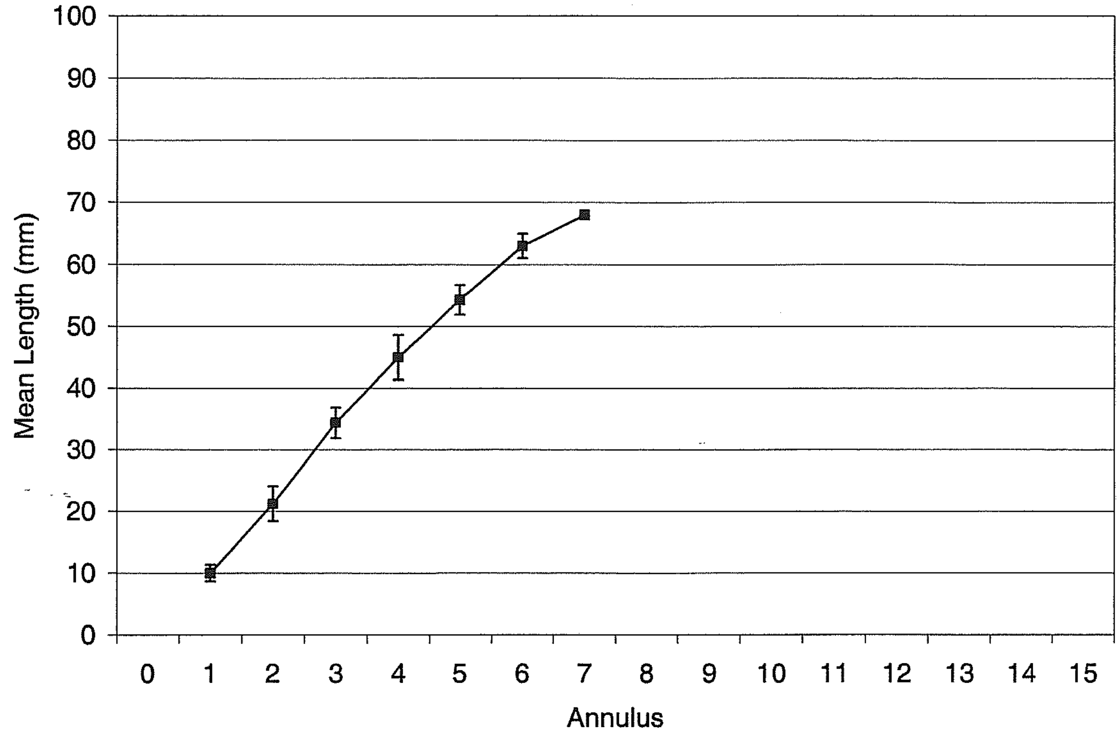


Figure 101. Mean length-at-annulus of softshells collected at the head of Ououkinsh Inlet, July 9, 2002.

Error bars represent 95% confidence intervals.

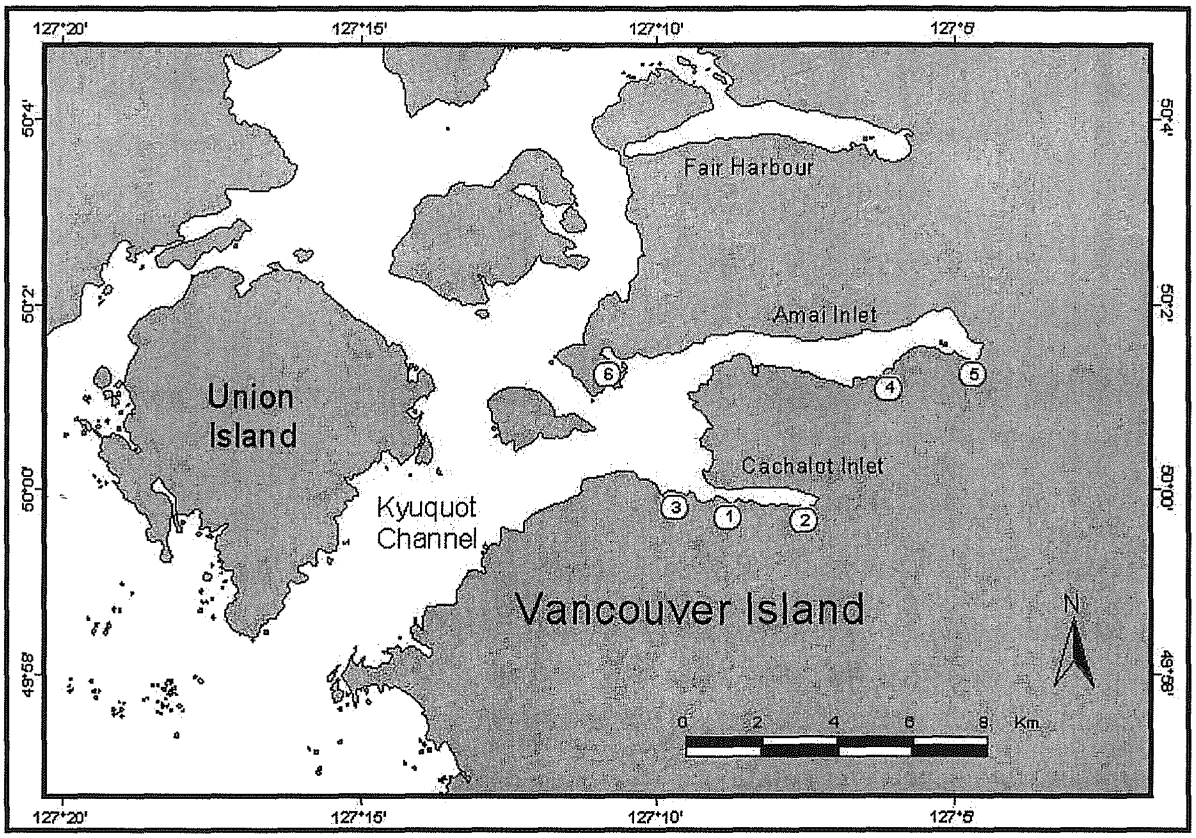


Figure 102. Locations of beaches surveyed in Kuyoquot Sound, July 10, 2002.

Legend: 1 – Cachalot Inlet 1; 2 – Cachalot Inlet 2; 3 – Whaling Station; 4 – Amai Inlet 1; 5 – Amai Inlet 2; 6 – Amai Inlet 3.

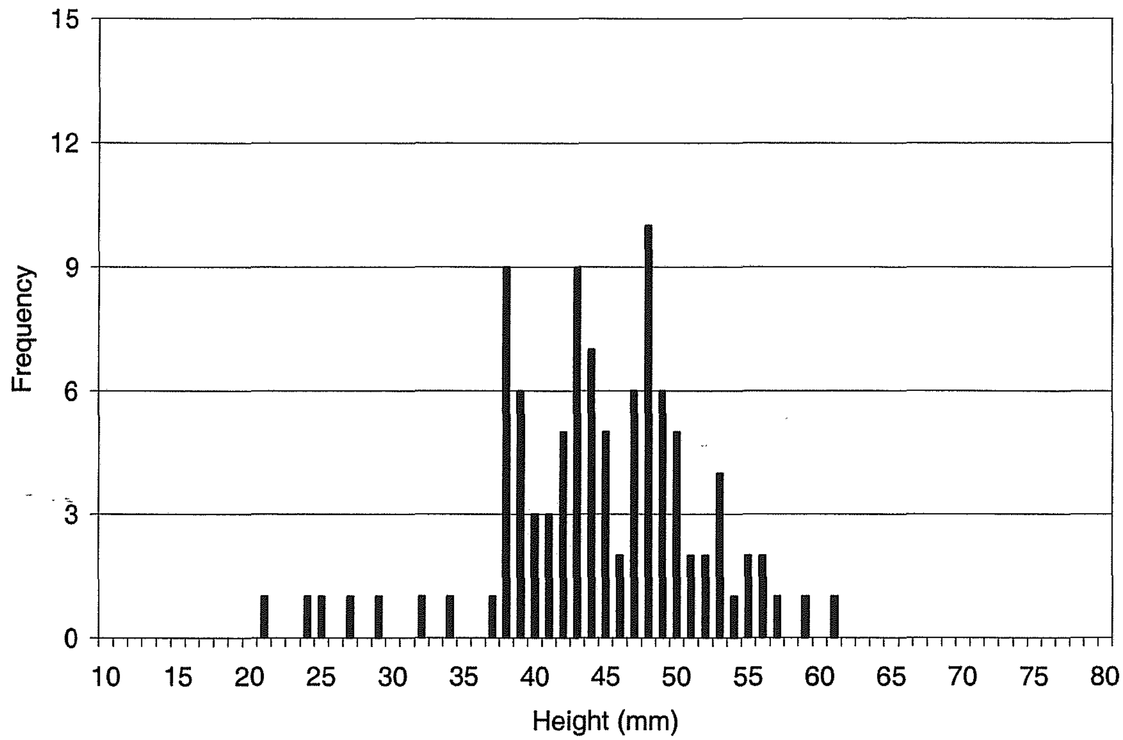
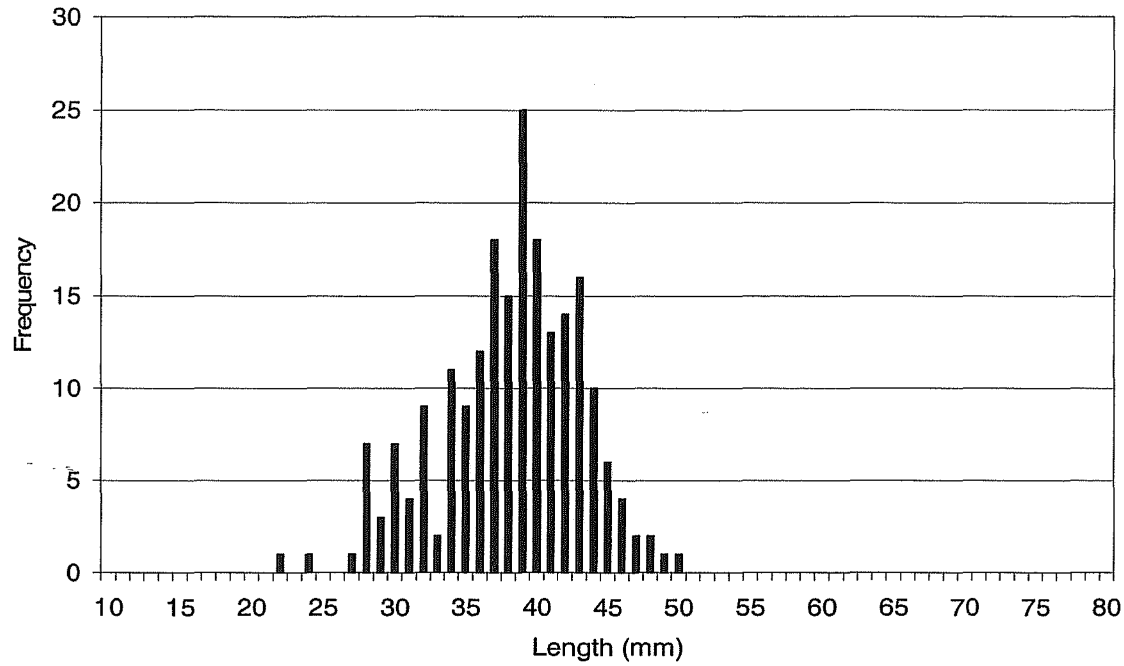


Figure 103. Height frequency distribution of Olympia oysters collected in Amai Inlet, Kuyoquot Sound, July 10, 2002.



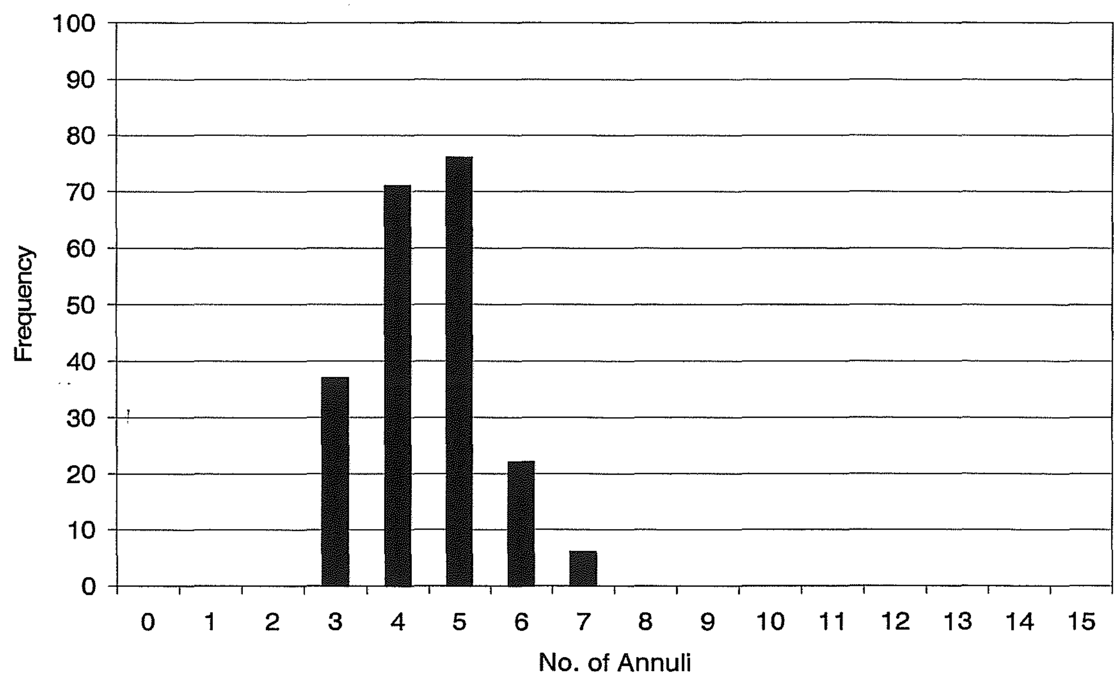


Figure 104. Length (top) and age (bottom) frequency distributions of Manila clams collected from the south side of Cachalot Inlet, Kuyoquot Sound, July 10, 2002.

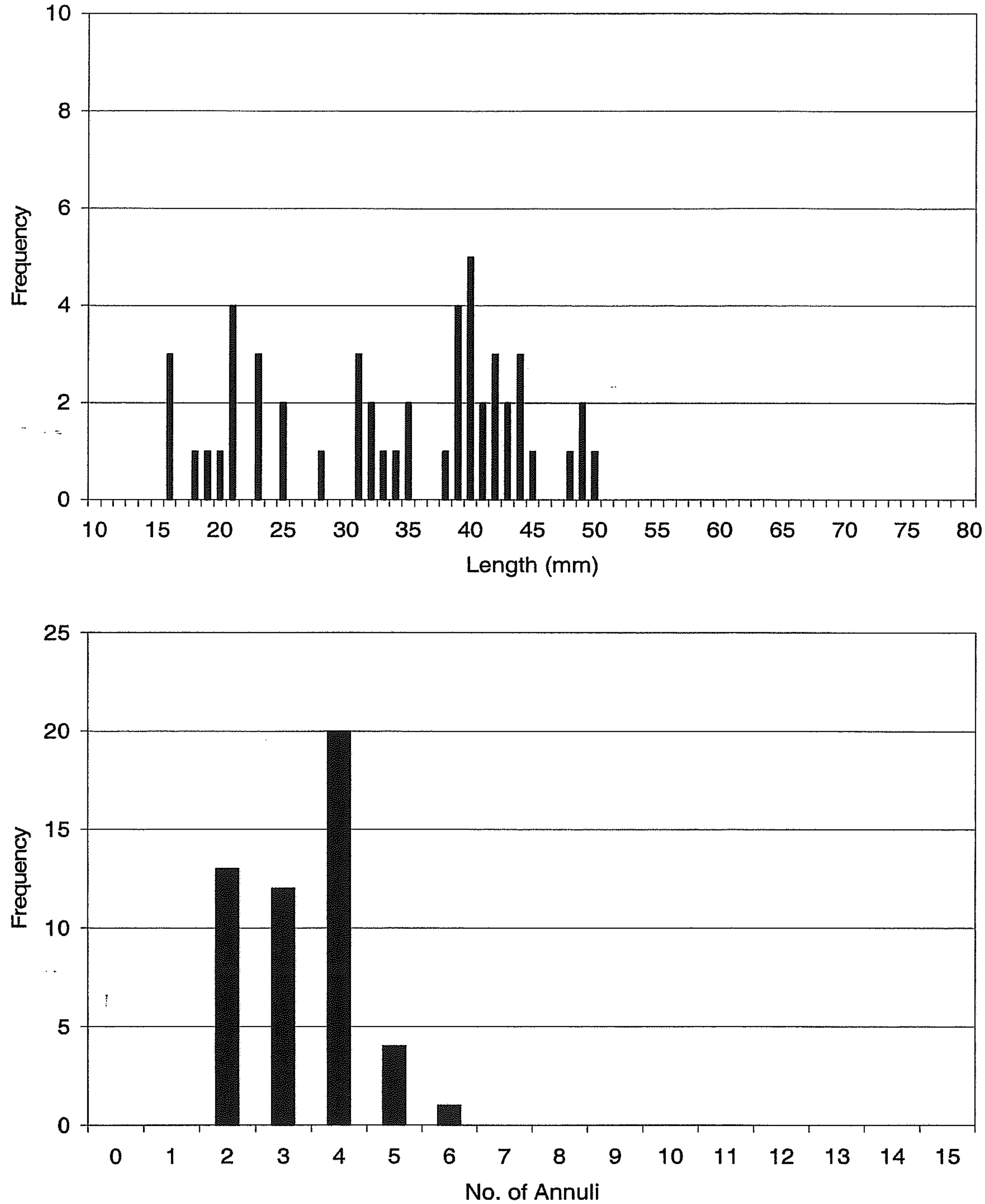


Figure 105. Length (top) and age (bottom) frequency distributions of Manila clams collected at the whaling station, Cachalot Inlet, Kuyoquot Sound, July 10, 2002.

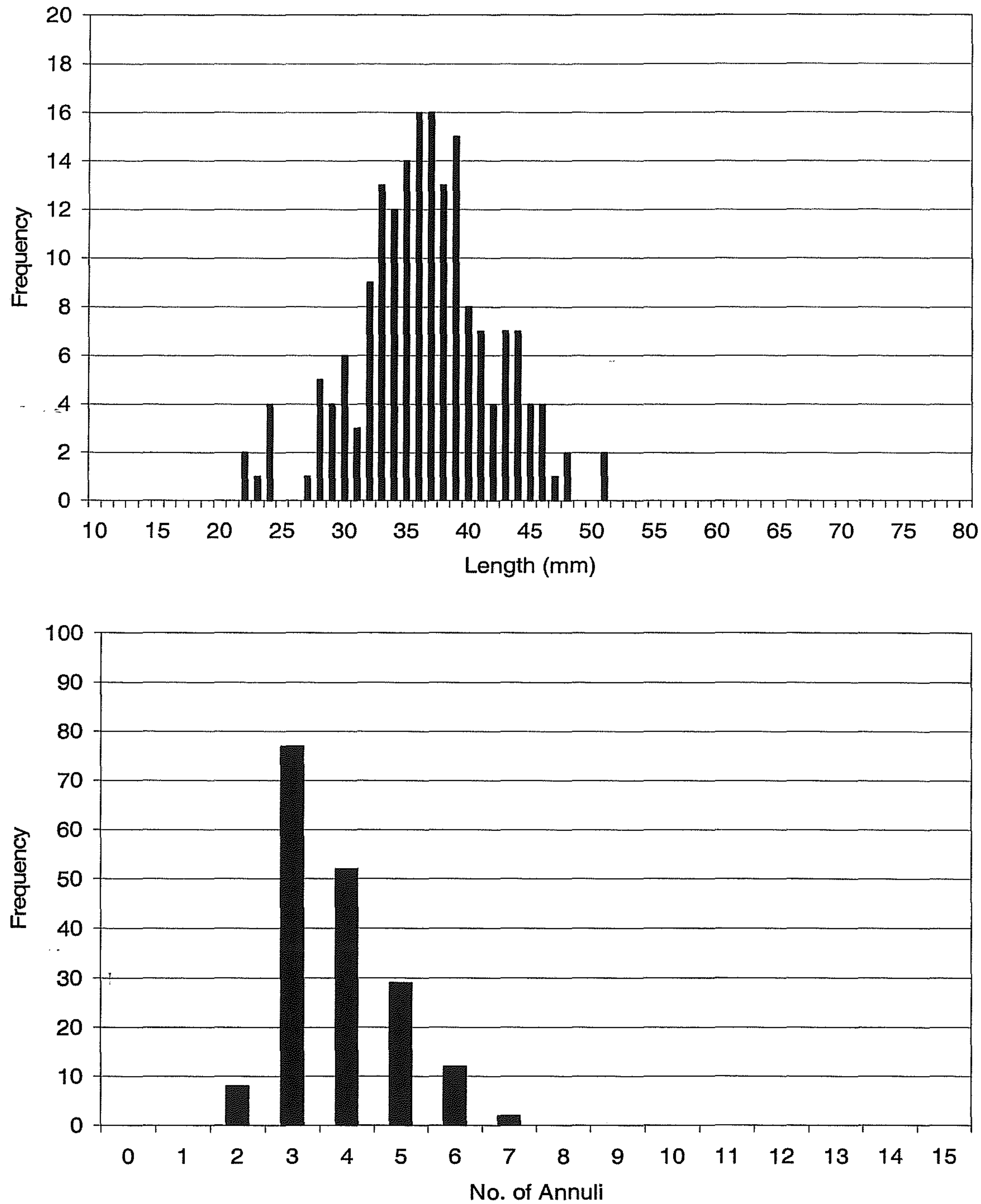


Figure 106. Length (top) and age (bottom) frequency distributions of Manila clams collected from the south side of Amai Inlet, Kuyoquot Sound, July 10, 2002.

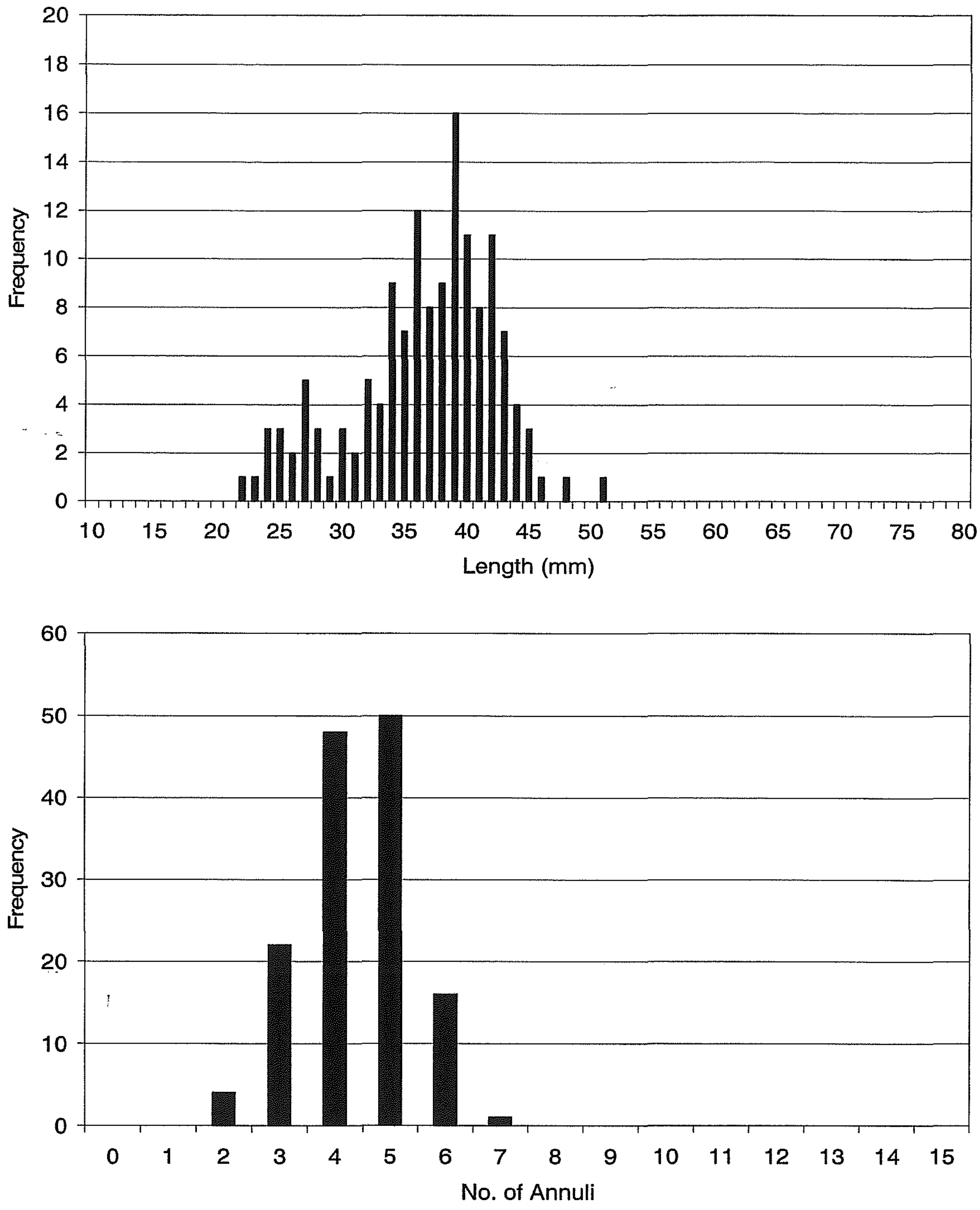


Figure 107. Length (top) and age (bottom) frequency distributions of Manila clams collected at the mouth of Amai Inlet, Kuyoquot Sound, July 10, 2002.

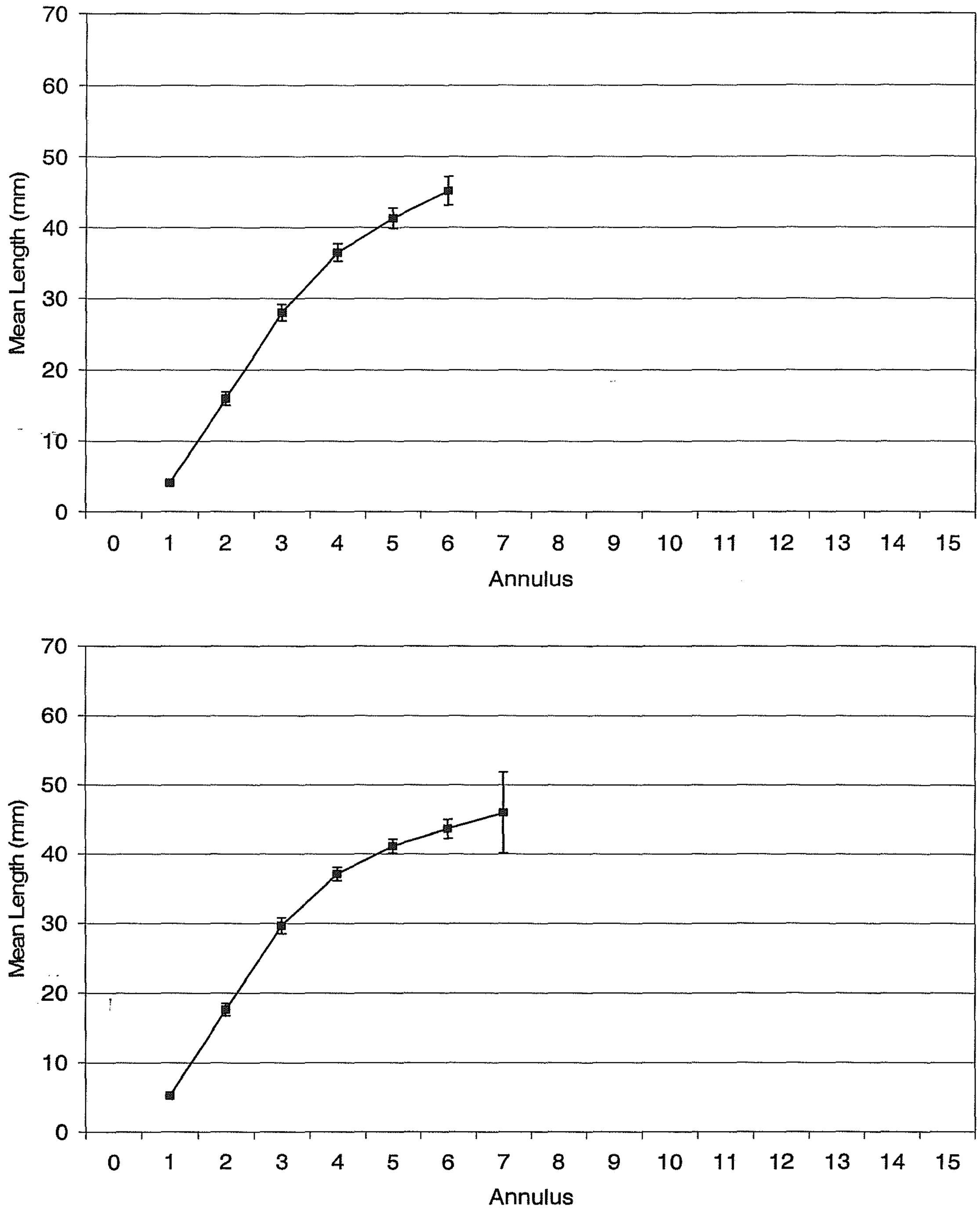


Figure 108. Mean length-at-annulus of Manila clams collected in Cachalot Inlet (top) and Amai Inlet (bottom), Kuyoquot Sound, July 10, 2002.

Error bars represent 95% confidence intervals.

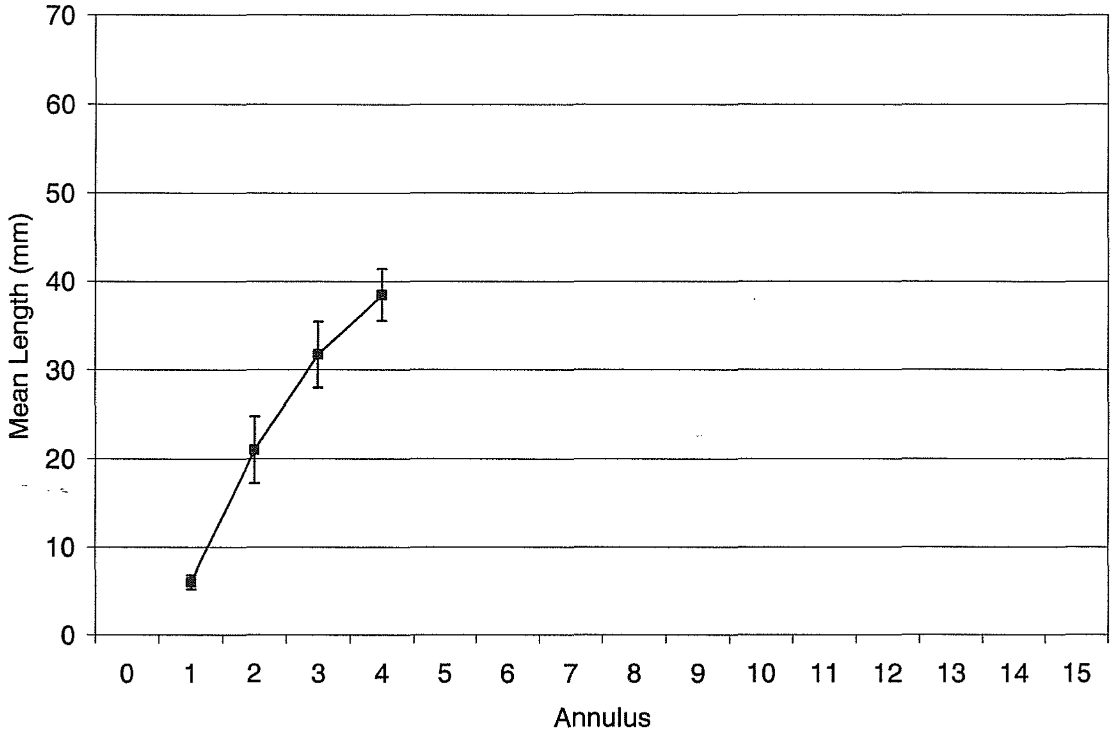


Figure 109. Mean length-at-annulus of varnish clams collected in Amai Inlet, Kuyoquot Sound, July 10, 2002.

Error bars represent 95% confidence intervals.

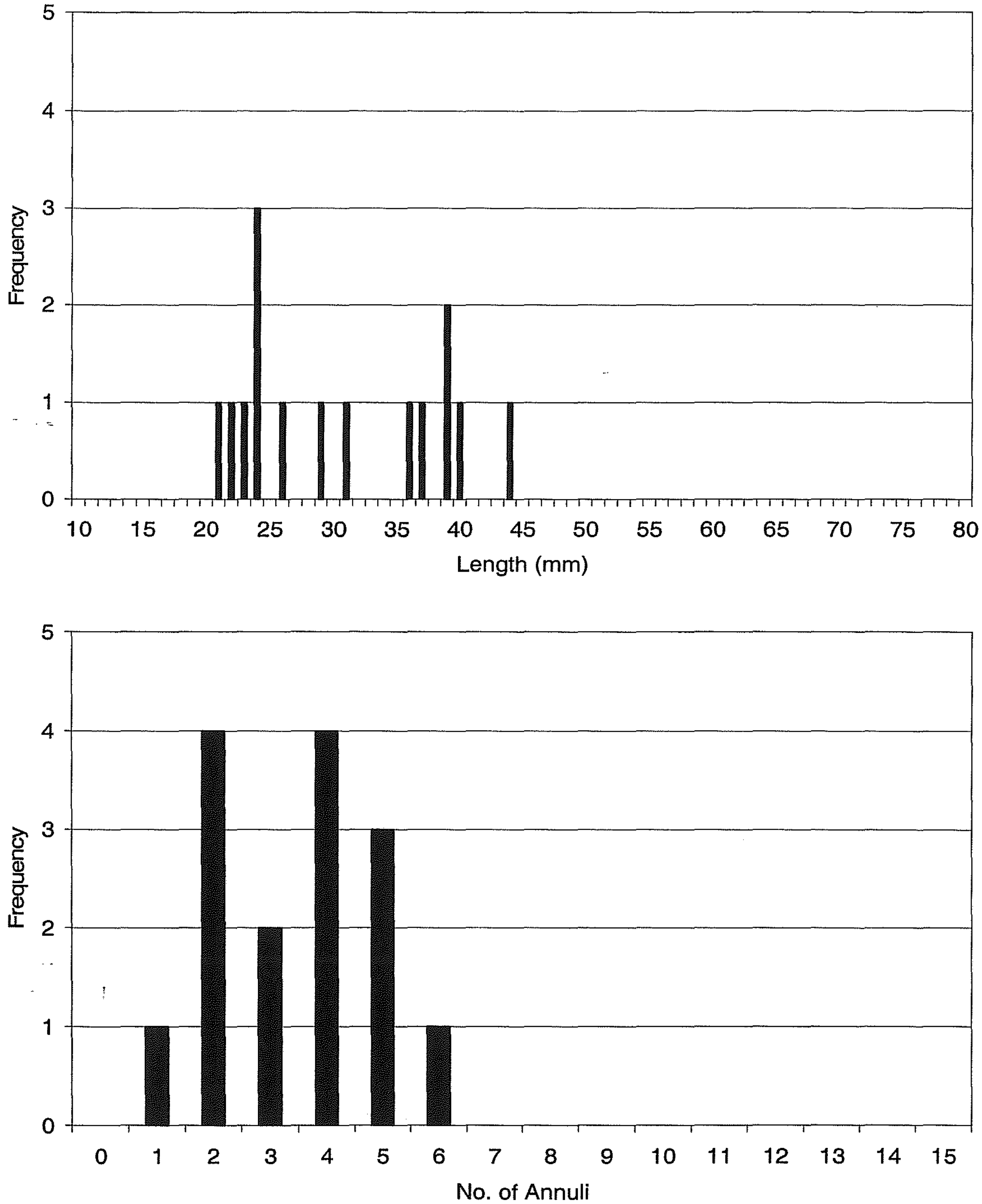


Figure 110. Length (top) and age (bottom) frequency distributions of littleneck clams collected from the south side of Cachalot Inlet, Kuyoquot Sound, July 10, 2002.

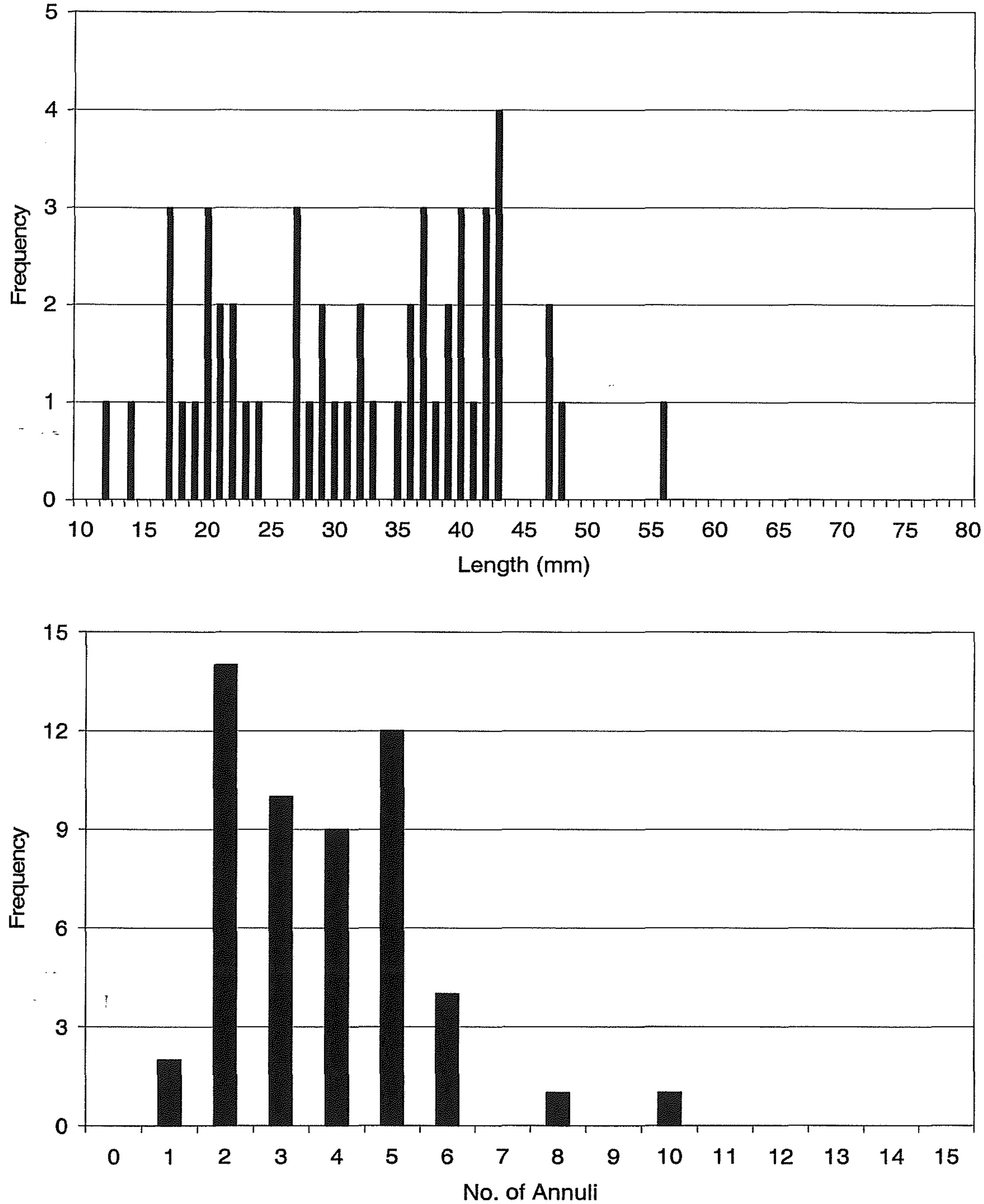


Figure 111. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the whaling station, Cachalot Inlet, Kuyoquot Sound, July 10, 2002.

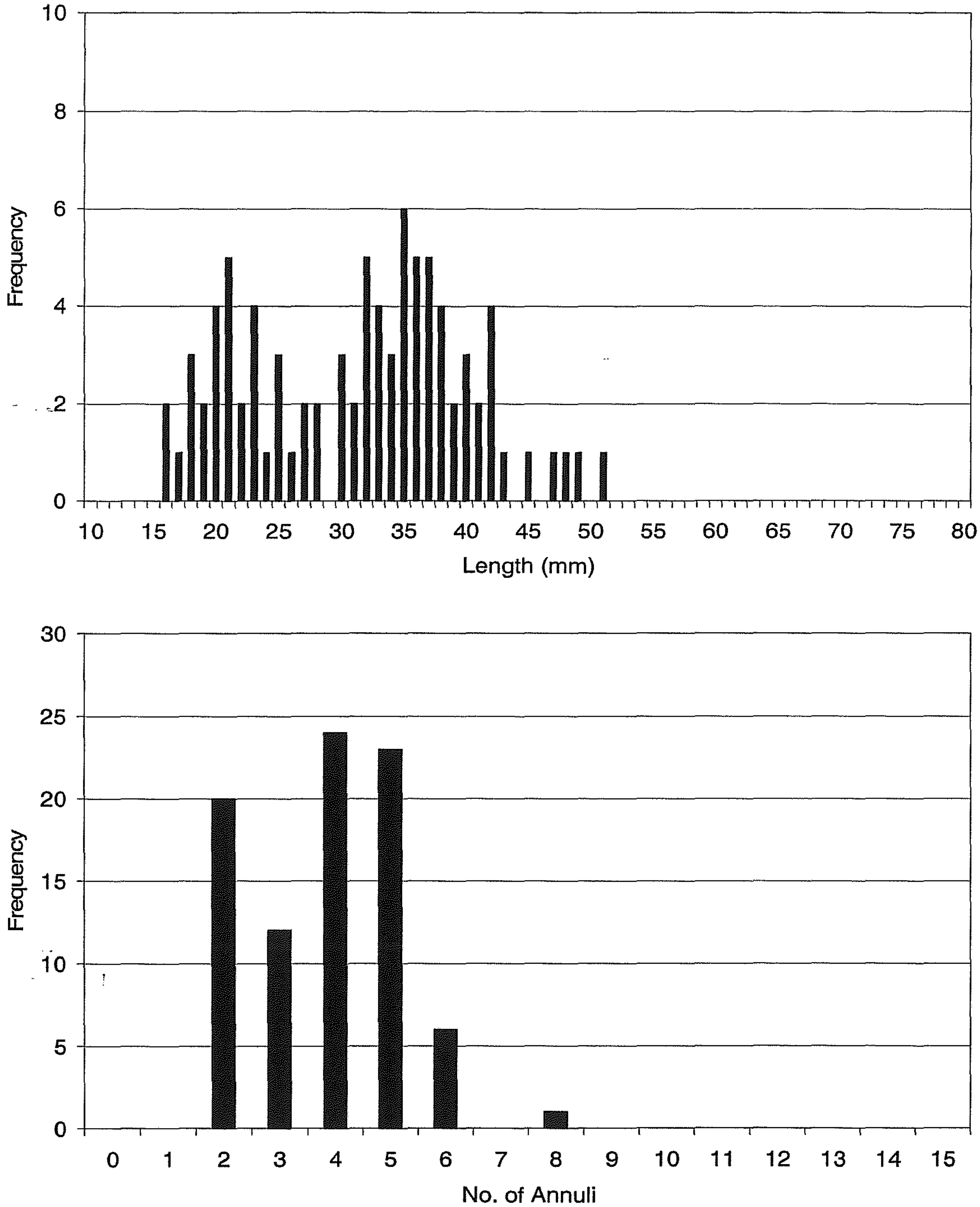


Figure 112. Length (top) and age (bottom) frequency distributions of littleneck clams collected from the south side of Amai Inlet, Kuyoquot Sound, July 10, 2002.

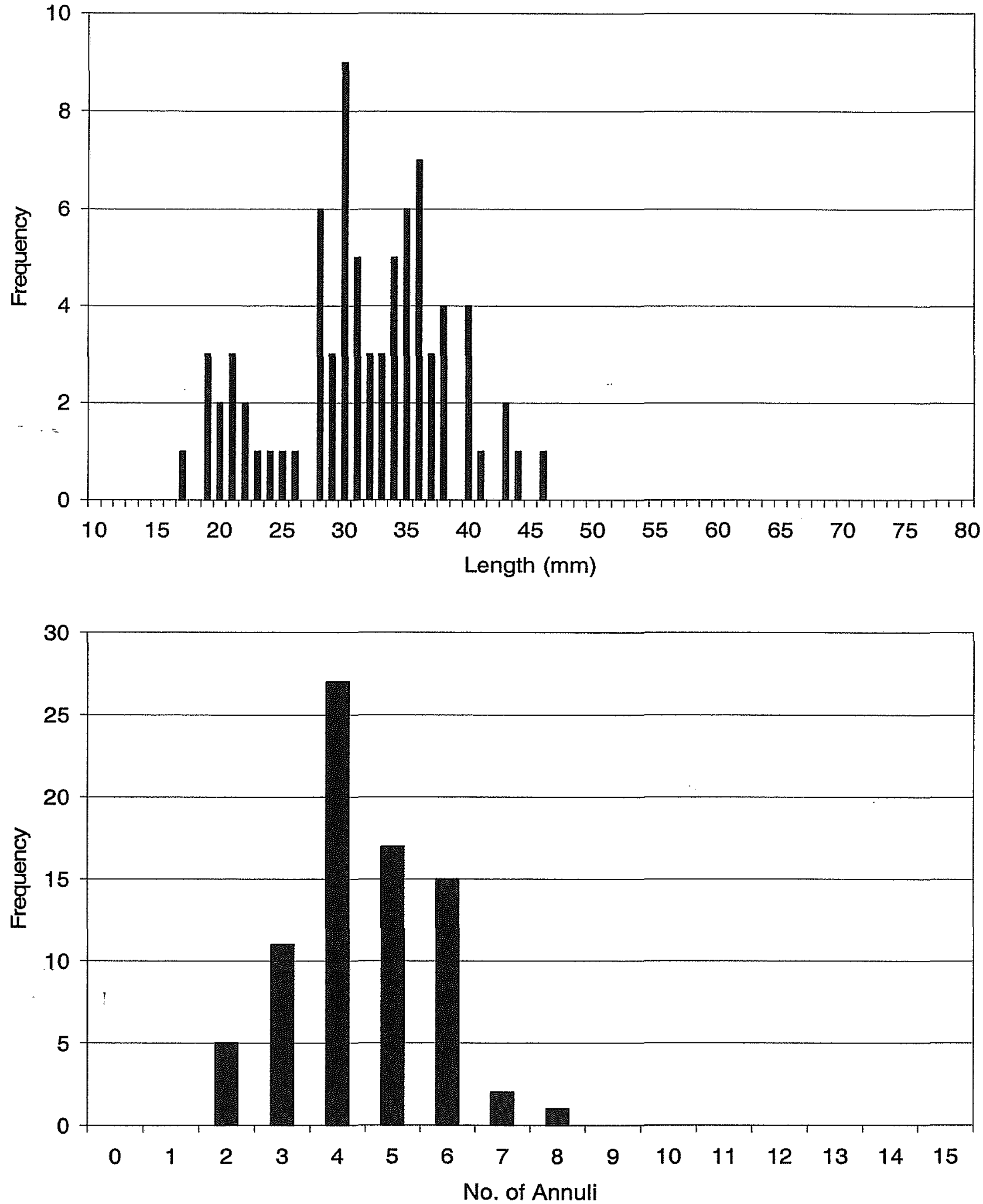
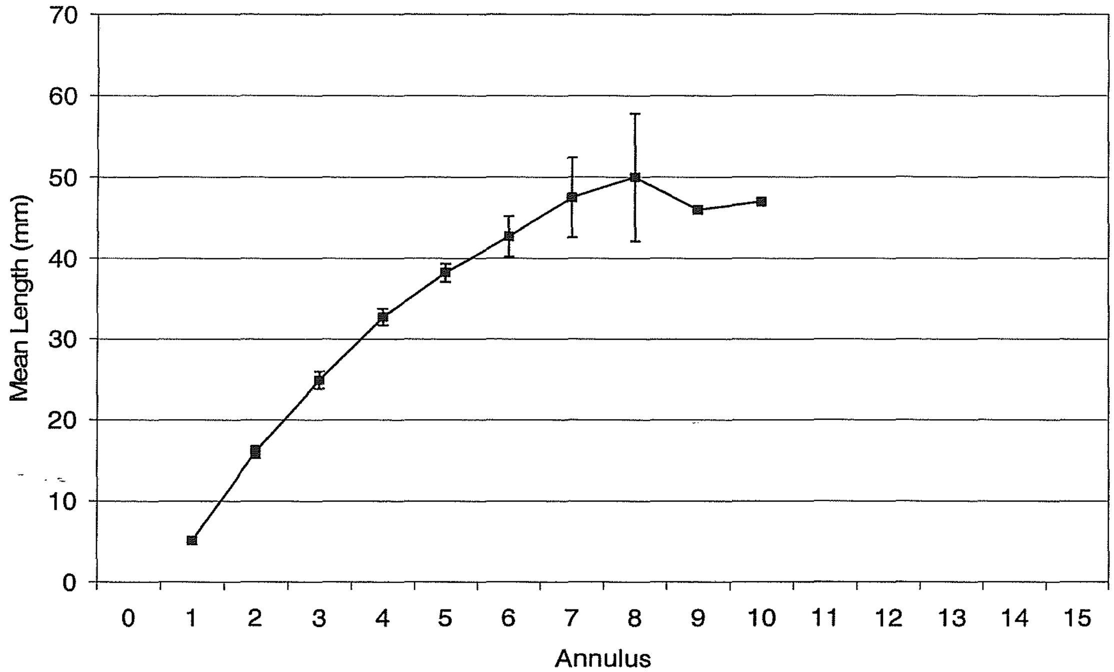


Figure 113. Length (top) and age (bottom) frequency distributions of littleneck clams collected at the mouth of Amai Inlet, Kuyoquot Sound, July 10, 2002.



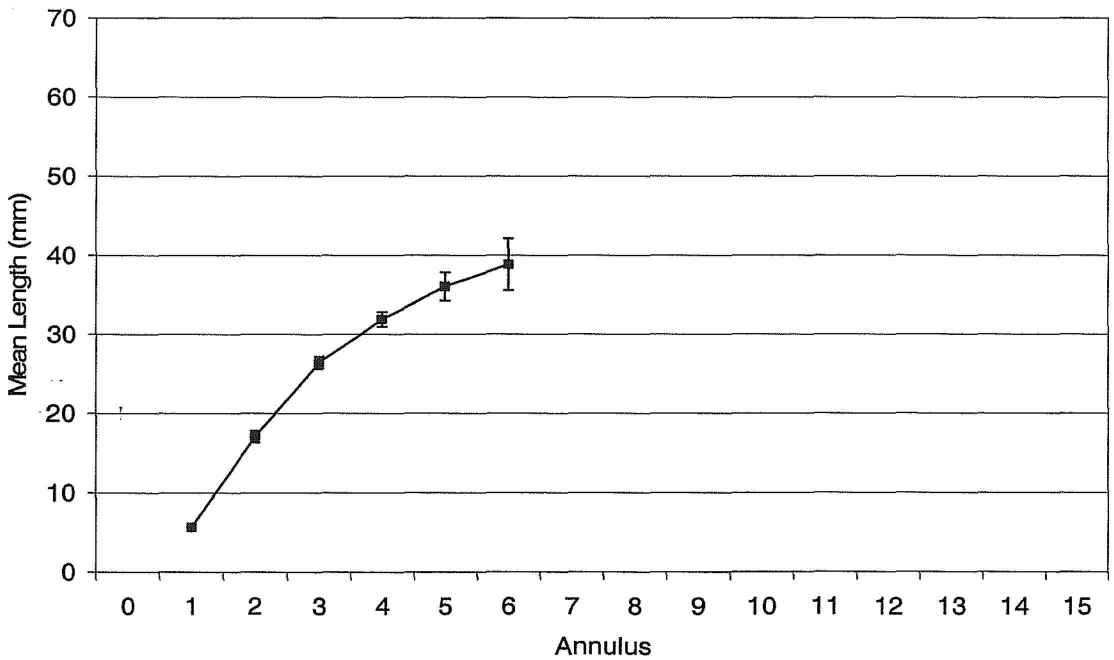
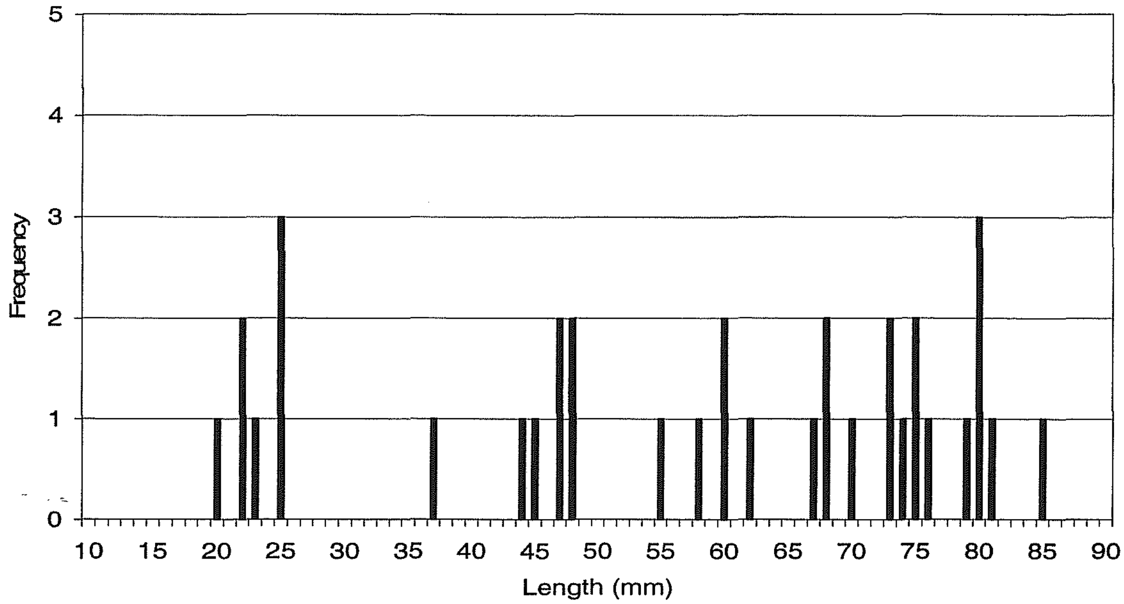


Figure 114. Mean length-at-annulus of littleneck clams collected in Cachalot Inlet (top) and Amai Inlet (bottom), Kuyoquot Sound, July 10, 2002.

Error bars represent 95% confidence intervals.



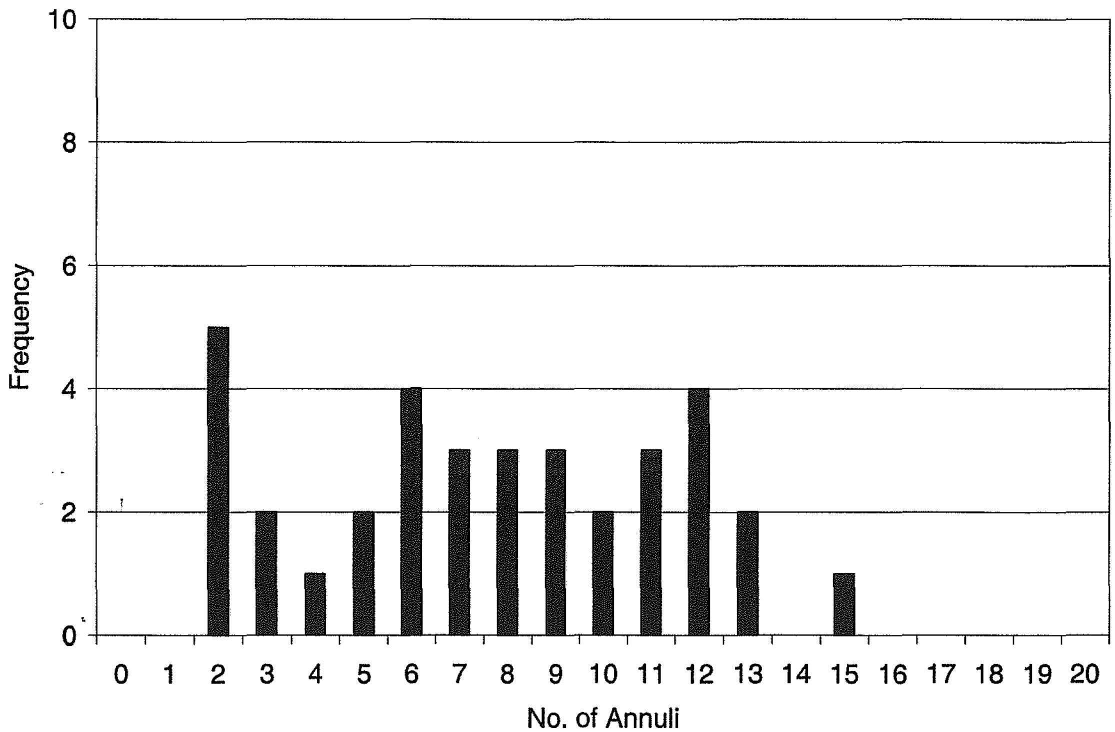
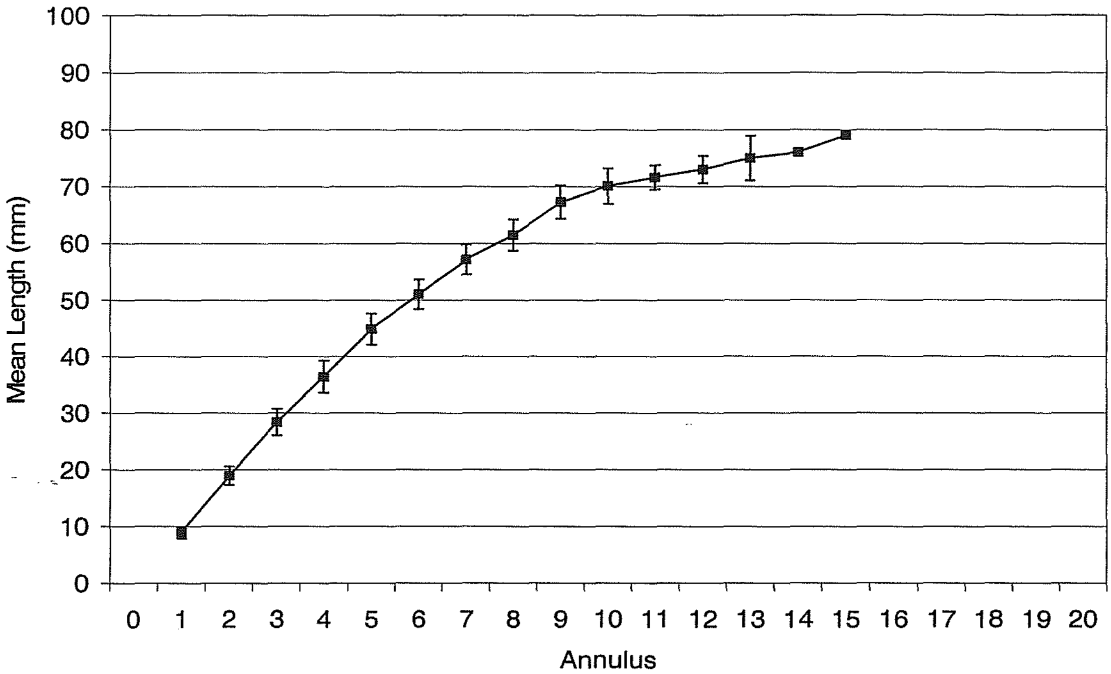


Figure 115. Length (top) and age (bottom) frequency distributions of butter clams collected in Cachalot Inlet, Kuyoquot Sound, July 10, 2002.



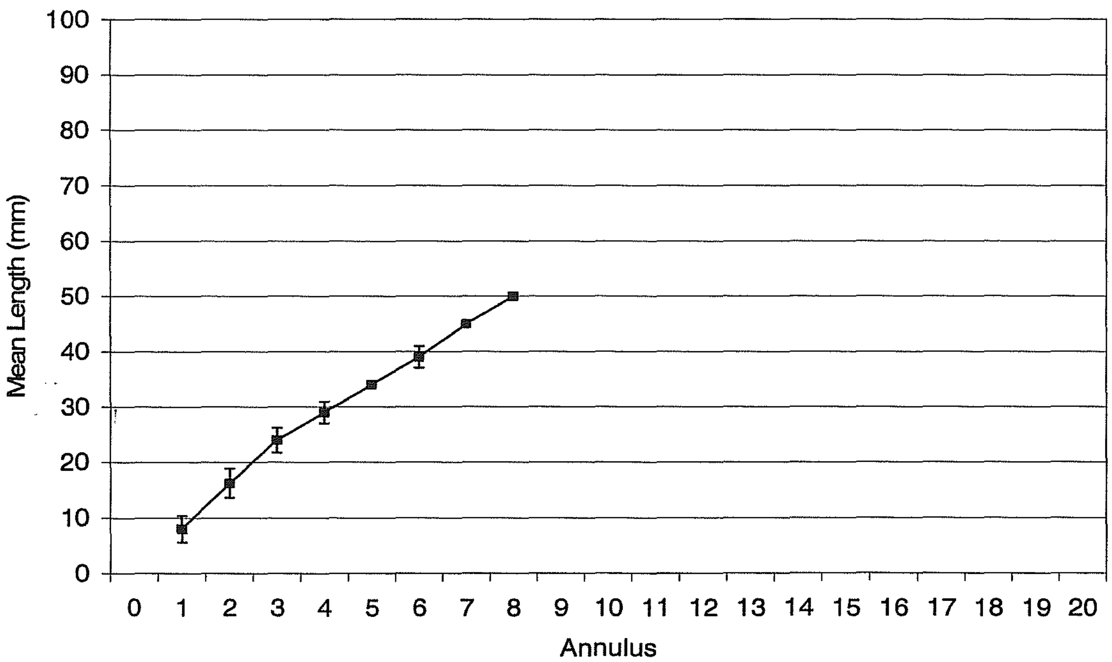
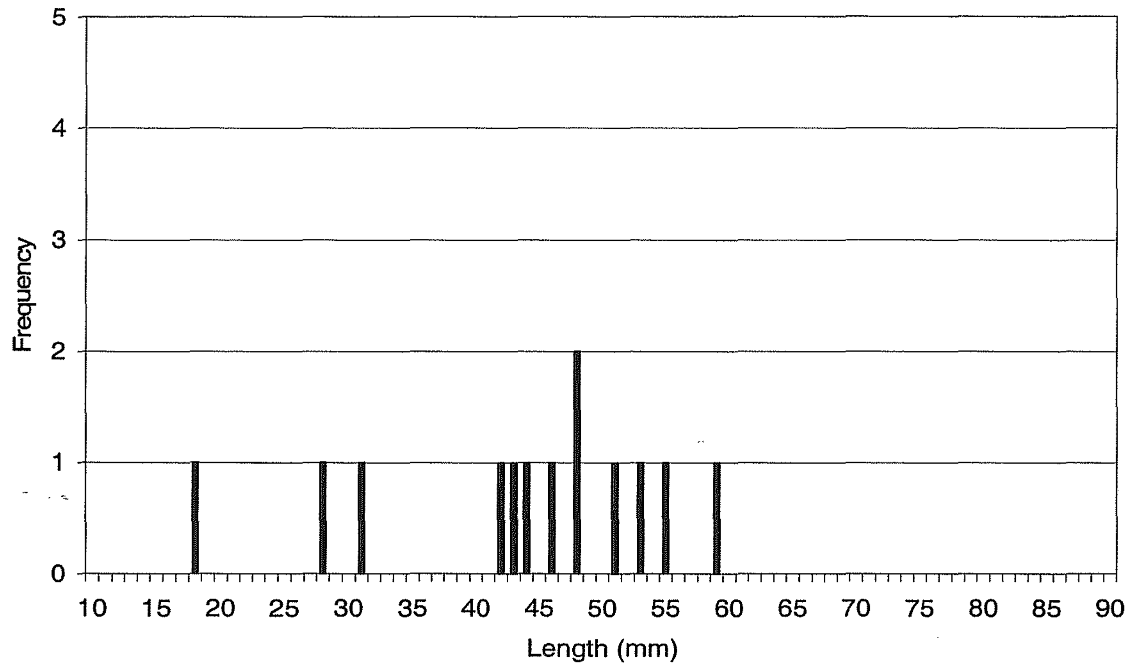


Figure 116. Mean length-at-annulus of butter clams collected in Cachalot Inlet (top) and Amai Inlet (bottom), Kuyoquot Sound, July 10, 2002.

Error bars represent 95% confidence intervals.



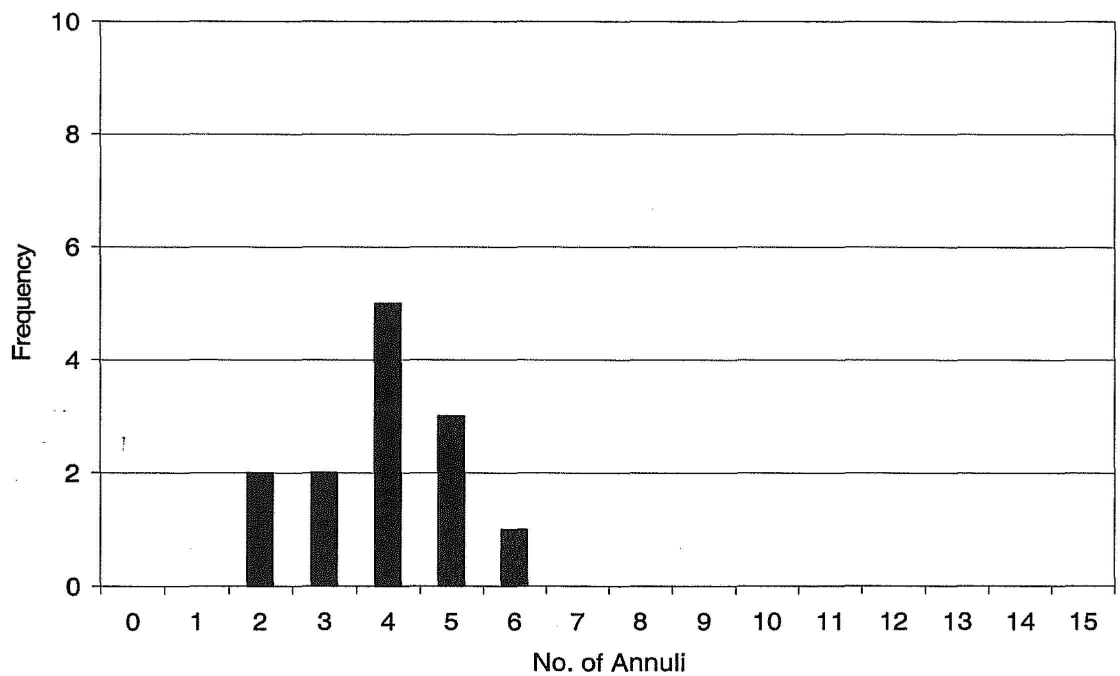


Figure 117. Length (top) and age (bottom) frequency distributions of softshells collected in Cachalot Inlet, Kuyoquot Sound, July 10, 2002.

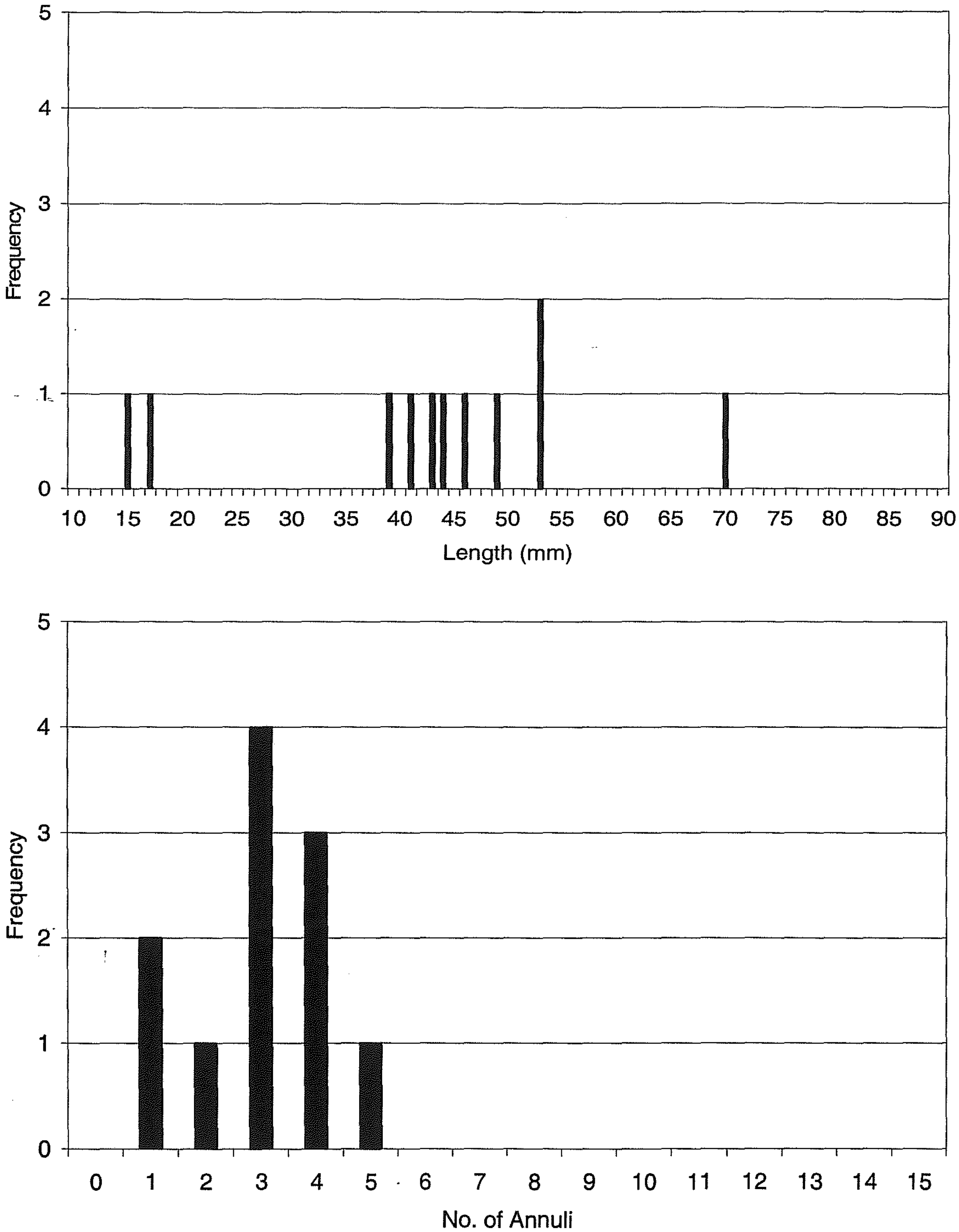


Figure 118. Length (top) and age (bottom) frequency distributions of softshells collected in Amai Inlet, Kuyoquot Sound, July 10, 2002.

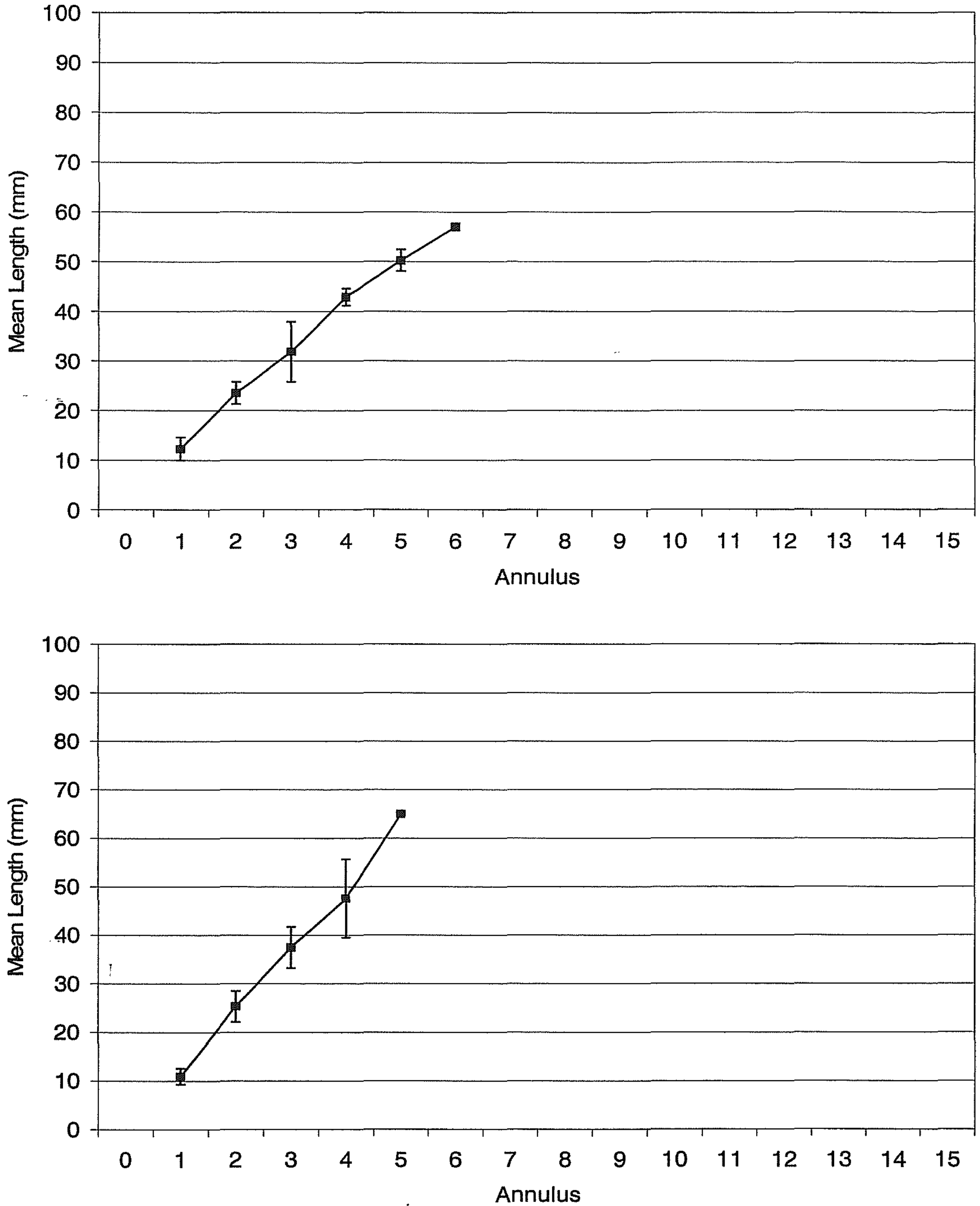


Figure 119. Mean length-at-annulus of softshells collected in Cachalot Inlet (top) and Amai Inlet (bottom), Kuyoquot Sound, July 10, 2002.

Error bars represent 95% confidence intervals.

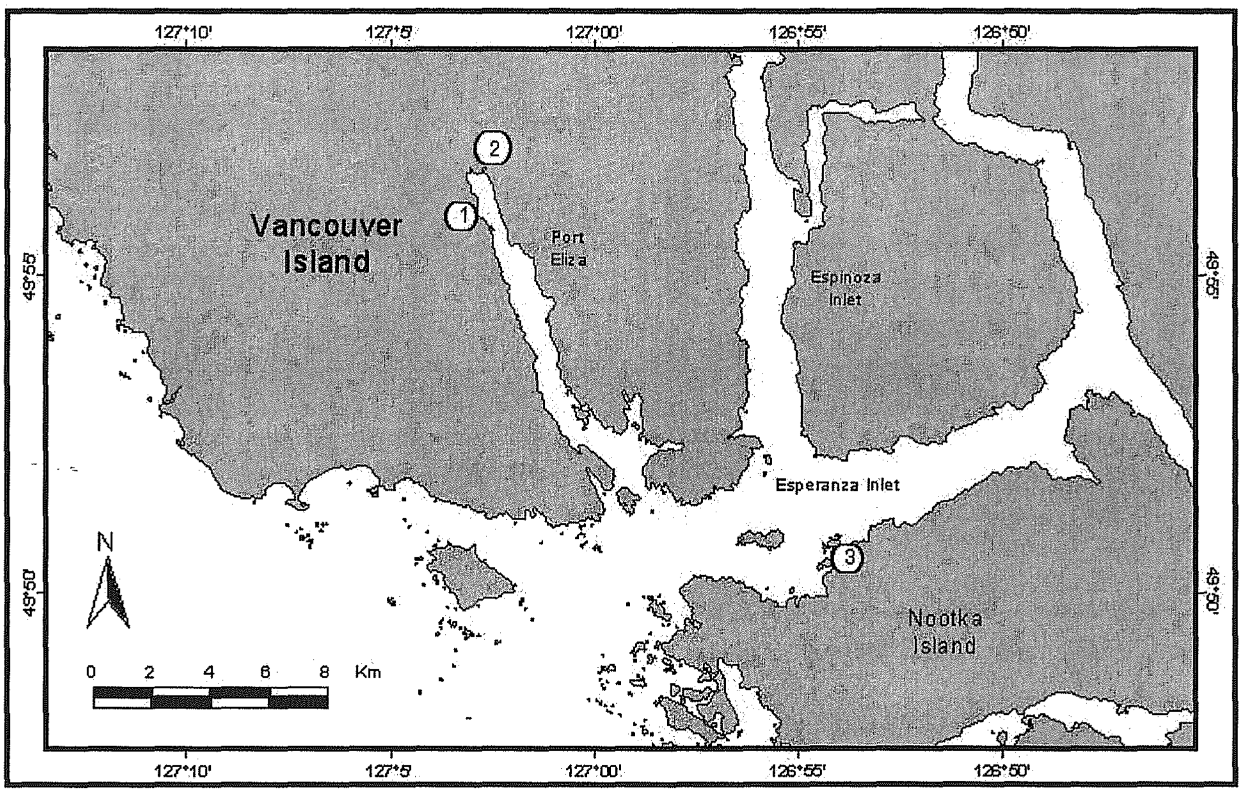


Figure 120. Locations of beaches surveyed in Esperanza Inlet, July 11, 2002.
Legend: 1 – Port Eliza 1; 2 – Port Eliza 2; 3 – Garden Point.

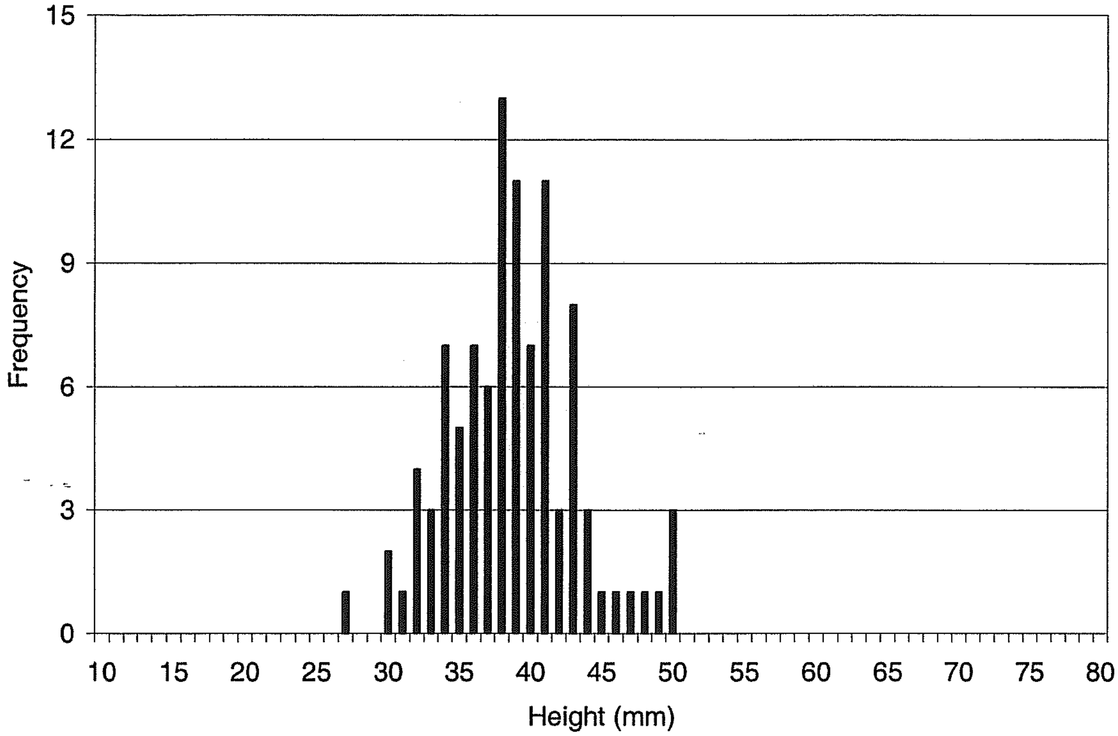


Figure 121. Height frequency distribution of Olympia oysters collected in Port Eliza, July 11, 2002.

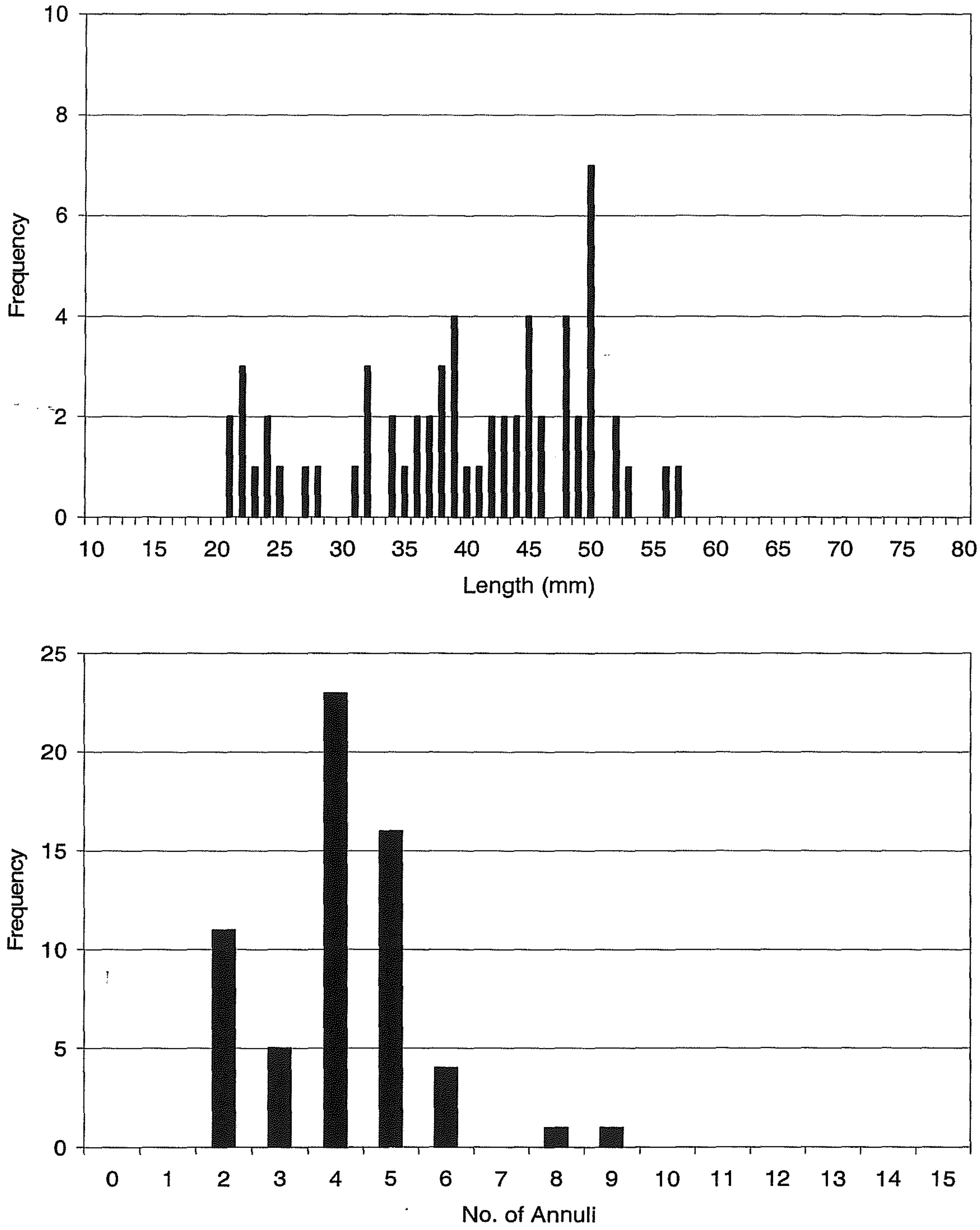


Figure 122. Length (top) and age (bottom) frequency distributions of Manila clams collected in Port Eliza, Esperanza Inlet, July 11, 2002.

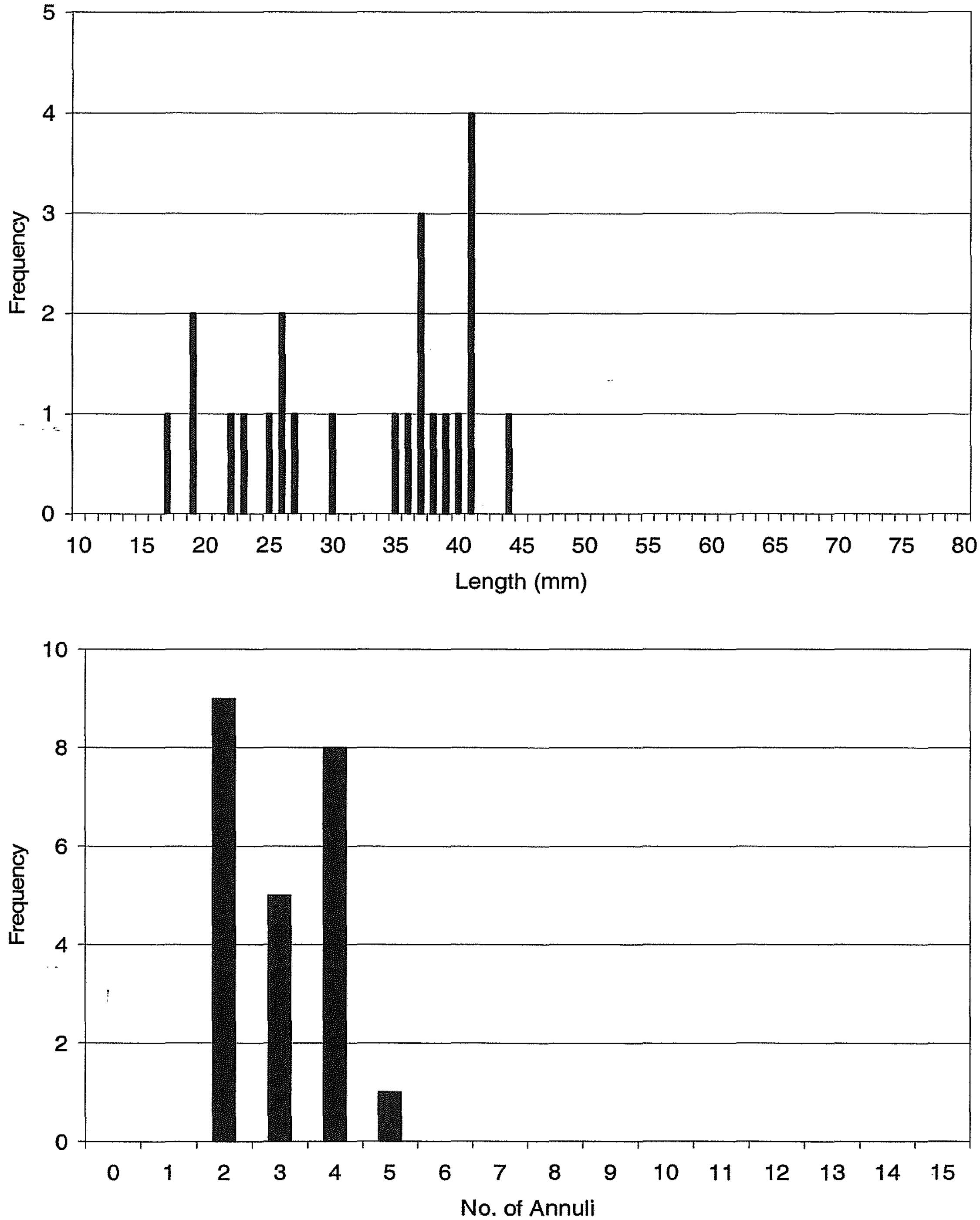


Figure 123. Length (top) and age (bottom) frequency distributions of Manila clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

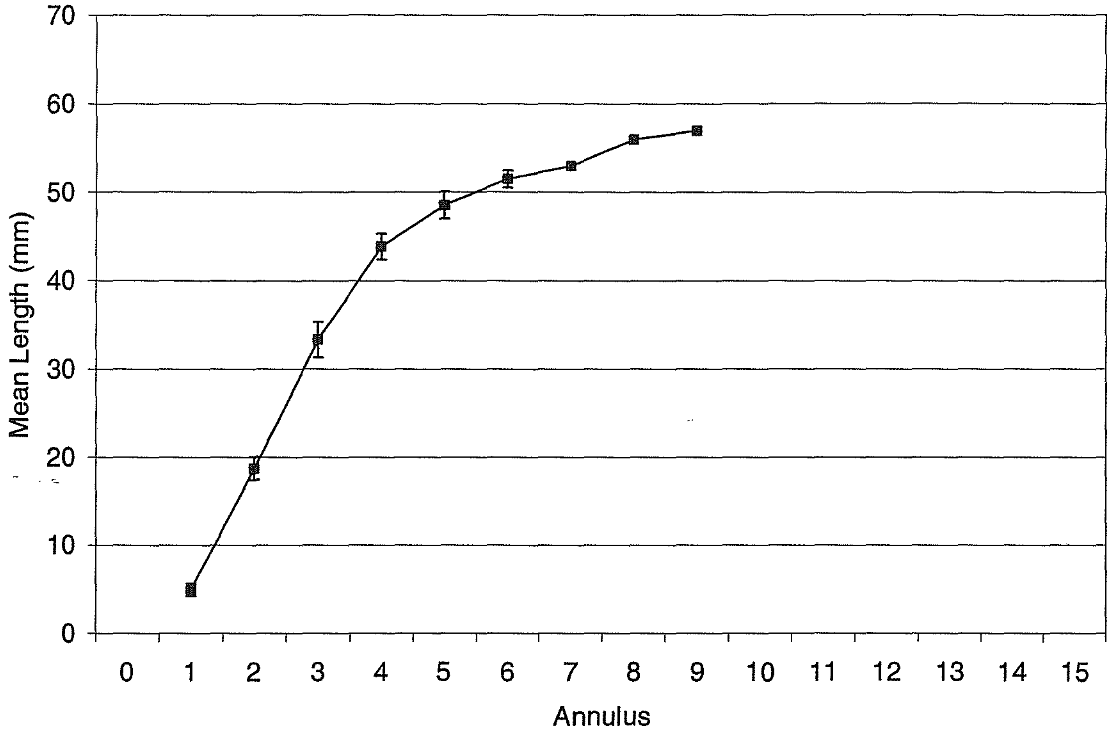


Figure 124. Mean length-at-annulus of Manila clams collected in Port Eliza, Esperanza Inlet, July 11, 2002.

Error bars represent 95% confidence intervals.

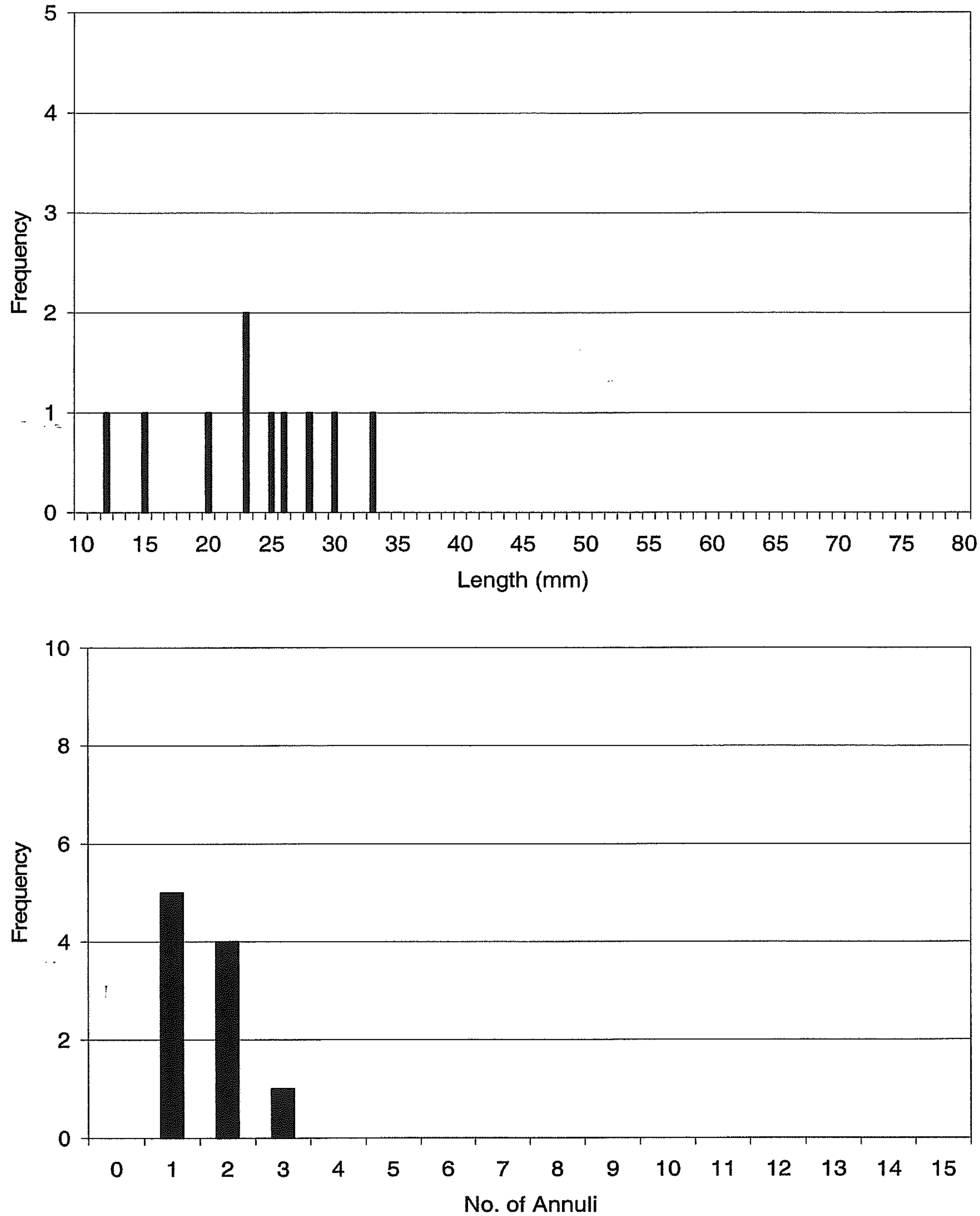
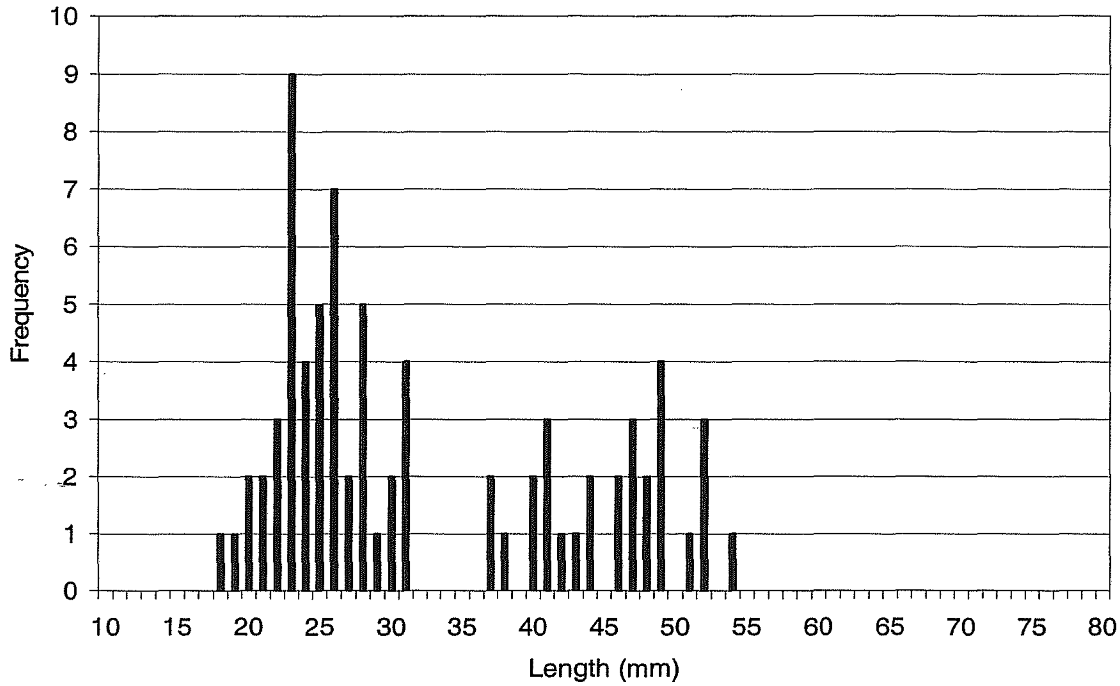


Figure 125. Length (top) and age (bottom) frequency distributions of varnish clams collected in Port Eliza, Esperanza Inlet, July 11, 2002.



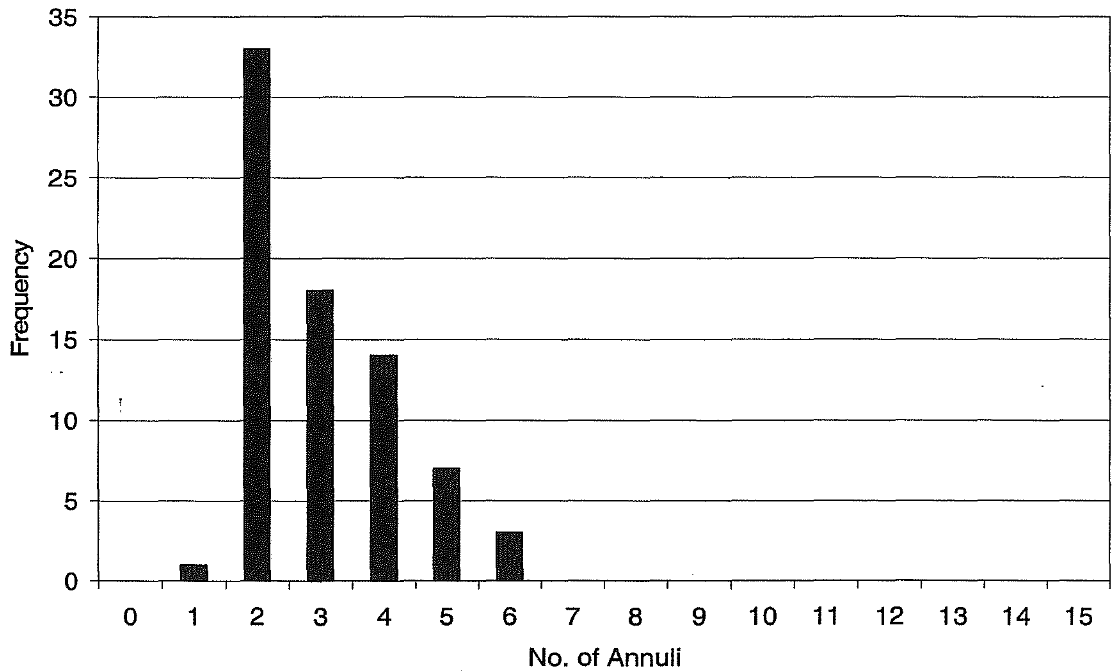


Figure 126. Length (top) and age (bottom) frequency distributions of varnish clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

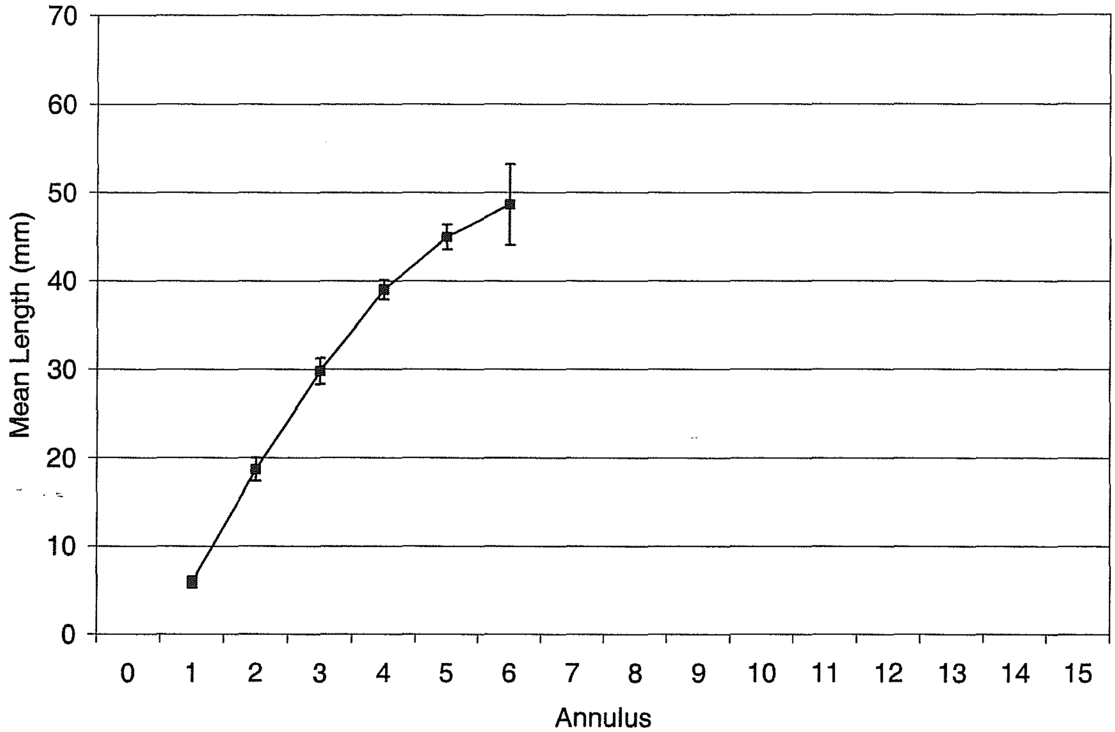


Figure 127. Mean length-at-annulus of varnish clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

Error bars represent 95% confidence intervals.

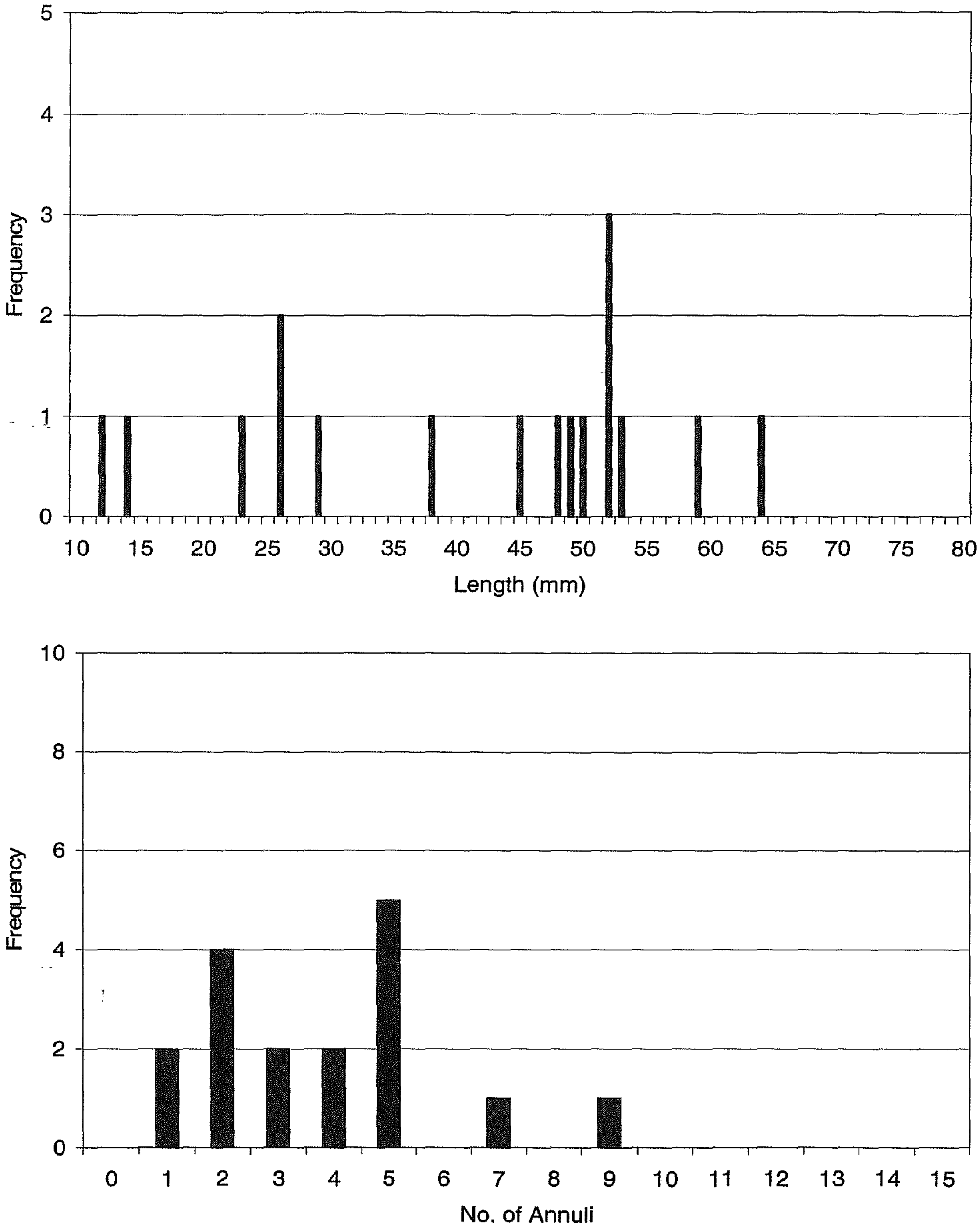


Figure 128. Length (top) and age (bottom) frequency distributions of littleneck clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

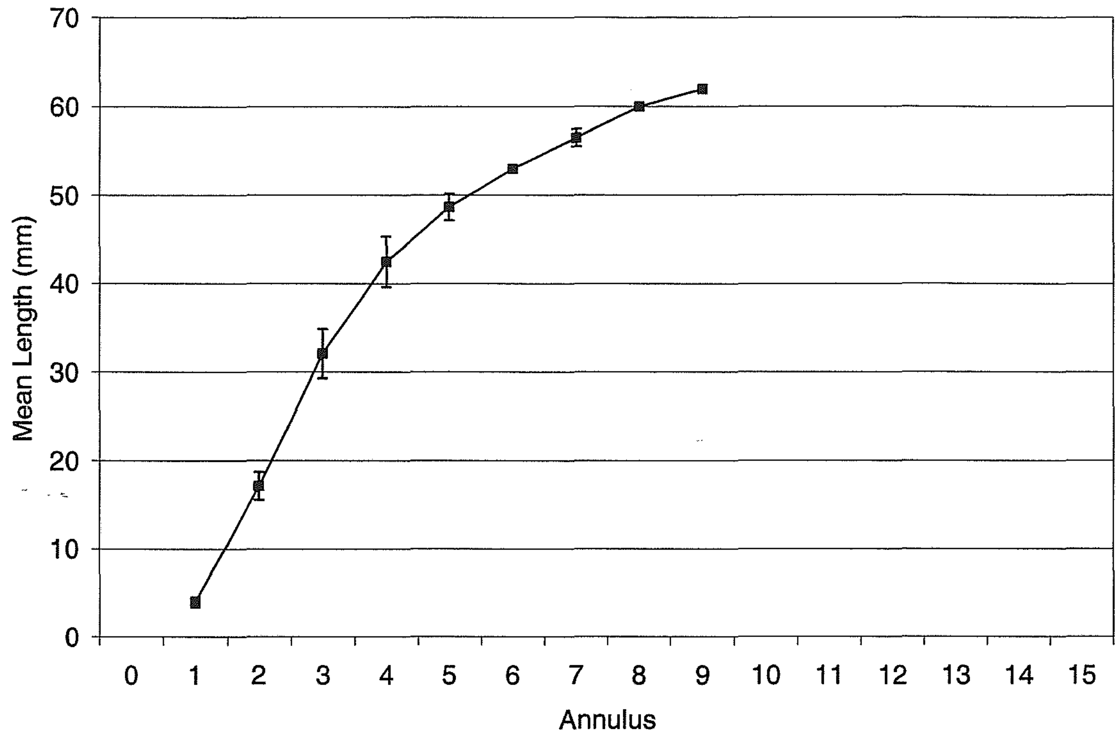


Figure 129. Mean length-at-annulus of littleneck clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

Error bars represent 95% confidence intervals.

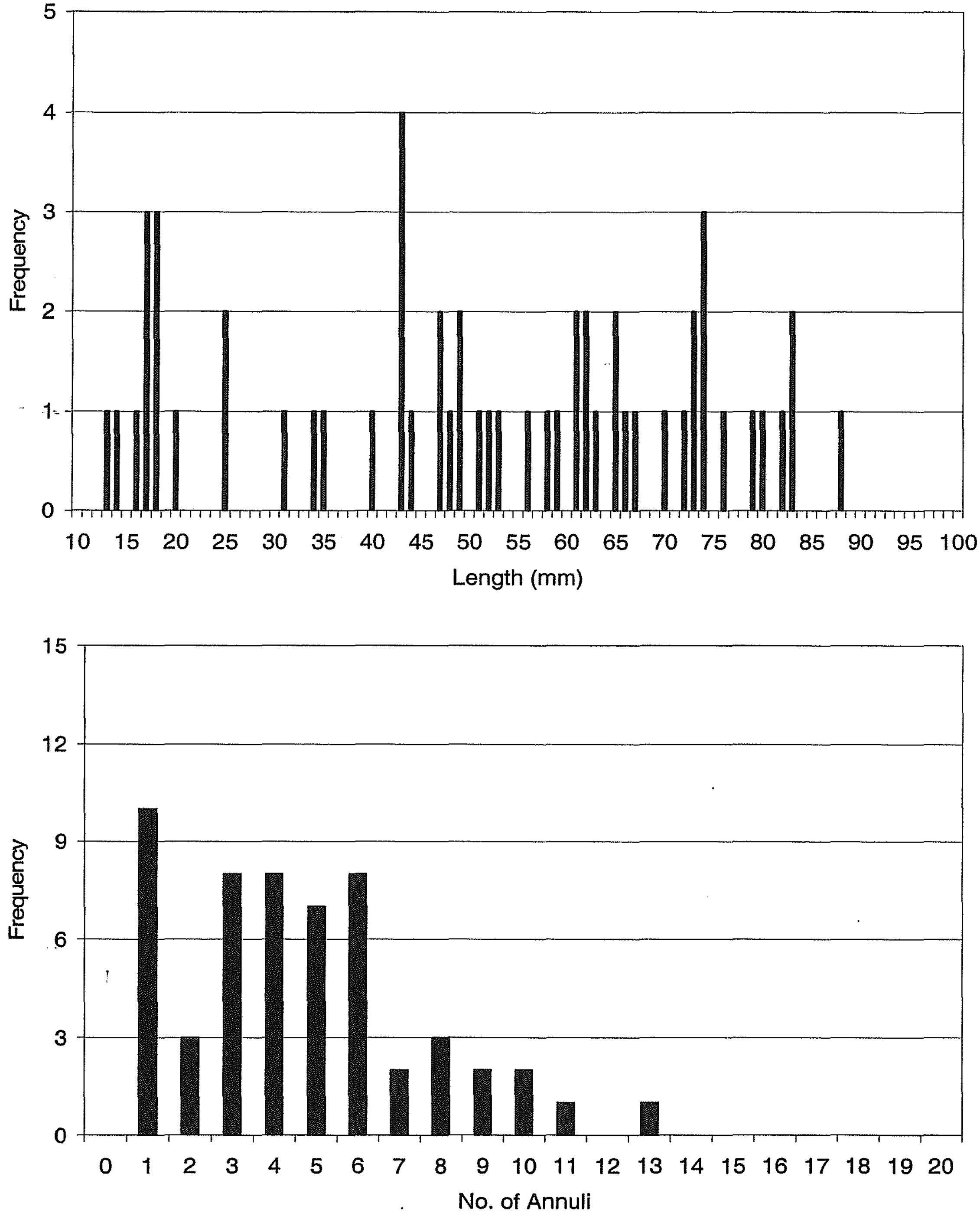


Figure 130. Length (top) and age (bottom) frequency distributions of butter clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

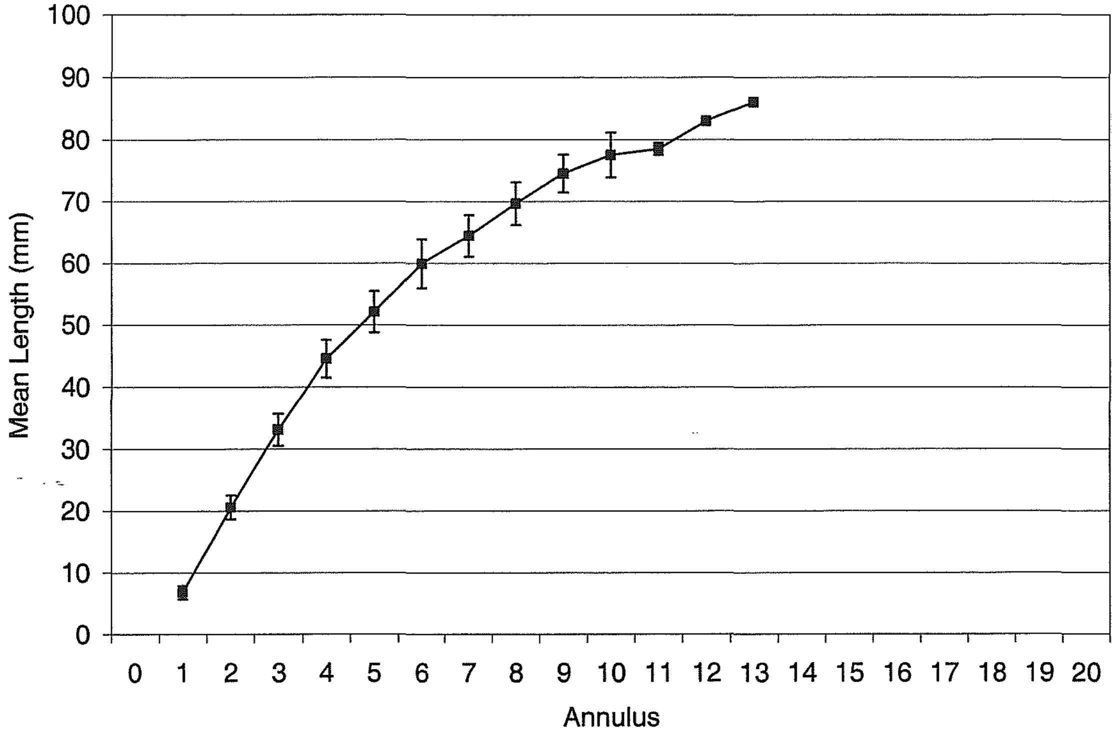


Figure 131. Mean length-at-annulus of butter clams collected at Garden Point, Esperanza Inlet, July 11, 2002.

Error bars represent 95% confidence intervals.

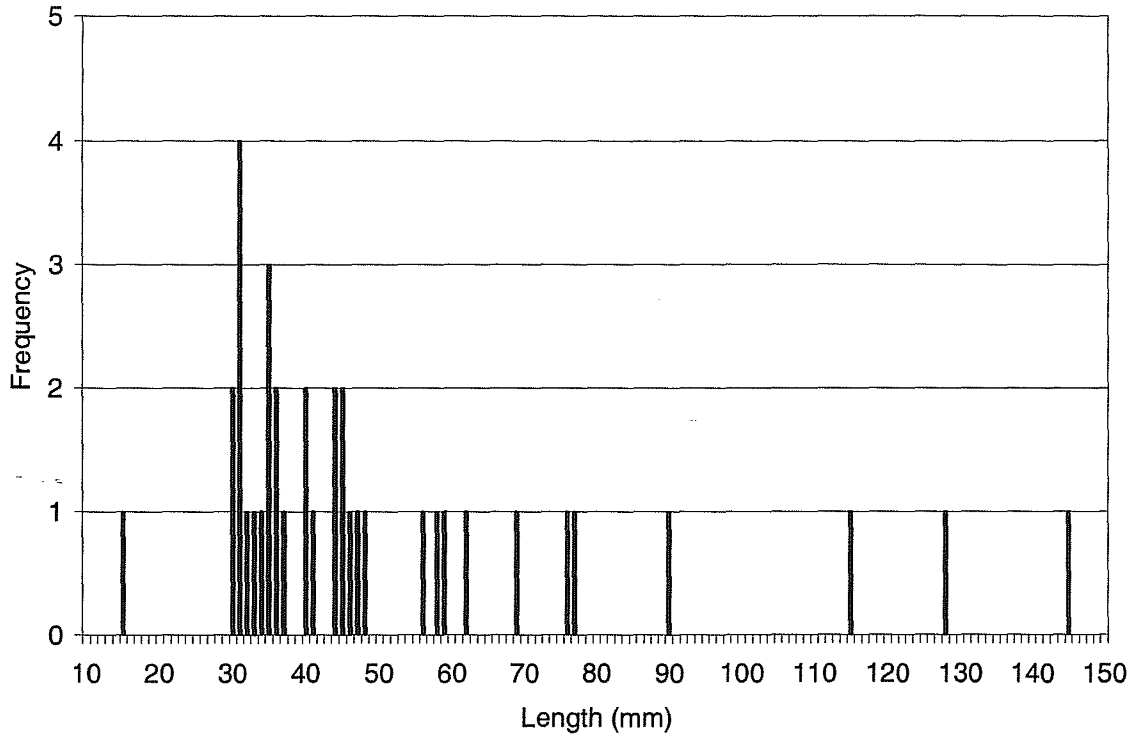
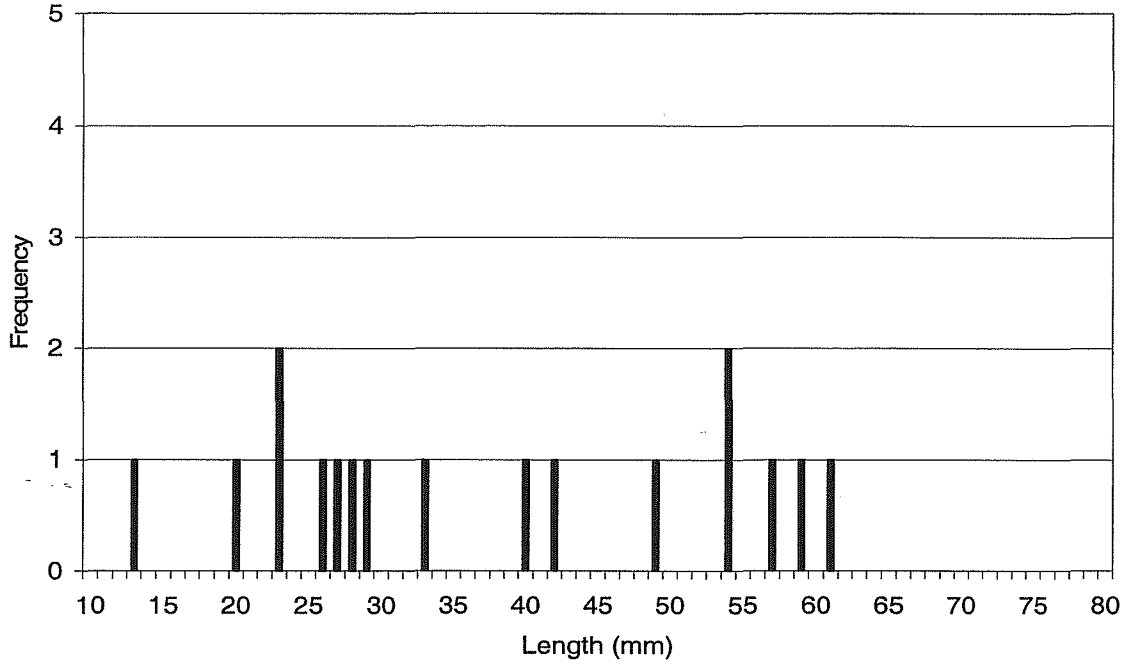


Figure 132. Length frequency distribution of horse clams (*T. capax* and *T. nuttallii*) collected at Garden Point, Esperanza Inlet, July 11, 2002.



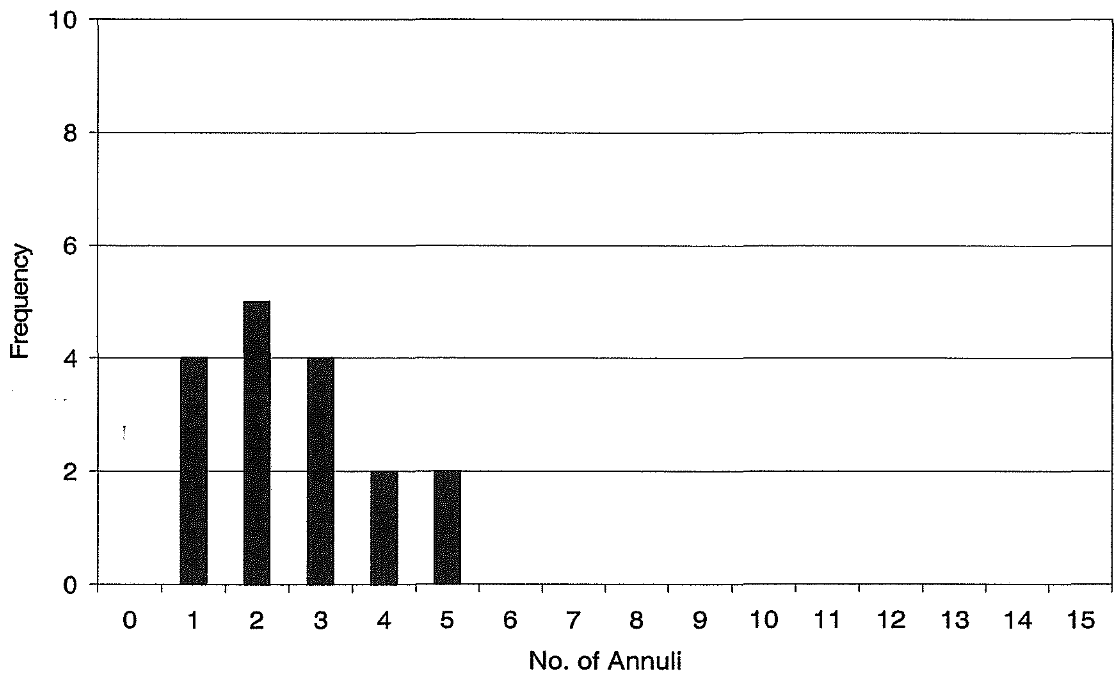


Figure 133. Length (top) and age (bottom) frequency distributions of softshells collected at Garden Point, Esperanza Inlet, July 11, 2002.

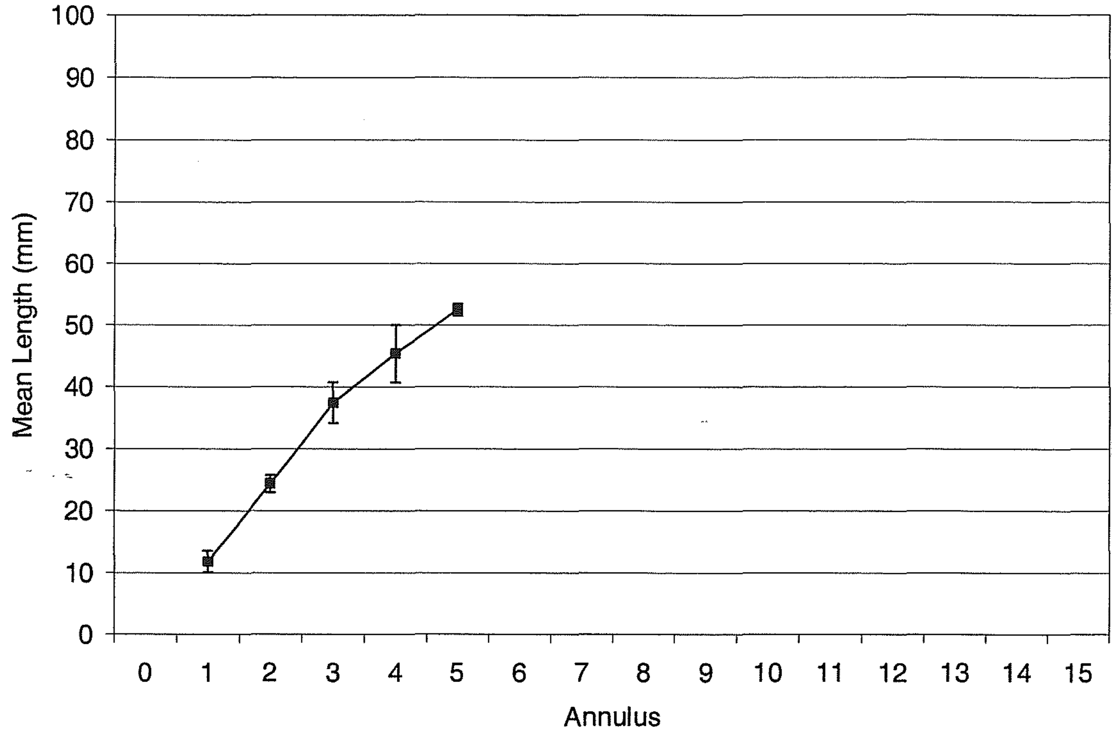


Figure 134. Mean length-at-annulus of softshells collected in Port Eliza (n=2) and at Garden Point (n=16), Esperanza Inlet, July 11, 2002.

Error bars represent 95% confidence intervals.

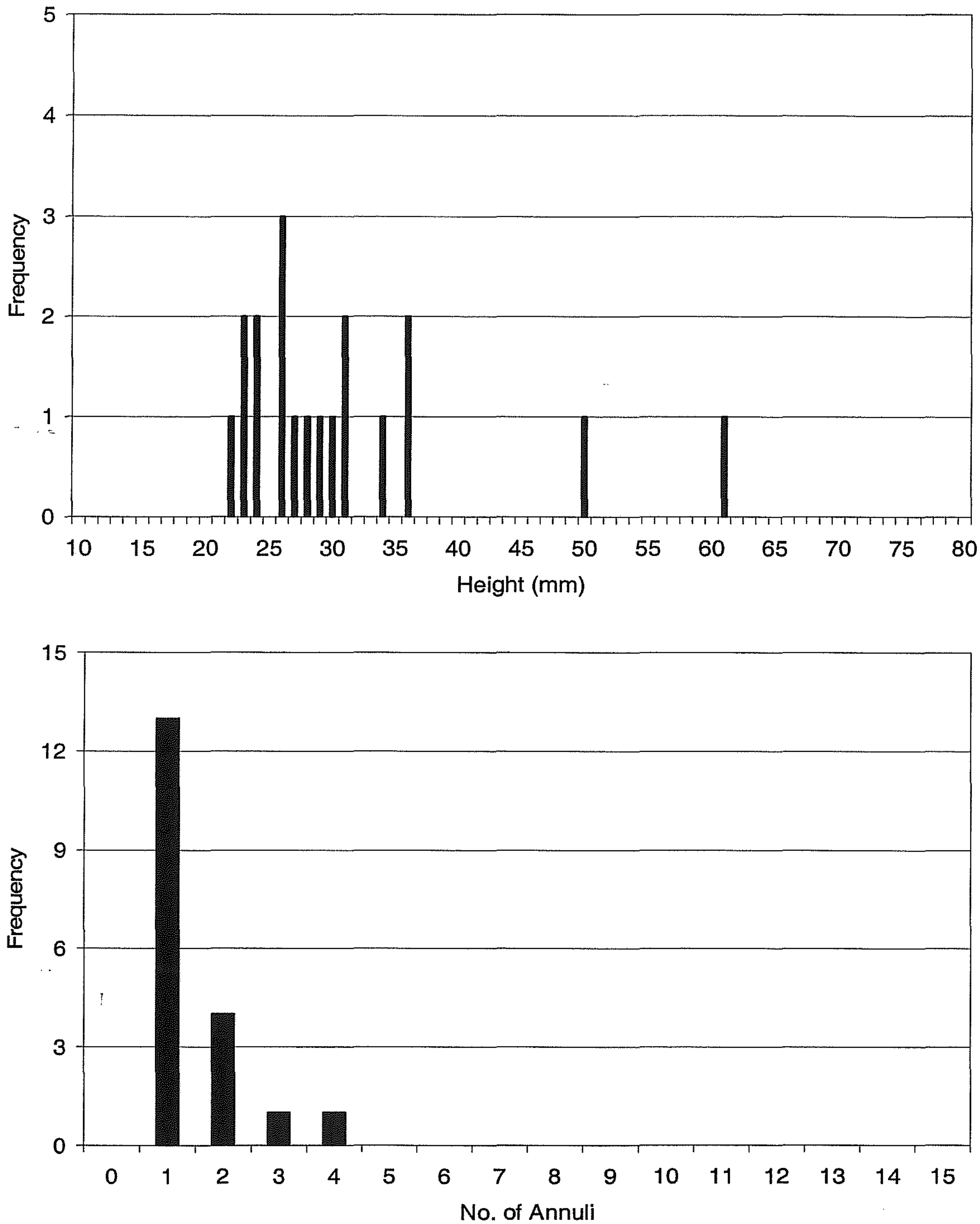


Figure 135. Height (top) and age (bottom) frequency distributions of cockles collected at Garden Point, Esperanza Inlet, July 11, 2002.

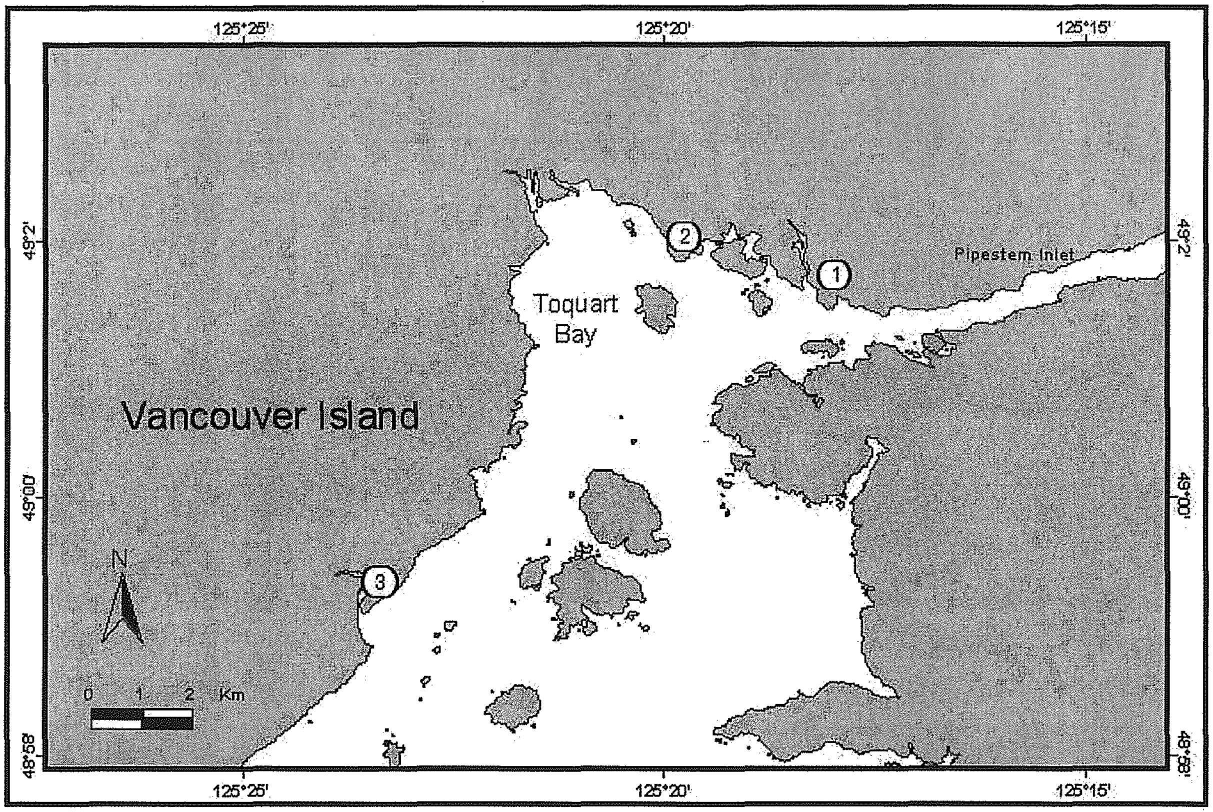


Figure 136. Locations of beaches surveyed in Toquart Bay, Barkley Sound, July 12, 2002. Legend: 1 – Lucky Creek, 2 – Hilleri Island; 3 – Maggie River estuary.

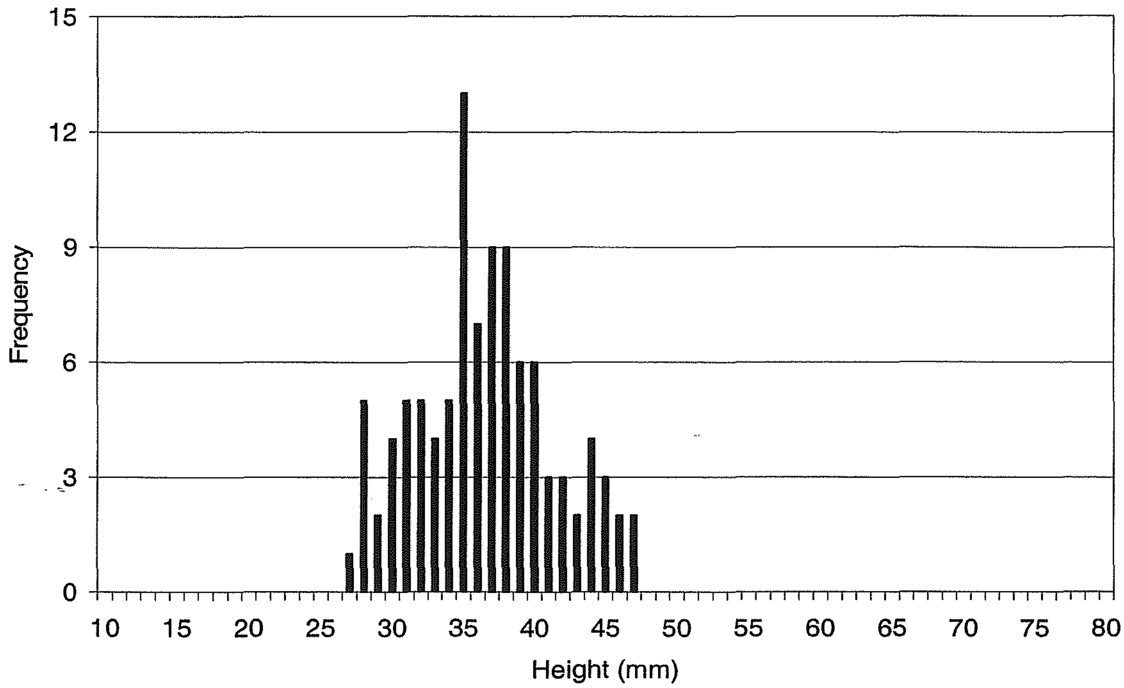


Figure 137. Height frequency distribution of Olympia oysters collected at Lucky Creek, Toquart Bay, July 12, 2002.

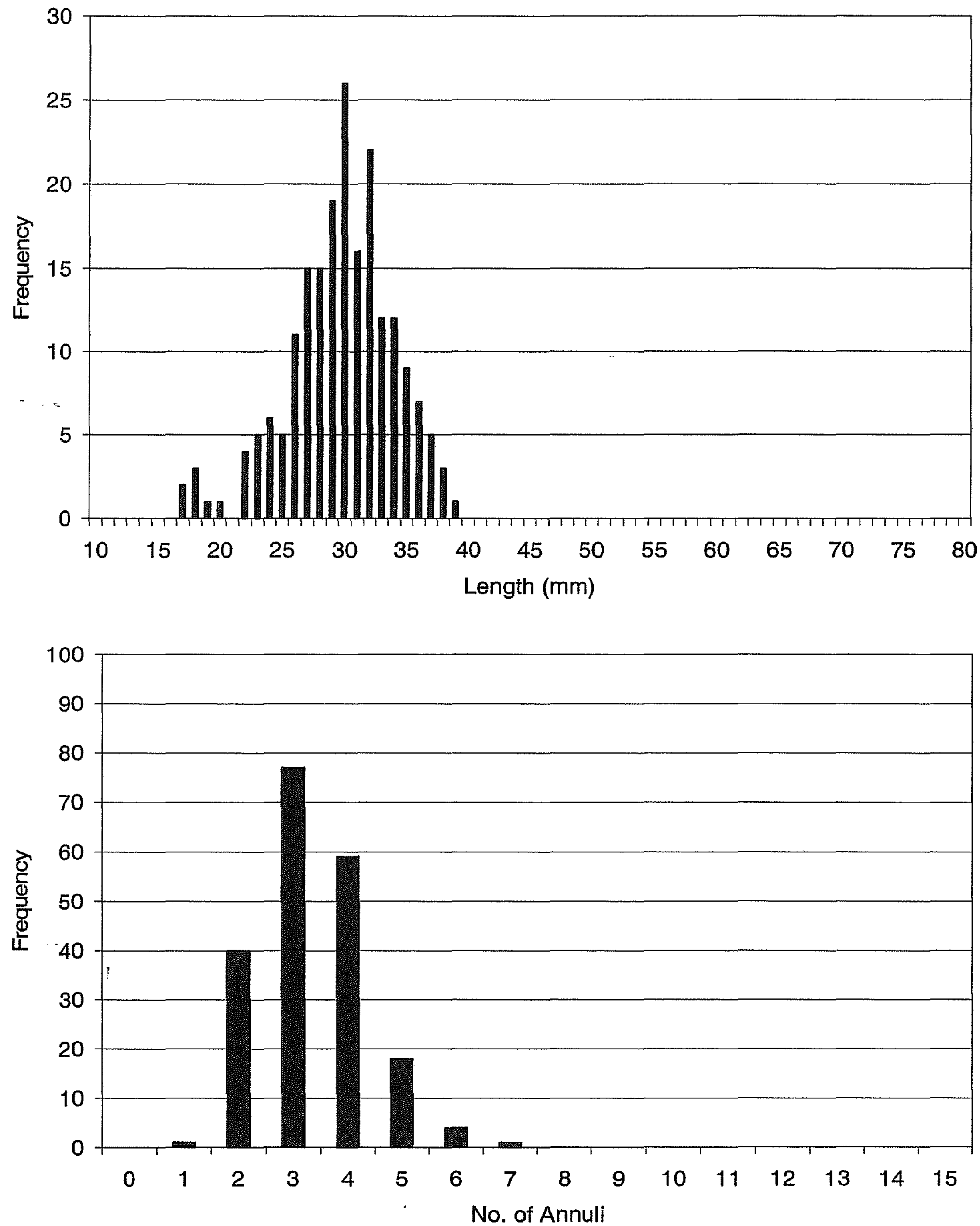
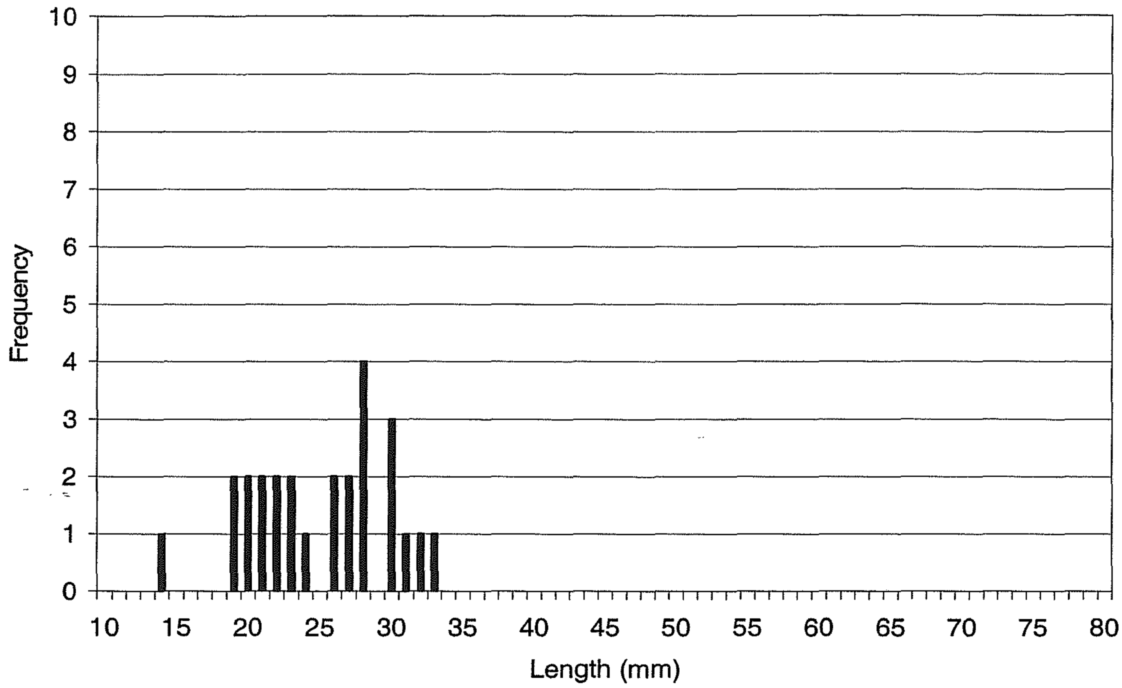


Figure 138. Length (top) and age (bottom) frequency distributions of Manila clams collected at Hillier Island, Toquart Bay, July 12, 2002.



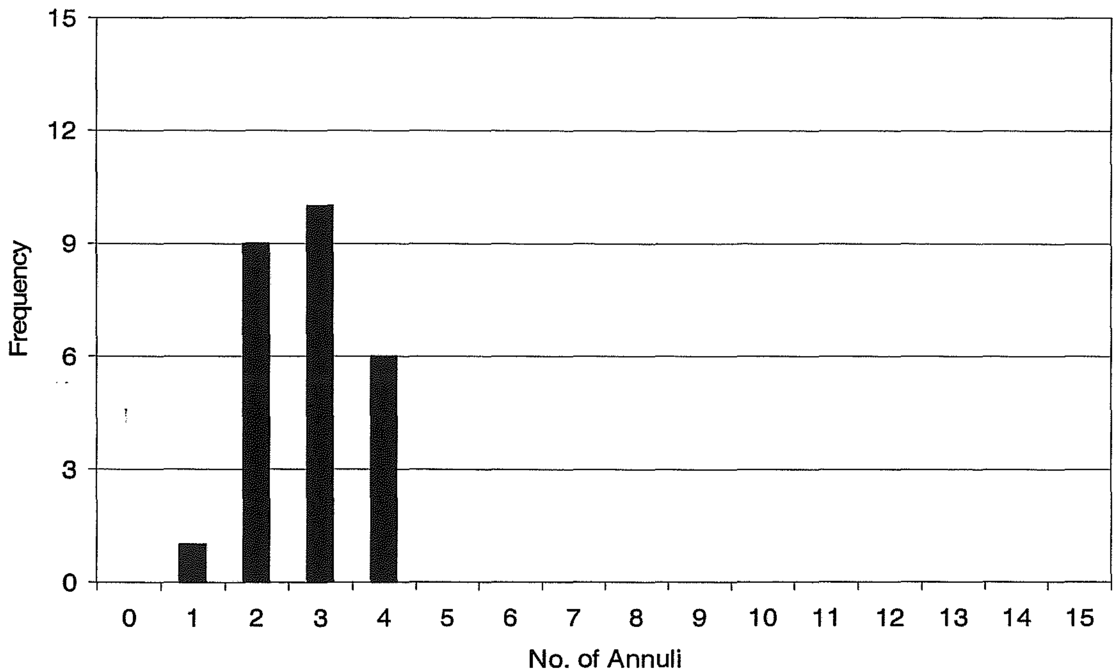
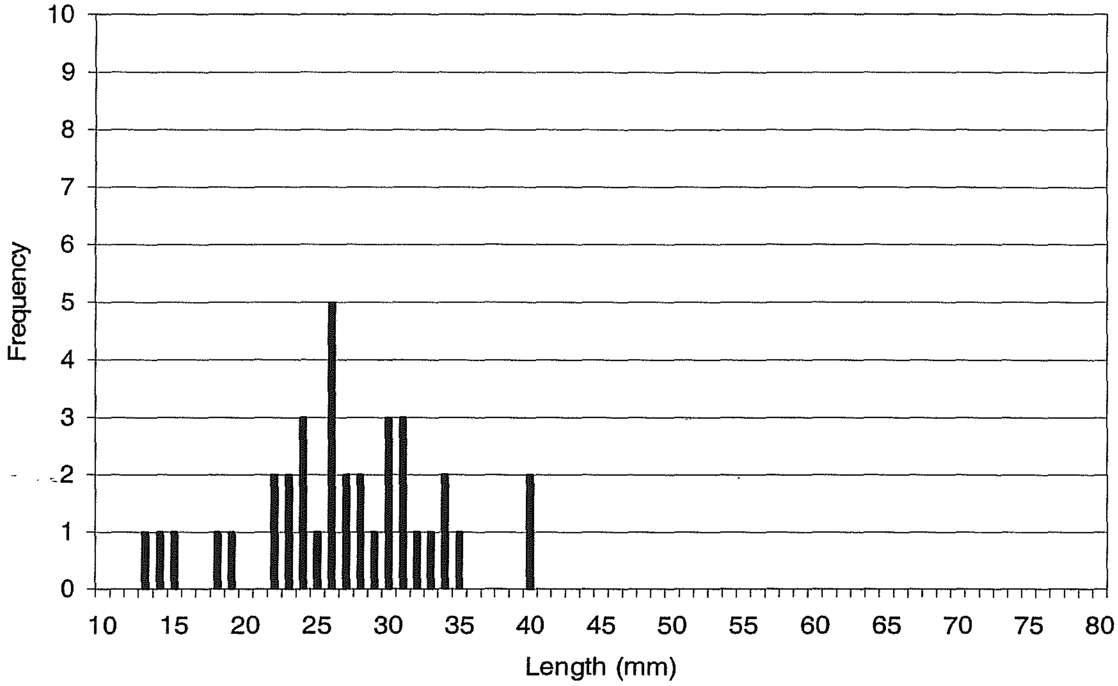


Figure 139. Length (top) and age (bottom) frequency distributions of Manila clams collected at Maggie River, Toquart Bay, July 12, 2002.



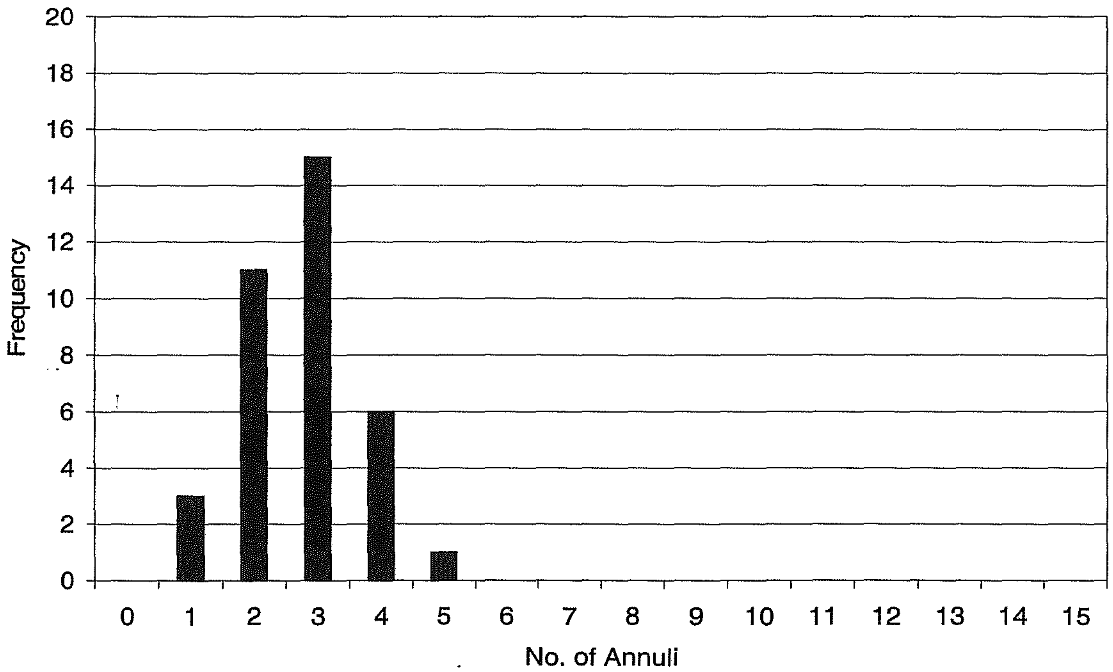


Figure 140. Length (top) and age (bottom) frequency distributions of varnish clams collected at Hillier Island, Toquart Bay, July 12, 2002.

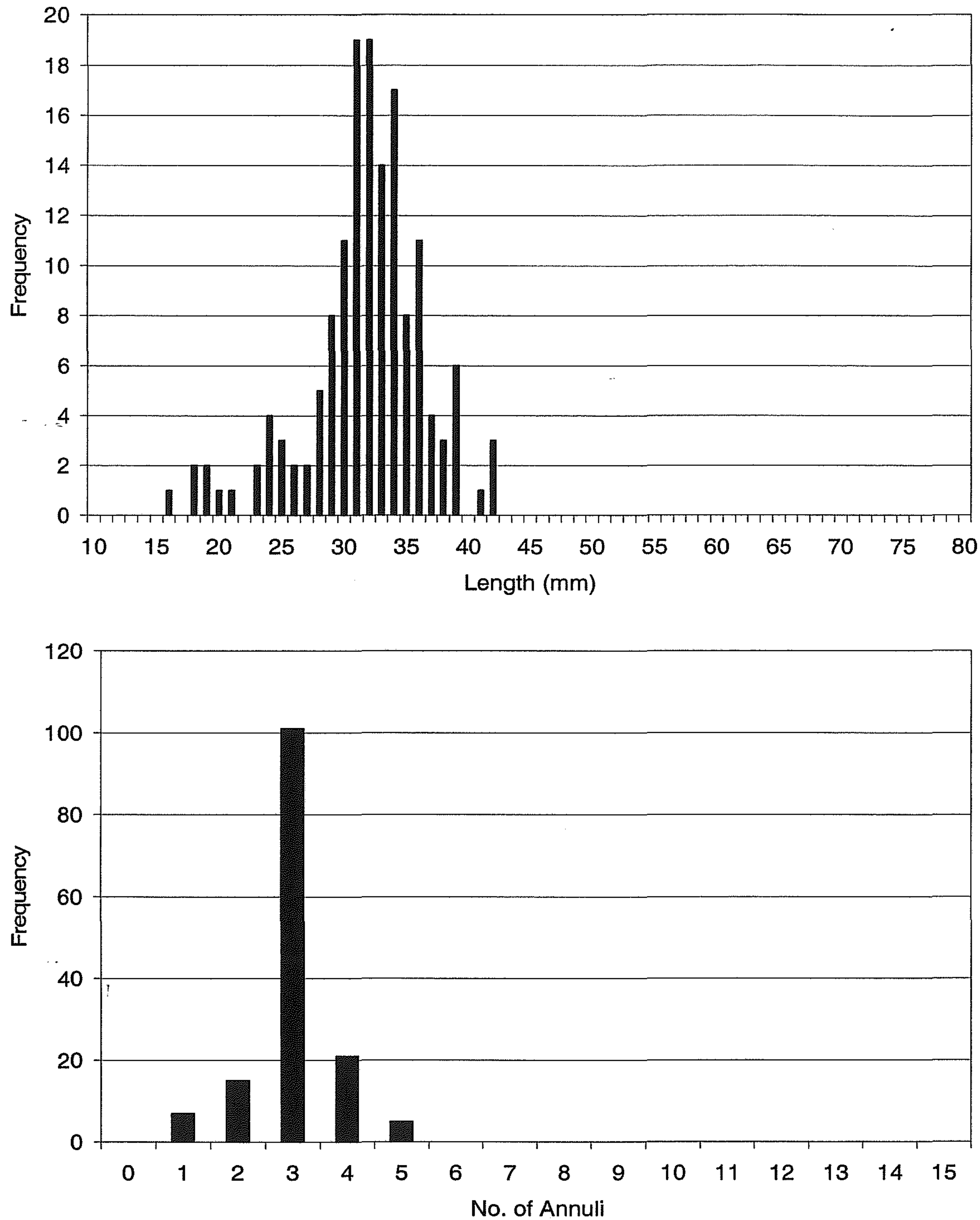


Figure 141. Length (top) and age (bottom) frequency distributions of varnish clams collected at Maggie River, Toquart Bay, July 12, 2002.

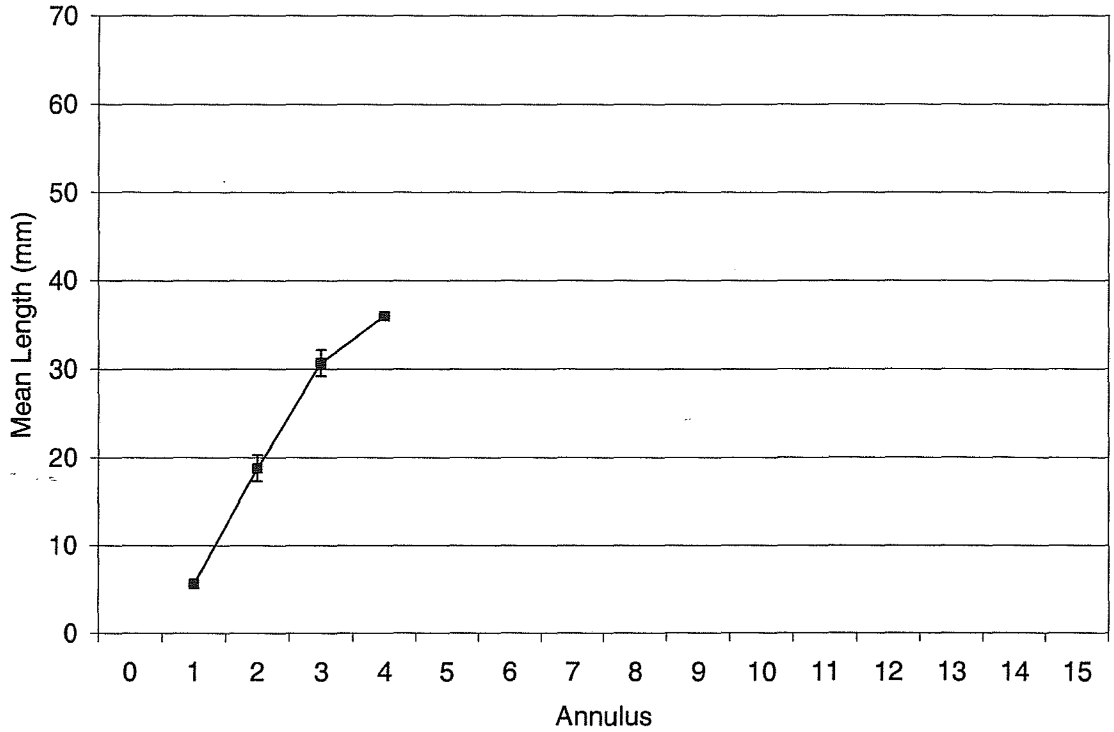


Figure 142. Mean length-at-annulus for varnish clams collected at Maggie River, Toquart Bay, July 12, 2002.

Error bars represent 95% confidence intervals.

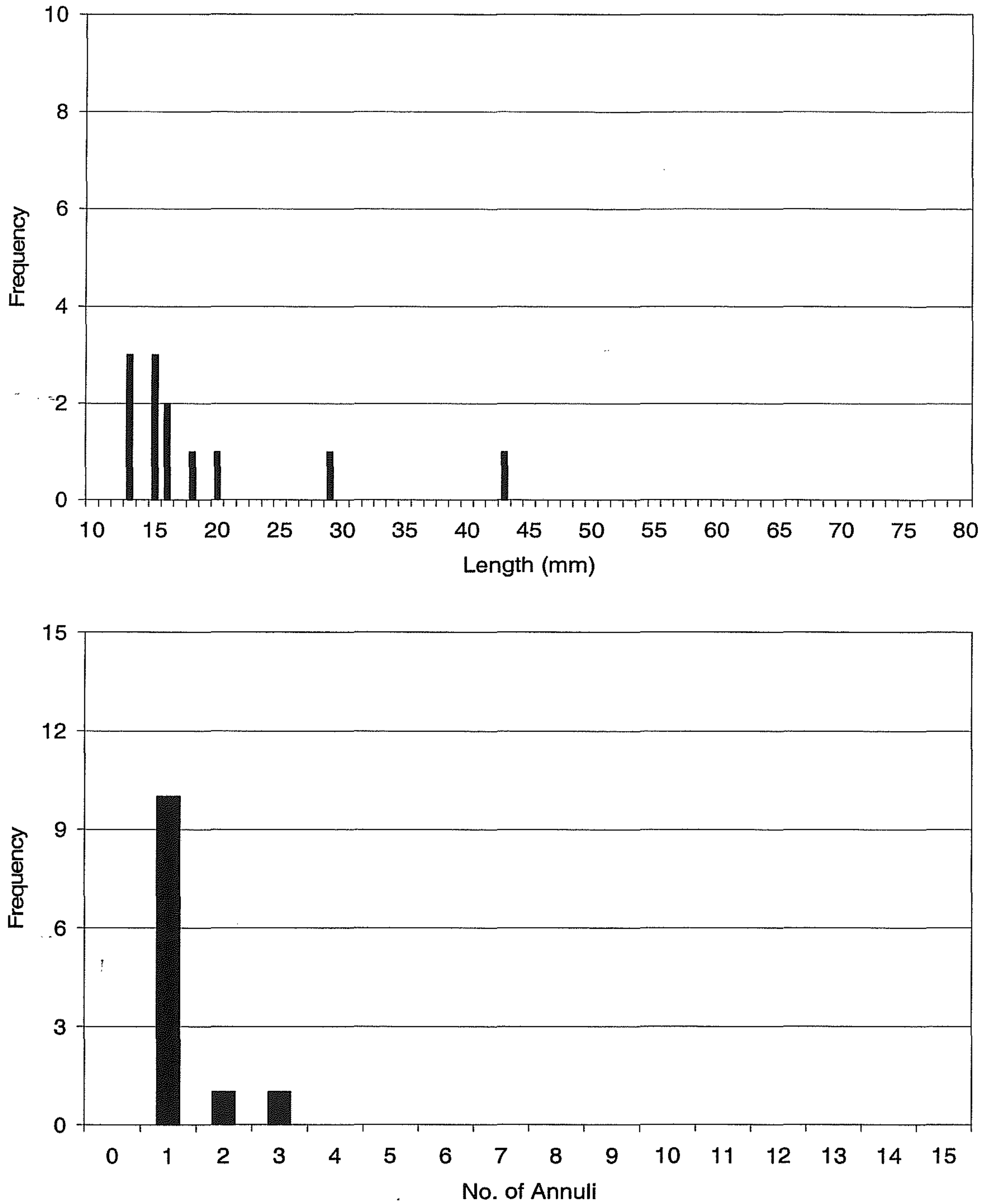


Figure 143. Length (top) and age (bottom) frequency distributions of softshells collected at Maggie River, Toquart Bay, July 12, 2002.

Appendix 1. Common and scientific names of organisms recorded on intertidal bivalve surveys in British Columbia in 2002.

Common name	Scientific name	Common name	Scientific name
	Bivalve Molluscs		
Feathery shipworm	*Bankea setacea*	Softshell clam	*Mya arenaria*
Cockle	*Clinocardium nuttallii*	Truncated softshell	*Mya truncata*
Pacific oyster	*Crassostrea gigas*	Varnish clam	*Nuttallia obscurata*
California sunsetclam	*Gari californica*	Olympia oyster	*Ostrea conchaphila*
Arctic hiatella	*Hiatella arctica*	Green false-jingle	*Pododesmus macrochisma*
Kellyclam	*Kellia suborbicularis*	Littleneck clam	*Protothaca staminea*
Baltic macoma	*Macoma balthica*	Butter clam	*Saxidomus gigantea*
Pointed macoma	*Macoma inquinata*	Hooked surfclam	*Simomactra falcata*
Bentnose macoma	*Macoma nasuta*	Fat horse (gaper) clam	*Tresus capax*
White sand macoma	*Macoma secta*	Pacific horse (gaper) clam	*Tresus nuttallii*
Blue mussel	*Mytilus edulis* complex	Manila (Japanese littleneck) clam	*Venerupis philippinarum*
California mussel	*Mytilus californianus*		
	Gastropods		
Lewis' moonsnail	*Euspira lewisi*	Dogwinkle	*Nucella* sp.
Dire whelk	*Lirobuccinium dirum*		
	Crustaceans		
Ghost shrimp	*Callianassa californiensis*	Red rock crab	*Cancer productus*
Graceful crab	*Cancer gracilis*	Green crab	*Carcinus maenus*
Dungeness crab	*Cancer magister*	Mud shrimp	*Upogebia pugettensis*
	Barnacles		
Acorn barnacle	*Balanus glandula*	Thatched barnacle	*Semibalanus cariosus*
	Echinoderms		
Leather star	*Dermasteris imbricata*	Giant pink star	*Pisaster brevispinis*
Sunflower star	*Picopodium helianthoides*	Purple star	*Pisaster ochraceus*
	Plants		
Rockweed	*Fucus gairdneri*	Sea lettuce	*Ulva* sp.
Eelgrass	*Zostera marina*		
	Fish		
Pacific sand lance	*Ammodytes hexapterus*	Flatfish	Pleuronectidae
Sculpins	Cottidae		

Sources: Coan *et al.* 2000; Druehl 2000; Harbo 1999; Hart 1982; Lambert 1997, 2000; Turgeon *et al.* 1998.