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Status of Manila Clam (*Venerupis philippinarum*) Stocks in Area 7, British Columbia, with a Proposal for Active Management of a Data-Limited Fishery

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ABSTRACT

The Area 7 intertidal clam fishery has been active since 1992, resulting in production of over 600 t of Manila clams, *Venerupis philippinarum*. The fishery was managed using arbitrary total allowable catches (TACs) of 113.6 t (250,000 lb) for each of Manila, littleneck, *Protothaca staminea*, and butter, *Saxidomus gigantea*, clams until review in 1999, when the TAC was reduced to 68.2 t (150,000 lb) for Manilas and the other two species were removed from the commercial fishery. An assessment program was developed in 1999 that identified important beaches within each subarea that were heavily harvested and these beaches were surveyed in both 1999 and 2000.

Four of five subareas assessed exhibited declines in biomass of legal sized clams from 1999 to 2000, as did the overall aggregate biomass of all index beaches in Area 7. This paper examines the application of the Magnussen-Stefansson feedback gain model to the first two years of data collected. Two options are discussed – adjustment of the overall Area 7 TAC based on the aggregate results, and establishment of harvest thresholds for individual subareas, which would allow opportunity to harvest the remainder of the TAC from underutilized subareas.

The paper recommends that managers consider adopting the second option (subarea thresholds), with a review of the appropriateness of index beaches currently assessed, establishment of index beaches in subareas not currently assessed, and that managers and harvesters acknowledge that continued reductions in subarea thresholds will require re-assessment of the overall Area 7 TAC.

RESUME

Une pêche de la palourde s'exerce dans la partie intertidale de la zone 7 depuis 1992, la production totalisant plus de 600 t de palourdes japonaises, Venerupis philippinarum. Elle a été gérée au moyen de totaux admissibles de captures (TAC) fixés de façon arbitraire à 113,6 t (250 000 lb) pour chacune des espèces, soit la palourde japonaise, la palourde du Pacifique, Protothaca staminea, et la palourde jaune, Saxidomus gigantea, jusqu'à leur révision en 1999, alors que le TAC a été réduit à 68,2 t (150 000 lb) pour la palourde japonaise et que les deux autres espèces ont été retirées de la pêche commerciale. Un programme d'évaluation mis sur pied en 1999 a permis d'établir les plages importantes dans chaque sous-zone où les captures étaient abondantes, et ces plages ont fait l'objet d'un relevé en 1999 et en 2000.

Dans quatre des cinq sous-zones, la biomasse des palourdes de taille réglementaire a diminué de 1999 à 2000, à l'instar de la biomasse globale à toutes les plages repères de la zone 7. Cet article examine l'application du modèle à gain rétroactif de Magnussen-Stefansson aux deux premières années de collecte de données. Deux options y sont discutées : l'ajustement du TAC pour l'ensemble de la zone 7 en fonction des résultats globaux et l'établissement de seuils de récolte pour chaque sous-zone, ce qui permettrait de récolter le reste du TAC des sous-zones sous-utilisées.

Enfin, il est recommandé que les gestionnaires envisagent d'adopter la seconde option (seuils pour les sous-zones), vérifient dans quelle mesure les plages repères actuellement évaluées sont appropriées et établissent des plages repères dans les sous-zones qui ne sont pas actuellement évaluées, d'une part, et que les gestionnaires et les pêcheurs reconnaissent que des réductions continues des seuils dans les sous-zones nécessiteront une nouvelle évaluation du TAC pour l'ensemble de la zone 7, d'autre part.

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INTRODUCTION

Intertidal clams have long been a traditional food source for First Nations people in British Columbia (B.C.), and have supported commercial fisheries since the late 1800s (Quayle and Bourne 1972). In the late 1970s, market demand in the commercial fishery shifted to live steamer clams, both Manila, *Venerupis philippinarum*, and native littleneck, *Protothaca staminea*, clams from the traditional fishery for butter clams, *Saxidomus gigantea*. The intertidal clam fishery currently concentrates on Manila clams, with relatively minor landings of littlenecks, butters and razor clams, *Siliqua patula* (Figure 1). There is also interest in developing a fishery for recently introduced exotic varnish clams, *Nuttallia obscurata* (Gillespie *et al*. 1999b).

Intertidal clam fisheries in the North Coast of B.C., Pacific Fisheries Management Areas (PFMA) 1-10 (Figure 2), were closed in 1963 due to Paralytic Shellfish Poisoning (PSP), and the lack of monitoring programs to detect hazardous algal blooms and elevated levels of faecal contamination. Exploratory surveys conducted in the 1990s identified significant populations of Manila clams that might support commercial harvest (Bourne and Cawdell 1992; Bourne *et al*. 1994; Heritage *et al*. 1998). The pilot Manila clam fishery in Area 7 exists through special arrangements for water quality certification and monitoring (Gillespie *et al*. 1999a). Production from this fishery is small relative to total B.C. landings (Figure 3), but is very important to this relatively remote coastal community.

This report reviews recent performance of the Manila clam fishery in Area 7, reviews survey efforts by the Heiltsuk Fisheries Program (HFP), characterises stock status, assesses the effect of the fishery on stock status, and provides recommendations for continuation of a sustainable Manila clam fishery in the area.

MANILA CLAM BIOLOGY

Manila clams, also called Japanese littlenecks, are exotics to British Columbia. The first specimens found in Ladysmith Harbour in 1936 (Quayle 1964) were described as a new species, *Paphia bifurcata* (Quayle 1938). It was decided they were accidentally introduced into British Columbia with seed of the Pacific oyster, *Crassostrea gigas*, from Japan (Quayle 1941; Bourne 1982). They quickly spread throughout Georgia Strait and, after introduction into Barkley Sound, spread up the west coast of Vancouver Island (Quayle 1964). Intentional introductions in the North Coast and Queen Charlotte Islands failed to produce sustainable populations (Gillespie and Bourne 1998). Recruitment into the Central Coast is believed to have resulted from larvae from Quatsino Sound (Bourne 1982).

In the South Coast, Manila clams soon became economically important and were gradually accepted by the commercial fishery (Quayle and Bourne 1972). Landings increased dramatically in the 1980's and peaked in 1988 at 3,909 t (Figure 1). Landings subsequently decreased, and currently are stable at around 1,300 t/yr (commercial harvests not including aquaculture production). Decreased landings are a result of more restrictive management measures in response to concerns of overharvest, decreased opportunity due to toxic algal blooms and loss of beaches to faecal contamination (Webb and Hobbs 1997). Exploratory surveys in the early 1980's first found Manila clams in the area around Waglisla, and subsequent surveys have attempted to define the northern limit of their distribution in B.C., presently the head of Laredo Inlet, 52°59'N (Gillespie and Bourne 2000).

Manila clams are found in the upper half of the intertidal zone in B.C., in mixed substrates of mud, sand and gravel (Quayle 1960). No subtidal populations of Manila clams have been found in B.C. (Bernard 1983). They live shallow in the substrate, and are susceptible to extremes of temperature, including catastrophic mortalities ("winter kills"). These occur when low tides coincide with low air temperatures and strong winds (Bower *et al*. 1986; Bower 1992).

Sexes are separate and at spawning, gametes are released into the water column, where fertilization occurs. Spawning usually occurs between June-September in the Strait of Georgia (Bourne 1982). The planktonic period is approximately three to four weeks, depending upon temperature and availability of food, after which larvae settle and take up an infaunal existence. Recruitment, the introduction of adults into a population, is variable due primarily to environmental conditions (Bourne 1982; Quayle and Bourne 1972). Size at first maturity is 20-25 mm total length (TL) (Holland and Chew 1974). Fecundity increases with size, with estimates ranging from 432,000 eggs/female at 20 mm TL to 2,350,000 eggs/female at 40 mm TL for a population in Hawaii (Yap 1977), and 188,000 eggs/female at 19 mm TL to 1,503,000 eggs/female in China (Ponurovsky and Yakovlev 1992). Maximum size of 75 mm TL occurs after 8-10 years, and maximum age in B.C. is 14 years (Bourne 1987). Age at recruitment to legal size (38 mm total length [TL]) varies from beach to beach and between areas on a single beach, depending on tidal height and substrate conditions. Under optimal conditions, Manila clams can reach legal size in approximately 3-4 years in Georgia Strait (Quayle and Bourne 1972; Bourne 1982), 4 years on the west coast of Vancouver Island (Bourne and Farlinger 1982), and 3-4.5 years in the Central Coast (Bourne and Cawdell 1992; Bourne *et al*. 1994; Bourne and Heritage 1997; Heritage *et al*. 1998).

Warmer water temperatures in the South Coast have allowed Manila clams to become established there (Bourne 1982). However, even in the South Coast, Manila clam recruitment can be irregular (Gillespie *et al*. 1998; Gillespie 2000). Early surveys in Area 7 indicated that recruitment was erratic, and that close management would be required to ensure a sustainable fishery (Bourne and Cawdell 1992; Bourne *et al*. 1994; Heritage *et al*. 1998).

THE AREA 7 MANILA CLAM FISHERY

In 1988, the Heiltsuk Tribal Council (HTC) requested that the possibility of establishing a clam fishery in the North Coast be examined. Exploratory surveys conducted by DFO in 1990 (Bourne and Cawdell 1992) indicated that there were harvestable densities of Manila clams on beaches in the Waglisla area. Based on this information, and after consultation with the HTC, DFO established a pilot communal commercial fishery for the Heiltsuk First Nation in selected subareas within Area 7 (Figure 4).

Management Framework

In 1993, the Heiltsuk Clam Fishery Agreement was drafted and ratified, allowing for a framework for co-operative management of a pilot fishery and covered aspects of licencing, regulation, monitoring, PSP sampling and enforcement. This document was a sub-agreement to the main Fisheries Agreement and was amended in subsequent years until its expiration on March 31, 1999.

Under the original clam agreement, participation in the fishery was restricted to 75 Heiltsuk First Nation members, with 50 of those participating in Manila harvest and 25 in littleneck harvest. As with diggers in the South Coast, they are required to carry a Fishers' Registration Card while harvesting as well as a licence issued by the HTC. Size limits in the fishery are consistent with regional standards, as are requirements for tagging of sacks and wet storage of clams. Clams are harvested during low tides, which in the winter are primarily early in the morning or late at night. The processing plant in Waglisla receives all harvests and they are marketed through buyers in the South Coast. Through an enforcement protocol set out in the main fisheries agreement, monitoring and enforcement of the fishery is done primarily by Heiltsuk Guardians, with local C&P staff providing expertise in enforcement when required.

Management plans included total allowable catches (TACs) of 113.6 t (250,000 lb) for each of three species: Manila, littleneck and butter clams. However, landings have been almost exclusively Manilas. Little interest was shown in landing littleneck clams, and none in butter clams. The lack of interest was primarily economic; prices offered for littleneck and butter clams were less than Manilas, and fishers declined to fish for the prices offered (HFP 1998). In 1993/94, 1994/95 and 1996/97, pre-harvest samples of butter clams indicated PSP levels above human health standards, and the butter fishery was postponed (HFP 1994, 1995, 1997). Similar problems affected some subareas in 1995/96 (HFP 1996).

The comanagement plan developed by the HTC and DFO requires the HTC to provide catch, effort and assessment information on Manila, littleneck and butter clams in the areas open to harvesting. Survey work was carried out by HFP, in consultation with DFO Stock Assessment, but documentation and results of these surveys were not forwarded to DFO, and inconsistencies in methods and documentation limited the utility of the survey results (Gillespie *et al*. 1999a). Catch and effort reporting similarly suffered due to lack of continuity in standards and methods.

In 1996, an amending agreement required that quota recommendations be developed and reviewed through the Pacific Stock Assessment Review Committee (PSARC). In 1998, after reading statements in the HFP annual report, DFO Fish Management questioned whether the 113.6 t (250,000 lb) quota was sustainable. At that time, little information on stock status was available from either DFO or HFP to evaluate sustainability. Because the Heiltsuk were suggesting that new subareas needed to be opened to sustain harvest levels, DFO managers were concerned that the open areas for the fishery may have been depleted, and that the fishery was not sustainable. Managers were particularly concerned that beaches in subareas closest to Waglisla had experienced the heaviest harvesting pressure, and that recruitment and growth rates had not been sufficient to offset fishery removals.

Gillespie *et al*. (1999a) reviewed all information on stock status and fishery performance that were available at that time. Recommendations of that review included:

- Managers consider reducing the annual Manila clam quota from the preliminary estimate of 113.6 t (250,000 lbs) to a level that reflects a more realistic expectation based on historic production;
- The HFP continue their stock assessment program with annual assessment of index beaches from each subarea harvested;
- DFO and HFP develop a harvest log card that would allow assignment of catch and effort to each subarea harvested in each delivery; and
- Catch and effort be monitored by subarea during the fishery and effort re-distributed should concerns arise in any subarea.

As a result of this review, and through consultation with the HTC, a number of changes were instituted for the 1999/2000 fishery.

Target Species

Managers chose to remove littleneck and butter clams from the fishery following the 1998/1999 season. Landings of littleneck clams were extremely limited, primarily due to lower market demand and thus lower prices offered for littlenecks (Gillespie *et al*. 1999a). Butter clams had never been landed in the fishery, again in part due to lower market demand. Managers restricted commercial opportunities to Manila clams, reserving littleneck and butter clams for Food, Social and Ceremonial use.

TAC Reduction

Managers reduced the annual Manila clam quota from 113.6 t to 68.2 t (150,000 lbs) for the 1999/2000 season. Reduction of the original quota was based on stock assessment work by the HFP in conjunction with DFO (Gillespie *et al*. 1999a). The original TAC was not based on quantitative assessments and therefore was arbitrary in nature.

HFP Stock Assessment

The HFP has historically undertaken annual stock assessments of important beaches in Area 7. Gillespie *et al*. (1999a) recommended that annual surveys continue with emphasis on index beaches in heavily harvested subareas to track the effects of harvest on stock status. Surveys are conducted in summer months and the results discussed between Stock Assessment and Fishery Managers prior to the start of the next year's fishery. This assists in management of the fishery, particularly in guiding in-season management changes.

Catch Monitoring

Dockside validation of landings was undertaken during the 1999/2000 season. Total reported landings for the 1999/2000 season were 69.9 t (153,815 lbs) which represented a 2.5% overage of the allotted quota (Table 1). In 2000/2001, total reported landings were 72.0 t (158,432 lbs) or approximately 5.6% over the TAC (Table 1).

Logbooks have been used in the Area 7 fishery for a number of years, but inconsistencies in units of measure used and low resolution in areas harvested historically limited the utility of log information. The importance of providing good logbook information, including identification of actual beaches harvested, was re-emphasised in 1999/2000. Initially, encouraging harvesters to accurately record catch, effort and location was a challenge, but the introduction of dockside validation during the season increased logbook compliance. This was due in part to the harvester's pay being tied into having their logbooks complete. The 2000/2001 season saw logbook compliance increase and become a standard procedure in the fishery. In order to code location data, the HFP completed a beach inventory, assigning numbers to all beaches harvested in the area.

In-season Management

The fishery was co-managed on a subarea basis in both the 1999/2000 and 2000/2001 seasons. Subareas were opened primarily based on harvesters' preferences, usually beaches that were known to be high production areas or relatively easily accessible from Waglisla. Closures of subareas were based primarily on information from harvesters, often their opinion that stocks had been reduced to unattractive levels. The situation often developed where areas close to Waglisla that were closed early in the season were requested to be re-opened later in the season, when weather made access to areas further from home more difficult.

The 2000/2001 fishery was the first full season with a dockside-monitoring program in place as per requirements in the management plan and the communal licence. Regular timely communication of these data, combined with specific subarea harvest targets or thresholds would greatly increase the efficacy of in-season management.

Water Quality Monitoring

Under the Canadian Shellfish Sanitation Program, there are requirements for growing water quality testing. These surveys are conducted on a three year rotation by Environment Canada staff, with funding assistance from the HTC. There are a number of areas around Waglisla that have been designated as closed to harvesting due to contamination (Table 2). Growing water surveys completed in 2000 resulted in two new sanitary closures at Ardmillan Bay and Joassa Channel. The area is due for re-testing in 2003.

A biotoxin monitoring program is carried out by the HFP, in conjunction with the Canadian Food Inspection Agency (CFIA), to ensure that PSP contaminated shellfish do not present a human health risk. HFP staff establish mussel monitoring stations, and collect and send samples to CFIA in Vancouver. Stations were sampled every week in the summer (April 1 to October 30), and every other week in the winter (November 1 to March 31). In 1997/98, sampling stations were established at Grief Island (7-12), Troup Passage (7-15), Spirit Island and Lizzie Cove (7-17), Wakesiu Passage (7-21), Dundivan Inlet (7-22), Gow Island (7-23), Raymond Passage (7-24), Sans Peur Pass (7-25) and Raby Islets (7-32). In addition to mussels, samples of commercial shellstock (geoduck viscera, littleneck and butter clams) were assessed for levels of PSP.

Assessment Framework

The HFP began using standardized survey methods on several beaches in 1999 (Gillespie *et al*. 1999a), and have continued these surveys for most beaches in 2000. Replicate surveys were completed on six beaches: Bachelor Bay (7-12-7), Odin Cove (7-12-12), Kakushdish Harbour (7-17-22/23), Rainbow Island (7-17-4), Gale Passage (7-21-1), Joassa Channel (7-23-6) and Raymond Passage (7-24-13). Surveys were also conducted on four other beaches in 2000: Troup Passage (7-15-12), Joassa Channel (7-23-18) and Raymond Passage (7-24-12).

ASSESSMENT OF STOCK STATUS

Landings

Nine seasons have been completed in the Area 7 clam fishery, beginning in 1992/1993. Landings in the fishery have averaged 72.9 t over this period, and have fluctuated between 25.3 and 114.1 t in the 1997/1998 and 1994/1995 seasons, respectively (Table 1, Figure 5). Reduced landings in 1997/1998 reflect an inability to agree on a management plan which delayed opening of the season until January 1998 (Gillespie *et al*. 1999a). Peak landings coincided with the opening of seven new subareas (7-8, 7-13, 7-15, 7-22, 7-25, 7-27 and 7-28) which accounted for

55% of that years' harvest. The only significant loss of opportunity due to PSP closures was the complete closure of subareas 7-15 and 7-17 for the balance of the 1995/1996 season (subareas 7-27 and 7-28 were also closed but have not been major harvesting areas). Historic landings by subarea are shown in Figures 5-16.

Subareas 7-17 (Gunboat Passage/Hunter Channel/ Lama Passage), 7-21 (Gale Passage), 7-15 (Troup Passage/Return Channel) and 7-12 (Seaforth Channel) have accounted for 22.2%, 18.3%, 17.8% and 16.2% of the total landings since 1992/1993, an aggregate contribution of 74.5% (Table 1). In 2000/2001, subarea 7-12, 7-15, 7-23 and 7-17 accounted for 75.7% of the total landings, and subarea 7-24 (Raymond Passage) produced an additional 12.4 t (17.3% of the total landings), the most the subarea had produced since inception of the fishery (Figure 15).

Subarea 7-8 was closed after the 1998/1999 (Figure 6) season when it was discovered that, through a misinterpretation of subarea boundaries, all of the landings were from Reid Pass in subarea 7-9 (Gillespie *et al*. 1999a).

Subareas 7-18 (Tribal Group, Figure 11) 7-25 (Queens Sound, Figure 16) and 7-32 (St. John Harbour, Figure 17) have each recorded landings in one year only; <200 lb each for the first two and approximately 1,600 lbs in the 1998/99 season from the last. Subareas 7-19 (Thompson Bay), 7-20 (Wakesiu Passage), 7-27 (Lower Kildidt Sound) and 7-28 (Upper Kildidt Sound) have no reported landings, though all have been open to the fishery for at least six seasons.

HFP Index Beach Surveys

The HFP have undertaken clam surveys on beaches in Area 7 since 1992 (Gillespie *et al*. 1999a). Inconsistent selection of survey designs over time rendered these data of limited utility for comparisons of mean densities or total abundance estimates. Surveys completed on the same beaches using standardized designs in 1999 and 2000 can be compared to give a general indication of changes in stock size and structure.

Seaforth Channel (Subarea 7-12)

Two beaches were surveyed in subarea 7-12 in 2000; Bachelor Bay (beach 7-12-7, referred to in Gillespie *et al*. [1999a] as Bachelor Bay 1) and Odin Cove (beach 7-12-12). Both were replications of surveys undertaken in 1999.

Biomass of legal sized Manilas at Bachelor Bay was estimated at 1,598 kg in 1999 (Table 4) and increased to 2,587 kg in 2000 (Table 5). Biomass of sublegal sized Manilas also increased from 1,430 to 3,076 kg. Length frequency distributions were similar in both years (Figure 18), and age frequency distributions differed in the change of modal age from 3 in 1999 to 4 in 2000 and a much smaller proportion of the population at age 2 in 2000 (Figure 19).

Biomass of legal sized Manilas at Odin Cove was estimated at 728 kg in 1999 (Table 6) and increased to 938 kg in 2000 (Table 7). Biomass of sublegal sized Manilas likewise increased from 158 kg in 1999 to 477 kg in 2000. Length frequency distributions showed a coalescence of the broad distribution below 40 mm and the second mode at about 44mm in 1999 into a more compact, approximately unimodal distribution between 25 and 50 mm in 2000 (Figure 20). Age distributions for the two years differed little except for the shift of modal age from 3 to 4 years and a very small proportion of the population at 2 years of age in 2000 (Figure 21).

Strong 1996 and 1997 year classes detected in the 1999 surveys (Gillespie *et al*. 1999a) are presently recruiting to legal size, replacing clams removed by harvesters, but there is little in the way of sublegal stock to sustain these rates if recruitment does not occur in the next few years.

Troup Passage/Return Channel (Subarea 7-15)

Because different beaches were surveyed in 1999 and 2000, only the 2000 survey will be documented here. Estimated biomass of legal sized Manilas was 1,325 kg and biomass of sublegal sized Manilas was estimated as 1,259 kg (Table 8). Estimated abundance of sublegals was nearly three times that of legals. Length frequency distribution exhibited a large proportion of the population below 36 mm TL, and modal age was 4 years (Figure 22). The 2-year-old age class was a very small proportion of the population.

Lama Passage/Gunboat Passage/Hunter Channel (Subarea 7-17)

Two beaches were surveyed in subarea 7-17 in 2000; Kakushdish Harbour (beach 7-17-22/23, referred to as Kakushdish Harbour beaches 1 and 2 in Gillespie *et al*. [1999a], herein regarded as two strata of a single beach survey), and Rainbow Island (beach 7-17-4). Both of these surveys replicated designs used in 1999.

Estimated biomass of legal sized Manilas in Kakushdish Harbour was 7,109 kg in 1999 (Table 9) and decreased to 3,810 kg in 2000 (Table 10). Biomass of sublegal Manilas remained relatively constant, estimated at 3,590 kg in 1999 and decreased slightly to 3,003 kg in 2000. Length frequency distribution in 1999 was roughly unimodal with a peak at 35 mm TL (Figure 23). Length distribution was bimodal in 2000, with modes at approximately 20-24 mm and 35 mm TL. Age distribution shifted dramatically, with the mode at 3 years in 1999 advancing to 4 years in 2000, and a large mode appearing at 2 years in the 2000 distribution (Figure 24).

Estimated biomass of legal sized Manilas at Rainbow Island decreased from 1,781 kg in 1999 (Table 11) to 890 kg in 2000 (Table 12). Estimated biomass of sublegals remained relatively constant at 1,617 kg in 1999 and 1,610 kg in 2000. Length frequency distribution was altered through loss of many larger clams, and the appearance of relatively more clams below 25 mm TL (Figure 25). Age distribution altered little other than the progression of the major mode from 3 years in 1999 to 4 years in 2000 (Figure 26).

The shifts in biomass, abundance and length and age distributions indicate a reduction in the number of older, larger clams from both beaches, probably as a consequence of intensive harvest. Kakushdish Harbour appears to have enjoyed a significant recruitment event in 1998, as evidenced by the large 2-year-old age class detected in 2000 (Figure 24). Rainbow Island does not appear to have experienced the same intensity of recruitment (Figure 26).

Gale Passage (Subarea 7-21)

Estimated biomass of legal sized Manilas at the index beach in Gale Passage decreased from 4,307 kg in 1999 (Table 13) to 1,262 kg in 2000 (Table 14). Estimated biomass of sublegals increased from 2,130 kg in 1999 to 6,242 kg in 2000. Length frequency distribution in 1999 was dominated by a mode at approximately 24 mm TL, and in 2000 was roughly bimodal with peaks at approximately 15-19 mm and 27-30 mm TL (Figure 27). Age distributions showed progression of the single strong mode at age 2 in 1999 to age 3 in 2000, with relatively small contributions by age classes 1 and 2 in 2000 (Figure 28).

The index beach in Gale Passage appears to have had the little remaining legal stock removed by the fishery in 1999/2000, and is awaiting recruitment of the 1997 year class to legal size. Some of these clams will have recruited to legal size by 2001, but the bulk of the year class will likely not be legal size for 2-3 years.

Joassa Channel/Louise Channel (Subarea 7-23)

The beach surveyed in 1999 in Joassa Channel (7-23-6) was surveyed again in 2000, although the survey design was altered by surveying only one of the two strata examined in 1999. Comparisons presented here include only the stratum common to the two surveys.

Estimated biomass of legal sized Manilas decreased from 405 kg in 1999 (Table 15) to 179 kg in 2000 (Table 16). Estimated biomass of sublegals remained relatively constant at 106 kg in 1999 and 105 kg in 2000. Length frequency distributions differed little between the two surveys (Figure 29). The strongest mode was just under the legal size limit at 35-36 mm TL in 1999 and 36-38 mm TL in 2000. A secondary mode above 45 mm TL in 1999 had disappeared in 2000, and a minor mode at 26 mm in 1999 had progressed to 30-33 mm TL in 2000. Age distributions likewise differed little, with the major mode a 4 years in 1999 progressing to 5 years in 2000 (Figure 30).

A second beach in Joassa Channel (7-23-18) was surveyed in 2000. It was also a very small pocket beach (344 m^2 in area) with a small estimated legal stock of 67 kg and sublegal stock of 53 kg (Table 17). Although the sample size was small (n=85), length frequency was roughly trimodal, with peaks at 19, 33 and 40 mm TL (Figure 31). Age distribution was rather compact, with only 4 age classes present. A significant proportion of the population was 2 years old, indicating successful recruitment in 1998.

The clam population on the index beach in Joassa Channel is dominated by older, legal or nearly-legal sized clams. There is no evidence of recent recruitment on beach 7-23-6, but the relatively large 2-year-old age class detected on beach 7-23-18 provides some encouragement that some recruitment is occurring in the subarea.

Raymond Passage (Subarea 7-24)

The index beach surveyed in 1999 in Raymond Passage (7-24-13) was resurveyed in 2000. Estimated biomass of legal sized Manilas decreased from 1,381 kg in 1999 (Table 18) to 695 kg in 2000 (Table 19). Estimated biomass of sublegals increased from 140 kg in 1999 to 308 kg in 2000. Biological sample size in 2000 was relatively small (n=122). The 1999 length frequency was roughly bimodal with a major mode between 33-35 mm TL and a smaller mode at approximately 45 mm TL (Figure 32). Age distributions changed little, with both samples dominated by 4- and 5-year-olds, with little contribution from age class 2 (Figure 33).

A second beach in Raymond Channel (7-24-12) was surveyed in 2000. Although of similar size to the index beach, 1,386 versus 1,360 m^2 in area, the clam stocks supported by the new beach are larger, with biomass of legal sized Manilas estimated at 1,549 kg and biomass of sublegals at 457 kg (Table 20). The length frequency is roughly unimodal with a broad peak between 35-53 mm TL (Figure 34). Age distribution peaked at 3 years with strong contributions by age classes 4 and 5. There were relatively few 2-year-olds detected by the survey.

Both beaches surveyed in Raymond Passage in 2000 showed little sign of recent recruitment. This, coupled with the sharp decline in biomass of legals at the index beach, causes us to reiterate our statement of 1999 that the area might support harvests in the short term, but will require recruitment to remain productive. The longer this area goes without significant recruitment, the more likely that it will fail to support large harvests in the long term.

THE MAGNUSSON-STEFANSSON FEEDBACK GAIN RULE

The Magnusson-Stefansson feedback gain rule was outlined by Caddy (1998) for use as a reference point from past fishery yields in data-poor situations when only commercial or survey indices are available. This rule is reported to be particularly useful for restoring a depleted fishery that has been declining in stock size over time. The rule is:

$$Y_t = Y_{t-1}\left(1 + g\left(\frac{B_{t-1} - B_{t-2}}{B_{t-2}}\right)\right) \tag{1}$$

where *Y* is catch and *B* is an index of biomass (from survey or commercial CPUE index) in year *t*, and *g*, referred to as the feedback gain, reflects the degree of proportionality between changes in biomass between the last and current year. Values of *g* of 1 or greater were reported to contribute to precautionary approaches in simulations, although higher values of *g* were effective through leading to progressively more frequent closures (Caddy 1998).

We propose to apply this rule in determining target yields for the Area 7 Manila clam fishery, as no information beyond two years of dependable survey data for index beaches and commercial landings by PFM subarea are available (Gillespie *et al*. 1999a). We used two values of feedback gain; *g* = 1.0, in which case change in threshold yield is directly proportional to change in index biomass, and *g* inversely proportional to the change in index biomass. The latter option is more precautionary. As more data become available, more sophisticated assessment models can be utilized.

Biomass of legal size clams increased in only one of the five subareas that had index beach comparisons between 1999 and 2000 (Table 21, Figure 35). Subarea 7-12 exhibited increases of 29% at Bachelor Bay (7-12-7) and 62% at Odin Cove (7-12-12). In 1999/2000, fisher's logs were somewhat ambiguous as to landings from beach 7-12-7 and 7-12-6 – after discussions with harvesters, HFP staff concluded that most of these landings had, in fact, come from the index beach. In both the 1999/2000 and 2000/2001 seasons, however, the combined landings of these two beaches was the highest in the subarea. The large increase in biomass of legals at Odin Cove may be due to a combination of reasonable recruitment to legal size and low production relative to other beaches in the subarea.

In subarea 7-17, biomass of legals decreased 46% in Kakushdish Harbour (7-17-22/23) and 50% at Rainbow Island (7-17-4)(Table 21). Beaches 7-17-22/23 were the highest production beaches in the subarea in both 1999/2000 and 2000/2001. There were no landings reported from the Rainbow Island reference beach in 1999/2000, although the beaches nearby accounted for a large proportion of the subarea landings. It is possible that a considerable proportion of these landings might have come from the index beach. None of the beaches on Rainbow Island reported significant landings in 2000/2001.

The reference beach in Gale Passage, 7-21-1, exhibited a 71% decrease in biomass of legals between the 1999 and 2000 surveys (Table 21). In 1999/2000, this was the most productive beach in the subarea. In 2000/2001, other beaches accounted for a greater proportion of subarea production, but total subarea production was markedly reduced relative to previous years (Table 1, Figure 12).

The index beach for Joassa Channel, 7-23-6, was the lowest production beach in the subarea and showed little evidence of having been extensively dug in either 1999 or 2000. Although the beach showed a 56% decrease in biomass of legals between 1999 and 2000, it may not be the best indicator of stock status for the subarea.

The index beach for Raymond Channel, 7-24-12, reported the highest landings for the subarea in 1999/2000, and exhibited a 50% decrease in biomass of legals in the 2000 survey. Other beaches were more productive in the 2000/2001 fishery, and overall production from the area increased (Figure 15).

DISCUSSION

Commercial Harvest Data

Utilization of harvest logbooks and development of the dockside validation program have vastly improved the quality of landings information for this fishery. While collection of data has increased with use of logbooks, there is still a gap between the HFP receiving the information, collating and providing it to DFO in-season. In general, only summary sheets are forwarded to DFO, which do not provide information regarding the amount harvested by subarea. This can be improved, in order to make better in-season management decisions.

Survey Methods and Analyses

Adoption of consistent designs and statistically valid survey methods (*fide* Gillespie and Kronlund 1999) has enabled comparison of beaches on an annual basis. This is a vast improvement over the situation when this fishery was last reviewed (Gillespie *et al*. 1999a). Representativeness of the selected index beaches must be determined, and index beaches for subareas not currently monitored need to be established.

Summary of Stock Status

Trends in subarea production fall generally into two patterns (Gillespie *et al*. 1999a). Three subareas (7-17, 7-21 and 7-24) have exhibited relatively consistent production, although production from Raymond Passage (7-24) had been at a relatively low level until the 2000/2001 season. However, subarea 7-17 exhibited a generally declining trend in production since its peak in 1996/1997, and subarea 7-21 reported its lowest landings since the inception of the fishery in 2000/2001.

Historically, there was evidence from assessment surveys that recruitment events were more frequent in these areas, replenishing stocks that have been reduced by harvest (Gillespie *et al*. 1999a). Although many subareas experienced strong recruitment from the 1996 year class, sublegal densities were highest in Gale Passage, Rainbow Island and Kakushdish Harbour. Gale Passage also experienced strong recruitment of the 1997 year class. The 1996 year class is still strongly represented at Kakushdish Harbour (Figure 23) and Rainbow Island (Figure 25), and Kakushdish Harbour shows a strong 1998 year class. However, the 1996 year class appears to have been largely harvested from Gale Passage (Figure 27), with the 1997 year class dominating distribution and a relatively weak 1998 year class following. Although both the index beaches in subarea 7-17 still have some legal size clams, at greatly reduced densities than in previous years' surveys, the index beach in Gale Passage has virtually no legal size stock remaining.

Six subareas (7-8, 7-12, 7-13, 7-15, 7-22 and 7-23) that had peak landings in their first or second season exhibited generally declining trends in production, and have produced average landings that are less than half of peak landings. This suggested that these areas supported an accumulated stock of older clams from one or a few significant recruitment events, and that subsequent recruitment has been poor, failing to replenish populations after harvest (Gillespie *et al*. 1999a). Subareas 7-12, 7-15 and 7-23 have exhibited increased production in recent years, indicating that some recruitment has occurred, or that reduced production from core subareas has forced effort into these subareas. Subarea 7-8 has not been opened to the fishery in the last two seasons, and subareas 7-13 and 7-22 have not shown any recovery in production.

The remaining areas have either not attracted harvesting effort (7-19, 7-20, 7-27 and 7-28) or have had production levels too low to allow meaningful discussion of trends (7-18, 7-25 and 7-32)(Gillespie *et al*. 1999a).

The fishery occurs primarily in areas immediately adjacent to Waglisla. Lack of production from areas open to Queen Charlotte Sound (7-18, 7-19, 7-20, 7-25, 7-27, 7-28 and 7-32) may be due in part to distances involved and the logistics of reaching the areas safely in winter weather conditions. However, survey information indicates that these areas do not have recruitment as frequently as more protected areas, nor support significant populations of Manilas, as evidenced by the lack of the 1996 year class at index beaches in Joassa Channel and Raymond Passage in 1999 (Gillespie *et al*. 1999a) and the 1998 year class in 2000. Although it is fortunate that the area most accessible to fishers is also the most productive area for Manila clam populations in the Central Coast, these same areas are showing signs of overharvest.

Recruitment events were only evident at Kakushdish Harbour (Figure 24), Gale Passage (Figure 28) and Joassa Channel 18 (Figure 31). Contribution of the 1998 year class at Gale is somewhat swamped by the size of the 1997 year class. All other beaches surveyed did not show 2-year-old clams to be abundant. Size and age distributions sampled at these beaches lead us to believe that the survey methods are not size selective, and the lack of these sizes and ages from other surveys represents poor recruitment.

These observations confirm concerns of previous authors (Bourne and Cawdell 1992; Bourne *et al*. 1994; Heritage *et al*. 1998; Gillespie *et al*. 1999a) that limited or sporadic recruitment in the Central Coast might require more active management to ensure healthy Manila clam stocks and a sustainable fishery in the area.

Selection of Index Beaches

It is extremely difficult to select representative index beaches based on only one or two years' catch data. When index beaches were selected in 1999, we attempted to target beaches that were most productive, *i.e.*, those beaches that were most important to the fishery in each subarea. In most cases, however, it appears that harvests within the subarea are of a rotational nature, and as the most productive beaches are depleted, harvesters maintain production from beaches that they would not have harvested previously. As a time series of good catch information by beach is accumulated, appropriate index beaches can be selected to reflect long-term trends in landings.

The primary index beaches currently established in subareas 7-12 (beaches 7 and 12), 7-17 (beach 22/23), 7-21 (beach 1) and 7-24 (beach 13) appear to be representative of stock condition in those subareas. The secondary beach for 7-17 at Rainbow Island should be reselected, with consideration given to more productive beaches in the Rainbow and Cypress Islands area or other beaches in Kakushdish Harbour. A secondary index beach for Gale Passage should be selected for survey in 2001, and the secondary beach surveyed in 2000 in 7-24 (beach 13) should be considered as an index beach. Index beaches for subarea 7-23 should be reviewed. The index beach currently selected does not appear to be indicative of stock dynamics in the subarea.

Selection of index beaches in subareas where stocks are relatively diffusely distributed amongst a large number of small pocket beaches will likely rely on ensuring that each distinct geographic unit within the subarea is represented (*e.g.*, upper Joassa Channel, Boddy Narrows and Louise Channel in subarea 7-23). It must be recognized that for index beaches to be useful there must be, at the very least, two consecutive years' data available. Thus, changes in index beaches must be phased in over at least two years to ensure that assessment information for the subarea is available for effective in-season management.

If the fishery is to expand into subareas not currently monitored by assessments (7-13, 7-15, 7-18, 7-19, 7-20, 7-22, 7-25, 7-27, 7-28 and 7-32) then index beaches should be established there in 2001. Gillespie *et al*. (1999a) proposed that some unharvested beaches, likely those removed from the fishery due to contamination, be surveyed to determine if recruitment patterns were driven by environmental factors alone, or whether harvests had an impact. To date these surveys have not been established.

Management Considerations

TAC overages in the 1999/2000 and 2000/2001 seasons do not appear to be due to an increase in biomass, but rather to more consistent effort expended by harvesters. In both seasons, all deliveries had close to the fifty diggers allowed, with the 2000/2001 season being the more consistent of the two.

Review of the 1999/2000 landings and the 2000 survey results raised concerns regarding stocks on the beaches closest to Waglisla. These beaches tended to be preferred locations for harvesting when weather conditions were not ideal. Managers might consider opening the fishery in more remote areas that have not received significant effort over the previous few seasons to test the potential of these areas to support harvest, and to allow more intensely harvested areas time to recover. Should the entire Area 7 TAC be achieved from outlying areas (the ideal situation, although we acknowledge that this is unlikely) then the subareas closest to Waglisla could have an entire year of recovery before they were considered for harvest again. Continued surveys of index beaches in these subareas would provide valuable information on recovery rates of unharvested populations.

Managers should be aware, however, that underutilized areas might not support production in the long term. These areas are known to support fewer, smaller clam populations, and to suffer more erratic recruitment than beaches closer to Waglisla. These areas might be fished in pulses to give the beaches closer to Waglisla a chance to recover, but would likely require several years to recover from harvest themselves.

Manila clam populations in Area 7 are the northernmost populations known in North America, and likely in the world. Fluctuations in recruitment will likely result in fluctuations in the overall population size, and these will be more pronounced if the populations are harvested. If the management objective for this fishery is to have sustained harvests, rather than pulse fishing with periods of total closure for stocks to recover, then stock status and landings will have to be closely monitored to determine if a lower overall TAC is required.

Model Assumptions

The Magnussen-Stefansson feedback gain model presented in this paper is based entirely on biomass estimates and reported landings, and thus has three major assumptions:

1. That stock surveys are representative of the true stock condition on each beach, or at least have been consistent enough to accurately reflect relative changes in legal stock size;
2. That landings are reported accurately by subarea; and
3. That stock condition on index beaches are representative of stock condition for the entire subarea.

Shortcomings in the utility of stock assessment data collected by DFO and HFP prior to 1999 were documented in Gillespie *et al*. (1999a). Inconsistent or invalid survey methodology and widely differing objectives of exploratory and assessment surveys rendered much of the data of limited value for making comparisons between beaches and/or years. Confidence in results of stock assessment surveys in Area 7 has been greatly increased by the provision of standardized survey protocols by DFO (Gillespie and Kronlund 1999) and efforts of the HFP to ensure that these protocols are followed diligently.

Confidence in the accuracy of landing statistics was relatively low prior to the 1999/2000 season (Gillespie *et al*. 1999a) but increased as the season progressed and the dockside validation program was established. Confidence in the accuracy of landings reported in the 2000/2001 season was the highest it has been since inception of the fishery.

Little advice was given in Caddy (1998) regarding appropriate ranges of values of *g* that could be useful. If *g* remains at 1.0 then the threshold for the following year increases or decreases proportionally to the change in biomass. If *g* is greater than 1.0 then yields are reduced from proportionality when biomass increases (*i.e.*, the yield increases at a much reduced rate than the rate of increase in biomass) and yields drop relatively quickly as biomass decreases.

If *g* is inversely proportional to the change in biomass between years, then for the index beaches examined in this paper, values could range from 0.6 in subarea 7-12 (where the combined biomass of legals of the two index beaches increased 1.5-fold) to 2.3 in subarea 7-23 (where biomass on the index beach in 2000 was 0.44 times the biomass estimated in 1999)(Table 21).

Model Application

Use of the Magnussen-Stefansson feedback gain model could be undertaken on two levels of resolution. At the extreme scale, the overall difference in stock size from all seven index beaches could be used to adjust the overall TAC for Area 7. This would have required the overall TAC to be drastically reduced in the 2000/2001 season, from 68.2 t (150,000 lbs) to somewhere between 23.1 and 42.0 t (50,884 to 92,398 lbs), depending on the value of *g* selected (Table 22).

A more rational approach might be to set threshold harvests for subareas without decreasing the overall TAC for all of Area 7. This would allow re-distribution of effort to under-utilized subareas if the TAC was to be met. However, most of these areas do not have proven production potential, and this approach would require that index beaches be established in those subareas that currently do not have them (7-13, 15, 18-20, 22, 25-28 and 32) to closely monitor changes in stock levels under more intensive harvests.

Had the subarea approach been taken in the 2000/2001 season, recommended thresholds for subareas 7-17, 7-21, 7-23 and 7-24 would have been considerably reduced from production levels in 1999/2000 (Table 22). Under the more precautionary value of *g* subareas 7-21 and 7-23 would have been closed, and 7-24 reduced to such a low level of harvest that it likely would not have been opened. Under the *g* = 1.0 option, harvest would have been curtailed in these areas at levels much lower than the fishery achieved in 2000/2001, with the exception of 7-21, which produced 3.8 t (8,479 lb) very close to the proposed threshold of 3.77 t (8,326 lb). Under either option, recorded harvests for subarea 7-12 would have been less than the proposed threshold harvest levels.

If this approach is to be adopted for the Area 7 fishery, then the reference points recommended from the model should be considered as thresholds that are not to be exceeded, rather than targets with some acceptable probability of overage. Likewise, if this approach is adopted and thresholds for most areas continue to decline, then managers and harvesters must recognize that the overall TAC for Area 7 might not be sustainable.

Recommendations

1. **Managers should consider establishing in-season threshold levels for monitored subareas based on changes in biomass on index beaches, using the Magnussen-Stefansson feedback gain model.** This will allow re-distribution of effort to underutilized subareas without reduction in the overall quota. This would require analyses utilizing the 2000/2001 fishery yields and results of assessment surveys in the summer of 2001.
2. **Managers and Stock Assessment personnel from both DFO and HFP should regularly examine landing records and anecdotal information from harvesters to determine if the existing index beaches are representative of the subareas they monitor.** Index beaches were selected based on relatively

limited landings data and anecdotal information from harvesters. The rotational nature of harvests in some subareas, which is apparent from review of the last two years landings data, requires that index beaches be reviewed regularly.

3. **HFP and DFO Stock Assessment personnel should establish index beaches in subareas not currently monitored.** These will provide baseline data for in-season management should the fishery expand in to these subareas.
4. **Managers and harvesters should acknowledge that continued reduction in thresholds for monitored subareas, if coupled with reductions in newly exploited subareas, will require re-assessment of the overall TAC for the Area 7 fishery.** The fishery has sustained itself largely on production from a few subareas close to Waglisla. If beaches from other subareas can support the full TAC until the beaches closer to home have recovered, then a rotational harvest approach can be developed. If outlying subareas show signs of harvest stress similar to the nearby areas before the latter can recover, then the existing quota cannot be considered sustainable in the long term.

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Table 1. Landings (t) from the Area 7 Manila clam fishery by Pacific Fishery Management Subarea and season.

	Subarea																
Season	8/9	12	13	15	17	18	19	20	21	22	23	24	25	27	28	32	Total*
92/93		24.1			8.8		0.0	0.0	18.5		20.5	7.4				0.0	79.3
93/94		12.1			24.7	0.0	0.0	0.0	16.7		3.7	7.5				0.0	64.8
94/95	5.9	9.0	8.0	43.5	19.3	0.0	0.0	0.0	8.3	5.4	9.0	5.5	0.1	0.0	0.0	0.0	114.1
95/96	0.3	9.0	15.6	24.5	0.0	0.1	0.0	0.0	22.6	0.4	2.7	6.7	0.0	0.0	0.0	0.0	81.9
96/97	1.6	13.2	0.9	9.6	33.3	0.0	0.0	0.0	9.6	0.3	0.6	2.0	0.0	0.0	0.0	0.0	71.1
97/98	2.4	2.6	1.0	2.2	4.7	0.0	0.0	0.0	11.0	0.0	0.7	0.2	0.0	0.0	0.0	0.0	25.4
98/99	1.7	11.0	3.9	7.9	25.3	0.0	0.0	0.0	16.7	0.1	1.1	5.2	0.0	0.0	0.0	0.7	77.6
99/00		10.5	0.7	15.7	16.6				12.9		9.7	4.0					70.2
00/01		14.6	1.2	13.4	13.1				3.9		13.4	12.4					72.0
Total	11.9	106.2	31.3	116.8	145.8	0.1	0.0	0.0	120.3	6.2	61.4	51.0	0.1	0.0	0.0	0.7	656.5
%	1.8	16.2	4.8	17.8	22.2	0.0	0.0	0.0	18.3	0.9	9.4	7.8	0.0	0.0	0.0	0.1	99.3

N.B. – a blank cell indicates the subarea was not open; a zero indicates the subarea was open, but no landings were reported.

* - total landings for 1997/98 include 0.7 t that could not be assigned to a subarea; total landings for 1998/99 include 3.9 t that could not be assigned to a subarea; total landings for 1999/2000 include 0.03 t that could not be assigned to a subarea.

Table 2. Contamination closures in PFMA 7.

Closure	PFMA	Description
General	all	Any Canadian fisheries waters of the Pacific Ocean within 125 m of any wharf, dock, platform or other structure used for vessel moorage; or any permanently anchored floating structures, including float homes, barges, platforms and vessels.
Higgins Passage	7-3	The waters and intertidal foreshore of Higgins Passage, at the north end of Price Island, lying inside a line drawn from a point on land at 52°28.25' north latitude and 128°39.00' west longitude thence north-westerly to a point on the opposite shore at 52º28.40' north latitude and 128º39.10' west longitude.
Klemtu	7-5	The waters and intertidal foreshore of Trout Bay, Klemtu, lying inside a line drawn from Klemtu Point to the northern headland of the bay.
Berry Inlet	7-8	The waters and intertidal foreshore of the head of Berry Inlet, at the south end of Don Peninsula, lying inside a line drawn from the headland on the western shore at the entrance to the inlet at 52°16.15' north latititude and 128°19.50' west longitude, thence to the northernmost point of the unnamed island immediately north of Evening Island, to a point on the eastern shore at 52°16.15' north latitude and 128°19.10' west longitude.
Tuno Creek	7-9	The waters and intertidal foreshore of the mouth of Tuno Creek, at the south end of Don Peninsula, lying inside a line drawn from a point on land at 52º16.80' north latitude and 128º19.45' west longitude, thence north-westerly to a point on the opposite shore at 52º16.95' north latitude and 128º19.50' west longitude.
Ardmillan Bay	7-12	The waters and intertidal foreshore of Ardmillan Bay, on the north end of Campbell Island, lying within a 200 meter radius of the small headland at 52º11.40' north latitude and 128º07.20' west longitude.
Wigham Cove	7-12	The waters and foreshore of Wigham Cove, Yeo Island, inside a line drawn from the headland at the eastern end of the cove entrance at 52º16.64' north latitude and 128º10.40' west longitude, thence west to the opposite shore at 52º16.64' north latitude and 128º10.51' west longitude. MAY 31 TO SEPTEMBER 30
Spiller Channel	7-13	The waters and intertidal foreshore of Spiller Channel, at the southeast end of Don Peninsula, lying inside a line drawn from a point on land at 52º17.50' north latitude and 128º15.60' west longitude, thence north-easterly to a point on the opposite shore at 52º17.60' north latitude and 128º15.49' west longitude.
Yeo Cove	7-13	The waters and intertidal foreshore of Yeo Cove lying inside a line drawn from Dove Point on the northern headland of the Cove thence south to the westernmost point of land on the southern headland.
Return Channel	7-15	The waters and intertidal foreshore of Return Channel lying inside a line drawn from the headland west of McArthur Point, Yeo Island at 52º18.00' north latitude and 128º06.95' west longitude, thence south-west to the south end of the foreshore at 52º17.80' north latitude and 128º07.10' west longitude.
Chatfield Island	7-15	The waters and intertidal foreshore at the head of the large unnamed bay on the north-eastern side of Chatfield Island, inside a line drawn from the point at the western end of the bay at 52º16.61' north latitude and 128º02.60'west longitude, thence east to the eastern shore at 52º16.60' north latitude and 128º02.33' west longitude.
Chatfield Island	7-15	The waters and intertidal foreshore at the head of the small unnamed cove on the southeastern side of Chatfield Island, inside a line drawn from the rock outcrop at 52º13.87' north latitude and 128º05.90' west longitude, thence east to the headland on the eastern side of the cove entrance at 52º13.95' north latitude and 128º05.74' west longitude.
Bella Bella	7-17	The waters and intertidal foreshore of Bella Bella, lying south of a line drawn from the western headland of Cavin Cove to the northern tip of Spirit Island thence to Robins Point, and north of a line drawn from the northern headland of McLoughlin Bay due east to the shore of Denny Island.
Joassa Channel	7-22	The waters and intertidal foreshore of Joassa Channel, at the northeast point of Dufferin Island, lying inside a line drawn from a point on land at 52º12.40' north latitude and 128º17.62' west longitude, thence northwesterly to the north end of an unnamed island at 52º12.45' north latitude and 128º17.68' west longitude, thence northwesterly to a point on the opposite shore at 52º12.50' north latitude and 128º17.95' west longitude.
Cultus Sound	7-25	The waters and intertidal foreshore of Cultus Sound, at the west end of Hunter Island, lying inside a line drawn from a point on land at 51º53.84' north latitude and 128º12.50' west longitude, thence north-westerly to the north end of the unnamed island at 51º53.89' north latitude and 128º12.60' west longitude, thence westerly to a point on the opposite shore at 51º53.89' north latitude and 128º12.90' west longitude.
Goose Island	7-25	The waters and intertidal foreshore lying inside a line drawn from the southwesternmost point of Goose Island to the northern most tip of Duck Island, thence along the eastern foreshore to the southernmost point of the Island, thence south-easterly to the westernmost point on Gosling Island and continuing north along the western foreshore to the northernmost tip of Gosling Island, thence north-westerly to the 51º55.98' north latitude and 128º26.72' west longitude on Goose Island.
Spider Island	7-27	The waters and intertidal foreshore of the unnamed bay at the south end of Spider Island, on the east side of Queens Sound, lying inside a line drawn from a point on land at 51º50.20' north latitude and 128º15.10' west longitude, thence north-westerly to a point on the opposite shore at 51º50.35' north latitude and 128º15.20' west longitude.
Bainbridge Cove	7-30	The waters and intertidal foreshore of Bainbridge Cove, Cunningham Island, inside a line drawn from the point at the southern end of the cove entrance at 52º11.62' north latitude and 127°54.22' west longitude, thence north to the point on the northern end of the cove entrance at 52º11.75' north latitude and 127º54.28' west longitude.
St. John Harbour	7-32	The waters and intertidal foreshore of St. John Harbour, Athlone Island, lying inside a line drawn from a point on land at 52º10.73' north latitude and 128º27.34' west longitude, thence northerly to a point on the opposite shore at 52º10.87' north latitude and 128º27.35' west longitude.
Athlone Island	7-32	The waters and intertidal foreshore of the southwest portion of Athlone Island lying inside a line drawn from a point on land at 52º09.90' north latitude and 128º29.70' west longitude, thence northwesterly to a point on the opposite shore at 52º10.10' north latitude and 128º29.90' west longitude.
Dyer Cove	7-32	The waters and foreshore of Dyer Cove, in St. John Harbour, bounded between a line drawn from the first outcrop at 52º11.08' north latitude and 128º28.30' west longitude to 52º11.19' north latitude and 128º27.85' west longitude and a line drawn at the narrow entrance to the inner harbour. MAY 31 TO SEPTEMBER 30

Table 3. Reference beaches for the Area 7 Manila clam fishery, 1999-2000.

Subarea Name	PFMA Subarea	Reference Beach(es)
Seaforth Channel	7-12	Bachelor Bay (7-12-7)
		Odin Cove (7-12-12)
Spiller Channel	7-13	n/a
Return Channel/Troup Passage	7-15	n/a
Lama Passage/Gunboat Passage/Hunter Channel	7-17	Kakushdish Harbour (7-17-22/23)
		Rainbow Island (7-17-4)
Tribal Group	7-18	n/a
Thompson Bay	7-19	n/a
Wakesiu Passage	7-20	n/a
Gale Passage	7-21	Gale Passage (7-21-1)
Dundivan Inlet	7-22	n/a
Joassa Channel/Louise Inlet	7-23	Joassa Channel (7-23-6)
Raymond Passage	7-24	Raymond Passage (7-24-13)
Queen Sound	7-25	n/a
Kildidt Sound	7-27/7-28	n/a
St. John Harbour	7-32	n/a

Table 4. Results of HFP Manila clam survey at Bachelor Bay (7-12-7), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	2,500	29.538	6.487	77.846	25.448	26	73,846	32,436	194,615	127,238
2	800	3.200	1.304	1.600	0.883	10	2,560	2,087	1,280	1,413
Total	3,300	23.153	4.925	59.362	19.280	36	76,406	33,471	195,895	131,034
				df Legals	25.53		t Legals	2.0595	Leg precision	43.8%
				df Subl	25.02		t Subl	2.0595	Subl precision	66.9%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	2,500	0.613	0.121	0.569	0.185	26	1,533	606	1,421	923
2	800	0.082	0.031	0.011	0.006	10	66	49	9	9
Total	3,300	0.484	0.092	0.433	0.140	36	1,598	627	1,430	950
				df Legals	25.84		t Legals	2.0595	Leg precision	39.2%
				df Subl	25.01		t Subl	2.0595	Subl precision	66.4%

Table 5. Results of HFP Manila clam survey at Bachelor Bay (7-12-7), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	2,500	49.217	8.172	136.174	37.008	23	123,043	40,860	340,435	185,039
2	800	6.222	2.588	9.333	6.690	9	4,978	4,141	7,467	10,705
Total	3,300					32	128,021	42,479	347,901	192,195
				df Legals	23.13		t Legals	2.0687	Leg Precision	33.2%
				df Subl	22.37		t Subl	2.0739	Subl Precision	55.2%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	2,500	0.988	0.148	1.215	0.320	23	2,469	742	3,038	1,599
2	800	0.148	0.060	0.048	0.032	9	118	96	38	51
Total	3,300					32	2,587	774	3,076	1,659
				df Legals	23.81		t Legals	2.0687	Leg precision	29.9%
				df Subl	22.11		t Subl	2.0739	Subl precision	53.9%

Table 6. Results of HFP Manila clam survey at Odin Cove (7-12-12), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,200	27.867	6.971	19.467	4.790	30	33,440	16,730	23,360	11,496
Total	1,200	27.867	6.971	19.467	4.790	30	33,440	17,109	23,360	11,756
				df Legals	29.00		t Legals	2.0452	Leg precision	51.2%
				df Subl	29.00		t Subl	2.0452	Subl precision	50.3%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,200	0.607	0.159	0.132	0.032	30	728	380	158	77
Total	1,200	0.607	0.159	0.132	0.032	30	728	389	158	79
				df Legals	29.00		t Legals	2.0452	Leg precision	53.4%
				df Subl	29.00		t Subl	2.0452	Subl precision	49.7%

Table 7. Results of HFP Manila clam survey at Odin Cove (7-12-12), September 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,200	38.800	6.492	48.000	8.082	30	46,560	15,581	57,600	19,397
Total	1,200					30	46,560	15,934	57,600	19,835
				df Legals	29.00		t Legals	2.0452	Leg precision	34.2%
				df Subl	29.00		t Subl	2.0452	Subl precision	34.4%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,200	0.781	0.143	0.398	0.065	30	938	344	477	155
Total	1,200					30	938	352	477	159
				df Legals	29.00		t Legals	2.0452	Leg precision	37.5%
				df Subl	29.00		t Subl	2.0452	Subl precision	33.3%

Table 8. Results of HFP Manila clam survey at Troup Passage (7-15-12), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	2,838	20.800	7.835	66.400	14.915	10	59,030	44,471	188,443	84,657
Total	2,838					10	59,030	50,300	188,443	95,753
				df Legals	9.00		t Legals	2.2622	Leg precision	85.2%
				df Subl	9.00		t Subl	2.2622	Subl precision	50.8%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	2,838	0.467	0.191	0.444	0.111	10	1,325	1,085	1,259	630
Total	2,838					10	1,325	1,227	1,259	713
				df Legals	9.00		t Legals	2.2622	Leg precision	92.6%
				df Subl	9.00		t Subl	2.2622	Subl precision	56.6%

Table 9. Results of HFP Manila clam survey at Kakushdish Harbour (7-17-22/23), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	3,200	45.533	14.487	57.867	20.226	15	155,307	92,715	185,173	129,448
2	2,000	99.600	22.828	106.400	30.205	10	199,200	91,311	212,800	120,821
Total	5,200	68.174	12.513	76.533	17.026	25	354,507	136,183	397,973	184,682
				df Legals	19.66		t Legals	2.0930	Leg precision	38.4%
				df Subl	20.38		t Subl	2.0860	Subl precision	46.4%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	3,200	0.954	0.291	0.523	0.183	15	3,053	1,864	1,674	1,173
2	2,000	2.028	0.481	0.958	0.286	10	4,057	1,922	1,916	1,144
Total	5,200	1.367	0.257	0.690	0.157	25	7,109	2,802	3,590	1,714
				df Legals	19.02		t Legals	2.0930	Leg precision	39.4%
				df Subl	19.79		t Subl	2.0930	Subl precision	47.7%

Table 10. Results of HFP Manila clam survey at Kakushdish Harbour (7-17-22/23), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	3,200	34.667	6.232	64.000	15.342	30	110,933	39,884	204,800	98,186
2	2,000	48.000	20.427	95.200	36.743	10	96,000	81,707	190,400	146,973
Total	5,200					40	206,933	101,293	395,200	194,515
				df Legals	10.46		t Legals	2.2281	Leg precision	48.9%
				df Subl	11.79		t Subl	2.2010	Subl precision	49.2%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	3,200	0.680	0.127	0.577	0.166	30	2,175	811	1,846	1,064
2	2,000	0.817	0.310	0.579	0.229	10	1,635	1,240	1,158	917
Total	5,200					40	3,810	1,631	3,003	1,481
				df Legals	11.67		t Legals	2.2010	Leg precision	42.8%
				df Subl	17.77		t Subl	2.1098	Subl precision	49.3%

Table 11. Results of HFP Manila clam survey at Rainbow Island (7-17-4), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,980	30.000	12.977	25.200	15.064	10	59,400	51,390	49,896	59,654
2	1,050	24.667	8.843	193.333	66.234	6	25,900	18,570	203,000	139,092
Total	3,030	28.152	9.017	83.464	24.974	16	85,300	59,528	252,896	185,164
				df Legals	12.30		t Legals	2.1788	Leg precision	69.8%
				df Subl	6.12		t Subl	2.4469	Subl precision	73.2%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,980	0.683	0.342	0.194	0.113	10	1,352	1,355	383	449
2	1,050	0.409	0.148	1.175	0.391	6	429	311	1,233	820
Total	3,030	0.588	0.229	0.534	0.154	16	1,781	1,549	1,617	1,144
				df Legals	10.51		t Legals	2.2281	Leg precision	86.9%
				df Subl	6.84		t Subl	2.4469	Subl precision	70.8%

Table 12. Results of HFP Manila clam survey at Rainbow Island (7-17-4), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	N	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,980	12.444	8.334	8.444	5.180	9	24,640	33,002	16,720	20,513
2	1,050	15.200	8.885	209.600	74.859	5	15,960	18,659	220,080	157,204
Total	3,030					14	40,600	41,721	236,800	220,085
				df Legals	11.95		t Legals	2.2010	Leg precision	102.8%
				df Subl	4.08		t Subl	2.7765	Subl precision	92.9%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	N	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,980	0.309	0.214	0.050	0.032	9	612	848	99	125
2	1,050	0.264	0.156	1.439	0.493	5	277	327	1,511	1,035
Total	3,030					14	890	1,000	1,610	1,448
				df Legals	11.24		t Legals	2.2010	Leg precision	112.4%
				df Subl	4.06		t Subl	2.7765	Subl precision	89.9%

Table 13. Results of HFP Manila clam survey at Gale Passage (7-21-1), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	3,000	64.800	16.580	263.600	69.193	10	194,400	99,481	790,800	415,156
Total	3,000	64.800	16.580	263.600	69.193	10	194,400	112,520	790,800	469,575
				df Legals	9.00		t Legals	2.2622	Leg precision	57.9%
				df Subl	9.00		t Subl	2.2622	Subl precision	59.4%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	3,000	1.436	0.402	0.710	0.189	10	4,307	2,413	2,130	1,132
Total	3,000	1.436	0.402	0.710	0.189	10	4,307	2,730	2,130	1,280
				df Legals	9.00		t Legals	2.2622	Leg precision	63.4%
				df Subl	9.00		t Subl	2.2622	Subl precision	60.1%

Table 14. Results of HFP Manila clam survey at Gale Passage (7-21-1), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	N	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	3,000	23.200	7.319	494.000	118.996	10	69,600	43,916	1,482,000	713,975
Total	3,000					10	69,600	49,673	1,482,000	807,563
				df Legals	9.00		t Legals	2.2622	Leg precision	71.4%
				df Subl	9.00		t Subl	2.2622	Subl precision	54.5%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	3,000	0.421	0.112	2.081	0.441	10	1,262	674	6,242	2,647
Total	3,000					10	1,262	762	6,242	2,994
				df Legals	9.00		t Legals	2.2622	Leg precision	60.4%
				df Subl	9.00		T Subl	2.2622	Subl precision	48.0%

Table 15. Results of HFP Manila clam survey at Joassa Channel (7-23-6), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	126	6.800	3.236	10.800	4.798	10	857	816	1,361	1,209
2	399	42.800	17.269	25.600	7.309	10	17,077	13,781	10,214	5,833
Total	525	34.160	13.148	22.048	5.673	20	17,934	15,614	11,575	6,737
				df Legals	9.06		t Legals	2.2622	Leg precision	87.1%
				df Subl	9.76		t Subl	2.2622	Subl precision	58.2%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	126	0.158	0.081	0.062	0.029	10	20	20	8	7
2	399	1.016	0.420	0.265	0.072	10	405	335	106	58
Total	525	0.810	0.320	0.217	0.055	20	425	380	114	66
				df Legals	9.07		t Legals		Leg precision	89.4%
				df Subl	9.29		t Subl		Subl precision	57.7%

Table 16. Results of HFP Manila clam survey at Joassa Channel (7-23-6), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
2	399	21.818	5.798	27.636	5.251	11	8,705	4,627	11,027	4,191
Total	399					11	8,705	5,155	11,027	4,669
				df Legals	10.00		t Legals	2.2281	Leg precision	59.2%
				df Subl	10.00		t Subl	2.2281	Subl precision	42.3%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
2	399	0.449	0.119	0.263	0.052	11	179	95	105	41
Total	399					11	179	106	105	46
				df Legals	10.00		t Legals	2.2281	Leg precision	59.0%
				df Subl	10.00		t Subl	2.2281	Subl precision	43.8%

Table 17. Results of HFP Manila clam survey at Joassa Channel (7-23-18), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	344	10.400	5.548	23.600	10.002	10	3,578	3,817	8,118	6,882
Total	344					10	3,578	4,317	8,118	7,784
				df Legals	9.00		t Legals	2.2622	Leg precision	120.7%
				df Subl	9.00		t Subl	2.2622	Subl precision	95.9%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	344	0.195	0.115	0.155	0.072	10	67	79	53	49
Total	344					10	67	89	53	56
				df Legals	9.00		t Legals	2.2622	Leg precision	133.3%
				df Subl	9.00		t Subl	2.2622	Subl precision	104.9%

Table 18. Results of HFP Manila clam survey at Raymond Passage (7-24-13), August 1999.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,360	41.600	8.123	11.800	2.961	20	56,576	22,094	16,048	8,053
Total	1,360	41.600	8.123	11.800	2.961	20	56,576	23,122	16,048	8,428
				df Legals	19.00		t Legals	2.0930	Leg precision	40.9%
				df Subl	19.00		t Subl	2.0930	Subl precision	52.5%

Biomass										
Stratum	Area (m^2)	Mean Wt Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean Wt Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,360	1.016	0.199	0.103	0.025	20	1,381	542	140	69
Total	1,360	1.016	0.199	0.103	0.025	20	1,381	567	140	72
				df Legals	19.00		t Legals	2.0930	Leg precision	41.1%
				df Subl	19.00		t Subl	2.0930	Subl precision	51.2%

Table 19. Results of HFP Manila clam survey at Raymond Passage (7-24-13), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,360	23.600	9.869	25.200	17.471	10	32,096	26,844	34,272	47,521
Total	1,360					10	32,096	30,363	34,272	53,750
				df Legals	9.00		t Legals	2.2622	Leg precision	94.6%
				df Subl	9.00		t Subl	2.2622	Subl precision	156.8%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,360	0.511	0.207	0.227	0.161	10	695	562	308	437
Total	1,360					10	695	636	308	495
				df Legals	9.00		t Legals	2.2622	Leg precision	91.5%
				df Subl	9.00		t Subl	2.2622	Subl precision	160.5%

Table 20. Results of HFP Manila clam survey at Raymond Passage (7-24-12), July 2000.

Abundance										
Stratum	Area (m^2)	Mean No. Legals (clams/m^2)	S.E. Legals (clams/m^2)	Mean No. Sublegals (clams/m^2)	S.E. Sublegals (clams/m^2)	n	Estimated Legal Stock (clams)	95% CI	Estimated Sublegal Stock (clams)	95% CI
1	1,386	52.400	14.719	47.600	10.497	10	72,626	40,802	65,974	29,097
Total	1,386					10	72,626	46,150	65,974	32,911
				df Legals	9.00		t Legals	2.2622	Leg precision	63.5%
				df Subl	9.00		t Subl	2.2622	Subl precision	49.9%

Biomass										
Stratum	Area (m^2)	Mean No. Legals (kg/m^2)	S.E. Legals (kg/m^2)	Mean No. Sublegals (kg/m^2)	S.E. Sublegals (kg/m^2)	n	Estimated Legal Stock (kg)	95% CI	Estimated Sublegal Stock (kg)	95% CI
1	1,386	1.118	0.307	0.330	0.107	10	1,549	852	457	297
Total	1,386					10	1,549	964	457	336
				df Legals	9.00		t Legals	2.2622	Leg precision	62.2%
				df Subl	9.00		t Subl	2.2622	Subl precision	73.6%

Table 21. Changes in biomass (kg) of legal sized Manila clams from index beach surveys undertaken in 1999 and 2000 in Area 7, and values of the Magnussen-Stefansson *g* parameter if inversely proportional to the change in biomass.

Subarea	Beach	1999 estimate	95% CI	2000 estimate	95% CI	Difference	*g*
7-12	Bachelor Bay (7-12-7)	1,598	627	2,587	352	1.29	0.78
	Odin Cove (7-12-12)	728	389	938	774	1.62	0.62
	Combined	2,326	1,016	3,525	1,126	1.52	0.66
7-17	Kakushdish (7-17-22/23)	7,109	2,802	3,810	1,631	0.54	1.85
	Rainbow Island (7-17-4)	1,781	1,549	890	1,000	0.50	2.00
	Combined	8,890	4,351	4,700	2,361	0.53	1.89
7-21	Gale Passage (7-21-1)	4,307	2,730	1,262	762	0.29	3.45
7-23	Joassa Channel (7-23-6)	405	335	179	106	0.44	2.27
7-24	Raymond Passage (7-24-13)	1,381	567	695	636	0.50	2.00
Overall		17,309	3,632	10,361	1,504	0.60	1.67

Table 22. Proposed subarea yield thresholds for the 2000/2001 Manila clam fishery in Area 7, based on index beach surveys using the Magnussen-Stefansson feedback gain model.

Subarea	1999 Index Biomass (kg)	2000 Index Biomass (kg)	1999/2000 Yield (kg)	*g*	2000/2001 Threshold (kg)	2000/2001 Yield (kg)	Overage/Underage
7-12	2,326	3,525	10,438	1.00	15,819	14,596	1,223
				0.66	18,616		4,021
7-17	8,890	4,700	16,596	1.00	8,774	13,042	4,268
				1.89	1,812		11,229
7-21	4,307	1,262	12,886	1.00	3,776	3,845	70
				3.41	0		3,845
7-23	405	179	9,672	1.00	4,275	13,321	9,046
				2.26	0		13,321
7-24	1,381	695	3,999	1.00	2,012	12,413	10,400
				1.99	46		12,367
Overall	17,309	10,361	70,005	1.00	41,904	71,851	29,947
				1.67	23,077		48,775

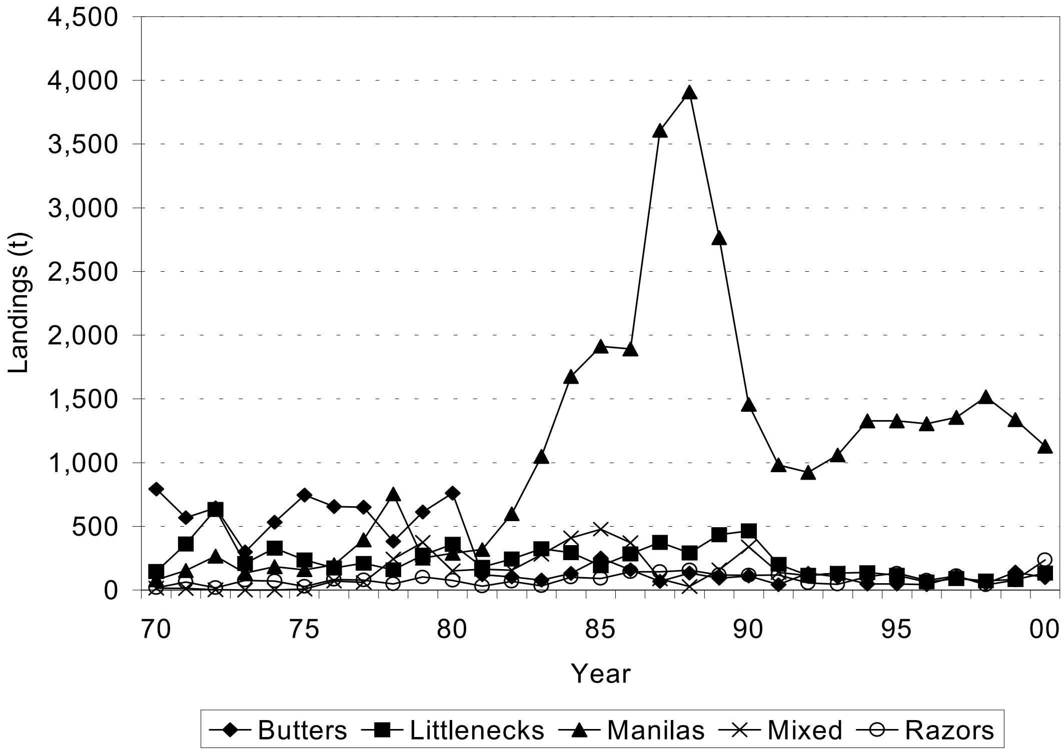


Figure 1. Annual landings (t) of intertidal clams from commercial clam fisheries in British Columbia, 1970-2000. 1999 and 2000 statistics are preliminary.

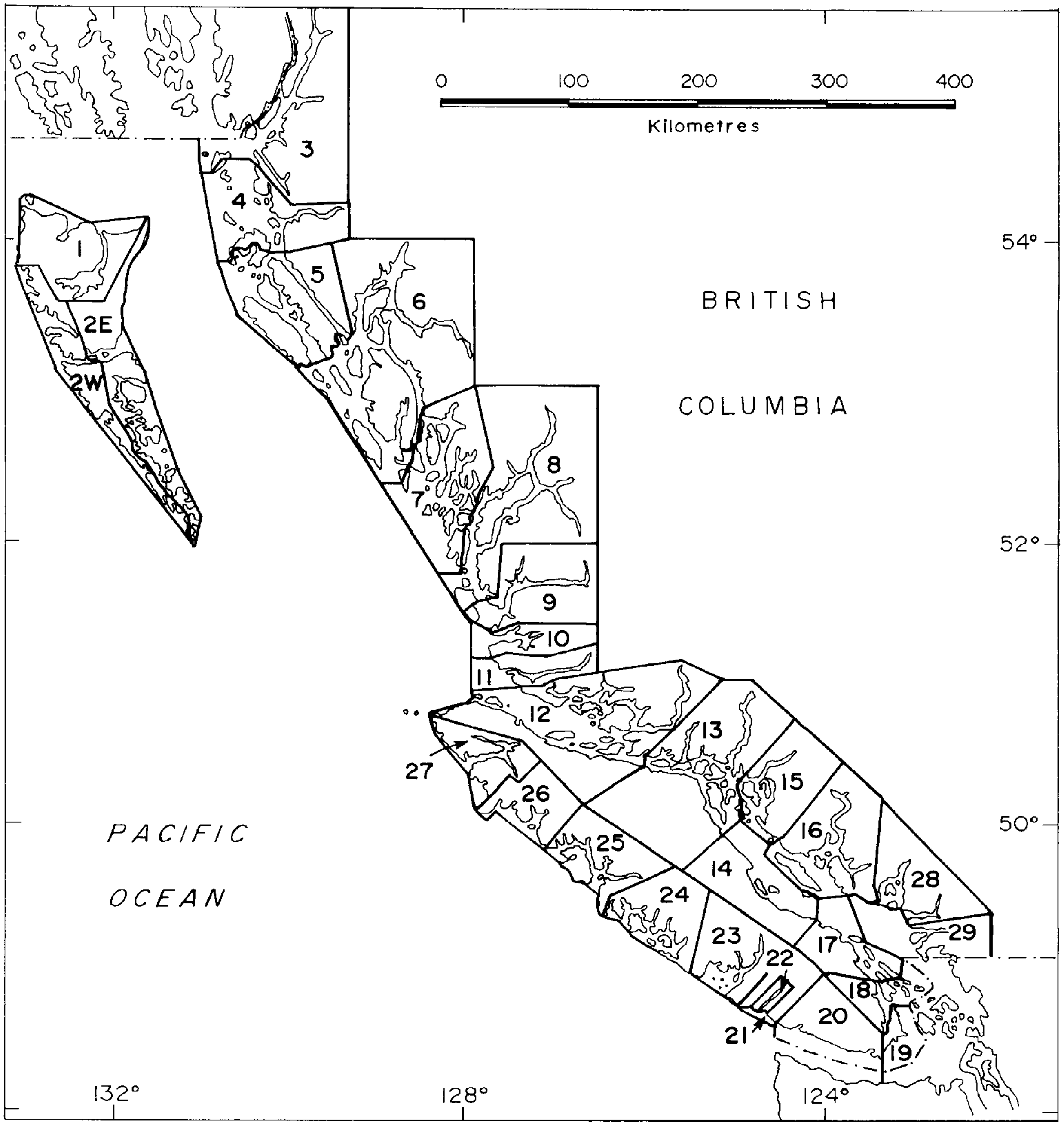


Figure 2. Pacific Fisheries Management Area boundaries for coastal British Columbia.

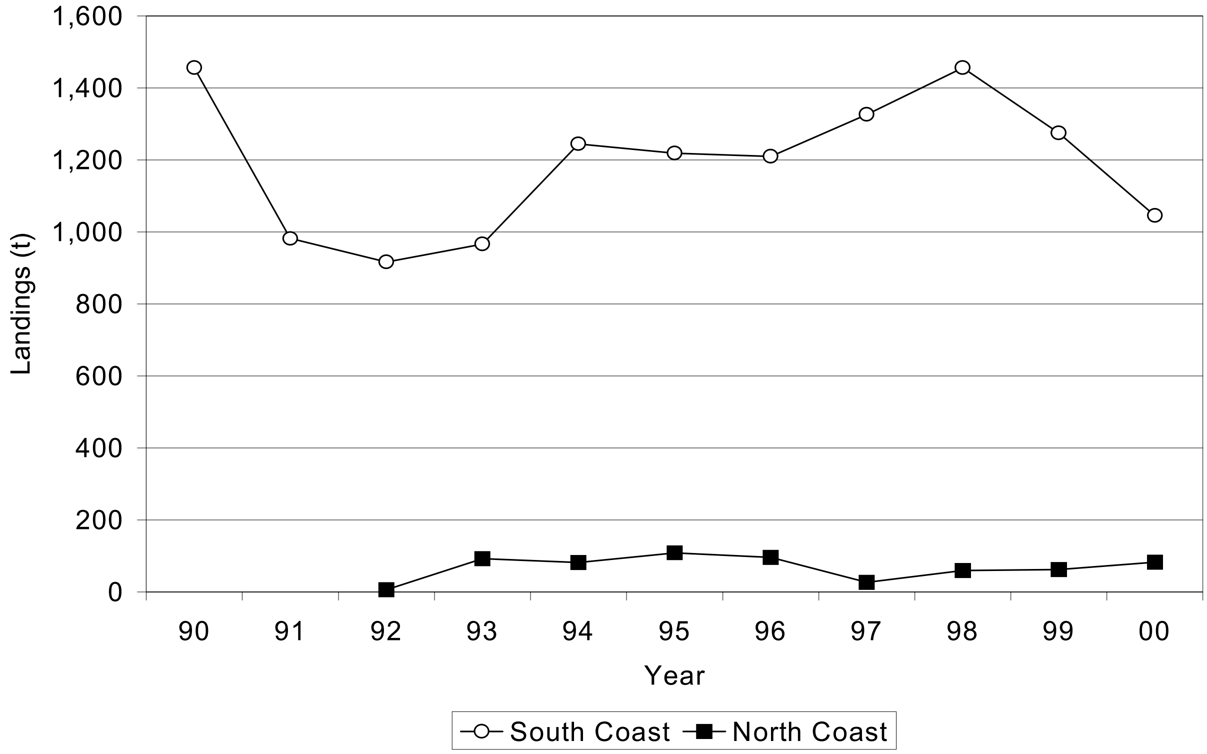


Figure 3. Annual landings (t) of Manila clams form the North and South Coast Districts of British Columbia, 1990-2000. 1990-93 South Coast landings are from sales slips, 1994-2000 South Coast landings are from plant hails, all North Coast landings are from harvest logs, sales slips and validated deliveries.

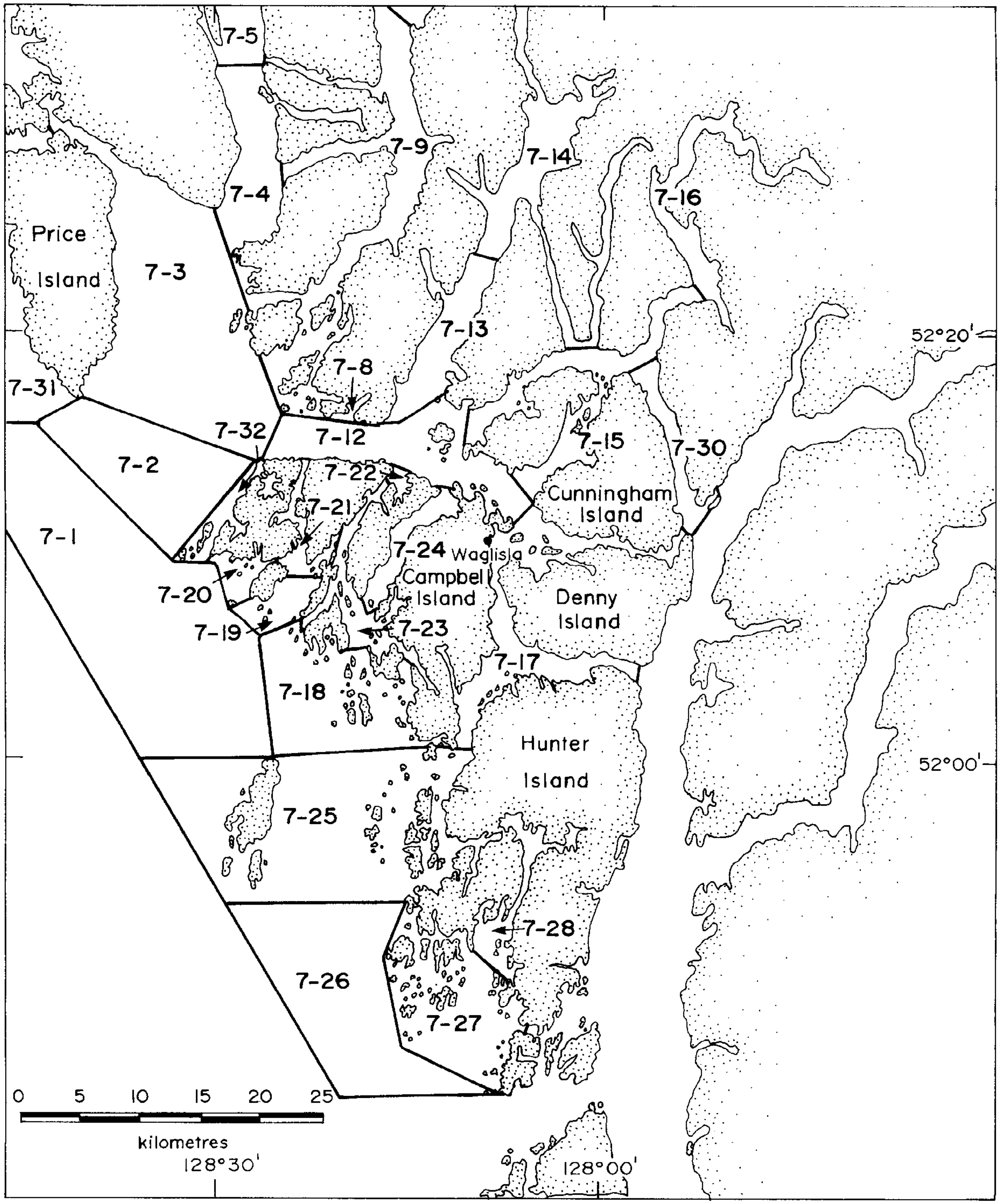


Figure 4. Pacific Fisheries Management Subarea boundaries in the portion of PFMA 7 opened to the Area 7 clam fishery.

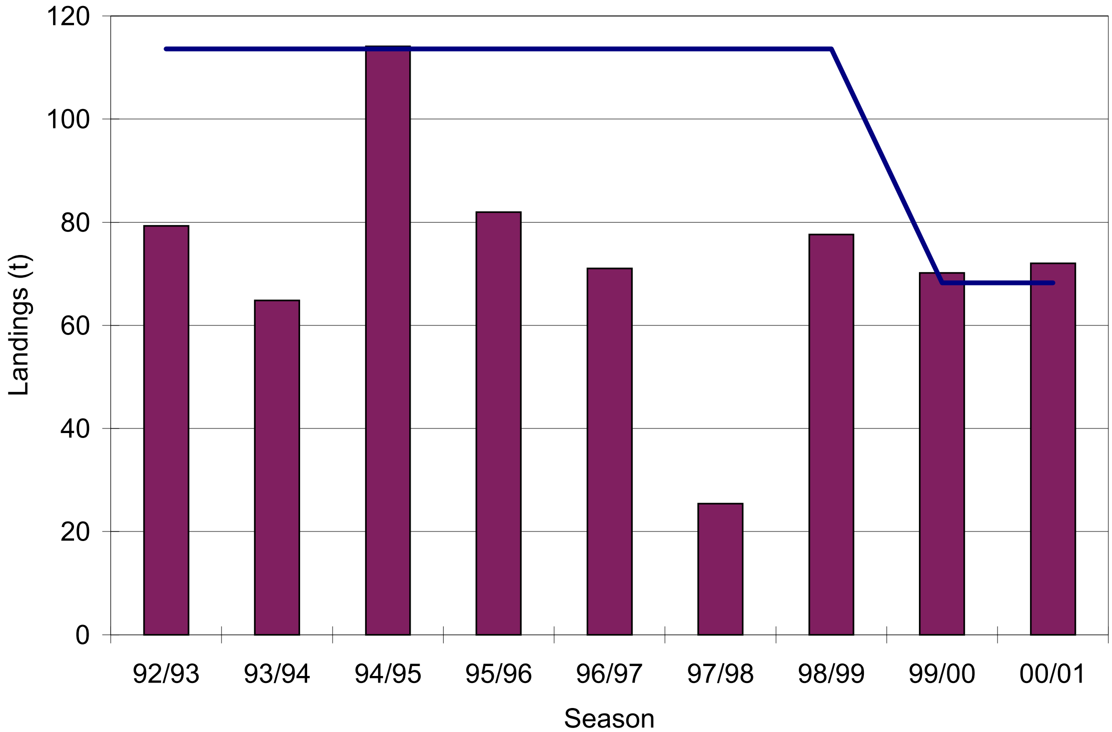


Figure 5. Landings (bars) and quota (line) for Manila clams by season from the Area 7 commercial clam fishery.

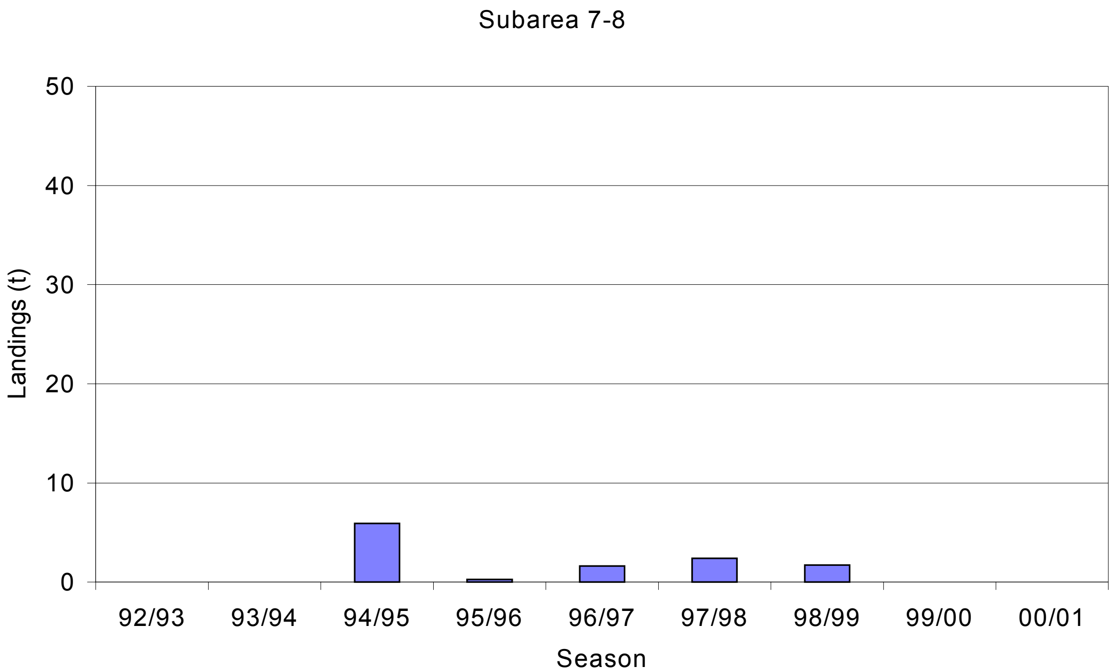


Figure 6. Landings (t) of Manila clams from PFMA 7-8/7-9 (Berry Inlet/Reid Passage) by season.

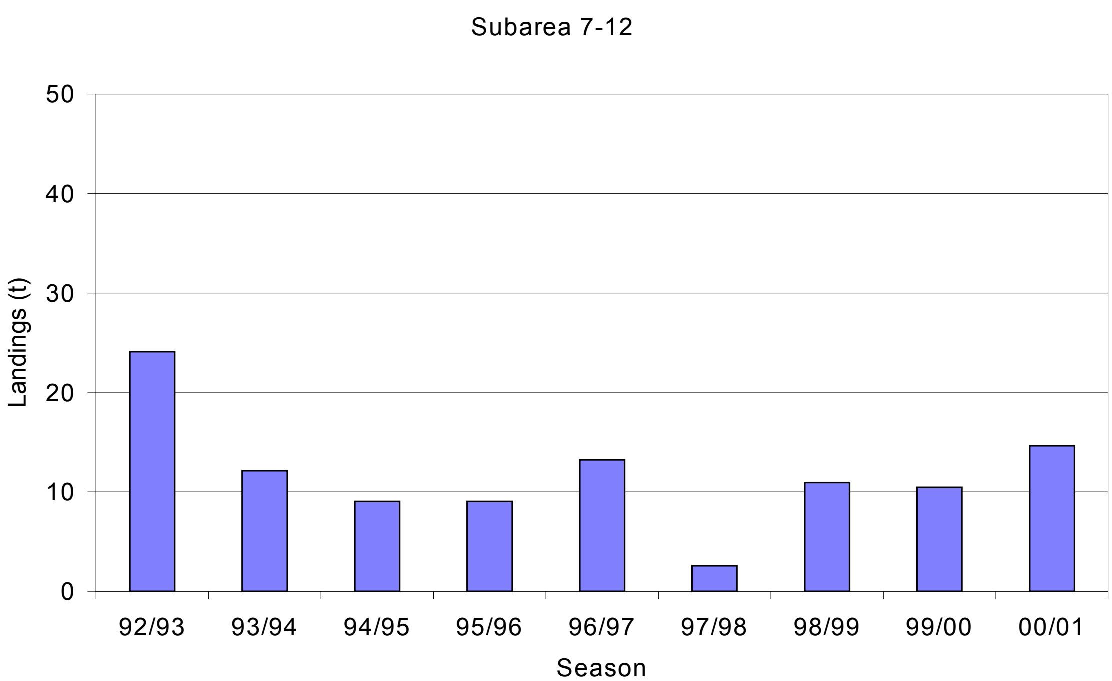


Figure 7. Landings (t) of Manila clams from PFMA 7-12 (Seaforth Channel) by season.

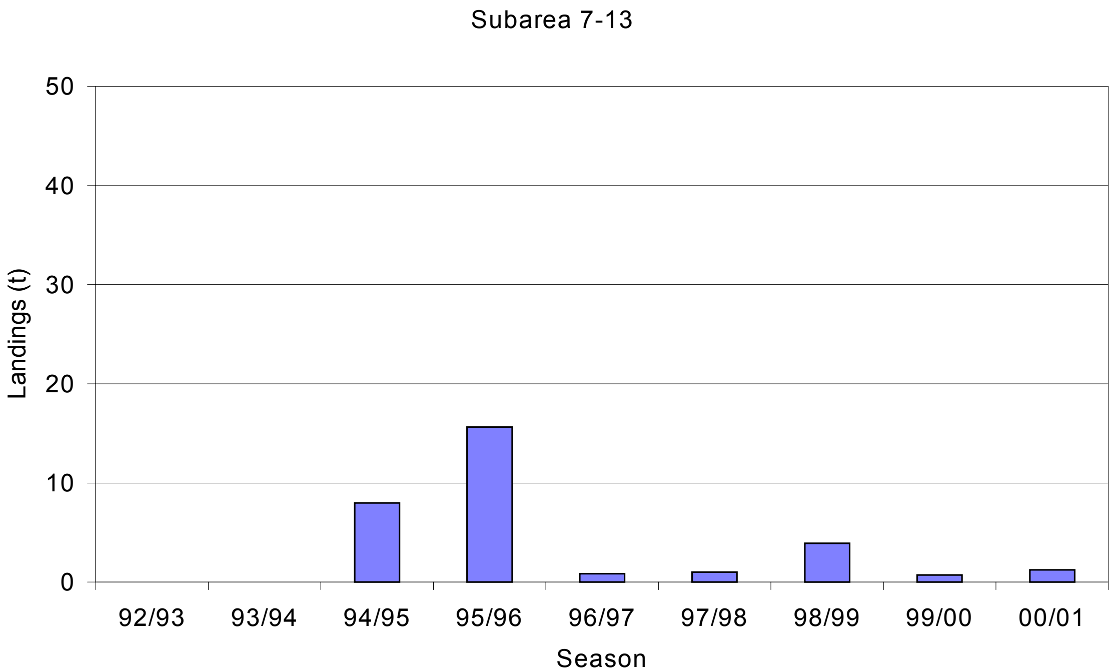


Figure 8. Landings (t) of Manila clams from PFMA 7-13 (Spiller Channel) by season.

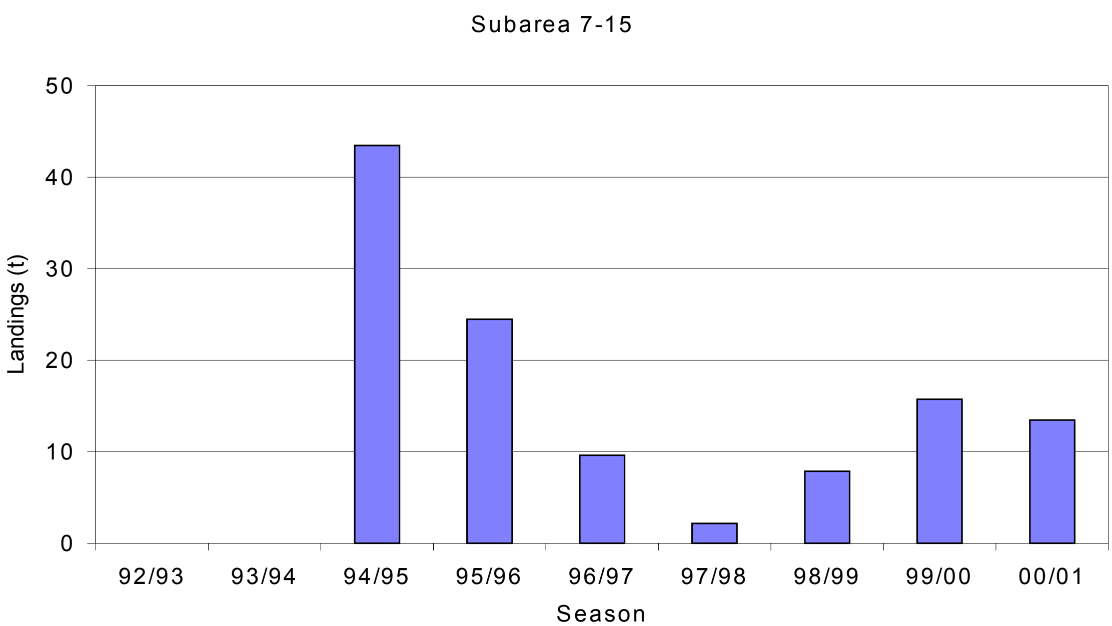


Figure 9. Landings (t) of Manila clams from PFMA 7-15 (Return Channel/Troup Passage) by season.

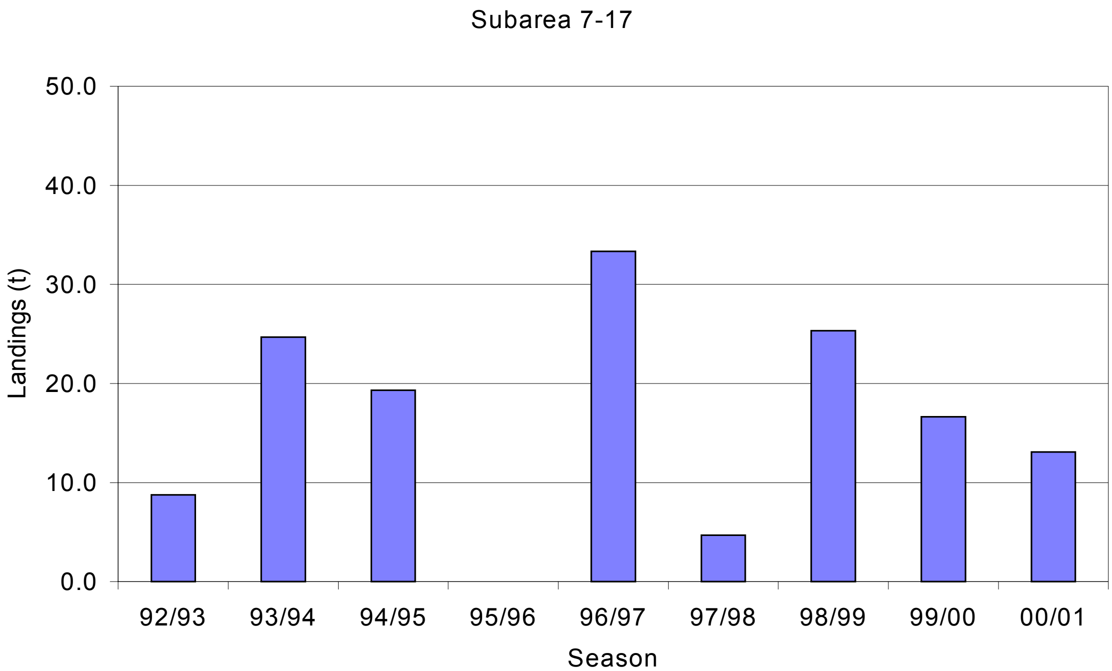


Figure 10. Landings (t) of Manila clams from PFMA 7-17 (Lama Passage/Gunboat Passage/Hunter Channel) by season.

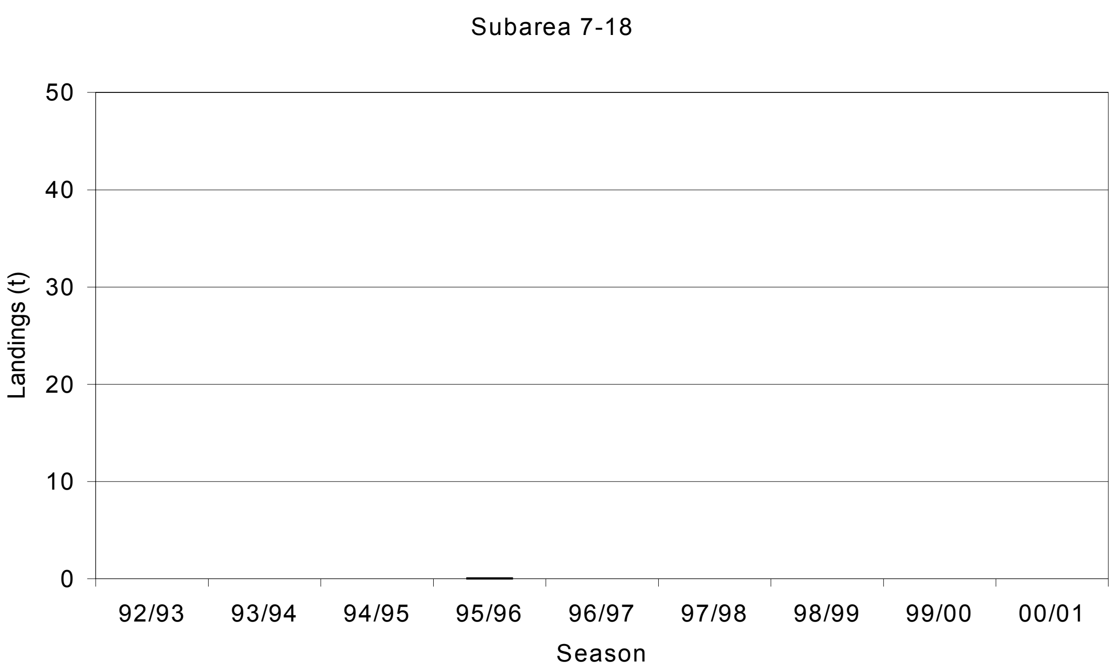


Figure 11. Landings (t) of Manila clams from PFMA 7-18 (Tribal Group) by season.

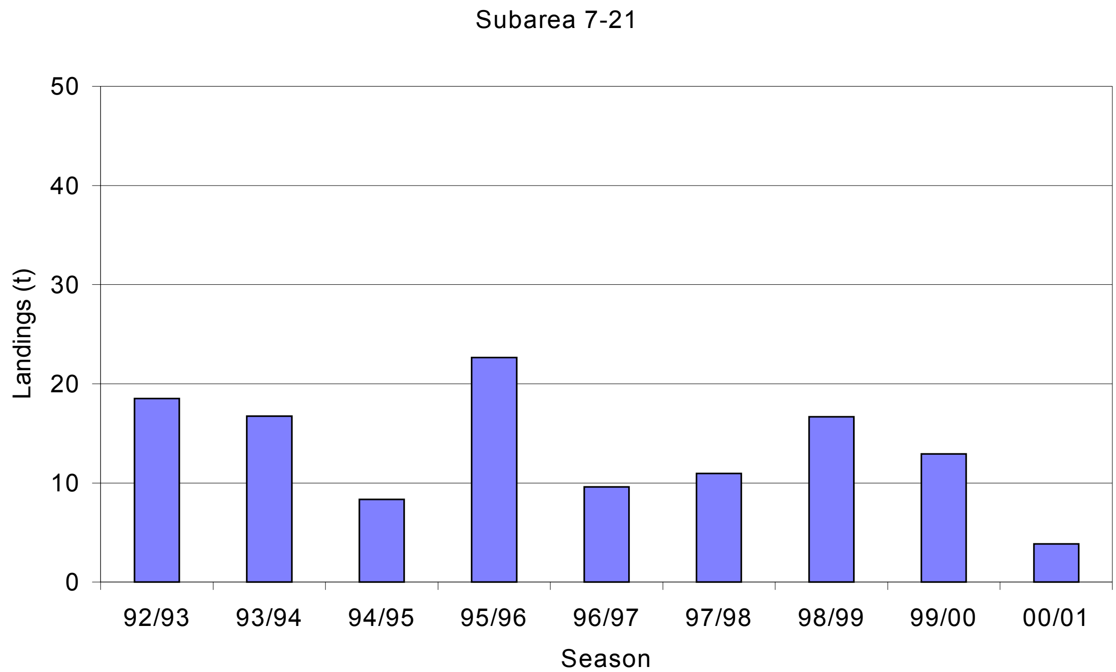


Figure 12. Landings (t) of Manila clams from PFMA 7-21 (Gale Passage) by season.

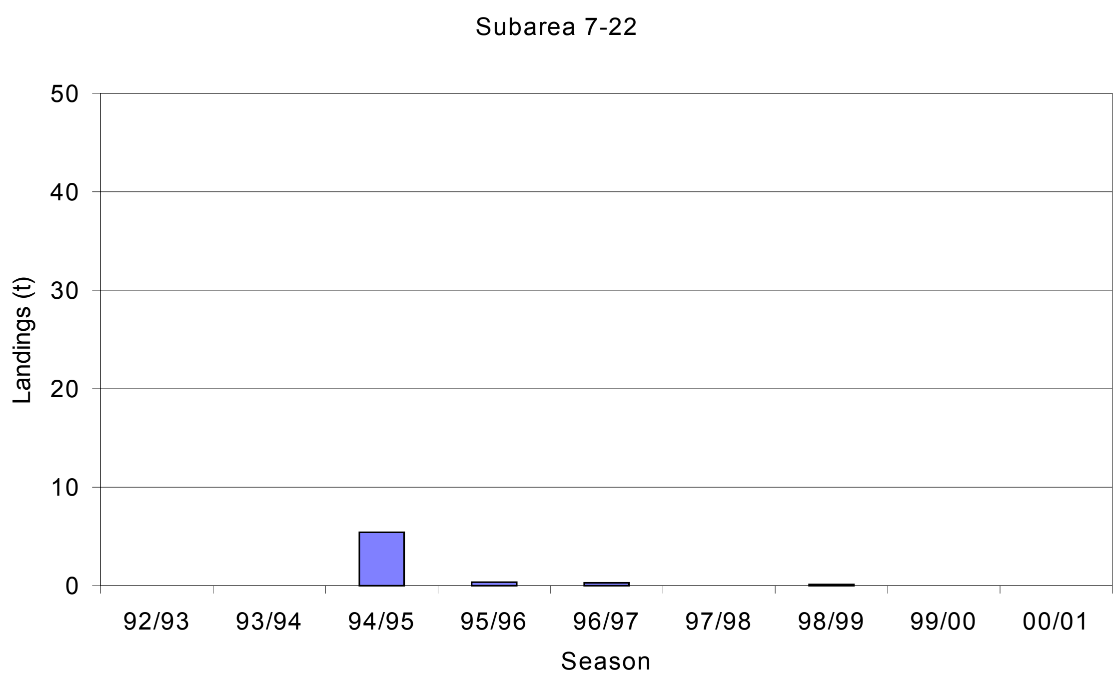


Figure 13. Landings (t) of Manila clams from PFMA 7-22 (Dundivan Inlet) by season.

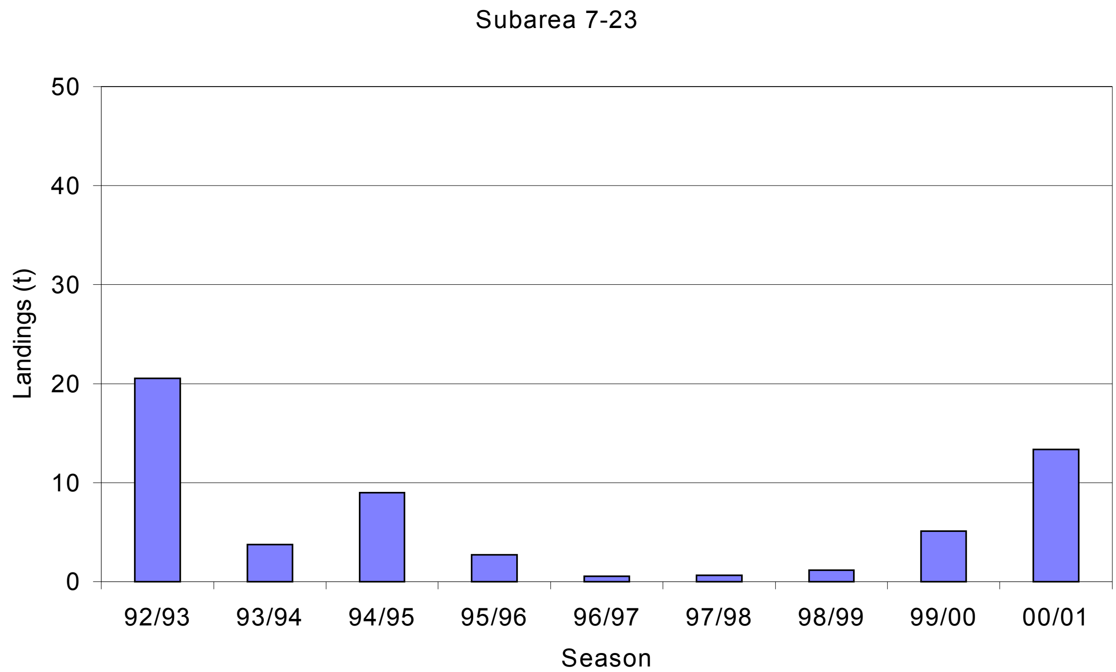


Figure 14. Landings (t) of Manila clams from PFMA 7-23 (Joassa Channel/Louise Channel) by season.

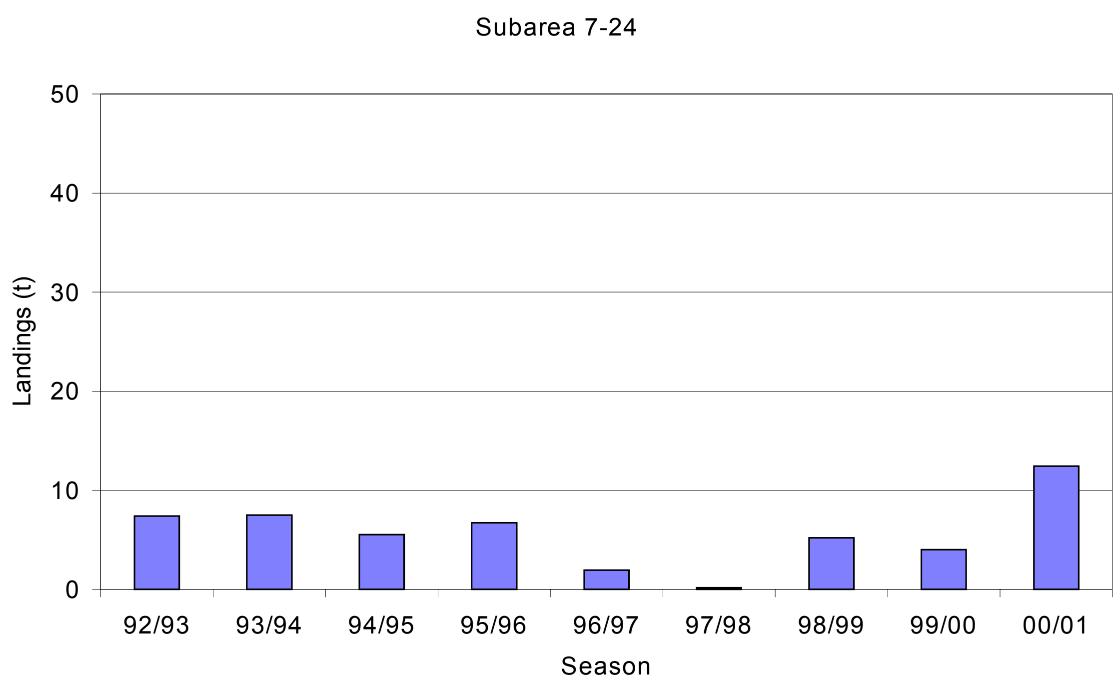


Figure 15. Landings (t) of Manila clams from PFMA 7-24 (Raymond Passage) by season.

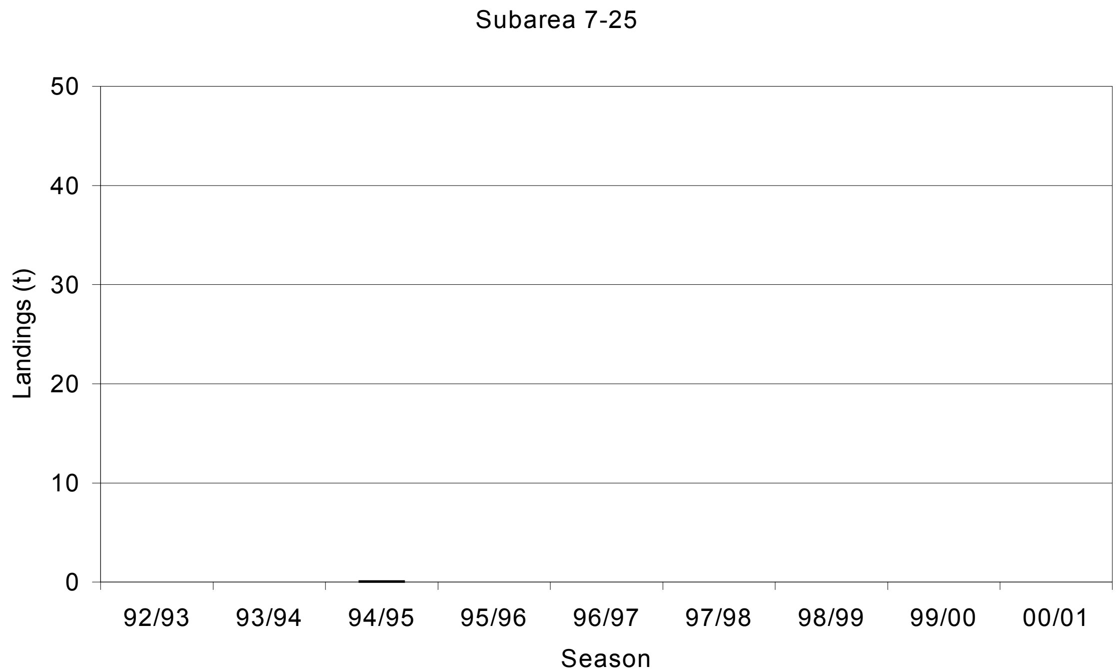


Figure 16. Landings (t) of Manila clams from PFMA 7-25 (Queen Sound) by season.

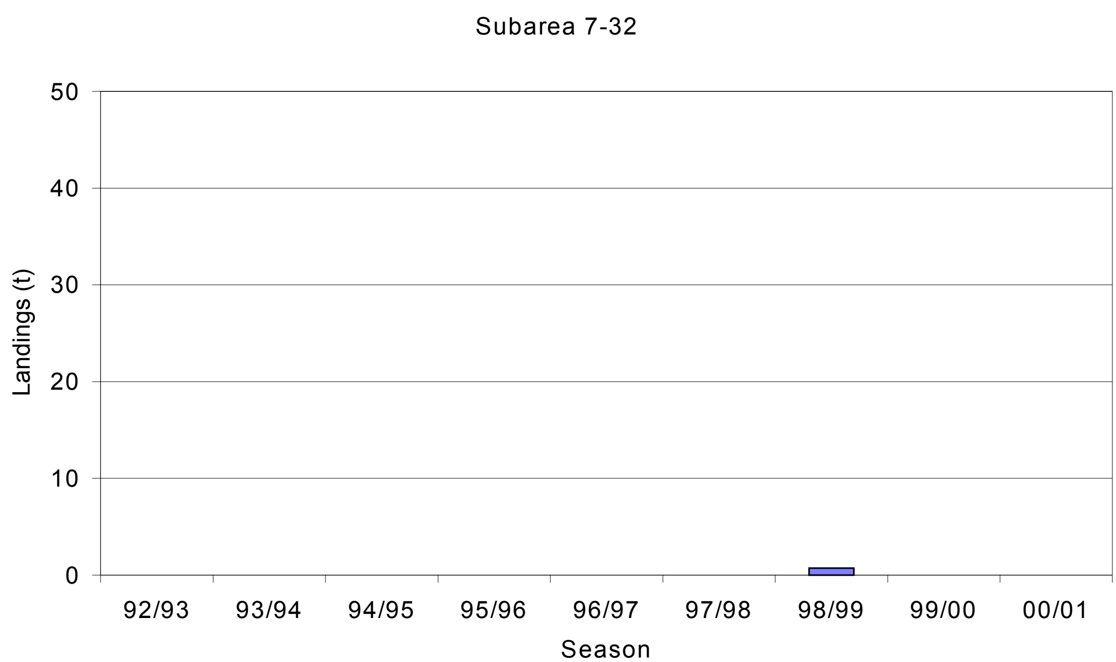


Figure 17. Landings (t) of Manila clams from PFMA 7-32 (St. John Harbour) by season.

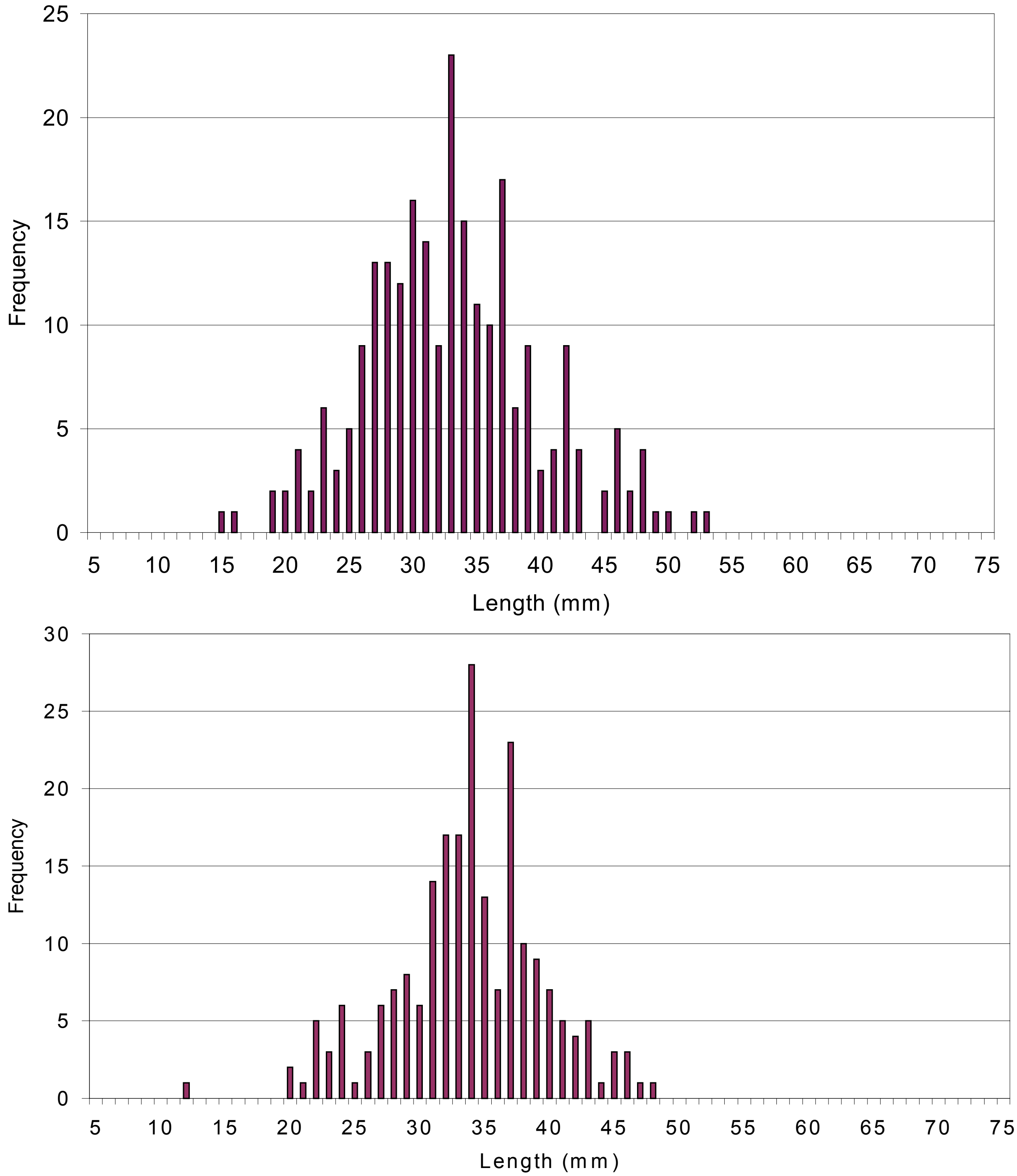
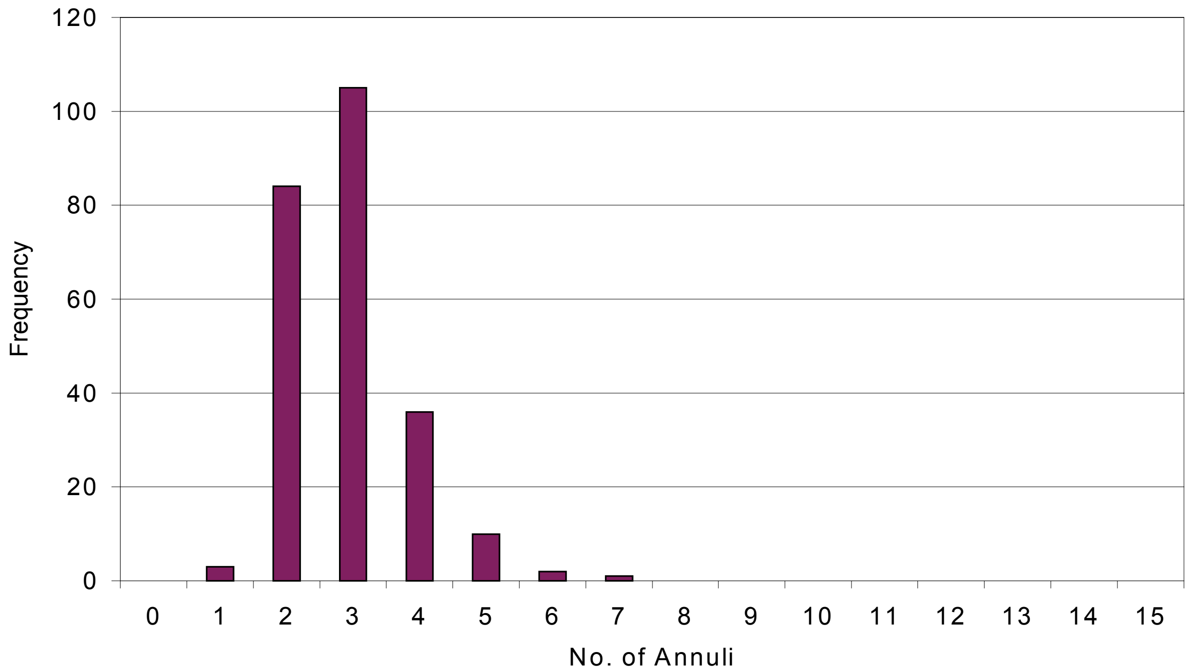


Figure 18. Length frequency distributions of Manila clams from surveys at Bachelor Bay (7-12-7) in 1999 (top, n=240) and 2000 (bottom, n=217).



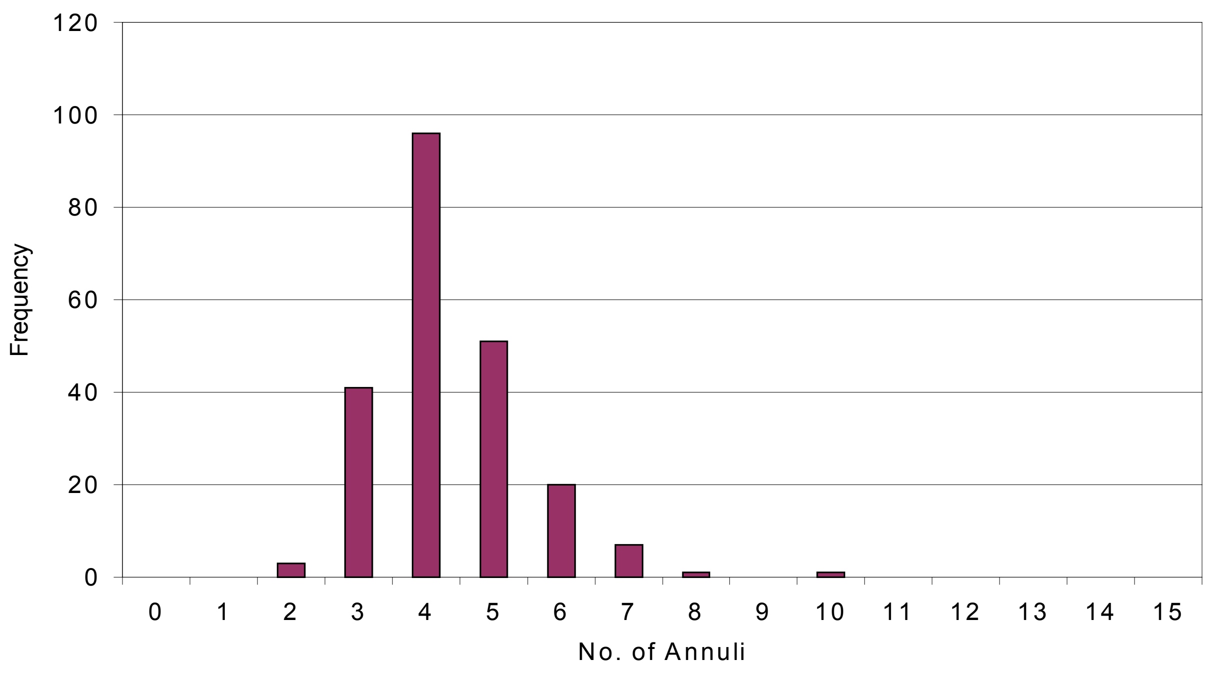


Figure 19. Age frequency distributions of Manila clams from surveys at Bachelor Bay (7-12-7) in 1999 (top, n=241) and 2000 (bottom, n=220).

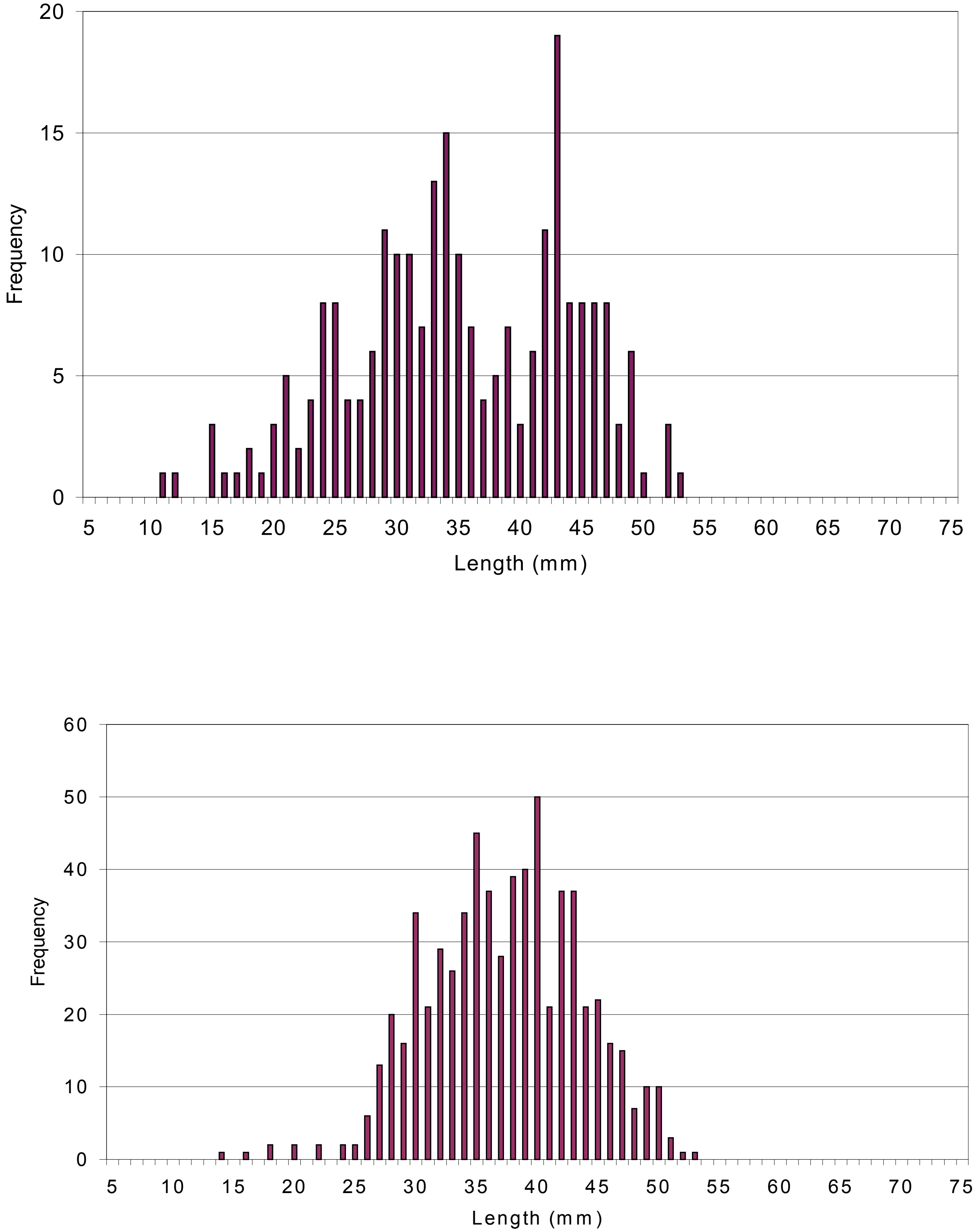
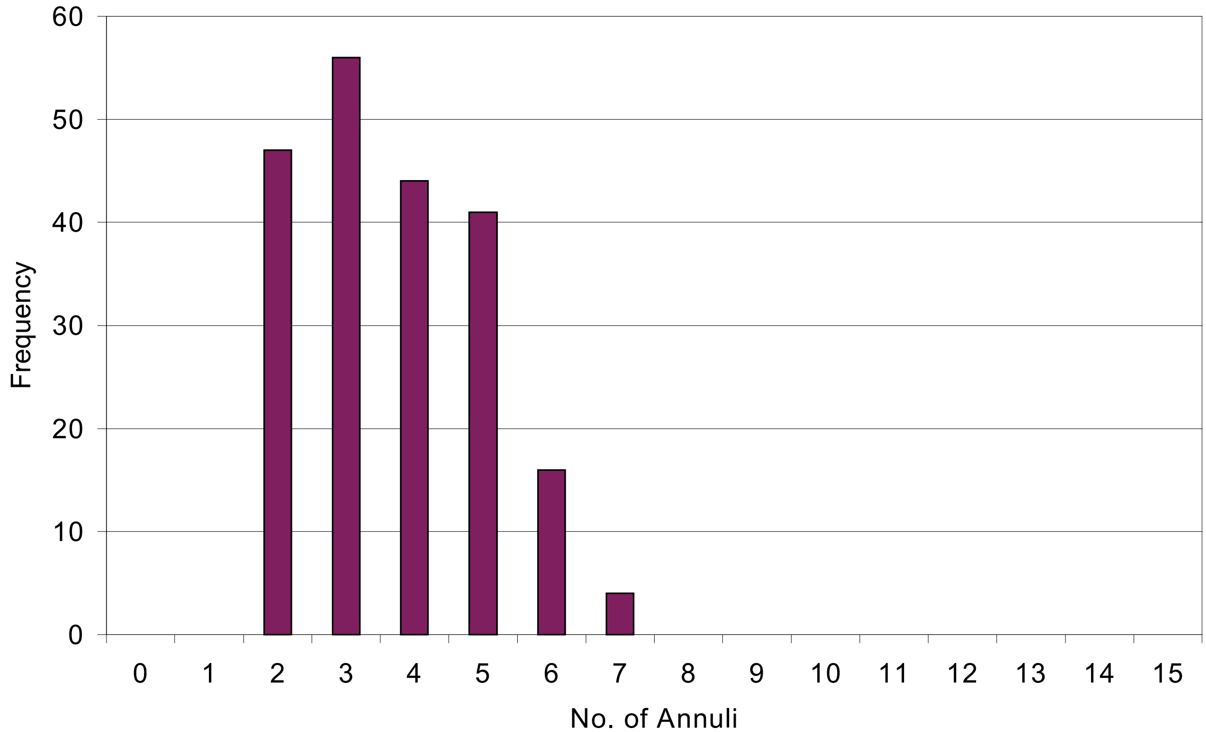


Figure 20. Length frequency distributions of Manila clams from surveys at Odin Cove (7-12-12) in 1999 (top, n=238) and 2000 (bottom, n=651).



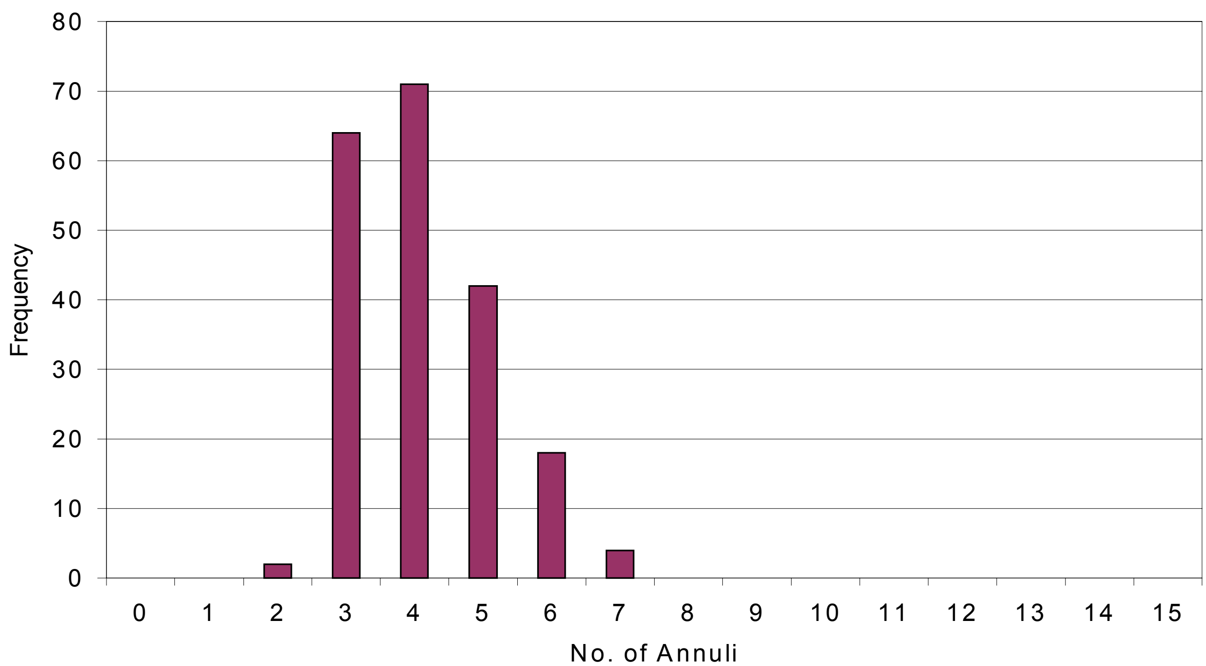
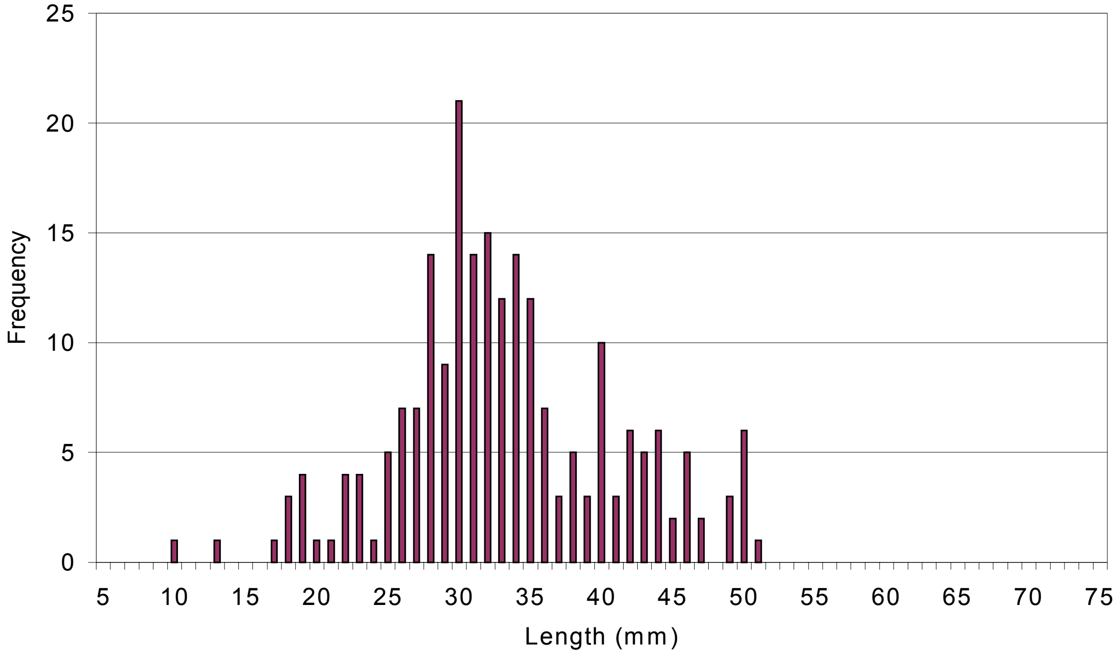


Figure 21. Age frequency distributions of Manila clams from surveys at Odin Cove (7-12-12) in 1999 (top, n=208) and 2000 (bottom, n=201).



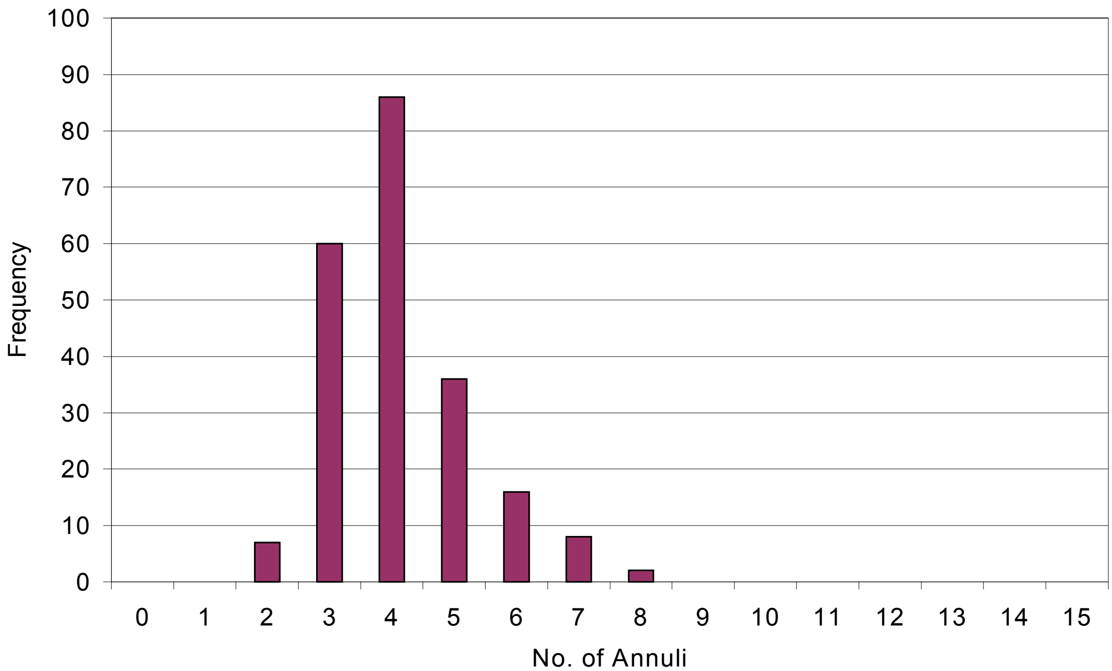
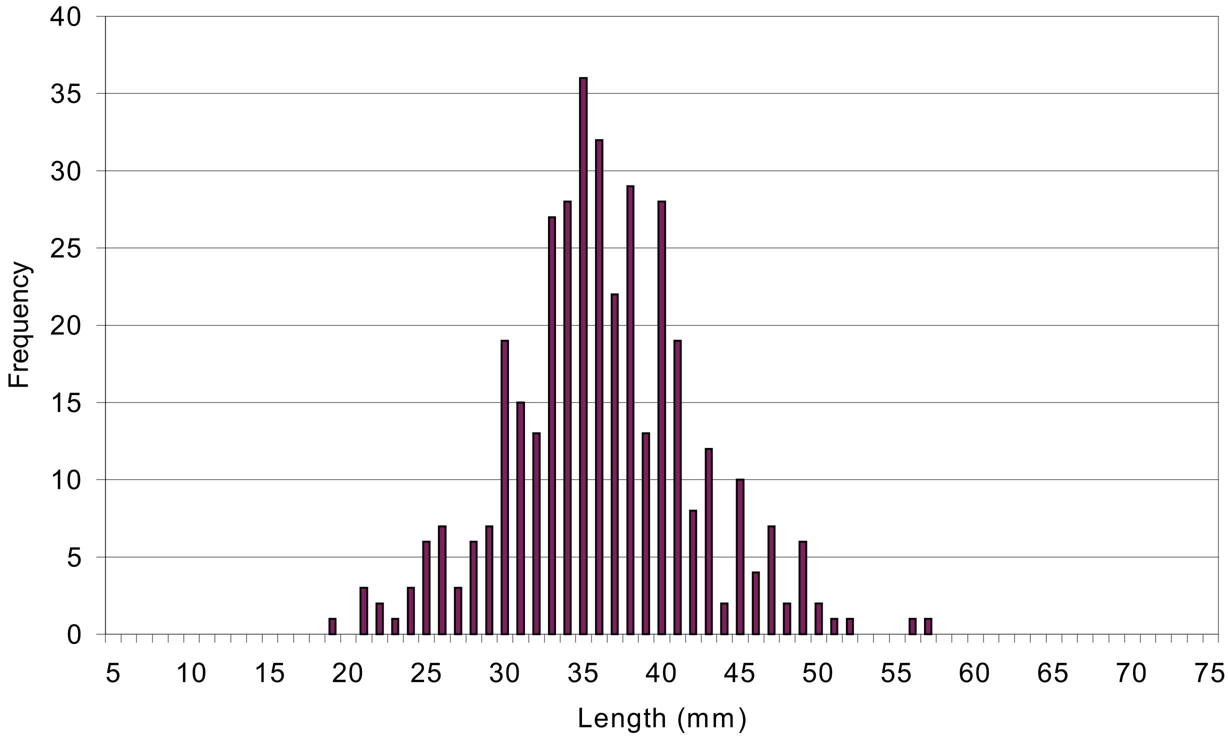


Figure 22. Length (top, n=218) and age (bottom, n=215) frequency distributions of Manila clams from the 2000 survey at Troup Passage (7-15-12).



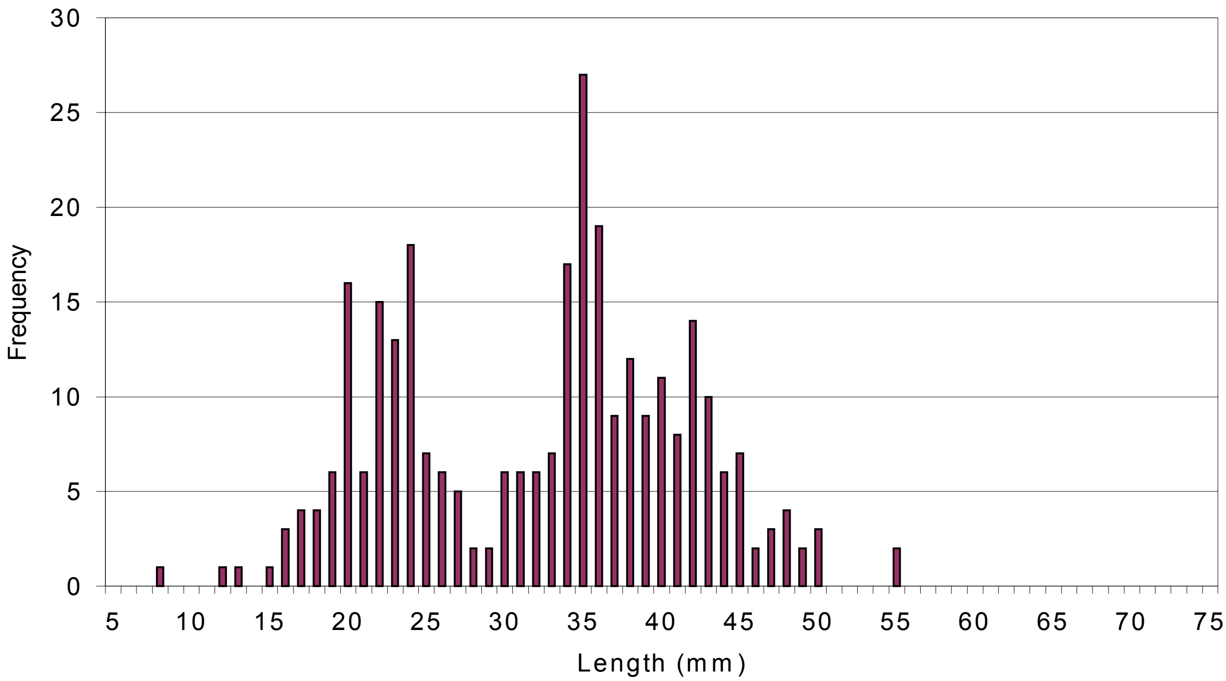


Figure 23. Length frequency distributions of Manila clams from surveys at Kakushdish Harbour (7-17-22/23) in 1999 (top, n=377) and 2000 (bottom, n=301).

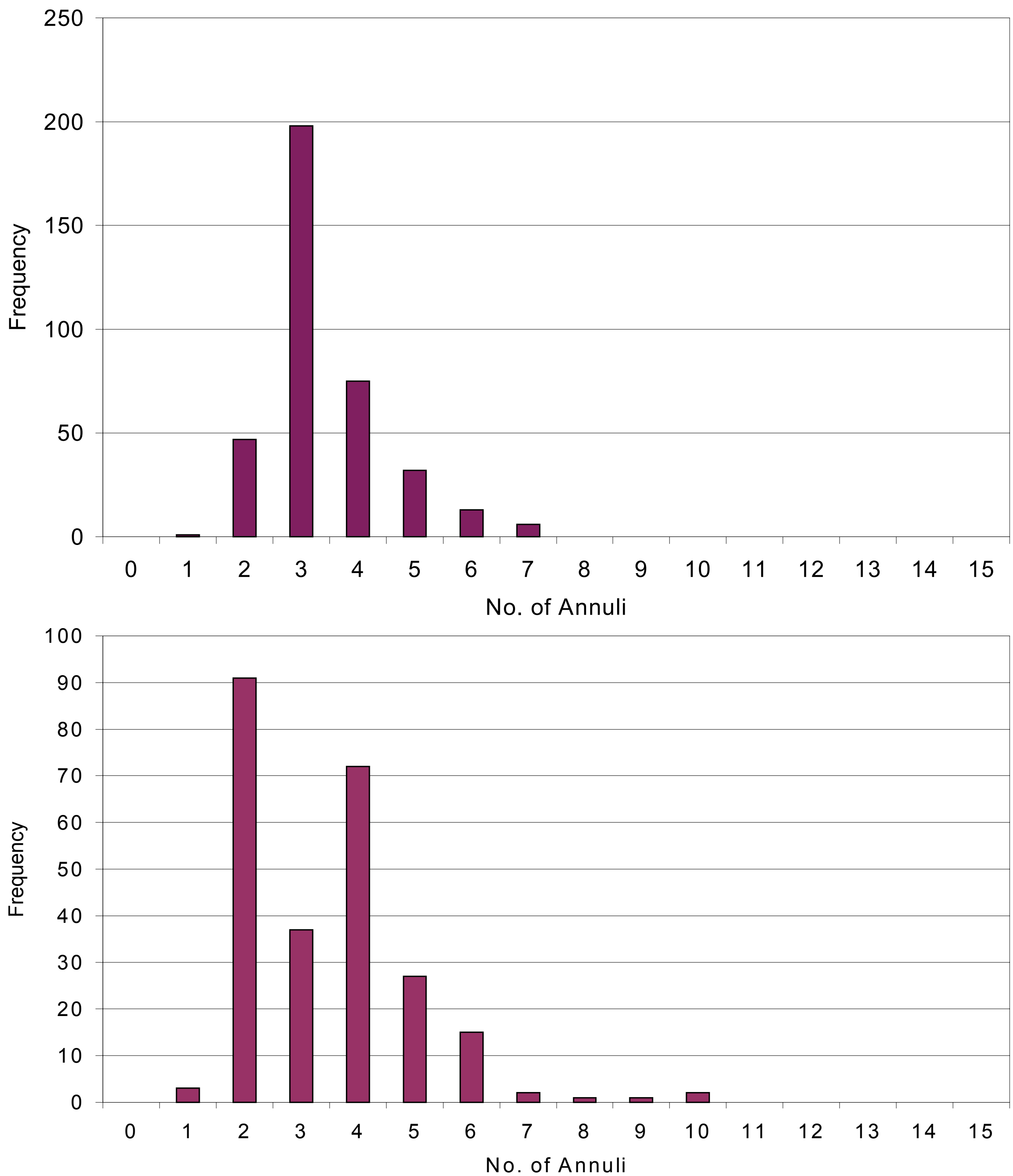


Figure 24. Age frequency distributions of Manila clams from surveys at Kakushdish Harbour (7-17-22/23) in 1999 (top, n=372) and 2000 (bottom, n=251).

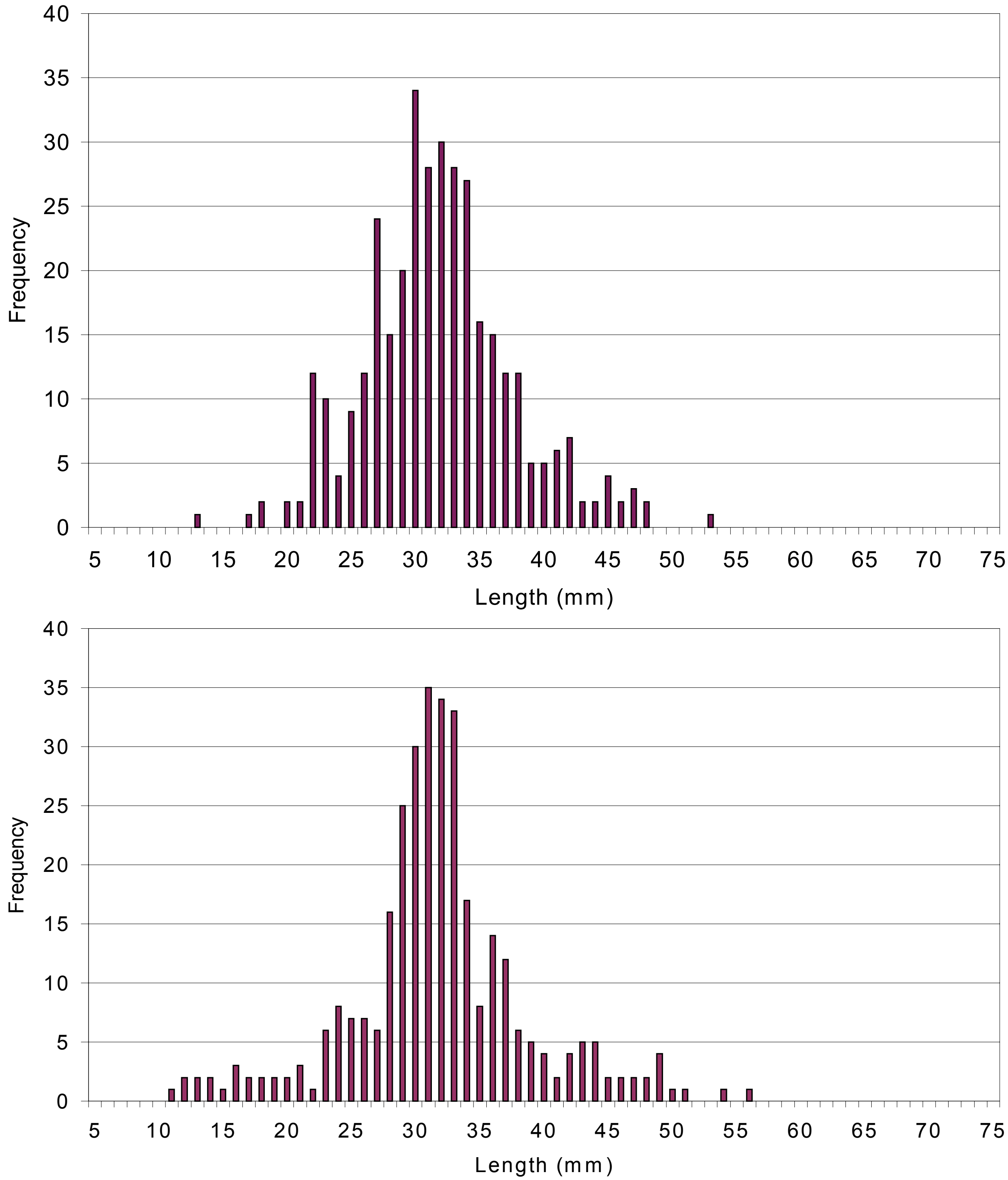


Figure 25. Length frequency distributions of Manila clams from surveys at Rainbow Island (7-17-4) in 1999 (top, n=355) and 2000 (bottom, n=328).

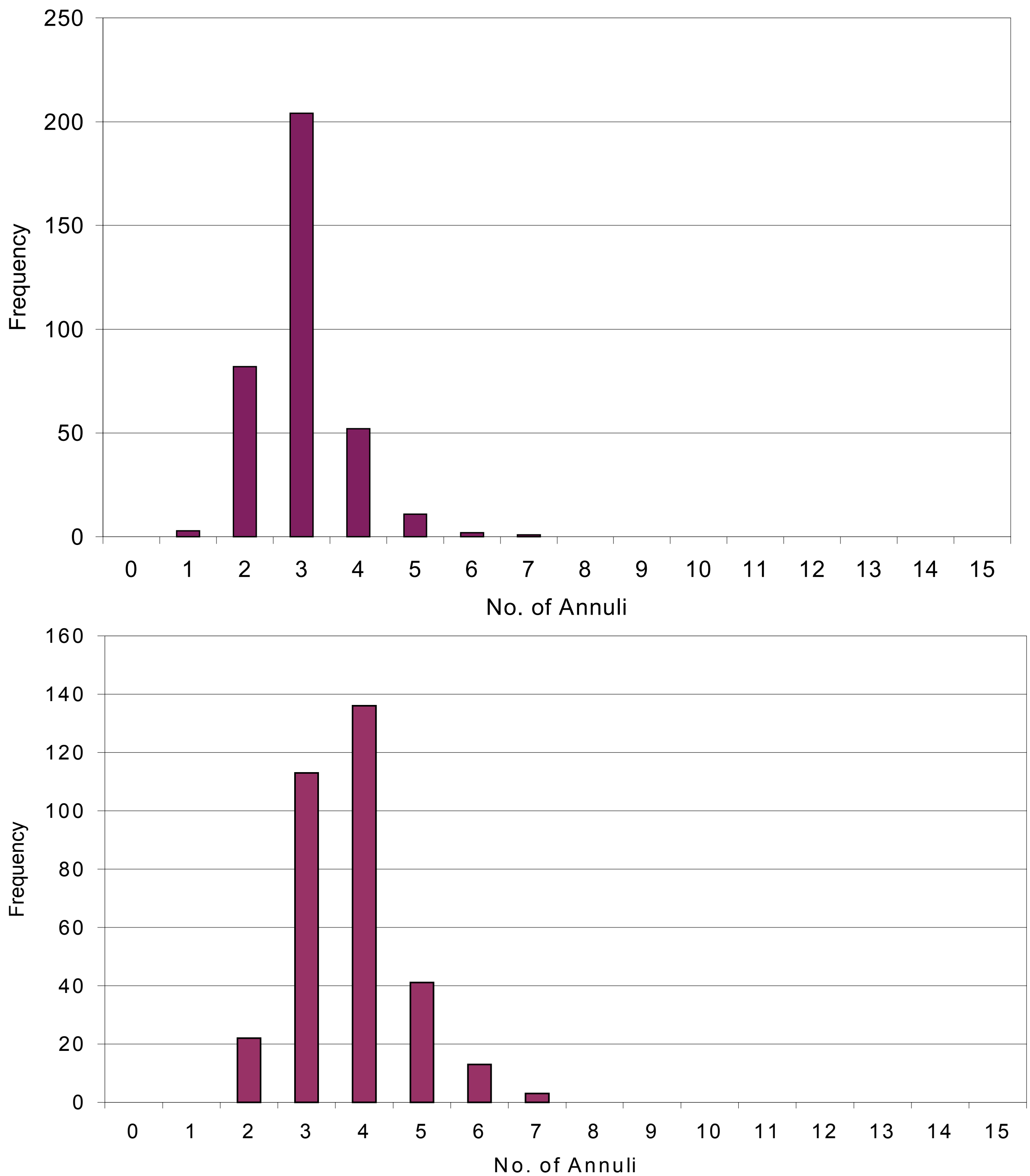


Figure 26. Age frequency distributions of Manila clams from surveys at Rainbow Island (7-17-4) in 1999 (top, n=355) and 2000 (bottom, n=328).

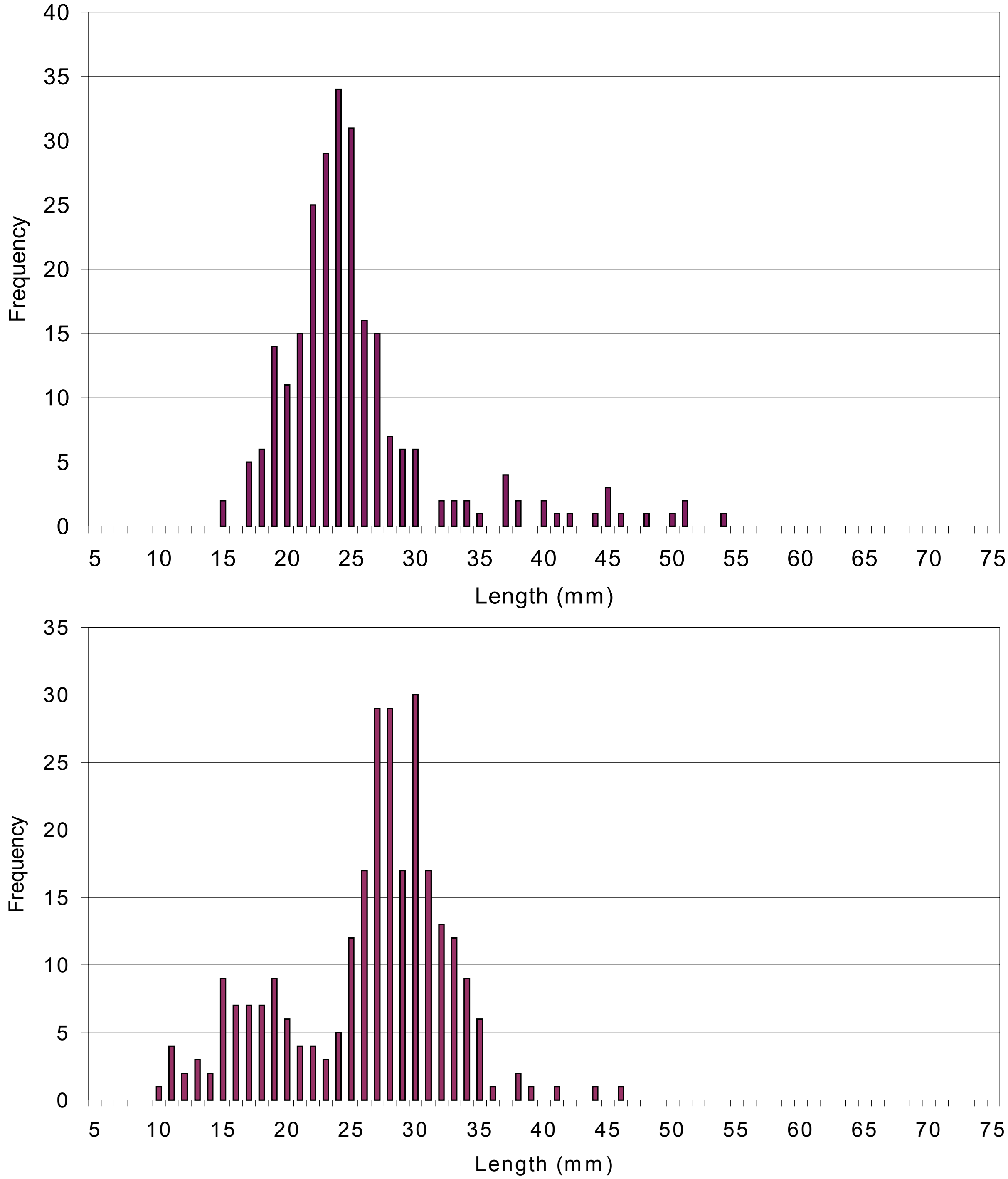


Figure 27. Length frequency distributions of Manila clams from surveys at Gale Passage (7-21-1) in 1999 (top, n=249) and 2000 (bottom, n=271).

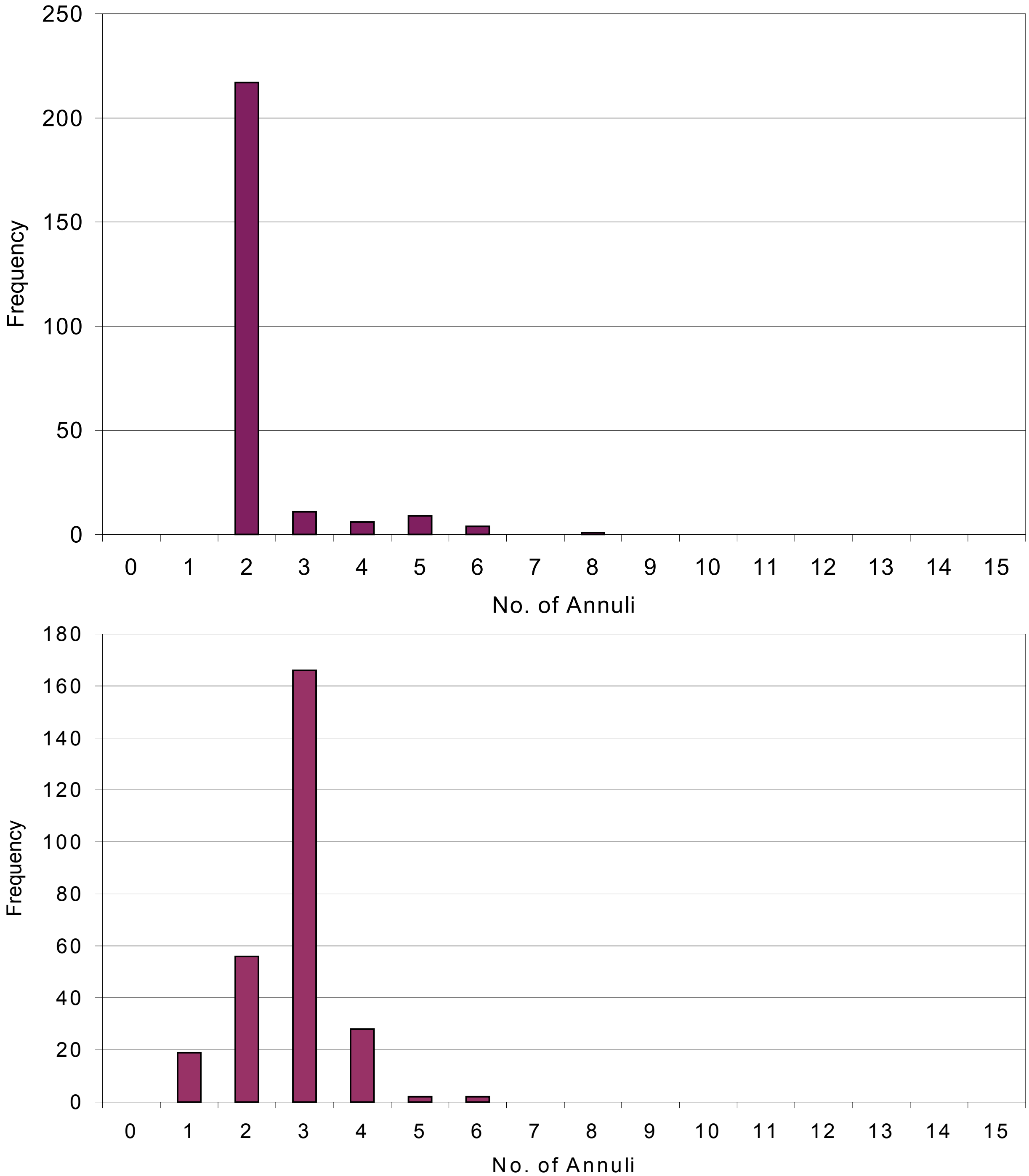
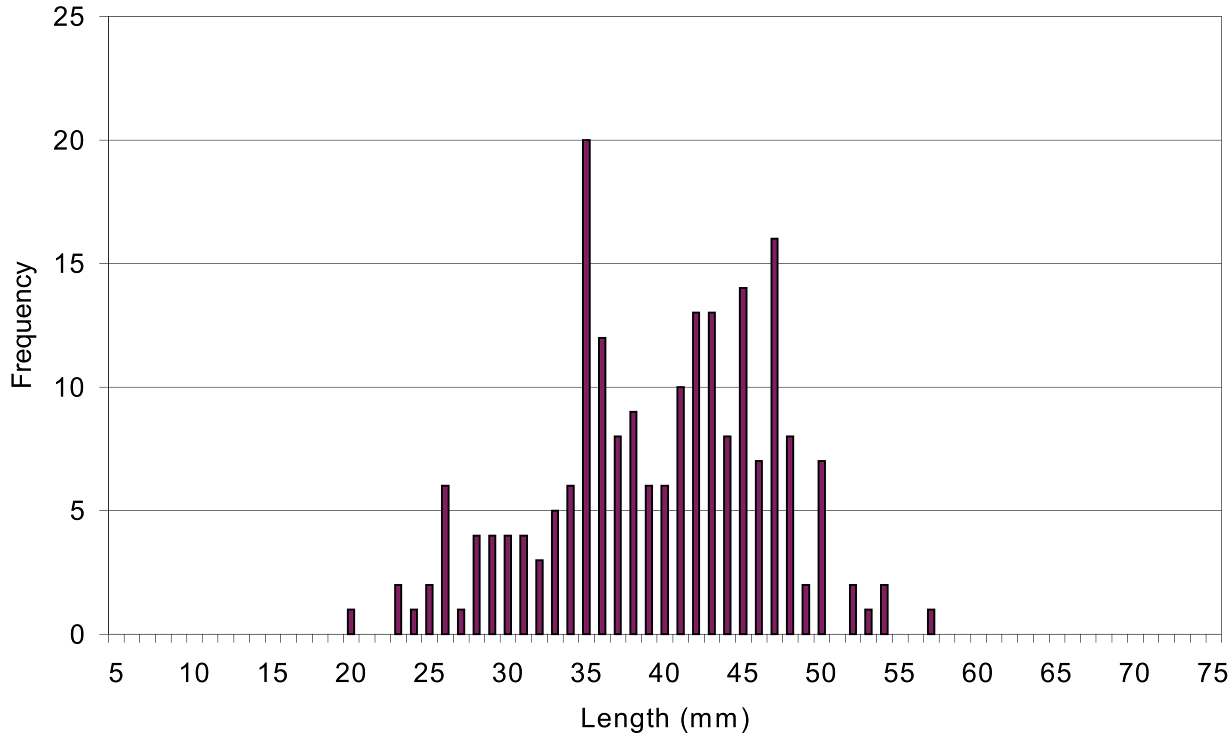


Figure 28. Age frequency distributions of Manila clams from surveys at Gale Passage (7-21-1) in 1999 (top, n=248) and 2000 (bottom, n=273).



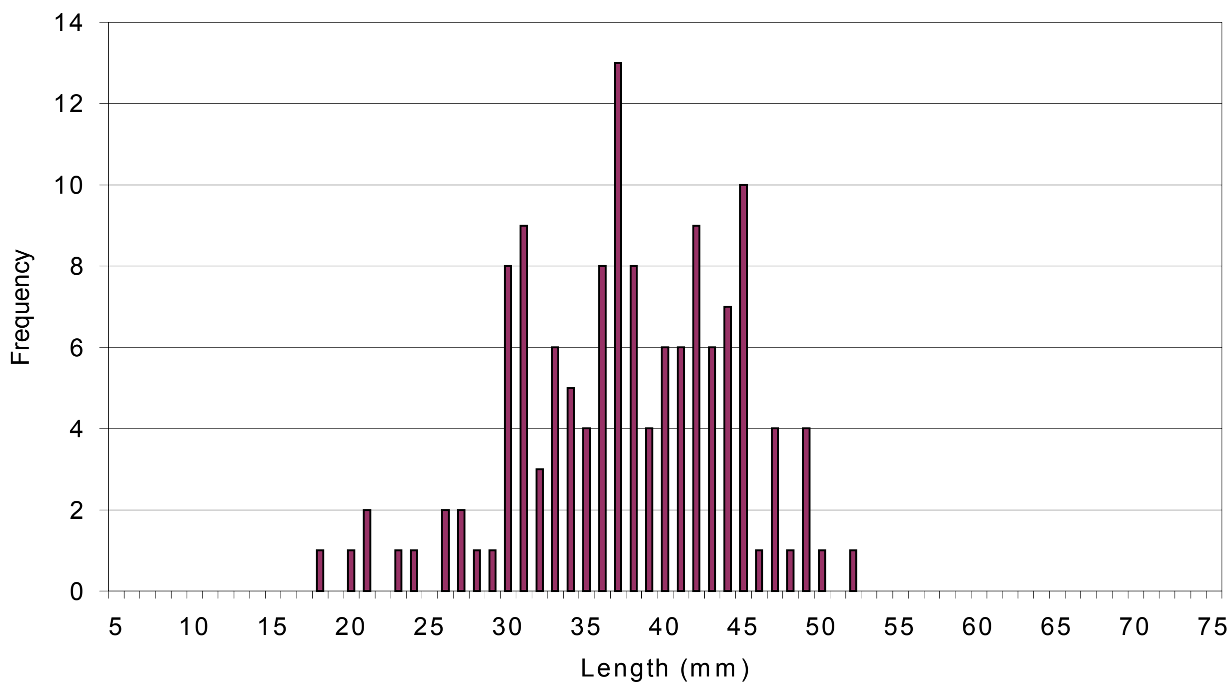


Figure 29. Length frequency distributions of Manila clams from surveys at Joassa Channel (7-23-6) in 1999 (top, n=208) and 2000 (bottom, n=136).

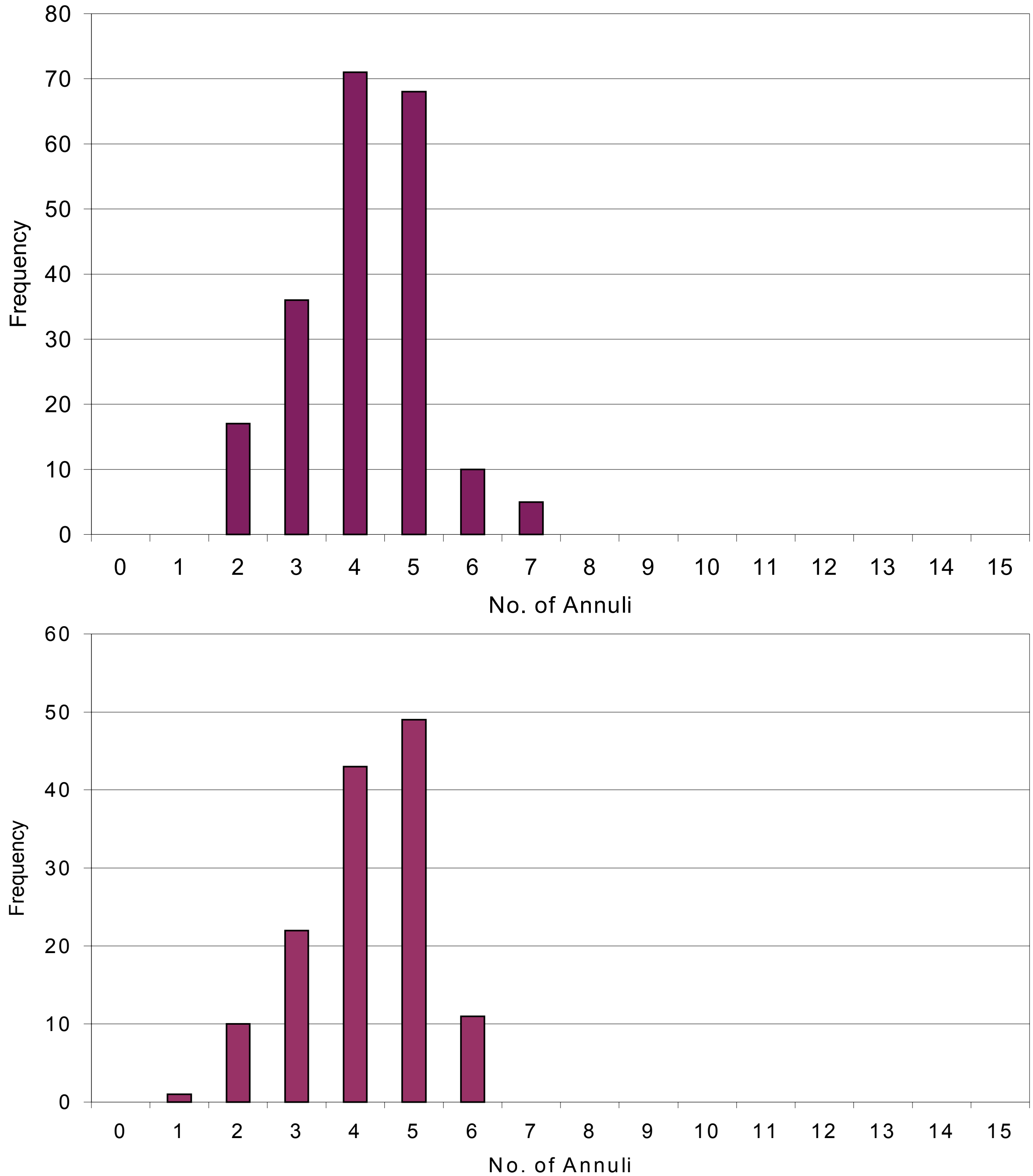


Figure 30. Age frequency distributions of Manila clams from surveys at Joassa Channel (7-23-6) in 1999 (top, n=207) and 2000 (bottom, n=136).

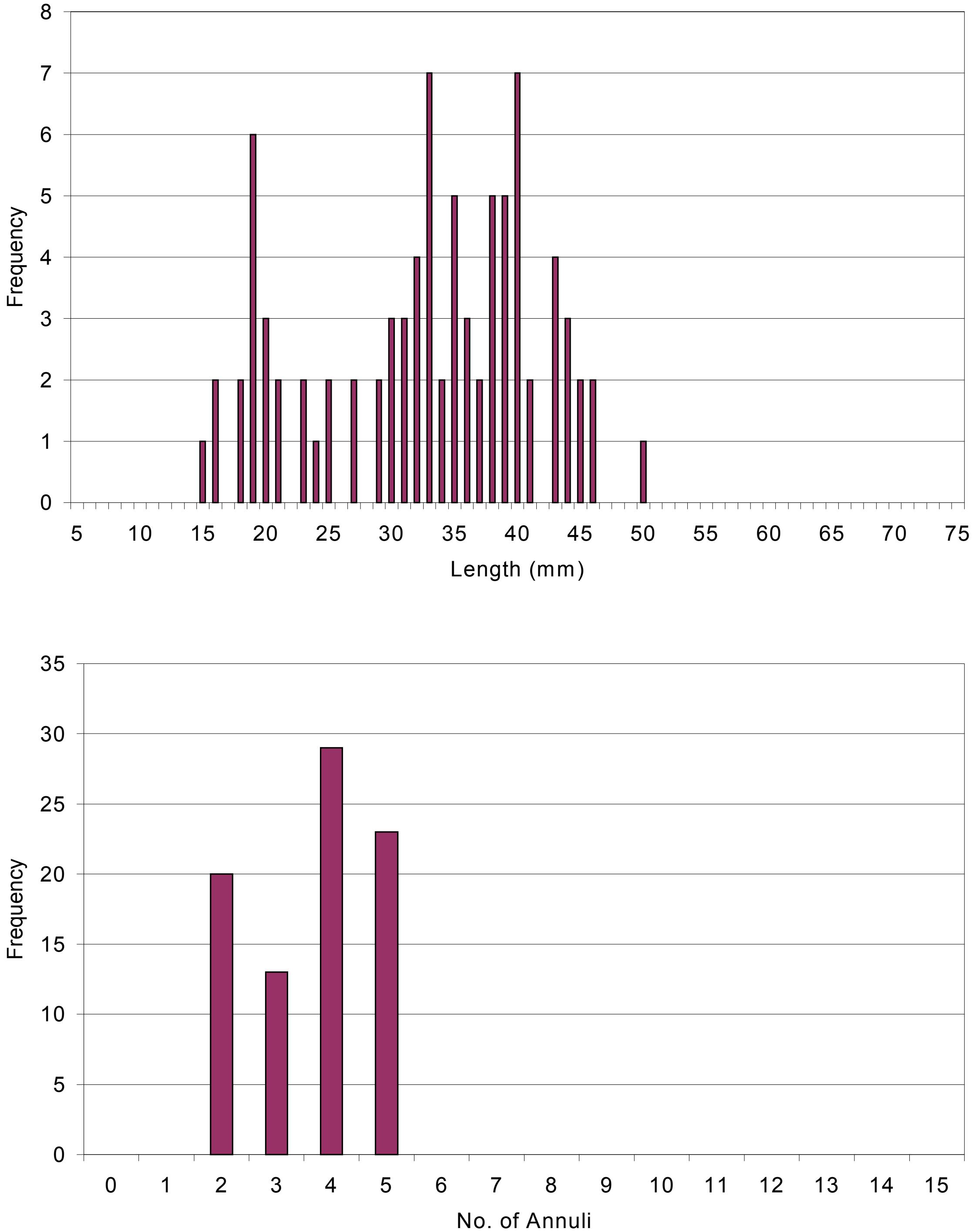


Figure 31. Length (top, n=85) and age (bottom, n=85) frequency distributions of Manila clams from the 2000 survey at Joassa Channel (7-23-18).

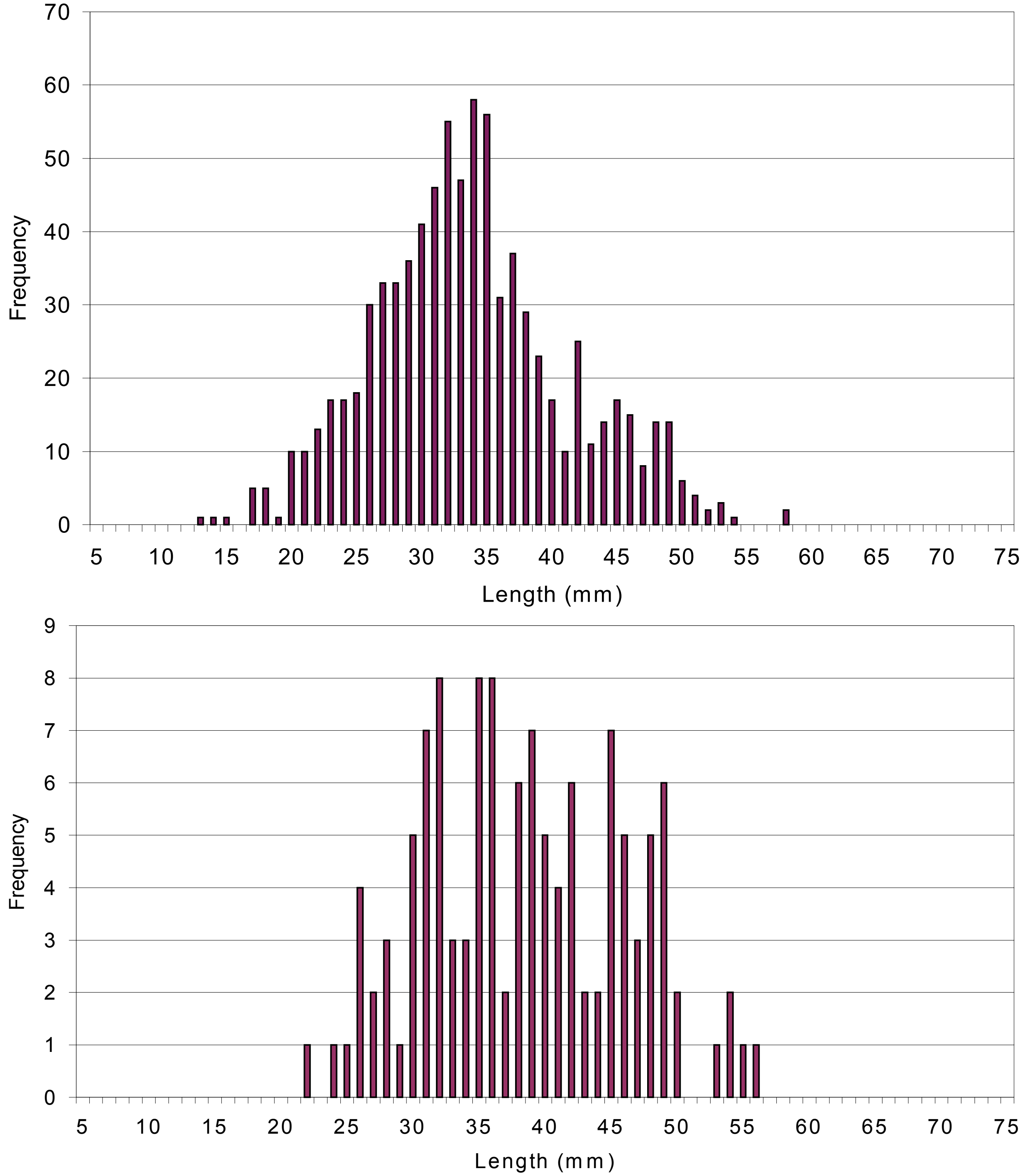


Figure 32. Length frequency distributions of Manila clams from surveys at Raymond Passage (7-24-13) in 1999 (top, n=818) and 2000 (bottom, n=122).

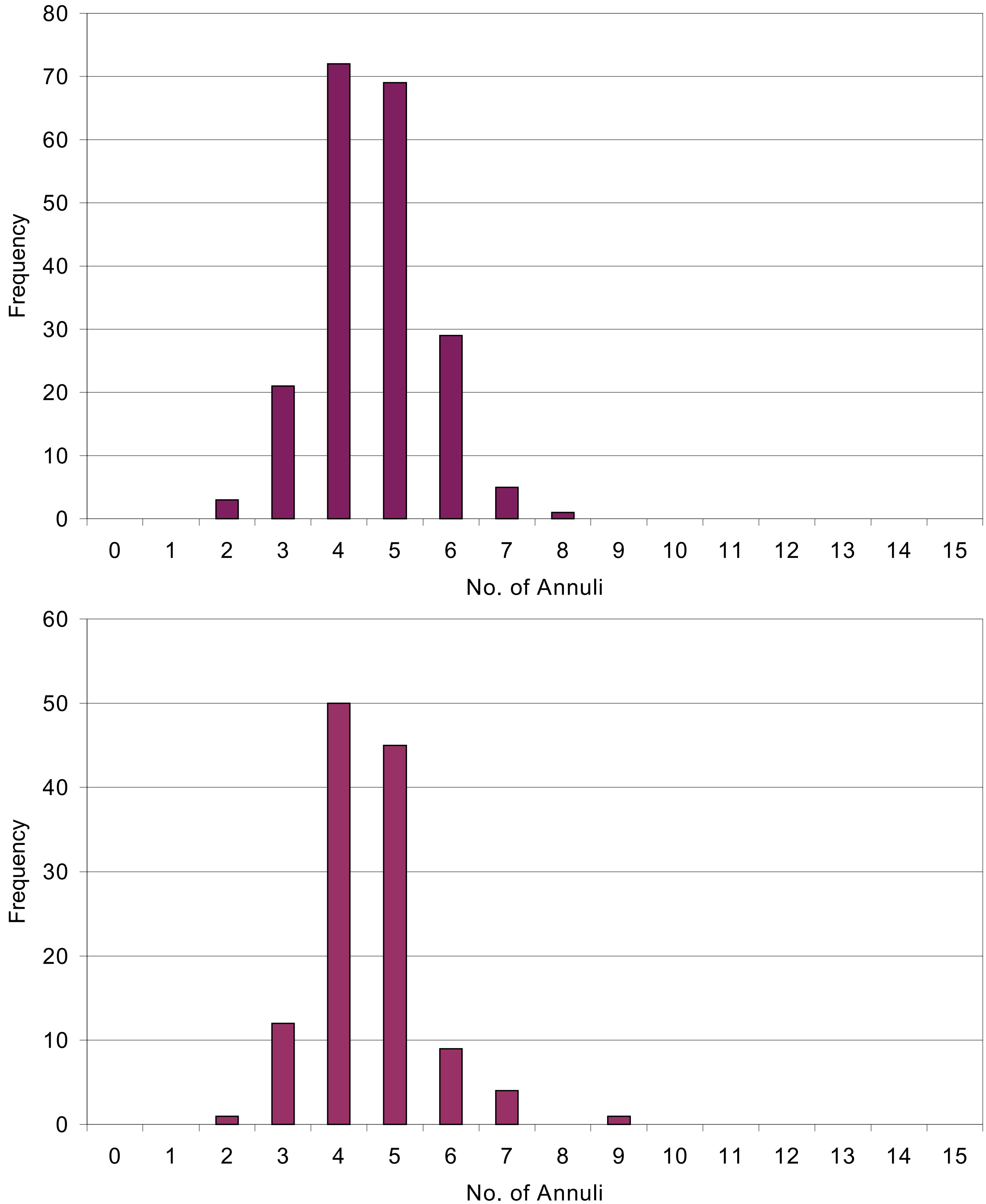
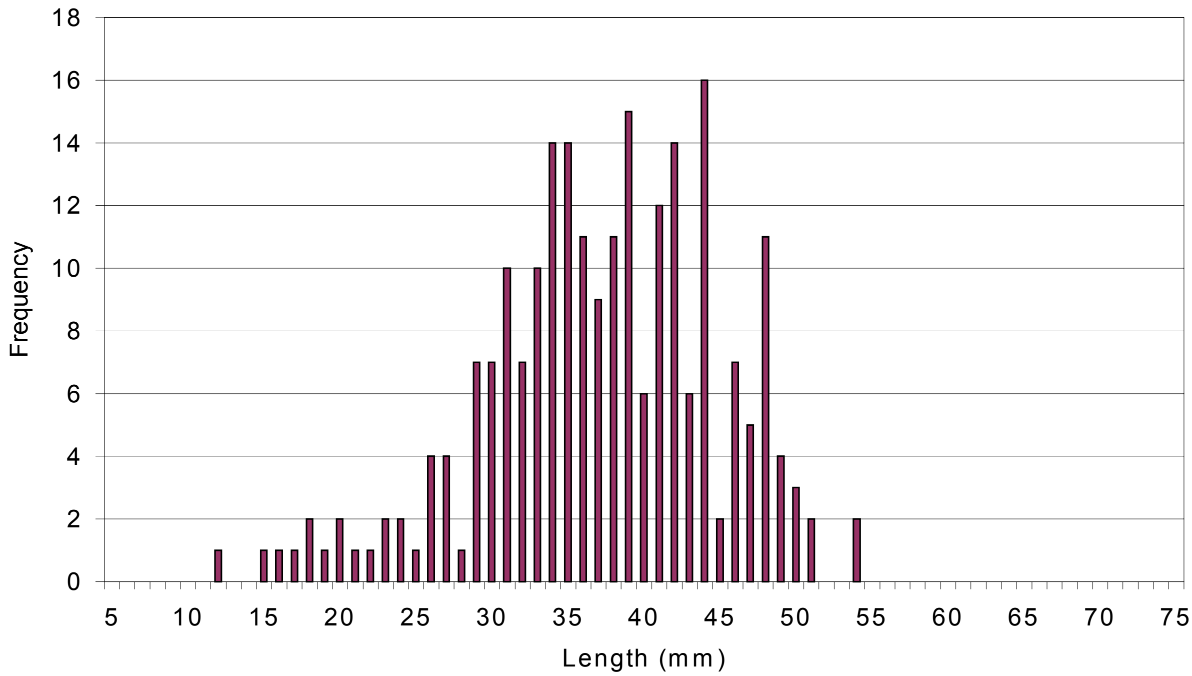


Figure 33. Age frequency distributions of Manila clams from surveys at Raymond Passage (7-24-13) in 1999 (top, n=200) and 2000 (bottom, n=122).



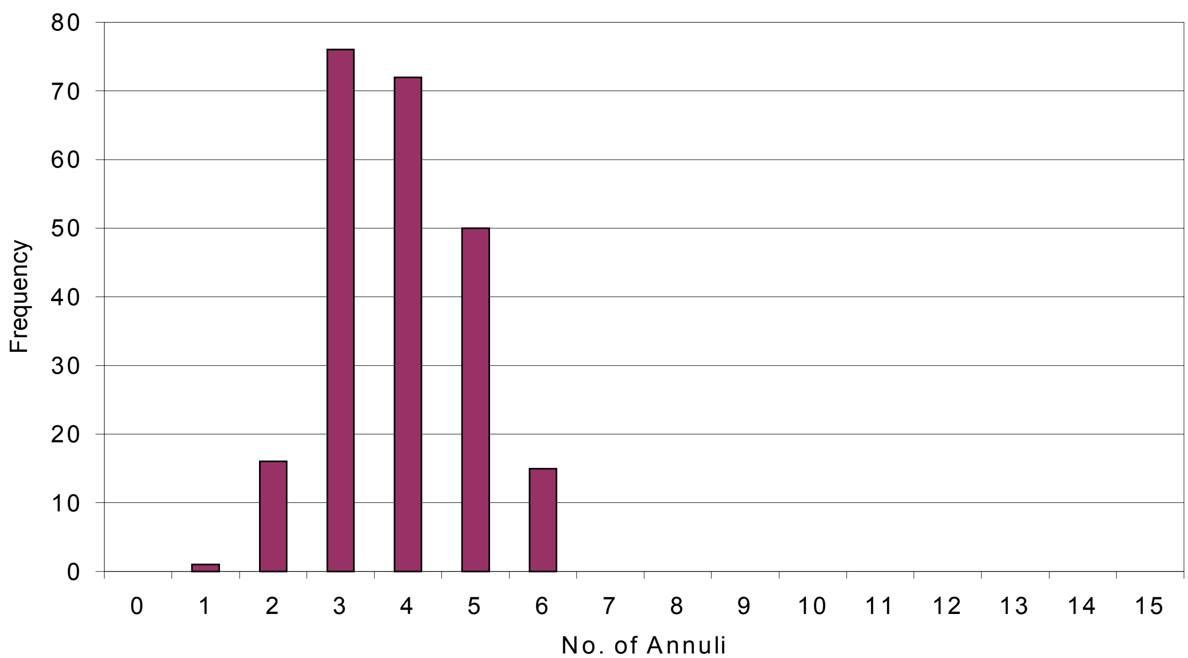


Figure 34. Length (top, n=230) and age (bottom, n=230) frequency distributions of Manila clams from the 2000 survey at Raymond Passage (7-24-12).

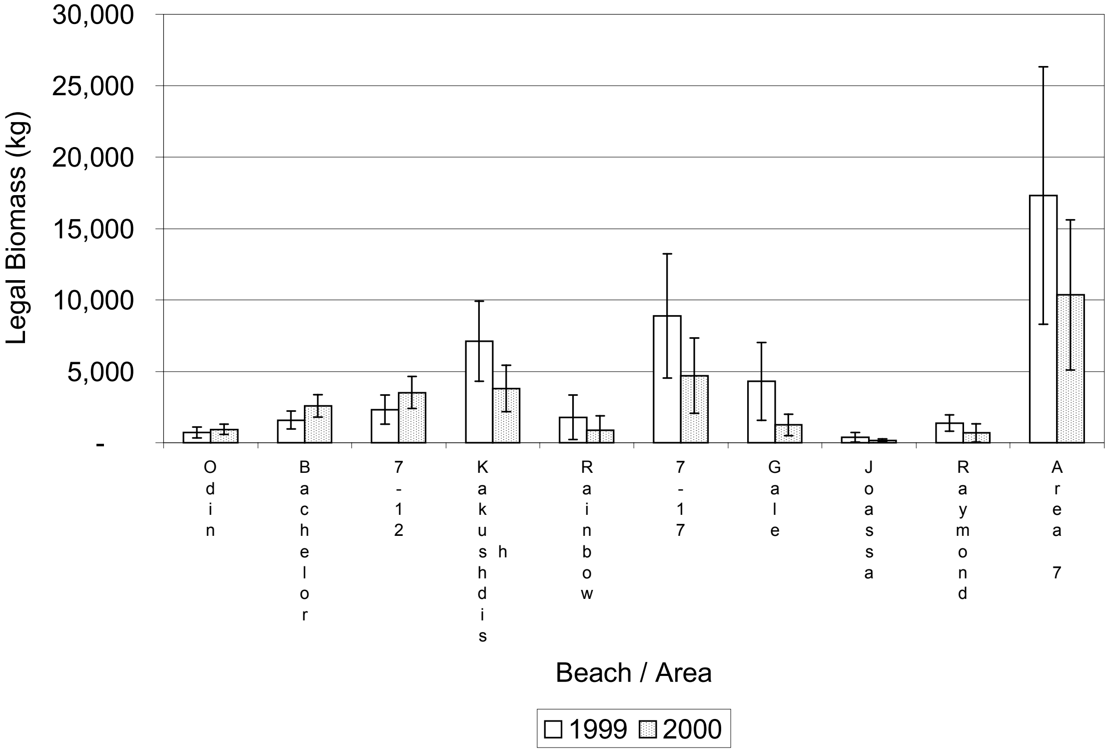


Figure 35. Changes in estimated biomass of legal sized Manila clams for index beaches surveyed in 1999 and 2000 in Area 7. Subarea and area categories are the sum of estimates for beaches in each subarea or area. Error bars are 95% confidence intervals.

APPENDIX 1

PSARC INVERTEBRATE SUBCOMMITTEE
REQUEST FOR WORKING PAPER

Area 7 (Heiltsuk) Clams

Date Submitted: FEBRUARY 19, 2001

Individual or group requesting advice: Fish Management/Science
(Fisheries Manager/Biologist, Science, SWG, PSARC, Industry, Other stakeholder etc.)

Proposed PSARC Presentation Date: JUNE 2001

Subject of Paper (title if developed): Area 7 Clam Fishery: Management/Science Actions Analysis

Stock Assessment Lead Author: Graham Gillespie – DFO, Tammy Norgard – Heiltsuk Fisheries

Fisheries Management Author/Reviewer: Fiona Scurrah – DFO

Rationale for request:
(What is the issue, what will it address, importance, etc.)

To review the progress to date of the fishery with the feedback mechanism loop proposed from the 1999 paper.

Question(s) to be addressed in the Working Paper:
(To be developed by initiator)

To examine manila clam stock levels within Area 7 based on survey data. To determine if the quota (TAC) established is appropriate. To examine if management actions in conjunction with science has developed a sustainable manila clam fishery within Area 7.

Objective of Working Paper:
(To be developed by FM & StAD for internal papers)

Review of Manila clam stock status in Area 7. Examination of feedback gain rule as management tool.

Stakeholders Affected: Heiltsuk Tribal Council

How Advice May Impact the Development of a Fishing Plan:

Determination

Timing Issues Related to When Advice is Necessary