Fisheries Research Board of Canada





# the clam fisheries of British Columbia

D. B. Quayle • N. Bourne

BULLETIN 179
Ottawa 1972

RECEIVED
FEB 15 1973
DEPUTY MINISTER OF
THE ENVIRONMENT

# THE CLAM FISHERIES OF BRITISH COLUMBIA

Fisheries
Research
Board of
Canada

Bulletins are designed to assess and interpret current knowledge in scientific fields pertinent to Canadian fisheries. Recent numbers in this series are listed at the back of this Bulletin.

The Board also publishes the *Journal of the Fisheries Research Board of Canada* in annual volumes of monthly issues, an *Annual Report*, and a biennial *Review* of investigations. The *Journal* and *Bulletins* are for sale by Information Canada, Ottawa. Remittances must be in advance, payable in Canadian funds to the order of the Receiver General of Canada. Publications may be consulted at Board establishments located at Ottawa; Nanaimo, Vancouver, and West Vancouver, B.C.; Winnipeg, Man.; Ste. Anne de Bellevue, Que.; St. Andrews, N.B.; Halifax and Dartmouth, N.S.; and St. John's, Nfld.

---




*Environment Canada*
*Fisheries Research Board of Canada*
*Office of the Editor, 116 Lisgar Street*
*Ottawa, Canada*
*K1A 0H3*

BULLETIN 179

# the clam fisheries of British Columbia

D. B. Quayle

N. Bourne

Fisheries Research Board of Canada
Biological Station, Nanaimo, B.C.

FISHERIES RESEARCH BOARD OF CANADA
Ottawa 1972

Available by mail from Information Canada, Ottawa K1A 0S9
and at the following Information Canada bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
1182 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $3.00 Catalogue No. Fs 94-179

Price subject to change without notice

Information Canada
Ottawa, 1972

# *Contents*

# Contents (*concluded*)

## Abstract

*Annual clam landings in British Columbia are not extensive, but the fishery is important to many communities along the coast. Since 1900, landings have fluctuated from under 1 million lb to a high of about 8 million lb in 1938; the value has varied from $10,000 to $220,000. In recent years landings have declined.*

*Four clam species are exploited commercially. The butter clam* (Saxidomus giganteus) *is the most important and most research has been done on this species. The biology is described in some detail and serves as a model of the life history of the other species. Fishery methods described include standard fork digging as well as newer types of mechanical digging and their applicability to British Columbia clam beaches. Productivity of clam beds is discussed and estimates of annual sustained yields are given. The history of the fishery, the uses to which clams are put, clam farming possibilities, and regulations are also discussed.*

*Two species of littleneck clams, the native* (Protothaca staminea) *and the exotic Manila* (Venerupis japonica), *are discussed. These occur in habitats slightly different from the butter clam and from each other. The fisheries for the two species are similar and are centred mainly in the Strait of Georgia. Both species are used fresh for steaming and enter the United States Pacific coast market.*

*The fourth commercial species is the razor clam* (Siliqua patula), *that occurs only on surf-swept open sand beaches in contrast to the protected sand-gravel habitat of the other three species. A different digging technique is required since each clam is dug individually. The only commercial population is near Masset in the Queen Charlotte Islands.*

*Other species with future potential such as the cockle* (Clinocardium nuttalli), *horse clam* (Tresus capax), *soft-shell clam* (Mya arenaria), *bay mussel* (Mytilus edulis), *and sea mussel* (Mytilus californianus), *are mentioned briefly.*

*Results of 1960 and 1961 surveys to assess deepwater clam resources in British Columbia are presented. These surveys contributed extensively to our knowledge of the distribution and occurrence of shallow-water invertebrates, but pointed out that no commercial quantities of deepwater clams occur in British Columbia.*

*The potential of the industry in British Columbia is mentioned.*

*Digging Manila clams at Bute Island,*
*Ladysmith Harbour, B.C.*

## Introduction

Clams and other molluscs have long been used for food by the Indians on the Pacific coast of Canada. Shellfish were also important to the early settlers and before the turn of this century a clam fishery was established. Although it is of minor importance when compared to the total landed weight and value of fishery products in the province, it does form a part of the economy of many local communities along the coast. Since 1900, clam landings have fluctuated from slightly under 1 million lb to a high of about 8 million lb in 1938, while the landed value has fluctuated from about $10,000 to a high of $220,000 in 1952 (Fig. 1). The clam resources also constitute an important recreational resource and are being used more and more extensively in the sport fishery.

Periodic decreases in clam production have been of concern to both industry and government officials, and several studies have tried to explain these fluctuations. Results have been used in part to form the basis of the clam regulations. Considerable information has accumulated from these studies, and the purpose of this Bulletin is to condense these data into a convenient summary. This will provide a basis for a general assessment of the present situation in the clam industry and provide guidelines for future utilization of the resource.

Over 800 species of molluscan shellfish have been recorded from British Columbia coastal waters, but only a few are used commercially or locally for food. The Pacific oyster (*Crassostrea gigas*) is the most important commercial species with recent landed values of over $500,000. Only the major clam resources are discussed in this text; such molluscan species as oysters, abalone, octopus, and squid will not be considered.

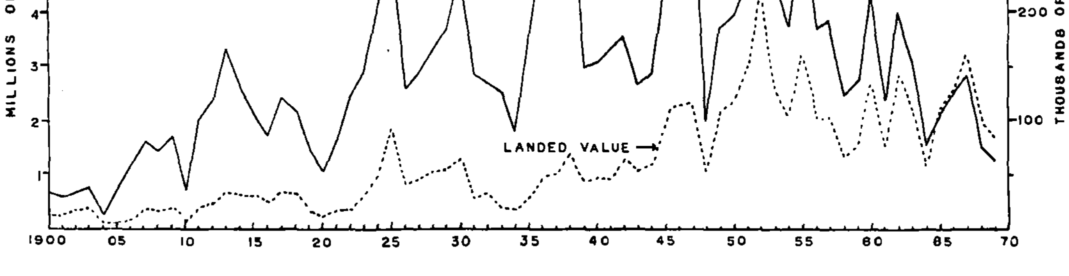



*Fig. 1. Landings and landed value of clams in British Columbia, 1900–69.*

## Biology

Some knowledge of clam biology is necessary to understand the problems of the industry and a brief resumé will provide the pertinent information. Several excellent texts on molluscan biology are available for additional information. These are mentioned in the General Reading List.

### Taxonomy

Clams belong to the phylum Mollusca, a group that includes such diverse animals as chitons, snails, tusk shells, squid, and octopus, as well as clams and oysters. The phylum has six classes, clams being grouped in the class Lamellibranchiata or Bivalvia. These animals are compressed laterally and the soft body is completely or partially enclosed by the shell, which is composed of two hinged valves. The gills or ctenidia of animals in this class are well-developed organs, specialized for feeding and respiration.

### External Anatomy

The umbo is a hump or bulge in the valves along the dorsal margin. The two valves, which may or may not be equal according to species, are composed mostly of calcium carbonate that has three layers: the inner or nacreous layer, the middle or prismatic layer that forms most of the shell, and the outer layer or periostracum, a brown leathery layer that is often missing through abrasion or weathering.

Although clams do not have an obvious head or tail, the anatomical terms used to describe other animals are also applied to clams. The foot is at the antero-ventral position and the siphons at the posterior. The valves are joined at the dorsal margin by a hinge ligament, and along the inner surface of this area are irregular toothlike projections called hinge teeth (Fig. 2). These fit into grooves on the opposite valve and the interlocking arrangement fits both valves together. The length of a clam is the greatest distance between the anterior and posterior margin of the shell; the height is the distance from the umbo to the ventral margin.

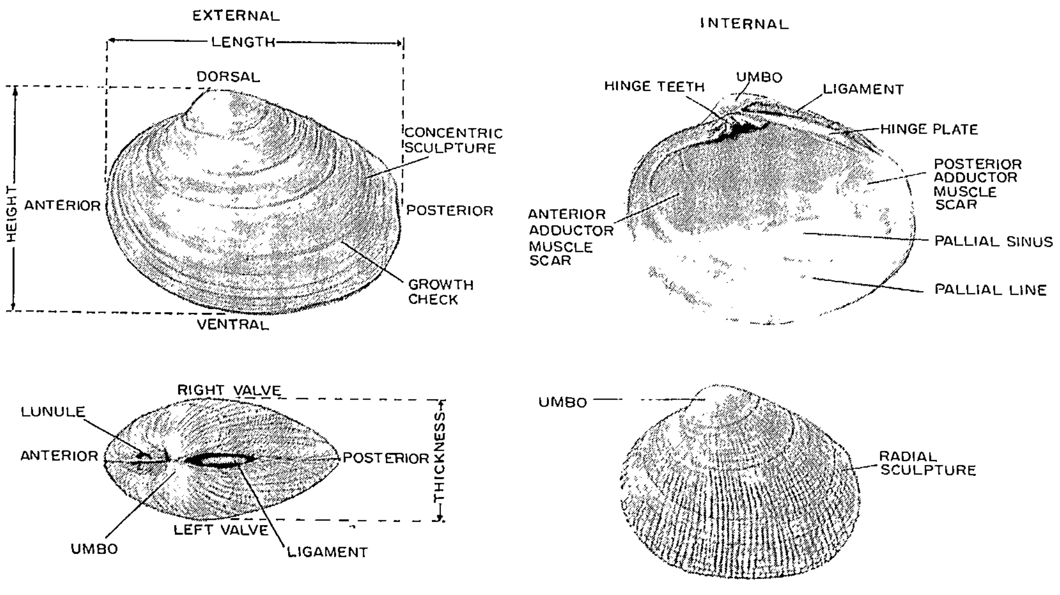



*Fig. 2. Parts and characteristics of external and internal surfaces of bivalve shells.*

## Internal Anatomy

The soft parts of a clam are covered by the mantle that is composed of two thin sheaths of tissue thickened at the edges (Fig. 3 and 4). The main function of the mantle is to secrete shell, but it also has a respiratory function. The mantle extends to the edge of the valves, but is attached to the shell for only about two-thirds the distance from the umbo to the ventral margin. The area of attachment is termed the pallial line (Fig. 2).

The two adductor muscles are located near the anterior and posterior ends of the shell (Fig. 3). In some bivalves such as scallops and oysters there is only one adductor muscle. These muscles close the valves and act in opposition to the ligament, which springs the valves open. Clams that live buried in the soil seem to require external pressure to keep the valves closed for they die if kept in tanks out of the soil. The muscles apparently weaken and the valves open.

The prominent gills or ctenidia form one of the major characteristics of lamellibranchs. They are leaflike organs used partly for respiration and partly for filtering food from water. Two pairs of gills lie on each side of the main body, which is called the visceral mass. Two pairs of pointed flaps called labial palps surround the mouth just posterior to the anterior adductor muscle. Currents created by cilia (vibrating fine hairlike structures) on the palps sort and direct food into the mouth.

At the base of the visceral mass is the foot, a well-developed organ in species that burrow. In nonburrowing molluscs such as mussels and scallops it is much reduced or lacking.

The digestive system consists of a short oesophagus connecting the mouth and stomach, which is a hollow-chambered sac with several openings. One opening leads to the much curled intestine that extends into the foot and ends in the anus dorsal to the posterior adductor muscle. Another opening leads to a closed saclike tube containing the crystalline style. This is a clear gelatinous rod, varying in length up to 3 inches, usually rounded at one end and pointed at the other. Often thought to be a worm, it is a vital part of the clam's digestive system. It rotates food in the stomach and secretes an enzyme essential to digestion. Two other openings connect the stomach with the surrounding dark green digestive gland or digestive diverticulum commonly called the "liver."

The reproductive system occupies much of the visceral mass and is particularly evident prior to spawning (Fig. 4). In species with a well-developed foot, the gonad is located above the foot and closely associated with the digestive gland. In those species with a poorly developed foot, the gonad is more diffuse and may be dispersed through parts of the mantle tissue. Sexes are separate in most bivalves but hermaphroditism occurs in some, such as the cockle. Many bivalves may reverse sex from one spawning season to another. Some species are initially always male, then switch to female and later may revert to male.

A clam in spawning condition is white and plump and in prime condition for use. Immediately after spawning the gonad becomes flaccid, much reduced in size, and in some species the colour of the visceral mass darkens. As the gonad ripens again it increases in size and once again occupies much of the visceral mass. Following is a histological description of the seasonal changes in the gonad of butter clams.

The spawned-out gonad has the appearance as shown in the thin tissue sections in Fig. 5A (female) and Fig. 6A (male). Reproductive tubules have been largely emptied of gonad products but a few residual eggs or sperm remain. They may retain their identity and be discharged at the next spawning or they may be destroyed by resorption. Soon after spawning the intertubular spaces become filled with vesicular connective tissue (Fig. 5B, 6B) and the tubule area becomes much reduced or disappears. Depending on when spawning occurs, the amount of connective tissue may vary. Usually by midsummer, gonad development begins and the tubules enlarge and developing sex cells are seen around the edges (Fig. 5B, 6B). This proceeds throughout the fall and winter, and half-ripe stages are shown in Fig. 5C (female) and Fig. 6C (male). By the new year, both males and females are nearly ripe with the tubules filled with ripe eggs or sperm and with virtually no vesicular connective tissue remaining (Fig. 5D, 6D); the clams are ready to spawn.

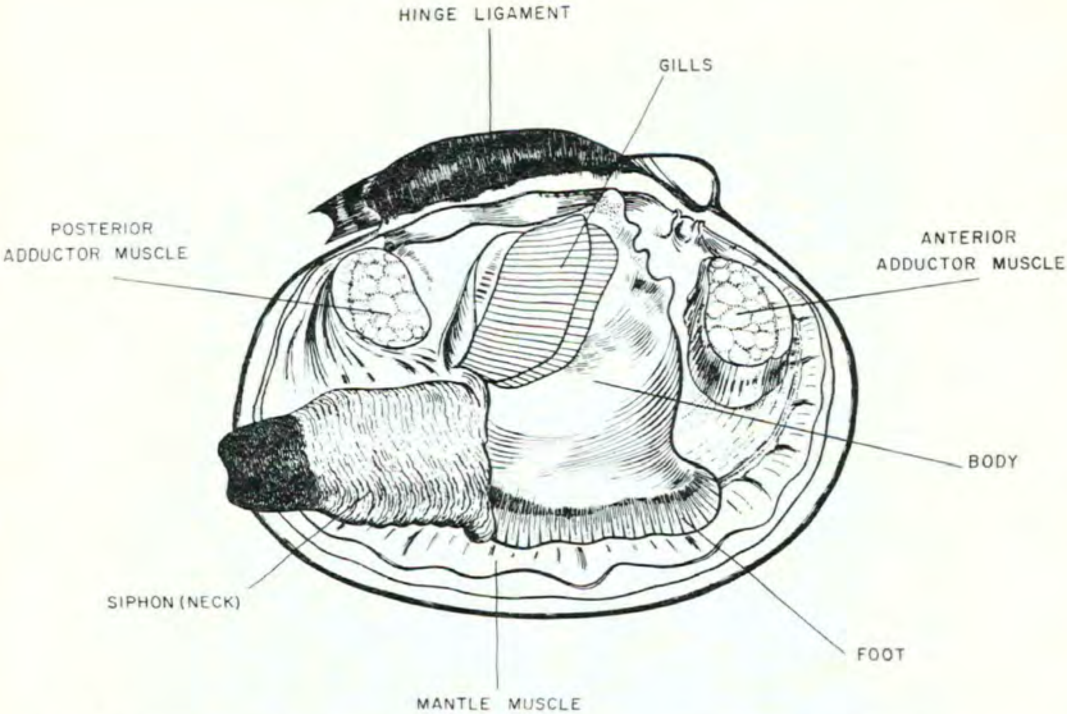



*Fig. 3. Butter clam* (Saxidomus giganteus) *with right valve removed to show main body parts.*

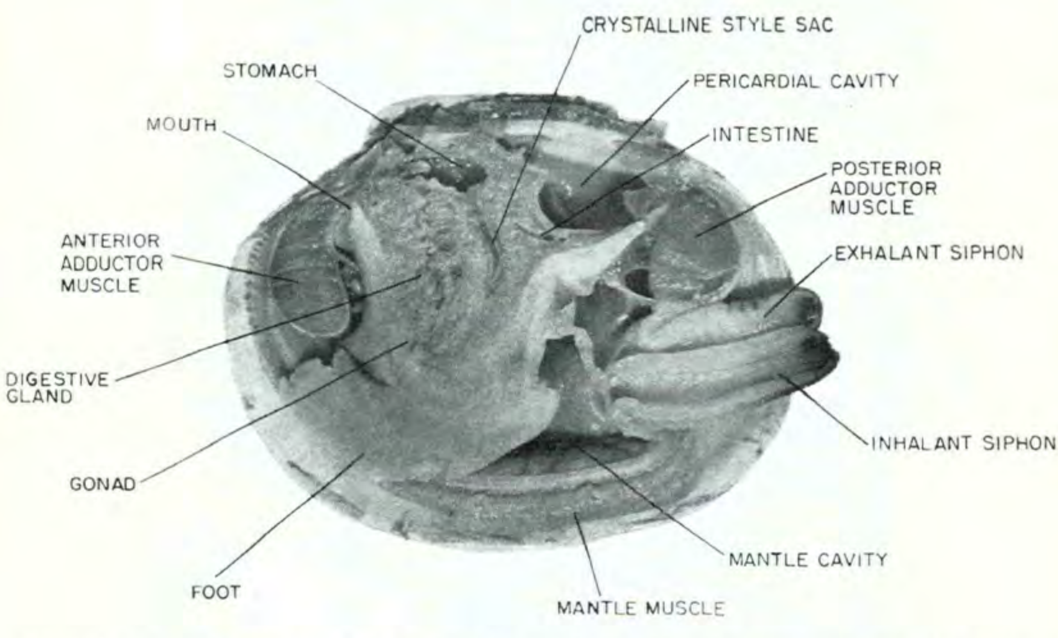



*Fig. 4. Longitudinal section of a butter clam* (S. giganteus) *showing position of main body parts.*

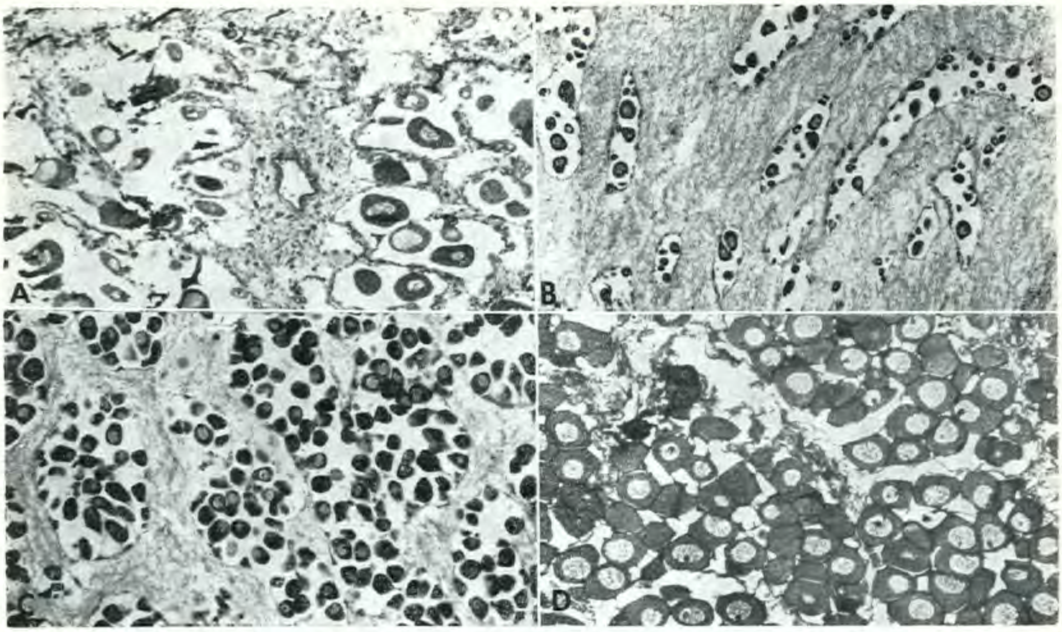



*Fig. 5. Histological sections of gonads from female butter clams* (S. giganteus) *showing seasonal changes. A, spawned out.* × *50; B, gonad beginning to fill out.* × *50; C, half-ripe stage.* × *100; D, ripe.* × *100.*

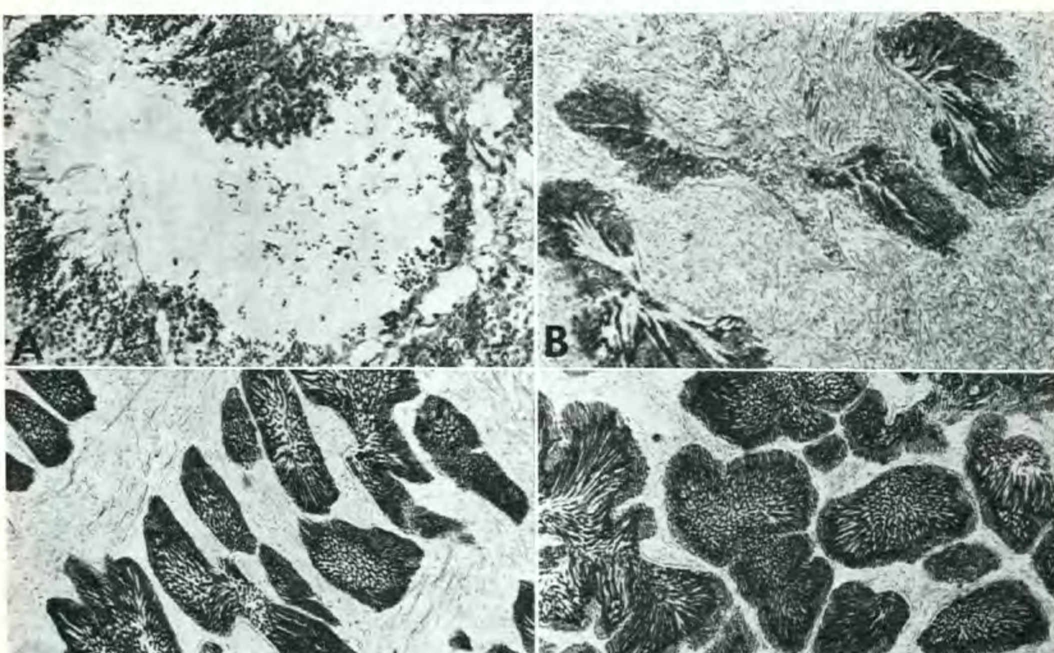



*Fig. 6. Histological sections of gonads from male butter clams* (S. giganteus) *showing seasonal changes.* × *78. A, spawned out; B, gonad beginning to fill out; C, half-ripe stage; D, ripe.*

The sexes in most species may be determined only by microscopic examination of the gonad, although in some there are obvious colour differences between males and females. In scallops, the male gonad is creamy white in colour and the female gonad bright red.

The number of eggs a female bivalve may produce in a spawning season varies with species and the size and age of the animal. Female clams may spawn up to 25 million eggs in one season. Some species release eggs or sperm in a single spawning, others spawn over an extended period of time.

An excretory system is present but it is small and difficult to trace.

The circulatory system consists of a three-chambered heart located below the hinge area; the remainder of the system is irregular and difficult to follow with many veins ending in open sinuses.

The nervous system is composed of three nerve centres or ganglia with connectives. The ganglia are small, about the size of a pinhead and reddish in colour. One is located in the foot, one near the mouth, and another below the posterior adductor muscle. The outer edges of the mantle and siphon tips have tentacles that are sensitive to stimuli and when touched cause the animal to quickly withdraw the mantle and siphons and close the valves. An organ called the osphradium is located on the undersurface of the posterior adductor muscle and is apparently sensitive to the quality of water entering the animal.

**Life History**

The life history of bivalves varies with species but the following description is applicable to those described here. Rate of growth depends largely on geographic location. Clams become sexually mature at different ages, and sexual maturity is a function of size rather than of age; in butter clams, it occurs at a length of about 1½ inches.

Most bivalves discharge eggs and sperm through the exhalant opening or siphon, and fertilization takes place in open water. In others, fertilization and initial development take place in the mantle cavity of the female. Mass spawning occurs to ensure fertilization. Immediately after fertilization the eggs divide rapidly (Fig. 7A–E) and develop into swimming larvae, which in essence are simply tiny clams.

Duration of larval stages varies with species and factors such as temperature and food, but is generally about 3 weeks. A ciliated motile trochophore forms the first larval stage within 12 hr after fertilization, and is about 60–80 $\mu$ (microns) or 0.004 inch in size. Development of two valves, a digestive system, and other organs follows. In the next 24 hr the larvae develop into the veliger stage, sometimes referred to as the straight hinge, "D," or Prodissoconch I stage (Fig. 7F, G). The two valves are now well developed, along with a velum, an organ peculiar to molluscan larvae, which enables them to swim only well enough to maintain themselves in the upper layers of water. The larvae feed on small phytoplankton and in about 1 week after fertilization reach a length of about 150 $\mu$ (0.006 inch).

The next stage is the umboned or Prodissoconch II stage, which lasts about 2 weeks, when they have attained a shell length of 230–250 $\mu$ (Fig. 7H, I). Umboned larvae swim and feed actively and organ development continues. The umbones become prominent and it is possible to distinguish between species. At optimum size for the species, the larvae settle to the bottom and crawl on the well-developed foot until they find a suitable location such as a pebble or piece of shell to which they can attach a byssus. This is a fine organic thread secreted by a gland in the foot and serves as a temporary holdfast. The byssus is retained in some adult clams and is the means of attachment for mussels.

When bivalve larvae settle they are called spat (Fig. 7J). At spatting, considerable anatomical changes occur and larval organs such as the velum are lost. After initial byssal attachment a spat may break free and move about on the foot for a time and then reattach to the substrate. Usually, when about 5 mm long, the spat burrows permanently and thereafter there is no horizontal movement other than that caused by wave action.

The larval stage is a critical one and breeding success or failure is frequently determined at this time. Larvae are essentially at the mercy of currents and although this is im-

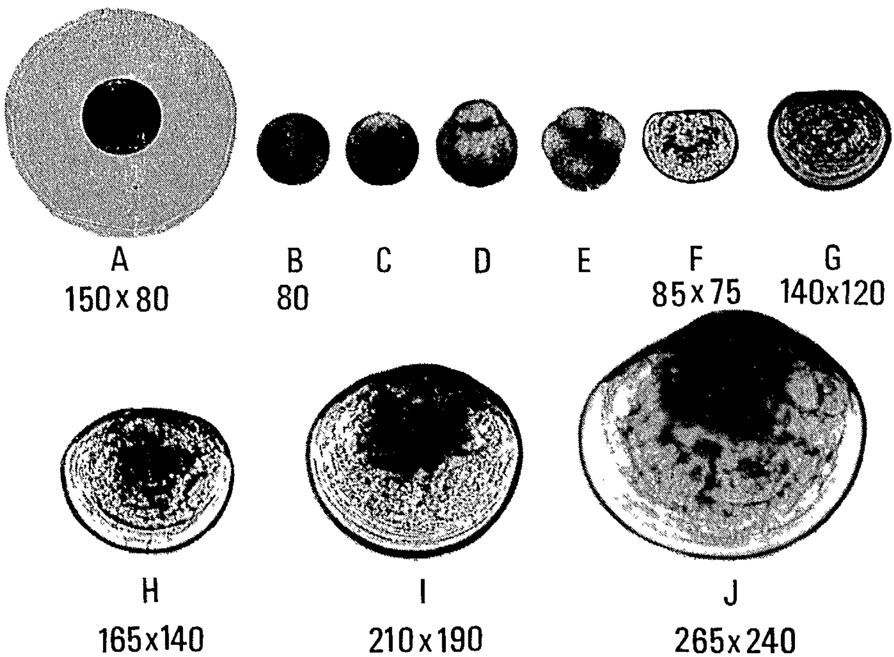



*Fig. 7. Some stages in the larval development of butter clams raised at 15 C (59 F) in the laboratory at Nanaimo. All measurements in microns, length first. A, unfertilized egg, note thick vitelline sheath; B, fertilized egg; C, fertilized egg with polar body; D, two-cell stage; E, four-cell stage; F, early straight-hinge stage, 2 days old; G, late straight-hinge stage, 6 days; H, early umboned stage, 12 days; I, late umboned stage, 18 days; J, metamorphosed larvae or spat, 25 days.*

portant in dispersal, they may often be carried away from settling areas and perish. The degree of dispersal is surprising: oyster larvae may be carried as far as 50 miles from the spawning area; so larvae from one area may seed another some distance away.

**Ecology**

Bivalves are adaptable animals and occupy a variety of aquatic habitats. They are found in great oceanic depths; high in the intertidal zone; and occur in salt, brackish, and fresh waters. Species such as scallops, oysters, and mussels do not burrow, while others dig or bore into some type of substrate such as mud, sand, gravel, rock, and wood. The destructive shipworm is a bivalve which burrows into wood, and piddocks are clams able to burrow into hard clay or rock.

Clams mentioned in this Bulletin occur in the lower three-quarters of the intertidal zone down to subtidal depths of about 60 ft. The type of substrate and tidal level are important factors in determining clam distribution on a beach. They occur at different depths in the substrate; cockles live just below the surface while others, such as horse clams and geoducks, may be buried 1½–3 ft. Clams burrow only to a depth from which the siphons can reach the surface.

**Feeding**

The ctenidia or gills are covered with cilia that are tiny vibrating hairlike structures whose concerted beat produces water currents, and assist in movements of food. Most bivalves have large gills and are filter feeders. Water is pumped through the inhalant siphon into the mantle cavity, then over and through the gills where food is filtered out and enmeshed in mucus. Strands of food-laden mucus are passed anteriorly by means of ciliary action along special grooves on the gills to the palps where some selection takes place. Other species feed directly on surface mud from which they extract food.

Clams feed on a variety of organisms and nonliving food particles, but undoubtedly phytoplankton forms a major part of the diet. However, the species of phytoplankters best suited for growth are not known. Zooplankton and even bivalve larvae are probably ingested with phytoplankton. Probably detritus and bacteria are also important. Clams exert some selection over the food ingested and periodically small compacted clumps of rejected particles (pseudofaeces) are expelled from the inhalant siphon.

## Growth

The growth rate of most clams is relatively slow and decreases with age. Growth is rapid in spring and summer when abundant food is present and water temperatures are high, but decreases and virtually stops in winter, forming annual checks (Fig. 8). However, these winter growth checks must not be confused with other checks laid down during the summer. With practice it is possible to decide which rings are true winter checks, and by counting them the growth rate and age of a clam may be determined.

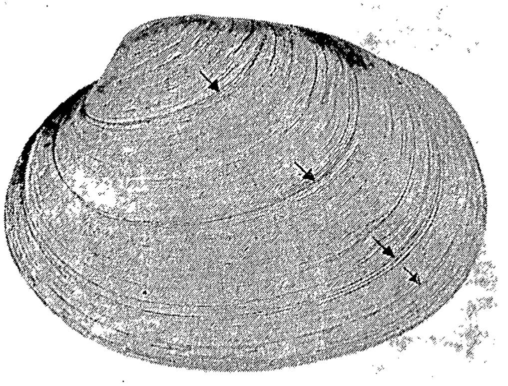


*Fig. 8. Outer surface of 5-year-old* ***butter clam*** *shell showing annual winter growth checks. Winter checks 2–5 are indicated by arrows.*

The growth rate of bivalves may vary between years, beach level, and various areas. Butter clams may attain an age of 20 years or more.

## Locomotion

Spat of some clams are capable of slight horizontal movement. Adult razor clams can rapidly dig vertically into the sand, and mussels move slightly by cutting byssus threads and reattaching at another point. Adult cockles move horizontally over a clam beach by flexing the foot. However, most species are sedentary and can only burrow slowly.

Tests were made to determine whether hardshell clams below legal size would burrow back after a clam bed had been dug commercially. Experiments were repeated four times at 3-month intervals to note possible influence of seasonal air and water temperature conditions. In summer, tides are low during the day, hence the clams were exposed to high air temperatures during low-tide periods as well as to high water temperatures. In winter, low tides occur at night, consequently the clams were subjected to low air and water temperatures. The percentages of sublegal-size clams that reburrowed within a 24-hr period were:

| | Butter clams | | Littleneck clams | |
|---|---|---|---|---|
| | Hard ground | Soft ground | Hard ground | Soft ground |
| Jan. | 97 | 93 | 100 | 98 |
| Apr. | 92 | 90 | 98 | 88 |
| Aug. | 55 | 68 | 96 | 91 |
| Nov. | 74 | 85 | 95 | 96 |

It is apparent that both species readily burrow back into the beach and do so relatively soon after being turned out. Little difference in burrowing ability between "hard" and "soft" ground is shown, except perhaps for butter clams in the last two tests, which also indicate that summer temperature conditions may have some effect.

**Enemies, Pests, and Diseases**

Because of the burrowing habits of clams it might be expected they are well protected from predators. This is partly true, but there are burrowing predators. No major mortalities due to epidemic diseases have been recorded for British Columbia clams, although this is not to say that they have not occurred. On rare occasions tumours from unknown causes have been observed and, somewhat more frequently, shell malformations. These are likely caused by inclusions of solid material, which the cleansing mechanisms have not been able to cope with, and the resulting damage has been subsequently covered by shell secreted by the mantle.

Clams may perish from a variety of physical and biological causes. Environmental factors such as changes in water temperature or salinity may retard growth or kill larvae. Water currents may carry larvae miles away from the beaches of origin to areas unsuitable for settlement. Plankton-feeding fish and other animals take a heavy toll of bivalve larvae.

Adult clams are preyed upon by many animals such as starfish, snails, crabs, worms, fish, and ducks.

MOON SNAILS

Probably the most unique clam predator is the moon snail (*Polinices lewisi*). This gastropod, which may attain a diameter of 5 inches, lives mainly under the soil surface and moves, completely "submerged," through sand and gravel like a subterranean submarine.

The moon snail (Fig. 9) has an almost circular coiled shell with a flat brown chitinous operculum or door with which it can close off the shell cavity. Clams are attacked and devoured by means of a toothed device called a radula. This is protruded from the mouth and with a rasping action it drills a countersunk hole (Fig. 10) through the valve of a clam to reach the body.

Males grow at a slower rate than females, which have a thinner shell. It is thought the male life-span is about two-thirds that of the female, which may live about 14 years. Moon snails commence breeding when 2 inches in diameter and lay their eggs in a sand collar (Fig. 9) that is formed around the expanded foot. Eggs are deposited in a jelly layer between two other layers of sand grains that are held together by mucus. Developing snails (termed larvae) are released by breakdown of the sand collar about 6 weeks later. The free-swimming life of the larvae is short, and settled young are found offshore 30–50 ft below zero tide level, usually on seaweed in the earlier stages, but later in sand. At first the food is vegetable matter, but when only ¼ inch or so in diameter, they begin feeding on small clams. A shoreward movement begins when they are just over 1 inch long, although a proportion of the population remains subtidal.

*Fig. 9. Moon snail,* Polinices lewisi, *and egg collar.*

*Fig. 10. Shell of butter clam with hole drilled by moon snail.*

Populations on intertidal clam beaches vary from sparse to four per square yard. An adult snail requires about 4 days to consume a clam of average size. Movements underground are random and clams are not sensed from any distance, although the snails do possess sensory mechanisms and are able to detect other feeding drills. From a study of drilled shells, the position of the drill site on the clam was shown to be fairly consistent in the umbonal region, with 92 % of the holes occurring in that area. Left valves were drilled in 69 % of the cases against 31 % for the right.

Of the common species of clams preyed upon by moon snails, butter clams and native littlenecks are attacked most frequently, since they are the most abundant species in the tidal range occupied by moon snails. Cockles and horse clams are rarely attacked, the former possibly because of the corrugated shell and the latter because of the depth at which it normally lives. Oysters are apparently not attacked. Aquarium studies show that butter clams may be attacked and consumed without being drilled.

It is difficult to make an actual assessment of the annual damage to clams by moon snails on a clam bed, but it appears to be significant.

### SEA STARS

Sea stars or starfish are predators on molluscs. Several types of sea stars occur in these waters (Fig. 11), but only two may be classed as serious clam predators. The main one is the sun star (*Pycnopodia helianthoides*) and to a lesser extent the pink star (*Pisaster brevispinus*). Both species are essentially subtidal animals but on occasion are found intertidally, particularly in winter. They can burrow to a depth of a foot or more by using the tube feet on the undersurface of the arms to move sand and gravel particles. The pink sea star can locate clams in a sand-gravel bottom. Sea stars open tightly closed shells of clams by holding the valves with the suction-tipped tube feet which, together with the musculature of the arms, can apply a pressure of about 10 lb per square inch. This pressure eventually tires the adductor muscles of the clam and when the valves open slightly the sea star inserts an eversible stomach that begins initial digestion. The adductor muscles then relax to a still greater extent and the digestion is completed in the internal stomach. The sea star has little difficulty in feeding upon butter and horse clams, which are unable to close their shells entirely. Sun stars have been found with several littleneck clams within their stomachs.

A sea star can devour a clam in less than 24 hr. Although causing some damage, they cannot be regarded as major predators, particularly to intertidal clam stocks. Sea stars may be controlled either by direct removal from the area or by killing them with a tablespoon of lime scattered over their backs. Mutilation does not necessarily destroy sea stars, as they are able to regenerate arms.

### PARASITIC COPEPODS

An unwelcome introduction with oysters from Japan is the parasitic copepod *Mytilicola orientalis* (Fig. 12). This is a small bright red crustacean, distantly related to shrimps. It is not more than ⅜ inch long, and occurs in the small intestine of various molluscs, being most abundant in mussels, followed by the Pacific and native oysters. It also occurs in lesser numbers in the California mussel, butter clams, and cockles. There may be up to five or six *Mytilicola* in a single mollusc. Egg capsules are found on the female at any time during the year but they are most abundant in summer. The method of infection is not clear but it seems that molluscs are infested by free-swimming larvae. In British Columbia they are found in bays where Pacific oyster seed from Japan has been planted. These are mainly estuarine tidal flats, where few clams occur. In Europe another species has apparently caused serious mortality and reduced condition in mussels. *Mytilicola* is unlikely to become a

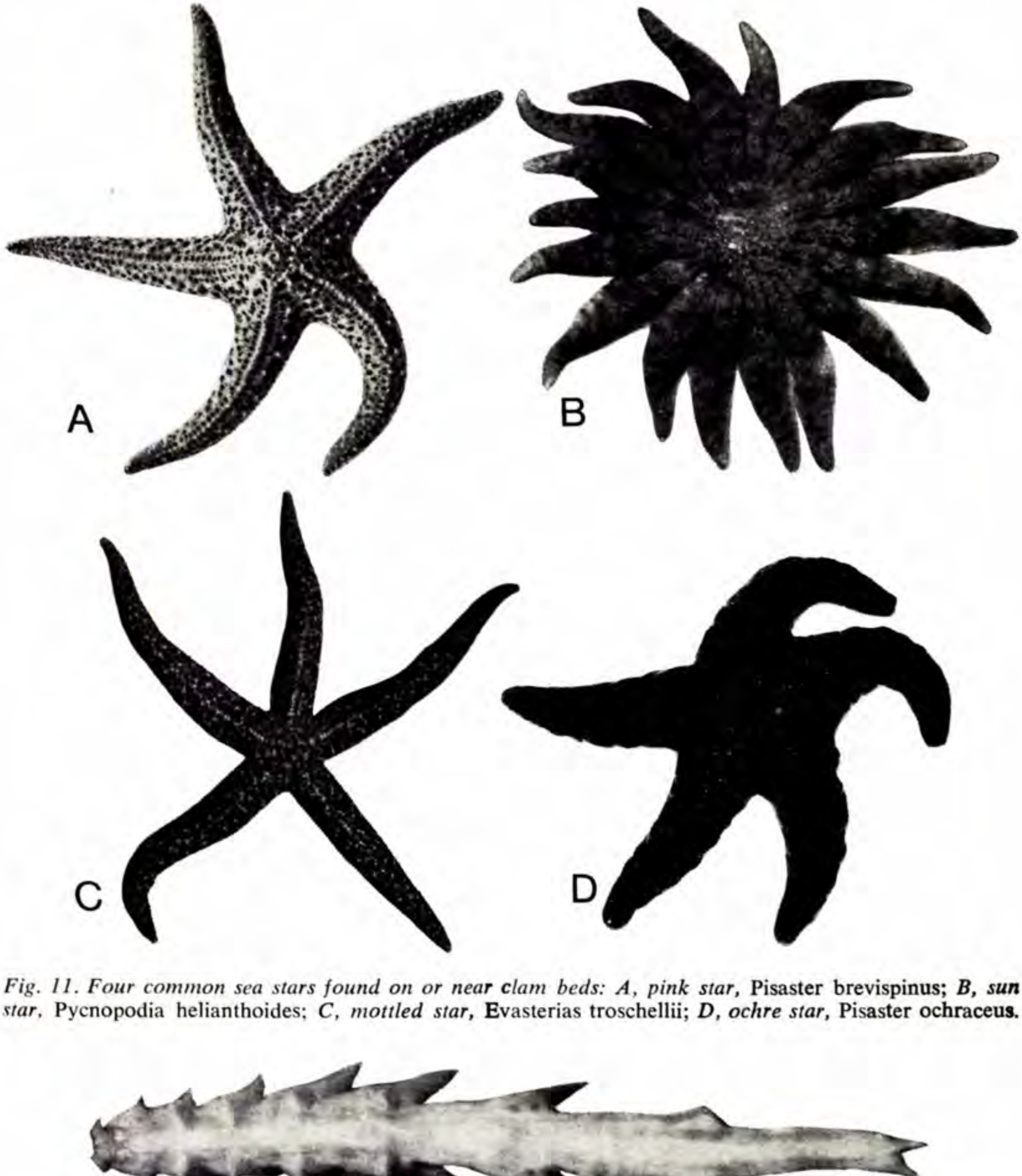



*Fig. 11. Four common sea stars found on or near clam beds: A, pink star,* Pisaster brevispinus; ***B, sun star,*** Pycnopodia helianthoides; *C, mottled star,* Evasterias troschellii; ***D, ochre star,*** Pisaster ochraceus.

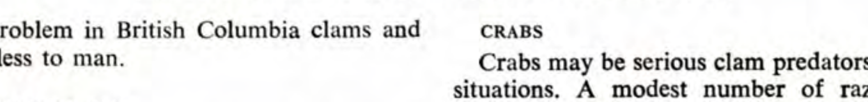


*Fig. 12 The parasitic copepod* Mytilicola orientalis. × 22.

major problem in British Columbia clams and is harmless to man.

PARASITIC WORMS

Clams harbour relatively few parasitic worms and those that occur in British Columbia clams have been little studied.

CRABS

Crabs may be serious clam predators in some situations. A modest number of razor clam shells with typical signs of crab attack (Fig. 13) are found cast upon the beach. Razor clams are excellent bait for Dungeness crabs (*Cancer magister*). Abundant concentrations of crabs have caused mortalities to adult and young hard-shell clams. Small crabs may be serious predators on very young clams of all species that are at or near the surface.

*Fig. 13. Valve of razor clam damaged by crab.*

COMMENSALS

Commensals are animals that live in other organisms without causing them harm, reaping benefits in protection or availability of food. Clams are favourite homes for a group of pinnotherids known as pea crabs. When in the floating larval stage, these crabs enter the mantle cavity of clams and spend the remainder of their life within the confines of the clam shell. The maximum size pea crabs attain is about 1 inch. Females are considerably larger than the males and of a different shape (Fig. 14). The colour is usually white or beige because they are not exposed to light and the shells are relatively soft. In some species such as the horse clam, pea crabs such as *Pinnixa faba*, or *Pinnixa littoralis*, are invariably present. In others they occur infrequently or are abundant in certain areas, such as *Fabia subquadrata*, in the butter clam in Theodosia Narrows, Malaspina Inlet, and at Doyle Island near Port Hardy. They are harmless to man.

A nemertean worm, *Malacobdella grossa*, lives in the mantle cavity of the sand clam, *Macoma secta* and the razor clam. Another unidentified species lives in the pericardial cavity of the latter species.

PEARLS

Most British Columbia bivalves produce pearls, some frequently, others rarely. Pearls are simply layers of nacre secreted around a nucleus, which may be a sand grain or a cyst of a parasitic worm. The sea mussel, *Mytilus californianus*, produces pearls in considerable numbers in some localities; some are found free or loose, and many are blister pearls, being protuberances of nacre on the inner lining of the shell. The quality of a pearl depends on the hardness and lustre of the nacre of the bivalve. In clams the nacre is usually without lustre and very soft, so pearls produced by British Columbia species are of no monetary value.

## Pollution and Toxicity

### Pollution

Fortunately, most clam beds in British Columbia are far from centres of population and have not yet been affected by pollution. It is unlikely that in the foreseeable future this situation will change. However, in the Strait of Georgia, where there are concentrations of population and industry, pollution has reached proportions significant enough to affect both the utilization and well-being of molluscs. The two main forms of pollution that affect shellfish are domestic sewage and industrial wastes.

SEWAGE POLLUTION

Sewage pollution involves bacteria and/or viruses associated with the discharge of raw or

*Fig. 14. Pinnotherid or pea crabs, commensal with butter clams; male left, female right.* × 2.

partially treated sewage into the sea. The organisms of concern are coliform bacteria, which are normal constituents of the intestinal tract of warm-blooded animals, *Salmonella,* which causes typhoid, and a virus that causes infectious hepatitis. Coliforms are the indicator organisms used to determine whether or not shellfish or shellfish-bearing waters are polluted. Samples of shellfish or water are added to solutions of nutrient chemicals in which the coliform-type bacteria will grow, and there are procedures for determining the number of bacteria per unit volume of water according to the amount of bacterial growth. The bacteria from shellfish samples are also grown on agar plates and enumerated. High coliform content indicates potential danger from typhoid or hepatitis. Large numbers of coliform organisms by themselves may cause intestinal upsets.

All leased shellfish grounds and products from them are regularly tested. Since there is little leased clam ground, map surveys show areas of potential danger such as population concentrations and wharf areas that are examined, and the taking of clams is restricted or prohibited if there is potential danger. Such areas are usually posted. Shellfish may also become bacteriologically polluted by improper handling, and care should be taken to see that clams are stored and shipped under the highest sanitary conditions. Refrigeration is important in this respect, and also helps prevent spoilage. If clams are to be shucked it is necessary that it be done in shucking houses licensed by the Department of the Environment.

Holds and decks of vessels or barges used to transport clams should be thoroughly washed and disinfected after each shipment. At one time clams were shipped mainly in sacks or in boxes without any refrigeration. Now ice is used to cover boxes of loose clams to keep the shipment cool. Refrigerated sea water might be suitable for transporting clams.

#### INDUSTRIAL POLLUTION

So far, the main sources of industrial pollution are pulp mills and logging operations.

*Pulp mills* — Shellfish can be seriously affected by the toxicity of discharged effluents of pulp mills. In British Columbia most pulp mills use the sulphate process, which produces effluents less toxic than the alternative sulphite process. Pulp mills located on tidewater discharge effluents into the sea. Although attempts are made to recover as much material as possible from the wastes, both chemicals and some wood fibre are lost and discharged. This results in toxic effects by the chemicals on living marine organisms, reduction of the oxygen content of sea water as a result of the decomposition of organic materials in the effluent, and consequent deprivation of this necessary oxygen to fish and invertebrates. Particulate material such as wood fibres, wood chips, and bark are heavy enough to sink and form an impenetrable mat on the bottom, smothering organisms and creating anaerobic conditions.

These factors cause increased mortality in clams, as well as low growth rates, reduced fatness, and poor breeding success.

*Logging operations* — Both log dumping and log booming operate in a similar manner and can seriously affect shellfish. Bark dislodged from logs sinks to the bottom to form an effective barrier layer that prevents oxygenation of the subsoil. Living material in the subsoil and bark both rot to form gases, which may be seen bubbling to the surface at log dumps. These are toxic to shellfish and tides carry the effect some distance from the actual dump itself.

The propellor wash of tugboats, towing log booms over shallow water clam areas, digs deep furrows in clam beds. If this practice is continued for some time the beds can eventually be destroyed.

Fortunately, few pulp mills are located near major clam-producing areas and booming grounds are usually associated with estuarine tidal mud flats where clam populations are not extensive.

### Paralytic Shellfish Poison

The problem of paralytic shellfish poisoning is a difficult one, and it is the purpose of this account to indicate why this is so and to show how the use of shellfish may be made as safe as possible.

#### HISTORY OF SHELLFISH POISONING IN BRITISH COLUMBIA

The history of shellfish poisoning in British Columbia began in June 1793 when one of Captain Vancouver's sailors died and four others became ill after eating mussels at Poison Cove, in Mathieson Channel not far from Ocean Falls.

The next known occurence was in Barkley Sound in May 1942 when three persons died and eight others became ill from eating clams or mussels. As a result, the whole west coast of Vancouver Island and the Gordon group of islands in Queen Charlotte Strait were closed to the taking of butter clams and mussels. This closure continued until 1953.

The next instance of poisoning was in late October 1957 when 60 certain and 50 probable cases of illness occurred from eating various species of shellfish, including oysters, in the Comox area. At this time, toxicity was recorded along the east coast of Vancouver Island between Campbell River and Ladysmith.

The next known outbreak occurred in mid-June of 1963 when high toxicity in butter clams was found near Namu, on the central British Columbia coast. Subsequent testing showed toxic clams to occur along the whole coast between Cape Caution and the Alaska border, including the Queen Charlotte Islands. The closure applied at that time is still in effect, for there is still a moderate amount of toxin present in these areas and, as a result, commercial production of butter clams has been seriously curtailed.

On June 1, 1965, one death occurred and four people became ill from eating cockles taken in Malaspina Inlet, which lies in the northeast corner of the Strait of Georgia. Several other species of shellfish including clams, mussels, and oysters were found to be toxic. Subsequent testing showed that all species except butter clams had lost most of the poison within 6 weeks of the peak toxicity.

The latest outbreak occurred in early May 1970 at Viner Sound, Gilford Island (Fishery Area 12), when two people became ill from eating butter clams. This is the first known instance of toxicity from the general area.

The location of all these outbreaks is shown in Fig. 15.

This historical summary shows shellfish toxicity may occur almost anywhere along the British Columbia coast at any time from May through October. However, the danger of toxicity may exist throughout the year as butter clams can retain some poison for a considerable time.

#### SOURCE OF TOXIN

Studies have shown that the source of the poison is a microscopic, one-celled organism,

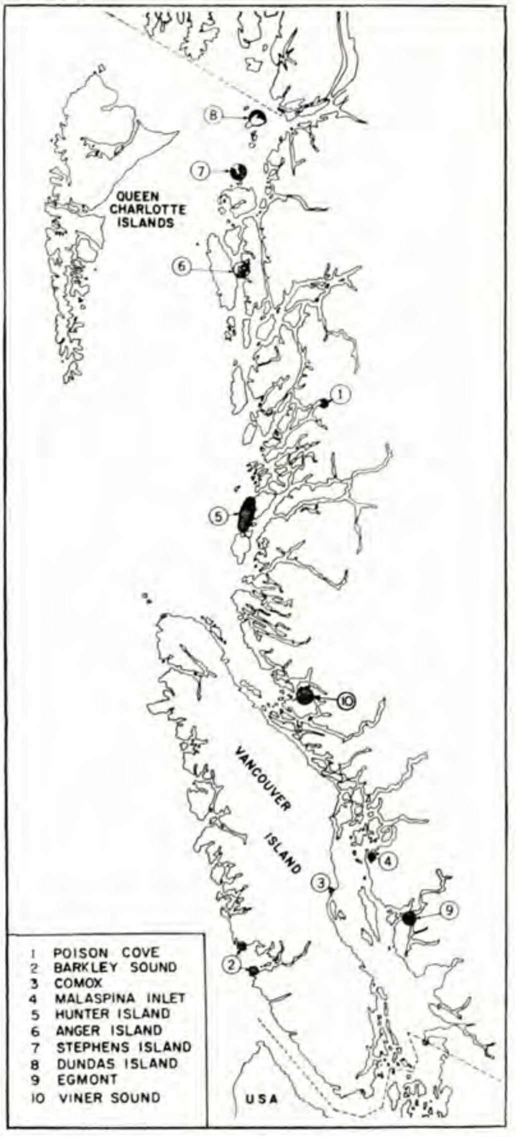



*Fig. 15. Map of British Columbia coastline showing areas where outbreaks of PSP have occurred.*

*Fig. 16.* Gonyaulax acatenella. *Chain of four cells. × 450.*

*Processing* — Cooking and canning. The earliest work on paralytic shellfish poison showed that heat destroyed a considerable part, but not all, of the toxin. Commercial canning was more effective than domestic cooking in reducing toxicity of the eastern soft-shell clam (*Mya arenaria*). Precooking fairly toxic clams with steam for 10 min reduced the poison content by about 90 %, but additional steaming time caused no further reduction. Further retorting at 250 F for 45 min reduced the toxin content only an additional 3 %, and 90 min caused only a further 1 % reduction.

In 1950, studies on butter clams in Alaska demonstrated that removal of the siphons from shucked meats, steaming for 10 min, followed by retorting at 250 F for 75 min, reduced the toxin content of the clams up to 93 % with no effect on quality. However, the process was not adopted since the shellfish industry in Alaska felt it was unprofitable.

In British Columbia since 1963, about 500 bioassays have been made on canned clams or nectar. Pertinent data on the reduction in toxicity by the canning process, carried out either by commercial canners or in the laboratory where commercial methods were followed, are given in Table 3. Larger scale tests with normal cannery techniques on about 4 tons (round weight) of butter clams were also done to verify the laboratory studies. This resulted in a pack of over 3000 cans each containing about 7 ounces of meat. Clams were taken from a high toxicity area (Prescott Pass) with an average toxicity of 400 $\mu$g (24 samples ranging from less than 100 to over 800 $\mu$g), and from a low toxicity area (Metlakatla Bar) with an average of 150 $\mu$g (12 samples ranging from over 100 $\mu$g to over 200 $\mu$g). Results are shown in Tables 4 and 5.

Another experiment determined the effect of canning when highly toxic clams were com-

TABLE 3. Change of toxicity in butter clams (*Saxidomus giganteus*) after canning.

| | Source of clams | Product | Toxicity of whole raw clams ($\mu$g) | Toxicity of canned clams ($\mu$g) |
|---|---|---|---|---|
| *1963* | | | | |
| Nov. 15 | Kitkatla | Whole clams | 192 | <32 |
| | Metlakatla | " | 48 | <32 |
| | Dundas Island | " | 126 | <32 |
| | Dundas Island | " | 176 | <32 |
| | Port Simpson | " | 240 | <32 |
| Nov. 16 | Metlakatla | " | 192 | <32 |
| | Metlakatla | " | 352 | <32 |
| | Area 4 | " | 560 | <32 |
| | Area 4 | " | 368 | <32 |
| Nov. 29 | Nalau Pass | " | 787 | 102 |
| Nov. 30 | Metlakatla | " | 66 | <32 |
| | Kitkatla | " | 78 | <32 |
| Dec. 3 | Dudevoir Pass | " | 144 | <32 |
| Dec. 6 | Kitkatla | " | 149 | <32 |
| Dec. 9 | Kitkatla | " | 284 | <32 |
| *1964* | | | | |
| Aug. 26 | Cosine Island | " | 1,126 | 81 |
| | Cosine Island | Bodies only | 1,126 | 40 |
| *1966* | | | | |
| Mar. 3 | Theodosia Inlet | Bodies only | 1,216 | 42 |
| May 26 | Theodosia Inlet | Whole clams | 415 | 109[a] |
| | Theodosia Inlet | Whole clams less siphon tip | 415 | 96 |
| | Theodosia Inlet | Bodies only | 415 | 35 |

[a]All whole clams except this sample were canned with black siphon tip removed.

TABLE 4. Effect of canning toxic whole butter clams with tips only and with whole siphons removed. Initial mean toxicity of raw clams; Prescott Pass 400 μg, Metlakatla 150 μg.

| Area | Treatment | No. of samples | Toxicity (μg/100 g) |
|---|---|---|---|
| Prescott Pass | Whole siphon removed | 48 | all < 44 |
| | Tips only removed | 72 | 61 < 44[a] |
| Metlakatla | Whole siphon removed | 24 | all < 44 |
| | Tips only removed | 12 | all < 44 |

[a]Eleven ranged from 56 to 95.

TABLE 5. Effect of canning toxic minced butter clams with tips only and with whole siphons removed.

| Area | Treatment | No. of samples | Toxicity (μg/100 g) |
|---|---|---|---|
| Prescott Pass | Siphons removed | 9 | all < 52 |
| | Tips removed | 24 | all < 60 |
| Metlakatla | Mixture of clams prior to canning; some with siphon removed, others with tips only removed | 9 | all < 44 |

bined with those of low toxicity. It was shown that toxicity of such canned clams level out, thus removing the danger of poisoning by one highly toxic clam when canned with those of lower toxicity.

It was concluded from these data that toxicity of clams with values up to about 500 μg can be reduced to safe levels by removal of the black siphon tips only. Variations in results may be accounted for by differences in the actual amount of siphon tip removed, for ¼ inch of siphon near the tip contains a considerable amount of toxin in a moderately toxic clam. Removal of the whole siphon (cut off right at the mantle edge) reduced toxicity of clams with a total raw score of about 1000 μg to a body score of about 200 μg, a fairly safe level for canning. Storage of canned clams up to 8 months caused no change in toxicity as shown in Table 6. If the above procedures had been taken butter clams might have been utilized from the closed north coast area since 1963.

TABLE 6. Toxicity (μg/100 g) of Cosine Island butter clams with paralytic shellfish poisoning level of 1126 μg when raw, canned August 28, 1964, and assayed at monthly intervals.

| Date assayed | Meats | Nectar (from can) |
|---|---|---|
| *1964* | | |
| Aug. 28 | 81 | 78 |
| Sept. 9 | 59 | 70 |
| Oct. 13 | 67 | 81 |
| Nov. 9 | 81 | 78 |
| Dec. 22 | 63 | 54 |
| *1965* | | |
| Jan. 26 | 71 | 57 |
| Feb. 16 | 53 | – |
| Mar. 10 | 70 | – |
| Apr. 14 | 53 | 64 |

After steaming, between 50 and 75 % of the toxin content of whole raw clams is contained in the nectar that should be discarded.

Freezing. Raw butter clams have also been frozen and assayed later to determine whether toxicity changes. Samples of 32 lots of raw butter clams with a mean toxicity of 74 μg (range of 34–256 μg) were frozen for 3 months. Assays then showed a mean of 79 μg (range of 33–432 μg) indicating virtually no change.

### LEGAL REQUIREMENTS

In the United States, fresh, frozen, or canned clams are acceptable only if the whole clam product has an average toxicity of 80 μg or less per 100 g of content. No individual package is permitted to exceed 400 μg/100 g of meat. For minced or chopped clams the average toxicity is required to be less than 500 μg/100 g.

In Canada no toxicity is permitted in the canned product, and raw clams used for processing must not exceed 1000 mouse units, now equivalent to 220 μg. However, this criterion is based on the situation in eastern Canada where the "siphon" problem of the butter clam does not exist.

about 1/1000 of an inch in diameter, which occurs in sea water in varying abundance in various parts of North America. The species on the Pacific coast are *Gonyaulax catenella* and *Gonyaulax acatenella* (Fig. 16).

When this organism becomes numerous the water is coloured, hence the name "red tide" that has become associated with paralytic shellfish poisoning. However, in British Columbia, there are a dozen or so species of one-celled organisms that may cause coloured water; yet of these only the two species of *Gonyaulax* are known to cause shellfish to become poisonous.

When filter-feeding shellfish feed on high concentrations of these organisms (such increases are called "blooms"), they become toxic by extracting and accumulating the minute quantity of poison held in each *Gonyaulax* cell. Millions of cells may be ingested by a single shellfish, which itself is not harmed by the toxin it accumulates. The poison is dangerous only to warm-blooded animals.

The symptoms of paralytic shellfish poisoning in humans are usually initial tingling and numbness in the lips and tongue, followed by similar sensations in the finger tips and toes, and a final loss of control of voluntary movements. Also, there may be difficulty in breathing. The effect of the toxin seems to be greatest when the stomach is empty. There is no known antidote, and treatment consists of emptying the stomach with an emetic, and use of a rapid laxative. Artificial respiration should be applied if breathing becomes difficult.

### TESTING FOR POISON

There is still no rapid way to determine whether or not shellfish are toxic. The standard procedure is to inject an extract of clam meats into the body cavity of laboratory mice. From the time to death of several mice, the poison content of the shellfish meat may be calculated in terms of what are called mouse units of toxin. Toxicity is now reported as micrograms ($\mu$g) of toxin per 100 g (3.5 ounces) of clam meat. Approximately 5 mouse units are equivalent to 1 $\mu$g of poison.

The amount of poison that will cause death cannot be accurately stated, for it seems that there are individual differences in susceptibility. However, mild symptoms of poisoning occur at values up to 1000 $\mu$g/100 g of meat, and beyond that point the symptoms become more and more severe.

Testing is a cooperative venture between the Department of the Environment and the Microbiology Division of the Department of National Health and Welfare.

### CONTROL MEASURES

Since the mouse test is the only way to determine the toxicity of shellfish, control for the safety of clams in British Columbia at the present time requires a continuous sampling program. To this end, samples of butter clams and oysters are taken at specific locations along the whole coast twice monthly during the summer. Clearly this is not a perfect system since there is always a period of time between samples during which shellfish may become toxic. Further, it is impossible to adequately sample 15,000 miles of coastline. Nevertheless, the method has worked moderately well for the last 20 years.

Whenever toxicity values of shellfish exceed 88 $\mu$g/100 g of meat, the area or areas involved are closed to the taking of shellfish and warnings are posted at wharves, marinas, and post offices.

No one in British Columbia has suffered poisoning from shellfish that have gone through commercial channels, and the few occurrences have resulted from private recreational use of shellfish.

### SPECIES OF SHELLFISH INVOLVED

As indicated previously, all filter-feeding molluscs may become toxic. However, not all filter feeders become toxic to the same extent, and the rate at which the toxin is lost varies from species to species.

The time during which *Gonyaulax* occurs in sufficient number to cause toxicity is variable, but usually it does not last for more than a week or so. When *Gonyaulax* disappears, the amount of toxin in the shellfish begins to decline and, with only one exception, all species of shellfish become virtually nontoxic in 4–6 weeks. The notable exception is the butter clam that may retain some toxicity for 2 years or more after initial toxification. In this species a considerable proportion of the toxin concentrates in the siphon and gills. These organs lose their toxicity slowly while the body of the clam does so relatively rapidly. At the time of peak toxicity, butter clams may concentrate up to 80 % of the total toxin in the gills and siphons, which represent about 30 % of the meat weight of a clam, the black tip of the siphon being the most poisonous part.

Razor clams are seldom affected, and then only to a modest extent; the siphon tips, gills, stomach, and digestive glands are normally removed both in the domestic and commercial preparations of this species.

## Canning Toxic Butter Clams

Since 1963 about half the clam-producing area (between Cape Caution and the Alaska border, Fishery Areas 1–8) has been closed because of paralytic shellfish poisoning (Fig. 17). This situation has led to much thought on ways in which these toxic clams may be utilized.

### DETOXIFICATION METHODS

Possible methods of detoxification of clams include: detoxification of the live animal; chemical treatment; removal of the more toxic parts; processing (canning).

*Detoxification of the live animal* — This may be done by transplanting toxic clams to an area known to be nontoxic. Detoxification occurs in these circumstances, but no more rapidly than in the native bed unless retoxification occurs there. In addition, costs of transplanting and reharvesting make this method uneconomical.

*Chemical treatment* — Recently acquired knowledge of the chemical formula of paralytic shellfish poison, along with empirical observations, indicate the toxin may be destroyed under acidic conditions, particularly in the presence of oxygen. Based on this information, experiments in Alaska with both live butter clams and shucked meats under acidic conditions as low as *p*H 5.0, failed to reduce toxicity. In British Columbia, toxic butter clams boiled under a range of low *p*H levels (1.8–4.9) for various periods of time (2½–10 min) did not show any real differences in toxicity.

*Removal of the more toxic parts* — The concentration of toxin in the siphon (neck) appears to be a peculiarity of only butter clams, and is responsible for some of the difficulties caused by this species. The toxicity of various organs of butter clams is given in Table 1, and the extreme toxicity of various parts of the siphon will be noted. In the initial stages of the toxification process, the body is more toxic than the siphon, but loses the toxin more rapidly than the latter. These changes with time are shown in Table 2. After 1 year the siphons are still relatively toxic, containing about 90 % of the toxin in 30 % of the total raw wet body weight. The siphon is actually only 11–15 % of the wet body weight, for the data in Table 2 include the gills with the siphon. It is obvious that removal of the whole siphon, rather than just the black tip, which is current commercial practice, would remove a considerable proportion of the toxin in butter clams.

TABLE 1. Toxicity in various organs of butter clams (*Saxidomus giganteus*) from Anger Island, August 26, 1964.

| Organ | Toxicity (μg/100 g) | Sample weight (g) | % meat weight | Total toxin (μg) | % toxin |
|---|---|---|---|---|---|
| Whole clam | 2,400 | – | – | – | – |
| Gonad | 448 | 450 | 14.5 | 2,016 | 2.3 |
| Adductor muscle | 94 | 369 | 11.8 | 347 | 0.4 |
| Pallial muscle | 368 | 447 | 14.4 | 1,645 | 1.9 |
| Foot | 192 | 145 | 4.7 | 278 | 0.3 |
| Body walls | 432 | 411 | 13.2 | 1,775 | 2.0 |
| Digestive gland | 1,920 | 220 | 7.0 | 4,224 | 4.7 |
| Gill and mantle | 2,400 | 402 | 13.0 | 9,648 | 10.8 |
| Inner siphon | 2,560 | 207 | 6.7 | 5,299 | 5.9 |
| Middle siphon | 13,020 | 330 | 10.7 | 42,966 | 47.7 |
| Tip of siphon | 17,920 | 120 | 4.0 | 21,504 | 24.0 |

TABLE 2. Changes in toxicity and toxin content of Theodosia Narrows butter clams with time. Toxicity in micrograms per 100 grams of meat and toxin content based on the ratio of body weight to siphon and gill weight of 70–30%.

| | Whole clam (μg/ 100 g) | Siphon–gill (μg/ 100 g) | % toxin[a] | Body (μg/ 100 g) | % toxin[a] |
|---|---|---|---|---|---|
| *1965* | | | | | |
| June 3 | 8,640 | 6,860 | 40 | 5,280 | 60 |
| July 12 | 624 | 8,480 | 85 | 608 | 15 |
| Aug. 25 | 1,344 | 6,400 | 90 | 368 | 10 |
| Oct. 14 | 1,120 | 4,160 | 90 | 176 | 10 |
| Dec. 20 | 1,123 | 5,120 | 90 | 240 | 10 |
| *1966* | | | | | |
| Feb. 21 | 864 | 3,200 | 90 | 158 | 10 |
| Mar. 3 | 960 | 4,860 | 90 | 215 | 10 |
| June 16 | 1,012 | 3,520 | 90 | 205 | 10 |
| Aug. 29 | 330 | 1,430 | 80 | 123 | 20 |

[a]Compared to total clam toxicity.

## History of the Clam Fishery

Clams were used by native Indians before the early white explorers reached the coast and undoubtedly formed an important part of their diet. Evidence for this is seen in Indian middens which contain large quantities of clam shell. Some molluscs were used for primitive tools, jewellery, and money, but most were used for food.

Judging from the contents of the middens, the main species utilized were butter clams, littleneck clams, cockles, and in the Masset area, razor clams. Dried horse clams were used as a medium of trade as well as a staple food. Apparently mussels were not used extensively.

### Early Fishery — Before 1900

There is little information on the clam fishery prior to 1900 although landings have been recorded since 1882. Much information on the early fishery comes from reports of fishery inspectors and government surveyors such as G. M. Dawson and W. F. Thompson who made a comprehensive assessment of the molluscan shellfish resources in 1912 and 1913.

Commercial clam production apparently started in 1882 when 50 cases of 48 1-lb cans (about 10,000 lb of clams, probably butter; valued at $250) were packed at Rivers Inlet. In 1883, 180 cases were canned for home consumption at the Metlakatla Cannery near Prince Rupert, and further canning was undertaken in 1884. From 1884 to 1900 there was a hiatus (at least according to statistics) except for 1896 when 16,944 cases of clams, valued at $2541, were canned. The reason for this cessation is unknown, but it may have been due to adverse markets. At Sidney, 3500 cases of clams, valued at $13,500, were canned in 1900 under the Saanich label, which remained the quality brand for many years. Before 1900 there was a cannery at Friday Harbour in the USA and in exchange for raw clams, groceries were smuggled into Sidney.

There are reports of clam canning in some local areas along the coast not recorded in the statistics, but production in these small canneries was limited, and the entire pack may have been sold locally. Clams were also sold fresh, particularly in Vancouver and Victoria. Estimates of the amounts are reported in the statistics but no mention is made of the species. However, they were probably mostly littleneck clams with some butter clams and cockles. In 1885, the fresh landings were valued at $2500; in 1888, 370,000 lb of clams valued at $3000 were sold; in 1893, landings of fresh clams reached a high of 750,000 lb valued at $10,625. From 1897 to 1899 the catch of fresh clams and mussels was estimated to be worth $9080.

Prior to 1900 moderate quantities of bay mussels were marketed fresh along with clams. In 1888, 25,000 lb valued at $200 were marketed; in 1889, 37,500 lb valued at $600, and from 1893 to 1896 the value was $480.

### Fishery Since 1900

Since 1900, clam landings and their value have been reported annually. The statistics, along with reports of early workers such as W. F. Thompson, fishery inspectors and staff at the Biological Station, Nanaimo, provide fairly complete data since then.

Prior to 1951, landings of all clam species were grouped together, and it is only since then that separate statistics have been recorded for individual species. Total clam landings and value are shown in Fig. 1 and Table 7. The landings and value of individual species since 1951 are given in Tables 8 and 9, and are discussed in their respective sections. Landings are reported for the Department of Fisheries and Forestry (now Department of the Environment, Fisheries Service) statistical areas and districts which are shown in Fig. 17.

Clam landings were slightly under 1 million lb at the turn of the century and increased gradually to a high of 5.3 million lb in 1925. The catch then began to decline, but 4.7 million lb were harvested in 1930. Production declined again but began to increase in 1935, and reached a record high of 7.65 million lb in 1938. During the war years (1939–45) production declined, but increased to 6.45 and 6.65 million lb in 1947 and 1952. Since 1952 landings have gradually declined.

The landed value of clams has not been great (Fig. 1). At the turn of the century it was less than $10,000, but increased gradually with highs in 1925, 1930, and 1938. There was an increase after the war years due partly to increased landings and partly to higher prices. A record value of $220,000 was reached in 1952.

Most landings (80–90 %) were butter clams, the remainder before 1923 were almost

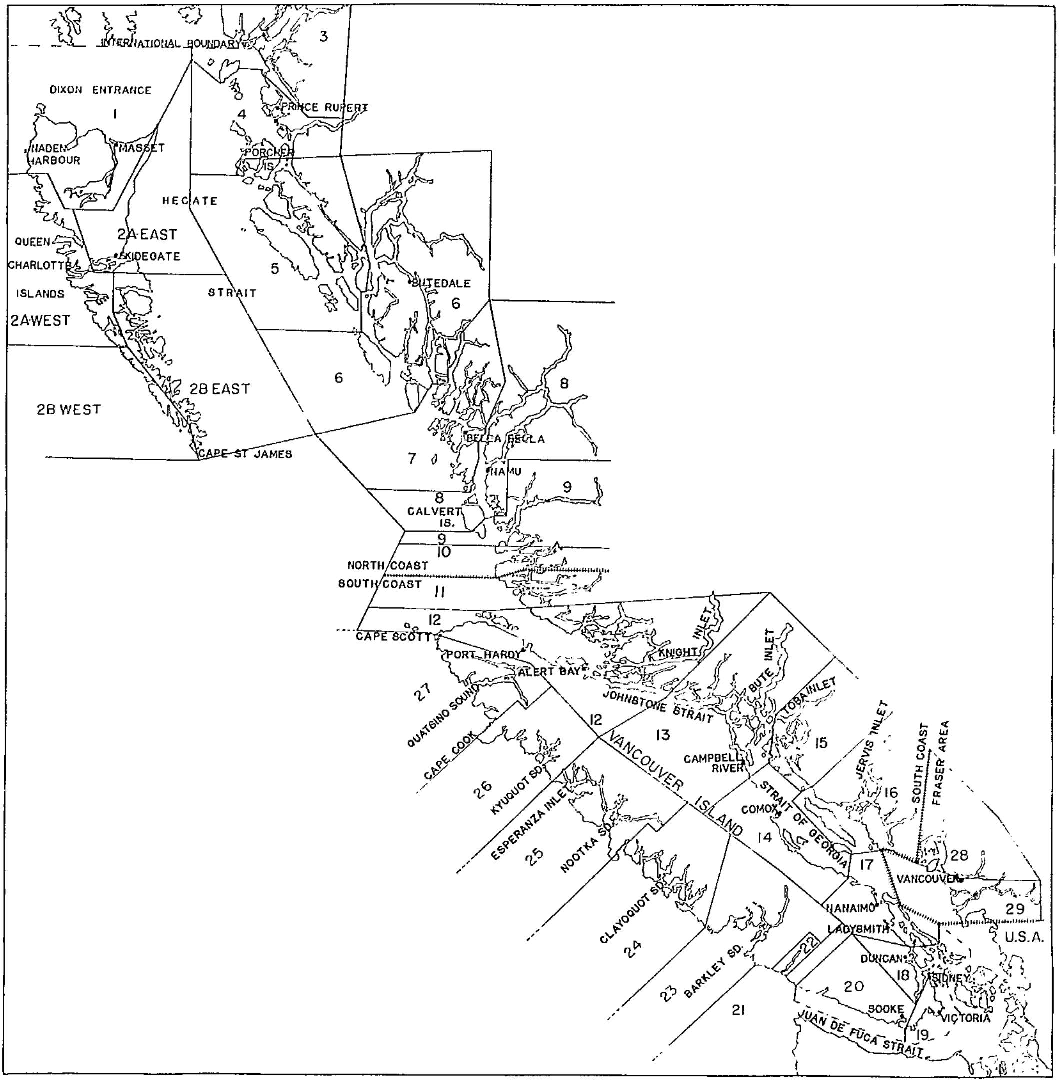



*Fig. 17. Fisheries Service, Department of the Environment statistical map of British Columbia showing statistical districts and areas.*

all littlenecks with a few cockles and horse clams. The razor clam fishery began at Masset in 1923 and Manila clams entered the fishery in the Strait of Georgia about 1940. However, landings of these latter three species are minor when compared with butter clam landings (Table 8).

Several reasons account for these fluctuations. Although clams were used extensively in the early period, most were consumed locally and there were few markets for the canned product. As the industry became established and markets were found, landings increased. Razor clams were first canned in 1923 and the start of this fishery contributed to the high total clam landings in 1925. The 1935–36 peak was due in part to a relaxation of tariff laws, which permitted the export of raw butter clams to the United States. In 1936, the Alert Bay area was opened and by 1938, this area,

TABLE 7. Annual weight and value of all species of clams landed in British Columbia, 1900–50. Landings reported for the three statistical districts of the Fisheries Service, Department of the Environment. Conversion Factors: 1 Barrel = 200 lb of butter and littleneck clams; 1 Barrel = 1 case of canned clams (48 tins of 6 oz of clam meat); 3 Bushels = 1 barrel; 80 lb of razor clams = 1 case of canned clams (48 tins of 6 oz of clam meat each).

| | | | Fraser Area (District 1) | | North Coast (District 2) | | South Coast (District 3) | |
|---|---|---|---|---|---|---|---|---|
| Year | Total weight (*lb*) | Total value ($) | Weight (*lb*) | Value ($) | Weight (*lb*) | Value ($) | Weight (*lb*) | Value ($) |
| 1900 | 700,000 | 13,500 | | | | $ 9,000 | | |
| 1901 | 600 000 | 12,000 | | | *Plus, for* | $11,600 | | |
| 1902 | 660,000 | 15,840 | | | *fresh clams* | $12,000 | | |
| 1903 | 723,000 | 17,352 | | | *and mussels* | $13,000 | | |
| 1904 | 260,000 | 6,240 | | | | $ 7,000 | | |
| 1905 | 695,625 | 6,845 | Some landings but | | 80,000 | 1,920 | 615,625 | 4,925 |
| 1906 | 1,107,500 | 9,820 | not specified | | 60,000 | 1,440 | 1,047,500 | 8,380 |
| 1907 | 1,597,500 | 18,540 | " | " | 360,000 | 8,640 | 1,237,500 | 9,900 |
| 1908 | 1,421,250 | 16,810 | " | " | 340,000 | 8,160 | 1,081,250 | 8,650 |
| 1909 | 1,683,125 | 19,705 | " | " | 390,000 | 9,360 | 1,293,125 | 10,345 |
| 1910 | 691,600 | 6,917 | 10,000 | 100 | – | – | 681,600 | 6,817 |
| 1911 | 1,935,400 | 20,776 | 142,400 | 2,846 | – | – | 1,793,000 | 17,930 |
| 1912 | 2,315,400 | 23,154 | 542,400 | 5,424 | – | – | 1,773,000 | 17,730 |
| 1913 | 3,313,400 | 33,134 | 1.113,400 | 11,134 | 200,000 | 2,000 | 2,000,000 | 20,000 |
| 1914 | 2,588,200 | 29,766 | 503,800 | 8,922 | 220,000 | 2,200 | 1,864,400 | 18,644 |
| 1915 | 2,129,600 | 29,903 | 872,000 | 17,327 | 200.000 | 2,000 | 1,057,600 | 10,567 |
| 1916 | 1,707,600 | 23,738 | 666,200 | 13,324 | 200,000 | 2,000 | 841,400 | 8,414 |
| 1917 | 2,399,600 | 33,658 | 966,200 | 19,324 | – | – | 1,433,400 | 14,334 |
| 1918 | 2,125,200 | 31,471 | 1,009,200 | 20,311 | – | – | 1,116,000 | 11,160 |
| 1919 | 1,508,400 | 16,213 | 101,400 | 2,028 | – | – | 1,407,000 | 14,185 |
| 1920 | 1,085,800 | 11,939 | 59,800 | 1,644 | – | – | 1,026,000 | 10,295 |
| 1921 | 1,619,200 | 15,722 | 107,800 | 1,886 | – | – | 1,511,400 | 13,836 |
| 1922 | 2,394,800 | 15,117 | 54,600 | 1,905 | – | – | 2,340,200 | 13,212 |
| 1923 | 2,893,200 | 28,755 | 447,000 | 8,940 | 49,400 | 1,235 | 2,396,800 | 18,580 |
| 1924 | 4,006,000 | 49,835 | 206,800 | 8,462 | 732,400 | 24,115 | 2,066,800 | 17,218 |
| 1925 | 5,305,400 | 90,508 | 198,800 | 5,964 | 1,669,080 | 48,672 | 1,861,800 | 35,872 |
| 1926 | 2,562,600 | 40,455 | 134,400 | 4,032 | 648,880 | 17,763 | 1,244,000 | 18,660 |
| 1927 | 2,883,800 | 47,374 | 192,800 | 5,784 | 397,200 | 8,742 | 2,005,600 | 32,848 |
| 1928 | 3,366,800 | 53,242 | 109,600 | 4,384 | 373,040 | 13,989 | 2,324,600 | 34,869 |
| 1929 | 3,651,400 | 55,209 | 140,000 | 4,200 | 272,280 | 8,490 | 2.834,600 | 42,519 |
| 1930 | 4,797,400 | 65,271 | 305,600 | 9,094 | 868,560 | 27,143 | 2,320,400 | 29,034 |
| 1931 | 2,880,600 | 29,052 | 95,200 | 2,380 | 342,640 | 10,707 | 2,227,200 | 15,965 |
| 1932 | 2,681,600 | 34,677 | 71,600 | 2,178 | 338,160 | 8,792 | 1,764,600 | 23,707 |
| 1933 | 2,549,800 | 20,071 | 54,200 | 1,355 | – | – | 2,495,600 | 18,716 |
| 1934 | 1,796,200 | 18,732 | 61,000 | 1,525 | 28,600 | 141 | 1,706,600 | 8,533 |
| 1935 | 3,580,400 | 29,137 | 120,800 | 12,089 | 600 | 3 | 3,459,000 | 27,045 |
| 1936 | 5,144,600 | 48,248 | 173,800 | 5,175 | 49,000 | 405 | 4,921,800 | 42,668 |
| 1937 | 4,607,800 | 51,208 | 602,200 | 18,066 | 29,400 | 294 | 3,976,200 | 32,848 |
| 1938 | 7,663,100 | 69,260 | 8,100 | 243 | 1,220,000 | 10,671 | 6,435,000 | 58,346 |
| 1939 | 2,911,700 | 43,607 | 673,500 | 12,145 | – | – | 2,238,200 | 31,462 |
| 1940 | 3,079,900 | 47,783 | 249,100 | 7,517 | – | – | 2,830,800 | 40,266 |
| 1941 | 3,352,400 | 46,662 | 155,400 | 4,662 | 496,000 | 4,960 | 2,701,000 | 37,330 |
| 1942 | 3,551,600 | 64,351 | 120,400 | 6,020 | 556,800 | 11,136 | 2,874,000 | 47,195 |
| 1943 | 2,666,600 | 54,793 | – | – | 1,585,900 | 22,018 | 1,080,700 | 32,775 |
| 1944 | 2,836,600 | 58,869 | – | – | 1,294,300 | 21,680 | 1,542,300 | 37,189 |
| 1945 | 4,666,400 | 110,993 | – | – | 1,136,300 | 16,116 | 3,530,100 | 94,877 |
| 1946 | 4,932,400 | 114,306 | – | – | 2,976,700 | 57,949 | 1,955,700 | 56,357 |
| 1947 | 6,421,000 | 116,000 | 220,100 | 8,804 | 3,717,500 | 74,453 | 2,482,900 | 82,761 |
| 1948 | 1,983,000 | 53,000 | – | – | 218,700 | 6,039 | 1,763,800 | 52,940 |
| 1949 | 3,714,000 | 108,100 | 12,000 | 480 | 848,000 | 21,908 | 2,854,000 | 85,693 |
| 1950 | 3,928,000 | 117,200 | 2,200 | 88 | 1,645,800 | 33,524 | 2,279,600 | 83,551 |

TABLE 8. Weight and value of the four commercial species of clams landed in British Columbia, 1951–69.

| Year | Total weight (*'000 lb*) | Total value ($) | Razor clams Weight (*lb*) | Razor clams % of catch | Butter clams Weight (*lb*) | Butter clams % of catch | Manila clams Weight (*lb*) | Manila clams % of catch | Littleneck clams Weight (*lb*) | Littleneck clams % of catch | Mixed clams Weight (*lb*) | Mixed clams % of catch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 4,483 | 148,533 | 135,300 | 3.0 | 3,520,000 | 77.5 | 178,900 | 4.0 | 521,900 | 11.6 | 127,000 | 2.8 |
| 1952 | 6,662 | 222,000 | 125,500 | 1.9 | 5,493,300 | 82.5 | 405,900 | 6.1 | 493,300 | 7.4 | 143,700 | 2.2 |
| 1953 | 4,587 | 127,000 | 154,500 | 3.4 | 3,691,300 | 80.5 | 387,700 | 8.5 | 308,800 | 6.7 | 44,500 | 1.0 |
| 1954 | 3,774 | 104,000 | 271,800 | 7.2 | 2,896,900 | 76.8 | 450,000 | 11.9 | 144,500 | 3.8 | 11,200 | 0.3 |
| 1955 | 5,544 | 159,000 | 218,300 | 3.9 | 4,783,500 | 86.5 | 456,000 | 8.2 | 80,200 | 1.4 | 5,600 | 0.1 |
| 1956 | 3,694 | 102,000 | 238,500 | 6.5 | 3,205,700 | 86.8 | 218,300 | 5.9 | 31,400 | 0.9 | 100 | – |
| 1957 | 3,836 | 102,000 | 186,600 | 4.9 | 3,540,700 | 92.3 | 63,200 | 1.6 | 21,300 | 0.6 | 24,500 | 0.6 |
| 1958 | 2,428 | 65,000 | 164,400 | 6.8 | 2,177,000 | 89.7 | 32,600 | 1.3 | 39,800 | 1.6 | 13,800 | 0.6 |
| 1959 | 2,744 | 75,000 | 200,200 | 7.3 | 2,412,100 | 87.9 | 54,600 | 2.0 | 47,500 | 1.7 | 29,300 | 1.1 |
| 1960 | 4,348 | 133,000 | 225,100 | 5.2 | 3,967,000 | 91.2 | 13,900 | 0.3 | 90,100 | 2.1 | 51,600 | 1.2 |
| 1961 | 2,336 | 76,000 | 229,000 | 9.8 | 1,825,600 | 78.2 | 105,800 | 4.5 | 102,000 | 4.4 | 74,100 | 3.2 |
| 1962 | 3,963 | 139,000 | 165,500 | 4.2 | 3,347,800 | 84.5 | 152,900 | 3.9 | 201,900 | 5.1 | 95,100 | 2.4 |
| 1963 | 3,146 | 103,000 | 147,500 | 4.7 | 2,736,800 | 87.0 | 130,400 | 4.1 | 130,700 | 4.2 | 900 | – |
| 1964 | 1,575 | 59,000 | 107,100 | 6.8 | 1,256,100 | 79.8 | 58,000 | 3.7 | 152,700 | 9.7 | 1,300 | – |
| 1965 | 2,097 | 106,000 | 150,100 | 7.2 | 1,551,900 | 74.0 | 213,600 | 10.2 | 181,300 | 8.6 | – | – |
| 1966 | 2,472 | 125,000 | 76,700 | 3.1 | 1,832,700 | 74.1 | 328,700 | 13.3 | 232,100 | 9.4 | 2,000 | – |
| 1967 | 2,761 | 163,000 | 102,400 | 3.7 | 2,148,500 | 77.8 | 202,800 | 7.3 | 305,900 | 11.1 | 1,000 | – |
| 1968 | 1,500 | 98,000 | 26,200 | 1.7 | 879,500 | 58.6 | 360,900 | 24.1 | 200,500 | 13.4 | 33,100 | 2.2 |
| 1969 | 1,280 | 85,000 | 17,800 | 1.4 | 833,000 | 65.1 | 177,900 | 13.9 | 235,900 | 18.4 | 15,600 | 1.2 |

TABLE 9. Weight in pounds of the four commercial species of clams landed in British Columbia, 1951–69. Landings reported for the three statistical districts.

| | Fraser Area (District 1) | | | | North Coast (District 2) | | | | South Coast (District 3) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Razor | Butter | Manila | Little-neck | Razor | Butter | Manila | Little-neck | Razor | Butter | Manila | Little-neck |
| 1951 | – | 7,200 | – | 39,100 | 135,300 | 1,284,800 | – | – | – | 2,228,000 | 178 900 | 482,800 |
| 1952 | – | 3,700 | – | 28,600 | 125,500 | 3,343,700 | – | – | – | 2,145,900 | 405,900 | 464,700 |
| 1953 | – | 1,800 | – | 34,400 | 154,500 | 1,700,900 | – | – | – | 1,988,600 | 387,700 | 274,400 |
| 1954 | – | 7,000 | – | 9,800 | 271,800 | 1,491,200 | – | – | – | 1,398,700 | 450,000 | 134,700 |
| 1955 | – | 2,600 | – | 17,100 | 218,300 | 2,431,300 | – | – | – | 2,349,600 | 456,000 | 63,100 |
| 1956 | – | 4,700 | – | 8,900 | 238,500 | 1,259,500 | – | – | – | 1,941,500 | 218,300 | 22,500 |
| 1957 | – | 1,400 | – | 6,800 | 184,900 | 1,868,800 | – | – | 1,700 | 1,670,500 | 63,200 | 14,500 |
| 1958 | – | 2,200 | – | 8,000 | 164,400 | 1,178,600 | – | – | – | 996,200 | 32,600 | 31,800 |
| 1959 | – | 500 | – | 5,400 | 200,200 | 1,404,800 | – | – | – | 1,006,800 | 54,600 | 42,100 |
| 1960 | – | 200 | – | 1,200 | 225,100 | 2,100,200 | – | – | – | 1,866,600 | 13,900 | 88,900 |
| 1961 | – | 2,000 | – | – | 229,000 | 941,900 | – | – | – | 881,700 | 105,800 | 102,000 |
| 1962 | – | – | – | 100 | 165,500 | 998,900 | – | – | – | 2,348,900 | 152,900 | 201,800 |
| 1963 | – | – | – | – | 146,700 | 1,148,100 | – | – | 800 | 1,588,700 | 130,400 | 130,700 |
| 1964 | – | – | – | – | 106,400 | – | – | – | 700 | 1,256,100 | 58,000 | 152,700 |
| 1965 | – | – | – | – | 150,100 | 3,700 | – | – | – | 1,548,200 | 213,600 | 181,300 |
| 1966 | – | – | – | – | 76,700 | – | – | – | – | 1,832,700 | 328,700 | 232,100 |
| 1967 | – | – | – | – | 102,400 | – | – | – | – | 2,148,500 | 202,800 | 305,900 |
| 1968 | – | – | – | – | 26,200 | – | – | – | – | 879,500 | 360,900 | 200,500 |
| 1969 | – | 100 | – | – | 17,800 | 71,100 | – | – | – | 761,800 | 177,900 | 235,900 |

and the west coast of Vancouver Island were the most important producing regions. The decline in 1939 may have been due in part to an increase in the legal-size limit of butter clams from 1½ to 2½ inches shell length. Low landings from 1939 to 1945 were due to a scarcity of labour during the war years. During this period, clam stocks were under little fishing pressure, and this factor, along with the increased labour force after the war, accounted for the increased landings to 1948. The second highest landings occurred in 1952, but since then the landings have decreased for several reasons. Since 1963, the northern part of the province (District 2) has been closed because of paralytic shellfish poison. Encroachment of civilization and an increase in pollution has caused the destruction of some clam beaches, particularly on the southern coast. A major reason for the decrease in landings has been important social changes in the lives of diggers who can now obtain more lucrative and less arduous jobs than digging clams. Factors such as unemployment insurance and government assistance make clam digging even less attractive. Finally, some clam stocks, particularly in the Strait of Georgia area, have been reduced in recent years.

**Canneries**

The number of plants processing clams has varied over the years, but there were never many. Commercial clam production began in 1882 at Rivers Inlet and whole clams were put up by the salmon canning process in use at that time. In the remaining part of the 19th and the early part of this century other small short-lived canning operations were started. During these early years wooden retorts were used and cans were soldered by hand.

After his 1912 survey, Thompson reported three clam canneries operated in that year; one each at Sidney, Nanaimo, and Bag Harbour in the Queen Charlotte Islands. Prior to 1912, clams had been canned in the Prince Rupert area, at Porcher Island, Alert Bay, Namu, Quatsino Sound, and Skidegate, but most were small operations. From 1918 to 1936 inclusive, the number of clam canneries is recorded in the federal Department of Fisheries of Canada statistics, and from 1937 to the present in the provincial Department of Fisheries reports (Table 10). The number of plants has varied from one to 11 but might be slightly less than recorded in the latter statistics because no distinction was made between plants canning clams and those canning other types of shellfish, such as crabs or shrimp.

In most cases the plants are primarily salmon canneries, and clam processing occupies a small part of the overall operation, usually during winter when plants are normally idle. Canning of clams usually ceases toward the end of April when most plants are busy preparing for the coming salmon season, and because clams begin to feed on the spring phytoplanton bloom. When these clams are canned the green pigments of the digestive gland permeate and discolour the meats. In winter, when clams are not feeding, the digestive gland contains little or no pigment. Almost the entire canned pack is butter clams. The only plant processing razor clams is at Masset.

**Fishing Methods**

In his 1912 and 1913 reports, Thompson gives a summary of methods used in the clam fishery, and these have not changed since then. Most digging is done by Indians, often by the whole family. The men dig and the women and children pick up the clams, although some women may also dig. The equipment is simple and inexpensive; some type of transportation to the clam beds, a lantern (since most of the low tides in the winter are at night), a fork or rake, and a basket. Digging is discussed in detail later (p. 33).

Diggers usually arrive on the beach 2–3 hr before low water and remain for about the same period after. On the northern coast, little if any commercial digging is undertaken when the low tide is 5 ft or higher, and on the southern coast, when 3 ft or more. Clams are sacked (100 lb to the sack) and taken to the buyers. In some cases the sacks are buoyed and picked up by the buyer boats at high tide. The catch may be shipped daily to the plant but usually a buyer boat will remain in the area for a series of low tides. Recently some vessels have iced in bulk in the hold when transporting them to the cannery.

The type of clam beach in British Columbia has to a large extent determined the type of digging. In the 15,000–17,000 miles of coastline, there are few extensive clam beaches. The shoreline is typically rocky and much of it plunges directly to considerable depths, so the intertidal zone in these areas is also rocky. In

TABLE 10. Number of canneries licensed to can shellfish in British Columbia, 1918–69.

| Year | Recorded in statistics of federal Dep. of Fisheries (D, District) | Recorded in statistics of B.C. Dep. Commercial Fisheries | Best estimate no. canning clams |
|---|---|---|---|
| 1918 | 1 in D. 3 | – | 1 |
| 1919 | 1 in D. 3 | – | 1 |
| 1920 | 1 in D. 3 | – | 1 |
| 1921 | 1 in D. 3 | – | 1 |
| 1922 | 4 in D. 3 | – | 4 |
| 1923 | 4 in D. 3 | – | 4 |
| 1924 | 2 in D. 2; 2 in D. 3 | – | 4 |
| 1925 | 2 in D. 3 | – | 2 |
| 1926 | 2 in D. 2; 1 in D. 3 | – | 3 |
| 1927 | – | – | – |
| 1928 | 1 in D. 2; 1 in D. 3 | – | 2 |
| 1929 | 1 in D. 3 | – | 1 |
| 1930 | 1 in D. 2; 1 in D. 3 | – | 2 |
| 1931 | 1 in D 2; 1 in D. 3 | – | 2 |
| 1932 | 1 in D. 2; 1 in D. 3 | – | 2 |
| 1933 | 1 in D. 3 | – | 1 |
| 1934 | 1 in D. 3 | – | 1 |
| 1935 | 1 in D. 1; 1 in D. 3 | – | 2 |
| 1936 | 1 in D. 2; 1 in D. 3 | – | 2 |
| 1937 | 2 in D. 3 | 6 | 6 |
| 1938 | 2 in D. 2; 2 in D. 3 | 6 | 6 |
| 1939 | 1 in D. 3 | 4 | 4 |
| 1940 | 1 in D. 3 | 5 } all operated (1937–43) | 5 |
| 1941 | – | 4 | 4 |
| 1942 | – | 4 | 4 |
| 1943 | – | 3 | 3 |
| 1944 | – | 4, 2 operated | 2 |
| 1945 | – | 9, 6 operated | 6 |
| 1946 | – | 11, 7 operated | 7 |
| 1947 | – | 11, 8 operated | 8 |
| 1948 | – | 9, 7 operated | 7 |
| 1949 | – | 6 | 6 |
| 1950 | – | 7 | 7 |
| 1951 | – | 10 | 10 |
| 1952 | – | 11 | 11 |
| 1953 | – | 7 } all operated (1949–56) | 7 |
| 1954 | – | 10 | 10 |
| 1955 | – | 9 | 9 |
| 1956 | – | 8 | 8 |
| 1957 | – | 8 | 8 |
| 1958 | – | 8 | 8 |
| 1959 | – | 9 | 9 |
| 1960 | – | 9 | 9 |
| 1961 | – | 9 | 9 |
| 1962 | – | 8 | 8 |
| 1963 | – | 12 | 12 |
| 1964 | – | 14 | 14 |
| 1965 | – | 10 | 10 |
| 1966 | – | 11 | 11 |
| 1967 | – | 11 | 11 |
| 1968 | – | 5 | 5 |
| 1969 | – | 7, 5 operated | 5 |

most cases at the heads of inlets, river deposits create soft mud flats unsuitable as clam habitats, and river discharge causes relatively low salinity for a considerable part of the year. Intertidal beaches are usually small and vary in size from a few square yards to a few acres, and usually contain much rock (Fig. 18). Literally thousands of these small pocket beaches, often widely separated and isolated, occur along the coast. However, the location of beaches with clam densities that will support commercial digging is largely a matter of local knowledge. An indication of clam density can frequently be obtained from the type of bottom, presence or absence of siphon holes, clam squirting, and test digging. When a productive spot is located, digging is continued, working down the beach as the tide recedes and up the beach as it floods.

Clam beaches are part of the Crown foreshore, and the one clam lease in British Columbia is at False Narrows just south of Nanaimo. Clam digging is permitted in all areas except on this lease, on oyster leases, and in areas that have been closed because of pollution or paralytic shellfish poison.

## Commercial Species of Clams

Of the many species of clams that occur in British Columbia most are of no commercial importance because they are too small, occur in low abundance, or are unavailable because they live in deep water. There are essentially only four commercial species and these are first the butter clam, *Saxidomus giganteus,* followed in production by the two littleneck clams, the native, *Protothaca staminea,* and the introduced Manila, *Venerupis japonica,* and then the razor clam, *Siliqua patula.* Occasionally the cockle, *Clinocardium nuttalli,* and the horse clam, *Tresus capax,* enter the commercial catch, and the latter has some potential. The two species of mussels, *Mytilus edulis,* and *Mytilus californianus,* also have some potential. The soft-shell clam, *Mya arenaria,* an important Atlantic coast species, is not used at the present time although there are areas of abundance. These species will be described in some detail.

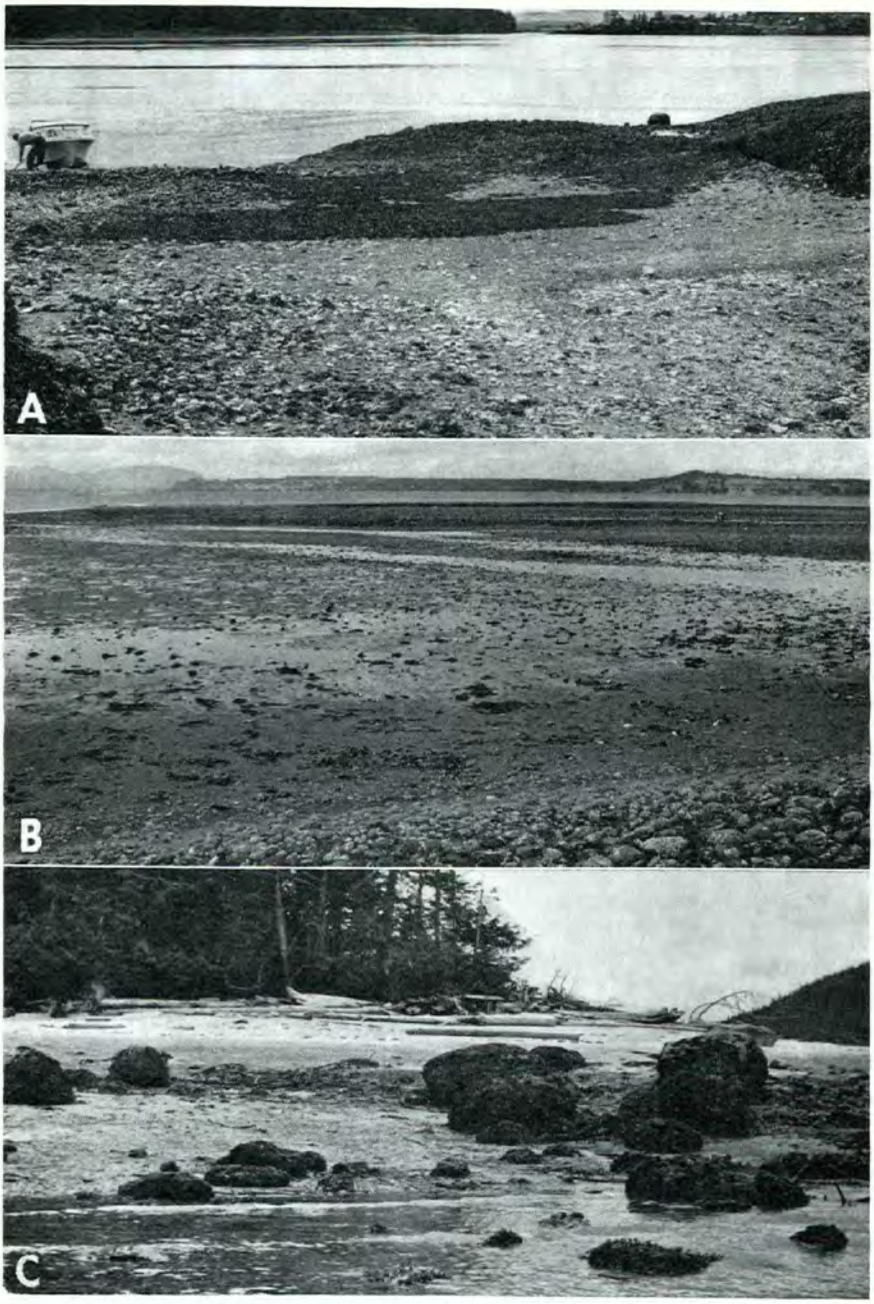



*Fig. 18. Three types of clam beaches found in British Columbia. A, small sand-mud-gravel pocket beach at Brandon Island, Departure Bay; B, Seal Island, a large mud-gravel-shell beach; C, small sand-shell beach, typical of the Alert Bay region.*

**Butter Clam**

BIOLOGY

The butter clam, *Saxidomus giganteus* (Fig. 19) is the most important commercial clam species in British Columbia. It is a relatively large clam, attaining a length of 5 inches. The shells are heavy and solid, square to oval in shape. The external surface has prominent concentric striations and deep winter checks. Shells are yellow in colour in the young, changing to grey-white with age, but the colour is often affected by the type of substrate in which it lives. The internal surface is white and smooth, but not glossy. There is a strong, prominent external hinge ligament and pronounced umbones.

*Fig. 19. Butter clam,* Saxidomus giganteus.

DISTRIBUTION

Butter clams occur from the Aleutian Islands to northern California, and are common throughout British Columbia wherever suitable conditions occur. They live in a wide variety of soil types from pure sand to pure gravel, but the typical substrate is a porous mixture of sand, broken shell, and small gravel. They occur mainly in the lower third of the tidal zone, but are also found to a depth of 30 ft below the zero tide level. Pure sand may be a good substrate providing there is no significant wave action; when found on exposed beaches the clams tend to be stunted. They can withstand a fairly wide range of temperature and salinity. During periods of low tide in winter, the temperature of buried clams may be just above the freezing point. Summer temperatures up to 25 C (77 F) may be experienced briefly in some areas. In the Strait of Georgia and in some inlets, salinity may drop for fairly extended periods to 20 $^0/_{00}$ or less, while on beaches near the open ocean salinity probably does not fall below 30 $^0/_{00}$.

Although the butter clam is widely distributed, there are areas where abundance and productivity is higher largely because of topographic and oceanographic conditions. Greatest concentrations of clams occur where gravel bars are formed by current configurations, such as at Seal Island near Comox (Fig. 18 and 20). Gravel bars may also be formed as continuations of shore deposits, and the False Narrows clam beach on Gabriola Island is so formed. Accumulations of sand with a high percentage of broken shell deposited on rocky shores, often only a few square yards in area, form important clam beaches and are typical of the Alert Bay area.

Clams burrow to a depth limited by the maximum extension of their siphons. Thus, small butter clams are found at shallow depths, while mature clams are found up to 12 inches below the surface. There is no horizontal movement but there may be small vertical movements. Clams, particularly smaller ones when removed from the soil will reburrow.

The vertical distribution of butter clams on intertidal beaches is variable, and on most the greatest concentration occurs between the 0- and 3-ft tidal level where the maximum tidal range is about 15 ft. In northern areas where the tidal range exceeds 20 ft, the upper limit of occurrence of butter clams may be as high as 8 ft. Butter clams also occur to a depth of 25 or 30 ft below the zero tide level.

BREEDING

Sexes of butter clams are separate and spawning takes place in late spring. Examina-

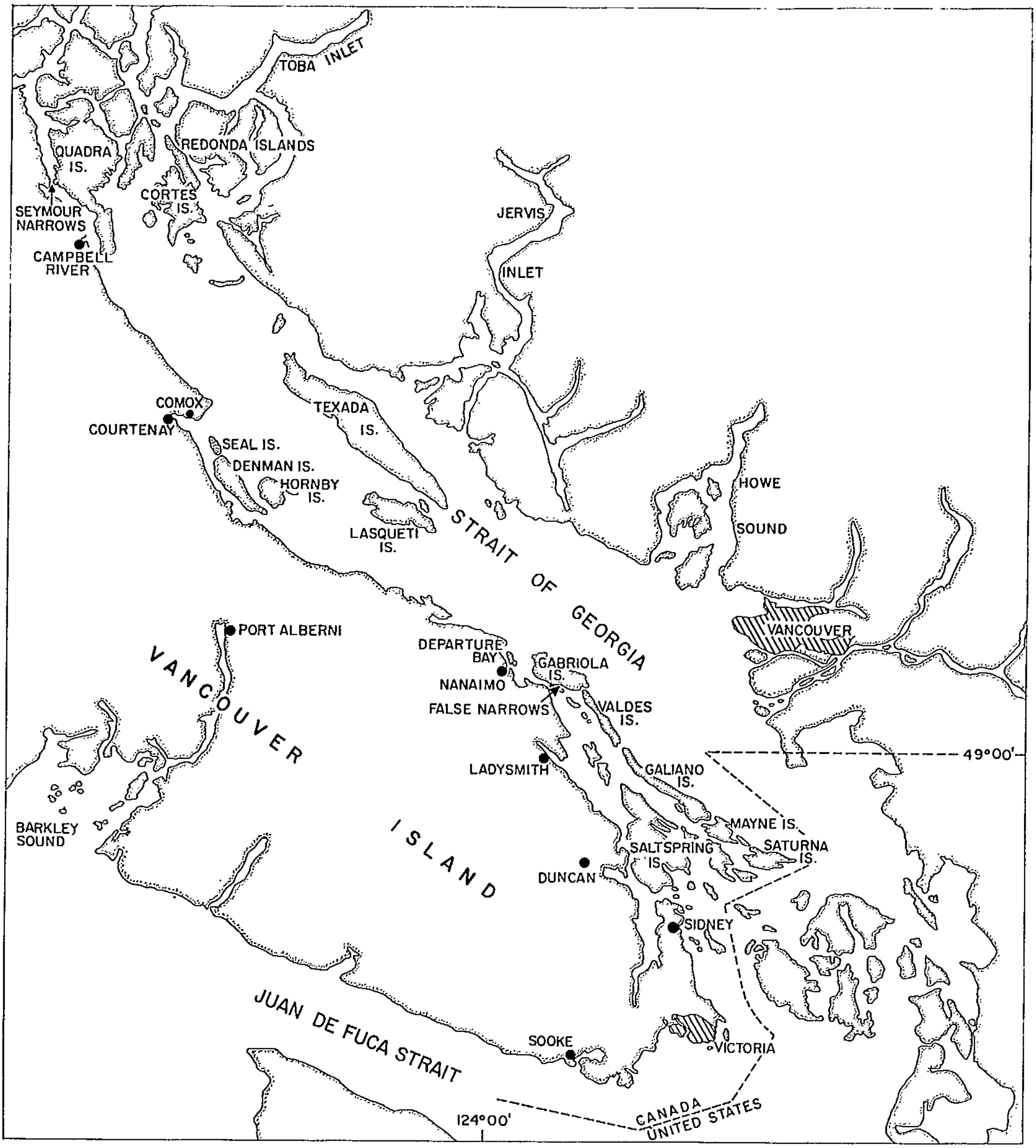



*Fig. 20. Strait of Georgia area of British Columbia showing some areas mentioned in the text.*

tion of gonad sections taken throughout the year shows that spawning may occur as early as April and May, although spent gonads may be found at any time during the year (Fig. 5A and 6A). In 1969 mass spawning of butter clams was observed at Seal Island on May 8. The spring-spawning time is supported by the fact that larval cultures in the laboratory are most successful at the springtime water temperatures of about 15 C (59 F).

Young-of-the-year may be found in the fall. If spawned early enough in the spring, they may be ¼ inch or more in length when growth ceases at the end of October, but if spawned late in the summer they may be less than ⅛ inch in length. This may lead to confusion in

TABLE 11. Estimated population of sublegal-size and legal-size butter clams on Seal Island, 1940–67.

| Year | No. of plots dug | Legal size | | No. sublegal size | Total legal and sublegal | % legal | % sublegal | % 10 years or older | Legal size | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | Weight (*lb*) | | | | | | Mean length (*mm*) | Mean weight (*g*) |
| 1940 | 14 | 4,791,600 | 556,600 | 1,391,400 | 6,183,000 | 77 | 23 | 18 | 71 | 99 |
| 1942 | – | 3,250,000 | 975,000 | – | – | – | – | – | 77.7 | 130 |
| 1945 | 22 | 4,181,760 | 1,500,000 | – | – | 88 | 12 | – | 78 | 161 |
| 1948 | – | – | – | – | – | 78 | 22 | 70 | – | 164 |
| 1949 | 35 | 945,000 | 334,950 | 71,000 | 1,016,000 | 93 | 7 | 87 | 78.7 | 159 |
| 1950 | 100 | 543,193 | 191,171 | 112,385 | 655,578 | 83 | 17 | 74 | 73 | 167 |
| 1952 | 121 | 717,288 | 249,163 | 143,458 | 860,746 | 75 | 25 | 73 | 80.7 | 159 |
| 1955 | 119 | 499,391 | 186,340 | 141,618 | 641,009 | 78 | 22 | 62 | 82.6 | 170 |
| 1959 | 126 | 986,150 | 394,460 | 126,227 | 1,112,377 | 89 | 11 | 63 | 83.6 | 196 |
| 1961 | 126 | 615,357 | 236,676 | 78,892 | 694,249 | 89 | 11 | 70 | 82.4 | 187 |
| 1964 | 119 | 663,370 | 268,330 | 298,144 | 961,514 | 69 | 31 | 50 | 75 | 176 |
| 1967 | 140 | 657,030 | 219,010 | 254,052 | 911,082 | 72 | 28 | 35.2 | 81.5 | 156 |

determining the position of the first winter ring.

Successful breeding is not a regular occurrence on British Columbia beaches. All age-classes are not equally represented in the various populations and successful reproductive years are infrequent. There is evidence that some populations may fail to spawn in some years, and these irregular seedings result in fluctuations in the adult populations.

Annual recruitment has been studied for many years at Seal Island, where there has not been a spatfall since 1934 or 1935 that approached the magnitude attained at that time. The highest proportion of clams of sublegal size on Seal Island was 31 % in 1964, and the lowest was 7 % in 1949 (Table 11 and Fig. 21).

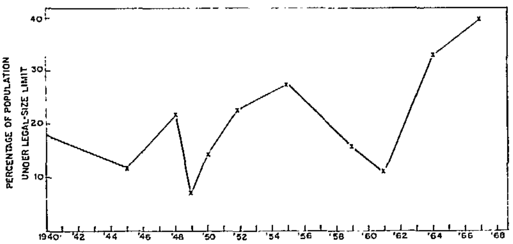



*Fig. 21. Percentage of butter clams under legal size (shell length less than 2½ inches) at Seal Island, 1945–67.*

In 1940, there were an estimated 6 million clams on the 15 acres under study. By 1950 about 850 tons of commercial-sized clams, equivalent to about 5 million clams, had been removed. Since then the total population of combined legal and sublegal size has been about 1 million or less. In 1940 only 18 % of the population was over 10 years of age, but since 1948 the average proportion over 10 years has been 60 %.

For some time recruitment of young in the Strait of Georgia has been poor, while in the northern areas it has been quite good.

MATURITY

There is a legal-size limit of 2½ inches shell length to insure that some breeding takes place before clams are taken by the fishery. With the presence of fully developed eggs and sperms as a criterion, the data given in Table 12 show the age and size at maturity at various locations along the east coast of Vancouver Island over a distance of about 200 miles.

Attainment of maturity appears to be associated with size rather than age. Since the mean length at maturity is about 1½ inches and the legal length is 2½ inches, there may be two or three spawning seasons before butter clams enter the commercial catch. The amount of spawn produced by young clams is much less than that from larger older ones.

TABLE 12. Length (inches) and age of butter clams at maturity.

| Locality | Smallest mature clam | Largest immature clam | Mean | Probable age (*years*) |
|---|---|---|---|---|
| Knapp Island | 1.53 | 1.53 | 1.53 | 3 |
| False Narrows | 1.32 | 1.39 | 1.36 | 4 |
| Departure Bay | 1.47 | 1.70 | 1.59 | 4 |
| Seal Island | 1.28 | 1.61 | 1.45 | 3 |
| Alert Bay | 1.56 | 1.64 | 1.60 | 5 |

GROWTH

Growth may vary from area to area, year to year, from beach to beach, or at different locations on the same beach. On the southern coast the legal-size limit of 2½ inches is reached in 4–5 years, while in the north it requires up to 8 or 9 years. A typical growth rate for Strait of Georgia butter clams is shown in Fig. 22, and the relation between shell length and total

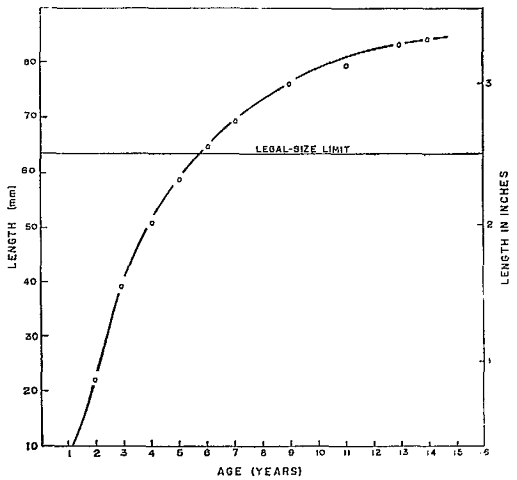



*Fig. 22. Growth rate of butter clams from Seal Island, Strait of Georgia, B.C.*

TABLE 13. Average length (*inches*) of butter clams at annual winter checks along the British Columbia coast to show the difference in growth rate with northward distribution.

| Area and locality | Winter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *Barkley Sound* | | | | | | | | | | | | |
| Dodgers Cove | 0.181 | 0.862 | 1.496 | 1.972 | 2.374 | 2.649 | 2.917 | 3.129 | | | | |
| Effingham Is. | 0.224 | 0.929 | 1.586 | 2.090 | 2.511 | 2.838 | 3.106 | 3.389 | 3.606 | | | |
| *Strait of Georgia* | | | | | | | | | | | | |
| Coal Is. | 0.125 | 0.685 | 1.350 | 1.870 | 2.358 | 2.692 | 2.952 | 3.129 | | | | |
| Piers Is. | 0.200 | 0.874 | 1.484 | 1.996 | 2.389 | 2.708 | 2.968 | 3.181 | | | | |
| Knapp Is. | 0.204 | 0.803 | 1.362 | 1.834 | 2.220 | 2 555 | 2.795 | 2 988 | 3.157 | 3.283 | | |
| Cape Keppel | 0 212 | 0.826 | 1.326 | 1.708 | 2.059 | 2.354 | 2.574 | 2.799 | 2.984 | 3.102 | | |
| Dunsmuir Is. | 0.181 | 0.799 | 1.259 | 1.665 | 2.011 | 2.271 | 2.503 | | | | | |
| Departure Bay | 0.236 | 0.767 | 1.295 | 1.669 | 2.003 | 2.295 | 2.496 | 2.673 | | | | |
| Seal Is. | 0.224 | 0.984 | 1.519 | 1.964 | 2.299 | 2.562 | 2.814 | 3.023 | 3.224 | | | |
| *Johnstone Strait and Alert Bay* | | | | | | | | | | | | |
| Johnstone Strait | 0.169 | 0.712 | 1.295 | 1.688 | 2.031 | 2.314 | 2.562 | 2.787 | 2.976 | 3.137 | 3.255 | |
| Port Harvey | 0.169 | 0.712 | 1.295 | 1.688 | 2.031 | 2.314 | 2 562 | 2.787 | 2.976 | 3.137 | 3.255 | |
| Echo Bay | 0.122 | 0.452 | 0.940 | 1.326 | 1.692 | 2.007 | 2.295 | 2.539 | 2.740 | 2.913 | 3.098 | |
| Alert Bay | 0.173 | 0.503 | 0.901 | 1.263 | 1.598 | 1.881 | 2.114 | 2.311 | 2.511 | 2.696 | 2.874 | 3.098 |
| *Prince Rupert* | | | | | | | | | | | | |
| Metlakatla | 0.185 | 0.570 | 0.913 | 1.267 | 1.566 | 1.854 | 2.106 | 2.299 | 2.484 | 2.653 | 2.814 | |
| Jap Inlet | 0.212 | 0 480 | 0.811 | 1.133 | 1.456 | 1.736 | 1.996 | 2.224 | 2.417 | 2.574 | 2.716 | 2.870 |
| Baron Is. | 0.169 | 0.484 | 0.811 | 1.098 | 1.362 | 1.633 | 1.913 | 2.141 | 2.338 | 2.492 | 2.614 | 2.838 |
| Baron Is. | 0.173 | 0.503 | 0.834 | 1.098 | 1.381 | 1.622 | 1.885 | 2.098 | 2.330 | 2.531 | 2.712 | 2.854 |

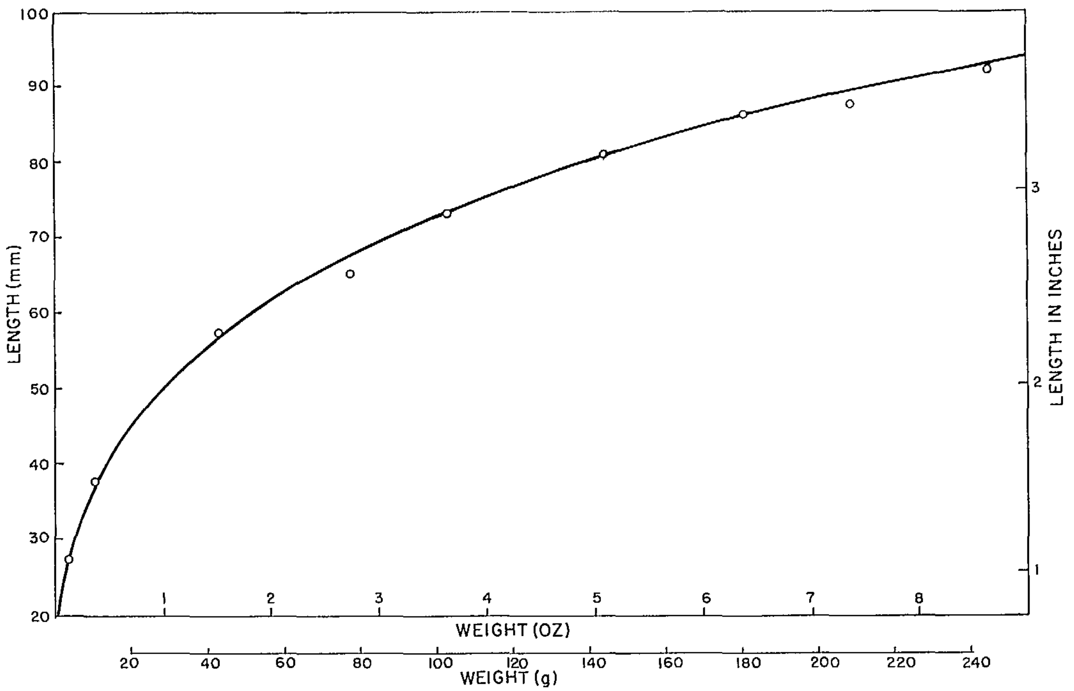



*Fig. 23. Relation between shell length and total weight of butter clams from Seal Island, Strait of Georgia, B.C.*

weight is shown in Fig. 23. About two-thirds of the normal potential growth is attained in the first 5 years of life; thereafter the growth rate is relatively slow. The relation between age and total weight of legal-size butter clams is shown in Fig. 24, and demonstrates clearly a straight line relation where ½ ounce is added every year. At the legal-size limit of 2½ inches the weight is about 2½ ounces. The proportion of meat drops somewhat as the clam grows older, from 40 % at age 6 to 33 % at age 20 (Fig. 25). The absolute

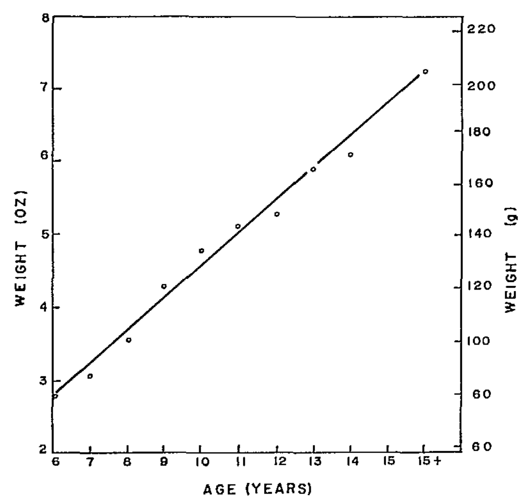



*Fig. 24. Relation between age and total weight of butter clams from Seal Island, Strait of Georgia, B.C.*

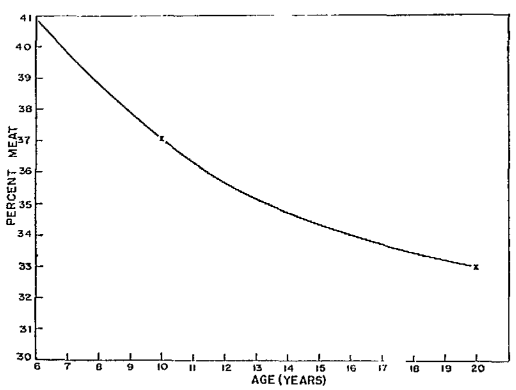



*Fig. 25. Relation between age and percentage meat weight of legal-sized butter clams from Seal Island, August 1964.*

amount of meat increases, but not as rapidly as the shell weight.

### LATITUDINAL GROWTH

A comparative study of measurements of winter growth checks confirmed that growth rates of butter clams vary along the coast. Table 13 shows the considerable variation in growth on various beaches, even those in close proximity. Coal Island, Piers Island, Knapp Island, and Cape Keppel are within a radius of about 3 miles. Approximate ages at which the legal length of 2½ inches is attained indicates that clams in Barkley Sound require 4½–5 years; Strait of Georgia, 5–6½ years; Alert Bay, 6½–8½ years; and Prince Rupert, 9 years. Such differences in growth rate to legal size indicate that management techniques, if required, must be on a regional basis.

### DIGGING METHODS

The standard, time-honoured method of digging butter clams is with an ordinary garden type, long-handled, four-tined potato fork (Fig. 26). Usually the abundance of clams is indicated by the number of holes left by the siphons, which are withdrawn as the tide recedes. Only experience or test digging may establish where clams are most abundant. Once the spot is chosen, the ground is turned over to the full length or more of the fork tines in a manner much as one digs or turns over a section of garden. If possible, digging should always be in a relatively straight line and the soil evenly spread along this line in front of the digger. If large mounds of turned-over soil are made, the young clams at the bottom will likely not survive.

As the soil is turned over, most of the clams will be seen, but it is necessary to rake over the soil lightly since up to 25 % of the available clams may be missed, either by not raking the turned-out soil thoroughly, or by not digging deeply enough. The amount of ground turned over by the average digger is about 25–40 square yards in the usual 4-hr period on normal low tides. At today's clam prices a minimum concentration of 4–5 lb per square yard is necessary to provide modest wages.

Few diggers operate in a methodical way and as soon as clam abundance drops slightly, they move to another spot. Consequently, on all but the smallest beaches there are scattered pockets of undug ground. This is the reason beaches may be revisited a number of times successively and clams will continue to be found. This leads to the oft-proclaimed supposition that digging is "good" for a beach. That beaches are rarely completely depleted is due to the fact that not all clams are taken from a dug area.

Until 1966, regulations permitted butter clam digging only from November 1 to April 30 when low tides occur mostly at night. Although regulations were altered to permit digging year-round, there is an automatic closure by processors from April through October because clams are then actively feeding on green pigmented diatoms (green feed) which colour the digestive gland.

*Fig. 26. Four-tined garden fork commonly used to dig butter clams.*

### TRANSPORTING RAW CLAMS

After clams are dug they are usually sacked in 100-lb potato sacks and delivered to a buyer (Fig. 27). The sacked clams may be left on the beach for several days until enough

*Fig. 27. Butter clams sacked in jute bags being taken to a buyer.*

have accumulated to make worthwhile a delivery to the buyer. Holding clams in sacks is a time-honoured procedure but because of lack of circulation some suffocation occurs, particularly during the warmer seasons. A better storage method would be in wide-mesh baskets.

Buyers, licensed by the provincial Commercial Fisheries Branch (a licence for digging is not required), use vessels between 30 and 70 ft in length, or anchored fish buying scows. The buyer may move from beach to beach and village to village, or may remain in one spot and allow the diggers to come to him. The sacked clams are usually measured into 60-lb wooden boxes by the buyer and may be transported to the processing plant in this manner (Fig. 28). Recently there has been a trend toward transporting butter clams in bulk in a seine-boat hold, where they may be iced. It is claimed icing reduces loss, particularly if the vessel is held up for any reason and toward the end of the season when air temperatures begin to rise.

On receipt of the clams, the buyer is required by the Department of the Environment, Fisheries Service, to make out a sales slip for statistical purposes.

*Fig. 28. Butter clams in boxes on buyer boat.*

PROCESSING

Butter clams are invariably canned. From time to time they have appeared fresh on the

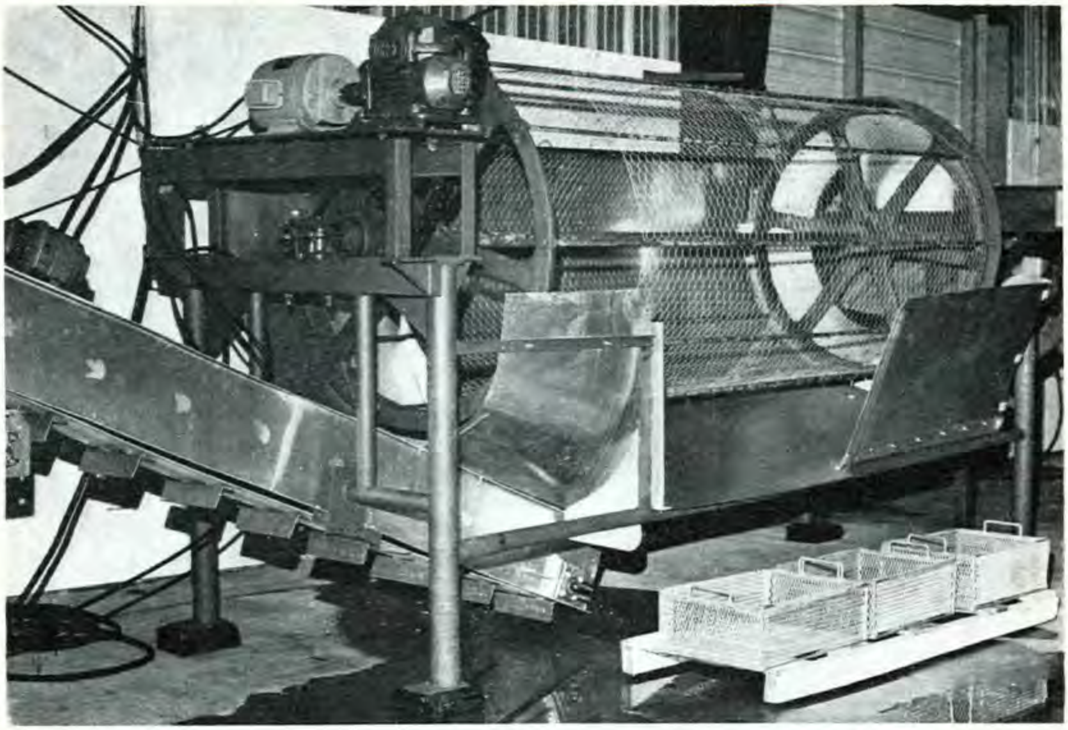


*Fig. 29. Revolving wire-mesh drum that shucks clams in canneries.*

market in small cartons, but this is not a standard practice. They are normally shipped live in the shell but may also be shucked like oysters and frozen into 50-lb blocks. Butter clams may be exported only in wooden boxes containing not more than 80 lb in the shell.

In canning, the clams are first steamed to cause the shells to gape, and are then placed in a slanted revolving drum covered with a mesh of a diameter that allows the meats to fall through but retains the shells (Fig. 29). The shells are either discarded or used for chicken scratch. After washing, the meats are carried to tables or along moving belts where the black tips of the siphons are clipped off with scissors, pieces of shell removed, and discoloured clams culled out. Packing is done by hand into cans of various sizes for whole pack, or ground for a minced pack. Nectar is added and the cans topped and exhausted at 210 F for about 8 min. They are then sealed and retorted for 70–90 min at 220 F. Actual times and temperatures vary slightly according to the individual packer. In British Columbia butter clams are usually packed in cans of ½- or 1-lb sizes.

### PRODUCTIVITY

The productivity of clam beds is variable and depends on many factors. Size of the bed is important, for a small one may be quickly dug out, while it is difficult to do this with a large one. Type of ground is a factor, for it will influence the ease and rate of digging. Difficult ground with many rocks does not receive the digging pressure of easily dug ground. Annual recruitment and growth rate are also factors of importance.

For individual beaches, Seal Island is the only one for which good data are available. This was the main producing beach in the Comox area for many years prior to about 1930, when it suffered a decline in population and it seemed that for it to recover, a closure to commercial digging was necessary. This was applied in 1939. However, a detailed examination of the beach disclosed an extremely abundant year-class from a spawning probably in 1934, with 80 % of the population estimated to be 6 years of age or less (1940, Table 11), and just over the legal-size limit of 2½ inches (Fig. 30). The beach was opened to controlled commercial digging in 1942. A catch limit of 100 tons per year was established and continued until 1950, when reduced returns (156 lb per man tide) to diggers caused lack of interest, and production has been sporadic and small since then. The beach was released from control on January 1, 1965.

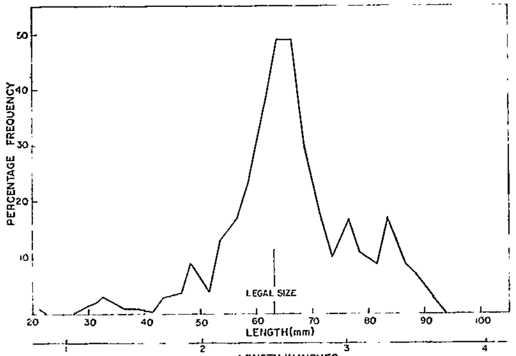



*Fig. 30. Size-frequency distribution of butter clams from Seal Island, 1940.*

Thus in 9 years of controlled digging about 850 tons of clams were taken from approximately 15 acres of digging area (Table 14).

TABLE 14. Butter clam production at Seal Island, 1942–50.

| Year | Catch (*lb*) | No. clams | Catch per man tide (*lb*) | Mean weight per clam (*ounces*) |
|---|---|---|---|---|
| 1942 | 235,757 | 825,149 | 600 | 4.6 |
| 1943 | 236,825 | 757,840 | 601 | 5.0 |
| 1944 | 209,211 | 627,633 | 792 | 5.3 |
| 1945 | 207,160 | 600,764 | 436 | 5.5 |
| 1946 | 196,072 | 548,994 | 443 | 5.5 |
| 1947 | 186,035 | 502,294 | 352 | 5.4 |
| 1948 | 196,287 | 549,603 | 241 | 5.4 |
| 1949 | 163,170 | 473,193 | 220 | 5.5 |
| 1950 | 77,229 | 280,518 | 156 | 6.0 |
| Total | 1,707,746 | 5,275,988 | | |

Since 1950 the population of legal-sized clams has varied between 90 and 200 tons, with an average of 130 tons, which was the last estimate in 1967 (Table 11). Virtually all clams taken during the 9-year period mentioned were of the 1934 year-class. Thus, a single year-class of good strength produced, in round figures, 100 tons per acre.

However, Seal Island during this period represented what may be an exceptional set of circumstances, for densities up to 75 lb of clams per square yard were encountered. Most beaches along the coast have between 2 and 10 lb per square yard.

Production in the clam fishery has fluctuated greatly over the years, presumably as a response to either the economic climate or the availability of diggers, that usually is associated with the degree of success of the previous salmon season. Therefore, the potential productivity of the provincial fishery as a whole is difficult to assess. The maximum production in any one year occurred in 1938, when 7,663,300 lb were produced.

The average butter clam production for the 11-year period from 1951–61 inclusive was approximately 3,600,000 lb, divided equally between District 2 (north of Queen Charlotte Sound) and District 3 (Table 9), and this is near the 60-year average for the province. Therefore, since there has been general underexploitation, the minimum annual sustained yield may be taken as 1800 tons and the optimum is probably between 2500 and 3000 tons. That this is not an overestimate may be deduced by considering that the present average production of 1800 tons is probably produced from digging about 150 acres. This assumes an average catch of 200 lb per man tide from a digging area of 40 square yards per tide. Although there has been no attempt to measure the total acreage of clam-bearing ground in the province, it is probably more than 10 times this amount.

The distribution of butter clam landings from 1951–69 is shown in Table 15. The northern region, District 2, contributed about half of the annual catch until 1963 when the district was closed because of paralytic shellfish poisoning. In 1969, the southern two areas of this district (Areas 8 and 9) were opened to commercial digging and small landings were made. Largest landings in the north coast district came from the Prince Rupert region and the area to the south (Areas 4 and 5). Substantial catches were also made in the Butedale and Bella Bella regions (Areas 6 and 7). Only minor amounts came from the Queen Charlotte Islands. In the southern region, District 3, the largest landings have consistently originated from the Alert Bay area (Area 12). The west side of the Strait of Georgia (Areas 14, 17, and 18) has been the other major producing area in this district. Only minor landings have been made in District 1, and virtually none since 1961.

With a summer closure of 5 months, 45 % of the butter clam catch has been taken in February and March with only 7 % in November and 3 % in May (Table 16). It is unlikely the present situation with no closed season will have a significant effect on this seasonal pattern of production.

It is apparent that butter clam stocks are not now being fully exploited. Studies have been made on methods of canning slightly toxic clams and, as was shown, this requires removal of the whole siphon. With this proviso it is possible for the industry to make use of stocks now under restriction in the central and northern areas. The other major problem is availability of diggers. The obvious solution is mechanical harvesters, discussed in a later section.

### DIGGING FREQUENCY

A 7-year experiment was conducted at five sites between Alert Bay (Area 12) and Saanich Peninsula (Area 18), which are nearly 200 miles apart, to determine the relation between digging frequency and productivity. Blocks of 25 by 25 ft were divided into 5- by 5-ft plots at the different sites. Five groups of randomly chosen plots in each block were subjected to the following digging frequencies: 1. Twice per year. 2. Once per year. 3. Every second year. 4. Every third year. 5. At the end of the experiment (7 years).

The average yield in pounds of clams per plot expressed as a percentage of the total yield for each site is given in Table 17, as well as the mean yield per plot.

There is not a great difference between any of the first four treatments. Number five is decidedly the worst and, except for the contribution of Seal Island, which had an exceptionally high mean yield, would have been strikingly lower. On the basis of this experiment there appears to be no advantage between digging intervals of ½, 1, 2, and 3 years from the point of view of total yield. However, when effort is considered, digging every third year in this experiment was most efficient since only three digs were required to produce about the same quantity of clams as in 14, 7, and 4 digs for the other treatments. This is also seen in Fig. 31, which shows the trend in production from the different treatments. In general, there is a significant decrease after the first two digs.

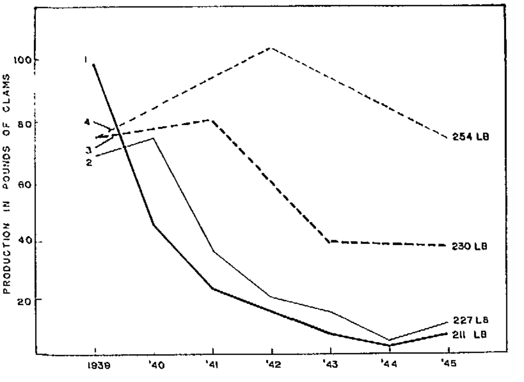



*Fig. 31. Trend of combined annual production of butter clams from five plots with four digging frequencies at Seal Island, 1939-45. 1, plots dug twice per year; 2, plots dug once per year; 3, plots dug every other year; 4, plots dug every third year.*

### REGULATIONS

At present the only restriction governing the taking of butter clams in the commercial fishery is the minimum legal-size limit of 2½ inches shell length. There are no restrictions in the recreational fishery.

### SUMMARY

The commercial butter clam fishery will probably continue primarily as a winter fishery and offer off season employment to fishermen. Although landings have fluctuated greatly since 1900, an annual sustained yield of 3000 tons could probably be realized from the entire coast. To attain this yield, processing techniques would have to be modified to permit use of clams from District 2, which is now closed, and digging methods must be improved by mechanization to make clam digging more rewarding.

TABLE 15. Annual landings in pounds of butter clams in the areas of the three statistical districts in British Columbia, 1951–69. (No landings have been recorded in Areas 21, 22, and 27 of the South Coast District.)

| | North Coast (District 2) | | | | | | | | | | | Fraser Area (District 1) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2AE | 2BE | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 28 | 29 |
| 1951 | – | 600 | – | 1,000 | 322,200 | 569,100 | 101,000 | 246,100 | 44,800 | – | – | 7,200 | – |
| 1952 | – | – | 120,400 | 47,900 | 1,121,900 | 1,010,400 | 284,600 | 460,800 | 84,800 | 27,400 | 185,500 | 3,700 | – |
| 1953 | – | – | 17,800 | 55,200 | 381,700 | 633,400 | 134,000 | 284,300 | 173,500 | 4,500 | 16,500 | 1,800 | – |
| 1954 | – | – | – | 5,100 | 534,600 | 627,200 | 89,000 | 235,300 | – | – | – | 7,000 | – |
| 1955 | – | – | – | 17,400 | 1,000,400 | 943,300 | 236,500 | 233,700 | – | – | – | 2,600 | – |
| 1956 | – | – | – | 33,500 | 281,500 | 791,600 | 96,500 | 56,400 | – | – | – | 4,700 | – |
| 1957 | – | – | – | 8,500 | 288,500 | 1,268,600 | 55,700 | 231,200 | 16,300 | – | – | 1,400 | – |
| 1958 | – | – | – | – | 172,600 | 711,400 | 38,800 | 114,900 | 83,000 | 5,100 | 52,800 | 2,200 | – |
| 1959 | – | – | 7,600 | 36,200 | 288,700 | 691,800 | 54,200 | 114,600 | 211,200 | – | 500 | 500 | – |
| 1960 | 40,400 | 13,800 | – | 188,400 | 119,400 | 604,600 | 217,400 | 303,200 | 296,000 | – | – | 200 | – |
| 1961 | 1,500 | – | – | 110,600 | 184,200 | 410,300 | 49,300 | 216,300 | 34,500 | – | – | – | 2,000 |
| 1962 | 600 | – | – | 59,200 | 215,400 | 569,300 | 16,500 | 124,200 | 16,400 | 9,000 | 19,500 | – | – |
| 1963 | – | – | – | 57,200 | – | 823.500 | 3,100 | 47,100 | 1,800 | – | – | – | – |
| 1964 | No landings | | – | – | – | – | – | – | – | – | – | – | – |
| 1965 | – | 3,700 | – | – | – | – | – | – | – | – | – | – | – |
| 1966–68 | No landings | | – | – | – | – | – | – | – | – | – | – | – |
| 1969 | – | – | – | – | – | – | – | – | – | 27,300 | 43,800 | – | 100 |

South Coast
(District 3)

| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 100 | 1,329,200 | 18,500 | 76,200 | 29,900 | 14,000 | 471,400 | 270,900 | 15,900 | 1,900 | – | – | – | – | – | – | – |
| 1952 | 3,200 | 1,050,300 | 120,800 | 5,300 | 6,700 | 13,400 | 635,600 | 305,100 | 5,500 | – | – | – | – | – | – | – | – |
| 1953 | – | 1,401,600 | 158,100 | 29,000 | 6,000 | 3,300 | 244,200 | 134,800 | 4,100 | 2,200 | – | – | – | 5,300 | – | – | – |
| 1954 | – | 709,600 | – | 117,700 | 1,900 | 33,700 | 324,300 | 190,100 | 1,800 | 1,700 | – | – | 17,900 | – | – | – | – |
| 1955 | – | 1,299,800 | 16,400 | 67,100 | 300 | 600 | 508,100 | 203,400 | 4,600 | – | – | – | 228,500 | 20,800 | – | – | – |
| 1956 | – | 1,168,700 | 16,600 | 72,000 | 6,400 | 1,500 | 463,700 | 176,100 | – | – | – | – | – | 36,500 | – | – | – |
| 1957 | – | 1,042,900 | 25,000 | 47,500 | – | 400 | 251,900 | 184,900 | 600 | – | – | – | – | 70,100 | 20,400 | 26,800 | – |
| 1958 | – | 773,000 | – | – | – | 800 | 55,400 | 164,300 | 2,600 | 100 | – | – | – | – | – | – | – |
| 1959 | – | 825,700 | 300 | – | – | 600 | 112,500 | 25,600 | 300 | – | – | – | – | 41,800 | – | – | – |
| 1960 | – | 1,356,700 | – | 213,900 | – | 7,100 | 271,200 | 6,900 | 100 | 3,200 | – | – | 400 | 7,100 | – | – | – |
| 1961 | – | 780,400 | 11,000 | 18,500 | 500 | 8,700 | 32,000 | 17,700 | 1,300 | 2,000 | – | – | – | 9,600 | – | – | – |
| 1962 | – | 1,932,800 | 59,700 | 37,300 | 1,500 | 2,100 | 143,900 | 54,800 | 10,200 | 11,900 | – | – | – | 57,500 | – | 37,200 | – |
| 1963 | – | 1,140,900 | 200 | 6,000 | 1,600 | 2,600 | 57,200 | 80,500 | 11,100 | 35,500 | – | – | 7,300 | 130,200 | 22,500 | 93,100 | – |
| 1964 | – | 964,500 | 37,500 | 8,800 | 4,500 | 1,200 | 96,500 | 45,200 | 3,900 | 36,300 | – | – | 3,800 | 53,900 | – | – | – |
| 1965 | – | 1,080,100 | 41,100 | 46,700 | 4,300 | 5,800 | 221,500 | 40,300 | 2,400 | 81,600 | – | – | 10,800 | – | 13,600 | – | – |
| 1966 | – | 1,240,300 | – | 13,900 | – | 4,800 | 445,600 | 63,400 | 1,400 | 37,200 | – | – | 14,900 | 11,200 | – | – | – |
| 1967 | – | 1,376,100 | 54,400 | 227,000 | – | 200 | 464,400 | 10,500 | 1,100 | 12,800 | – | – | 2,000 | – | – | – | – |
| 1968 | – | 399,300 | 6,100 | 122,300 | 1,200 | 600 | 251,200 | 54,700 | 13,900 | 29,200 | – | – | 1,000 | – | – | – | – |
| 1969 | – | 390,100 | 600 | 123,000 | – | – | 173,300 | 29,000 | 6,700 | 17,100 | – | – | – | 22,000 | – | – | – |

TABLE 16. Monthly landings of butter clams in pounds in the three statistical districts of British Columbia, 1951–69. (No commercial landings reported in the Fraser and South Coast Districts from July–September and none in the North Coast District from June–September.)

| Year | Jan. | Feb. | Mar. | Apr. | May | June | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *Fraser Area (District 1)* | | | | | |
| 1951 | 200 | 700 | 500 | 2,400 | 2,900 | – | 300 | 200 | – |
| 1952 | – | 100 | 300 | 3,200 | 100 | – | – | – | – |
| 1953 | – | 200 | 100 | 300 | 500 | – | 200 | 200 | 300 |
| 1954 | 400 | – | – | 1,700 | 4,600 | 100 | – | 200 | – |
| 1955 | 400 | 300 | 200 | 600 | 600 | 100 | – | 100 | 300 |
| 1956 | 400 | 400 | 1,400 | 1,600 | 800 | – | – | 100 | – |
| 1957 | – | – | – | 400 | 100 | – | – | 200 | 700 |
| 1958 | – | 100 | 100 | 1,300 | 400 | – | – | 300 | – |
| 1959 | 100 | – | 200 | – | 200 | – | – | – | – |
| 1960 | 100 | – | 100 | – | – | – | – | – | – |
| 1961 | – | – | – | – | – | – | – | – | 2,000 |
| 1962–68 | No landings | | – | – | – | – | – | – | – |
| 1969 | – | – | 100 | – | – | – | – | – | – |
| | | | | *North Coast (District 2)* | | | | | |
| 1951 | 57,000 | 311,200 | 272,000 | 590,600 | 49,200 | – | – | – | 4,800 |
| 1952 | 102,400 | 862,400 | 1,323,800 | 633,400 | – | – | 1,000 | 197,200 | 223,500 |
| 1953 | 70,800 | 555,700 | 910,800 | – | – | – | 700 | 50,300 | 112,600 |
| 1954 | 110,500 | 219,500 | 979,700 | 180,500 | – | – | – | 300 | 700 |
| 1955 | 119,500 | 418,000 | 1,511,900 | 73,400 | – | – | – | 71,000 | 237,500 |
| 1956 | 89,400 | 292,300 | 690,900 | 42,100 | – | – | 7,800 | 81,900 | 55,100 |
| 1957 | 367,600 | 522,200 | 553,600 | 173,800 | – | – | – | 107,300 | 144,300 |
| 1958 | 139,900 | 321,100 | 469,300 | 170,000 | – | – | – | 41,700 | 36,600 |
| 1959 | 55,500 | 173,400 | 426,700 | 148,500 | – | – | – | 307,000 | 293,700 |
| 1960 | 221,100 | 598,800 | 527,400 | – | – | – | 2,300 | 571,600 | 179,000 |
| 1961 | 235,100 | 287,700 | 3,300 | – | – | – | 800 | 239,600 | 175,400 |
| 1962 | 139,600 | 263,600 | 237,900 | – | – | – | 2,700 | 146,100 | 209,000 |
| 1963 | 190,200 | 242,100 | 321,000 | – | – | – | 50,100 | 160,800 | 183,900 |
| 1964 | No landings | | – | – | – | – | – | – | – |
| 1965 | – | 3,700 | – | – | – | – | – | – | – |
| 1966–68 | No landings | | – | – | – | – | – | – | – |
| 1969 | 5,400 | 26,800 | 38,900 | – | – | – | – | – | – |

*South Coast*
*(District 3)*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1951 | 206,300 | 366,400 | 551,800 | 661,200 | 296,500 | – | – | 17,800 | 128,000 |
| 1952 | 218,800 | 480,400 | 486,400 | 519,400 | 70,000 | – | – | 69,900 | 301,000 |
| 1953 | 541,100 | 752,300 | 490,500 | 5,900 | 45,700 | – | – | 7,700 | 145,400 |
| 1954 | 86,000 | 231,000 | 341,200 | 441,500 | 26,700 | 7,700 | – | 60,700 | 203,900 |
| 1955 | 498,100 | 679,500 | 589,500 | 148,200 | 600 | – | – | 57,000 | 376,700 |
| 1956 | 427,100 | 424,400 | 578,100 | 361,500 | 11,500 | – | – | 38,700 | 100,200 |
| 1957 | 413,700 | 502,900 | 488,000 | 90,800 | 100 | – | – | 33,200 | 141,800 |
| 1958 | 348,200 | 248,900 | 331,200 | 23,700 | 600 | – | – | 26,700 | 16,900 |
| 1959 | 77,300 | 193,600 | 241,000 | 204,200 | – | – | – | 112,000 | 178,700 |
| 1960 | 365,100 | 382,800 | 362,600 | 87,500 | 1,900 | 1,000 | – | 251,300 | 414,400 |
| 1961 | 106,200 | 201,300 | 257,200 | – | 100 | – | – | 126,800 | 190,100 |
| 1962 | 374,400 | 371,200 | 233,200 | 422,500 | 15,000 | – | – | 707,900 | 224,700 |
| 1963 | 501,000 | 315,900 | 380,500 | 14,200 | 10,600 | – | 46,600 | 81,300 | 238,600 |
| 1964 | 167,300 | 375,600 | 374,600 | 73,900 | 20,400 | – | – | 85,000 | 159,300 |
| 1965 | 294,600 | 395,100 | 452,000 | 34,300 | 42,800 | 3,300 | – | 166,600 | 159,500 |
| 1966 | 204,800 | 225,700 | 274,800 | 429,400 | 249,800 | – | 12,300 | 227,100 | 208,800 |
| 1967 | 327,700 | 383,200 | 402,100 | 544,200 | 131,400 | – | 28,200 | 169,200 | 162,500 |
| 1968 | 174,200 | 293,600 | 187,700 | 140,100 | 12,700 | 100 | 2,500 | 40,400 | 28,200 |
| 1969 | 85,200 | 168,300 | 202,200 | 69,000 | 13,800 | – | 12,400 | 43,100 | 167,800 |

TABLE 17. Production in pounds per plot at five locations between Knapp Island and Echo Bay, B.C. Digging frequencies: 1, twice per year; 2, once per year; 3, every second year; 4, every third year; 5, at the end of the experiment (7 years).

| | Digging frequency | | | | | Mean yield per plot |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | (*lb*) |
| Knapp Island | 21.6 | 22.3 | 18.6 | 24.4 | 13.1 | 17.0 |
| Dunsmuir Island | 27.5 | 23.3 | 18.0 | 20.6 | 10.6 | 9.5 |
| Departure Bay | 18.8 | 22 2 | 23.7 | 20.3 | 16.0 | 7.6 |
| Seal Island | 16.4 | 17.6 | 17.8 | 19.7 | 28.5 | 51.7 |
| Echo Bay | 19.7 | 24.7 | 19.2 | 20.0 | 16.4 | 33.9 |
| Mean | 20.7 | 22.0 | 19.5 | 21.0 | 16.8 | 24.0 |

## Littleneck Clam

### BIOLOGY

The littleneck clam, ***Protothaca staminea*** (Fig. 32), also called the native littleneck, is a common intertidal bivavle of British Columbia. It is medium sized, up to 2½ inches in length, with a solid, oval to round shell. The external surfaces of the valves have radiating ribs with less prominent concentric ridges. The colour of the external surfaces may vary from white to chocolate brown; often angular patterns are present. A lunule is present and the hinge ligament is external. The interior surface is smooth and white with a crenulated internal ventral margin.

*Fig. 32. Littleneck clam,* Protothaca staminea.

Littleneck clams occur from lower California to the Aleutian Islands. Although they are found along with butter clams, they usually occur in a more gravelly, firmer type of beach, and at a slightly higher tidal level. Littlenecks burrow to a maximum depth of about 6 inches and occur from slightly above the mid-intertidal beach zone to the subtidal region. They have been recorded to a maximum water depth of about 40 ft.

Spawning occurs in late spring, although sporadic spawning may take place throughout the summer. The larval period is approximately 3 weeks and they settle when about 260–280 $\mu$ (0.01 inch) in length. The umboned larvae are fairly easily identified by their shape and the yellow ventral margin of the shell. Growth is slow and clams entering the fishery in the Strait of Georgia at 1½ inches are 3½–4 years old (Fig. 33). Those that reach the maximum size of 2½ inches are about 10 years old.

FISHERY

Littleneck clams are frequently dug along with butter clams, and methods and equipment in the two fisheries are similar. Littlenecks are sorted out and sacked separately. On beaches with extensive populations of littlenecks but few butter clams, diggers may use long-tined rakes that are pulled through the soil and the littlenecks are turned out. Some diggers concentrate on littleneck clams.

They are usually sold fresh for steaming. These clams are able to close the valves tightly

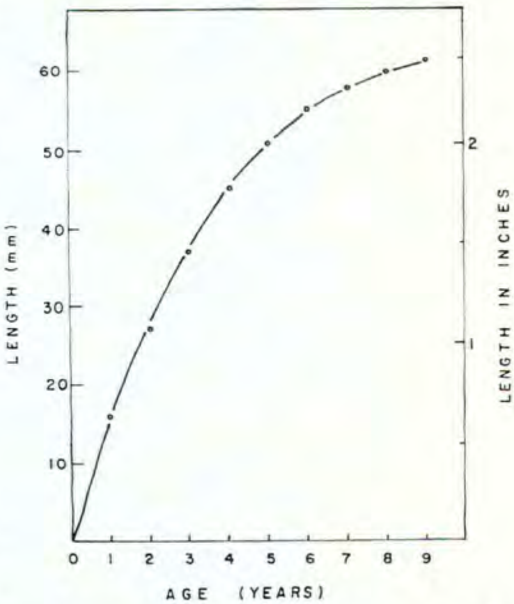



*Fig. 33. Growth rate of littleneck clams from the Strait of Georgia area, B.C.*

*Fig. 34. Sink float used to hold littleneck and Manila clams.*

TABLE 18. Landings in pounds of butter, littleneck, and Manila clams in British Columbia as recorded by personnel at the Fisheries Research Board of Canada, Biological Station at Nanaimo, 1940–50.

| Year | Butter clams | Littleneck and Manila clams |
|---|---|---|
| 1940–41 | 2,434,815 | – |
| 1941–42[a] | 3,032,397 | ca. 200,000 |
| 1942–43 | 2,893,222 | 248,920 |
| 1943–44 | 2,238,627 | 237,753 |
| 1944–45 | 3,508,342 | 368,880 |
| 1945–46 | 4,021,230 | 547,586 |
| 1946–47 | 6,314,673 | – |
| 1947–48 | – | – |
| 1948–49 | 1,625,688 | 436,327 |
| 1949–50 | 2,640,368 | 842,043 |

[a]Additional species included 8418 lb of horse clams in 1941–42.

and thus prevent desiccation by retaining liquid over the soft parts. Hence, they may remain out of water for a moderate period of time and be transported fresh over long distances. Most of the catch is sold in the United States, as far away as San Francisco.

Formerly they were held in sink floats until market conditions were favourable (Fig. 34). Recently because of the all-year open season and strong market conditions, they have usually been marketed directly without storage.

As stated previously, fishery statistics did not separate clam landings into species until 1951, and it is only since then there has been a true picture of littleneck landings. Prior to this, there is frequent mention in the statistics of clams being sold fresh and undoubtedly a portion of this catch was littlenecks. In 1912 and 1913, Thompson reported littlenecks were widely used, but most commercial digging was in Burrard Inlet with some on Vancouver Island, and the catch was sold mainly in Vancouver and Victoria. An active fishery for littlenecks has continued to the present on the south coast.

From 1941–51 some statistics were kept by investigators at the Fisheries Research Board of Canada Biological Station at Nanaimo, and these show combined landings of both littleneck and Manila clams (Table 18). Landed weight was about 200,000 lb in 1941–42 and rose to a high of 842,043 lb in 1949–50. No indication is given of the origin of the landings. The catch per man tide in 1941 was 130 lb; in 1942, 128 lb; in 1943, 153 lb; in 1944, 127 lb; and in 1945, 184 lb.

Catches of littlenecks since 1951 are shown in Tables 8 and 9, and with four exceptions, littlenecks accounted for less than 10 % of the total clam catch. Actual landings are probably slightly higher than shown in the tables since mixed clam figures (Table 8) combine littleneck and Manila clams. The catch of littlenecks decreased from the high of 521,900 lb in 1951 to a mere 21,300 lb in 1957, but since then has increased steadily to over 200,000 lb.

Since 1963 the entire littleneck catch has originated in District 3 (Table 9); prior to this some landings came from District 1. Although no commercial landings have been made from District 2, they are common here and are consumed locally. The reason for lack of commercial landings is that it is not economic to ship littlenecks so far from the major markets. This is an area where clam productivity might be increased.

Table 19 shows the source of the catch since 1951. Most came from the Strait of Georgia, Areas 15–18 (Fig. 17). The Victoria area (Area 19) has also been a consistent producer since 1951, and in recent years the Sooke and Barkley Sound regions (Areas 20 and 23) have produced significant quantities.

Although the Alert Bay area (Area 12) has been a major producer of butter clams, few littlenecks have been landed although they are abundant in the region. As in District 2, the area is too far from the urban markets.

Until recently all littleneck landings were made from November 1 to April 30, and mostly during February and March (Table 20). This was because digging was not permitted from May 1 to October 30. The closed season was rescinded in 1966 and moderate commercial landings of littlenecks are now made during the summer months as the market is usually strong then.

### REGULATIONS

The only regulation now governing the taking of littleneck clams in the commercial fishery is the minimum legal-size limit of 1½ inches shell length. There are no restrictions in the recreational fishery.

### SUMMARY

At present virtually all littleneck clam landings come from the southern part of District 3.

TABLE 19. Annual landings in pounds of littleneck clams in the areas of statistical Districts 1 and 3, British Columbia, 1951–69. (No commercial landings have been recorded from Areas 11, 22, 25, 27, and 29.)

| | South Coast (District 3) | | | | | | | | | | | | | Fraser Area (District 1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 23 | 24 | 26 | 28 |
| 1951 | 300 | 14,300 | 100 | 184,200 | 72,100 | 95,700 | 100,800 | 15,100 | 200 | – | – | – | – | 39,100 |
| 1952 | 9,900 | 52,700 | – | 79,300 | 115,500 | 74,700 | 128,900 | 3,700 | – | – | – | – | – | 28,600 |
| 1953 | 8,200 | 5,400 | 2,600 | 27,700 | 50,200 | 93,100 | 72,000 | 14,700 | – | – | – | 500 | – | 34,400 |
| 1954 | – | – | – | 3,600 | 50,600 | 32,400 | 23,800 | 23,400 | – | – | 900 | – | – | 9,800 |
| 1955 | – | 200 | – | 900 | 53,600 | 3,500 | 1,000 | 3,900 | – | – | – | – | – | 17,100 |
| 1956 | – | 2,000 | – | 1,500 | 17,700 | 1,300 | – | – | – | – | – | – | – | 8,900 |
| 1957 | 100 | 4,000 | – | – | 4,100 | 2,700 | 100 | 3,500 | – | – | – | – | – | 6,800 |
| 1958 | – | – | – | – | 300 | 10,300 | 1,100 | 20,100 | – | – | – | – | – | 8,000 |
| 1959 | – | – | – | – | 200 | 22,100 | 1,600 | 18,100 | 100 | – | – | – | – | 5,400 |
| 1960 | – | – | 800 | – | 14,300 | 9,200 | 31,600 | 32,900 | 100 | – | – | – | – | 1,200 |
| 1961 | – | 19,200 | – | 2,400 | 26,100 | 15,800 | 800 | 36,600 | 1,100 | – | – | – | – | – |
| 1962 | 3,800 | – | 1,800 | 2,600 | 6,300 | 33,300 | 98,300 | 43,000 | 12,700 | – | – | – | – | 100 |
| 1963 | 1,000 | – | – | 1,900 | 8,700 | 4,600 | 32,200 | 51,800 | 29,500 | – | – | – | 1,100 | – |
| 1964 | 10,900 | 2,100 | 12,700 | 2,300 | 30,000 | 14,600 | 5,200 | 15,100 | 28,400 | – | 31,400 | – | – | – |
| 1965 | 3,300 | 700 | 4,500 | – | 26,500 | 5,600 | 9,500 | 26,400 | 22,100 | – | 82,700 | – | – | – |
| 1966 | – | – | 2,400 | – | 29,000 | 24,700 | 7,500 | 8,900 | 36,800 | – | 120,500 | 2,300 | – | – |
| 1967 | – | 1,400 | 24,400 | – | 23,200 | 61,400 | 8,600 | 46,400 | 32,200 | 300 | 108,000 | – | – | – |
| 1968 | 1,400 | 8,800 | 20,800 | – | 800 | 43,600 | 50,800 | 16,800 | 32,200 | – | 25,300 | – | – | – |
| 1969 | 3,700 | 20,400 | 27,000 | – | 100 | 109,500 | 20,600 | 3,600 | 47,600 | – | 700 | 2,700 | – | – |

TABLE 20. Monthly landings of littleneck clams in pounds in statistical Districts 1 and 3, British Columbia, 1951–69.

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Fraser Area* (*District 1*) | | | | | | | |
| 1951 | 5,100 | 3,200 | 4,400 | 9,800 | 11,500 | – | – | – | – | 800 | 1,400 | 2,900 |
| 1952 | 900 | 1,400 | 1,400 | 12,500 | 9,300 | – | – | – | – | – | 2,400 | 700 |
| 1953 | 300 | 300 | 2,300 | 11,200 | 17,200 | – | – | – | – | – | 2,400 | 700 |
| 1954 | 300 | 1,800 | 300 | 2,300 | 3,500 | 1,400 | – | – | – | – | 100 | 100 |
| 1955 | 100 | 300 | 1,900 | 4,600 | 4,100 | 4,600 | – | – | – | – | 400 | 1,100 |
| 1956 | 700 | 300 | 500 | 1,300 | 5,100 | – | – | – | – | – | 800 | 200 |
| 1957 | 1,400 | 300 | 900 | 1,200 | 2,300 | 100 | – | – | – | – | 400 | 200 |
| 1958 | 800 | 200 | 200 | 2,300 | 3,500 | – | – | – | – | – | 1,000 | – |
| 1959 | 100 | 100 | 400 | 600 | 3,900 | – | – | – | – | – | – | 300 |
| 1960 | 100 | – | 100 | – | 1,000 | – | – | – | – | – | – | – |
| 1961 | – | – | – | – | – | – | – | – | – | – | – | – |
| 1962 | – | – | – | – | 100 | – | – | – | – | – | – | – |
| 1963–69 | No landings | | – | – | – | – | – | – | – | – | – | – |
| | | | | | *South Coast* (*District 3*) | | | | | | | |
| 1951 | 49,700 | 42,800 | 76,400 | 168,300 | 111,700 | – | – | – | 500 | 500 | 15,200 | 17,700 |
| 1952 | 35,100 | 60,900 | 93,800 | 156,900 | 72,100 | – | – | – | – | – | 18,900 | 27,000 |
| 1953 | 39,300 | 33,200 | 25,300 | 73,100 | 76,900 | – | – | – | – | – | 4,000 | 22,600 |
| 1954 | 9,800 | 20,200 | 28,200 | 33,500 | 29,700 | – | – | – | – | 1,000 | 3,700 | 8,600 |
| 1955 | 12,100 | 3,900 | 14,800 | 22,300 | 3,900 | 4,000 | – | – | – | – | – | 2,100 |
| 1956 | 1,500 | 700 | 2,200 | 7,300 | 4,300 | – | – | – | – | – | 5,400 | 1,100 |
| 1957 | 200 | 6,000 | 4,300 | 1,600 | 1,400 | – | – | – | – | – | – | 1,000 |
| 1958 | 3,900 | 10,300 | 5,800 | 4,900 | – | – | – | – | – | – | 3,000 | 3,900 |
| 1959 | 5,800 | 6,200 | 5,200 | 17,000 | 100 | – | – | – | – | – | 3,900 | 3,900 |
| 1960 | 15,800 | 31,100 | 8,900 | 9,300 | 4,100 | – | – | – | – | – | 7,400 | 12,300 |
| 1961 | 6,200 | 10,000 | 8,000 | 23,000 | 12,200 | – | – | – | – | 1,300 | 14,900 | 26,400 |
| 1962 | 12,800 | 62,900 | 11,600 | 15,000 | 54,600 | – | – | – | – | 900 | 11,900 | 32,100 |
| 1963 | 29,000 | 24,700 | 21,300 | 18,200 | 8,100 | – | – | – | – | 3,900 | 6,700 | 18.800 |
| 1964 | 11,600 | 17,000 | 30,200 | 24,400 | 13,400 | – | – | – | – | – | 22,000 | 34,100 |
| 1965 | 23,100 | 26,200 | 26,600 | 64,800 | 25,100 | 1,700 | – | – | – | – | 5,800 | 8,000 |
| 1966 | 9,800 | 12,800 | 28,500 | 55,100 | 23,200 | – | – | – | – | 1,800 | 62,100 | 38,800 |
| 1967 | 35,600 | 39,100 | 39,700 | 54,500 | 70,300 | 4,300 | 5,700 | 10,400 | 2,800 | 7,900 | 16,500 | 19,100 |
| 1968 | 11,900 | 25,400 | 17,600 | 49,300 | 18,300 | 20,800 | 10,300 | 15,000 | 6 500 | 6,400 | 17,200 | 1,800 |
| 1969 | 6,700 | 16.300 | 33,900 | 37.500 | 23,200 | 26,900 | 20,000 | 21,900 | 17,300 | 19,000 | 9,400 | 3,800 |

With better handling and cheaper transportation methods, landings from the entire district are possible, and an annual yield of 500,000 lb could probably be sustained. This yield could be doubled if littlenecks from District 2 could be marketed economically.

## Manila Clam

### BIOLOGY

Manila clams, *Venerupis japonica* (Fig. 35), sometimes called Japanese littlenecks, are similar in appearance to native littleneck clams, but the valves are longer than high so the clam has a distinct oblong shape. The valves are heavy with radiating ribs and less prominent concentric ridges. The external colour varies from greyish-white, through yellowish-buff to brown, often with geometric patterns of black and white in the young. The internal surface is smooth and yellowish-white with deep purple at the posterior end. The internal ventral margin of the shell is smooth, distinct from the crenulated margin of native littlenecks. The external hinge ligament is prominent and a lunule is present. The tip of the siphon is split.

Manila clams are native to Japan between latitudes 25° and 45°N. They were accidentally introduced with Japanese oyster seed and were first recorded in Ladysmith Harbour in 1936. The clam spread rapidly and by 1941 it was the dominant clam in Departure Bay. At present it occurs throughout the Strait of Georgia but has not been taken north of Seymour Narrows or the Yuculta Rapids. On the west coast of Vancouver Island it has spread northward from Barkley Sound, around Brooks Peninsula to Quatsino Sound, 50°30′N lat, 128°00′W long. The present distribution on the west coast of North America is from San Francisco Bay north to just beyond 50°N lat.

In 1962 an attempt was made to introduce this species into Naden Harbour and Masset Inlet in the Queen Charlotte Islands. Although there was survival, growth was slow, and the clam apparently did not breed, probably because of low water temperatures.

Manila clams occur from about the 3-ft tide level to well above the half tide level on protected mud-gravel beaches, and have proven to be an advantageous introduction because they do not compete for space with littleneck or butter clams. They live just under the surface and because of this and their position well up the intertidal beach, they are susceptible to cold winter temperatures that cause significant mortalities. Subtidal populations are unknown in British Columbia.

*Fig. 35. Manila clam,* Venerupis japonica.

The sexes are separate and spawning occurs in late spring, although some spawning may continue throughout the summer. The larval period is approximately 3 weeks. Umboned larvae may be distinguished by shape of the valves, which are yellowish-orange but not as deep in colour as native littlenecks. Growth is relatively slow due to the high beach position that reduces feeding time. Clams entering the fishery at 1½ inches are about 3 or 4 years old (Fig. 36).

### FISHERY

Manila clams may be dug in the same manner as butter and littleneck clams. However, as they are just below the surface, diggers frequently use ordinary short-tined garden rakes. The rakes are pulled through the soil and the clams turned out. The clams are gathered,

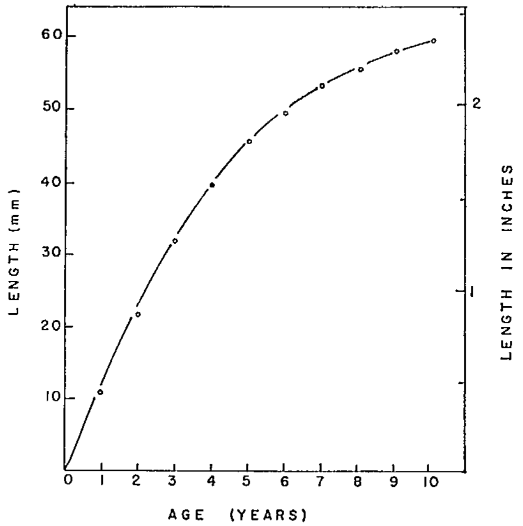



*Fig. 36. Growth rate of Manila clams from the Strait of Georgia area, B.C.*

sacked, and usually marketed fresh along with littlenecks.

Manila clams were first reported in the commercial catch in 1941 but, as indicated previously, catch statistics from 1941 to 1951 did not separate landings of littleneck and Manila clams (Table 18). Landings of Manila clams since 1951 are shown in Tables 8 and 9. Generally, Manila clam landings have accounted for less than 10 % of the annual clam catch. The true figures are slightly higher than shown as the mixed clam figures (Table 8) are combined littleneck and Manila clams. The catch increased to a high of 456,000 lb in 1955 and then steadily declined. Since 1960, the catch increased steadily to over 200,000 lb annually, but dropped below this figure in 1969.

The entire Manila clam catch comes from District 3 (Table 21). Largest landings originate from southern Strait of Georgia, in Areas 17 and 18. From 1951 to 1957 consistent landings came from Areas 15 and 16. Recently the Sooke and Barkley Sound regions (Areas 20 and 23) have produced significant quantities of Manila clams.

Until recently, landings of Manila clams were made from November 1 to April 30, mostly in February and March (Table 22). However, with the present year-round open season, Manila clams are dug throughout the year.

REGULATIONS

The only regulation governing the taking of Manila clams in the commercial fishery is the minimum legal-size limit of 1½ inches shell length. There are no restrictions in the recreational fishery.

SUMMARY

Manila clams spread rapidly throughout the southern coast, but it is doubtful if they will spread much farther in the province because water temperatures are probably too low to permit successful breeding. Landings will be restricted to District 3, but an annual sustained yield of 500,000 lb is quite possible.

## Razor Clam

BIOLOGY

Razor clams, *Siliqua patula* (Fig. 37) are local in occurrence, distinctive in appearance, and unlike any other clam along the coast. The valves are thin and brittle, long and rather narrow in shape, and may measure up to 7 inches in length. The shell is covered with an olive-green to dark brown shiny covering (the periostracum), which may be worn off in the umbonal region of older animals. The interior is glossy white, often with a tinge of purple along the margin, with a prominent rib extending from the umbone to the ventral margin.

Razor clams range from Pismo Beach, California, to the Aleutian Islands. In British Columbia they occur in concentration at two localities; Long Beach between Clayoquot and Barkley sounds on the west coast of Vancouver Island, and on the northeast coast of Graham Island (Queen Charlotte Islands) from Masset to Rose Spit. Small populations also occur on beaches in three other areas; the west coast of Graham Island, Rose Spit to Cape Ball, and on the west coast of Calvert Island.

This species requires surf-swept sand beaches and is usually found standing vertically just below the surface in the upper 10 inches of the sand with the hinge towards the surf. They have a prominent muscular foot and are able to rapidly dig vertically in the sand; down to depths of 2 ft within a minute. If left on the surface of the beach they will quickly reburrow.

TABLE 21. Annual landings in pounds of Manila clams in the areas of statistical District 3 (South Coast), British Columbia, 1951–69. (No commercial landings have been recorded from Areas 11, 21, 22, 24, 25, 26, and 27.)

| Year | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | – | 1,700 | – | 5,000 | 18,500 | 147,200 | 6,500 | – | – | – |
| 1952 | – | – | – | 1,300 | 1,800 | 338,800 | 64,000 | – | – | – |
| 1953 | – | – | – | – | 800 | 331,800 | 51,500 | 3,700 | – | – |
| 1954 | – | – | – | 9,400 | 5,100 | 355,400 | 80,100 | – | – | – |
| 1955 | – | 400 | 16,900 | 6,600 | 16,500 | 257,800 | 157,800 | – | – | – |
| 1956 | – | 12,100 | – | 32,100 | 700 | 157,000 | 16,400 | – | – | – |
| 1957 | – | – | – | 7,500 | 9.000 | 38,100 | 8,600 | – | – | – |
| 1958 | – | – | – | – | – | 12,100 | 20,500 | – | – | – |
| 1959 | – | – | – | – | – | 42,200 | 7,400 | – | 5,000 | – |
| 1960 | – | – | – | – | – | 7,700 | 1,600 | 1,100 | 3,500 | – |
| 1961 | – | – | – | – | 700 | 95,900 | 2,600 | 600 | 6,000 | – |
| 1962 | 600 | – | – | – | 1,200 | 84,100 | 25,000 | – | 42,000 | – |
| 1963 | – | – | – | – | – | 6,800 | 94,600 | 100 | 28,900 | – |
| 1964 | – | – | – | 600 | – | 14,000 | 18,400 | 200 | 17,700 | 7,100 |
| 1965 | – | – | – | – | – | 3,000 | 85,300 | – | 2,200 | 123,100 |
| 1966 | – | – | – | – | – | 6,800 | 22,300 | 900 | 17,900 | 280,800 |
| 1967 | – | 37,200 | – | – | – | 30,900 | 59,500 | 17,700 | 6,900 | 50,600 |
| 1968 | – | 91,800 | – | 16,100 | – | 78,300 | 40,700 | 400 | 64,500 | 69,100 |
| 1969 | 100 | 14,300 | 300 | – | – | 32,100 | 36,100 | – | 78,400 | 16.600 |

TABLE 22. Monthly landings of Manila clams in pounds in statistical District 3 (South Coast), British Columbia, 1951–69.

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | – | – | 2,600 | 16,200 | 151,400 | 1,400 | – | – | – | – | 1,100 | 6,100 |
| 1952 | 100 | 4,800 | 52,000 | 102,400 | 246,600 | – | – | – | – | – | – | – |
| 1953 | 100 | 36,600 | 134,300 | 126,100 | 67,200 | – | – | – | – | – | 2,600 | 20,800 |
| 1954 | 13,200 | 46,100 | 116,400 | 94,100 | 161,900 | 15,600 | – | – | – | – | – | 2,700 |
| 1955 | 14,400 | 20,500 | 66,900 | 142,100 | 201,200 | 7,200 | – | – | – | – | 400 | 3,300 |
| 1956 | 6,700 | 21,600 | 38,600 | 61,000 | 90,400 | – | – | – | – | – | – | – |
| 1957 | – | 500 | 19,700 | 40,100 | 2,900 | – | – | – | – | – | – | – |
| 1958 | – | 2,300 | 7,700 | 16,700 | 5,500 | – | – | – | – | – | 400 | – |
| 1959 | – | 500 | 36,100 | – | 17,200 | 800 | – | – | – | – | – | – |
| 1960 | 1,600 | 1,100 | – | 5,000 | 5,500 | 700 | – | – | – | – | – | – |
| 1961 | 400 | – | 500 | 40,300 | 60,900 | – | – | – | – | – | 3,700 | – |
| 1962 | – | 400 | 31,000 | 52,100 | 64,300 | – | – | – | – | 100 | 5,000 | – |
| 1963 | 1,500 | 2,400 | 25,200 | 59,900 | 36,100 | – | – | – | – | 100 | 4,600 | 600 |
| 1964 | 3,800 | 9,500 | 11,900 | 18,400 | 2,800 | – | – | – | – | – | 8,300 | 3,300 |
| 1965 | 26,300 | 33,200 | 47,900 | 35,000 | 23,000 | 1,800 | – | – | – | – | 24,700 | 21,700 |
| 1966 | 83,100 | 97,200 | 67,900 | 59,700 | 11,100 | – | – | – | – | 300 | 4,300 | 5,100 |
| 1967 | 5,200 | 14,600 | 25,900 | 48,100 | 19,700 | 8,500 | 7,200 | 10,600 | 28,900 | 21,200 | 9,500 | 3,400 |
| 1968 | 7,300 | 17,900 | 47,200 | 129,600 | 41,100 | 25,100 | 28,600 | 21,900 | 19,500 | 7,700 | 8,700 | 6,300 |
| 1969 | – | 800 | 17,500 | 19,200 | 40,400 | 21,500 | 29,600 | 25,200 | 9,300 | 11,800 | 1,600 | 1,000 |

*Fig. 37. Razor clam,* Siliqua patula.

Razor clams are found from the mid-beach region to subtidal depths of 60 ft. In 1966 and 1967 the commercial clam population was assessed on the Masset beaches (Fig. 38). Tagged clams were planted in transects on North and South beaches, and the population was calculated from the ratio of tagged to nontagged recoveries when the transects were re-dug on three successive occasions. A summary of the results is shown in Table 23. The average clam density for the lower half of North Beach was slightly higher than South Beach (2.39 clams per square yard compared to 1.86 clams per square yard). However, on both beaches clams were more plentiful closer to the low waterline than at higher levels. The total population of commercial-sized razor clams in the lower half of North and South beaches was 13.51 million clams of which 72 % (9.71 million) was in the lowest 200-ft strip of beach.

Subtidal populations may be fairly extensive. Numerous siphons show in 1–3 ft of water below the zero tide line, and have been observed in 30 ft of water off North Beach by scuba divers. Crab fishermen have reported razor clams in traps in 60 ft of water in the same area.

No population estimates have been made of razor clams at Long Beach but it is more variable than at Masset, and is dependent on dominant year-classes. This means that successful

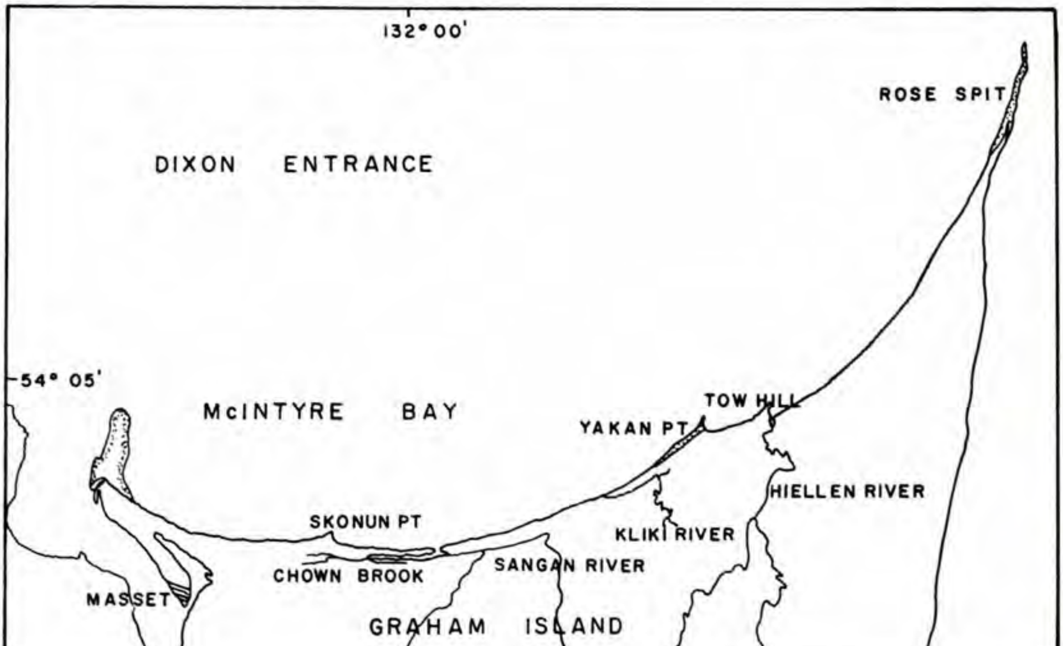



*Fig. 38. Northeast part of Graham Island, Queen Charlotte Islands, showing location of the Masset beaches. South Beach extends from Skonun Point to Yakan Point; Horseshoe Beach from Yakan Point to Tow Hill; and North Beach from Tow Hill to Rose Spit.*

breeding occurs at infrequent intervals and these have been as long as 10 years.

The sexes are separate, and spawning at Masset, as determined from histological sections, occurs in July. Evidence shows that spawning may occur slightly earlier on South Beach than North Beach. Some spawning apparently must take place prior to July, probably as early as mid-May because clams measuring ¼ inch in length have been found in July, and by winter they have reached ¾ inch.

Growth rate is faster on North Beach and more rapid closer to the water than farther up the beach (Fig. 39). Clams in the lowest part of North Beach enter the fishery at 3½ inches when slightly under 3 years old, while in other locations at 3 years or slightly older.

Growth at Long Beach is more rapid than at Masset and clams enter this fishery when 1½ years old (Fig. 40).

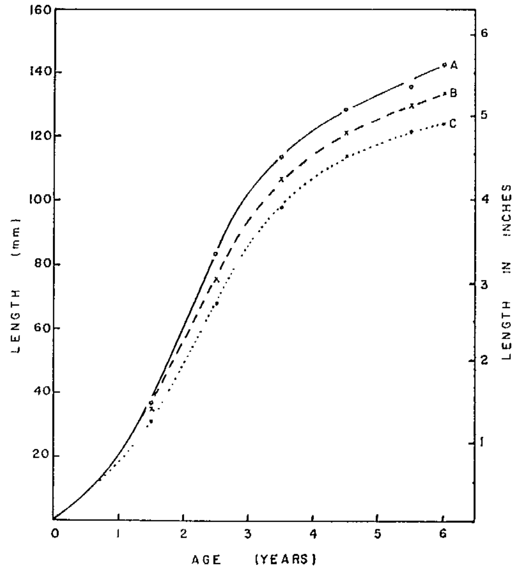



*Fig. 39. Growth rates of razor clams from three different intertidal beach levels on North Beach, Masset. A, near the low tide line; B, 200–400 ft above the low tide line; C, 400–600 ft above the low tide line.*

TABLE 23. Estimated population of razor clams on North and South beaches, Masset, Queen Charlotte Islands, B.C., 1967.

| | Calculated clam density | | Total | |
|---|---|---|---|---|
| | Mean no./yd$^2$ | Mean lb/yd$^2$ | No. (*millions*) | Weight (*'000 lb*) |
| North Beach | | | | |
| Lower half | 2.39 | 0.53 | 7.59 | 1696 |
| Lowest 61 m | 5.85 | 1.36 | 6.19 | 1442 |
| South Beach | | | | |
| Lower half | 1.86 | 0.29 | 5.92 | 935 |
| Lowest 61 m | 3.33 | 0.52 | 3.52 | 545 |

FISHERY

Razor clams are dug individually (pinpoint digging), not randomly, as are hard-shell clams. When disturbed they frequently produce a "show" on the surface of the sand (Fig. 41). The number of shows produced depends on several factors, such as weather, state of the tide, amount of surf, and are usually more numerous on hot, dry days than on cold, wet ones. Diggers try to make clams produce shows by stomping on the beach. Trucks have been driven back and forth over the beach to stimulate the clams to show.

Razor clams are dug with a shovel called a "clam gun," which varies slightly in size and shape according to individual preference. The thin blade, which may be straight or curved, is

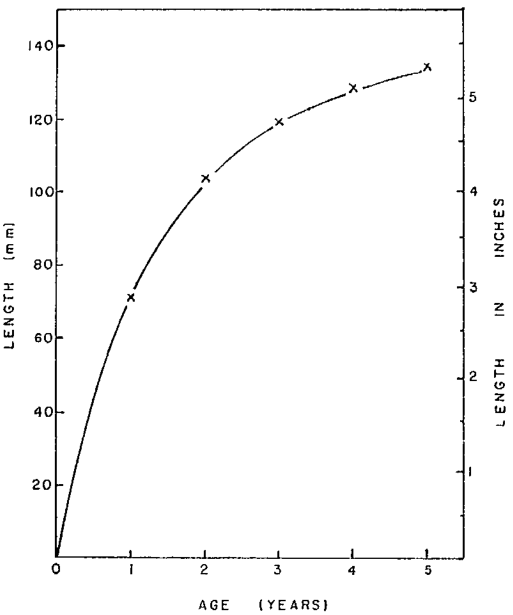
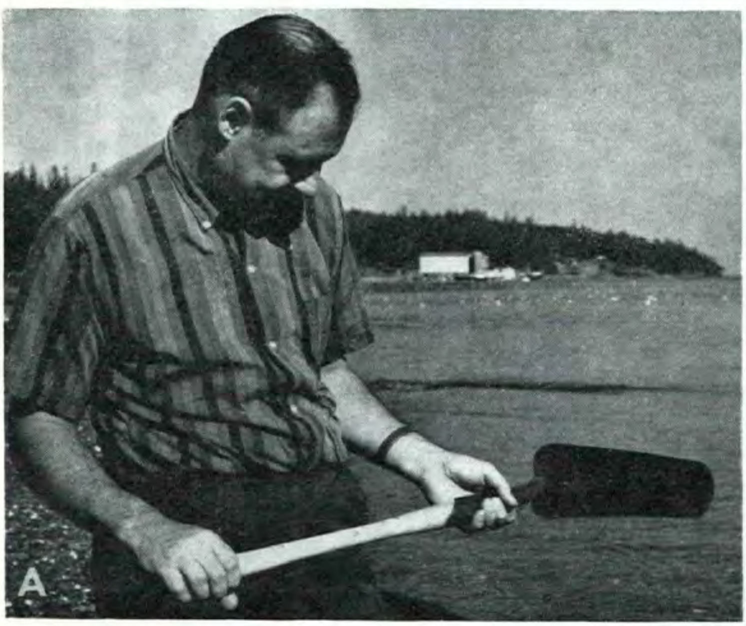



*Fig. 40. Growth rate of razor clams at Long Beach, Vancouver Island.*

*Fig. 41. Razor clam "show."*



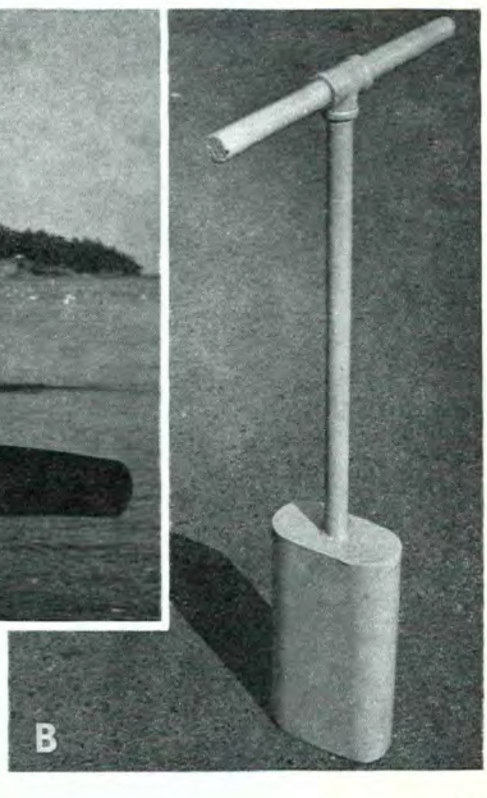




*Fig. 42. Tools used to dig razor clams; A, razor clam shovel; B, sandpiper.*

*Fig. 43. Razor clam digger with drag attached to his waist.*

TABLE 24. Landings of razor clams in pounds in British Columbia as recorded from various sources, 1923–50.

| Year | Dep. of Fisheries statistics: Cases | Dep. of Fisheries statistics: Round weight (*lb*) | British Columbia Prov. Biologist rep. | Data recorded at Biological Station | Best estimate |
|---|---|---|---|---|---|
| 1923 | (247 bl) | 49,400 | | | 49,400 |
| 1924 | 5,000 | 400,000 | | | 400,000 |
| 1925 | 13,131 | 1,669,080 | | | 1,669,080 |
| 1926 | 4,461 | 356,880 | | | 356,880 |
| 1927 | 2,400 | 192,000 | | | 192,000 |
| 1928 | 4,663 | 373,040 | | | 373,040 |
| 1929 | 3,370 | 269,600 | | | 269,600 |
| 1930 | 10,857 | 868,560 | | | 868,560 |
| 1931 | 4,283 | 342,640 | | | 342,640 |
| 1932 | 4,227 | 338,160 | | | 338,160 |
| 1933–37 | No landings | | | | |
| 1938 | – | 955,000 | | | 955,000 |
| 1939–41 | No landings | | | | |
| 1942 | – | 556,800 | 590,200 | 590,200 | 590,200 |
| 1943 | – | 412,500 | 389,825 | 389,825 | 389,825 |
| 1944 | – | 344,100 | 298,400 | 298,400 | 298,400 |
| 1945 | – | 138,900 | 144,860 | 144,860 | 144,860 |
| 1946 | – | 216,577 | 216,577 | 216,577 | 216,577 |
| 1947 | – | – | 98,296 | 98,296 | 98,296 |
| 1948 | – | – | – | – | – |
| 1949 | – | – | 229,559 | 229,559 | 229,559 |
| 1950 | – | – | 352,358 | 176,179 | 352,358 |

3–5 inches wide and 10–14 inches long (Fig. 42A). With the shovel a small wedge of sand is removed seaward of a "show" to expose the siphon that is quickly grasped and the clam removed. Care must be taken not to tilt the shovel too far or the shell will be broken. If the clam is not caught on the first attempt, commercial diggers move to another show since the clam rapidly burrows beyond reach. Clams are put into boxes or sacks (drags) attached to the waist (Fig. 43); if left for long on the sand they will quickly reburrow. The number dug depends partly on skill and partly on whether the clams are "showing" well, but an experienced digger can consistently dig 200–300 lb of clams per tide of 4 hr.

The "sandpiper" (Fig. 42B) is also used to dig clams, particularly by amateur diggers.

A pilot plant canning operation was undertaken at Tow Hill near Masset (Fig. 39) in 1923 and, encouraged by the results, a commercial fishery and canning operation began in 1924. In that year 5000 cases (49,700 lb of whole clams) were processed. Landings of razor clams since 1923 are shown in Tables 8, 9, and 24.

Production increased rapidly to a high of 1.6 million lb in 1925 and then dropped sharply. Highs of 0.87 and 0.95 million lb were landed in 1930 and 1938. Since 1951, the catch has been less than 10 % of the total clam catch and usually below 5 %. Although landings have been made in most months of the year, the major part of the catch has been taken from March to June (Table 25). Recently landings have been well below 200,000 lb due mainly to a lack of diggers to ensure a steady and adequate supply of clams.

In the mid 1940's, there was an attempt to study fluctuations in the clam population and production by comparing the catch per unit of effort over 5 years. (Catch per unit of effort was expressed as average catch per man tide.) Results from 1943 to 1947 are shown in Table 26.

Although high landings had been experienced prior to 1943, the razor clam population at the beginning of the experiment must have been relatively low as shown by the low initial catch per man tide. Furthermore, since there had been little exploitation during the previous 9 years, it must be concluded that recruitment during this period must have been slight. Most of the production in the experiment came from North Beach although the catch per unit of effort was generally higher on South Beach. It was considered that the continued reduction in catch per man tide was not due to variations in meteorological conditions or the efficiency of the diggers, but represented a real reduction in the population of legal-sized clams. This can only be attributed to fishing pressure during the 5-year period when the low recruitment of previous years continued. Unfortunately, the study was discontinued and in recent years the fishery has been so small that adequate data have not been available for further study. Recovery of the population was shown by a catch of 104 lb per man tide in 1951.

The small commercial landings of razor clams made at Long Beach have all been used for crab bait. There is now a fairly active sports fishery on this beach.

#### REGULATIONS

Formerly some of the Masset beaches were held as clam leases by the cannery, but in 1968 they lapsed and the beaches are now open. The only regulation governing the taking of razor clams at present in the commercial fishery is a minimum shell length of 3½ inches. The size limit has been rescinded in the recreational fishery but there is a daily bag limit at Long Beach on the west coast of Vancouver Island.

#### SUMMARY

Razor clam beaches in British Columbia are few and the commercial fishery will be confined to the Masset beaches. Population estimates undertaken in 1967 indicate an annual yield of ¾–1 million lb can probably be sustained here. However, to attain this yield some type of mechanical harvester will undoubtedly have to be used.

## Cockle

#### BIOLOGY

The cockle *Clinocardium nuttalli* (Fig. 44) is a common bivalve along the coast of British Columbia with a distinctive appearance. The valves are heavy, more or less triangular in shape, and may be up to 5 inches in length. There are about 37 prominent radiating ridges

TABLE 25. Monthly landings of razor clams in pounds in statistical District 2 (North Coast), British Columbia, 1951–69.

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | – | – | 7,300 | 79,000 | 41,600 | 7,400 | – | – | – | – | – | – |
| 1952 | – | – | 32,100 | 51,600 | 41,800 | – | – | – | – | – | – | – |
| 1953 | – | – | 13,100 | 84,300 | 34 400 | – | 13,600 | 6,300 | 2,800 | – | – | – |
| 1954 | 5,100 | – | 22,600 | 119,800 | 92,700 | 9,100 | 8,300 | 10,800 | – | 3,400 | – | – |
| 1955 | – | – | 28,400 | 94,600 | 62,900 | 12,300 | 9,400 | 10,700 | – | – | – | – |
| 1956 | – | – | 56,100 | 84,700 | 75,400 | 6,700 | 8,500 | 800 | 6,300 | – | – | – |
| 1957 | – | – | 32,400 | 67,300 | 46,600 | 38,600 | – | – | – | – | – | – |
| 1958 | – | – | 38,900 | 95,700 | 19,200 | 7,600 | – | – | – | – | 3,000 | – |
| 1959 | – | – | 37,600 | 100,800 | 35,800 | 11,000 | 13,000 | 900 | 200 | 200 | – | – |
| 1960 | – | – | 27,000 | 43,500 | 57,500 | 68,600 | 23,600 | – | 1,400 | 200 | – | – |
| 1961 | 400 | 700 | 10,100 | 86,500 | 63,900 | 66,300 | 100 | 1,100 | 200 | – | – | – |
| 1962 | – | 3,300 | 3,200 | 119,600 | 19,600 | 4,600 | 13,100 | 5,400 | – | – | – | – |
| 1963 | – | 400 | 13,900 | 72,400 | 44,100 | 4,900 | 4,400 | 5,800 | 700 | 500 | – | – |
| 1964 | 700 | – | 7,500 | 3,500 | 74,100 | 18,300 | 2,300 | – | – | – | – | – |
| 1965 | – | – | 3,200 | 49,200 | 30,000 | 40,900 | 26,400 | 400 | – | – | – | – |
| 1966 | – | – | – | 4,300 | 38,200 | 32,700 | 1,500 | – | – | – | – | – |
| 1967 | – | – | 8,500 | 69,900 | 24,000 | – | – | – | – | – | – | – |
| 1968 | – | – | 5,800 | 6,300 | 10,600 | 3,500 | – | – | – | – | – | – |
| 1969 | – | – | 1,100 | 9,900 | 6,800 | – | – | – | – | – | – | – |

TABLE 26. Production and effort in the razor clam fishery on the three Masset beaches, 1943–47 (m-t, number of man tides; Prod., production of clams in pounds; avg, average catch per man tide.)

| | North Beach | | | Horseshoe Beach | | | South Beach | | | All beaches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | m-t | Prod. | Avg | m-t | Prod. | Avg | m-t | Prod. | Avg | m-t | Prod. | Avg |
| 1943 | 1,518 | 118,400 | 78.0 | 806 | 83,350 | 102.2 | 1,631 | 189,075 | 115.9 | 3,955 | 389,825 | 98.6 |
| 1944 | 2,661 | 147,300 | 55.4 | 458 | 30,450 | 66.5 | 1,303 | 120,650 | 92.9 | 4,422 | 298,400 | 67.5 |
| 1945 | 1,787 | 104,675 | 58.5 | 173 | 8,803 | 50.9 | 518 | 31,382 | 60.6 | 2,478 | 144,860 | 58.5 |
| 1946 | 2,507 | 146,769 | 58.5 | 308 | 18,833 | 61.1 | 775 | 50,975 | 65.8 | 3,590 | 216,577 | 60.3 |
| 1947 | 1,799 | 85,245 | 47.4 | 109 | 4,462 | 40.9 | 282 | 8,589 | 30.5 | 2,190 | 98,296 | 44.9 |

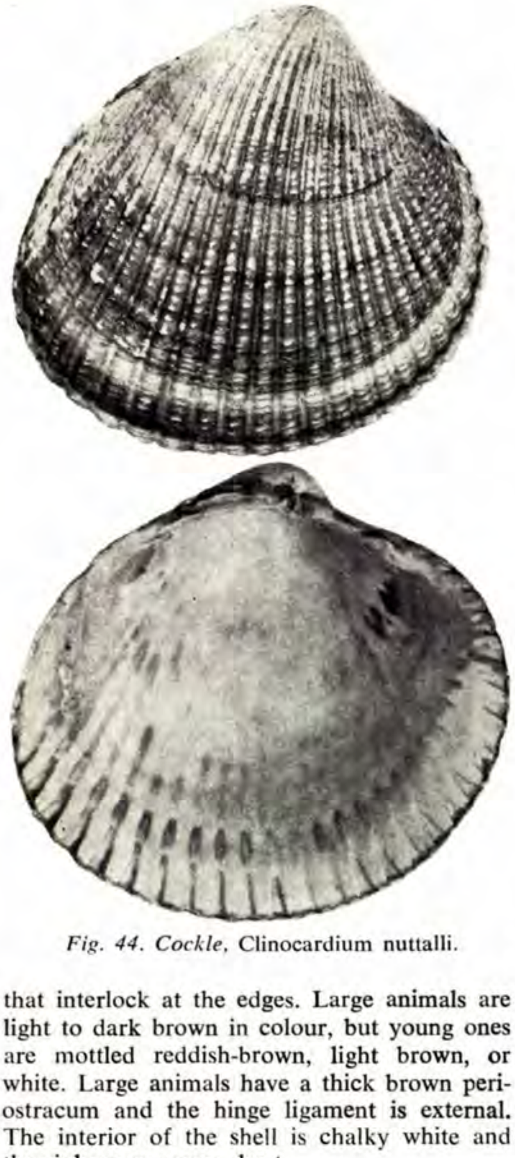


*Fig. 44. Cockle,* Clinocardium nuttalli.

that interlock at the edges. Large animals are light to dark brown in colour, but young ones are mottled reddish-brown, light brown, or white. Large animals have a thick brown periostracum and the hinge ligament is external. The interior of the shell is chalky white and the siphons are very short.

Cockles occur from southern California to the Bering Sea and are widely distributed in British Columbia but nowhere are they abundant. They inhabit sand-mud soil and often live in beds of eelgrass. Subtidal populations exist but are not extensive. The siphons are short and cockles are not buried deeply, frequently large animals are slightly exposed. They have a large muscular foot, are quite active, and can move horizontally. Short trails left by these molluscs may be seen on clam beaches.

Cockles are hermaphroditic and spawning takes place mainly in late spring but may extend over a fairly long period. In late July 1969, a strong year-class settled on Seal Island and measured about ¼ inch in shell length. A length of about ½ inch is reached during the first winter and about 3 inches after 4 years (Fig. 45). Cockles are sexually mature after 2 years and the life span is rarely beyond 7 years when they are about 4½ inches in length.

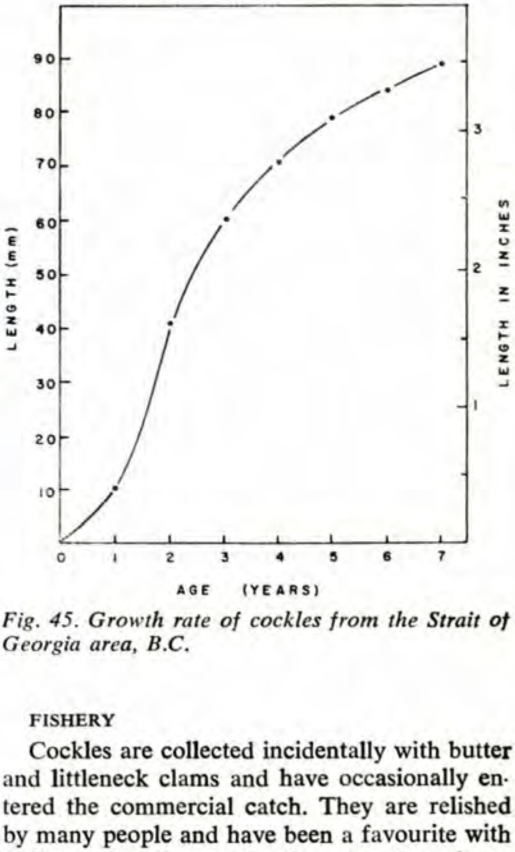



*Fig. 45. Growth rate of cockles from the Strait of Georgia area, B.C.*

FISHERY

Cockles are collected incidentally with butter and littleneck clams and have occasionally entered the commercial catch. They are relished by many people and have been a favourite with Indians who often prefer them to other clams. There is an intensive fishery for an allied species of cockle (*Cardium edule*) in Europe. European cockles are steamed but many are pickled and are available in British Columbia stores.

FUTURE USE

It is doubtful if cockles are abundant enough or the market suitably attractive to support a commercial fishery. Although the populations are limited, they are exploitable and could be marketed along with other species of clams, particularly if mechanical harvesters were used. The cockles could be minced and canned with other species.

Wider use of this clam could be made in the sports fishery.

## Horse Clams

BIOLOGY

Two species of horse clams (Fig. 46), *Tresus nuttalli* and *T. capax* occur in British Columbia. The former has a large shell up to 5–6 inches in length and 3 inches high. The umbones are displaced well to the anterior end with an upswept extended posterior region which gapes widely. The shell is white with fairly smooth concentric sculpture and varying amounts of brown to black periostracum which peels readily. The interior of the shell is sometimes chalky, sometimes nacreous. The external ligament is small but the internal platform (resilifer) is large and strong with a heavy brown resilium (internal elastic hinge ligament). The umbones are placed well to the anterior.

*Tresus capax* is similar in size to *T. nuttalli* but has nearly equilateral valves and the umbones are centrally located. The shell varies from thin and brittle to quite thick and heavy and the surface is usually much rougher than that of *T. nuttalli*. The habitats differ; *T. nuttalli* occurs in soils of almost pure sand while *T. capax* is found along with butter and littleneck clams in gravel-shell soils.

Other common names include summer clam, Washington clam, otter clam, and gaper. Both species are frequently mistaken for geoducks (*Panope generosa*).

Horse clams occur in the lower third of the tidal zone and burrow deeper than butter clams, down to about 18 inches, with *T. nuttalli* being found at greater depths than *T. capax*.

*Tresus nuttalli* is considered to be a summer spawner. Observations at Seal Island and plankton tows taken in the Strait of Georgia

*Fig. 46. Horse clams,* Tresus nuttalli *(above) and* Tresus capax *(below).*

show that *T. capax* spawns in late February or early March.

In 1968 an abundant year-class settled in several locations in the Strait of Georgia. In late June at Seal Island they had a shell length of ½ inch and by the end of the first winter, 1 inch. The growth rate of *T. capax* at Seal Island is shown in Fig. 47.

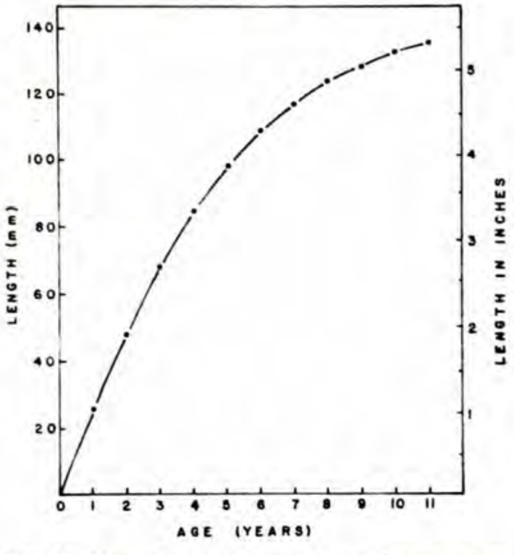



*Fig. 47. Growth rate of horse clams,* Tresus capax, *from the Strait of Georgia area, B.C.*

The genus, formerly known as *Schizothaerus,* occurs from Alaska to California. *Tresus nuttalli* may be found in localized sandy areas such as Rathtrevor Beach, Qualicum, and Clayoquot Sound, while *T. capax* has a much more general distribution.

Virtually all *T. capax,* even as small as 1 inch, have commensal pinnotherid crabs.

FISHERY

This clam is dug along with butter clams but at present it is discarded for it is not usually accepted by the canners. It is taken in the sports fishery in some parts of the United States and is used locally in British Columbia.

FUTURE USE

Horse clams have not been used commercially because fork digging usually breaks the shells. This causes the clam to lose water from within the shell and the meat dries rapidly. Also, because the valves gape, even unbroken clams do not keep well. However, with rapid transport now available and the ability to ship in ice, utilization is possible. Hydraulic diggers break very few shells and in some areas turn out considerable quantities of horse clams along with butter clams. The industry should consider the utilization of this species, which would increase the earnings of diggers. It would prevent waste, for adult horse clams have difficulty in digging back into the soil and become easy prey to fish and birds. There are problems in its use for although 25–30 % of the total weight is edible meat, the neck, which forms about 60 % of the body weight, requires special attention. It has a skin that may be removed after blanching, and because the neck is very muscular it is usually minced. However, it produces excellent white meat.

## Other Species

In addition to the species described in some detail there are other bivalves that are of marginal importance or have some future potential.

Probably the most important of these is the blue or bay mussel (*Mytilus edulis*) (Fig. 48), a species cultured extensively in Europe. It is used locally in British Columbia and limited

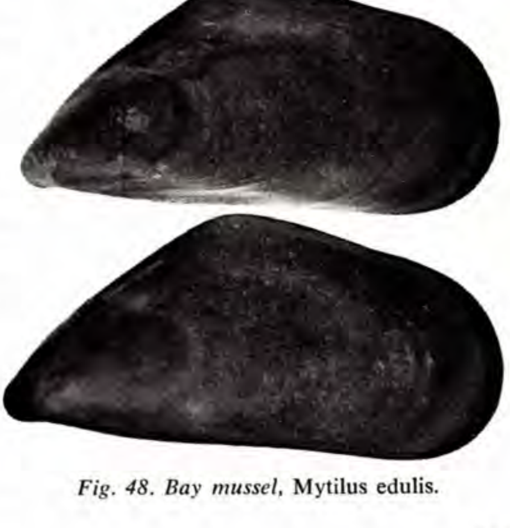


*Fig. 48. Bay mussel,* Mytilus edulis.

attempts have been made to market it, but there is little interest in large-scale exploitation. Individuals in wild populations are somewhat smaller in size than those marketed in Europe. Culture methods, such as those used in other countries, would undoubtedly produce mussels of marketable size. It is a prolific species and procurement of seed is no problem. Bay mussels occur throughout the British Columbia coast in a variety of environments and withstand wide variations in temperature and salinity. On rafts in Departure Bay up to 40 lb of mussels have been produced on hanging ropes 20 ft long in a period from April to October. Individuals reached a size of 2 inches or more, but the average was less.

The California or sea mussel (*Mytilus californianus*) (Fig. 49) is a larger species and grows to a length of 10 inches. It occurs only on the open coasts where salinity is high. It is used locally, but harvesting wild populations might not be economical, although raft culture may be considered.

*Fig. 50. Soft-shell clam,* Mya arenaria.

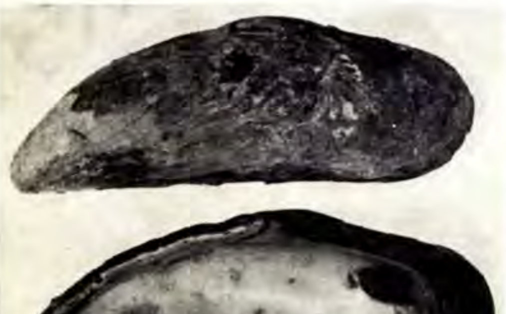


*Fig. 49. Sea mussel,* Mytilus californianus.

The soft-shell or mud clam (*Mya arenaria*) (Fig. 50) is a species accidentally imported from the Atlantic coast and now occurs along the whole British Columbia coast. It is an important commercial species on the Atlantic coast, but it has not gained equal favour on the Pacific coast. Modest populations are found in estuaries and occasional specimens are taken with butter clams. It is doubtful if it occurs in sufficient quantities for a specific fishery.

### Deepwater Clam Survey

For several years, many people have assumed the existence of extensive subtidal clam populations in British Columbia. In 1959, representations were made to the Department of Fisheries of Canada by fishing interests for a study of the possibilities of a deepwater clam fishery. The plan was to use hydraulic dredges similar to those used to harvest the surf clam (*Spisula*) on the Atlantic coast of the United States from depths down to 20 fath.

These requests were based on information that the clam *Spisula polynyma*, a species similar to that taken by the Atlantic coast fishery, was known to occur in the Hecate Strait area because shells were frequently cast up on the adjacent shores. In addition, intertidal species such as cockles and razor clams were taken, under certain conditions, in crab gear. Live cockles frequently occurred on the shore after storms, as did considerable numbers of the large weathervane scallop (*Pecten caurinus*) and some butter clams. It was a reasonable assumption that commercial concentra-

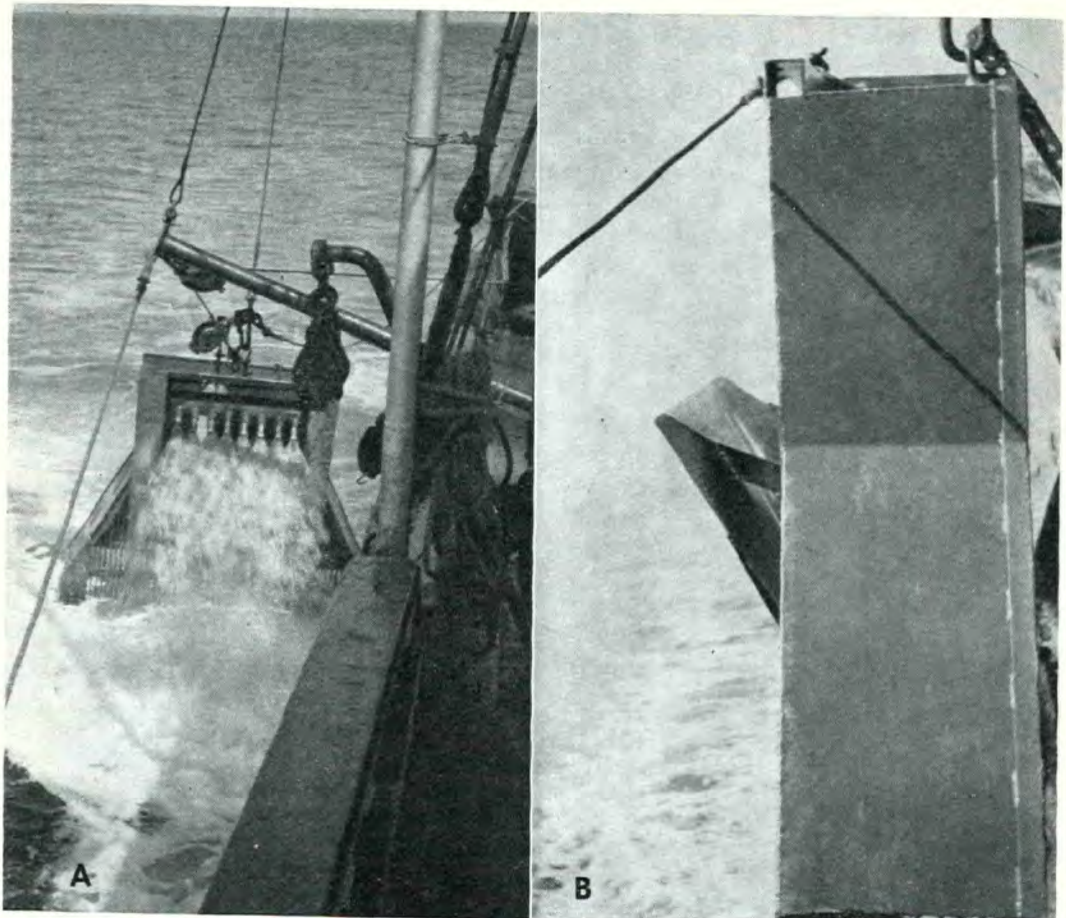



*Fig. 51. Hydraulic drag dredge used in 1960 and 1961 deepwater clam surveys. A, nozzles and frame of dredge; B, bottom of dredge showing cutter bar.*

tions of clams might occur subtidally along the British Columbia coast, particularly in the Hecate Strait area.

A survey to assess the potential subtidal clam populations was begun in 1960 and completed in 1961.

### Gear

The basic gear used in these surveys was the Long Island version of the hydraulic drag dredge, which is used so extensively along the Atlantic coast of the United States (Fig. 51).

Since the hydraulic gear can work effectively only on a specific type of ground, a preliminary survey was necessary to ensure the bottom was satisfactory. For this purpose a Fall River rocker-type dredge was used (Fig. 52). A short drag with this gear usually indicated whether the hydraulic gear could be used safely.

Tows were made to assess the scallop resources during the survey, and the gear used was a standard 10-ft offshore-type drag used on the Atlantic coast and a 3-ft Digby-type drag.

Since all this gear must be towed from a boat, the surveys in both years were carried out from a chartered 80-ft seine boat.

### Location of Tows

Tows were made in all likely areas along the coast but the main region of interest was the Hecate Strait area, primarily on the submarine plain known as the "Hecate Flat." This plain has an area of about 1600 square nautical miles

*Fig. 52. Rocker dredge used in 1960 and 1961 deepwater clam surveys.*

under 20 fath, which is within the range of the hydraulic dredge.

In 1960 a total of 454 stations were sampled, 263 with the rocker dredge, 34 with the hydraulic dredge, 123 with scallop gear, and 34 with a Petersen sampler. In 1961, 156 stations were sampled, 63 with the rocker dredge, 3 with the hydraulic dredge, and 90 with scallop gear. In addition to the 156 stations sampled in 1961, 13 dives were made with standard (hard hat) diving gear to confirm that the results from the dredges were representative of the material on and in the bottom.

Figures 53 and 54 show the type of drag coverage given to the Hecate Strait and McIntyre Bay areas; each arrow represents a drag.

**Results**

Results of these surveys were disappointing as far as establishing a deepwater clam fishery in the province. Occasional live clams were taken but the indications were that although several species of clams, butter, littleneck, and surf clams and cockles occurred in the area, they were not widely distributed and they did not occur in commercial concentrations in British Columbia waters.

The clam species taken in greatest numbers was *Compsomyax subdiaphana,* a clam belonging to the same general group as the butter and littleneck clam. It has a brittle shell, reaches a length of 2½ inches and occurs in muddy bottom down to about 30 fath. Up to one-half bushel of these clams was taken in a 10-min tow in Trincomali Channel in the Strait of Georgia area. Unfortunately, the species does not appear very palatable.

Cockles were the next most abundant species and the greatest number in any one drag was 24, caught off Argonaut Hill in about 10 fath. Butter clams were taken on only three occasions and littlenecks on one. These were also in the Argonaut Hill area as were the three stations at which the surf clam (*Spisula*) was taken. Horse clams were caught only once but geoduck (*Panope*) necks appeared frequently.

Great concentrations of clam shell were caught just south of Rose Spit. However, dense clam populations are not necessary to account for these shell deposits, for it is possible they have accumulated by current action over a long period of time from a wide area in which the clams are distributed sparsely.

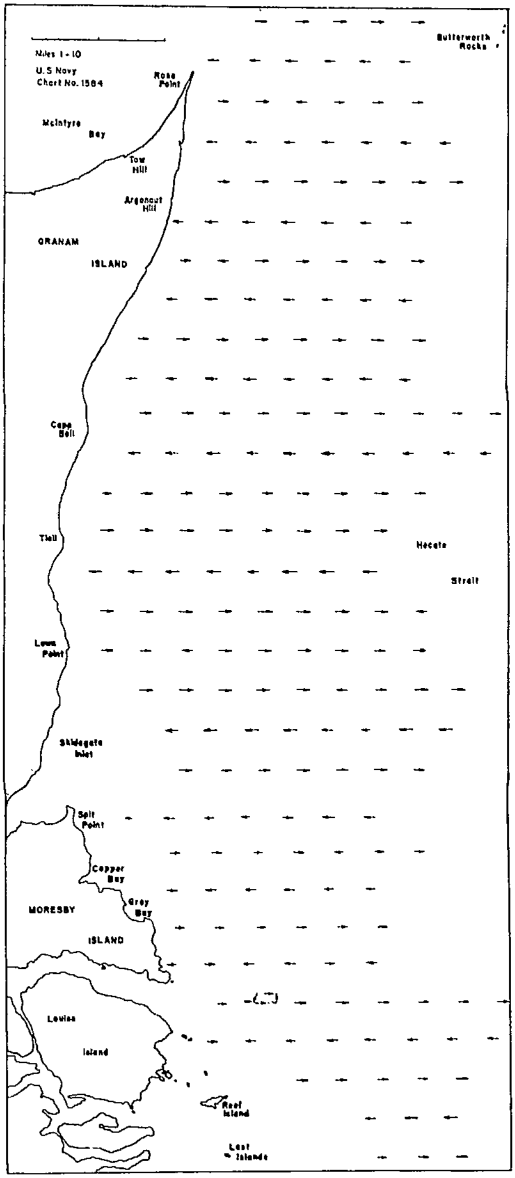



*Fig. 53. Location of tows made in Hecate Strait during the 1960 and 1961 deepwater clam surveys.*

No razor clams were taken in offshore areas, but this does not necessarily mean they do not occur there. The hydraulic gear was tested on the razor clam beach between Rose Spit and Tow Hill. Although some clams were caught it is unlikely this gear as such would be practical for commercial harvesting because of the surf, but a beach-based modification may have application.

Scallops (*Pecten*) were caught consistently in only two areas, Dixon Entrance and the Gulf Islands region of the Strait of Georgia. The best tow was in the latter area; 63 scallops in a 20-min tow, which is far below commercial abundance.

Other than clams and scallops, the only other mollusc that occurred in quantity was the deepwater mussel (*Modiolus*) of which 3 bushels were taken in Plumper Sound (Strait of Georgia) in one 10-min drag. This however was the only station at which it occurred.

### Summary

These surveys made a considerable contribution to our knowledge of the distribution and occurrence of shallow water invertebrates in the province. However, no commercial quantities of deepwater clams or scallops were found in British Columbia coastal waters.

## Mechanical Harvesters

In the last 15 years there has been a general decline in commercial clam landings (Fig. 1). As pointed out in previous sections of this Bulletin, there are several contributing factors but a major cause has been the lack of diggers. The decline in number of diggers is due to social and economic reasons, and the relatively low productivity under unpleasant working conditions (at night, in winter, in all weathers). In recent years, the maximum price paid for butter clams has been 9–10 cents per lb (round weight); 12–16 cents per lb for littleneck and Manila clams; and 11 cents per lb for razor clams. A good digger can regularly dig rarely more than 300 lb of butter clams per tide and smaller quantities of littleneck, Manila, and razor clams.

An increase in productivity is required to make digging more rewarding. In his 1912 and 1913 reports, Thompson describes clam digging methods employed at that time and they haven't changed since. If commercial clam landings are to increase, the digging methods must be greatly improved by mechanization.

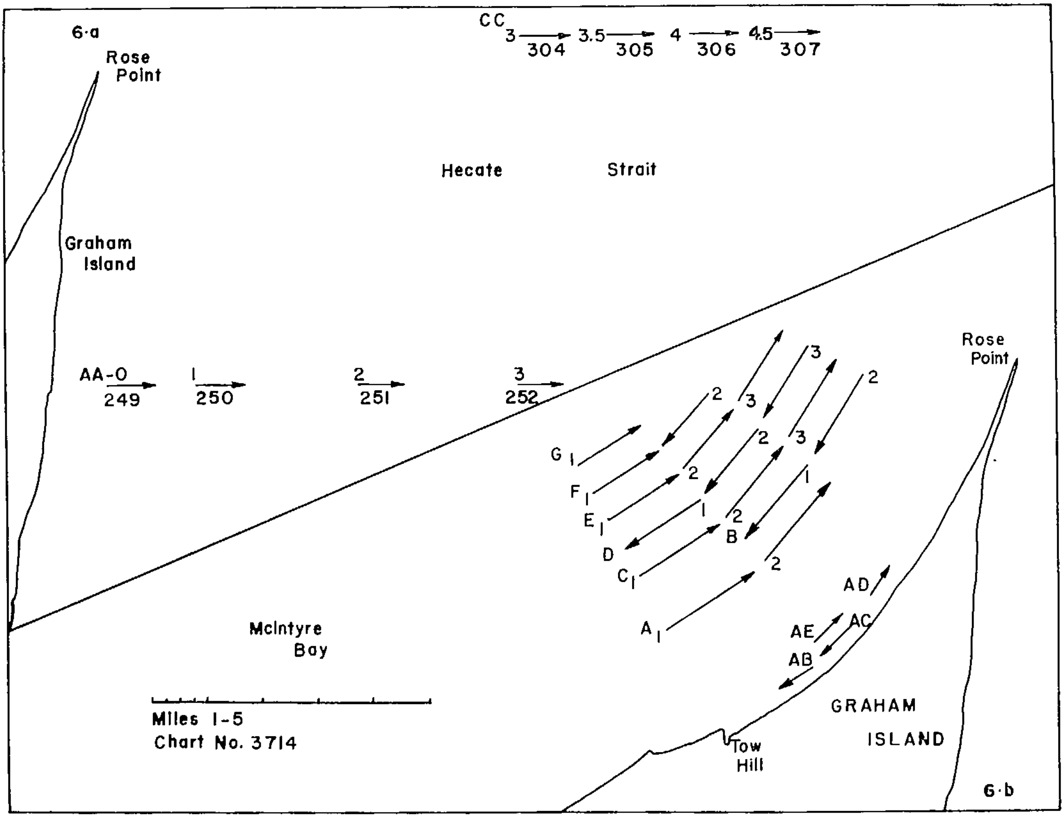



*Fig. 54. Location of tows made in Dixon Entrance during the 1960 and 1961 deepwater clam surveys.*

Until 1964 the fishery regulations prohibited mechanical diggers for harvesting clams, but it is now possible to use them under permit. A contributing reason for this change in regulations was the development on the Atlantic coast of hydraulic clam diggers that were not only efficient, but maintained the beach in a better condition than is the case with hand digging, and kept shell breakage to a minimum. It was hoped that the introduction of mechanical diggers would increase productivity to a point where clam digging would become more attractive and ensure a steady supply of clams to help stabilize the industry.

### Hydraulic Diggers

Several types of mechanical clam diggers have been built, but the most successful are referred to as "hydraulic diggers." They are so named because water is forced under pressure through nozzles and the resulting jets penetrate the soil to depths of 20 inches. An emulsion of water and soil is produced and the clams, having slight positive buoyancy in this slurry, float to the top where they can be harvested. The soil is redeposited behind the digger, heaviest particles on the bottom and lightest on the top, which is the normal order.

Hydraulic diggers have several advantages over conventional hand-digging methods. They are faster and more efficient, capturing 95 % of clams compared to 50–60 % for hand digging. Not only can more area be dug per unit of time but the yield is higher. Definite areas can be staked out and dug, and because of the high efficiency there is no need to rework dug areas, greatly reducing damage to the beach and to small clams. Hydraulic diggers can be used profitably on areas where clam density is too low to support conventional hand digging.

Not only are many legal-sized clams broken and frequently discarded in hand digging, but many juvenile clams are badly

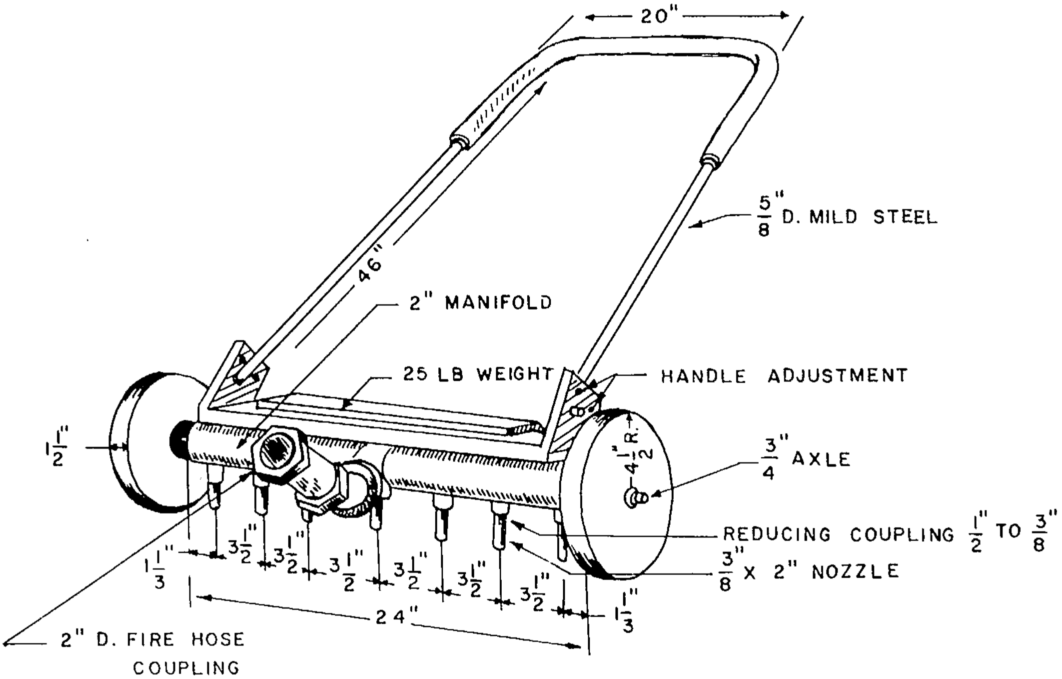



*Fig. 55. Perspective drawing of the manual hydraulic clam digger.*

damaged and lost to the future fishery. Hand digging, particularly by inexperienced diggers, can be very damaging to small clams. Breakage of both legal- and sublegal-sized clams is reduced to a minimum (about 5 %) with hydraulic diggers.

A further advantage of the hydraulic digger would accrue if all species of clams dug, including horse clams, soft-shell clams, and cockles, were marketed. With hydraulic diggers, breakage of horse clams is slight (5–10 %), and with proper care these could be harvested and processed.

Not all mechanical diggers are recommended, because some may damage the clam beds. A single jet firehose is not approved because it is inefficient and often gouges deep ruts on a beach, but it may be useful in extremely rocky areas. Some diggers with heavy caterpillar treads are not recommended since they may cause severe damage.

Of the several types of hydraulic diggers, three have been used, two commercially, one experimentally, in British Columbia.

#### MANUAL HYDRAULIC DIGGER

The manual hydraulic digger, weighing about 60 lb (Fig. 55), is a simple, easily built machine. It consists of a manifold 2 inches in diameter and 2 ft in length, with a number of equally spaced 3- by ½-inch nozzles. The manifold is held off the ground by two 9-inch wheels. Water is supplied by a pump delivering about 125 gal of water per min at a pressure of 25–30 lb per square inch. The pump is usually placed in a skiff with a short length of intake hose whose end is protected by a screen. The discharge hose connecting pump and digger is 1½- or 2-inch flexible firehose whose length depends on how far from the water supply the digger is operated if on a dry beach. The digger may be worked in water of wading depth, but experience so far indicates it is more efficient and easier to manipulate on a dry beach.

To operate, the digger is set so the water jets penetrate 12 inches or so into the soil. It is then pulled along slowly, the rate determined by experience. It is important not to allow the digger to sink too deeply, yet allow the jets to dig to the depth of the clams. The usual practice is for one person to operate the digger while another rakes the clams washed into the trench. A manure fork with 6- or 8-inch tines bent at right angles to the handle is satisfactory. Raking is necessary for some of the clams dislodged may be just under the surface and missed. The clams are picked by hand, since it is unlikely that an automatic collecting device such as a basket behind the digger would be successful on most beaches because of the amount of dead shell and rocks.

Results of an experiment comparing the efficiencies of this digger and hand digging carried out at Seal Island are shown in Table 27. Results of the second experiment are more accurate since a better pump gave deeper penetration of the water jets. These results show the hydraulic digger is about six times more productive than hand digging. Breakage of all sizes of clams and species is about 5 %, whereas with hand digging it may be as much as 25 % for butter clams and 50 % for horse clams.

Several of these diggers are in use at the present time. This hydraulic digger is inexpensive, about $500, portable and ideally suited for most of the small rocky clam beaches in British Columbia. It may be easily used on the smallest beach. With manifolds of various sizes, it may be operated on beaches with much rock.

TABLE 27. Comparison of digging speed and production of commercial-size butter and horse clams by manual hydraulic clam digger and clam fork, at Seal Island, August 1966.

| | Digger | | |
|---|---|---|---|
| | Expt 1 | Expt 2 | Fork |
| Digging speed: $yd^2$/hr | 86 | 43 | 10 |
| No. commercial-size butter clams/$yd^2$ | 7.0 | 37.6 | 23.6 |
| Pounds commercial-size butter clams/$yd^2$ | 2.7 | 13.8 | 9.3 |
| No. horse clams/$yd^2$ | 2.6 | 6.3 | 7.3 |
| Pounds horse clams/$yd^2$ | 0.9 | 9.0 | 5.4 |
| No. commercial-size butter clams/hr | 595 | 1613 | 236 |
| Pounds commercial-size butter clams/hr | 229 | 593 | 93 |
| No. horse clams/hr | 220 | 269 | 73 |
| Pounds horse clams/hr | 74 | 193 | 54 |

ESCALATOR HARVESTER

The escalator harvester (Fig. 56) was developed to dig submerged soft-shell clams in Chesapeake Bay. There, as well as in the Canadian maritime provinces, the clam ground is extensive and flat, consisting of sandy mud with few or no rocks. This is in contrast to the British Columbia situation where clam grounds are for the most part small in size, rarely level, and consist of much dead shell and rock.

The escalator harvester is operated from a boat or barge in 3–15 ft of water. It can be used for a much longer period of time than the manual hydraulic digger, since its operation does not depend on low tides and it can harvest subtidal populations. The escalator harvester is efficient when operating on ground to which it is suited. Unfortunately, such ground in British Columbia is limited. One escalator harvester has been used in the province. The cost of this harvester, digger, belt, pump, and boat is about $15,000.

DEEPWATER CLAM HARVESTER

The deepwater clam harvester is widely used on the Atlantic coast from New York to Maryland, especially for the surf clam (*Spisula solidisima*), and operates in water depths down to 20 fath. It was the dredge used in the 1960 and 1961 surveys of deepwater clam resources in British Columbia (Fig. 51).

The dredge used in these surveys has a hydraulic manifold, 36 inches long, 4 inches in diameter, hinged at each end, and with eight nozzles. The manifold is enclosed in a hood and immediately behind and below the manifold is the digging blade, which may be of various dimensions, allowing a digging depth of 6–20 inches. The blade is mounted on the sides of the hood. Immediately behind the actual cutting blade are parallel collecting bars. Attached to the hood is an expanded funnel-shaped section that leads into the main body of the dredge, which is essentially the "codend" or collecting device. The end of the dredge has a hinged door for unloading the catch. In operation, the dredge lies flat on two 6-inch steel runners. Water is supplied by a 5-inch pump that will deliver 500 gal per min at 100 psi (pounds per sq inch) to 1400 gal per min at 75 psi. The dredge is towed from a short boom and the

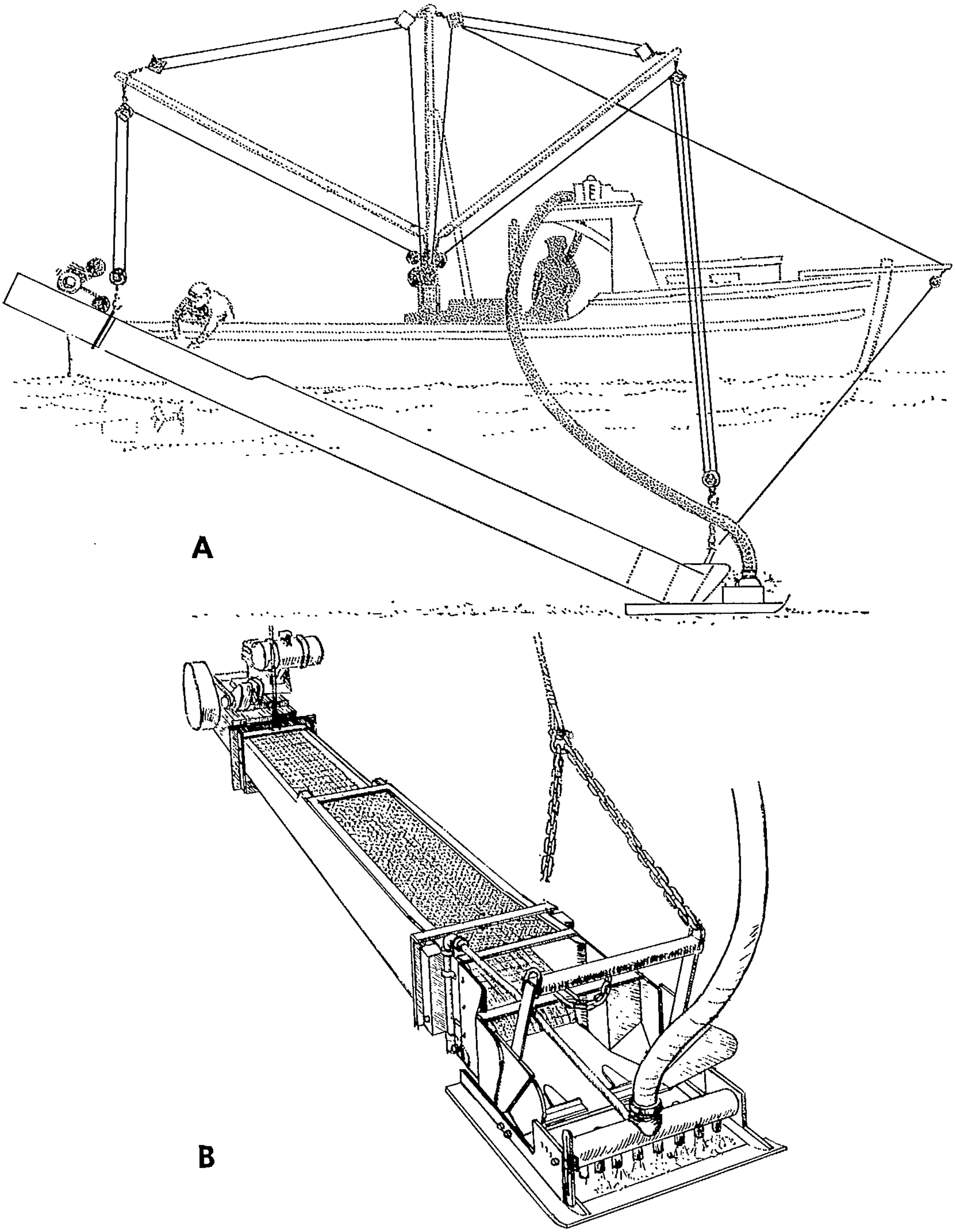



*Fig. 56. Schematic drawing of the escalator clam harvester developed at the Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B. A, digger in operation; B, head of digger showing the placement of the nozzles and the position of the escalator.*

towing speed is approximately 50 ft per min.

This dredge is also expensive for the dredge, pump, and hoses cost about $ 15,000 in 1960.

## Conclusions

Clam landings have decreased in recent years, although beach surveys indicate that the major clam populations in the province are not depleted except to a limited extent in the Strait of Georgia. The reduced landings are due to a variety of causes, among which are social and economic changes and closures owing to paralytic shellfish poison.

Clams have been harvested mainly during the winter months when weather conditions are not the best. This is the off-season for many fishermen who were able to supplement their income by digging clams. Recently, however, with generally increased affluence, clam digging has lost its attraction and production has declined.

There is no stability in an industry in which the supply of raw material is variable or intermittent. If the clam industry is to flourish, more financially rewarding methods of harvesting clams must be used. One obvious answer to this problem is mechanical harvesting, and this was one of the main reasons for rescinding the regulation forbidding mechanical diggers. A number of permits have been issued by the Fisheries Service of the Federal Department of the Environment (a necessary requirement) for mechanical diggers and, although production from them has been less than anticipated, such machines will require modifications, adaptations, and some time to develop skill in their operation before optimum production is realized.

### Pollution

Both domestic and industrial pollution pose problems to the well-being of molluscan shellfish fisheries. Already in British Columbia's oyster industry, 40 % of the leased oyster beds have been closed or restricted owing to sewage pollution and another 10 % are affected by industrial pollution. The situation will likely become worse and more clam-bearing areas will be affected, particularly in the Strait of Georgia. Recently a plant has been constructed in Ladysmith to artificially purify polluted oysters by holding them in tanks of water purified by ultraviolet light. The same technique is applicable to clams. Another alternative for purifying polluted clams is to transplant them from polluted to clean areas. However, both these processes are costly, much more so than the accepted practice of relaying oysters, and it is doubtful if under present conditions these methods can be used economically to purify polluted clams.

### Paralytic Shellfish Poison

For some time now, this problem has curbed the utilization of butter clams from various parts of the coast and is in part responsible for low total production in recent years. Studies have demonstrated, however, that clams from moderately toxic areas may be canned successfully and retain no toxin, providing the whole siphon is removed.

Paralytic shellfish poison is an intermittent but recurring phenomenon that has wide repercussions in the shellfish industry whenever it occurs. The market slumps badly and takes some time to recover, because the public usually overreacts, but every precaution is taken by fishery and health authorities to protect the public health.

### Clam Farming

Clams may be farmed in a manner similar to that used for oysters. Seed is gathered from areas known to be highly productive and planted on ground leased for the purpose. However, the cost of collecting seed, planting and harvesting clams is greater than for oysters and, since they fetch a lower price, clam farming in British Columbia under present conditions is uneconomic. Also, the clam farmer would be in competition with producers of clams from public beaches whose costs are only limited to digging and buying. Recently, several molluscan shellfish hatcheries have been constructed and are now commercially producing oyster seed. Similar techniques can be used for clams to ensure a continuous supply of seed clams, but at present this is not economical. In the future, clam farming may become feasible when shellfish hatchery procedures and costs reach satisfactory levels and the price of clams is considerably higher.

## Outlook

Although there are problems facing the clam industry in British Columbia there is no reason these cannot be surmounted. In the future there will be an increasing pressure on the clam stocks from the sports fishery, particularly in the Strait of Georgia. Already there is a bag limit on oysters for personal use and similar limitations may be forthcoming for clams. However, in general it may be stated that the yield of most species could be increased. Clam production in British Columbia has an annual potential of about 6 million lb of butter clams; 1 million lb of littleneck clams; ½ million lb of Manila clams; and ¾ million lb of razor clams. Collectively this would be worth about 1 million dollars to the diggers at present prices. These landings could be increased by utilization of other species such as horse clams and soft-shell clams. Although clam digging and processing does not represent a major part of the fishing industry, it can form a substantial auxiliary source of income for industrious fishermen and processors during the off-season winter months.

## Acknowledgments

Appreciation is expressed to Dr F. Neave for the use of much of his data compiled over a number of years on clam studies. Personnel of the Department of the Environment, Fisheries Service have assisted in many ways to make this work possible. The cooperation and help of numerous clam diggers and buyers such as Mr W. Scow of Alert Bay was invaluable, as was that of Mr J. S. Simpson of Masset. Mr P. A. Fraser assisted with the photographs.

## Suggested Reading

Since no references were given in the text, the following is a list that pertains either in a general or a particular way to British Columbia clams.

### General

FITCH, J. E. 1953. Common marine bivalves of California. Calif. Dep. Fish. Game Fish. Bull. 90: 102 p., 63 fig.

LOOSANOFF, V. L., AND H. C. DAVIS. 1963. Rearing of bivalve mollusks. Advan. Mar. Biol. 1: 1–136, 43 fig.

MORTON, J. E. 1960. Molluscs: an introduction to their form and function. Harper Torchbooks, New York, N.Y. 232 p., 23 fig.

QUAYLE, D. B. 1940. How to identify some common British Columbia clams. Fish. Res. Board Can. Pac. Progr. Rep. 46: 6–11.

1941. The edible molluscs of British Columbia, Rep. B.C. Fish. Dep. 1940: 75-87.

1960. The intertidal bivalves of British Columbia. B.C. Mus. Handb. 17: 104 p.

1964. Distribution of introduced marine Mollusca in British Columbia waters. J. Fish. Res. Bd. Canada 21: 1155-1181.

1969. Paralytic shellfish poisoning in British Columbia. Fish. Res. Board Can. Bull. 168: 68 p.

1969. Pacific oyster culture in British Columbia. Fish. Res. Board Can. Bull. 169: 192 p.

RICKETTS, E. F., AND J. CALVIN. 1968. Between Pacific tides. 4th ed. Revised by J. W. Hedgepeth. Stanford University Press. 614 p.

TRESSLER, D. K., AND J. M. LEMON. 1951. Marine products of commerce. Reinhold Publishing Corp., New York, N.Y. 782 p.

### Specific

BERNARD, F. R. MS 1967. Studies on the biology of the naticid clam drill *Polinices lewisi* (Gould) (*Gastropoda Prosobranchiata*). Fish. Res. Board Can. Tech. Rep. 42: 41 p.

BOURNE, N. MS 1967. Digging efficiency trials with a hydraulic clam rake. Fish. Res. Board Can. Tech. Rep. 15: 24 p.

MS 1969. Scallop resources of British Columbia. Fish. Res. Board Can. Tech. Rep. 104: 60 p.

MS 1969. Population studies on the razor clam at Masset, British Columbia. Fish. Res. Board Can. Tech. Rep. 118: 24 p.

CAHN, A. R. 1951. Clam culture in Japan. U.S. Fish Wildl. Serv. Fish. Leafl. 399.

FIELD, I. A. 1923. Biology and economic role of the sea mussel, *Mytilus edulis*. U.S. Bur. Fish. Bull. 38: 127–259.

FRASER, C. M. 1929. The spawning and free swimming larval periods of *Saxidomus* and *Paphia*. Trans. Roy. Soc. Can. Ser. 3, 23(5): 195–198.

1930. The razor clam, *Siliqua patula* (Dixon), of Graham Island, Queen Charlotte group. Trans. Roy. Soc. Can. Ser. 3, 24 (5): 141–154.

1931. Notes on the ecology of the cockle, *Cardium corbis* Martyn. Trans. Roy. Soc. Can. Ser. 3, 25(5); 59–72.

FRASER, C. M., AND G. M. SMITH. 1928. Notes on the ecology of the butter clam, *Saxidomus giganteus*. Trans. Roy. Soc. Can. Ser. 3, 22 (5): 271–286.

1928. Notes on the ecology of the little-neck clam, *Paphia staminea* Conrad. Trans. Roy. Soc. Can. Ser. 3, 22(5): 249–269.

HIRSCHHORN, G. 1962. Growth and mortality rates of the razor clam (*Siliqua patula*) on Clatsop beaches, Oregon. Oreg. Fish Comm. Contrib. 27: 55 p.

LINDSAY, C. E. 1966. The geoduck. Annu. Rep. Amer. Malacol. Union 1966: 67–68.

LINDSAY, C. E., AND C. E. WOELKE. 1960. Production of clam and oyster seed. Fisheries fish farming, fish management: Conservation propagation — regulation, I. Washington State Department of Fisheries. p. 81–85.

MARRIAGE, L. D. 1954. The bay clams of Oregon. Oreg. Fish Comm. Contrib. 20: 1–47.

NEAVE, F. 1942. The butter-clam (*Saxidomus giganteus* Deshayes): studies in productivity. Rep. B.C. Fish. Dep. 1941: 79–81.

1943. Biological investigations of commercial clams. Rep. B.C. Fish. Dep. 1942: 70–74.

1944. Biological investigations of commercial clams. Rep. B.C. Fish. Dep. 1942: 75–79.

1944. The spread of the Japanese little-neck clam in British Columbia waters. Fish. Res. Board Can. Pac. Progr. Rep. 61: 3.

1944. The legal size-limit in relation to the size at which butter clams mature. Fish. Res. Board Can. Pac. Progr. Rep. 61: 4–5.

1945. Biological investigations of commercial shellfish. Rep. B.C. Fish. Dep. 1944: 64–67.

1946. Condition of the butter-clam fishery in British Columbia. Rep. B.C. Fish. Dep. 1945: 67–74.

1947. Investigations on commercial clams. Rep. B.C. Fish. Dep. 1946: 72–74.

1948. Records of clam production. Rep. B.C. Fish. Dep. 1947: 87–89.

QUAYLE, D. B. 1939. The British Columbia clam problem. Fish. Res. Board Can. Pac. Progr. Rep. 39: 19–20.

1940. A preliminary report on the British Columbia clam problem. Rep. B.C. Fish. Dep. 1939: 67–71.

1943. Sex, gonad development and seasonal gonad changes in *Paphia staminea* Conrad. J. Fish. Res. Bd. Canada 6: 140–151.

1950. Investigations at Seal Island. Rep. B.C. Fish. Dep. 1949: 81–85.

1952. The relation of digging frequency to productivity of the butter clam (*Saxidomus giganteus* Deshayes). J. Fish. Res. Bd. Canada 8: 369–373.

MS 1960. Deepwater clam and scallop survey in British Columbia. Fish. Res. Board Can. MS Rep. 717: 80 p.

MS 1961. Deepwater clam and scallop survey in British Columbia. Fish. Res. Board Can. MS Rep. 746: 38 p.

1962. The Pacific razor clam. Can. Dep. Fish. Trade News 14: 8–9.

1966. Paralytic shellfish poisoning — safe shellfish. Fish. Res. Board Can. Nanaimo Biol. Sta. Circ. (Gen. Ser.) 75: 11 p.

MS 1967. Canning toxic butter clams (*Saxidomus giganteus*). Fish. Res. Board Can. MS Rep. 936: 8 p.

SMITH, G. M. 1928. Food material as a factor in growth rate of some Pacific clams. Trans. Roy. Soc. Can. Ser. 3, 22(5): 287–291.

1933. Further observations on the ecology, rate of growth and food supply of some Pacific clams. Trans. Roy. Soc. Can. Ser. 3, 27(5): 229–244.

SWAN, E. F., AND J. H. FINUCANE. 1952. Observations on the genus *Schizothaerus*. Nautilus 66: 19–26.

TAYLOR, C. C. 1959. Temperature, growth and mortality of the Pacific razor clam. J. Cons. Cons. Perma. Int. Explor. Mer 25: 93–100.

1960. Temperature, growth and mortality of the Pacific cockle. J. Cons. Cons. Perma. Int. Explor. Mer 26: 117–124.

TEGELBERG, H. C. 1964. Growth and ring formation of Washington razor clams. Wash. Dep. Fish. Res. Pap. 2: 69–103.

TEGELBERG, H. C., AND C. D. MAGOON. 1969. Growth, survival and some effects of a dense razor clam set in Washington. Proc. Nat. Shellfish. Ass. 59: 126–135.

THOMPSON, W. F. 1913. Report on the clam beds of British Columbia. Rep. B.C. Comm. Fish. 1912: 37–56.

1914. Report on the shell-fish beds of British Columbia (clams, mussels, and scallops). Rep. B.C. Comm. Fish. 1913: 103–125.

WEYMOUTH, F. W., AND H. C. MCMILLAN. 1931. Relative growth and mortality of the Pacific razor clam, *Siliqua patula*, and their bearing on the commercial fishery. U.S. Bur. Fish. Bull. 46: 543–567.

WEYMOUTH, F. W., AND S. H. THOMPSON. 1931. The age and growth of the Pacific cockle (*Cardium corbis* Martyn). U S. Bur. Fish. Bull. 46: 633–641.

## Recent Bulletins of the Fisheries Research Board of Canada

173 Freshwater fishes of northwestern Canada and Alaska.
MCPHAIL/LINDSEY
*385 pages* *$8.50*

174 Nearctic and Palaeartic *Chaoborus* (Diptera: Chaoboridae).
SÆTHER
*57 pages* *$2.50*

175 An economic study of the oyster fishery of the Maritime Provinces.
MORSE
*81 pages* *$2.25*

176 A synopsis of Canadian marine zooplankton.
SHIH/FIGUEIRA/GRAINGER
*256 pages* *$5.00*

177 Paralytic shellfish poisoning in eastern Canada.
PRAKASH/MEDCOF/TENNANT
*87 pages* *$3.00*

178 Pacific oyster raft culture in British Columbia.
QUAYLE
*34 pages* *$2.00*

*To obtain copies, write to*
*Information Canada*
*Ottawa, Canada*
*K1A 0S9*
*(Advance payment is required)*