

FISHERIES RESEARCH BOARD OF CANADA  
(FORMERLY BIOLOGICAL BOARD OF CANADA)

UNDER THE CONTROL OF  
THE HON. THE MINISTER OF FISHERIES

---

BULLETIN No. LXII

THE PACIFIC EDIBLE CRAB, *CANCER MAGISTER*

BY  
DONALD C. G. MACKAY  
University of Connecticut

OTTAWA  
1942

## THE PACIFIC EDIBLE CRAB, *CANCER MAGISTER*

BY DONALD C. G. MACKAY  
*University of Connecticut*

### INTRODUCTION

The Pacific edible crab, *Cancer magister* Dana, one of the largest crustaceans on the west coast of North America, supports an extensive fishery from Alaska to California. It is the purpose of the present bulletin to give a comprehensive account of the known facts concerning this valuable form.

The information is based largely upon the extensive data collected by the writer between 1930 and 1934 for the Biological Board of Canada (now the Fisheries Research Board of Canada) and that obtained by Professor F. W. Weymouth of Stanford University for the Provincial Fisheries Department of British Columbia. From these two investigations there is information available concerning over 30,000 crabs. Certain phases of the study have been published as follows:—

MacKay, D. C. G. and F. W. Weymouth. The growth of the Pacific edible crab, *Cancer magister* Dana. Journ. Biol. Bd. Can. 1 (3) 1935.

MacKay, D. C. G. The edible crab of the Pacific coast. Prog. Rep. Pac. 11, 1931.

MacKay, D. C. G. Migrations of the Pacific edible crab. Prog. Rep. Pac. 22, 1934.

MacKay, D. C. G. The growth and life history of the Pacific edible crab, *Cancer magister* Dana. Stanford University Bull. Abstracts of Dissertations, Series 5, No. 178, 1933-34.

MacKay, D. C. G. Story of the Pacific crab. Western Fisheries, Vol. 3, No. 6. April, 1932.

Weymouth, F. W. and D. C. G. MacKay. Relative growth of the Pacific edible crab, *Cancer magister*. Proc. Soc. Exp. Biol. & Medicine, XXX, pp. 1137-1139, 1934.

Weymouth, F. W. and D. C. G. MacKay. Analysis of the relative growth of the Pacific edible crab, *Cancer magister*. Proc. Zool. Soc. London, April, 1936.

Weymouth, F. W. Contributions to the life history of the Pacific edible crab. Paper No. 3, Rept. B.C. Comm. Fish. 1917.

Additional information is available through the study carried out at Clayquoy sound in 1925 by Professor G. J. Spencer of the University of British

Columbia and published in *Bulletin 30 of the Biological Board of Canada* under the title "*The commercial crab, Cancer magister Dana, in Clayoquot sound Vancouver island.*"

The writer is particularly indebted to Dr. R. E. Foerster, Director of the Pacific Biological Station, for assistance in the preparation of this bulletin and to the Fisheries Research Board of Canada for having financed the crab research conducted by the writer over a period of years. Grateful thanks are likewise accorded to Dr. W. A. Clemens, former director of the Pacific Biological Station, Nanaimo, and to Dr. D. B. Finn, former director of the Fisheries Experimental



FIGURE 1. The Pacific edible crab, *Cancer magister* Dana, showing numbered chicken tag at base of claw. Tags of this type were used for the migration studies.

Station, Prince Rupert, for having placed the facilities of these stations at the writer's disposal in earlier years. Sincere thanks are due also to: Drs. F. W. Weymouth and W. H. Rich of Stanford University for advice and assistance in working out growth and other problems; Drs. J. L. Hart and A. L. Pritchard for criticizing the manuscript; Messrs. H. J. Hollister and W. Anderson for assistance in drafting charts; Mr. Bruce Bryson for help in constructing live wells and in collecting crabs; Messrs. H. M. Frazer, H. S. Gerow, and W. Temblett, crab fishermen of Crescent, and to Messrs. Leonard Karsen and Claude Leigh of

Prince Rupert and many others for generous co-operation and valuable assistance in this investigation.

### DISTRIBUTION

The Pacific edible crab belongs to the genus *Cancer*, a group of crabs that has been in existence for some 60,000,000 years and which is to be found living only in the sea. (Some crabs live in fresh water or on land). The group is represented by nineteen living species distributed throughout the world. They inhabit the temperate zone and are practically absent from the tropics.

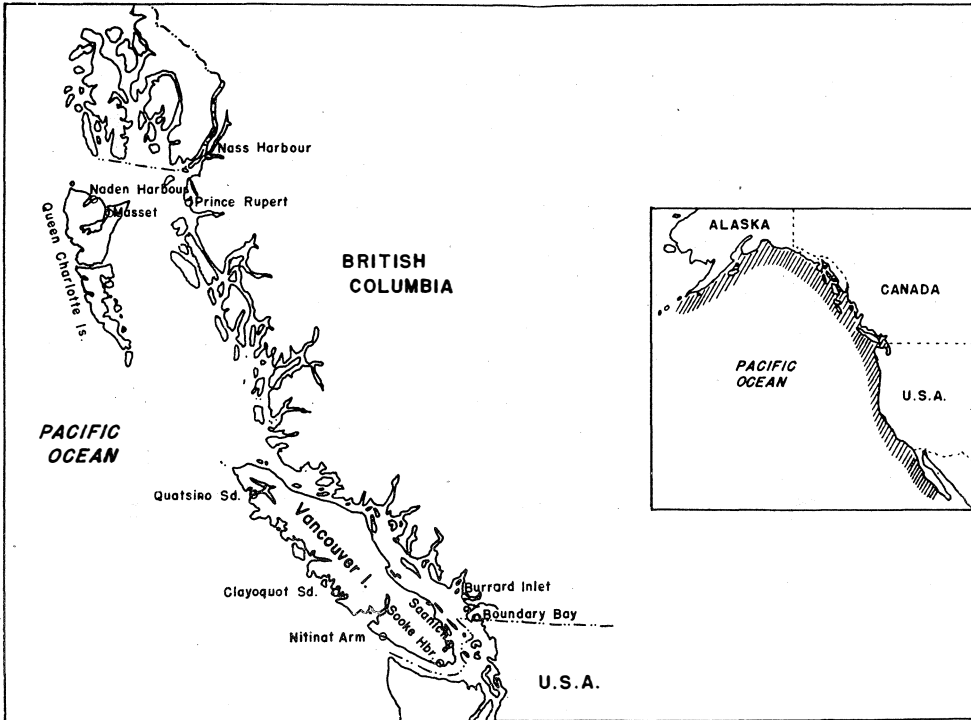


FIGURE 2. Map of British Columbia showing principal crab fishing areas. Inset shows complete distribution of the crab.

*Cancer magister* is to be found from Unalaska, Alaska, in the north to Magdalena bay, Mexico, in the south (fig. 2). In Alaska, British Columbia, Washington, Oregon, and California the species is present in large enough numbers to support fishing on a commercial scale.

In British Columbia the distribution of this valuable crab roughly corresponds to the distribution of areas characterized by sandy bottom and relatively shallow water (fig. 2). Such areas are especially noteworthy in southern British Columbia at Boundary bay, Burrard inlet, Sooke harbour, and in the vicinities of Sidney, Saanich, and Nanaimo, in Nitinat arm, Clayoquot and Quatsino sounds

on the west coast of Vancouver island and at Prince Rupert harbour, Morse lake (near Prince Rupert), Nass harbour and the Queen Charlotte islands in northern British Columbia. Other regions equally productive no doubt exist on other parts of the coast where they are further removed from cities and towns and from transportation facilities.

### RECOGNITION

It will be noted (figs. 3 and 4) that, as in the lobster, the body of the edible crab is composed of two parts, the *cephalothorax* and the *abdomen*. Unlike that of the lobster, however, the cephalothorax of the crab is very much larger than the abdomen. The covering of the cephalothorax is known as the *carapace* and in this species it is widest at the tenth tooth (fig. 3). The hand of the large

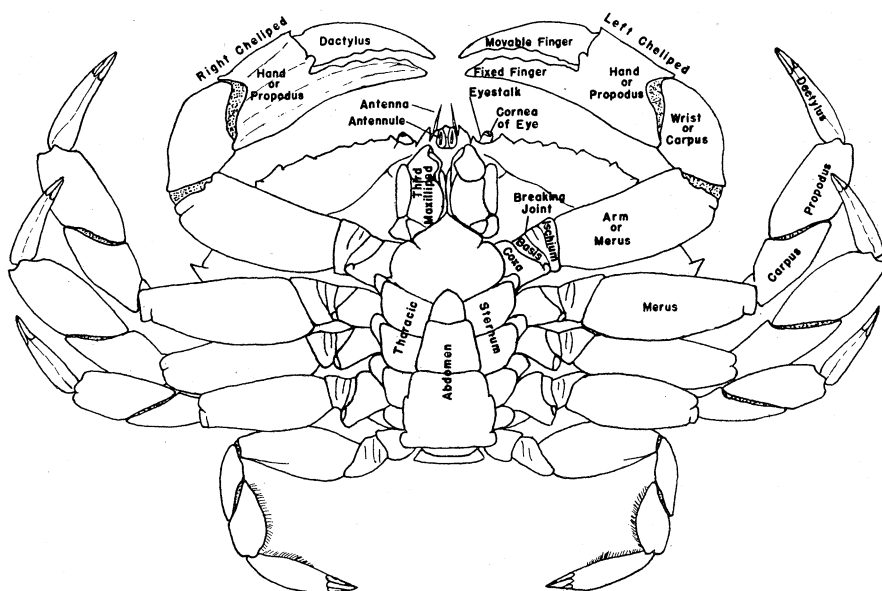


FIGURE 3. Diagram of the crab showing upper surface with structures labelled.

cheliped is armed with conspicuous spines set in rows; the legs are rough and very flat. The general colour is reddish-brown above and whitish beneath. In size the adult males are larger than the adult females and sometimes reach a maximum carapace width of 9 inches.

The rock crab, *Cancer productus* (fig. 5), is probably the only other full-grown crab to be found in British Columbia with which *Cancer magister* is likely to be confused. The former is much redder in colour, does not grow as large, and is somewhat different in shape. In general the rock crab is to be found, as its name implies, on rocky bottoms, whereas the edible crab is to be found on sandy bottoms. However, the two distributions frequently overlap on the fishing grounds and

both are often taken together by the crab fishermen. Although rock crabs are good to eat they are not sufficiently abundant to be commercially important in British Columbia.

The horse crab, *Telmessus cheiragonus* (fig. 5), is a yellowish-brown and hairy crab with a carapace rarely exceeding  $2\frac{1}{2}$  inches in width. It is not as common as the species which follow.

The kelp crab, *Pugettia producta* (fig. 5), is a larger crab than either the purple or the yellow shore crab. Although larger specimens have been found, the carapace does not often exceed  $3\frac{1}{2}$  inches in width. *Pugettia producta* is ordinarily found among kelp where its colour renders it quite inconspicuous.

The purple shore crab, *Hemigrapsus nudus*, and the yellow shore crab, *Hemigrapsus oregonensis*, are to be found, as their common names imply, on the

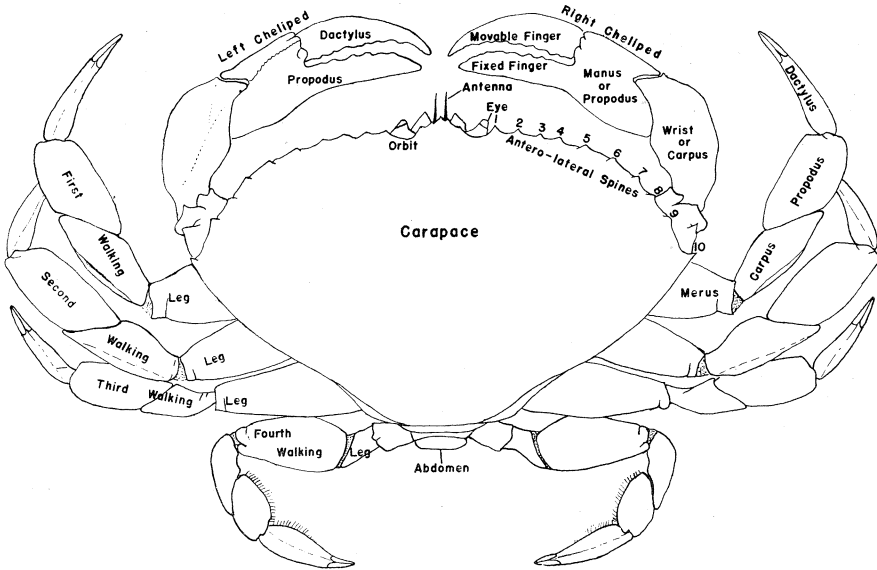


FIGURE 4. Diagram of male, showing under side. The female would differ chiefly in having a wider abdomen.

shore. Both have carapaces that are roughly square and legs that are relatively short. The purple shore crab is the larger of the two species (about  $1\frac{1}{2}$  inches across the carapace when full grown), and may be readily distinguished from the yellow shore crab both by its colour and by the absence of hair on the legs (fig. 5). These two species are frequently mistaken for the young of *Cancer magister*. However, a comparison of figures 5 and 7 will show that *Hemigrapsus* and the young of *Cancer magister* are very different in form.

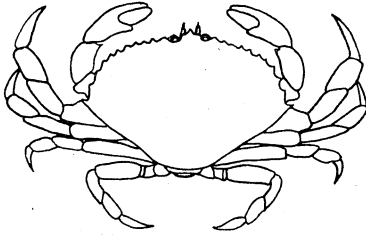
#### LIFE HISTORY

The unravelling of the complete life history of the edible crab has presented many difficulties. Rearing crabs in the laboratory is difficult and not necessarily

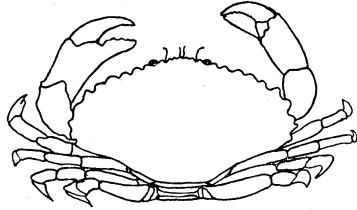
the same as occurs in nature; therefore, efforts have been made to determine the life history as it occurs in nature.

### SEXUAL MATURITY

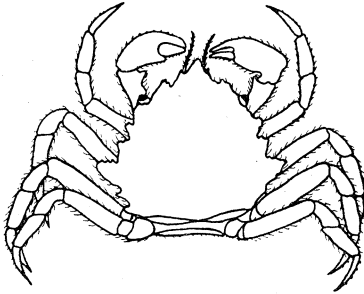
That sexual maturity probably occurs in female crabs at a carapace width of about 4 inches seems to be indicated by the observations that: (1) egg-bearing



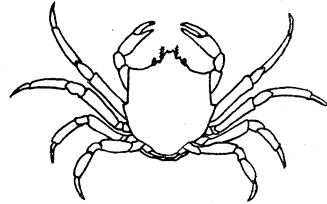
THE PACIFIC EDIBLE CRAB  
*Cancer magister*



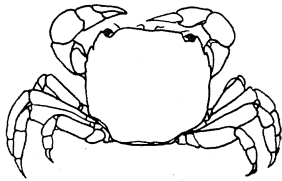
THE ROCK or RED CRAB  
*Cancer productus*



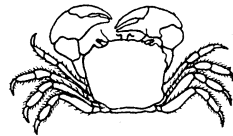
THE HORSE CRAB  
*Telmessus cheiragonus*



THE KELP CRAB  
*Pugettia producta*



THE PURPLE SHORE CRAB  
*Hemigrapsus nudus*



THE YELLOW SHORE CRAB  
*Hemigrapsus oregonensis*

#### OUTLINES OF SOME COMMON BRITISH COLUMBIA CRABS

FIGURE 5. Outlines of some common British Columbia crabs. For sizes see text.

crabs have been found as small as 4.4 inches; (2) crabs with egg capsules (indicating that they have already spawned and are therefore mature) have been found as small as 4.2 inches; (3) crabs with sperm in the sperm receptacle (indicating that they have mated) have been found at 3.6 inches; (4) marked changes

in the body shape of the female occur when the animal reaches a size of about 4 inches; (5) at about this size males and females begin to show different percentage rates of increase per moult; and (6) crabs of 3.2 inches size were found in the mating embrace (these having been on the point of moulting previous to actual copulation). In the last mentioned case the 3.2 inch crab would increase to about 3.8 inches at the moult which, in female crabs, must precede the actual sexual act. Several immature female crabs have been observed at 3.8 inches as well as a few that were larger. Crabs 5.2 to 5.4 inches in size were found in which the egg capsules (some of which remain after the eggs have hatched) provided definite evidence that the crabs had spawned. Thus it seems safe to say that female crabs become sexually mature at a size of approximately 4 inches maximum carapace width.

Unfortunately the evidence for maturity in male crabs is less conclusive. Examination of the reproductive organs has shown that some males are definitely mature at 5.4 inches although there is no reason to suppose that they do not mature earlier. The smallest male found in the mating embrace was 6 inches in width.

A male found in the mating embrace with a female is invariably larger than its mate. It is possible that a size difference is necessary and that, even if males and females do become mature at the same size and age, the males must moult again before they can mate. Evidence on this point is lacking at present.

In the male the reproductive organs occupy less space than they do in the female. The sperms are non-motile and very small, requiring a high magnification to be seen.

#### SEX PROPORTIONS

A study of sex proportions of larval and post-larval crabs, as well as cast exoskeletons in southern British Columbia, shows that the sexes are present in the total population in approximately equal numbers. In the Prince Rupert area in northern British Columbia, however, females are present in much larger numbers in the commercial catch than are the males. This is probably an indication of an actual scarcity of males, and the result of intense fishing in a region of small crab population.

Fishermen occasionally catch a disproportionate number of males or females when there is reason to believe that the sexes are about equal in numbers. During June and July, 1931, for example, the Boundary bay commercial catch by actual count contained about 98 per cent male crabs. This probably resulted from a segregation of sexes. Segregation apparently occurs on the basis of size or sex and may be related to such physical factors of the environment as depth and water temperature.

#### REPRODUCTIVE ORGANS

The female crab may be recognized by a "∩-shaped" abdomen and several pairs of abdominal appendages. The male, on the other hand, has a "∧-shaped" abdomen and only two pairs of appendages.

The reproductive organs of the female consist of a pair of *ovaries* located in the forward portion of the cephalothorax, one ovary on each side, which are connected on the outer side in each case with a sac known as a sperm receptacle or *spermatheca*. Each of these is in turn connected by means of a short tube, the *oviduct*, with the external openings on the sternum where they are covered by the folded abdomen. During the period in which the eggs are developing, the female reproductive organs come to occupy practically the whole internal dorsal surface of the body with the exception of the surface of the gills. They even fill the small spaces above and below the heart and around the digestive gland or liver.

The male organs of reproduction, which occupy considerably less space than those of the female, consist of the *testes* which lie just under the carapace (fig. 6). They are paired and one testis lies on each side of the stomach. During the mating season these pinkish-white organs become considerably enlarged. Connecting the testes with the external openings at the bases of the last pair of

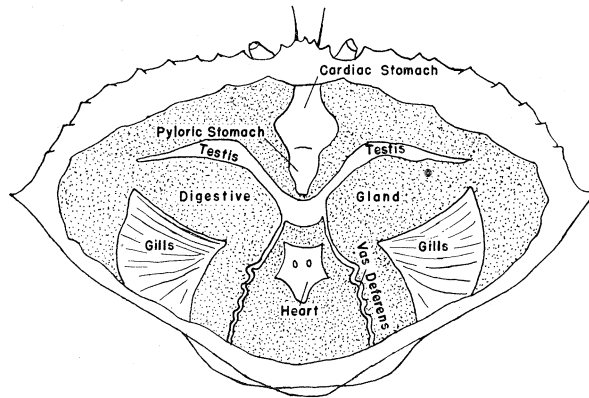


FIGURE 6. Diagram of male crab to show some of the organs that may be seen when the carapace is removed. In the female the large ovaries are located in approximately the position occupied by the testes.

walking legs is a pair of long convoluted tubes each of which is known as a *vas deferens*. The sperms, which are formed in the testes, pass down the vas deferens where they become collected into small "bundles" about each of which a capsule is secreted. The appendages of the first and second abdominal segments are modified to serve as copulatory organs, and during mating the sperms are transferred by means of these from the external openings at the bases of the last pair of walking legs of the male to the spermathecae of the female.

#### MATING

Mating of the edible crab occurs in British Columbia from April until September. It has been observed at Clayoquot sound from April to June. Prince Rupert fishermen state that they have observed mating chiefly in Sep-

tember, and the writer has found mating crabs in Boundary bay from May till September.

Mating takes place largely on the tide flats and seems to occur only between a soft-shelled female and a hard-shelled male. The female crab is frequently carried about by the male until she moults. During moulting there is reason to believe that the male releases the female and reclasps her later. Mating crabs become almost completely buried in the mud and covered by seaweed. The male clasps the female with his legs and they lie sternum to sternum in a nearly vertical position. At Clayoquot sound, according to Professor G. J. Spencer, holes dug during the mating embrace continue to be visible on the tide flats as long as two months after mating has occurred.

After copulation the cavity of the oviduct is closed by a secretion which hardens on contact with the salt water and thus closes off the passage and imprisons the spermatozoa within the spermatheca. Unlike those of most other animals, the spermatozoa of the crab remain alive for many months before fertilizing the eggs.

#### EGGS

The eggs develop within the ovaries where they undergo changes in colour from pale white to pink, salmon, and reddish. These colour changes are correlated with changes in size. Apparently also the number of eggs carried by a female crab is related to body size, a larger animal ordinarily carrying more eggs than a smaller one. As many as 1,500,000 eggs have been counted on one animal and this probably does not represent a maximum. It seems probable that an average female may produce during a life-time 3 or 4 broods with a total of 3 to 5 million eggs. The eggs on extrusion become fertilized and attached to the abdominal appendages where they undergo development.

#### EGG-BEARING PERIOD

Available evidence seems to indicate that the egg-bearing period for crabs in British Columbia is mainly from October to June, although Professor Spencer reports finding egg-bearing crabs during July and August. Seventeen per cent of the 339 female crabs examined by the writer in the vicinity of the Nass river in northern British Columbia in May, 1930, bore eggs.

#### HATCHING

Hatching of the crab larvae occurs from December until June, reaching its height in March in British Columbia. However, the hatching period can be stated only approximately at the present time.

#### LARVAE

The eggs of the edible crab hatch as *Protozoae*, a stage which is always of short duration. The protozoa swims rather ineffectively by active contortions

reminiscent of those of the mosquito larva. The feathered spines of the posterior part of the abdomen and the antennae are used for this purpose.

The protozoae moult into zoeae which, in contrast with the previous stage, are very active (fig. 7). They swim by rowing movements of the maxillipeds (mouth appendages), often in a peculiar inverted position with the head down and the dorsal spine forward. There are several zoeal stages. The zoeae are followed by a stage known as the *megalops* which is much larger than the zoea

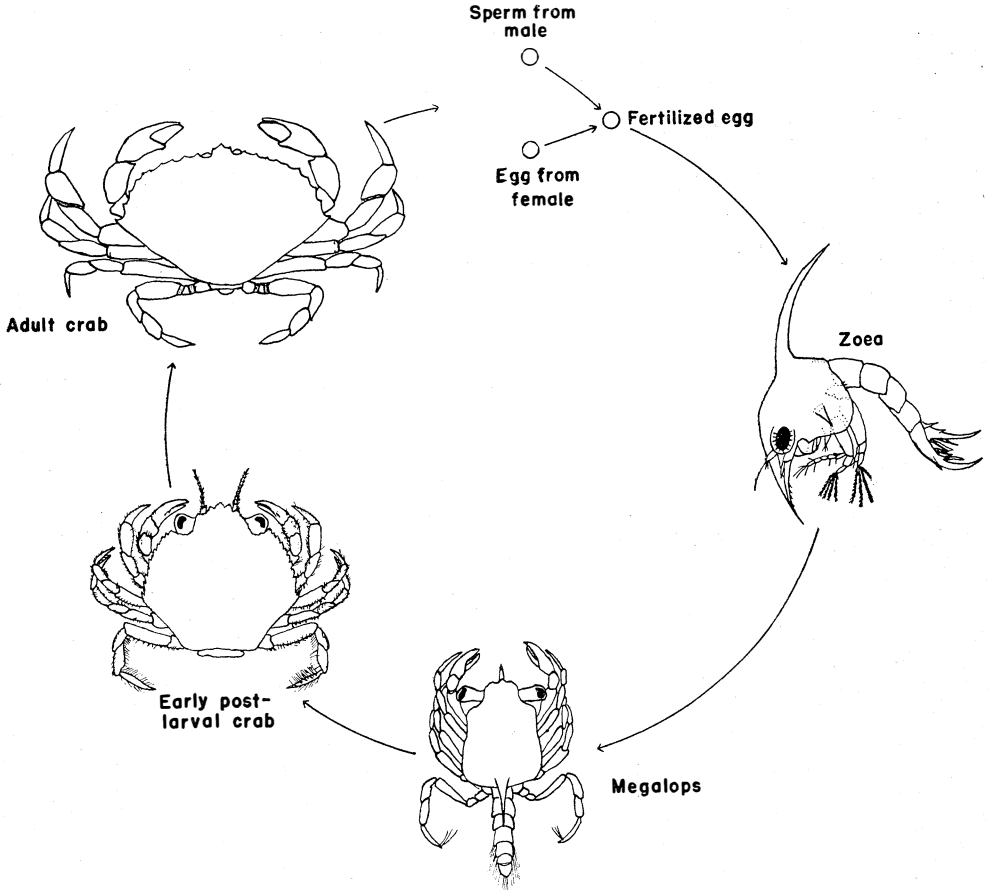


FIGURE 7. Diagram to illustrate the life history of the crab. For sizes of the different stages see figure 11.

and has an average width of about  $\frac{3}{32}$  of an inch and a length of about  $\frac{1}{4}$  of an inch. The length is much greater than the width at this stage, and the general shape somewhat resembles that of the lobster except that the abdomen of the crab is relatively shorter. Pigmentation is more pronounced in the megalops than in the zoea, and the dorsal spine is smaller (fig. 7). Respiration is carried on by means of the anus at this stage of development, by gills at all subsequent

stages. In British Columbia the megalops are to be found mainly during July and August and only occasionally as early as May or as late as September.

#### POST-LARVAL STAGES

The larval period includes those stages described above and ends with the megalops. Thereafter the young crab closely resembles the adult in form and continues throughout life to pass through one moult-stage after another. (See figure 11). The early post-larval stages have been identified both from monthly frequency distributions involving nearly 6,000 crabs, and from moulting records obtained in the laboratory and in the field. From these data it is clear that in Boundary bay megalops are chiefly present during July and August, crabs in the first post-larval stage during August, in the second stage during August and September, and in the third stage during September, October, and November. Some crabs reach the fourth stage as early as September.

During the summer and autumn months growth is rapid, moulting being frequent and the proportional size increase large. Several stages are passed before the onset of cold weather when growth apparently slows up. An indication of the duration of each of these stages may be gathered from the following records of crabs which moulted in the laboratory:

1st post-larval stage. . . . .	11.4 days
2nd " " " . . . . .	11.6 "
3rd " " " . . . . .	10.0 "
4th " " " . . . . .	21.6 "
5th " " " . . . . .	34.3 "

One crab kept by the writer spent 30 days in the 3rd stage. In general, the duration of progressive stages becomes greater until moulting becomes a yearly event about the time of sexual maturity.

#### MOULTING

The process of moulting, technically known as *ecdysis*, consists in the shedding of the rigid external skeleton together with the lining of the stomach and certain other internal parts and supporting structures. In the edible crab, when moulting is about to take place, splits in the exoskeleton occur posteriorly and along the sides of the carapace. Thus the exoskeleton is like a box that is hinged at the back and of which the carapace acts as a lid.

Large numbers of moulting crabs were found by the writer buried in the sand near low tide mark. They were ordinarily rather inactive when caught and most of those that moulted in live wells did so at night. The act of emerging from the old exoskeleton required only a few minutes in the cases observed but was preceded by a long period of preparatory muscular movements. The first part of the animal to emerge is the abdomen and this is followed by the body and legs.

Immediately after moulting the crab is ordinarily very active and it is probable that this new fleetness of movement makes up for the softness of the exoskeleton and the ineffectiveness of the claws. If a crab in this condition is taken out of the water it is completely helpless, the appendages being too weak to sustain the body under these conditions, and if the animal is placed on its back in the palm of the hand the heart can be felt beating. The shell soon begins to harden and in a few days the animal is reasonably well protected once more.

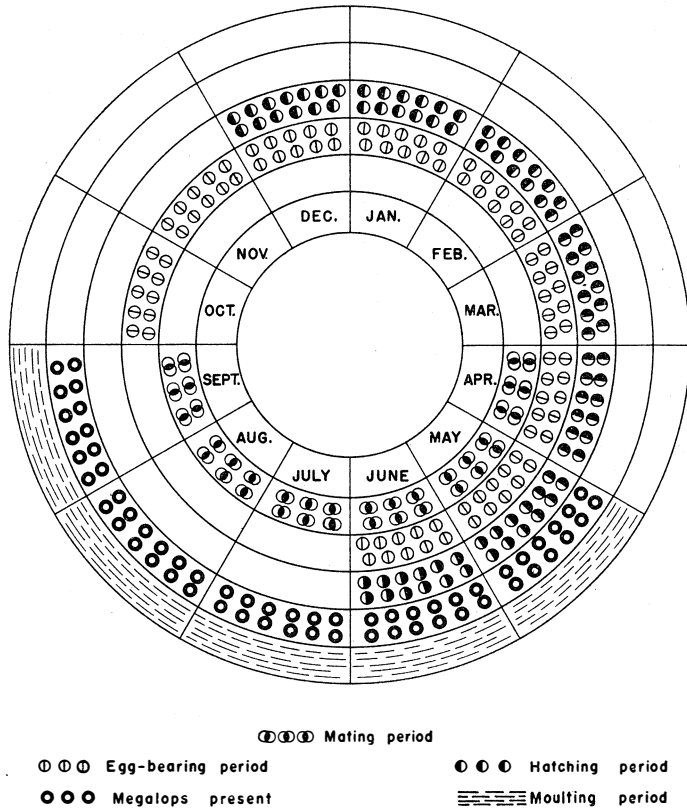


FIGURE 8. Diagram showing the months of the year during which mating, egg-bearing, hatching and moulting ordinarily occur as well as the months in which crabs are to be found in the megalops stage.

However, it must require upwards of two weeks for the shell to become completely hardened, the exact period not being accurately known at the present time.

Moulting in British Columbia occurs mainly from May until September and is probably at its height in June. Records indicate that it occurs during approximately the same period in California. There is reason to believe that crabs of all sizes moult in the spring and early summer and that moulting in the autumn occurs chiefly among 2 to 3¼-inch crabs. These crabs are probably about

two years old and are thought to be moulting for the second or third time during the third season. Mating and moulting occur during the same season and, in the case of the mature female, it may require less than two days for both activities.

## FOOD

The determination of the food of crabs is complicated by the fact that they are ordinarily caught with bait. Crabs eat oysters, cockles, and small fish. They sometimes practice cannibalism. Clams, birds, halibut and salmon heads, and chicken entrails make excellent crab bait.

The examination of stomachs has shown the following to be present (the items occur in the order of frequency): 1,—Crustacea (shrimps, small crabs, barnacles, amphipods, isopods, etc.); 2,—Mollusca (pieces of clam shell); 3,—worms (worm jaws and bits of skin); 4,—seaweed (rare); 5,—sand (thought to be accidental).

Where traps are baited it is a general observation that fresh bait is much more effective than old. In the laboratory it has been noted that when a piece of fresh food has been placed in the aquarium the crabs will often eat it ravenously even though older food of the same kind has been left unconsumed for days. Not all species of crabs show this preference, however. Some are vegetarians (e.g. the kelp crab), some are scavengers (e.g. the shore crabs), and some eat fresh animal food almost exclusively (e.g. the edible crab). People who object to eating crab meat after having seen crabs preying upon a carcass that is washed ashore are failing to differentiate between species. Some crabs undoubtedly are scavengers but the edible crab of this coast seems to be very particular about the selection of its food.

## PARASITES AND COMMENSALS

The question of parasitism is of particular interest in the case of the edible crab because of the fact that nothing on the subject has been published to date. Some investigators state that there are no parasites.

During the summer of 1932 the writer observed adhering to the carapaces of several crabs a species of worm which had apparently not been previously reported in association with *Cancer magister*. They were identified by Mr. and Mrs. C. Berkeley as very small specimens of the polychaete *Nereis cyclurus*, first described by Harrington (*Transactions, New York Academy of Science, vol. 16, pp. 214-221, 1897*) from Puget sound where they were found living commensally with various species of hermit crabs. The interesting question has been raised as to whether the small specimens found adhering to the edible crab live the first part of their lives with the true crabs and the latter part with the hermit crabs. If this should be so, then those free living members of the species which are sometimes found may be in process of migration.

During the course of crab observations made by the writer in 1930, minute worm-like animals were found on the abdomens of female crabs, either attached

to the abdominal appendages or in the inter-segmental regions. It was observed that in egg-bearing females these small animals tended to be much larger than in others, and that in these cases they were to be found chiefly among the eggs. None whatever were found on male crabs. From these facts it was believed that nourishment was derived from the eggs. They were positively identified on 83.8 per cent of the 361 crabs examined for them. Specimens have been sent to several competent authorities but so far they have not been identified. It is not believed that they are particularly harmful to the crab.

Barnacles are common on crabs but, aside from the fact that they sometimes grow in awkward positions and prevent the free action of the claws and legs, they are probably not detrimental. Barnacles were found on 45 per cent of one lot of 312 large crabs.

The absence of the parasite *Sacculina* on *Cancer magister* is of particular interest. This degenerate crustacean is found on many species of crabs and produces wide-spread effects in the individual parasitized, but it has never been reported for the Pacific edible crab. It cannot be common since among the 30,000 or more crabs examined for the present study none were found.

#### ENEMIES

Crab larvae form a part of the *plankton*, or minute floating organisms which constitute much of the food of larger aquatic animals. The examination of fish stomachs frequently reveals the presence of larval crabs. For example, a 4½ lb. coho salmon caught 4 miles SW. of Caines island on May 4, 1940, was found by Drs. A. L. Pritchard and A. L. Tester to contain 1,500 megalops of the edible crab. These larvae constituted 100 per cent of the stomach contents. Twenty-two other records are at hand which show that coho and spring salmon, chiefly during July and August, often eat large numbers of crab megalops. Crab larvae undoubtedly form a considerable part of the food of other marine animals as well. Examination of herring and pilchard stomachs by Mr. G. H. Wailes and Dr. J. L. Hart has likewise revealed the presence of crab larvae.

#### BEHAVIOUR

##### LOCOMOTION

In the larval stages crabs are free-swimming and are sometimes to be seen in large numbers near the surface. One megalops was observed to hold its own against a current of 35 feet per minute or four-tenths of a mile per hour.

Adult crabs characteristically walk sideways in either direction and their flattened legs are sometimes used for swimming although they are not nearly so well adapted for this purpose as are those of certain other crabs not found in British Columbia waters.

##### BURROWING

*Cancer magister*, unlike various other crustaceans, does not inhabit permanent burrows. However, it does at times bury itself in the sand. In May, 1932, when

crabs were scarce in Boundary bay, the writer discovered in the sand beneath a sheet of corrugated iron situated near low-tide mark, 12 crabs all within the three square feet covered by the metal. During May, June and July this locality was frequently observed and crabs were invariably found under metal or other solid objects. Other regions where similar conditions prevailed were subsequently discovered and likewise studied. Numerous crabs found in this way were on the point of moulting and many of the crabs which moulted in live wells within 48 hours of capture, were secured in this manner. In February, 1940, a similar observation was made by Dr. C. R. Elsey, who was using a duck-bill cultivator on some Boundary bay tide-flats in order to recover oysters that had become buried as the result of a storm. In doing so he turned up thousands of 2 to 3 $\frac{3}{4}$ -inch edible crabs where the surface of the sand gave no indication of their presence. The cultivator dug to a depth of about 4 inches and uncovered 10 to 15 crabs per square foot. They seemed to be present over the entire area.

Large numbers of small crabs have been found buried in the sand in the Boundary bay oyster beds in the spring of the year and especially in the month of June. It seems probable that the presence of abundant food in the form of young oysters is at least partially responsible for their presence there.

When disturbed in their natural surroundings small year-old crabs usually bury themselves in the sand, first retreating a short distance and then digging in rapidly.

Small crabs brought into the laboratory and placed in dishes with clean sand clearly show the method of burrowing. The walking legs push back and stir up the sand; the claws thrust the sand forward from the body. The stirred up sand settles on the crab and conceals all except the eyes and antennae. A small cavity is left just in front of the animal which allows for the exchange of water that is required for respiration. If more sand is sprinkled upon the animal it will rise toward its first position; if the sand is washed off by a stream of water it will dig deeper. This position affords obvious advantages. Although concealed to all but the closest observation the crab is still able to see, feel, and detect food or other chemical substances. It is in a position either to retreat further into the sand or to break cover in flight or in the pursuit of food. In the laboratory a movement of the hand above the dish in which the animal is living will stimulate the crab to withdraw its eyes beneath the sand indicating that it is able to see while in this position. The antennae likewise may be stimulated by an object moving over the sand.

#### RESPONSE TO LIGHT

In a laboratory experiment a number of megalops were placed in a long cylindrical glass vessel which was brightly illuminated by sunlight at one end and was quite dark at the other end. The larval crabs reacted quickly by going to the lighted end of the vessel. They did this irrespective of the position of the vessel or the end which happened to be darkened. Animals that go toward light

are said to be *positively phototropic*. The experiment with larval crabs furnishes an excellent example of this type of response in nature. Crab megalops are sometimes to be seen swimming near the surface. Adult crabs, on the other hand, ordinarily conceal themselves when this is possible and by so doing they get into dark places. It is therefore probable that the adult animals display the opposite response to light. In other words, they are probably *negatively phototropic*.

#### LOSS OF LEGS AND CLAWS

When a crab is caught by a claw or leg or when its limb is crushed or injured, it may cast off the appendage by a reflex action. This process is known as *autotomy* and the appendage always breaks off at a particular point near the

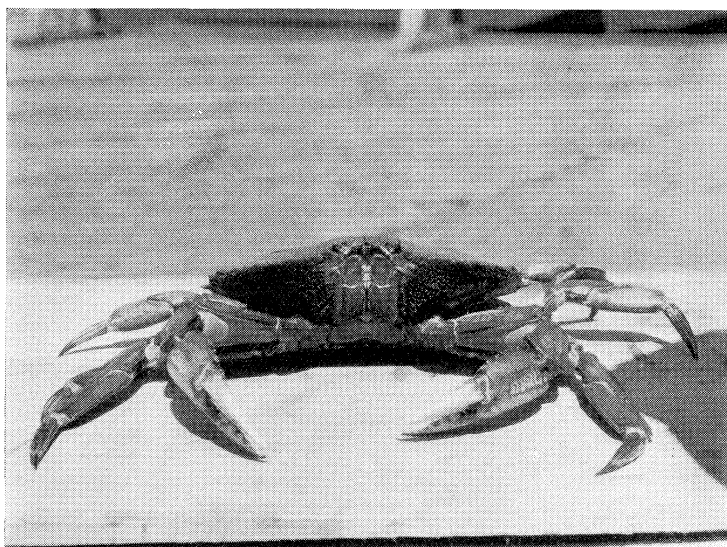


FIGURE 9. View of the crab from the front. (Photograph by Professor F. W. Weymouth).

body called the *breaking joint* (fig. 4). At this point the blood vessels are small and excessive bleeding is unlikely. Appendages lost in this manner are replaced, the complete process of replacement ordinarily requiring several moults.

#### MIGRATIONS

For the present purposes the word "migration" is taken to mean a *systematic directional movement*. Miscellaneous random movements, therefore, although sometimes referred to as migrations, will not be so regarded here.

The European edible crab, *Cancer pagurus*, a close relative of the Pacific species, is reported for the United Kingdom as migrating when over 4 inches in

breadth, and for the most part mature. The movements are characteristic of both male and female hard and soft-shelled crabs and may be grouped into a general offshore trend in the autumn and an inshore movement in the spring. From December to February the crabs occupy the offshore waters and it is there that the females spawn. The movement inshore, where the larvae hatch, begins in February and is probably completed by May.

For the Pacific edible crab the picture is unfortunately less clear. Four principal investigations of their migrating behaviour have been carried out, the first by Professor F. W. Weymouth at San Francisco, the second by Professor G. J. Spencer at Clayoquot sound, and the third and fourth by the present writer. The results of the first two investigations indicate that the maximum distances travelled were 15 miles and 400 yards respectively. There was no indication of a migration in the sense in which it has been defined.

TABLE I. Crab tagging experiment in the vicinity of Prince Rupert, 1930

Date liberated	Date recaptured	Elapsed time (days)	Sex	Distance covered
July 16	Aug. 3	18	female	less than one mile
" 16	July 29	13	male	" " " "
" 8	" 22	14	female	" " " "
" 16	Aug. 1	16	"	" " " "
" 16	" 16	31	"	" " " "
" 16	Oct. 13	89	"	" " " "
" 16	" 13	89	"	" " " "
" 8	July 26	18	"	" " " "
" 16	" 26	10	"	" " " "
" 8	" 26	18	"	" " " "
" 21	July 7 (1931)	351	"	approximately 1 mile

During the spring and early summer of 1930 a tagging experiment was carried on in the vicinity of Prince Rupert. Four hundred and seventy-seven large crabs of both sexes were tagged and liberated. One brightly coloured serially-numbered chicken tag was attached to the base of a claw of each crab (fig. 1). Only 11 recoveries were reported although intensive fishing was being carried on at the time. One mile was the greatest movement recorded (table I).

In Boundary bay, British Columbia, another migration study was made during the summer of 1931. Seven hundred and fifty-four crabs were marked and a reward of 25 cents offered for the return of the tags with information relative to the place and date of recapture. Care was taken to tag only active healthy crabs that had moulted not long before and which would therefore continue to carry their tags for the longest possible time. As with the Prince Rupert area, Boundary bay is intensively fished and much was hoped for from the experiment. However, only 13 recoveries were reported. The results of 11 of these are shown in table II; the records of the other two are incomplete.

The longest movement recorded was one of 6 miles. In general the movements appeared to be haphazard; they entirely failed to show any noticeable tendency with respect to direction except for those crabs liberated in the warm, shallow, brackish water near the mouths of the Nicomekl and Serpentine rivers. Some of these were recovered nearer to the fishing grounds where the water is colder, deeper, and more salt. This observation corresponds with the fact that the edible crab is ordinarily scarce in warm, brackish water.

TABLE II. Crab tagging experiment in Boundary Bay, 1931

Date liberated	Date recaptured	Elapsed time	Sex	Distance covered
June 17	July	1 month	male	about 3 miles
" 17	....	....	"	about 6 miles
" 17	Aug. 1	45 days	"	about 3 miles
" 17	June 26	13 "	"	about 3 miles
" 17	May 15 (1932)	333 "	"	—
Aug. 5	....	..	"	less than 2 miles
" 5	Jan., 1932	5 months	"	less than 3 miles*
" 6	Sept. 7	32 days	"	less than 2 miles
" 6	Sept. 3	28 "	..	about 3 miles
" 6	Oct. 8	63 "	male	less than 3 miles
" 25	Apr. 15 (1932)	234 "	"	less than 1 mile

\*Crossed international border and was recaptured in the United States.

#### OTHER EVIDENCE BEARING ON MIGRATIONS

It is well known in the crab fishing industry that the catch from season to season shows great fluctuation for any given locality. Naden harbour, Queen Charlotte islands, and Boundary bay are notable examples of this. The possible causes of this phenomenon are numerous but two are perhaps outstanding. It may be due to actual migration, although the available information does not favour this view, or it may be explained by changes in behaviour accompanying moulting, mating, temperature changes, and the search for food.

It is probable, however, that both inshore and offshore movements do occur since the fishermen seem to achieve their best results by following these assumed movements with their trap lines. The controlling factor is probably temperature.

There is some reason for believing that the sexes may become segregated at certain seasons of the year. On the fishing grounds female crabs are sometimes caught in greater numbers than the males, whereas at other times the males are predominantly present in the catch. As an example of the latter, 6,043 crabs caught in the commercial fishery in Boundary bay during the summer months of 1932 proved to be 98 per cent males. That the actual sex proportions existing in the bay as a whole are more nearly equal is shown by the early post-larval crabs and by more than 3,000 cast exoskeletons of all sizes in which the sexes were as nearly equal in numbers as could be expected by chance. Segregation on the

basis of sex has been reported for the European edible crab, the Atlantic blue crab, and the shrimp.

At certain seasons small and medium-sized crabs bury themselves in the sand, often in large numbers. In the spring the adult crabs mate on the tide flats, the females moulting before, and the males after, mating. The resultant absence of crabs from the fishing grounds would lead to a smaller catch at this season and hence to the assumption that the crabs were absent on a migration.

### GROWTH

The crab shares with other crustaceans such as lobsters and shrimps, and with the insects as well, the characteristic of having its skeleton on the outside of its body. The presence of this rigid outside covering, which is called the "exoskeleton", necessitates the periodic shedding of the old skeleton (ecdysis) and the formation of a new one (endysis) as the animal increases in size through normal growth. During the early free-swimming stages these moults occur frequently, and the task of determining the number and corresponding size-increases has been possible only through rearing the crabs in aquaria and compartment live-wells and checking the observations with large collections of crabs and exoskeletons made on the tide flats and fishing grounds. By these methods, together with extensive collections and measurements of the animals in more advanced stages, it has been possible to determine the number of moult stages, the rate of growth, the age at sexual maturity, the age at minimum legal size, and the probable duration of life. The present information is based on the study of more than 30,000 crabs of which over 600 moulted in live-wells under observed conditions. Upwards of 20,000 measurements were made in an endeavour to provide reliable data concerning growth.

### RATE OF GROWTH

The final determination of the rate of growth in the edible crab has had to be achieved by statistical means since the simpler and more obvious methods applicable to some animals cannot be used for a marine animal in which all the hard parts of the body are periodically shed. For this method the reader is referred to "*The growth of the Pacific edible crab, Cancer magister Dana*" by Donald C. G. MacKay and Frank W. Weymouth, *Journal Biological Board of Canada*, vol. 1, no. 3, 1935.

One fundamental requisite for a satisfactory growth study of the crab is a knowledge of the size increases per moult. This information was obtained in the present instance by securing records of crabs that had moulted naturally on the tide flats, leaving their cast-off shells behind, as well as by records of moulting in the laboratory and in compartment live-wells. From these data it has been found that the per cent increase per moult is greatest in young crabs where it reaches approximately 40 per cent at a body width of about  $\frac{1}{4}$  inch, that the per cent increase declines at about the same rate in both males and females up to

the time of sexual maturity (about 4 inches), and that thereafter the increase per moult is less in females than it is in males. The latter drop to approximately 15 per cent and the females to 8 to 10 per cent. As a result, males reach a larger size than females, and very few females ever reach the minimum legal size ( $6\frac{1}{2}$  inches).

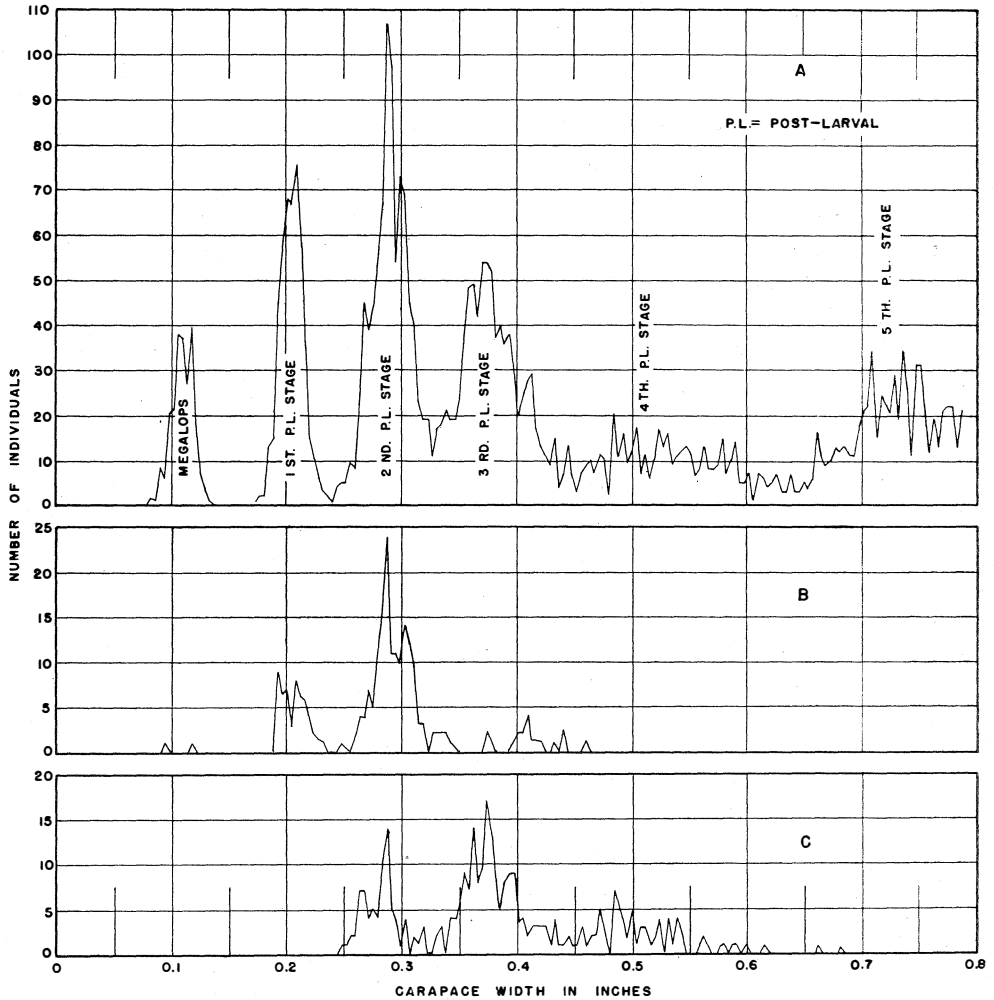


FIGURE 10. Frequency distributions of crabs under 0.8 inch carapace width to show at A the stages present in several thousand individuals collected over a period of months, and at B and C the sizes and stages present in Boundary bay on two successive dates during the same year. The collections shown at B were made between August 2 and 8, 1931, and those at C between September 16 and 20, 1931.

A further source of growth information has been the prevalent sizes (or size frequencies) month by month. This has been determined both from live animals

caught in large numbers without selection as to size, and from the cast-off exoskeletons that were found on the tide flats and on the shore.

It has been mentioned earlier that growth in crabs is achieved by means of a long series of "jumps" or moults, the crab remaining one size for a time and then suddenly increasing to a larger size which is maintained until the next sudden increase. When accurate measurements are made of large numbers of crabs under 0.8 inches and measurements are suitably charted, it is possible to determine the size of these jumps and the sizes at various larval stages. This is clearly

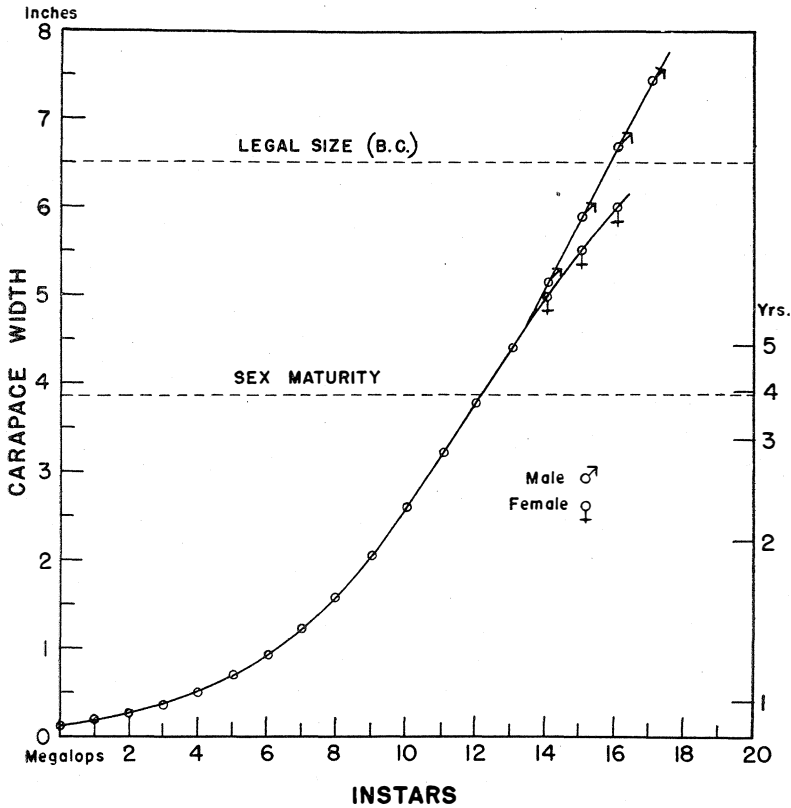


FIGURE 11. Instar number in relation to width of carapace. Megalops and first six post-larval stages (instars) based on size-frequencies; later stages based on moult increases.

shown at A in figure 10 which is based on measurements of thousands of individuals collected over a period of months. However, a collection made in any one day or week would show a preponderance of crabs of one or two of these stages (fig. 10, B and C). It would be possible by this means to find out readily whether the larval crabs of any one season were ahead of, or behind, those of another season in growth.

The intervals between successive stages increase with increasing age. Thus, during the first five post-larval stages, an increase from 11 days to 34 days has

been observed under laboratory conditions. Evidence from tagging experiments supports the conclusion that large numbers of crabs moult yearly. Intervals of two years, if they occur, must be infrequent.

#### NUMBER OF STAGES

From the average sizes in the early stages and from the increase per moult on the basis of size, the number of stages has been calculated and the approximate size of each determined. It seems probable that to reach the maximum sizes attained by male and female crabs in southern British Columbia, 17 and 16 post-larval stages respectively would be required (fig. 11).

TABLE III. Stages predominantly present in certain months in Boundary bay

Stage	Predominantly present in	Present to a lesser degree in
Megalops.....	July, August	May, June, September
1st post-larval.....	August	September
2nd " ".....	August, September	
3rd " ".....	September	October, November
4th " ".....		September
5th " ".....		
6th " ".....	May	
7th " ".....	June, July	May, August
8th " ".....	June, July, August	September
9th " ".....	July, August, September	
10th " ".....	August, September	
11th " ".....	May, June	
12th " ".....	May, June	

#### SEASONAL OCCURRENCE OF VARIOUS STAGES

Considering the sizes of large numbers of small crabs taken at different seasons from the point of view of the stages indicated in figure 11, the following results have been obtained for Boundary bay (table III).

#### GROWTH RATE

From an analysis of all available information concerning the growth rate of the edible crab the growth curve in figure 12 has been constructed. The central heavy line indicates what is thought to be the average growth rate and the lighter lines indicate the probable size-limits at corresponding ages. For widths above 4 inches the sexes differ and here the males are represented by a dashed, the females by a dotted, line. It will be noted that, in the older crabs, the males exceed in size the females of the same age. No attempt has been made in this figure to represent individual moult increases where moulting occurs more than once yearly.

## AGE AT SEXUAL MATURITY

It seems probable that most crabs become sexually mature in the fourth and fifth years but that some crabs become mature as early as the third year or as late as the sixth year.

## AGE AT LEGAL SIZE

Minimum legal size in British Columbia is  $6\frac{1}{2}$  inches, a size that is probably attained by the male during the seventh or eighth year. Very few females ever reach this size.

## MAXIMUM AGE

Allowing for one or two years during which crabs possibly do not moult, though there is no conclusive evidence that this often happens, the maximum age of the species would be ten years. Eight years probably represents the average

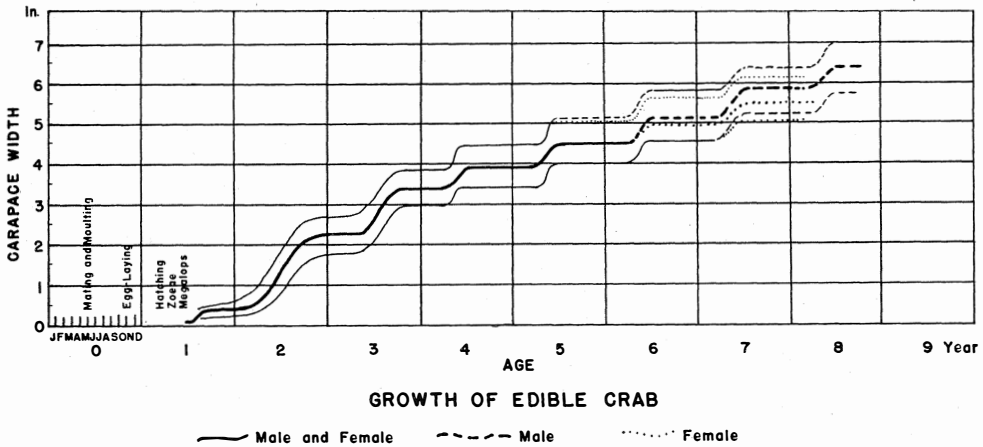


FIGURE 12. Size in relation to age. The central heavy line represents what is thought to be the average growth rate and the lighter lines indicate probable size limits at corresponding ages. No attempt has been made to show individual moults for small crabs that moult more than once yearly (see text).

duration of life in Boundary bay. The larger size observed at Prince Rupert and other northern points may indicate a greater age for the colder northern fishing grounds. This would be in harmony with the greater size and age observed in certain other forms having an extensive north and south distribution.

## RELATIVE GROWTH

A statistical study of changes in body form in the edible crab indicates a number of interesting facts. For example, after sexual maturity has been attained the legs of the male crabs grow more rapidly than the body, and the legs of the females grow less rapidly than the body. As a consequence the legs of

mature male crabs are longer than those of mature females of corresponding width. It has been found also that relative to the body the claws of male crabs grow more rapidly than do those of female crabs and especially so after the attainment of sexual maturity. As a result a mature male crab will have larger claws than will a female of like size.

A comparison of the carapace shape of the early post-larval crab in figure 7 with that of the adult in figure 3 will show that extensive changes in body form likewise occur as the animal grows.

Crabs from southeastern Alaska, both male and female, were found to be a little shorter in proportion to their width than were the corresponding Boundary bay crabs.

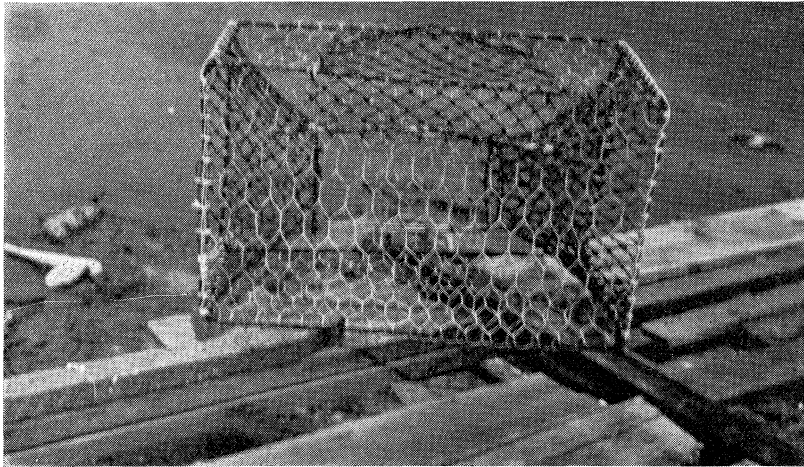


FIGURE 13. Type of trap in general use in Boundary bay.

### THE COMMERCIAL FISHERY

#### VALUE OF THE INDUSTRY

British Columbia in 1940 produced 1,405,300 pounds of crabs, of which 655,100 were sold fresh and 3,794 cases of the canned product were placed on the market. The pack for that year had a total value of \$80,628. Crabs came eighth among fishery products for the province in 1938, with a value of \$54,572, salmon came first with \$14,491,285 and shrimps eleventh with \$18,985.

TABLE IV. Value of crabs caught and number of crab fishing licenses issued in B.C. by years (value for calendar year, licenses for fiscal year)

Year.....	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
Value (\$.....)	45,447	29,177	27,914	16,832	34,296	32,325	44,525	38,855	52,188	54,572	61,633	80,628
Licenses.....	167	150	116	104	104	100	116	129	148	106	110	103

The yearly value of crabs caught in British Columbia covering the period 1929-38 and the number of fishing licences issued yearly during the same period is indicated in table IV.

## FISHING GEAR AND FISHING METHODS

Five methods of fishing crabs are used on the Pacific coast. The gear employed consists of traps, hoop nets, forked sticks, spears, and dip nets, the first two types of gear accounting for about 99 per cent of the catch.

Crab traps are usually constructed from light iron rods (3/8-inch material) and are rectangular in shape. The dimensions are approximately  $36 \times 26 \times 17$  inches. Each trap is provided with two funnel-shaped oval entrances of about  $4\frac{1}{2}$  by  $8\frac{1}{2}$  inches set in the tarred netting of the trap ends as shown in figure 13.

In Boundary bay, traps are ordinarily set out in lines of 50 as diagrammatically illustrated in figure 14. Shorter lines (15-25 traps) are used in Clayoquot sound and in certain other areas. Each line is complete with a buoy and an

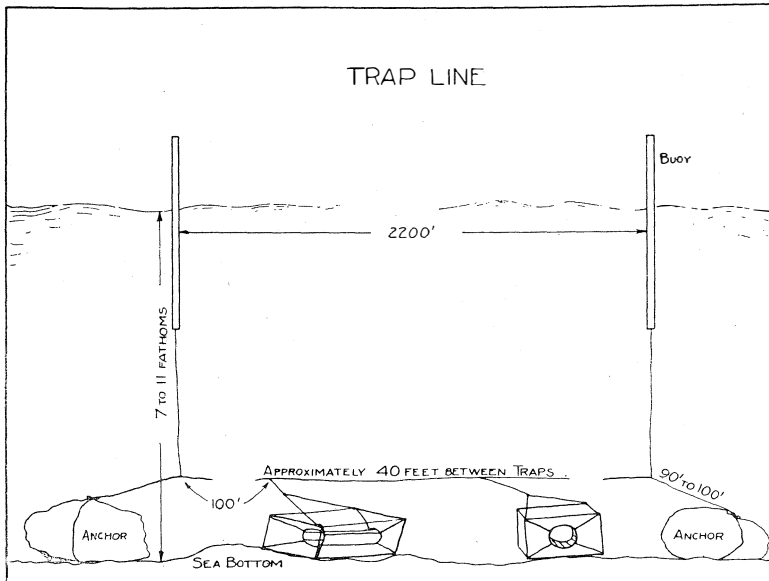


FIGURE 14. Diagram of a trap line of 50 traps as used in Boundary bay.

anchor at each end. The anchor frequently consists of a number of heavy rocks firmly fastened together. During the height of the season 20 or 30 such lines are used in Boundary bay alone. Occasionally, a trap is lost so that lines that have been out for some time have fewer traps than when they were originally set.

The boats used in the Boundary bay fishery are comparatively swift craft, several being powered with automobile engines (fig. 15). Due to the presence of a sheltered harbour and excellent shipping facilities, Crescent has become the headquarters of several Boundary bay fishermen. The shallowness of the water in the vicinity of the town makes it necessary to use boats of shallow draft. The fishing grounds are five or six miles distant by water and are 6 to 10 fathoms in

depth. The same area is regularly worked also by a number of crab fishermen operating from the town of Whiterock.

In the Queen Charlotte islands approximately 600 traps of a new kind (fig. 16) are being tried out for the first time in British Columbia. The frames of these traps are constructed of 5/8-inch welded steel rod covered with rubber tubing; the mesh is of copper wire. Each trap weighs roughly 50 pounds and with a suitable lifting device can be fished in about 55 seconds. Fishing is carried out in water approximately 10 fathoms in depth. Traps of this type cost about \$12.00 each and are said to be very effective. They are put out in lines of 15 and are baited with fresh razor clams.

In the Prince Rupert area the catch is smaller and the effort per unit of catch is probably greater than in Boundary bay and the Queen Charlotte islands. This results largely from a smaller crab population together with weather conditions that are less favourable for fishing. Trap lines are seldom employed and

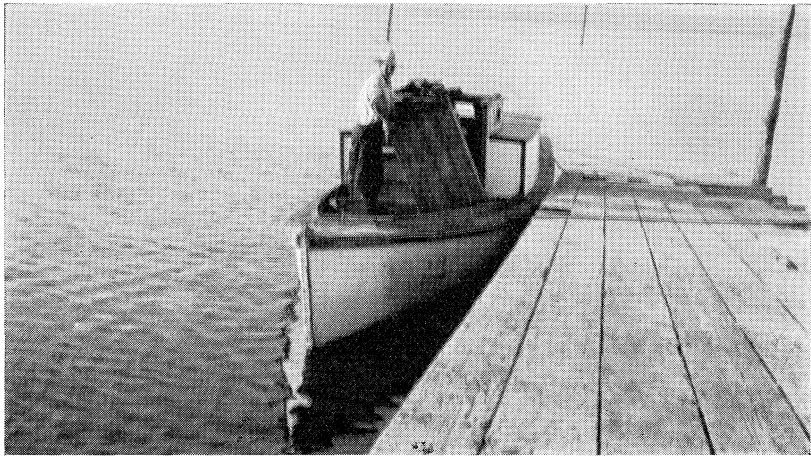


FIGURE 15. Crab fisherman unloading the day's catch in boxes ready for shipment.

fishermen occasionally go on trips of 150 to 200 miles for a week or ten days of fishing when weather conditions favour the undertaking. Nass harbour, where large but rather dark and unattractive looking crabs are obtained, is one of the places often visited on these protracted fishing expeditions.

Baited crab-rings, or crab-nets as they are sometimes called, are used to a considerable extent at Prince Rupert, Sooke, Saanich, and wherever traps are not the main means employed; they are used exclusively on extended fishing trips where it would be impracticable to transport traps.

Crab-rings are constructed from steel cart-wheel rims or from specially made steel rings. In the centre of the large ring is a smaller one, the whole surface being covered with netting. With this method of fishing the almost constant attention of one man is required since the nets must be frequently hauled to the

surface, ordinarily about once every half hour. The nets are baited with fish heads or other suitable material with the object of attracting crabs onto the surface of the net. The success of the method seems to be dependent both upon the hunger of the crabs and upon the fact that these animals tend to cling tenaciously to the nets as they are pulled sharply to the surface.

#### BAIT EXPERIMENTS

In northern British Columbia, on Vancouver island, and elsewhere, it is the custom to use bait in the fishery. Salmon heads, halibut heads, small pieces of fish, or clams of various kinds are used for this purpose. The bait is placed in the trap, sometimes loosely, sometimes secured by large fish-hooks and sometimes enclosed in bags made from netting or in punctured tin cans.

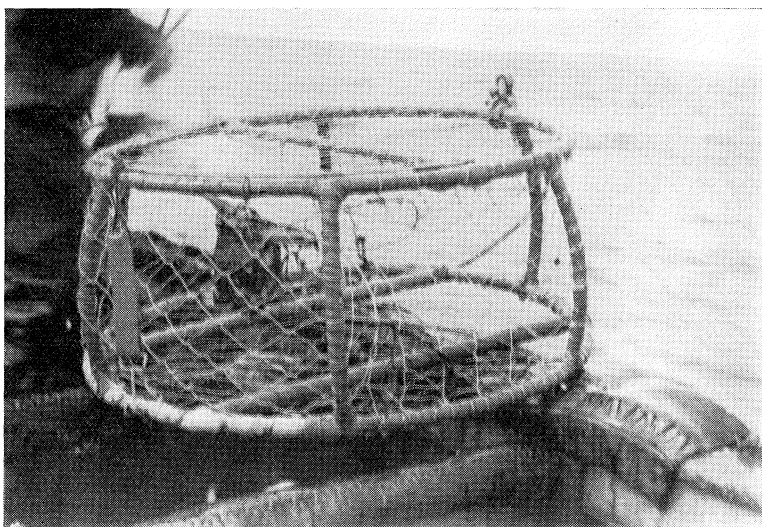


FIGURE 16. New type of trap used in the Queen Charlotte islands. (Photograph by D. B. Quayle).

It is said that about 25 or 30 years ago a certain Boundary bay fisherman neglected one morning to dig the clams that he usually used for bait. Instead of staying home, he proceeded to fish his traps that day without re-baiting them, and when the traps were next lifted no diminution in the catch could be detected. The labour of digging clams and baiting traps was soon abandoned. At the present time bait is not used in Boundary bay and the fishermen believe that it is entirely unnecessary.

When the writer proposed to test the possible advantage of baited over unbaited traps, a fisherman of his acquaintance was willing to wager that fewer male crabs of commercial size would be caught in the baited traps. "Bait," he said, "would merely attract females and undersized males neither of which can

be kept." The experiment was carried out with the full co-operation of the fisherman who very kindly allowed the writer the use of one of his trap lines for the experiment. The traps were put out on the regular fishing grounds off Whiterock, B.C. Thirty-six traps were used of which 18, or one half, were baited. The bait consisted of freshly dug clams and Japanese oysters from the adjacent oyster beds. These were placed in punctured tin cans in order to prevent the crabs arriving first from devouring all the food, thus leaving no "lure" for later arrivals. According to local custom, one crab was left in each trap.

When the traps were hauled two days later it was found that slightly more crabs of commercial size (the only ones wanted by fishermen) had been caught *without* bait than with it although the total number of crabs, including females and undersized males, was larger for the baited traps (table V).



FIGURE 17. A trap just hauled aboard the fishing boat.

The results of this experiment would seem to indicate that in Boundary bay the use of bait does not make much difference in the catch and that crabs of commercial size do not necessarily crowd into traps for food.

It was decided to determine the value of leaving one male crab in each trap, as in the foregoing experiment. It was thought by the fishermen that the crab might act as a lure in lieu of bait. A male crab is ordinarily left rather than a female because it is believed that males attract males (which are desired) and that females attract females (which cannot be sold and which occupy valuable space in the trap). In September, 1933, in a trap line consisting of 44 traps located on the regular fishing grounds in Boundary bay, a male crab was left in every second trap, while the other traps were empty and all were unbaited. The line was hauled a few days later with the following results:

With a crab . . . 4, 7, 6, 5, 4, 3, 2, 5, 3, 4, 6, 0, 0, 4, 1, 4, 4, 1, 7, 4, 4, 0 —Total 78  
 Without a crab . 6, 9, 2, 5, 9, 4, 4, 4, 2, 3, 2, 6, 4, 4, 5, 4, 3, 4, 1, 6, 3, 3 —Total 93

The results give no evidence in favour of this established custom, and the reason for the entrance of large numbers of crabs into the traps remains in doubt. It seems probable, however, that the success of baitless fishing in Boundary bay results from an excellent breeding ground and consequent abundance of crabs together with the constant exploratory activities of these animals.

TABLE V

With bait			Without bait		
Total males	Commercial sized males	Total females	Total males	Commercial sized males	Total females
12	11	4	11	6	0
9	7	8	10	9	6
14	9	14	14	10	6
13	9	3	9	6	4
7	6	8	7	4	3
10	8	3	11	6	12
10	8	6	15	8	3
13	6	7	11	8	8
11	8	4	17	12	2
12	7	7	2	2	3
10	8	15	13	5	12
12	5	6	14	9	6
8	5	9	6	5	8
7	6	9	9	6	4
13	6	3	8	5	4
10	6	4	13	7	12
9	4	5	19	14	1
11	5	9	14	8	6
191	124	134	203	130	100
Total with bait, 325			Total without bait, 303		

#### DISPOSITION OF THE COMMERCIAL CATCH

Most of the crabs caught in British Columbia waters are sold to the wholesale trade in the fresh condition. Those caught in Boundary bay are largely shipped alive to Vancouver and Victoria. The boxes used for this purpose are of uniform size ( $24 \times 13\frac{3}{4} \times 42$  inches, inside dimensions). On arrival at the destination by truck, train, or boat the crabs are thrown into boiling salt water, cooked, and offered for sale in the stores and on the beaches. During the process of boiling the crabs shrink slightly.

Canning of crabs is carried out in British Columbia principally at Masset in the Queen Charlotte islands. However, some canning is also carried on occasionally at Vancouver, Prince Rupert, and Tofino inlet, especially when more crabs are available than can be sold fresh. Canning is carried on much more intensively in some years than it is in others.

## FLUCTUATIONS IN PRODUCTION

The catch per trap shows enormous variation from season to season and from year to year. In an unusually good season a Boundary bay fisherman may sometimes take 50 dozen crabs of commercial size ( $6\frac{1}{2}$  inches or larger) from 40 traps at a single haul. In a very poor season two or three lines may not yield more than half this quantity. One fisherman may have several lines out at one time. Except when fishing is excellent or when the demand is great, he does not lift his traps more than two or three times per week.

Figure 18 graphically represents the catch per month of one Prince Rupert fisherman for one year. Unfortunately, the degree of effort cannot be measured,

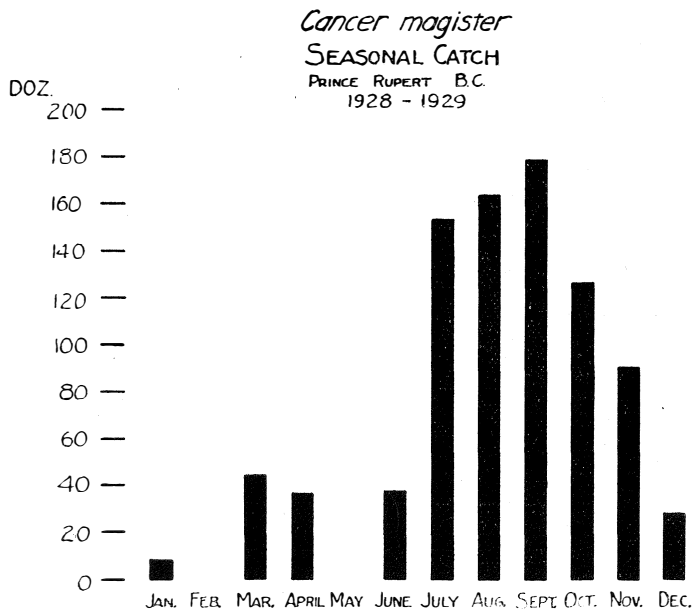


FIGURE 18. Monthly catch of one Prince Rupert crab fisherman.

but inasmuch as the records represent the total catch of one man who had no other occupation, it is probable that the effort was nearly uniform. There is ordinarily no overproduction in the region represented by these data. Weather conditions are partly responsible for the small catch during the winter months.

As has been mentioned, great fluctuations in production of canned crab meat occur from time to time. The total value of canned crab meat produced in British Columbia during 1921 was \$691; that for the year following was \$20,559. At the same time the value of crabs produced in the province increased from \$46,000 to \$60,000. Since most of the canning of crab meat is carried out in the Queen Charlotte islands, the fluctuations in production of the canned product are mainly related to the intensity of fishing and canning in these islands. The

potential production of the Queen Charlotte islands would appear to be large as is evidenced by a pack of approximately 2,000 cases in 1939.

Many factors work together to produce instability in this fishery. Most important of these seems to have been the importation of Japanese crab meat. The recent abundance of lobsters on the east coast is also considered to have depressed the industry. Crab meat is usually regarded as a luxury and as a consequence the demand shows greater correlation with general economic conditions than is probably the case with more staple articles of diet.

In addition to the economic factors, abundance is influenced by the weather since crab fishing is difficult or impossible in stormy weather, especially in the more exposed fishing areas. Furthermore, there are fluctuations from season to



FIGURE 19. A Prince Rupert crab fisherman showing type of trap in use there.

season and from year to year that have never been satisfactorily explained. It is possible that they may be due to dominant year groups, the spawning in one season, for example, having been more successful than in the preceding or following years. For a time, scarcity and abundance were thought to be due to periodic migrations, as mentioned on page 18.

#### CONSERVATION

The present laws for the conservation of the crab in British Columbia state that crabs under  $6\frac{1}{2}$  inches and egg-bearing crabs must not be taken. The latter clause is generally considered to refer to all females and not merely to crabs having

external eggs attached to the appendages on the under side of the abdomen. However, since few females grow as large as the minimum legal size, the effect of the law is to protect all females whether egg-bearing or not.

The present studies reveal the fact that sexual maturity occurs at a carapace width of about 4 inches. This means that, even though a male may happen to be caught just as he reaches the minimum legal size, he will have already mated once or twice. In view of this and since as a result of a single mating a million or more larvae may be produced, the present regulations should prevent extermination or serious depletion.