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A PRELIMINARY INQUIRY INTO THE CONDITIONS CONTROLLING THE SHRIMP INDUSTRY IN BRITISH COLUMBIA

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INTRODUCTION

Although it is usually one of the minor fishing industries, shrimp fishing is carried on in greater or less degree all over the world. North America is not an exception to this rule and in various parts of the United States this fishery brings in many hundreds of dollars per annum. For instance in 1916 Louisiana alone produced 23,160,586 pounds of shrimps. Nor is the Pacific Coast shrimp fishery a negligible quantity, for the statistics issued by the United States Bureau of Fisheries in 1925 valued the Californian trade at $146,023, and in 1926 gave the value of the Alaskan fishery at $195,828. Only between California and Alaska do the shrimps seem to be less valuable for in 1925 the value of the fishery in Washington was $5,363 and in British Columbia $16,035.

One of the main reasons for this being the case is the fact that the Californian shrimps almost all belong to the genus Crangon, fully 90 percent being Crangon franciscorum. These are shallow water forms, so that their habits are easily observed and the fishing is a fairly simple matter. In Washington and British Columbia, on the other hand, the shrimps are all comparatively deep sea forms, very few being taken in less than 12 fathoms. In 1899, Rathbun, in his review of fisheries of Washington and British Columbia said, "Shrimps and prawns of good quality seem to be plentiful, but they are not much fished for, and little information regarding them could be obtained. The habits of these forms are such as to place them generally outside the range of observation, so that fishermen may be scarcely aware of their presence, when an active search might disclose them in abundance." Very little has been added to this statement, so that the habits of the shrimps has remained a matter for investigation. An investigation was

accordingly started about June 1, 1927, intended to cover such matters as the times of mating and oviposition and the embryology of the shrimps together with a study of their rate of growth and food requirements. Obviously the work of one summer must necessarily be of a preliminary nature.

As it is proposed to publish a separate paper on the classification, food, and fishing methods it is only necessary to summarize the main points. The work on limiting factors is an essential preliminary to a study of the life history of the shrimps and so to an expansion of the whole shrimp fishery. Consequently a foundation was laid down for experimental research along this line, but more investigation will have to be carried out on a greater number of forms before the results can be considered definite. It seems advisable, however, to deal with these experiments in some detail in the present report.

The work here recorded was carried out at the Biological Station, Nanaimo during the summer of 1927. Thanks are due to the Biological Board for providing facilities for the work and to the Director, Dr. W.A. Clemens for his personal help and advice.

History of the Industry.

Shrimps and prawns were first mentioned in the Fisheries Statistics for British Columbia in 1899. At that time they were valued at $5000, and they have more or less steadily increased in value since then. As far as can be ascertained they seem to have been obtained for the most part in the neighbourhood of Vancouver and Victoria. This, of course, is only what might be expected, as these were the two largest markets. Spasmodic attempts have been made to fish farther afield, but, as long as the present methods of fishing and handling continue, difficulties of transportation make it impossible to go more than a few hours

journey from the nearest market. During the last few years a number of shrimps have been taken near Prince Rupert. These are usually shelled and shipped in five pound cans under refrigeration, most of them being sent to Seattle, as are the shrimps from Alaska. Thus little by little the fishery has grown and it is possible that the 1925 value of $16,035 may be appreciably increased within the next few years.

The principal competition in this industry comes from the United States in the form of canned shrimps, or picked shrimp meat shipped under refrigeration. These have two advantages, firstly the housewife finds them easier to use, saving her trouble in shelling, and secondly they can be shipped for considerable distances. Thus, although the cost of these prepared shrimps is much bigger, having the added cost of labour, transportation from the United States, and duty, they yet find a readier market than the fresh article, even though the latter, like all fresh products, may have a much better flavour.

The remedy for this, granted a sufficient supply of shrimps, is obviously the starting of a shrimp canning industry in British Columbia. True a little more care in the handling of the shrimps than is now used would probably enable them to be shipped for much greater distances, but even so there are difficulties of transportation in the handling of fresh shrimps which make it even more desirable to start canneries at places where shrimps may be found but markets are distant. It is possible that the salmon canneries, which now stand idle for several months of the year, might well be converted to can (during their slack season) the shrimps which are present the year round. Of course, there may be unforseen objections to this idea, and certainly something is wrong when the James Bacon Co. of Prince Rupert, the only company to attempt anything of this sort, send their product to Seattle whence they may be re-imported into British Columbia. It would thus appear that the operation of canneries would be one of the best hopes for the industry,

and at least merits consideration.

One shrimp, however, would be wasted by being canned. This is Pandalus platyceros, commonly known as a "prawn". They may reach a size of nine or ten inches in length, possibly more, yet the flavour, as all agree who have tasted them is better than that of the smaller forms. A few fair sized specimens are obtained in the ordinary shrimp trawls, but to obtain the largest individuals it is necessary to trap in at least 75 fathoms. It is only within the last year or two that a few enterprising fishermen have attempted this. At present they are nearly all sold to the Chinese who are willing to pay well but they deserve to be put on the ordinary market and to fetch the special price paid for luxuries. This can only be done successfully by giving them more careful handling and more rapid transportation than is done at present.

Methods of Fishing and Handling

Nearly all the shrimp fishing is done with a light beam trawl from a small power boat. As a rule there is only one man in each boat and the trawl is hauled by hand. As stated above a little fishing for the very deep water forms has been tried with traps within the last few years, but only on a very small scale.

The shrimps are usually cooked on the fishing boats as soon after catching as possible. After boiling in brine they are dipped in cold water, spread out in flat trays to cool, and then packed in ice. A few shrimps are sold, alive, to the Chinese.

Classification

Four species of shrimps are fished commercially in the neighbourhood of Vancouver and Victoria. It has not yet been ascertained what species are taken near Prince Rupert but judging by descriptions they are the same forms. All four species belong to the genus, Pandalus so that further south, near San Francisco, they would all be called "prawns". Here, however, the three smaller species, namely Pandalus danae, Pandalus hypsinotus and Pandalus borealis are commonly referred to as "shrimps" and only the very large form, Pandalus platyceros is called a "prawn". One other species Pandalopsis dispar, is occasionally taken in hauls of Pandalus borealis which it resembles superficially. Of all these forms Pandalus danae lives in the shallowest water, and therefore is most easily obtained. Unfortunately the supply of these near Vancouver is diminishing and the fishermen are being driven to trawl in deeper water in search of the other species.

Food

A number of stomachs of each of the four main species of Pandalus were taken from time to time and their contents noted carefully. There are, of course, slight differences between the food of one species and another, but in general it may be said that all the forms are essentially bottom feeders. They evidently use a great deal of discrimination in their choice of food as the diet was almost entirely restricted to worms and smaller crustacea. Molluscs and vegetable matter were only found in very small quantities that might have been picked up accidentally with the natural food. There were only two exceptions to this when the stomach was found packed full of algae, in one case a red alga in the other green. Generally then, the plankton has no direct effect upon the shrimps, and

they would merely have to move from one place to another along the bottom in search of pasture.

Early Stages

When the investigation was started about June 1, 1927 it was intended to begin by obtaining some of the ovigerous females, raising the larvae, and thus studying the larval stages. Unfortunately it was found that by June 1 all the eggs had hatched and most of the larval stages were completed. Some attempts were made to obtain larvae by towing, but only one of these, a haul taken at night one June 1 was at all successful.

This part of the research, then, had to be abandoned until the spring of 1928 when it is hoped to resume it at the Biological Station under conditions shown to be suitable by experiments carried out during 1927. Meantime enquiries were made among the fishermen and notes made of their observations, though these were but scanty. The general opinion seems to be that all the species spawn in very shallow water, and gradually divide out as they grow older into deep and shallow water forms. Two of the fishermen engaged in trapping the large, Pandalus platyceros, reported seeing some of the berried females, which ordinarily live at a depth of about 100 fathoms, in quite shallow water just at the time when the eggs were hatching.

Rate of Growth.

Throughout the summer of 1927 collections of Pandalus danae were made. These were always taken at the same place and as wide a range of size as possible was obtained. Thanks to the kindness of the men engaged in the trade these collections will be continued throughout the Winter. It is proposed to measure these specimens carefully during the summer of 1928 and it is hoped, in this way, to

divide them up into year groups, and determine the rate of growth, at least up to the time of maturity.

Factors Limiting Distribution

With a view to breeding the larvae and studying the various habits of the shrimps during the summer of 1928, it was felt advisable to make a preliminary attempt to keep some in captivity during the summer of 1927. A few notes had been made on the temperature and salinity of the water in which the shrimps were found. As the temperature was always considerably lower than that pumped out of Departure Bay near the Station and running in the salt water taps of the laboratory, apparatus was constructed to cool the salt water before it ran into the aquaria. About forty feet of copper pipe was coiled and placed in a wooden box in such a way that the structure could be filled with ice. This wooden box was then placed in another and the space between packed with sawdust. The water, after passing through this coil was cooled from about 20°C. to about 12°C. a temperature at which the shrimps should have thrived, had temperature been the main limiting factor. It was then led by a series of siphons through aquaria made out of battery jars. As a matter of fact later experiments seemed to show that temperature has very little direct effect though, in combination with other factors, it may have a very big indirect bearing on the vitality of the shrimps.

A number of shrimps, all Pandalus danae were brought over from Burrard inlet, being kept on the way in a glass battery jar full of sea water which was standing in ice. All these shrimps arrived in good condition and were immediately placed in the aquarium jars. However they became gradually comatose, within twelve hours several were dead and within thirty-six hours none were alive. The same day it was discovered that small specimens of Pandalus danae, and Pandalus

platyceros averaging about 3.5 cm. to 5.5 cm. in length could be obtained in Departure Bay in sufficient quantities for experimental purposes. A series of experiments were therefore started to discover whether copper poisoning might have been the cause of death in the above case, due to running the salt water through a copper pipe in the cooler. The availability of these shrimps also made it possible to try out the effects of temperature, salinity and light.

Effect of Copper

Wide mouthed quart jars were used with 650 cc. of sea water placed in each. In each case there was a control jar having no copper but otherwise kept under the same conditions. Thin sheet copper was used cut into pieces of varying areas. Only rough tools were at hand to cut up this copper so that the measurements of the copper given are only approximate. The results, however, are conclusive enough to be worth noting. In two cases all shrimps both those with copper and those without, died within a short period. Here some other factor was obviously at work and the results were discarded as worthless. In the first experiment there were two shrimps in each jar. In all other experiments there were three shrimps averaging 3.5 cm. to 5.5 cm. long in each jar. Three jars were run through at a time, two containing copper and one control. These were placed in a kerosene oil can packed around with sawdust, and with a lid. In this way the temperature and light conditions were kept constant and equal in the jars. When necessary a small piece of ice was introduced into the tin with the jars to lower the temperature. Both P. danae and P. platyceros were used but there seemed to be no differences in their reactions.

Area of copper	Average temperature	Length of Life
2 1/2 in. x 1 3/4 in.	8°C.	26 hrs.
4 pieces 1/2 in. sq.	16°C.	13 hr. - 15 hr.
2 pieces 1/2 in. sq.	16°C.	16 hr.
1 piece 1/2 in. sq.	19°C.	13 1/2 hr. - 15 hr.
1 piece 1/4 in. sq.	19°C.	15 hr. - 15 1/2 hr.

It may be noted that in the first experiment where there was the most copper the shrimps lived longest. Here, the temperature was lowest and in general, the higher the temperature the quicker the copper appeared to act. In all cases, the shrimps in the control jars were alive and healthy at the end of the experiment. It is clear, therefore, that the copper has a definite toxic effect, and the water cooling apparatus will be discarded in future.

Effect of High Temperatures.

In each of these experiments the shrimp was placed in a beaker containing sea water. This stood in a large dish of fresh water, to which small quantities of boiling water were added from time to time. The rise in temperature was a little uneven, tending to be quicker at the beginning but it averaged about 0.15°C. to 0.2°C. per minute. The water was stirred constantly to keep the temperature uniform throughout. At intervals of five minutes or less the temperature was noted and also any peculiar symptoms shown by the shrimps. Previous to experiment the animals were all held in large battery jars in the laboratory at a temperature of 18°C. to 21°C. It may be noted, in passing, that the shrimps seemed perfectly healthy in the laboratory in water up to 22°C. as long as this water was kept running fairly rapidly. This in spite of the fact that Schmitt (1921) says of the Pandalus danae in San Francisco Bay "no specimen was taken at a temperature

exceeding 12.2°C." and that near Vancouver and Departure Bay they were found at temperatures ranging from 7.7°C. to 15°C. The symptoms shown by the shrimps were the same in each case, first loss of equilibrium and a tendency to lie on the side, then rapid but irregular respiration and convulsive movements. Death was preceded by a peculiar jerky trembling in all the appendages and slow respiration. Finally all movements including that of the scaphognathite ceased together. The temperatures at which these various symptoms were apparent were noted in each case. In experiments 1, 2, 3 and 4 P. *danae* was used and in experiment 5 P. *platyceros*.

All temperatures are recorded in degrees centigrade.

	1	2	3	4	5
Beginning of experiment	18°	19°	21°	21.5°	21.5°
Loss of equilibrium	22.5	23.5	23.5	24.5	23
Rapid irregular respiration and convulsions	23	25	25.75	25.75	25
Trembling of appendages	25.75	26.25	27.25	27	26.75
Respiration and all movement ceases	26.5	26.75	27.5	27	27

It will thus be seen that the behaviour of the shrimps in response to high temperatures was remarkably constant, and that the two species used behaved in an almost identical manner.

Effect of Low Temperatures

These experiments were performed in a similar way to those on high temperature except that the beaker containing the shrimp was placed in a dish of iced water, cracked ice or ice and salt. The drop in temperature averaged 0.2°C. to 0.3°C. per minute although it was much more rapid at the beginning than at the end. The symptoms preceding death varied from those produced by high temperature in that there was no period of rapid respiration and convulsive movements. Instead the respiration merely became more and more slow and irregular until it ceased altogether.

At the end respiration was so slow that it was hard to say just when it ceased altogether. Frequently the persopods went on moving very feebly after the scaphognathite ceased to move. As before the first four specimens were Pandalus danae and the fifth a Pandalus platyceros but in this case they were all 3.3 cm. to 5.5 cm. in length. The observed results were as follows. As before all temperatures are recorded in degrees centigrade.

	1	2	3	4	5
Beginning of Experiment	17°	20°	17°	20°	20°
Loss of equilibrium	1.5°	0.5°	1.5°	3.5°	4.5°
Scaphognathite ceases to move	0°	-3.5°	0°	-2°	0.75°
Other appendages cease moving	-1°	-3.5°	-0.5°	-2°	0.5°

It will be noticed that the temperatures at which respiration ceased varied considerably for the different individuals. All, however, were considerably lower than that which any shrimp would meet under natural conditions. Hence low temperatures can have but little effect on their distribution.

Effect of Light.

Three half gallon jars were used in each of these experiments. One of these was left untouched, the second was painted black outside but had no lid, the third was painted black, and had a lid also painted black. These three jars were placed in a tub containing water and ice. By this means the water in all three jars was kept at about the same temperature, namely 10°C. - 17°C. The whole tub was kept on the lawn in front of the Station so that it was in bright sunlight for the greater part of the day. Each of the jars contained one litre of sea water, which was changed every twelve hours. Three shrimps were placed in

each jar and equal amounts of food (crab's liver) was given each time the water was changed. Considering that the shrimps live at a depth of at least twelve fathoms and frequently more it seemed probable that light would have an injurious effect. When the experiment was first started it appeared as though this expectation was about to be realized for the shrimps exposed to full sunlight made every attempt to avoid the direct rays. After a few hours however, they seemed to become accustomed to the conditions and from then on thrived equally well in light and dark jars, though they were slightly more active in the sunlight.

Both Pandalus danae and Pandalus platyceros were used but there was no perceptible difference on the results. This experiment was carried out twice, each time covering a period of several days. It is possible that if it was extended to cover several weeks the light might have an injurious effect by promoting a growth of diatoms, as was found to be the case in dealing with lobsters. It seems fairly evident, however, that light is not quickly harmful to the vitality of the shrimps.

Effect of Salinity

For this experiment seven 1/2 gallon sealers were used each with one litre of sea water. These were all placed in a tub which contained ice and water so that all jars were kept at the same temperature. One of the sealers contained sea water as it came from the tap in the laboratory. This water was tested for chlorine content, the value being expressed as grams of "chloride" chlorine per litre. To two of the sealers distilled water was added to lessen the amount of chlorine about three grams per litre and these were again analyzed. The remaining four jars had varying quantities of sodium chloride added and the amount of chlorine per litre was calculated. The number of grams of chlorine per litre is only given to the nearest tenth. In the first experiment the shrimps were taken straight from tanks in the laboratory and placed in the jars in which they were

destined to stay. Four shrimps were placed in each jar, two Pandalus danae, and two Pandalus platyceros. The laboratory water is that dealt with in Column 3.

Grams of Cl. per litre	7	10.1	13	16.1	19	22	25
Average length of life in hours	1.3	16.1	24			10.8	1.5

Those shrimps in the jars containing respectively 16.1 and 19 grams of chlorine per litre were still alive thirty-six hours after the beginning of the experiment.

In the second experiment the shrimps were gradually moved through water of varying salinity to that in which they were destined to remain. This was done to lessen the shock caused by taking a shrimp from water of one salinity and plunging it straight into water of greater or less salinity. As before four shrimps, two of each species were placed in each jar. The laboratory sea water is that dealt with in Column 3.

Grams of Cl. per litre	7.3	11	14.3	17.3	20.3	23	26.3
Average length of life in hours.	1.7	5.8	9.25	17.5	25.6	6.2	1.9

Evidently it was the actual salinity of the water and not the shock which caused shrimps in the water of extremely high or low salinity to die within a few hours. It may be noticed, also, that the shrimps did not live as well in the jars containing 13 to 14.3 grm. of Cl. per litre as they did in those having a slightly higher salinity. This agrees with Schmitt's observations on Pandalus danae in San Francisco Bay (1921) for he says, "No specimen was taken x x x in a salinity less than 25.7" and this salinity would be about 14.22 grm. of Cl. per litre. Further it may be said that, although small specimens of both Pandalus danae and Pandalus platyceros were found in Departure Bay in water having only 12.96 gm. of Cl. per litre they were never found in commercial quantities or of very great size in water

of less than 14.28 gm. per litre. The more rapid death of the shrimps in jars of medium salinity in the second experiment than in the first may be explained by the fact that the temperature was about 5°C. higher in the latter than it was in the former case.

SUMMARY AND CONCLUSIONS

1. History of the Industry

Shrimps have been caught in British Columbia, at least since 1899, nearly all near Vancouver and Victoria and a few near Prince Rupert. The principal competition in the industry is in the form of canned shrimps or picked shrimp meat imported from the United States. The remedy for this appears to be the starting of shrimp canneries in British Columbia. Pandalus platyceros, commonly known as the "prawn", is mentioned as one shrimp worthy of special attention. This shrimp is difficult to catch, but a delicacy worth the trouble.

2. Methods of Fishing and Handling

Nearly all the fishing is done with a light beam trawl from a small power boat. The larger Pandalus platyceros are caught in traps at a depth of at least 75 fathoms. The shrimps are usually cooked as soon after catching as possible, though as few are sold alive to the Chinese.

3. Classification

Four species are fished commercially near Vancouver and Victoria, namely Pandalus danae, Pandalus hypsinotus, Pandalus borealis and Pandalus platyceros.

4. Food

All four species of commercial shrimps are essentially bottom feeders, the

diet being almost entirely restricted to worms and small Crustacea.

5. Early stages

All larval stages being passed by June 1 when the investigation was started, they could not be considered during the summer of 1927. It is hoped to make another attempt in the spring of 1928 to keep the ovigerous females and raise the larvae. Meanwhile inquiries were made amongst the fishermen, and notes made of their somewhat scanty observations.

6. Rate of Growth

Collections of Pandalus danae are being made throughout the year 1927-28. It is hoped, by measuring these to obtain some idea of the rate of growth, at least up to the time of maturity.

7. Copper Poisoning.

It was found that very small quantities of metallic copper in the aquarium containing shrimps were sufficient to kill them within a few hours.

8. Effect of High Temperatures

Shrimps kept in water which was gradually heated died with characteristic symptoms at a temperature varying from 26.5°C. to 27.5°C. The temperature at which each of the symptoms appeared was also fairly constant for the different individuals in both species studied.

9. Effect of Low Temperatures

Shrimps kept in water which was gradually cooled died, as evidenced by lack of movement in the scaphognathite, at temperatures varying from -35°C. to .75°C. It appears that low temperatures can have but little effect on the distribution of the shrimps.

10. Effect of Light.

Shrimps were kept in jars that were painted black with a black lid, painted black but without a lid and unpainted. They seemed to thrive equally well in each during the few days for which the experiments were conducted.

11. Effect of salinity

Shrimps were kept in half gallon sealers containing water of various and known salinities. They appeared to be healthiest in water containing 13 gm. to 20.3 gm. of Cl. per litre. This corresponded with the salinity of the water in which the largest shrimps were found naturally in greatest numbers.

LITERATURE

1. Huntsman, A.G. 1924 - Limiting factors for marine animals. Contrib. Canad. Biol. 81-94.

2. Pacific Fisherman. 1926 - 1927. Annual Statistical Numbers.

3. Rathbun, Mary J. 1904 - Decapod Crustaceans of the Northwest Coast of North America. Harriman Alaska Expedition, X, 1-210, pls. 1-9.

4. Rathbun, Richard. 1884 - Notes on the shrimp and prawn fisheries of the United States. Bull. U.S. Fish. Comm. Sect. 1, 11, 816-825. 1887.
1887.- Shrimp and prawn fisheries of the United States. Fisheries and Fishery Industries of the United States, Sect. 5, 11, part 21, 799-810, 1884-1887.
1899 - A review of the fisheries in the contiguous waters of the State of Washington and British Columbia. Rep. U.S. Fish. Comm., 253-350.

5. Schmitt, Waldo L. 1921 - Marine decapod Crustacea of California. Univ. Calif. Publ. Zool. XXII.

6. Shelford, Victor E. 1916 - Physiological differences between marine animals from different depths. Puget Sound Mar. Sta. Publ. 1, 157-176.

7. Taylor, G.W. 1912 - Preliminary list of one hundred and twenty-nine species of British Columbia decapod crustaceans. Contrib. Canad. Biol. 187-214. 1906-1910.