

Results of Preliminary Shrimp Explorations

Off the Oregon Coast

in 1951

Introduction

Fishing for shrimp along the Pacific Coast started as early as 1869 in San Francisco Bay (Bonnat, 1932) and commercial fishing for shrimp has long been conducted in Alaska, British Columbia and Puget Sound, Washington. However, no commercial shrimp fishery of any sizeable magnitude has yet developed in the broad expanse of waters off the Pacific coast of North America between the Gulf of California and the Straits of Juan de Fuca. It has long been known, however, that shrimp of a commercial size do occur in these waters. There are numerous records of such shrimp being taken by government vessels engaged in scientific work, and commercial otter trawlers often catch small numbers of shrimp along with the various species of fish which form the basis of their livelihood.

Until recently, no serious attempts had been made to answer the question of whether shrimp were present in commercial quantities in the aforementioned waters. During the fall of 1950 and the spring and summer of 1951, the Bureau of Marine Fisheries of the Department of Fish and Game of California conducted explorations off the coast of California for the purpose of determining if shrimp were present in commercial quantities. The results of these explorations were very encouraging, and a commercial shrimp fishery may develop in California waters in the near future.

The shrimp were located in California waters as far north as the Oregon border. This suggested that shrimp should also be found in Oregon waters. Through the efforts of William Ellis Ripley, who directed the shrimp exploratory work off California, one of the shrimp trawls belonging to the California Bureau of Marine

Fisheries was secured on loan by the Fish Commission of Oregon, and explorations for shrimp were started during the fall of 1951. There were two major objectives in the explorations off Oregon: first was the opportunity to render a direct service to the fishing industry; and second was the desire to obtain information concerning the virgin shrimp populations as they exist before being subjected to a possible commercial fishery.

ACKNOWLEDGMENT

We wish to express our gratitude to the Department of Fish and Game of California and to acknowledge the many helpful suggestions received from Mr. Ripley concerning our exploratory work. We also wish to express our thanks to Dr. James B. Lynch of the School of Fisheries, University of Washington, for his help in the classification of the numerous species of shrimp obtained during our exploratory work.

Clark 1-1

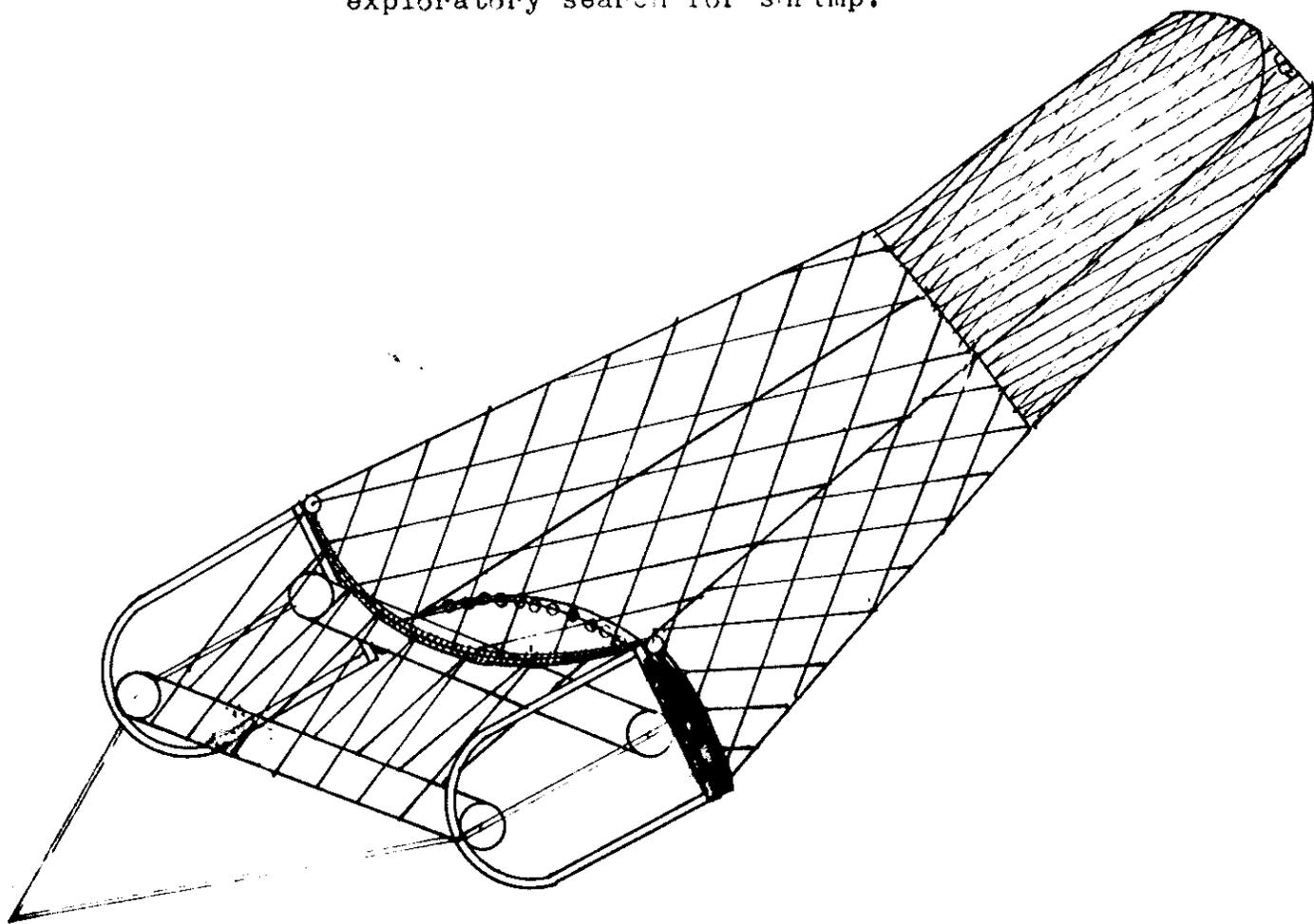
Methods and Materials

Beam Trawl

The beam trawl used in the explanatory work consists of two horseshoeshaped runners connected by two beams, and a funnel-shaped net with the open end of the net connected to the open ends of the runners (Fig.1). The beams consist of two pieces of heavily galvanized pipe each ten feet in length and 3 1/2 inches outside diameter. The runners are constructed of steel strap 3 1/2 inches wide and 1/2 inch thick. The bridle used to tow the trawl is 10 feet long and made of 3/8 inch diameter steel wire rope. Two swivels were attached between the head of the bridle and the single cable running from a winch of the fishing vessel (Fig.1).

The beams were filled with steel slugs to increase the weight of

Figure 1. Diagram of beam-trawl used in exploratory search for shrimp.



the trawl from its normal weight of approximately 320 pounds to a weight of about 700 pounds. This was necessary in order to obtain sufficient weight to sink the trawl to the bottom when fishing in deep water.

The net consisted of a 3 1/2 inch mesh body and a 1 inch mesh, 12 thread cod end. The mouth of the net was completely encircled by a lead line, and the top of the lead line was lashed to the front beam of the trawl so as to furnish an overhang.

Although more shrimp would have been caught with a net constructed of 1 inch mesh throughout, such a net was not available at the time the explorations were conducted. Tentative results obtained by the Department of Fish and Game of California, however, indicate that a net of 1 inch mesh construction throughout fishes from 5 to 7 times as effectively as the type with a 3 1/2 inch mesh in the body and a 1 inch mesh cod end.

The beam trawl was towed by a single cable running from a winch on the starboard side of a commercial otter-trawl vessel. The trawl was placed in the water and brought aboard the vessel by means of a hook line running from the boom on the vessel. The trawl framework was placed on the stern of the vessel inside of the gunwales. The net was ordinarily pulled aboard by hand, except when a large haul was obtained, at which time it was brought aboard by means of a hook line running from the vessel's boom.

end. here

Method of Determining the Areas to be Explored

Because of the limited facilities and time, it was evident that the areas of exploration would have to be rather restricted. The areas to be explored were chosen on the basis of two factors. Since the experience of the Department of Fish and Game of California was that shrimp were found on a green mud bottom, areas with such a bottom were given primary consideration. In addition, many commercial otter trawl fishermen were interviewed in order to determine the areas in which they found the largest quantities of shrimp.

Method of Delimiting the Shrimp Beds

Following California's example, drags were made at right angles to the coast from shallow to deep water until the center of abundance of the shrimp was located. This contour was then followed up and down the coast when possible until shrimp were no longer taken. Drags were then made at right angles to the aforementioned drags as a check against the possibility of the shrimp being located at different depths in the different areas.

Duration of Drags

Each drag was of 15 minutes duration, and the time counted was that actually spent by the net on the bottom. The net was considered to be on the bottom between the time the winch stopped after letting the cable out and the time the winch started up again to pull the beam trawl in. Although the net does not actually leave the bottom when the winch starts to wind in the cable, no method was found to compensate for this factor.

Method of Handling the Shrimp Taken in the Exploratory Drags

Although the primary objective of the exploratory work was to determine if shrimp were present in commercial quantities off Oregon, efforts were also made to learn something of the life history of the pink shrimp. Samples from each of the drags containing shrimp were accordingly saved and examined in the laboratory at the conclusion of each exploratory trip. While at sea, the shrimp were placed on ice in the vessel's hold, and upon return of the vessel to port the shrimp were frozen. Whenever samples were subsequently needed, they were removed from cold storage and allowed to thaw.

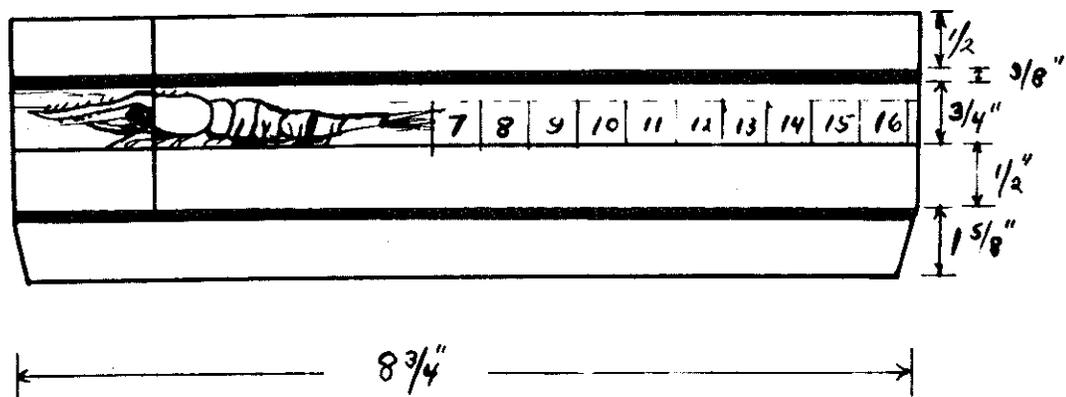
Method of Measurement of Shrimp

Berkeley (1930) found variation in the length of the rostrum of the same size shrimp, and for that reason she recommended that the rostrum be omitted from body length measurements. Another reason for the omission is that a large percentage of the shrimp have broken rostrums as a result of handling.

The measurements given in this paper include the distance, in millimeters, from the posterior base of the eyestalk to the tip of the telson when the shrimp is straightened out so that the longest possible measurement is obtained.

In order to facilitate the measurement of the shrimp a simple measuring device was constructed (Fig.2). A steel tape graduated in millimeters was glued in the groove of the measuring board, and a steel wire of small diameter was attached to the board so that the wire was superimposed over the zero millimeter mark on the tape. Each shrimp to be measured was placed on its side in the groove of

Figure 2. Diagram of Device used to measure shrimp.



of the board with its ventral surface pressed against the side of the board and then slid forward until the wire was directly over the posterior base of the eyestalk. The length in millimeters was then recorded to the tip of the telson.

Method of Sex Determination

Most of the shrimp taken in the exploratory drags were of one species, Pandalus jordani. The sex of Pandalus jordani may be determined from an examination of the structure of the inner ramus of the first pleopod or abdominal leg. A small rounded body, the organ of copulation, is present on the inner ramus of the males. The females do not have this organ of copulation, and the tip of the ramus is more pointed than in the male.

In addition to the above described sexual difference, the males have a structure known as the appendix masculina on the inner side of the inner ramus of the second pleopod. This structure is absent on the females.

The first pleopod was examined under a magnification of approximately 2 diameters. In most cases, such an examination was sufficient to determine the sex. In doubtful cases, however, the second pleopod was examined for the presence or absence of an appendix masculina.

Results

Areas of Exploration

Drags were made between the Columbia River and Yaquina Bay (Fig. 3). Each dot on the figure represents one drag of 15 minutes duration.

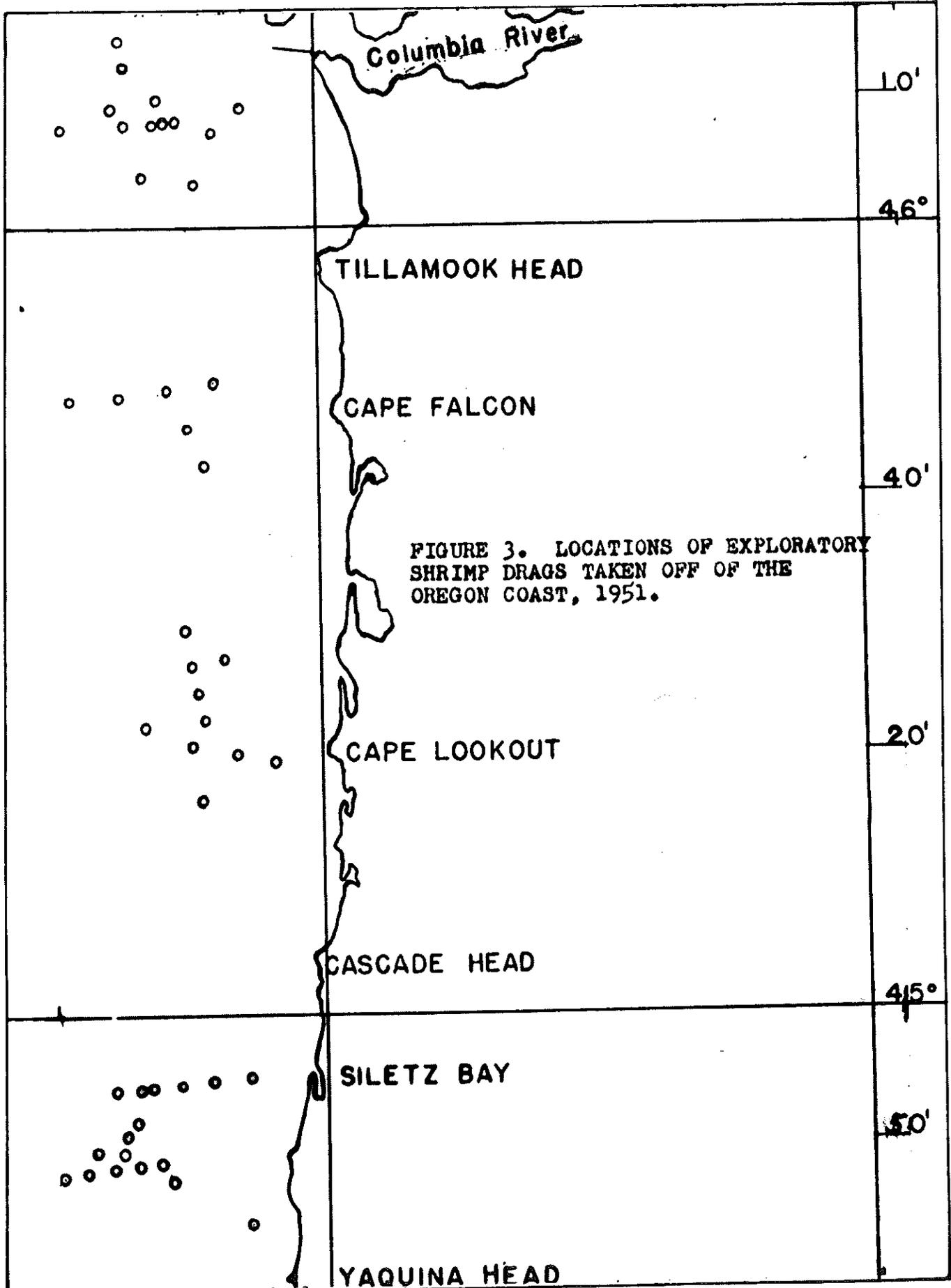


FIGURE 3. LOCATIONS OF EXPLORATORY SHRIMP DRAGS TAKEN OFF OF THE OREGON COAST, 1951.

Species of Shrimp in the Catches

As mentioned previously, most of the shrimp caught were the pink shrimp, Pandalus jordani. Other shrimp were taken in the hauls, but they at no time accounted for more than a small percentage of the total catch. For example, samples of 1556 shrimp taken from two separate hauls included 1556 shrimp, of which 88% were Pandalus jordani, 9% were Crago species, and 3 % were Spirontocaris species.

Abundance of Pink Shrimp (Pandalus jordani)
in the Areas of Exploration

Shrimp were taken in all the areas explored when the depth and type of bottom was favorable (Table 1). The pounds listed in the table refer to the actual amounts caught in the net, but it should be mentioned again that if a net of 1 inch mesh construction throughout had been used, an estimated 5 to 7 times as many shrimp would have been caught.

Table 1. Amount of Pink Shrimp (Pandalus jordani)
Taken in the Individual Areas of Exploration

Area	Number of Drags	Number of Drags Containing Shrimp	Total Pounds of Shrimp Caught	Pounds of Shrimp Drag ¹
Off Columbia River	13	8	81.0	10.1
Off Cape Falcon	6	3	18.0	6.0
Off Cape Lookout	10	8	69.0	8.6
Off Siletz Bay	17	11	58.5	5.3

¹ Includes only those drags in which shrimp were caught.

No shrimp were taken in water of a depth less than 50 fathoms, and the majority were taken at depths between 60 and 80 fathoms

(Table 2). Because of gear limitations, it was not possible to explore in water of a depth greater than 100 fathoms during the described explorations.

Table 2. Amounts of Pink Shrimp (Pandalus jordani) Caught by Depth of Water in the Individual Areas of Exploration.

Area	Depth in Fathoms	Number of Drags	Pounds of Shrimp Caught	Pounds of Shrimp Caught per Drag
Off Columbia River	30 - 50	1	0	0
	51 - 60	6	48.5	8.1
	61 - 70	5	32.5	6.5
	71 - 80	1	0	0
Off Cape Falcon	50 - 60	1	0	0
	61 - 70	1	0	0
	71 - 80	2	14	7
	81 - 90	1	3.5	3.5
	91 - 100	1	0.5	0.5
Off Cape Lookout	30 - 50	1	0	0
	51 - 60	2	0.5	0.25
	61 - 70	3	36.5	12.2
	71 - 80	3	27.5	9.2
	81 - 100	1	4.5	4.5
Off Siletz Bay	30 - 50	2	0	0
	51 - 60	2	0	0
	61 - 70	2	2.5	1.25
	71 - 80	5	40.5	8.1
	81 - 90	3	11.5	3.8
	91 - 100	3	4.0	1.3

The results of the explorations suggest that shrimp may be present in sufficient numbers off the Oregon coast to support a commercial fishery. The Fish Commission intends to continue the exploratory work during the spring and summer of 1952, at which time exploratory drags will be made in various localities from Newport, Oregon, south to the California border. During the forthcoming explorations, a net of 1 inch mesh construction throughout will be used, and such a net should provide a more reliable index to the commercial fishing possibilities of this shrimp.

Sizes of Pink Shrimp Encountered
in the Areas of Exploration

The number of shrimp (whole and headed) per pound varies somewhat in the different areas (Table 3). The tails of the shrimp, including the shells, made up almost 54 percent of the total weight (Table 3, Percent yield).

Table 3. Number of Pink Shrimp (Pandalus jordani)
- Whole and Headed -
Per Pound in the Indicated Areas of Exploration

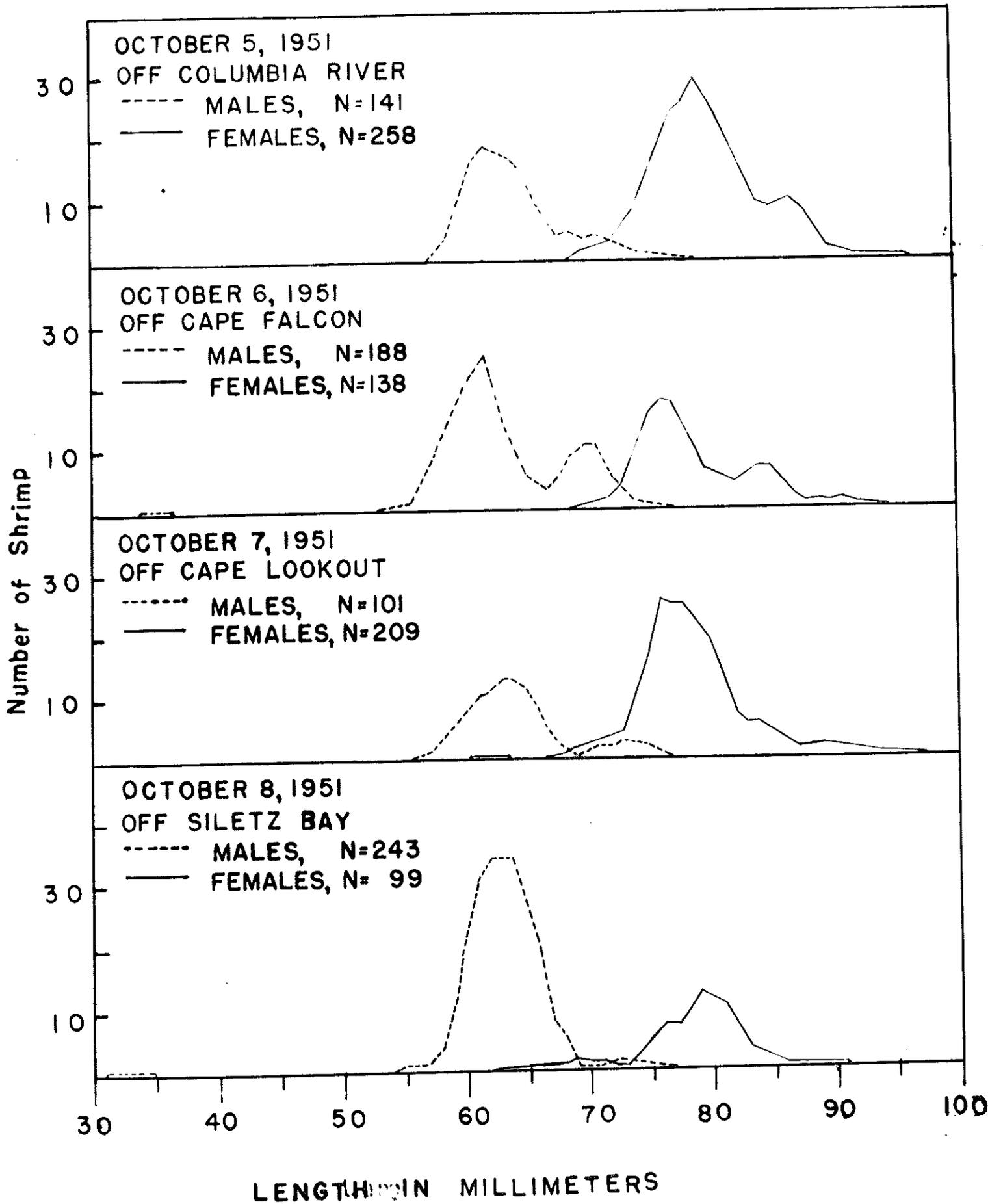
Area	Number of Whole Shrimp per Pound	Number of Headed Shrimp per Pound	Percent Yield
Off Columbia River	103.2	191.6	53.9
Off Cape Falcon	122.7	231.1	53.1
Off Cape Lookout	104.7	194.3	53.9
Off Siletz Bay	140.0	259.7	53.9

The varying number of shrimp per pound in the different areas is accounted for by the change in the sex ratio from one area to another. Samples taken off Cape Falcon and Siletz Bay contained a larger percentage of males than were obtained in the other areas (Fig. 4). Since the males are smaller than the females, in the areas where there was a greater percentage of males there were also more shrimp per pound.

Observations Concerning the Life History
of Pandalus jordani.

Berkeley (ibid) in her paper on the commercially important shrimps of British Columbia, found that all the species examined of the genus Pandalus underwent a change of sex. The species studied by Berkeley start their lives as males, function as males once or

Figure 4. Length frequencies of shrimp caught off the Oregon Coast.
(All figures smoothed by 3's)



twice, and then change to the female phase and remain females for the balance of their lives.

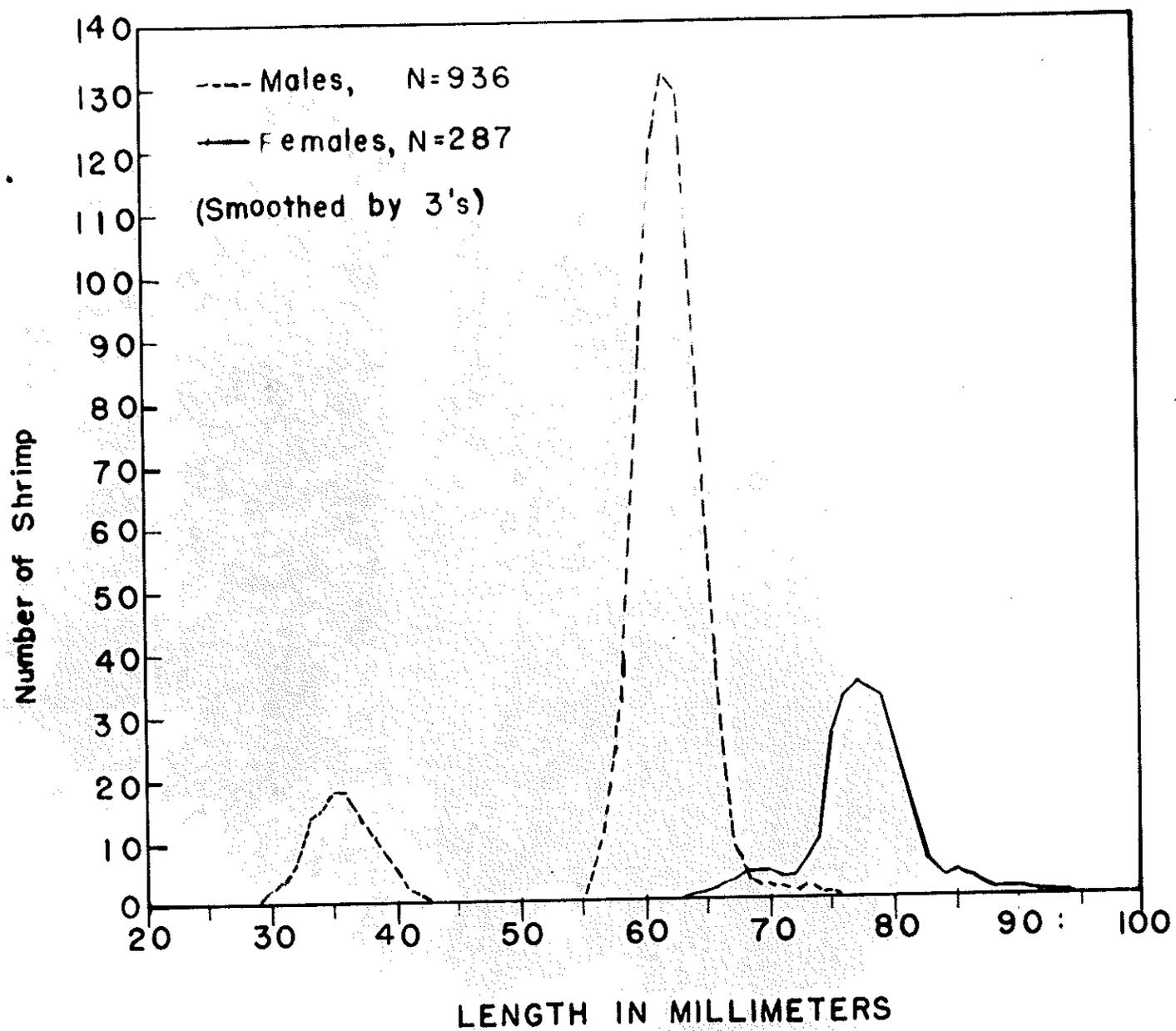
Unfortunately, Berkeley did not present any information in her paper concerning Pandalus jordani, but the following discussion of our observations demonstrates that this species probably has a life history similar to those worked out by Berkeley.

Length Frequencies

Length frequencies (smoothed by a moving average of three) obtained in the four general areas of exploration illustrate that there are two well-defined size groups present in the catches. The smaller of the two consists of males which have a modal length of about 62 millimeters, and the larger consists of females with a modal length of about 78 millimeters. Occasionally small males belonging to a third group of about 35 millimeters in length are captured. A suggestion of this smallest group is found in the length frequencies of the shrimp taken off Cape Falcon and Siletz Bay.

Length frequencies of Pandalus jordani were obtained off Siletz Bay on October 28, 1951, about three weeks later than those illustrated in Figure 4 (Fig.5). The general features of the two figures are the same, but Figure 5 is shown because it includes a fairly large sample of the smallest size group of shrimp. Whereas the two largest size groups of shrimp were measured after being frozen and allowed to thaw, the fragile nature of the smallest size group required that they be hardened in formalin before being measured. No correction factor has been applied to the data to compensate for any unequal shrinkage which may have resulted from the two different methods of preservation.

Figure 5. Length frequency of shrimp taken off Siletz Bay.



Although it would be necessary to follow the progression of the length frequency modes throughout a period of one year before any conclusions concerning the age of the shrimp could be justified, it is believed that each mode illustrated in Figure 5 represents a separate age group of shrimp. If such is the case, at least three separate age classes of Pandalus jordani are found in the catches. The two youngest are males and the oldest consists of females.

Percentage of Egg-Carrying Females

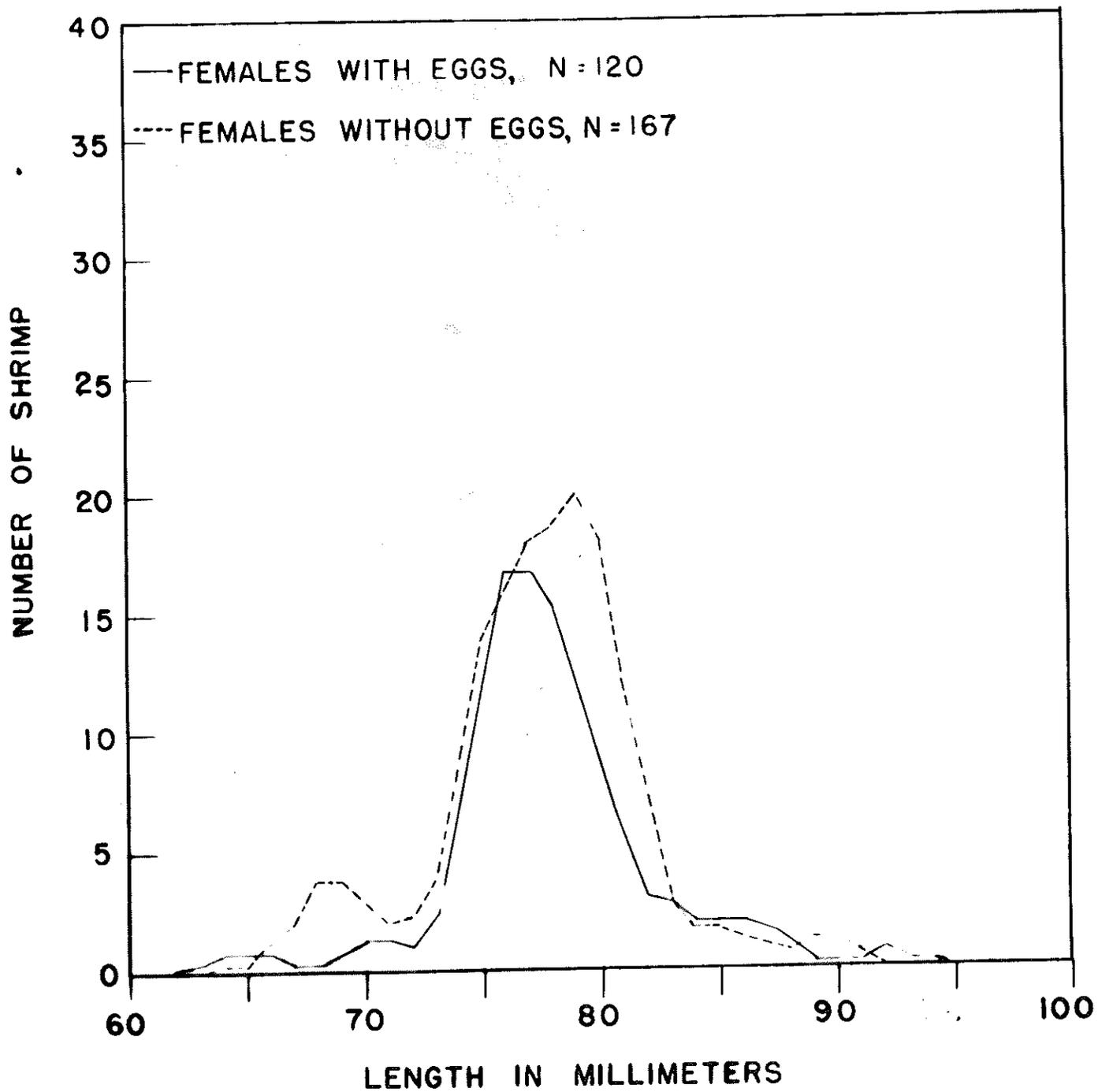
Less than three percent of the females obtained in the various areas of exploration on October 5 through October 8, 1951, were carrying eggs, but 42 percent of the females examined about three weeks later on October 28 bore eggs.

The length frequencies of both egg carrying and non-egg carrying females taken on October 28 are similar indicating that both the large and small females attain the egg carrying stage at about the same time. (Fig.6)

Occurrence of All Organisms in the Shrimp Trawl

If a commercial fishery for the pink shrimp should develop off Oregon an important item of consideration in the management of such a fishery would be the effect of the small mesh nets used upon the stocks of commercially important fish and shellfish found in the same areas as the shrimp. During the exploratory work, therefore, an accurate tabulation was made of all species of fish and shellfish taken in the shrimp net. In addition, lengths and sex ratios of the commercially important species of fish and shellfish taken in the shrimp hauls were obtained.

Figure 6. Length frequencies of egg-bearing and non-egg-bearing shrimp taken October 23, 1951



the number of shrimp and the number of fish taken in the drags: drags producing the most shrimp usually yielded the smallest number of fish.

By far the most numerous species of fish taken in the shrimp hauls were small specimens of slender sole (Lyopsetta exilis), rex sole (Glyptocephalus zachirus) and mottled sand dabs (Citharichthys sordidus). Dover sole (Microstomus pacificus) of a commercial size were regularly taken along with the shrimp, but they were at no time taken in large numbers. In addition to the aforementioned species, negligible numbers of petrale sole (Lopsetta jordani), turbot (Atheresthes stomias), hake (Merluccius productus) and various species of rockfish (Scorpaenidae), sea poachers (Agonidae), and eel pouts (Loarcidae) were taken along with the shrimp.

With the exception of a very small number of scallops (Pectinidae), snails (Gastropoda), and anomurans (chiefly Munida quadrispina), virtually no shellfish were taken along with the shrimp.

At depths between 90 and 100 fathoms sea urchins (Echinoidea) were taken consistently in the net in quite large numbers. Although no attempt was made to count the sea urchins, it is quite possible that they may be present in such large numbers as to prevent a successful fishery at such depths. Fortunately, the center of abundance of the shrimp was found to occur in water of a depth less than 90 fathoms where the number of sea urchins is not believed to be sufficiently large to seriously hinder fishing operations.

Summary

During the month of October 1951 a total of 46 exploratory shrimp drags were made in four areas off the coast of Oregon. Pink shrimp (Pandalus jordani) were taken in sizeable quantities in each of the areas explored.