The Fishery and Biology of the Dungeness Crab (*Cancer magister* Dana) in Oregon Waters

Kenneth D. Waldron

FISH COMMISSION OF OREGON
Portland, Oregon
Contribution No. 24
May 1958

FISH COMMISSION OF OREGON

Harold T. Johnson, Chairman ..... Astoria

Charles W. Mahaffy ..... Coos Bay

Omar C. Palmer ..... Portland

ALBERT M. DAY
State Fisheries Director

TABLE OF CONTENTS

	Page
INTRODUCTION	5
General	5
HISTORY OF THE FISHERY	8
Landings	8
Gear	13
Commercial Utilization	16
Regulations	17
TAGGING	19
Introduction	19
Definition of Season	19
Tagging Areas	20
Tagging Procedure	21
Recovery Procedure	24
Tags Released and Recovered	25
MOVEMENT OF CRABS	26
General	26
Time Out—Distance Traveled Relationship	27
Rate of Travel	29
Rate of Recovery	29
Effect of Missing Appendages	29
Average Movement	29
Inshore-Offshore Movement	31
North-South Movement	32
Area Movement	33
Bay Crabs—Tagging	34
Movement of Bay Crabs	34
BIOLOGY	37
Soft-Shell Season	37
Maturity	37
Growth	38
Predators	40
SUMMARY	41
ACKNOWLEDGMENTS	42
LITERATURE CITED	42

LIST OF FIGURES

		Page
Figure 1.	Map of Oregon coastline	7
Figure 2.	Commercial landings of crabs along the Oregon coast, 1889-1955	9
Figure 3.	Percentage of annual Oregon commercial catch of crabs by port of landing, 1947-1955	10
Figure 4.	Average monthly commercial landings of crabs in Oregon, 1944-1956	11
Figure 5.	Landings of crabs from Oregon bays, 1948-1955	12
Figure 6.	Crab ring or hoop	13
Figure 7.	Crab pot	15
Figure 8.	Crab with tag in place	20
Figure 9.	Chart of coastal areas showing tagging sites and distribution of individual recoveries for area I, 1947-1950	21
Figure 10.	Chart of coastal areas showing tagging sites and distribution of individual recoveries for area II, 1947-1950	22
Figure 11.	Chart of coastal areas showing tagging sites and distribution of individual recoveries for areas III and V, 1948-1950	23
Figure 12.	Chart of coastal areas showing tagging sites and distribution of individual recoveries for area IV, 1948-1950	24
Figure 13.	Growth of crabs, width prior to shedding and width increment	39

LIST OF TABLES

Table 1.	Oregon commercial crab landings in pounds, 1889-1955	8
Table 2.	Crab tagging and recovery areas along the Oregon coast	20
Table 3.	Numbers tagged, recovered, and percentage recovery of crabs released in offshore waters of Oregon, 1947-1950	25
Table 4.	Average miles traveled and days at liberty for crabs released in offshore waters of Oregon, 1947-1950	28
Table 5.	Movement of crabs released in offshore waters of Oregon, 1947-1950	30
Table 6.	Recoveries by general area of recapture of crabs released in offshore waters of Oregon, 1947-1950	31
Table 7.	Summary of chi-square test of the hypothesis that there is no significant difference in the numbers of crabs recovered to the north and to the south of the release point for crabs released in offshore waters of Oregon, 1947-1950	32
Table 8.	Numbers tagged, recovered, and percentage recovery of crabs released in Oregon bays, 1947-1950	35
Table 9.	Recoveries by general area of recapture of crabs released in Oregon bays, 1947-1950	36
Table 10.	Growth of two groups of young crabs held in laboratory aquaria	38
Table 11.	Growth of two male specimens of *C. magister* upon shedding	40

The Fishery and Biology of the Dungeness Crab (*Cancer magister* Dana) in Oregon Waters

Kenneth D. Waldron①

ABSTRACT

Results of studies beginning in 1947 on the biology of the Dungeness crab *(Cancer magister)* in Oregon coastal waters are reported. A review is made of the history of the fishery with regard to trend of the catch by magnitude, area, and season; the development and conduct of the fishery itself; and the regulations governing the fishery. The first reported commercial crab landings in Oregon were 6,628 pounds in 1880. The fishery expanded slowly until 1933 after which the catch rose sharply to a peak of about 11 million pounds in 1943. Landings in recent years have fluctuated between 6 and 11 million pounds from a commercial fishery which is carried out along the major portion of the Oregon coast. During the period 1947-50, 6,249 tagged crabs were released in offshore and bay waters of Oregon and 34.6 per cent of the tags were subsequently recovered. The average movement of 1,042 recoveries of crabs released in offshore waters, as measured by the distance from the tagging site, was 8.3 miles (range 0-133 miles) in 80 days. For crabs released within bays, 606 recoveries averaged a minimum distance traveled of 4.2 miles (range 0-81 miles). Fifty-seven per cent of the recoveries of offshore releases and 84 per cent of the recoveries of bay releases were made within 4 miles of the respective tagging sites. Over 90 per cent of the recoveries of offshore releases were made within 6 months, although 3 crabs were out more than a year with 1 at liberty 878 days. Tagged crabs moved from offshore to bays, from bay to bay, and from bays to offshore. There was no significant difference in percentage recovery for crabs with or without missing appendages. Egg-bearing female crabs are present in offshore waters during the period October to March, inclusive. Larval crabs assumed to be *C. magister* were observed in offshore waters from April to July, inclusive. Considerable variation in early growth of post larval crabs was observed in laboratory experiments. The amount of growth of crabs between 6.4 and 146.0 mm., as observed by measuring them before and after molting, increases until a shoulder width of about 95 mm. is reached. The increase with each subsequent molt thereafter remains relatively constant. Macroplankton-eating fishes feed upon free swimming crab larvae. Adult crabs up to at least 114 mm. in shoulder width are preyed upon by voracious fish such as ling-cod *(Ophiodon elongatus)*, the great marbeled sculpin *(Scorpaenichthys marmoratus)*, wolf eel *(Anarrhichthys ocellatus)*, halibut *(Hippoglossus stenolepis)*, and some of the rock fishes of the genus *Sebastodes*.

① Formerly Aquatic Biologist with the Oregon Fish Commission; now with the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service.

INTRODUCTION

General

In 1947, the Fish Commission of Oregon inaugurated a study of the Dungeness crab *(Cancer magister)*. From this study it was planned to obtain information on the adequacy of the existing regulations, the magnitude of the fishery, and the biology of the crab in Oregon waters with particular reference to its migratory habits. The economic importance of

the crab fishery to the state of Oregon was a motivating factor in instituting this investigation.

The Dungeness crab is one of 20 species comprising the genus *Cancer* (MacKay and Weymouth, 1943). It is known to occur along the Pacific Coast from Unalaska in the Aleutian Islands to Magdalena Bay in Lower California, and ranges from the intertidal zone to depths of at least 93 fathoms (Phillips, 1935). Other species of the genus are present in the North Atlantic and North Pacific Oceans and off the coasts of South America and New Zealand. While showing a preference for sandy or sandy-mud bottom, the Dungeness crab may be found on almost any type of bottom and is present within bays and estuaries as well as on the floor of the open ocean.

Crabs taken in the commercial fishery off the Oregon coast averaged about 6⅞ inches (175 mm.) shoulder width based on measurements of 12,843 crabs caught in offshore waters in 1949-50. During the same period 6,900 crabs caught in offshore waters weighed an average of 2 pounds apiece.

The largest Dungeness crab taken from Oregon waters and measured by a Fish Commission biologist was 8-11/16 inches in shoulder width, i.e., the straight-line distance across the carapace immediately anterior to the tenth anterolateral spine. Crabs of this species reportedly attain sizes up to 11 inches shoulder width along the Pacific Coast.

Upon reaching a legal size (5¾ inches shoulder width in bays and 6¼ inches in the Columbia River and offshore waters of Oregon) male Dungeness crabs may be marketed. This market is supplied by a commercial fishery prosecuted in the bay and offshore waters of the Pacific Coast from San Francisco to Alaska. There is also a recreational fishery for this crab in the protected waters along the Oregon coast with a minimum size limit of 5¾ inches shoulder width and a daily bag limit of 12 male crabs per individual fisherman. The regulations vary among California, Washington, British Columbia, and Alaska.

Oregon has approximately 300 miles of general coastline bordering the Pacific Ocean, and crab fishing is carried out along a major portion of this distance wherever conditions are favorable. The fishery is confined to relatively shallow waters, usually less than 25 fathoms in depth. Most of the commercially-caught crabs are landed at the following ports, listed in order of their occurrence from north to south: (1) Warrenton and Astoria; (2) Garibaldi and Bay City; (3) Newport; (4) Reedsport; (5) Charleston, North Bend, and Coos Bay; and (6) Port Orford (Figure 1).

With the exception of Port Orford, all of these ports are situated on estuaries and, consequently, fishing vessels leaving them must cross a bar to reach the open sea where the fishery is conducted. At times inclement weather may make these bars impassable, thus limiting the number of trips to the fishing grounds. Since there is no bar at Port Orford, the condition of the open sea determines whether or not fishing boats may venture out to the crabbing areas. Port Orford is unique in that all boats are kept on the dock in specially made trailers and must be lowered into the water by means of a powered boom. Spring and summer are usually the only times that boats can visit the offshore fishing grounds with any degree of regularity.

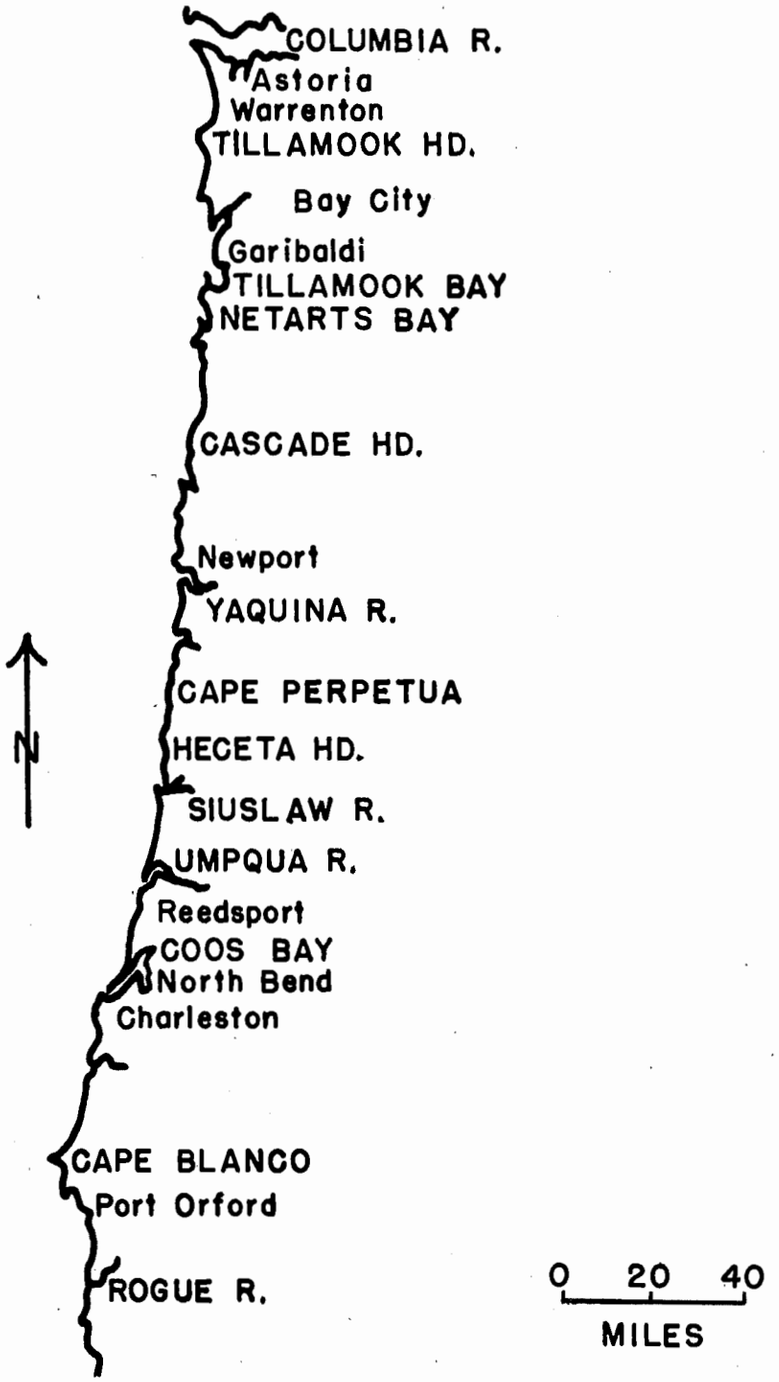

FIGURE 1. MAP OF OREGON COASTLINE.

HISTORY OF THE FISHERY

Landings

According to the U. S. Bureau of Fisheries' records (Wilcox, 1895) the first reported crab landings in Oregon were 6,628 pounds in 1889. Landings were also recorded for the succeeding three years (Table 1). The earliest

TABLE 1. **OREGON COMMERCIAL CRAB LANDINGS IN POUNDS, 1889-1955**①

Year	Landings②	Year	Landings
1889	6,628	1922	737,802
1890	4,200	1923	359,283
1891	3,521	1924	.....
1892	4,125	1925	522,201
1893	.....	1926	532,884
1894	.....	1927	599,852
1895	23,520	1928	492,811
1896	.....	1929	705,364
1897	.....	1930	547,125
1898	.....	1931	512,975
1899	.....	1932	863,425
1900	.....	1933	1,529,050
1901	.....	1934	1,812,525
1902	.....	1935	2,134,125
1903	211,600	1936	3,176,950
1904	246,266	1937	4,911,650
1905	318,300	1938	5,988,350
1906	405,000	1939	5,749,850
1907	.....	1940	6,716,000
1908	216,011	1941	6,918,875
1909	179,893	1942	7,787,350
1910	227,660	1943	10,958,325
1911	328,633	1944	9,358,250
1912	294,532	1945	6,078,750
1913	.....	1946	7,037,000
1914	.....	1947	9,286,000
1915	415,272	1948	9,815,000
1916	.....	1949	8,437,600
1917	.....	1950	6,947,975
1918	.....	1951	6,336,500
1919	.....	1952	5,996,900
1920	.....	1953	10,750,350
1921	.....	1954	7,449,375
		1955	6,545,750

① Landings after 1928 on fiscal year basis, April 1 of any one year to March 31 year following.
② 1889-92: Wilcox 1895; 1895, 1904: Wilcox 1898, 1907; 1903, 1905-06: State of Oregon 1898/99-1908; 1908-12: State of Oregon 1909-12; 1915: Radcliffe 1919; 1922-23, 1925: Sette 1926 and 1928; 1926: Sette and Fiedler 1929; 1927: Fiedler 1929; 1928-49: Cleaver 1951; 1950-55: State of Oregon fiscal year summary sheets.

record of crabs landed, according to State of Oregon records, is 211,600 pounds in 1903, although these reports extend back to 1888 (State of Oregon, 1898/99-1908). No poundage tax was paid to the state in the early years of the fishery, which may explain the incompleteness of the landing records. A gradual but fluctuating increase in production took place up

to 1931, in which year more than one half million pounds of crabs was landed commercially in Oregon (Figure 2). Production increased sharply from 1931 until 1943 when an all-time high of almost 11 million pounds was sold by commercial fishermen (Table 1). During the next 12 years (1944-1955) landings fluctuated between about 6 and 11 million pounds. The sharp increase in landings may be attributed primarily to the repeal in 1933 of a variable bag limit on commercial crabbing. With the elimination of this restriction there was an increase in the number of licensees and probably in the amount of gear fished by individual fishermen as well.

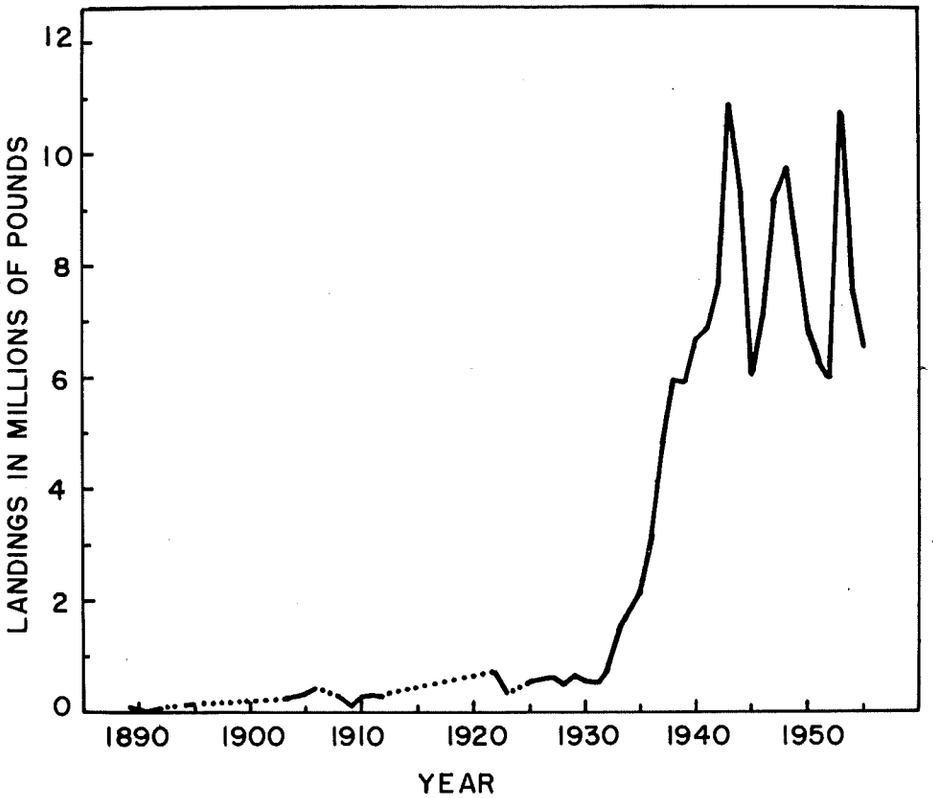

FIGURE 2. COMMERCIAL LANDINGS OF CRABS ALONG THE OREGON COAST, 1889-1955.

The total catch as well as the percentage contribution by port of landing has varied considerably in recent years. Data are available showing crab landings by port for the period 1947 to 1955. During this period there was a marked shift in the percentage of the total catch landed at some of the major ports. It can be seen from Figure 3 that percentagewise the Columbia River landings followed a downward trend from about 50 per cent of the total catch in 1947 and 1948 to about 25 per cent in recent years. The catches reported from the ports of Yaquina Bay, Coos Bay, and Port Orford assumed increasingly greater proportions of the total after 1948. The relative importance of the Tillamook Bay and Umpqua River landings remained approximately constant throughout the six-year

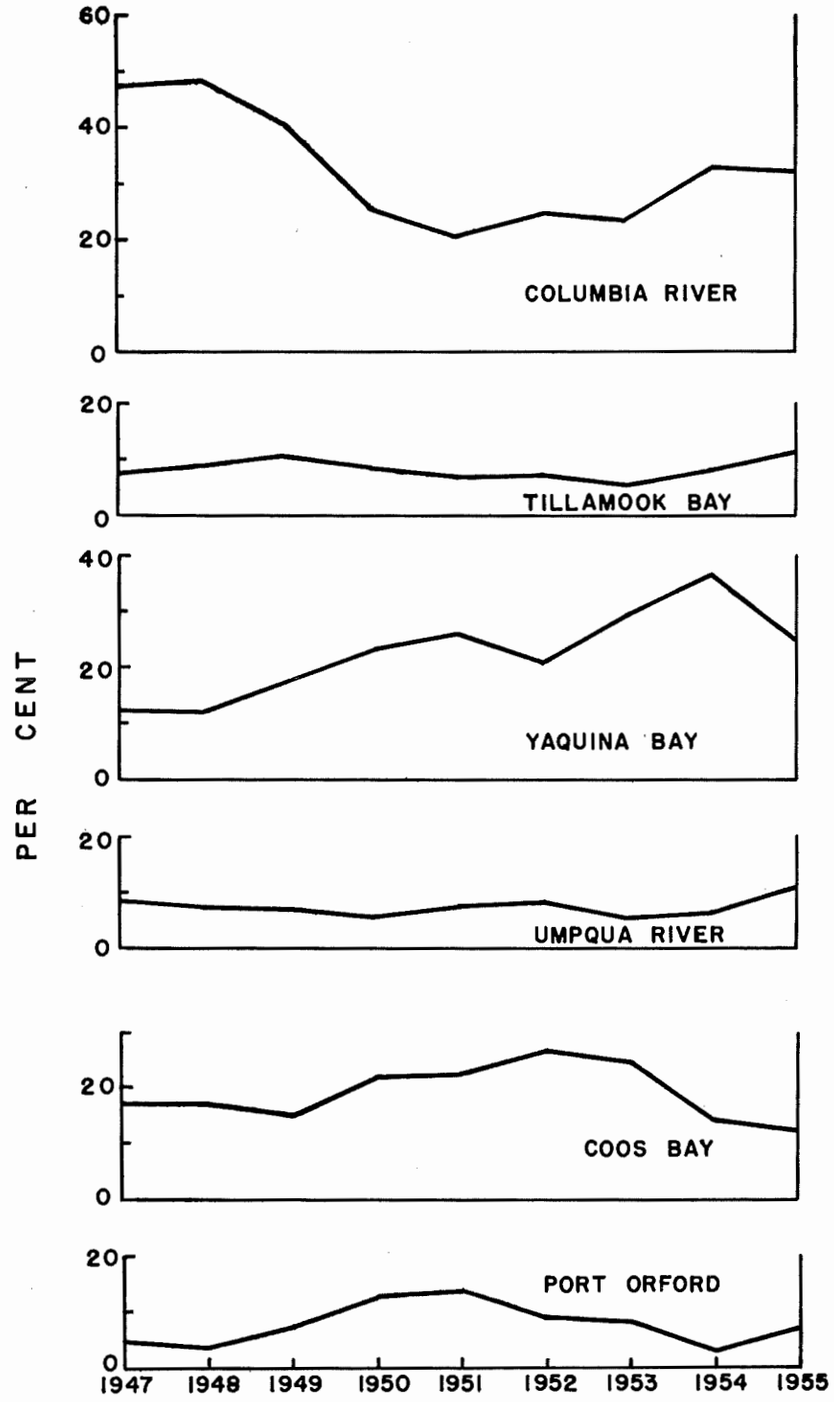

FIGURE 3. PERCENTAGE OF ANNUAL OREGON COMMERCIAL CATCH OF CRABS BY PORT OF LANDING, 1947-1955.

period. This shift in landings at various ports may be a reflection of the relative abundance of crabs in adjacent fishing grounds and/or the amount of gear being fished (i.e., fishing intensity) out of the different ports.

The increase in the value of the fishery can be seen when it is noted that the 1895 landings of 23,520 pounds had a value of about 2.7 cents per pound to the fishermen, while the 1951 landings of 6,400,000 pounds were sold by the fishermen for about $950,000 or 12.7 cents per pound (Anderson and Peterson, 1954).

For the period 1944-1956, landings of crabs in Oregon usually reached a seasonal peak in May with lesser amounts being landed in all other months (Figure 4). However, in 1954 the seasonal peak was in March, a full two

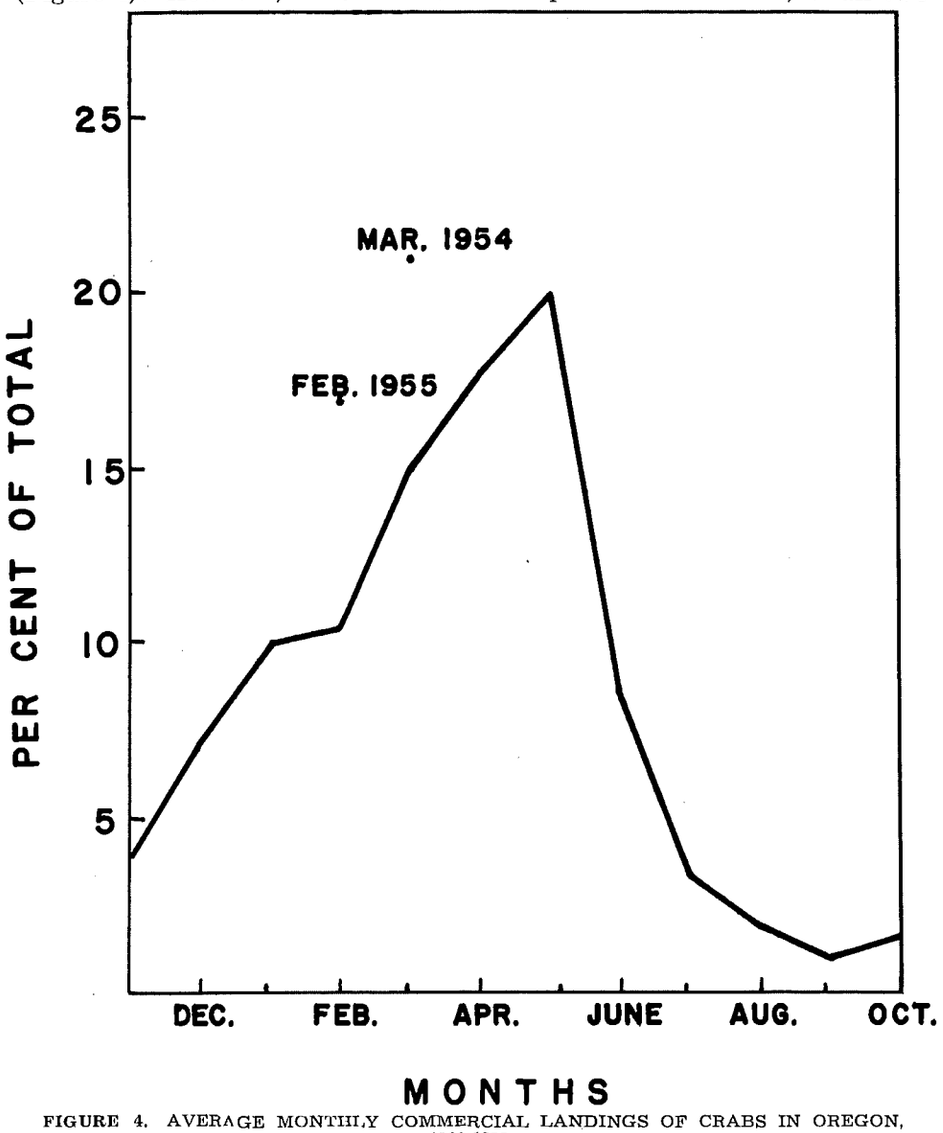

FIGURE 4. AVERAGE MONTHLY COMMERCIAL LANDINGS OF CRABS IN OREGON, 1944-1956.

months earlier; after March the catches rapidly fell off and by June very few crabs were being landed. Catches were exceptionally large at the beginning of the 1954 season which prompted the fishermen to place most of their pots out earlier than usual. Thus the available crabs were removed earlier in the season. The 1955 season landings peaked in February, but the peak was not as pronounced nor did the catch fall off so rapidly, following peaking.

Figure 5 shows the crab landings from the main estuaries along the Oregon coast during the months when the offshore season is closed. For

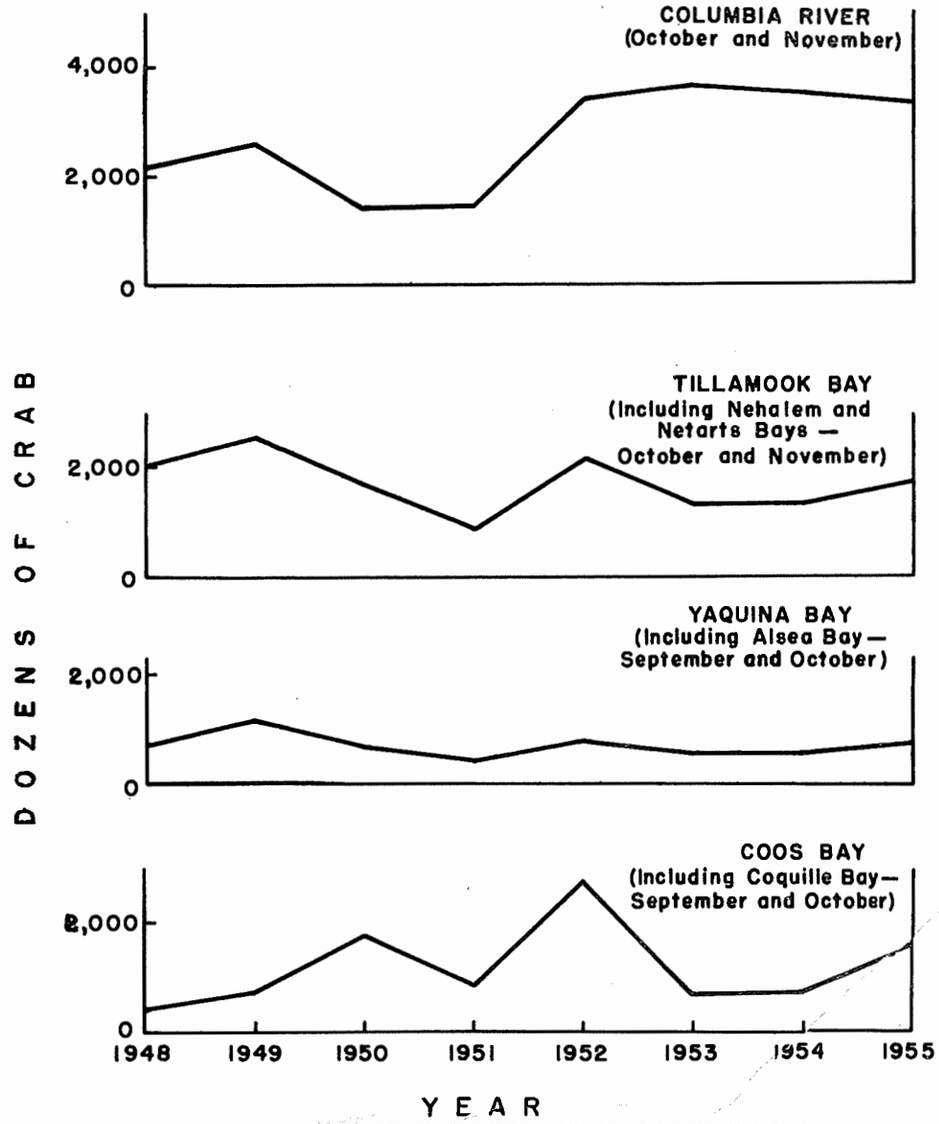

FIGURE 5. LANDINGS OF CRABS FROM OREGON BAYS, 1948-1955.

the period 1948-1955 Columbia River and Tillamook Bay were the leading producers of crab with Coos Bay not far behind.

Bays and other protected waters along the coast furnished the bulk of the crab catches during the early years of the fishery when the landings were relatively small. In 1915 over half of the crab landings in Oregon came from the vicinity of the Columbia River mouth, while the four bays, Alsea, Coos, Tillamook, and Yaquina, yielded the remainder. Crabs were first taken in numbers in the open ocean beyond the Columbia River bar in 1915. The offshore fishery continued to contribute an increasing proportion of the total landings until in 1952 approximately 95 per cent of the crabs landed in Oregon were caught in offshore waters.

Gear

The three types of gear which have been used at various times to take crabs for the commercial market are rakes, hoops or rings, and pots or traps.

Raking crabs out of potholes and tidepools is limited to the intertidal zone and adjacent shallow water. It consists of pulling a long-tined rake through the sand, thus dislodging any crabs which may be buried below the surface. The method was sufficiently productive in the past in some areas, e.g. Coos Bay, to supply a small market. At present this method may be used legally by recreational crabbers in all bays except Nehalem Bay, but not by commercial fishermen.

The crab ring or hoop (Figure 6) consists of a cotton-mesh basket attached to two iron hoops. Bait, usually clams or dead fish, is attached to the inside of the basket which is then lowered into the water. Upon reach-

FIGURE 6. CRAB RING OR HOOP.

ing bottom, the basket collapses and both rings rest upon the bottom, permitting the crabs easy access to the bait in the center. At intervals the ring is raised rapidly to the surface, thus forming a basket from which it is difficult for the crabs to escape. This method has been used extensively in the past and is still employed to a considerable degree by both sport and commercial crabbers. Radcliffe (1919) states that the fishery carried on beyond the Columbia River bar utilized this type of gear. It was also used in other offshore areas until after the mid-1930's, although at this time pots were replacing rings to a large extent. Rings are still used to a limited degree for offshore fishing in the vicinity of Coos Bay, and exclusively for commercial crabbing within Alsea, Nehalem, Siletz, Yaquina, and Coquille Bays.

The third type of gear, and that used in the majority of offshore fishing at present, is the pot or trap (Figure 7). This gear consists of a container with funnel-shaped entrances, the wide portion of the funnel being toward the outside and the small portion of the funnel toward the inside and elevated above the bottom. The pot is baited and lowered to the bottom. In this position it is easy for a crab to enter the wide portion of the funnel and proceed into the container, but it is much more difficult for the crab to escape through the narrow opening, especially since the inner end of the funnel is elevated above the bottom. This gear was originally adapted from the east coast lobster pot, and at first consisted of a small wooden frame covered with wooden slats with an entrance at each end. Subsequently, pots were constructed with an iron rod frame and covered with a cotton mesh of a size suitable to retain the crabs (Wilcox, 1907). The present type of pot is cylindrical, varying in diameter between 30 and 42 inches, but occasionally up to 72 inches, and approximately 14 inches high. It is usually constructed of five-eighths-inch diameter iron or stainless steel rod, and covered with stainless steel wire mesh. Normally there are two funnel-like entrances to the pot with the inner edge of the entrances equipped with loosely projecting wire to prevent the escape of crabs which have entered the pot. Most pots also have an escape hole on the top or side of a diameter, usually $4\frac{1}{8}$ inches, that will permit undersized crabs to escape. Crabs are removed from the pots through a hinged trap door on the top. The bait containers hung in the pots are usually constructed of wood, stainless steel, or plastic. The average cost of a new pot is about $25.00 complete with line, buoy, and bait container.

Cockles, *(Cardium corbis),* razor clams *(Siliqua patula),* and other miscellaneous clams as well as herring *(Clupea pallasii)* were used for bait during the early years of the fishery. Squid (*Loligo* sp.), imported from California, and razor clams are at present the most commonly used bait along the Oregon coast. Some work has been done to develop an effective artificial bait, although to date a satisfactory product has not been produced.

In the early years of the fishery when the bays and offshore waters immediately adjacent to the bays supplied most of the crabs, skiffs were used in conducting a profitable fishery. As the fishery expanded and the use of pots became more prevalent, larger boats were needed. Vessels up to 72 feet in length, powered by gasoline or diesel engines, and equipped to

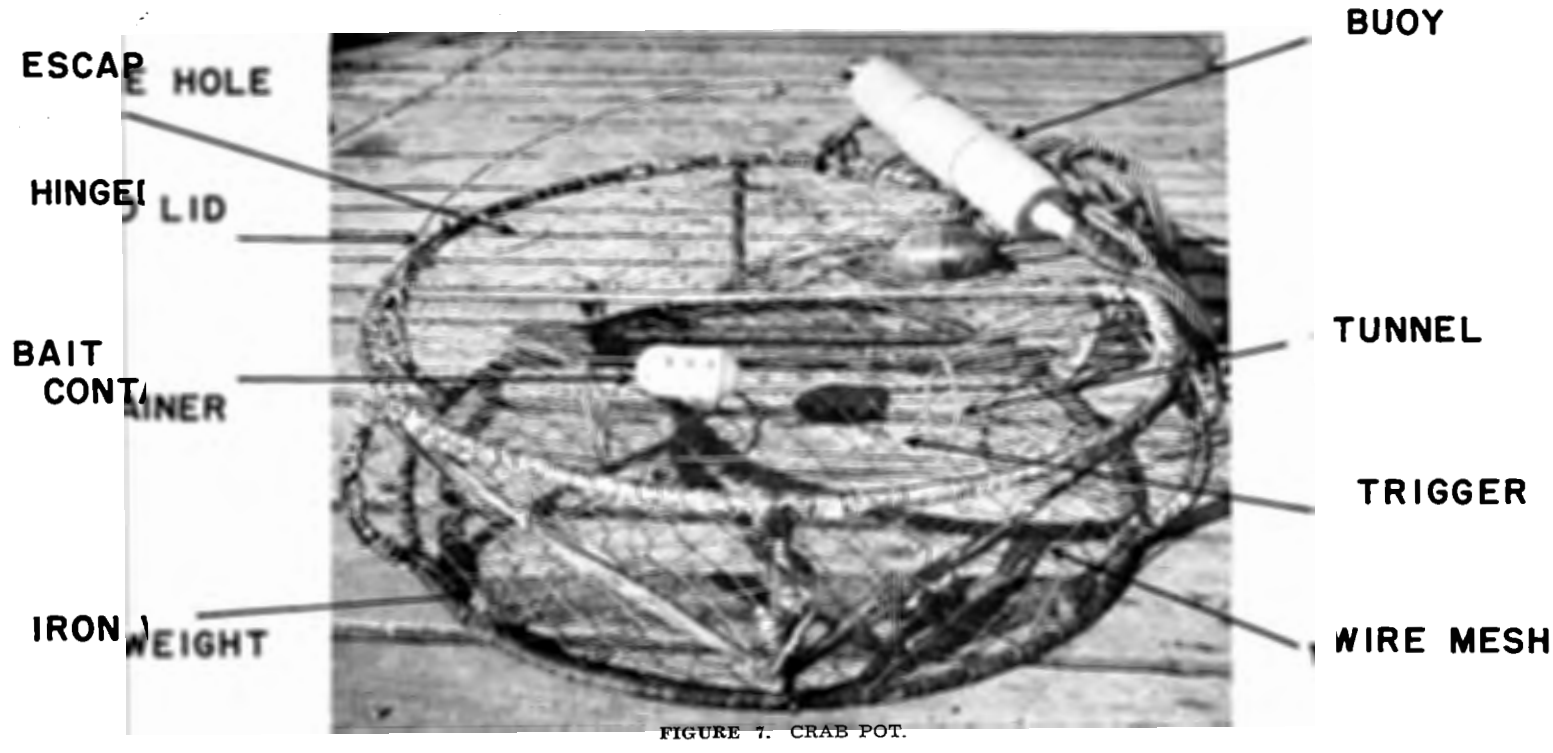

FIGURE 7. CRAB POT.

remain at sea for several days are presently used in the Oregon crab fishery. Many of the boats are equipped with fathometers, radio direction finders, and loran. Hauling of the pots is accomplished with the aid of a davit and power-driven gurdy. All of these improvements in equipment and techniques have significantly increased the efficiency and catch of the present day crab fishermen.

Crabs taken in the course of a day's fishing are usually placed in the vessel's hold or are retained on deck if the vessel has no hold.

In about 1937 the fishermen in the Newport area inaugurated the practice of placing their catches in a watertight compartment in the hold. This compartment was flooded with water and pumped out at regular intervals, thus keeping the crabs alive for longer periods of time and assuring a more marketable grade of crabs when sold to the plants. Another innovation appeared about 1947 when the watertight hold compartment was replaced by a removable steel tank. A steel grating, so arranged that it could be raised or lowered, aided in removing the crabs from the tank. Crabs were kept alive and in good condition up to three or four days by circulating sea water through the tank.

As the size of the boats became larger the number of pots fished by each boat increased. Some boats presently fish as many as 800 pots, although the average is about 180 pots. During the 1951-52 season there were about 15,700 pots being fished in Oregon waters by 86 boats. A two- or three-man boat crew can pull about 300 pots in one day, if the weather is good and the pots are in shallow water. Bad weather and deep water fishing reduce the efficiency. When the weather is good and crabs plentiful, pots may be lifted as often as once a day with profitable catches. On occasions during inclement weather some pots are not examined for as much as two weeks or longer.

The ever present possibility of loss of pots due to stormy weather is one of the factors which keep the fishing intensity low during the early winter months. Loss of pots may result from being "sanded-in" (covered or nearly covered with sand) due to bottom currents moving the sand. Attempts to pull sanded pots often result in broken lines and, therefore, loss of pots. In recent years hydraulic pumps have been used successfully in retrieving sanded pots. Another source of loss of pots is by heavy seas actually rolling the pots inshore into the surf where they cannot be recovered. Rolling also causes chafing of lines which often results in pot loss when the pot is being pulled. Seasonal pot loss due to the above causes may be as high as 80 per cent of the pots being fished by an individual, although the average loss is much lower. The loss of pots may be high during the early spring months when the fishermen move their pots into shallower waters. At this time a moderate storm or heavy swell may cause considerable loss.

Commercial Utilization

The earliest utilization of crabs was as a fresh-cooked product. Due to lack of refrigeration facilities, the market for this type of product was necessarily limited to coastal areas. Improved transportation and refrigeration facilities expanded this market to some extent, although fresh crabs

are still not sold a great distance inland. With the advent of canned crab meat the market for crab was greatly expanded, and at present this commodity may be purchased in almost any grocery store throughout the country. In recent years crab meat, which has been vacuum-packed in hermetically sealed containers and kept at sub-freezing temperatures, has been successfully shipped in a very marketable condition. The major portion of picked crab meat is shipped to markets in this fashion at the present time. However, this product is not sold great distances inland. With the improvement in marketing facilities, the demand for crabs by processors increased correspondingly. Today crabs are utilized as a fresh-cooked whole crab product, fresh-picked crab meat, smoked crab, canned crab meat, and fresh-frozen meat or whole crab.

Regulations

Regulation of the commercial fisheries of the state has been vested in various agencies or commissions. The first such group was the Fish Commission (1872-99), followed in turn by a Board of Control consisting of the Governor, Secretary of State, and State Treasurer (1899-1910), a Fish and Game Commission (1911-21), and last, a Fish Commission beginning in 1921. The latter group has administered the fishery since that time.

Laws regulating the fisheries during the first 45 years of the century were promulgated entirely by legislative action. In 1947 the Fish Commission was empowered to effect additional regulations needed for the wisest continued utilization of the state's fisheries resources. Regulations pertaining to the fishery are presently adopted through general orders of the Fish Commission or through laws passed by the legislature.

A license entitling a person to engage in commercial crab fishing has been required since the early 1900's, and the cost has gradually increased. It was $1.00 from 1909 to 1929, $5.00 from 1930 to 1948, $10.00 from 1949 to 1950, and has been $15.00 since (1951-56). The following licenses are required when fishing commercially for crabs: (1) If fishing within the 3-mile limit, a crab license of $15.00 issued to the skipper of the boat and a personal license of $7.50 issued to each person on the boat who is engaged in fishing for or assisting in the taking of crabs. (2) If fishing beyond the 3-mile limit and delivering crabs into the state, a delivery license of $7.50 for the boat and $7.50 for each crew member. If fishing both within and beyond the 3-mile limit, all licenses listed under conditions 1 and 2 above are required. Any dealer or processor of crabs, depending on his operations, is required to obtain certain licenses permitting him to operate within the state.

Additional fees have been imposed on the fishery at various times. The earliest was paid by the fisherman and was based upon his catch in the previous year. Subsequent to 1943 this fee was remitted by the person or firm who bought crabs from the fisherman. The fee varied from 10 cents per gross in 1915 to the 7½ cents per dozen presently charged. In addition, the canners paid a case tax of 1 cent per case during the period 1919-1922, and 2 cents per case for 1923-1945. There has been no such tax since 1945.

The minimum size limit, as measured across the back, for crabs sold commercially in Oregon was 6½ inches from 1909 to 1933 and 6 inches from 1933 to 1948. After 1925 these measurements were specified as being point to point and applicable to crabs of both sexes. In 1948 the taking of female crabs for any purpose was prohibited, although many fishermen had voluntarily refrained from landing females prior to enactment of this regulation. In addition to this conservation measure, the size limits for male crabs were revised in 1948 as follows:

(1) Male crabs taken from any of the bays or estuaries of Oregon, excepting the Columbia River, were to be not less than 6 inches in width across the points.

(2) Male crabs taken from waters of the Pacific Ocean and the Columbia River were to be not less than 6¼ inches across the back measured immediately in front of the lateral points, this measurement being termed shoulder-to-shoulder.

In 1949 the method of measuring crabs taken from bays and estuaries, excepting the Columbia River, was changed from point-to-point to shoulder-to-shoulder and the minimum size limit for these crabs was set at 5¾ inches. Since that time there has been no change in size regulations. As mentioned previously, the minimum size for sport fishermen is 5¾ inches shoulder width, and the daily limit is 12 crabs.

The commercial bag limit of 50 crabs per day per person in 1909 was increased until in 1933 it was 60 dozen per week. The repeal of the commercial bag limit law in 1933 undoubtedly was one of the major factors in the rapid increase in the amount of crabs landed subsequent to that time. Its repeal provided incentive for improving and increasing the amount of gear and utilizing larger boats which in turn resulted in greater production. Catches of more than 600 dozen crabs per week per boat are not uncommon at the present time. Another reason for the increase in catch is the change in scene of operations. Prior to the early 1930's crab fishing was mainly carried out on the bays. Subsequently the fishery moved into the ocean. Presently very few crabs are taken in the bays.

Beginning in 1911 it was unlawful during the months of July, August, and September to take crabs for the purpose of canning or shipping them out of the county in which they were taken. Certain counties were exempted from the provisions of this act, and the number of such counties increased until in 1947 all coastal counties but two (Lane and Coos) were permitted to can and ship crabs the year around. Yaquina Bay in Lincoln County was an exception with respect to the shipping provision of the above regulation, and thus crabs could not be taken legally from the bay for shipment out of the county; however, use within the county was permitted. In 1948 the regulation prohibiting the canning and shipping during July, August, and September was replaced by a closed season designed to prevent the taking of crabs when they were in poor condition and the meat yield was low. (For a discussion of this season see the section on soft-shelled crabs on page 37.

TAGGING

Introduction

The objective of the crab tagging program was to determine the extent and direction of movement of crabs in Oregon waters—information essential to the sound management of the fishery. During the period beginning November 1947 and ending January 1950, 6,249 crabs were tagged and released in various localities along the coast from Grays Harbor, Washington, to Ophir, Oregon (8 miles north of the Rogue River mouth).

Laboratory experiments were carried out to determine the feasibility of marking or tagging crabs by various means. Painting, inserting of internal metal tags, clipping of abdominal segments, and attaching of Petersen disk tags were tried; the first three of these methods were discarded for the reasons listed below.

(1) In painting the carapace, the four different liquids applied to the dorsal surface were: finger nail polish (Neuschafer), enamel (Nu-enamel), varnish (Valspar), and lacquer (Presto-lac). None of these remained visible for more than a few days. A slight improvement was noted when lacquer thinner was applied to the carapace prior to painting.

(2) Metal internal tags of the type used for pilchard tagging were inserted beneath the carapace at the joint between the first abdominal segment and the carapace by means of a pilchard tagging gun. High mortality among crabs tagged by this method as well as difficulties involved in recovery prevented the use of this type of tag.

(3) The removal of one or two terminal segments of the abdomen produced a mark that was fairly permanent and easy to effect. However, due to its inconspicuous nature and the fact that individual crabs could not be identified, this method was not used.

(4) Because the Petersen disk tag, when attached at the base of the right anterolateral spine of the carapace, did not produce excessive mortality in the laboratory aquaria and was easily seen, it was selected for use in the tagging program (Figure 8). Disadvantages to be considered with a tag of this type are that the tag is lost at the time the crab molts, and some tags are probably lost because of corrosion of the pin unless, of course, a noncorroding pin is used.

Definition of Season

The terms "tagging season" or "season" unless otherwise specified, are used in this paper to mean the period from September 1 to August 31 of the following year. This season is based on the fact that landings are at their lowest point during August and September.

Since 1948 the crab open season in Oregon has been November 15 to August 15 in the area south of Cascade Head (Latitude 45° 03.7′ N), and December 15 to September 15 in the area north of Cascade Head. This difference in seasons is because the shedding time varies somewhat between the two areas and, consequently, marketable crabs normally can be harvested earlier in the fall in the region south of Cascade Head.

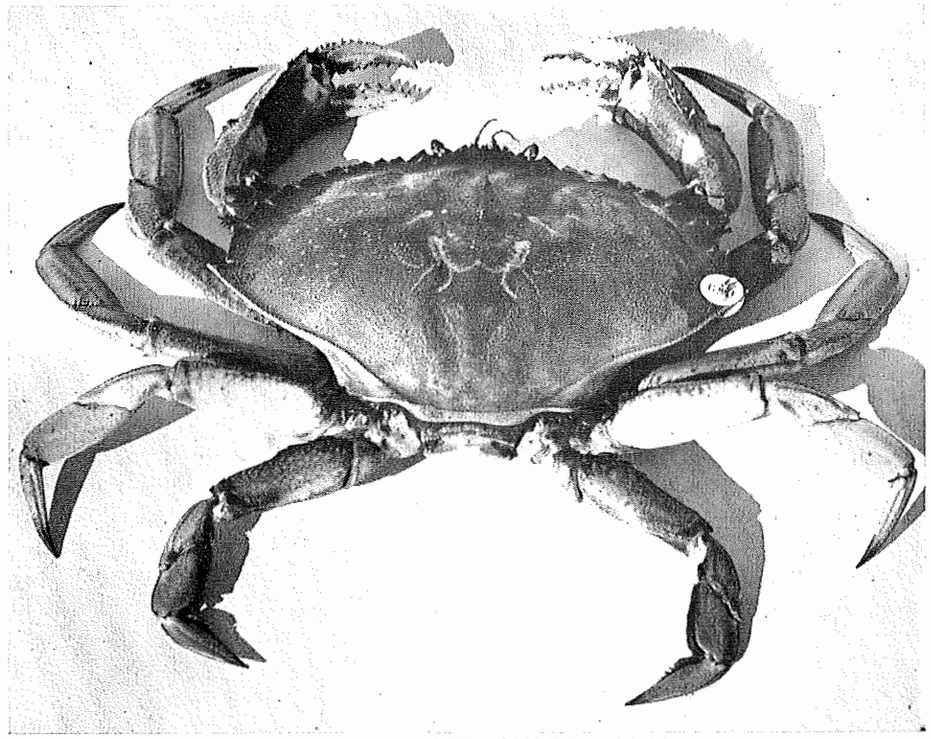

FIGURE 8. CRAB WITH TAG IN PLACE.

Tagging Areas

The areas in which tagged crabs were released are fished by crabbers sailing from ports between the mouth of the Columbia River and Port Orford, Oregon, as well as from Washington and California.

It was considered desirable to divide the offshore waters of the Oregon coast into tagging areas based on the fishing grounds covered by the fleets from the various ports. Table 2 and Figures 9-12 define the five offshore tagging areas. In addition, crabs were tagged and released within four of the bays along the Oregon coast—Columbia River, and Netarts, Yaquina, and Coos Bays.

TABLE 2. **CRAB TAGGING AND RECOVERY AREAS ALONG THE OREGON COAST**

Area No.	*Chief Port*	*Location*				
		Name	*Latitude N.*		*Name*	*Latitude N.*
I	Warrenton	Sealion Rock	47° 27.0′	to	Tillamook Head	45° 56.5′
II	Garibaldi	Tillamook Head	45° 56.5′	to	Cascade Head	45° 03.7′
III	Newport	Cascade Head	45° 03.7′	to	Suislaw River	44° 01.0′
IV	Coos Bay	Siuslaw River	44° 01.0′	to	Cape Blanco	42° 50.2′
V	Port Orford	Cape Blanco	42° 50.2′	to	Oregon-Calif. State Line	41° 59.9′

Tagging Procedure

Crabs tagged during this investigation were captured in pots, rings, or otter-trawl nets. All crabs released in offshore waters were caught in standard crab pots except for those tagged in Area I during the 1947-48 season which were taken by otter trawl. Crabs released within the bays were captured in either pots or rings.

As the gear was brought aboard the boat, the crabs were removed and placed on deck where they remained as long as an hour. In the case of

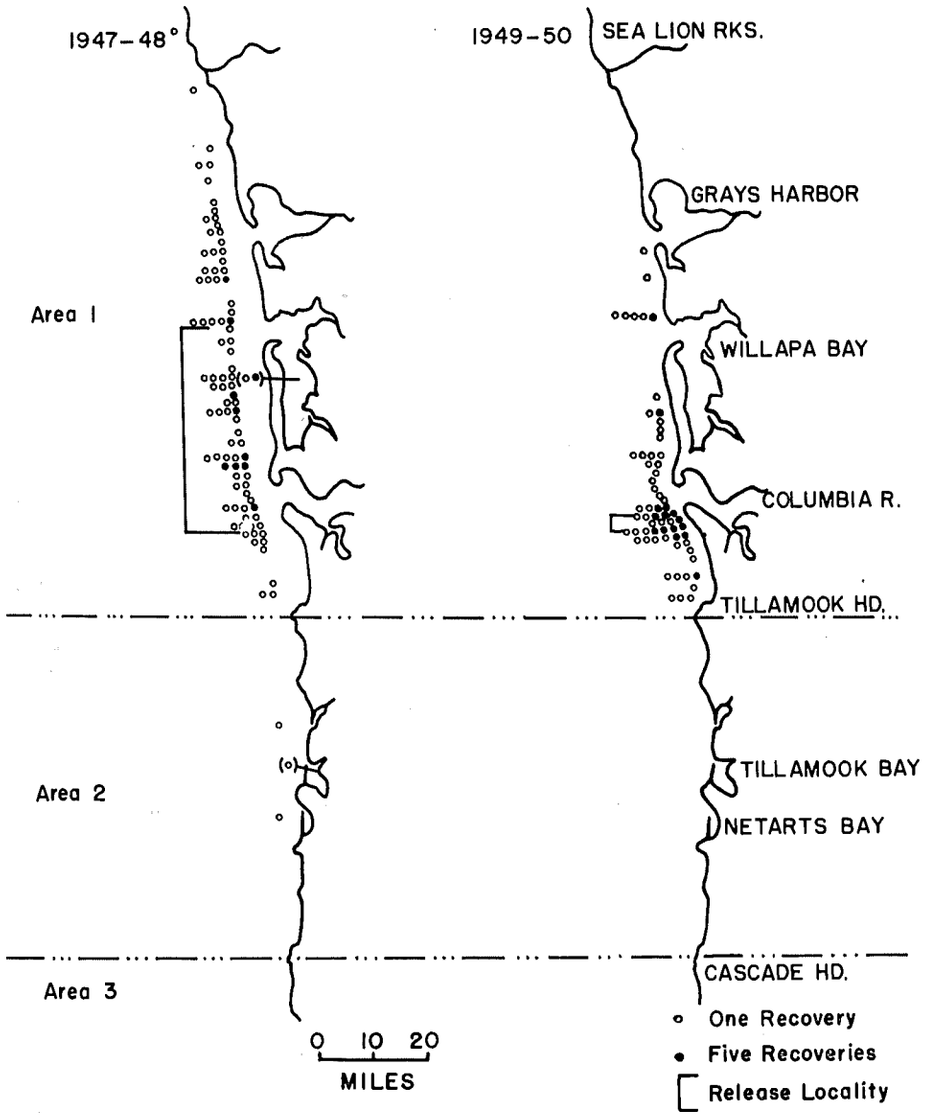

FIGURE 9. CHART OF COASTAL AREAS SHOWING TAGGING SITES AND DISTRIBUTION OF INDIVIDUAL RECOVERIES FOR AREA I, 1947-1950.

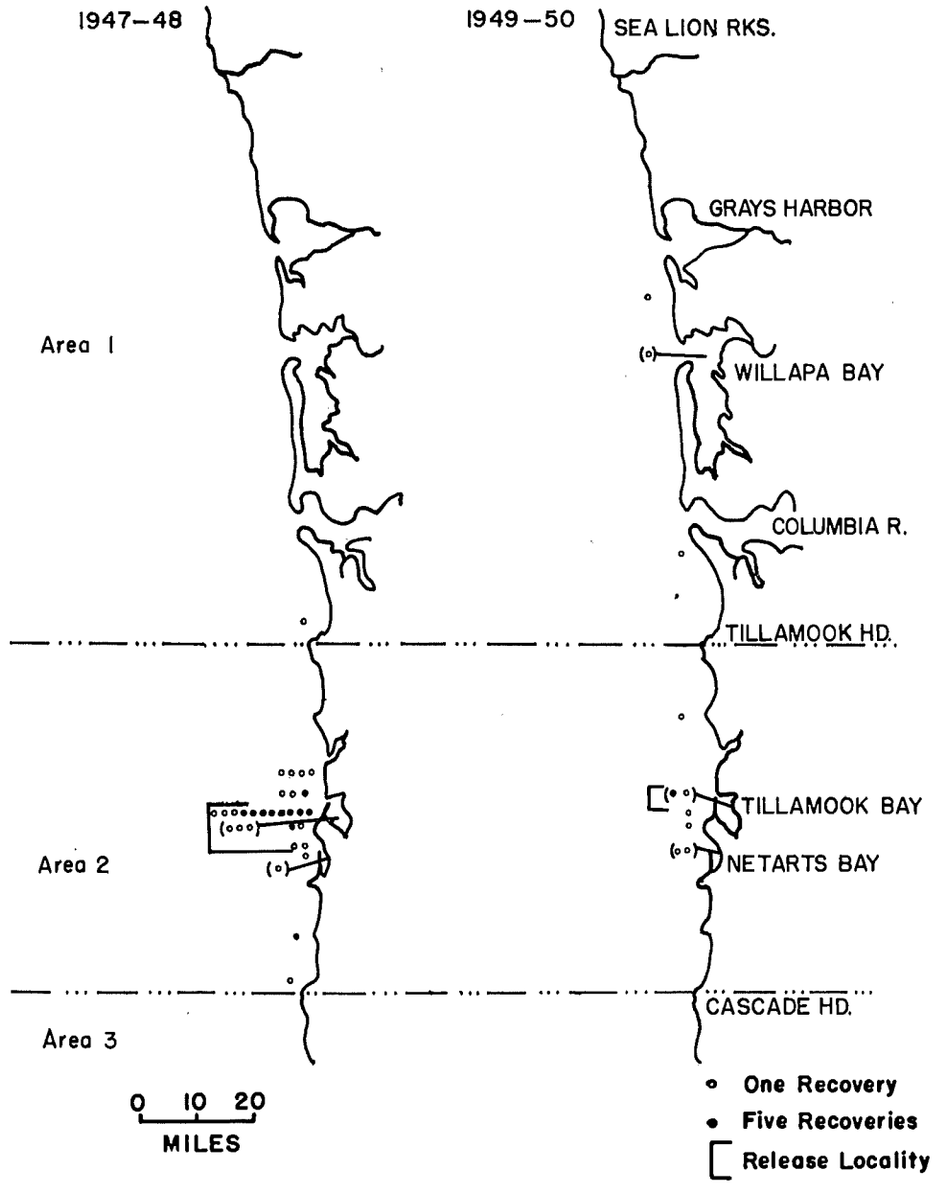

FIGURE 10. CHART OF COASTAL AREAS SHOWING TAGGING SITES AND DISTRIBUTION OF INDIVIDUAL RECOVERIES FOR AREA II, 1947-1950.

pot or ring fishing, the crabs were tagged and returned to the water as the boat traveled from one pot or ring to the next.

Offshore tagging was done by one or two biologists aboard a chartered commercial fishing boat, while tagging in bays was generally done aboard a skiff. One man measured the shoulder width of the crab; noted its shell condition, sex, and missing appendages; and tagged the crab, while the

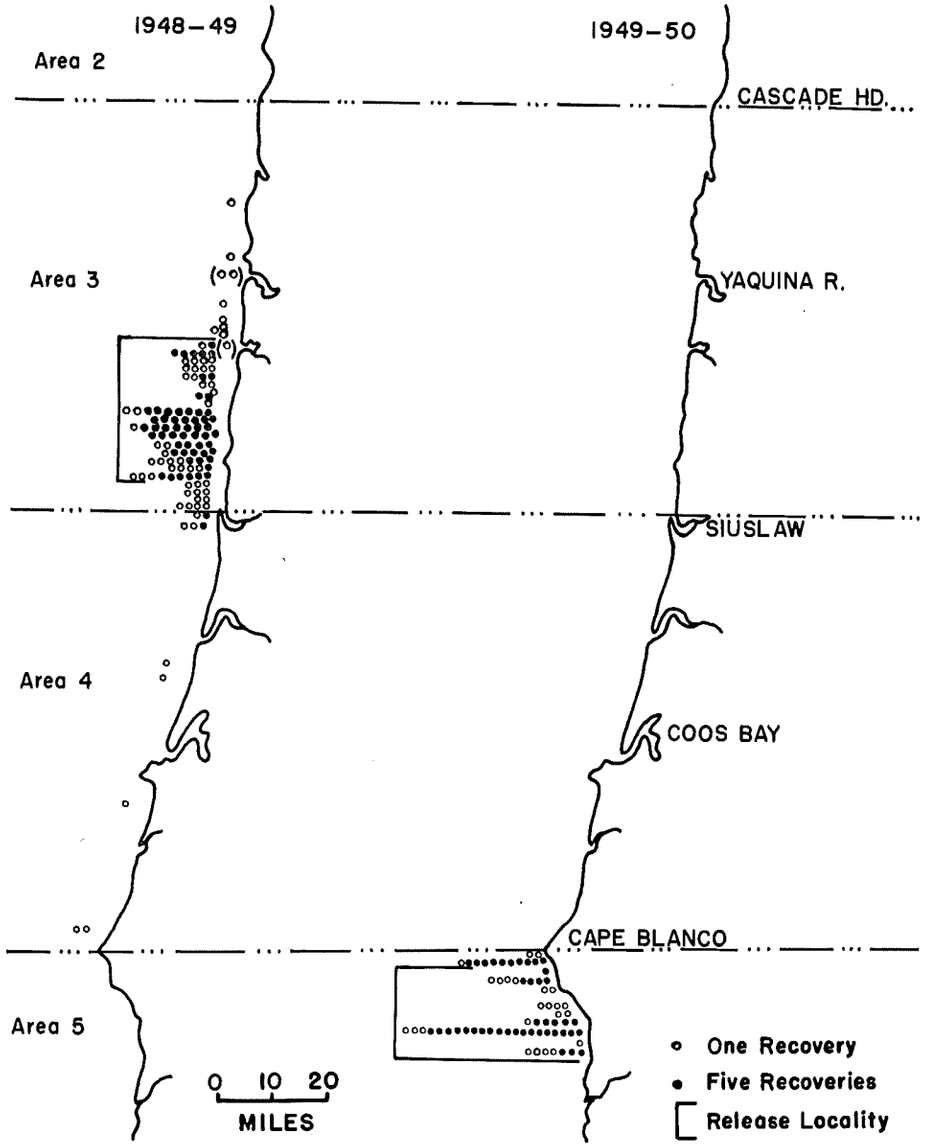

FIGURE 11. CHART OF COASTAL AREAS SHOWING TAGGING SITES AND DISTRIBUTION OF INDIVIDUAL RECOVERIES FOR AREAS III AND V, 1948-1950.

other man recorded the information. A hole was made at the base of the right tenth anterolateral spine of the carapace by means of a sharp-pointed awl. Then a nickel pin was inserted in sequence through a blank tag, the hole in the carapace from the under side, and a numbered tag, after which the pin was cut off and knotted. Inasmuch as the atmosphere was usually cool and moist, it was thought that holding the crabs out of water for a short time did not influence the mortality to a significant extent.

Recovery Procedure

An attempt was made to sample the commercial landings to obtain the ratio of tagged to untagged crabs. Due to lack of manpower this program was abandoned after examining 27,000 crabs and recovering two tags, both of which had been released by the Washington State Department of Fisheries in a concurrent tagging program. Periodic visits by the biologists were made to the respective fishing ports where fishermen, plant workers,

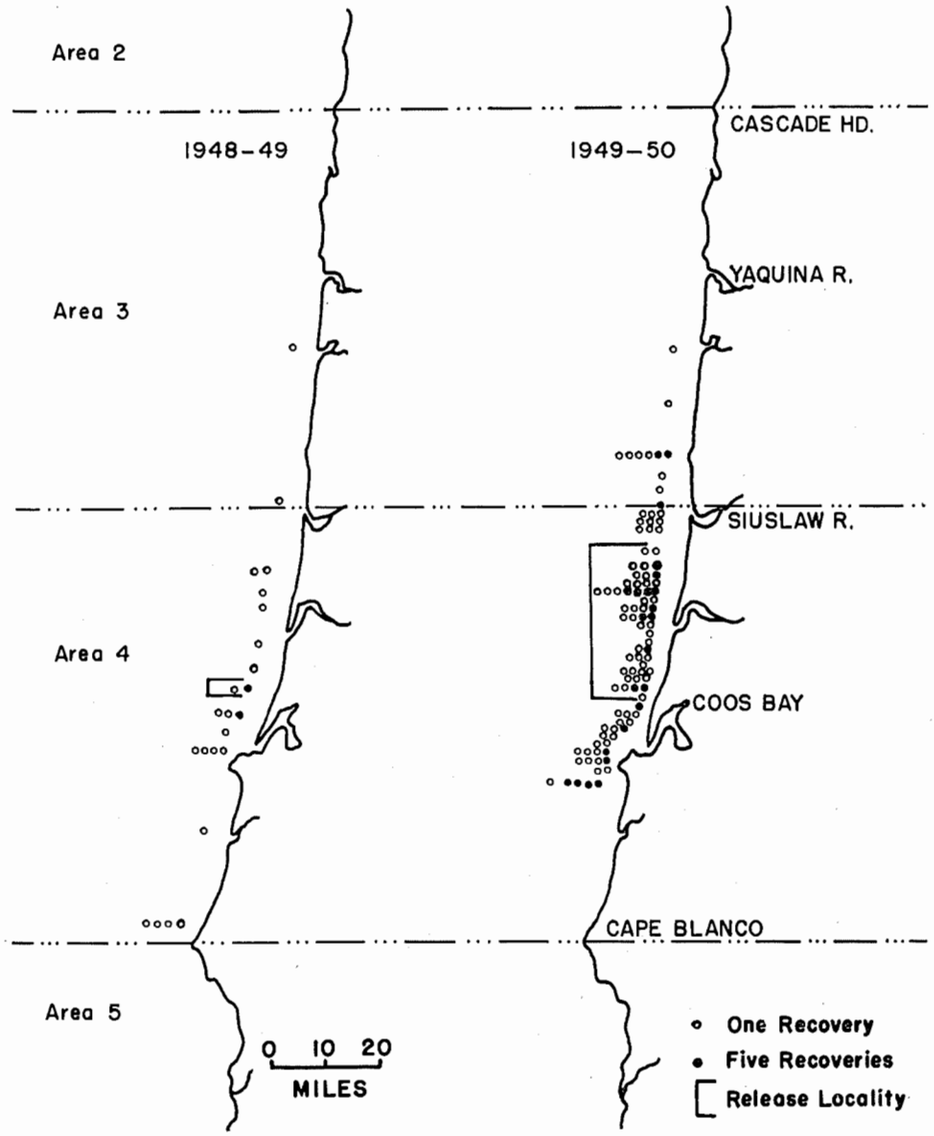

FIGURE 12. CHART OF COASTAL AREAS SHOWING TAGGING SITES AND DISTRIBUTION OF INDIVIDUAL RECOVERIES FOR AREA IV, 1948-1950.

and other persons associated with the crab fishing industry were contacted for possession of tags. Some were returned by members of the fishing industry by mail. No reward was paid for the return of tags.

The recovery of tags in various areas along the coast and the usability of the recovery data were probably influenced by two factors not directly attributable to condition or actions of the crabs or tags and pins. These factors may be stated as follows: (1) Ports far from the shellfish laboratory, which is located at Newport on Yaquina Bay, were not visited as often as those nearby, and as a result, the interest of the industry in the success of the investigation decreased through lack of personal contact and probably was reflected in the percentage of tags reported as well as information regarding returned tags from such areas, and (2) While fishermen and persons connected with the industry throughout the fishery gave excellent support to the program for the most part, in some instances recovery data were not complete enough to be used in the analysis. While the exact effect of these two factors could not be evaluated, they were considered in the analysis of the data.

Tags Released and Recovered

While tagged crabs were released in three tagging seasons, 1947-48, 1948-49, and 1949-50, all areas were not represented in each tagging season.

TABLE 3. **NUMBERS TAGGED, RECOVERED, AND PERCENTAGE RECOVERY OF CRABS RELEASED IN OFFSHORE WATERS OF OREGON, 1947-1950**

Area	*Season and Month of Release*	*Missing Appendages*	*Number of Releases* — *Shell Condition*① 1	2	*Number of Recoveries* — *Shell Condition*① 1	2	*Per Cent Recovery* — *Shell Condition*① 1	2
I	1947-48	none	320	85	110	15	34.4	17.6
	(Dec. 1947, Jan. 1948)	some	104	33	23	3	22.1	9.1
	1949-50	none	221	204	93	40	42.1	19.6
	(Dec. 1949)	some	56	57	22	15	39.3	26.3
II	1947-48	none	364	4	83	2	22.8	50.0
	(Feb., Mar. 1948)	some	98	1	24	0	24.5	C.0
	1948-49	none	0	2	0	1	0.0	50.0
	(Aug. 1949)	some	0	2	0	0	0.0	0.0
	1949-50	none	0	60	0	8	0.0	13.3
	(July 1950)	some	0	41	0	4	0.0	9.8
III	1948-49	none	582	15	252	1	43.3	6.7
	(Nov. 1948, Mar., Apr., May 1949)	some	256	11	119	3	46.5	27.3
IV	1948-49	none	101	9	21	2	20.8	22.2
	(Nov. 1948)	some	65	8	12	1	18.5	12.5
	1949-50	none	340	124	154	41	45.3	33.1
	(Nov. 1949)	some	107	61	38	10	35.5	16.4
V	1949-50	none	619	97	345	21	55.7	21.6
	(Jan. 1950)	some	42	3	22	0	52.4	0.0
Subtotal		none	2,547	600	1,058	131	41.5	21.8
		some	728	217	260	36	35.7	16.6
Total			4,092		1,485		36.3	

① Shell condition: 1—Carapace very rigid, exoskeleton of legs rigid or slightly pliable
2—Carapace slightly to moderately flexible

Table 3 shows the total numbers of crabs released in each offshore area and season, including re-releases—crabs which were tagged, released, recovered, and once more released bearing the same tag—as well as the total numbers and percentages recovered. Totals found in other tables may not agree with these because of the incompleteness of recovery data for certain tags which resulted in their being usable in certain analyses and not in others.

Uniformity of recovery for crabs released in the different categories such as time, condition, etc., was examined. Chi-square tests showed a significant difference in recovery for crabs released in different months in Area II in 1947-48, and Area III in 1948-49, and no significant difference for those released in Area I in 1947-48. Releases were made during only one month in all other area-seasons. Since the results were not consistent, no conclusive statement can be made regarding the uniformity of recovery for crabs released in different months.

Shell condition as noted at time of tagging was considered to be a factor in recovery of tagged crabs. The shell condition grades were determined by pinching between the thumb and forefinger the lateral edge of the carapace in a dorsoventral direction. At the time of tagging the crabs were graded according to the following criteria:

Grade	Shell Condition
1	Carapace very rigid; exoskeleton of legs rigid or slightly pliable.
2	Carapace slightly to moderately flexible.
3	Carapace very flexible, may be crushed in hand. None tagged in this condition.

Chi-square tests showed that there was a significant difference in recovery between crabs released in shell condition 1 and those released in shell condition 2 for all area-seasons tested. In other words, a significantly greater percentage of the crabs released in a hard shell condition were recovered than those released with a medium hard shell. Area-seasons not tested were those in which there was only one shell condition of crabs released, or where the expected number in any class fell below 5.

MOVEMENT OF CRABS

General

One of the purposes of tagging the crabs was to determine the extent of their movements in a northerly and southerly direction, inshore and offshore, and into and out of bays and estuaries. This knowledge would aid in formulating regulations designed to maintain the entire crab population on a maximum sustained yield basis. To illustrate the practical application of the information with an exaggerated example, if there were no movement of crabs between certain areas along the coast, a fishery could remove all of the crabs from one area without damage to the stocks of crabs in adjacent areas unless these adjacent areas depended upon the heavily fished area for their recruitment of larval crabs. If this were the case, each fishing area might have need for its own set of regulations.

The following factors must be taken into consideration in evaluating the movements of crabs:

(1) Location in which the crabs were released.
(2) Location of the fishing fleet in relation to the point of release.
(3) Proximity of bays to the point of release.
(4) Relative intensity of the bay and offshore fisheries.
(5) Time of tagging with respect to subsequent fishing intensity.

A crab released far from any fishing grounds would necessarily have to travel longer distances before being recovered than would a crab released close to a fishing area. Similarly, if there were no fishing fleet to the north, (or south) of the point of release, then no crabs would be recovered to the north (or south) of the release point. The recovery of tagged crabs within bays and estuaries is affected by the proximity of bays to the point of release as well as by the relative intensity of fishing in the bays and offshore waters. If there were no bays close to the point of release, there would be less likelihood of recovering any crabs in the bays, and if the fishing intensity within a bay were low, compared to the adjacent offshore waters, the expected recovery within the bay would be low.

While it is difficult to evaluate accurately the effect of these factors, they should be kept in mind while examining the data. Further mention of these points will be made as they are related to the individual tagging areas.

Recoveries used in studying the movement of the crabs were not weighted for intensity of the fishery in various areas because necessary data were not available. However, it is almost certain that the intensity of the fishery adjacent to points of release would affect the apparent movement of tagged crabs to some extent. This important point should be remembered when considering the following summary of the movement of tagged crabs.

In the five offshore areas during the period from 1947 to 1950, a total of 4,092 crabs was tagged. Of the 1,485 recovered, only 1,042 yielded usable migration information.

Time Out—Distance Traveled Relationship

Table 4 shows the average distance traveled and the period of freedom of tag recoveries by season and area of release, with a breakdown by shell condition and missing appendages at time of tagging. The relationship between days at liberty and distance traveled was examined to determine if a correlation existed between these two factors. Testing the hypothesis that rho (ρ), the population correlation coefficient between days at liberty and miles traveled, equals zero gave the following results for crabs released in shell condition 1 with no appendages missing: The hypothesis was rejected for Area I, 1949-50; Area II, 1947-48; Area III, 1948-49; and Area IV, 1948-49. For Area I, 1947-48; Area IV, 1949-50; and Area V, 1949-50 the hypothesis was not rejected. The results of the above tests indicate that for the area-seasons in which the hypothesis was rejected, generally the longer the tagged crabs were at liberty before recapture the greater

TABLE 4. **AVERAGE MILES TRAVELED AND DAYS AT LIBERTY FOR CRABS RELEASED IN OFFSHORE WATERS OF OREGON, 1947-1950.**

Tagging Area	Tagging Season	Shell Condition①	Missing Appendages		Days at Liberty 0–19	20–39	40–59	60–79	80–99	100–119	120–139	140–159	160–179	180–199	200–219	220–239	240–259	260–279	280–299	300–319	320–339	340–359
I	47–48	1	none	miles	2.0	2.0	14.9	14.1	19.6	13.8	18.3	17.8	21.3	....	....	....	37.0	....	....	....	....	....
				frequency	1	1	12	7	27	19	8	6	7	....	....	....	1	....	....	....	....	....
		1	some	miles	....	7.0	27.0	12.0	7.0	17.0	44.5	7.0	....	22.0	37.0	....	....	....	....	....	....	....
				frequency	....	1	1	4	1	4	2	1	....	2	1	....	....	....	....	....	....	....
	49–50	1	none	miles	2.0	7.0	4.0	5.0	3.7	5.7	4.0	7.0	5.3	9.5	....	....	....	....	....	....	....	....
				frequency	11	3	5	5	3	15	10	3	3	2	....	....	....	....	....	....	....	...
		1	some	miles	2.0	7.0	2.0	....	17.0	14.3	2.0	4.5	....	....	....	....	....	....	....	....	....	....
				frequency	3	1	1	....	2	3	1	2	....	....	....	....	....	....	....	....	....	....
		2	none	miles	2.0	2.0	2.0	23.0	2.0	19.5	5.7	14.5	12.0	12.0	....	....	....	....	....	....	....	....
				frequency	1	1	1	5	2	2	8	2	2	1	....	....	....	....	....	....	....	....
II	47–48	1	none	miles	2.0	5.3	4.1	2.0	2.0	4.5	....	2.0	13.2	....	7.0	....	7.0	....	....	....	....	....
				frequency	1	3	12	13	5	10	....	2	4	....	1	....	1	....	....	....	....	....
		1	some	miles	2.0	2.0	3.7	4.5	3.0	2.0	....	....	2.0	7.0	....	....	....	....	....	....	....	....
				frequency	1	1	3	2	5	1	....	....	1	1	....	....	....	....	....	....	....	....
III	48–49	1	none	miles	4.1	3.3	3.8	4.2	8.0	11.6	22.0	12.0	2.0	5.8	7.0	42.0	9.5	12.0	4.5	2.0	....	12.0
				frequency	52	51	74	47	21	14	5	1	1	4	1	2	2	1	2	1	....	1
		1	some	miles	4.4	4.1	3.4	3.2	5.8	4.5	9.0	....	12.0	7.0	12.0	....	....	....	....	....	....	....
				frequency	27	7	13	4	4	6	5	....	1	2	1	....	....	....	....	....	....	....
IV	48–49	1	none	miles	....	7.0	....	4.1	24.5	12.0	12.0	2.0	34.5	....	....	....	....	....	....	....	....	....
				frequency	0	1	0	7	2	3	1	1	2	....	....	....	....	....	....	....	....	....
	49–50	1	none	miles	2.0	9.5	18.0	12.4	12.7	17.5	8.4	10.3	7.5	16.3	....	....	....	....	....	....	....	....
				frequency	1	2	5	12	22	19	21	9	5	7	....	....	....	....	....	....	....	....
		1	some	miles	....	....	....	7.0	11.3	12.0	17.0	2.0	7.0	9.5	17.0	22.0	....	....	....	....	....	....
				frequency	....	....	....	2	7	6	2	1	1	2	1	1	....	....	....	....	....	....
V	49–50	1	none	miles	5.8	2.2	3.4	3.9	6.2	2.0	4.0	2.0	....	2.0	....	....	....	....	....	....	....	....
				frequency	4	26	62	34	6	9	10	4	....	2	....	....	....	....	....	....	....	....

① Shell condition: 1—Carapace very rigid, exoskeleton of legs rigid or slightly pliable
2—Carapace slightly to moderately flexible

distance they traveled. For those area-seasons in which the hypothesis was not rejected, this was not necessarily the case. Since the hypothesis was rejected in some of the area-seasons and not rejected in others, the results of this test should not be considered conclusive.

Rate of Travel

It is of general interest to note the rate at which tagged crabs traveled. One crab released in Area V was reportedly recovered 5 days later and 19 miles distant from the point of release, having traveled at a rate of 3.8 miles per day. Many of the crabs released in Area III traveled at an average rate of 2.0 miles per day for distances up to 10 miles, and others traveled at an average rate of 0.7 mile per day for distances exceeding 50 miles.

Rate of Recovery

Approximately 90 per cent of all recoveries were made within 6 months or less of the time of release. If it is assumed that the majority of crabs shed once a year and that the time of shedding is generally late spring and summer, then a large number of unrecovered tags put on during the winter months would be lost when these crabs shed. Because the fishing intensity remained relatively unchanged and since no great number of tagged crabs was recovered during the season following that in which the tagging was done, it may be assumed that very few of the tagged crabs with the tag intact were available for recovery. This may be due to one or more of the following causes: (1) the crabs had moved out of the fishing areas; (2) the crabs had died; (3) the tag was lost due to corrosion of the pin; or, (4) the tag was lost when shedding occurred, i.e., it remained with the old carapace.

Three crabs were recovered more than a year after the release date, the greatest length of time at liberty being 878 days. This would indicate that not all crabs shed once every year.

Effect of Missing Appendages

The hypothesis that there is no significant difference in the mean distance traveled by crabs with and without some missing appendages was tested. The results indicate that at the 5 per cent significance level this hypothesis need not be rejected; or in other words, in any certain time period, the crabs with some missing appendages did not migrate significantly different distances than those with no missing appendages.

Of those recovered crabs released in shell condition 1, there was no significant difference at the 5 per cent level in the mean number of days at liberty between those released having no missing appendages and those having some missing. In other words, crabs with missing appendages did not exhibit a tendency to be caught faster than those without missing appendages. Had one of these groups remained at liberty longer than the other, there is the possibility that this group would have suffered a greater natural mortality than the other before recapture.

Average Movement

Crabs released in offshore waters traveled an average of 8.3 miles in an average of 80 days from time of release to the time of recovery. All

TABLE 5. **MOVEMENT OF CRABS RELEASED IN OFFSHORE WATERS OF OREGON, 1947-1950**

Area	Season	Number of Recoveries with Movement Data Recorded	Non-directional Movement①		Directional Movement								Crabs Moving Out of Area			
					Average						Maximum					
					North			South			North	South	North		South	
			No.	%	Miles	No.	%	Miles	No.	%	Miles	Miles	No.	%	No.	%
I	1947-48②	127	22	17.3	25.0	79	62.2	14.8	26	20.5	71	57	0	0	3	2.4
	1949-50	121	78	64.5	18.1	31	25.6	11.6	12	9.9	41	12	0	0	0	0
II	1947-48	70	52	74.3	9.0	11	15.7	11.6	7	10.0	28	25	1	1.4	0	0
	1949-50	9	5	55.6	30.8	4	44.4	0	0	0	73	0	4	44.4	0	0
III	1948-49	352	239	67.9	12.7	55	15.6	13.8	58	16.5	133	89	1	0.3	5	1.4
IV	1948-49	30	14	46.7	22.0	6	20.0	20.2	10	33.3	55	38	1	3.3	0	0
	1949-50	161	44	27.3	16.7	39	24.2	18.0	78	48.4	37	35	18	11.2	0	0
V	1949-50	172	139	80.8	9.9	24	14.0	8.7	9	5.2	19	11	0	0	0	0
	Total	1,042	593	56.9	17.5	249	23.9	15.5	200	19.2	....	....	25	2.4	8	0.8

① Non-directional indicates a movement of 4 miles or less.
② Area I, 1947-48: Crabs captured in otter-trawl and released 5 miles or more from main fishing grounds.

distances are in nautical miles. This migration was measured as straight line distance approximately parallel to the coast. There was a further subdivision into movement north or south of the point of release. For this purpose crabs recovered 4 miles or less from the point of release were considered to have made a non-directional movement. Table 5 shows the directional and non-directional movement of crabs released in offshore waters during all seasons, but does not indicate the average movement for any given time period. It is of interest to note that 57 per cent traveled 4 miles or less. Of those migrating in a definite direction, 24 per cent moved north and 19 per cent moved south. The relatively small percentage of crabs exhibiting non-directional movement in Area I for 1947-48 probably resulted from the crabs' being caught for tagging in an otter-trawl net and released in 22 to 48 fathoms of water in an area of comparatively little fishing. In order to reach the main fishing grounds these crabs had to travel at least 5 miles. In all other areas and seasons the releases were made from pots on the immediate fishing grounds.

Inshore-Offshore Movement

Table 6 shows the number and the per cent of the crabs which were recovered either in offshore or bay waters in Oregon and Washington after

TABLE 6. **RECOVERIES BY GENERAL AREA OF RECAPTURE OF CRABS RELEASED IN OFFSHORE WATERS OF OREGON, 1947-1950**

Tagging Area	*Season*	*Recovery Area*						
		Offshore		*Bay*		*Unknown*		*Total*
		Number	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*	*Number*
I	1947-48	124	82.1	9①	6.0	18	11.9	151
	1949-50	132	77.6	0	0	38	22.4	170
	Total	256	79.8	9	2.8	56	17.4	321
II	1947-48	62	56.9	9②	8.2	38	34.9	109
	1949-50	5	41.7	5③	41.7	2	16.7	12
	Total	67	55.4	14	11.6	40	33.0	121
III	1948-49	364	97.8	3④	0.8	5	1.3	372
IV	1948-49	27	75.0	4⑤	11.1	5	13.9	36
	1949-50	213	87.6	20⑤	8.2	10	4.1	243
	Total	240	86.0	24	8.6	15	5.4	279
V	1949-50	376	95.7	0	0	17	4.3	393
	Grand Total	1,303	87.7	50	3.4	133	8.9	1,486

① Six in Willapa and 1 each in Tillamook, Netarts, and Nehalem Bays.
② Seven in Tillamook and 2 in Netarts Bays.
③ One in Willapa, 2 in Tillamook, and 2 in Netarts Bays.
④ Two in Yaquina and 1 in Alsea Bays.
⑤ All in Coos Bay.

being released in the offshore areas along the coast. More crabs released in Areas II and IV than in the other areas were recovered inside bays. Fishing intensity is a factor in the recovery of crabs both inside and outside the bays. However, it is not possible to correct for this since the intensity of the fishery either inside or outside the bays is not known. It is not surprising that crabs released in Area V were not recovered in any bay, since there are no bays within 25-30 miles of the release points.

North-South Movement

Chi-square was used to test whether or not a significantly greater number of tagged crabs were recovered either to the north or south of the release points. Table 7 shows the results of these tests. In one case,

TABLE 7. **SUMMARY OF CHI-SQUARE TEST OF THE HYPOTHESIS THAT THERE IS NO SIGNIFICANT DIFFERENCE IN THE NUMBERS OF CRABS RECOVERED TO THE NORTH AND TO THE SOUTH OF THE RELEASE POINT FOR CRABS RELEASED IN OFFSHORE WATERS OF OREGON, 1947-1950; CRABS MOVING 0-4 MILES ARE NOT INCLUDED IN THIS TABLE**

Area	*Season*	*Direction of Migration*	*Number of Recoveries*		$(O-E)^2$	X^2	*D.F.*	*P*
			Observed	*Expected*	*E*			
I	1947-48	North	79	52.5	13.38			
		South	26	52.5	13.38			
		Total	105	105.0	26.76	26.76	1	<0.001
	1949-50	North	31	21.5	4.20			
		South	12	21.5	4.20			
		Total	43	43.0	8.40	8.40	1	<0.01
II	1947-48	North	11	9.0	0.44			
		South	7	9.0	0.44			
		Total	18	18.0	0.88	0.88	1	>0.30
III	1948-49	North	55	56.5	0.04			
		South	58	56.5	0.04			
		Total	113	113.0	0.08	0.08	1	>0.70
IV	1948-49	North	6	8.0	0.50			
		South	10	8.0	0.50			
		Total	16	16.0	1.00	1.00	1	>0.30
	1949-50	North	39	58.5	6.50			
		South	78	58.5	6.50			
		Total	117	117.0	13.00	13.00	1	<0.001
V	1949-50	North	24	16.5	3.41			
		South	9	16.5	3.41			
		Total	33	33.0	6.82	6.82	1	<0.01

which is not included in the table, too few recoveries were made to test a difference.

For three of the area-seasons tested there was no significant difference in the numbers which were recovered either to the north or south of the release points. In three other cases a significantly greater number of recovered crabs was recovered to the north of the tagging location, and in one case the number recovered to the south was significantly greater. The results of these tests indicate that there is no directional movement of crabs common to all areas along the Oregon coast when analyzed by area-seasons.

Results obtained in Area I, immediately adjacent to the Washington crab fishing grounds, showed a movement pattern similar to that found by Cleaver (1949) who noted a general northward movement of crabs along the Washington coast from January to June with and without adjustment for fishing intensity. Lack of data on distribution of fishing intensity in the various Oregon areas casts some doubt on the validity of the apparent movement as indicated by chi-square tests. The higher the percentage recovery of tags the less effect fishing intensity adjustments will have on movement studies and conversely, the lower the percentage of tags recovered the more effect fishing intensity adjustments will have. It should be noted that most of the crabs tagged by the Oregon Fish Commission in Area I during the 1947-48 season were released just north of the Columbia River and might be expected to act similarly to the crabs tagged in adjacent areas by Cleaver.

Area Movement

While no definite measurement of the fishing intensity is available for the specific areas and time periods discussed here, crab gear was fished in sufficient numbers the length of the coast that any gross migration pattern should be evident in a tagging program of this sort. Although crab fishing gear was located on both sides of the respective area boundaries in all cases, very few crabs were recovered outside of the area in which they were released. Figures 9-12 show the latitude of recovery for crabs released in the respective offshore areas. It can be seen that there was some interchange of crabs between Areas I and II, and a greater interchange of crabs between Areas III and IV. One crab released in Area III moved north of Willapa Bay (not shown in Figure 11). The most striking example of an apparent barrier to movement is Cape Blanco where crabs were released very close to the Cape on the south side and fishing was being carried out both to the north and to the south. No tagged crabs were recovered to the north.

On the basis of movement alone, one could define three areas along the Oregon coast: (1) north of Cascade Head, that is Areas I and II, (2) Cascade Head to Cape Blanco which includes Areas III and IV, and (3) south of Cape Blanco, Area V. As may be seen from Table 5, the greatest amount of interchange was between Areas III and IV, where a total of 25 crabs moved from one area to the other. It is realized that the area divisions are only arbitrary and the results obtained are partially dependent upon numbers tagged, proximity to adjacent areas and fishing grounds, and size of the areas.

Bay Crabs—Tagging

Tagged crabs were released in four bays along the Oregon coast during the same seasons in which crabs were released in offshore waters. Much the same procedure was followed for the release and recovery of crabs within the bays as was practiced for offshore crabs. All of the crabs released within bays were first captured by pots with the exception of a portion of those released in Yaquina Bay during 1949–50 which were caught by rings. Recovery of tags was primarily dependent upon commercial fishermen and plant operators retaining tags found on crabs and turning them in to Fish Commission representatives. Some tags were also returned by sport fishermen.

A point to be considered with respect to recovery in offshore waters of crabs tagged within the bays is that the legal size limit for offshore crabs is 6¼ inches and for bay crabs 5¾ inches. Because the gear used by most offshore commercial fishermen is designed to permit the escape of crabs less than 6¼ inches in shoulder width, the probability of recovery in offshore waters of crabs less than 6¼ inches should be lower than for those over this size. Testing the results of the tagging by chi-square showed no significant difference in numbers recovered in offshore waters between the two size groups, i.e., those greater and those less than 6¼ inches shoulder width. In other words, the smaller crabs were taken in offshore waters as readily as the larger ones. However, these results should not be considered conclusive because again no corrections have been made for fishing intensity in the two areas, since data for this are lacking.

Table 8 presents a summary of the releases and recoveries of crabs released within four bays along the Oregon coast. These data were not tested for homogeneity of recovery relative to such factors as shell condition and missing appendages, as were the data for crabs tagged in offshore waters.

Movement of Bay Crabs

The average distance traveled by all crabs released within bays and subsequently recovered was 4.2 nautical miles. This is about half the average distance of 8.3 miles for crabs released in offshore waters. The greatest distance traveled by crabs released in bays was 81 miles and this was negotiated by two crabs, one released in Yaquina Bay and recovered in Coos Bay 152 days later, and the other released in Coos Bay and recovered in Yaquina Bay 92 days later. Of the 606 recoveries for which distance traveled is known, only 99 or 16.3 per cent traveled 5 miles or more while 43.1 per cent of the offshore tagged crabs traveled 5 miles or more.

Table 9 presents a summary of the recoveries by area for crabs released within bays. From this table it may be seen that nearly three-fourths of all recoveries were made in the same bay in which the crabs were originally released. In addition, 17.7 per cent of the recoveries were made in offshore waters and 1.5 per cent in other bays, which gives a total recovery of 19.2 per cent from outside of the bay in which the crabs

TABLE 8. **NUMBERS TAGGED, RECOVERED, AND PERCENTAGE RECOVERY OF CRABS RELEASED IN OREGON BAYS, 1947-1950**

Bay	Season	Missing Appendages	Number of Releases		Number of Recoveries		Per Cent Recovery	
			Shell Condition①		Shell Condition①		Shell Condition①	
			1	2	1	2	1	2
Columbia River	1947-48	none	10	24	0	1	0.0	4.2
	(Dec. 1947)	some	8	7	0	0	0.0	0.0
	1949-50	none	184	108	34	15	18.5	13.9
	(Dec. 1949)	some	119	41	18	9	15.1	21.9
Netarts Bay	1947-48	none	83	49	34	5	41.0	10.2
	(Jan., Feb., Mar. 1948)	some	81	43	29	8	35.8	18.6
	1948-49	none	0	18	0	2	0.0	11.1
	(Oct. 1948)	some	0	4	0	0	0.0	0.0
Yaquina Bay	1947-48	none	3	82	0	20	0.0	24.4
	(Aug. 1948)	some	1	43	0	10	0.0	23.3
	1948-49	none	9	203	2	29	22.2	14.3
	(Sept., Oct. 1948)	some	3	76	0	11	0.0	14.5
	1949-50	none	73	73	24	41	32.9	56.2
	(Oct. 1949, Jan. 1950)	some	42	14	20	3	47.6	21.4
Coos Bay	1948-49	none	8	49	2	15	25.0	30.6
	(Oct. 1948, July 1949)	some	16	24	4	4	25.0	16.7
	1949-50	none	252	113	149	61	59.1	54.0
	(Oct. 1949)	some	204	89	98	31	48.0	34.8
Subtotal		none	622	719	245	189	39.4	26.3
		some	475	341	169	76	35.6	22.3
Total			1,097	1,060	414	265		

① Shell condition: 1—Carapace very rigid, exoskeleton of legs rigid or slightly pliable
2—Carapace slightly to moderately flexible

were released. The recovery area was unknown for 7.0 per cent of the recoveries. In the offshore tagging 3.4 per cent of the releases were recovered within bays. Fishing intensity, which would be a factor in the recovery of tags from the bay and offshore fishing areas, cannot be evaluated from data on hand. Because of this factor it is difficult to say precisely what the relationship is between movement of crabs in and out of the bays of Oregon. It is only possible to state that crabs do move in and out of bays at an unknown rate and that they will occasionally move from one bay to another. A specially designed experiment is needed to obtain a clearer picture regarding the movement of crabs in and out of bays.

TABLE 9. **RECOVERIES BY GENERAL AREA OF RECAPTURE OF CRABS RELEASED IN OREGON BAYS, 1947-1950**

Tagging Area	*Season*	*Recovery Area*								
		Same Bay		*Other Bay*		*Offshore*		*Unknown*		*Total*
		Number	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*	*Number*
Columbia River										
	1947-48	0	0.0	0	0.0	1	100.0	0	0.0	1
	1949-50	12	15.4	2	2.6	44	57.1	19	24.7	77
	Total	12	15.4	2	2.6	45	57.7	19	24.4	78
Netarts Bay										
	1947-48	77	98.7	1	1.3	0	0.0	0	0.0	78
	1948-49	2	100.0	0	0.0	0	0.0	0	0.0	2
	Total	79	98.8	1	1.3	0	0.0	0	0.0	80
Yaquina Bay										
	1947-48	9	30.0	5	16.7	13	43.3	3	10.0	30
	1948-49	36	83.7	1	2.3	4	9.3	2	4.7	43
	1949-50	81	91.0	0	0.0	4	4.5	4	4.5	89
	Total	126	77.8	6	3.7	21	13.0	9	5.6	162
Coos Bay										
	1948-49	6	24.0	1	4.0	12	48.0	6	24.0	25
	1949-50	270	83.6	0	0.0	40	12.4	13	4.0	323
	Total	276	79.3	1	0.3	52	14.9	19	5.5	348
Total		493	73.8	10	1.5	118	17.7	47	7.0	668

BIOLOGY

Soft-Shell Season

Soft-shell crabs, i.e., those which have shed recently, are lighter in weight and the yield of meat is less than those from hard-shell crabs of similar width. Upon this basis it was concluded that a closed season covering the period when the majority of the crabs were soft-shelled would result in a greater overall total yield of meat on an annual basis.

In 1948 the Fish Commission provided for a closed season covering the period when the crabs were soft-shelled. It was decided that when 10 per cent or more of the legal size male crabs were soft-shelled, the season would be closed. It was further decided that the season would be reopened when less than 10 per cent of the legal size male crabs were soft-shelled. Condition of the crabs was to be determined through a sampling program conducted by biologists of the Fish Commission.

The above method was followed for closing the 1947–48 season and for opening the 1948–49 season. During 1948 the Fish Commission, using soft-shell data gathered previously, set the present fixed season for commercial crabbing because of the following reasons: (1) Weather conditions could delay sampling and, consequently, the opening of the season to a considerable degree. (2) The expense of catching crabs for sampling purposes by using boats and gear rented by the Commission constituted almost one-third of the shellfish research budget and it was felt that this money could be better utilized in other ways. (3) The uncertainty as to when the season would open made it difficult for fishermen, receivers, and processors to prepare their fishing gear and other equipment for the coming season. Consequently, the season was established as November 15 to August 15 in the area south of Cascade Head and December 15 to September 15 in the area north of Cascade Head.

Maturity

Examination of female crabs has shown that specimens of similar sizes collected at the same time may have ovaries in varying stages of maturity. Egg-bearing females have been found in the offshore waters of Oregon during the period October to March, inclusive. MacKay and Weymouth (1942) found egg-bearing females in every month but September in British Columbia waters, while Cleaver (1949) reported that most females were carrying eggs between November and February, inclusive, in Washington.

The immature ovary is a much-branched, translucent, tubular structure lying dorsal to the liver on each side of the crab. As development proceeds, the ovary becomes more opaque and the color changes from white to whitish-orange, finally becoming a bright orange. At this time the eggs are large enough to be seen with the unaided eye and give the ovary a granular appearance. The eggs are bright orange when first extruded and attached to the pleopods on the abdominal flap, becoming progressively darker until just prior to hatching when they are dark brown or nearly black. Thus eggs seen from October to December are usually quite orange while those seen from January to March are various shades of brown.

Growth

Stomachs of silver and chinook salmon taken in the troll fishery off the Oregon coast from June to September contained numbers of megalops and zoea larvae which may or may not have been ingested off the Oregon coast. Megalops larvae have been collected from the waters of Coos Bay in May and June, and fishermen report large numbers of crab larvae in the offshore waters at this time of year. Scattered observations by Fish Commission personnel indicate that larvae and juvenile crabs are present in waters of the coastal region of Oregon during the period of April to July. Further investigation is needed to determine whether all the crab larvae reported and seen at this time of year are those of *C. magister*.

On May 8, 1953 a number of crabs in the megalops stage were collected and held in laboratory aquaria. The mean length of these larvae, measured from the tip of the anterior spine to the tip of the posterior spine, was 8.7 mm. and the standard deviation was 0.33 mm. The majority of the larvae molted into the first post-larval instar during the period of May 9–15. These crabs were identified as the young of *C. magister*. The mean shoulder width of the post-larval crabs was 7.2 mm., with a standard deviation of 0.32 mm. and a range of 6.6 to 8.3 mm. None of the specimens developed further, and by May 17 all were dead. This group of juvenile crabs, representing the first post-larval instar, were about the same size as those found to the north in the state of Washington. Cleaver (1949) reported the first instar to range in size between 5 and 7 mm.

The growth of two groups of post-larval crabs has been observed at the shellfish laboratory. The first group was obtained on May 26 and held until October 2, 1948, a period of 129 days. During this time each crab was held in a separate container and the molts of individual specimens were recorded. The second group of crabs was held in the laboratory during the period from June 3 to August 12, 1954, or 70 days. The crabs of this second group were not held in separate containers and only the average measurements for each instar were obtained. A few measurements of the growth of individual crabs were also obtained from this experiment and are shown in Table 10.

TABLE 10. **GROWTH OF TWO GROUPS OF YOUNG CRABS HELD IN LABORATORY AQUARIA**

Period of Observation	*Average Shoulder Width (mm.)*					
	Instar					
	1	2	3	4	5	6
May–October 1948	7.4	10.4	12.8	16.3	18.9	22.0
Numbers of Crabs	12	13	10	8	5	1
June–August 1954	8.1	11.7	16.3	21.9		
Numbers of Crabs	7	13	12	6		

Table 10 presents a summary of the growth of the crabs of the first group as well as those of the second group for which the growth of in-

dividual crabs was observed. If it is assumed that each group was in the first post-larval instar when obtained, then there is considerable variation in the growth of post-larval crabs. Crabs of the first group required 6 instars to reach an average width of 22.0 mm., while crabs of the other group reached an average size of 21.9 mm. in 4 instars. Even if it is assumed that the latter group was in the second instar when obtained, they required only 5 instars to reach the same approximate size attained by those of the first group in 6 instars. On the basis of the observations made on the growth of these two groups, it can be stated only that there is considerable variation in the early growth of post-larval crabs. This variation may be due to different aquaria conditions under which the crabs were held, and it is possible that neither presents a pattern of the growth of unconfined young crabs.

At various times larger crabs have been held in the laboratory aquaria, and the growth upon molting noted. Figure 12 presents the growth increment for crabs with the original shoulder width varying between 6.4 and 146.0 mm. When arranged in 10 mm. size groups, there is a similarity between the Newport data and those presented by Cleaver (1949) for crabs caught off the Washington coast. It is noted in Figure 13 that the amount of growth per molt increases until a shoulder width of about 95 mm. is reached. The rate of increase with each subsequent molt becomes less and is relatively constant between 18 and 23 mm. The sex of crabs less than 30 mm. shoulder width was not determined and all of those of greater size were males. Direct data are lacking for crabs larger than 146 mm. shoulder width, but reported observations by fishermen indicate that the larger crabs increase about 1 inch (25.4 mm.) in shoulder width each time they molt.

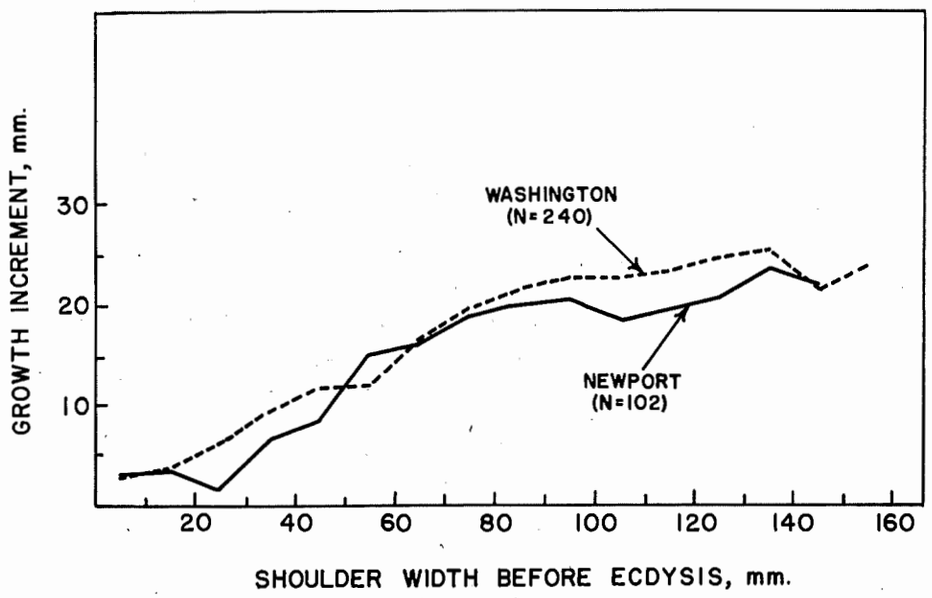

FIGURE 13. GROWTH OF CRABS, WIDTH PRIOR TO SHEDDING AND WIDTH INCREMENT.

Observations were made of the rate of expansion of the bodies of crabs immediately after shedding had taken place. These data are presented in Table 11. Two male crabs, 95 and 108 mm. shoulder width, respectively, were observed from the time they started to back out of the old shell for variable time periods afterwards. Measurements were made at intervals until maximum size had been reached. One crab attained maximum size in 1 hour and 45 minutes; the other crab attained its maximum growth within 5 hours and 10 minutes.

TABLE 11. **GROWTH OF TWO MALE SPECIMENS OF *C. MAGISTER* UPON SHEDDING**

	Shoulder Width (mm.)	*Cumulative Growth (%)*	*Total Growth (mm.)*
Crab No. 1:			
Old exoskeleton	95	.....	.....
New exoskeleton			
At emergence	104	69.2	9
5 hrs. 10 min. after molt	107	92.3	3
1 week after molt	108	100.0	1
Crab No. 2:			
Old exoskeleton	108	.....	.....
New exoskeleton			
30 sec. after molt	121	56.5	13
45 min. after molt	128	87.0	7
1 hr. 45 min. after molt	131	100.0	3
1 week after molt	131	100.0	0

From the above record it can be seen that these crabs had attained approximately 60 per cent of their growth for this instar by the time they had withdrawn completely from the old exoskeleton. This agrees closely with the observations by Cleaver (1949) who noted that 55.3 per cent of the growth was attained by the time the molting crab was free of the old shell. Observations on the second crab showed it began to feed actively when offered food approximately 3 days after shedding. Previously it had refused food at the time crabs in adjoining aquaria were feeding.

Fish, clams, and other organisms—either alive or recently dead— serve as food for the Dungeness crab. Crabs held in laboratory aquaria fed quite readily on freshly-killed fish or clams. However, these same items when in a putrid condition were not eaten by the crabs.

Predators

Predators of this crab may be divided into two classes: (1) those which prey on the larval crabs, and (2) those which prey on the adult form. Predators in the first classification include fish which feed on macroplankton. Megalops of what was believed to be *C. magister* have been

found in silver salmon stomachs and to a lesser extent in the stomachs of chinook salmon. Zoea larvae were also found in the silver salmon stomachs, although in a lesser amount than were the megalops. Larvae at or near the surface are undoubtedly preyed upon by various sea birds. Predators upon adult crabs include several of the more voracious fish such as lingcod (*Ophiodon elongatus*), the great marbled sculpin, (*Scorpaenichthys marmoratus*), wolf-eel (*Anarrhichthys ocellatus*), halibut (*Hippoglossus stenolepis*), and some of the rockfishes of the genus *Sebastodes*. The stomach of one *S. marmoratus* (70 cm. total length) contained 2 Dungeness crabs each of 114 mm. shoulder width as well as parts of 4 other smaller crabs. Other crabs and octopuses are predators upon the Dungeness crab to a limited extent. Cannibalism has also been observed among crabs in crab pots and aquaria, especially at shedding times.

SUMMARY

(1) The first reported commercial crab landings in Oregon were in 1889.

(2) The fishery expanded slowly until 1933 after which the catch rose sharply to a peak of about 11 million pounds in 1943. Landings in recent years have fluctuated between 6 and 11 million pounds.

(3) During the period 1947–50, 6,249 tagged crabs were released in offshore and bay waters of Oregon and 2,164 of these were recovered.

(4) A chi-square test showed the number of recoveries of crabs released while in a softshell condition was significantly less than the number of recoveries of crabs released in a hardshell condition.

(5) The average non-directional distance traveled by 4,092 crabs released in offshore waters, as judged by 1,042 recoveries, was 8.3 miles (range 0–133 miles). Fifty-seven per cent of the recoveries of offshore releases were made within 4 miles of the tagging site.

(6) The average non-directional distance traveled by 2,157 crabs released within bays as judged by 606 recoveries was 4.2 miles (range 0–81 miles). Eighty-four per cent of the recoveries of bay releases were made within 4 miles of the tagging site.

(7) For offshore tagging areas, only 7.4 per cent of the recoveries were made outside of the areas in which they were tagged, and the greatest interchange of crabs occurred between Areas I and II, and between Areas III and IV, while none of the crabs tagged in Area V were caught out of that area.

(8) Only 3.4 per cent of the recoveries of crabs tagged in offshore waters were made within bays, while of the recoveries of crabs tagged within the bays, 19.2 per cent were made outside of the bay in which they were tagged.

(9) Scattered observations show that egg-bearing females are present in offshore waters of Oregon during the period October to March, inclusive, and larval crabs assumed to be *C. magister* have been observed in offshore waters from April to July, inclusive.

(10) The growth of post-larval crabs was followed in the laboratory for approximately 4 months to determine rate of growth.

(11) The growth increment for a single molt, as measured by carapace width at time of molting, becomes fairly constant for crabs between 95 and 146 mm. in shoulder width, with an increase in shoulder width at each molt of 18–23 mm.

(12) Measurements of two crabs (95 and 108 mm. in shoulder width) before and after shedding indicate 60 per cent of the crab's growth for each instar was made by the time it had withdrawn completely from the old exoskeleton. After 1 hour and 45 minutes, one crab had attained 100 per cent expansion.

(13) Macro-plankton-eating fishes such as silver salmon feed upon free swimming crab larvae. Adult crabs up to at least 114 mm. in shoulder width are preyed upon by voracious fish such as ling-cod, the great marbeled sculpin, wolf-eels, halibut, and some of the rockfishes of the genus *Sebastodes*.

ACKNOWLEDGMENTS

Many members of the Oregon Fish Commission research staff contributed to various phases of this project. Mr. Roger D. Tollefson planned the original program under the direction of Mr. Donald L. McKernan, then Director of Research, and supervised the tagging and release phases. Messrs. Lowell D. Marriage, Stanley N. Wilkes, Donald W. Twohy, Grant H. Rae, and Edward P. O'Toole participated in the tagging operations. Without the generous cooperation of fishermen, fish plant workers, and other persons associated with the crab fishery, this project could not have been carried out. Dr. George Y. Harry, Jr., Director of Research, and Mr. Lowell D. Marriage offered many helpful suggestions in the preparation of this report.

LITERATURE CITED

Anderson, A. W. and Peterson, C. E.

1954. Fishery statistics of the United States, 1951. U. S. Fish and Wildlife Serv., Stat. Dig. No. 30, 341 pp.

Cleaver, Fred C.

1949. Preliminary results of the coastal crab (*Cancer magister*) investigations. Wash. Dept. Fish., Biol. Rep. No. 49A, pp. 47–82.

1951. Fisheries statistics of Oregon. Fish Comm. Oreg., Contr. No. 16, 176 pp.

Fiedler, R. H.

1929. Fishery industries of the United States, 1928. Appendix IX to the Report of the Commissioner of Fisheries for the fiscal year 1929. Bur. Fish. Doc. No. 1067, pp. 401-625.

MacKay, D. C. G. and Weymouth, F. W.

1943. Temperature and the world distribution of crabs of the genus *Cancer*. Ecology, Vol. 24, No. 1, pp. 113–115.

Phillips, J. B.

1935. The crab fishery of California. Calif. Fish and Game, Vol. 21, No. 1, pp. 38–60.

Radcliffe, Lewis

1919. Fishery industries of the United States. Report of the Division of Statistics and Methods for 1918. Appendix X to the Report of the U. S. Commissioner of Fisheries for 1918. Bur. Fish. Doc. No. 875, pp. 1–167.

Sette, O. E.

1926. Fishery industries of the United States, 1924. Appendix VII to the Report of the U. S. Commissioner of Fisheries for 1925. Bur. Fish. Doc. No. 997, pp. 217–408.

1928. Fishery industries of the United States, 1926. Appendix V to the Report of the U. S. Commissioner of Fisheries for 1927. Bur. Fish. Doc. No. 1025, pp. 337–483.

Sette, O. E. and Fiedler, R. H.

1929. Fishery industries of the United States, 1927. Appendix IX to the Report of the U. S. Commissioner of Fisheries for 1928. Bur. Fish. Doc. No. 1050, pp. 401–548.

State of Oregon

1898/99–1908. Annual Reports of the Department of Fisheries of the State of Oregon to the Legislative Assembly.

1909-12. Biennial Reports of the Department of Fisheries of the State of Oregon to the Legislative Assembly.

1950–55. Unpublished summary sheets.

Wilcox, W. A.

1895. Fisheries of the Pacific Coast. United States Commission of Fish and Fisheries. Part XIX. Report of the Commissioner for the year ending June 30, 1893. Appendix I, pp. 139-304.

1898. Notes on the fisheries of the Pacific Coast in 1895. Appendix XII to the Report of the U. S. Commissioner of Fish and Fisheries for the fiscal year ending June 30, 1896, pp. 575-659.

1907. The commercial fisheries of the Pacific Coast states in 1904. U. S. Bureau of Fisheries, Annual Report of the Commissioner of Fisheries for the fiscal year ending June 30, 1905. Bur. Fish. Doc. No. 612, pp. 1–74.