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PRELIMINARY RESULTS OF DEEP-WATER EXPLORATION FOR SHRIMP IN THE GULF OF MEXICO BY THE M/V OREGON (1950-1956)

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INTRODUCTION

The deep-water royal-red shrimp, Hymenopenaeus robustus, is a bottom-dwelling species, of a size equivalent to the present commercial shrimp species of the Gulf of Mexico. Preliminary accounts of explorations for this species by the Service's exploratory fishing vessel Oregon have been given by Springer and Bullis (1951 and 1954), and Springer (1954).

The first catches of royal-red shrimp in the Gulf were made while the Oregon was primarily engaged in explorations for brown-grooved shrimp, Penaeus aztecus. In July 1950, a series of trawling stations was made off the Mississippi Delta, in increasing depth intervals beyond the limits of the continental shelf. At that time, small numbers of royal-red shrimp were taken in depths of 195 to 232 fathoms. During the following four years, which were primarily devoted to exploration for shallower-water shrimp and for tuna, a short period of each trawling cruise was spent on additional deep-water dragging. By the end of 1954, exploratory coverage of the 100- to 300-fathom range in the eastern Gulf between the Mississippi Delta and Key West, and along the Texas Coast was extensive, with limited work carried out to depths of 500 fathoms. Only scattered drags were made off Louisiana, the Campeche Banks, and in the Gulf of Campeche, where generally poor trawling bottom was encountered.

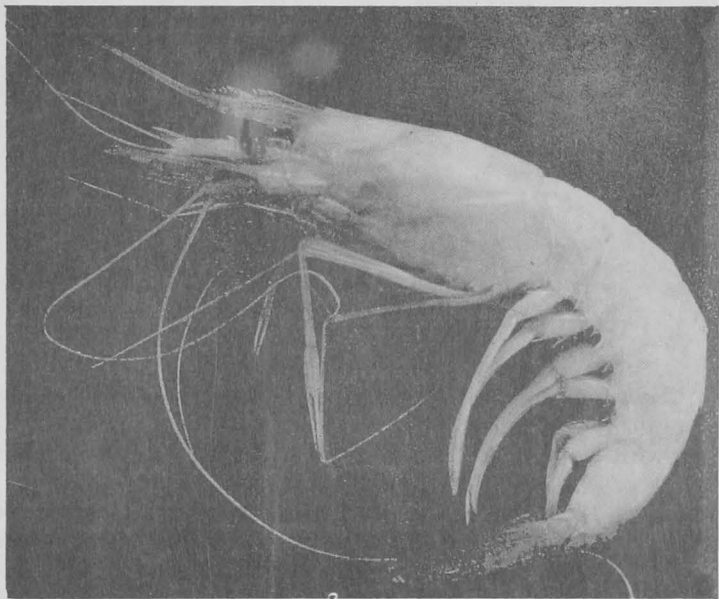


Fig. 1 - The deep-water royal-red shrimp (Hymenopenaeus robustus).

The distributional picture that emerged from this work showed royal-red shrimp to be present throughout the Gulf of Mexico on all types of bottom in a depth range of 190 to 270 fathoms, with a maximum range of 150 to 400 fathoms.

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In September 1952, a small amount of fishing for royal-red shrimp was carried out in the north Gulf by the M/V Antillas, owned by the Gibbs Corporation of Jacksonville, Fla., and operating in cooperation with the Fish and Wildlife Service

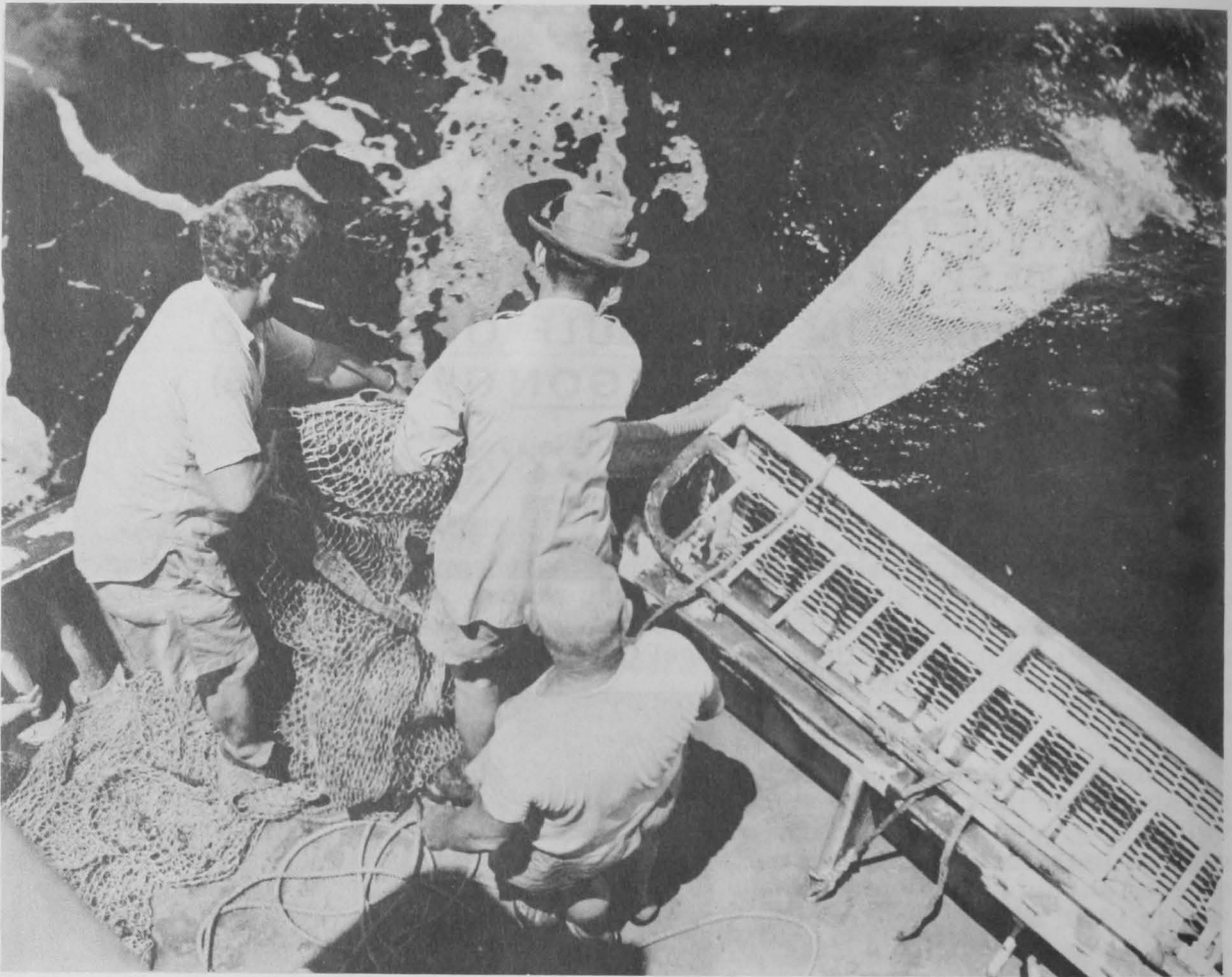


Fig. 2 - Hauling in the cod end of a 40-foot flat trawl after an exploratory drag in the 200-fathom depth range.

(Carlson 1953). Several drags were made off Louisiana, Mississippi, Alabama, and western Florida, in the general depth ranges suggested by prior catches of the Oregon. The best catches were approximately 70 pounds an hour along the 200-fathom curve east of the Mississippi Delta.

In 1955, with the completion of shallow-water shrimp exploration in the Gulf, a series of cruises were programmed for the Oregon to provide a more comprehensive picture of the commercial potentialities of royal-red shrimp. The following work plan was subsequently followed, using commercial-scale gear whenever suitable trawling conditions were found.

In March 1955, a series of 34 trawling stations were made in depths of 160 to 270 fathoms between the Mississippi Delta and Cape San Blas, Fla. In July, round-the-clock trawling was attempted in depths of 190 to 300 fathoms south and south-east of Dry Tortugas. Extensive gear damage was sustained while making 16 drags, and work was stopped ahead of schedule. Following this work, some exploration of the 200-fathom depth range was carried out on the eastern end of Nicolas Channel along the north coast of Cuba, and in the Straits of Florida off Key Largo. In

September, exploratory coverage was extended along the Louisiana Coast, where generally poor trawling bottom was encountered. During the last half of the cruise, the Delta to Cape San Blas area was reworked using 80-foot balloon trawls.

In March 1956, further commercial-fishing trials were run off the Mississippi and Alabama coasts. Six days of round-the-clock fishing were carried out through a two-week period of generally bad weather. In May, three weeks were spent trawling along the Mississippi, Louisiana, and Texas coasts. In June, simulated commercial-scale fishing was tried in the two restricted areas off Mobile and Dry



Fig. 3 - A moderate catch of mostly trash fish species in the cod-end of an 80-foot balloon trawl prior to dumping on dock.

Tortugas. These areas, based on previous results, appeared most promising for immediate exploitation. Following selection of optimum trawling depths, three days of round-the-clock fishing were carried out in each area.

To date, 308 trawling stations have been made by the Oregon between the 100- and 500-fathom curves in the Gulf of Mexico.

In the early months of 1956, a supplementary exploratory program was established on the South Atlantic Coast, to obtain information on the possible existence of deep-water shrimp resources in that area. The program has been financed with funds provided by the Saltonstall-Kennedy Act of 1954, and has operated with the chartered M/V Pelican and M/V Combat. This work is currently under way, and has so far led to the discovery of promising royal-red shrimp grounds. Results will be reported in detail in the near future.

GEAR AND METHODS

Several shrimp trawl modifications have been tried with varying degrees of success in the deep-water dragging. After initial trials with other types, a 40-foot flat trawl was used for all exploratory work (for a description of this trawl see Fishery Leaflet 394, pp. 7-10). This net has worked well under almost every trawling condition. It was towed on a single trawling warp rigged with a 25-fathom bridle, using weighted 5- and 6-foot trawl doors.

In each area explored, efforts were made to complete a series of trawl drags in close depth intervals. After the general royal-red shrimp depth range had been determined, 5- to 10-fathom depth intervals were trawled between the 150- and 300-fathom curves, in several different areas. Vessel courses while trawling were determined by depth-recorder readings. In general, this practice worked very well; however, occasionally the trawl was dragged into small "dead-end" crevices along the slope, which resulted in bogging and loss of gear.

It was our general practice to survey the intended trawling area using a depth recorder prior to lowering the gear. If recorder indications showed apparently trawlable bottom, the net was lowered and the trawling warp was run out while the vessel ran ahead at 7 to 8 knots. It was necessary to maintain a slight drag with the winch brake to prevent trawling warp blacklashes. A trawl cable meter was used to determine the length of wire going out; and when all but 100 fathoms of warp had been set, the vessel was slowed to trawling speed as the remaining warp was run out.

Exploratory drags were of 1- to 3-hours duration, usually depending upon the appearance of the bottom as shown by the depth recorder.

Occasionally, erratic trawl performance in usually trawlable areas indicated strong subsurface or bottom currents. (On one occasion off Freeport, Tex., five attempts were made to get a 40-foot trawl and heavily-weighted 5-foot doors on the bottom. Up to 800 fathoms of warp were run out without making a successful drag). Optimum warp length for a given depth has been found to vary, depending on weather and current conditions. Proper wire-depth ratio is important since water-hauls and bogging the trawl doors and net are the result of too little or too much warp. An approximate ratio of wire length to depth for the 200- to 250-fathom range is the depth times 3, necessitating winch drums that can hold up to 750 fathoms of $\frac{1}{2}$ inch-diameter wire. Minor adjustments in wire length can be made on subsequent drags, as indicated by catch and trawl performance.

Numerous changes in the design and rigging of trawl doors have been tried in an effort to reduce the high incidence of bogging gear in the soft mud off the Mississippi Delta. Modifications of the "rocking chair" door, which is used in the mud lump area off the Mississippi Delta, and use of mud ropes worked well; and early attempts at "production" fishing were carried out with this rig. Further tests revealed that satisfactory trawl-door performance was obtained by increasing the thickness and width of the steel runners to $\frac{3}{4}$ " x 6" or 8", and attaching a 4-foot piece of 1" x 4" flatbar to the outside of each door immediately above the runner for additional weight and balance. Apparently, the chief cause of bogging is the "laying down" of a trawl door and the subsequent digging of the forward edge as it is dragged along the bottom. Increasing the weight of the door has an added advantage in that it also permits using shorter warp.

Widely varying weights of catches in adjacent areas have also indicated inconsistent trawl behavior. A simple meter was devised which may be calibrated to give a reading for the distance the trawl is actually working on the bottom (see fig. 4). It consists of an 8" sprocket gear on a shaft attached to a flexible arm

bolted to the runner outside of either trawl door. A bicycle cyclometer is mounted on the top of the arm and is activated by a pin set in the inner surface of the gear. The unit was calibrated on land and checked with loran fixes in test drags. Using

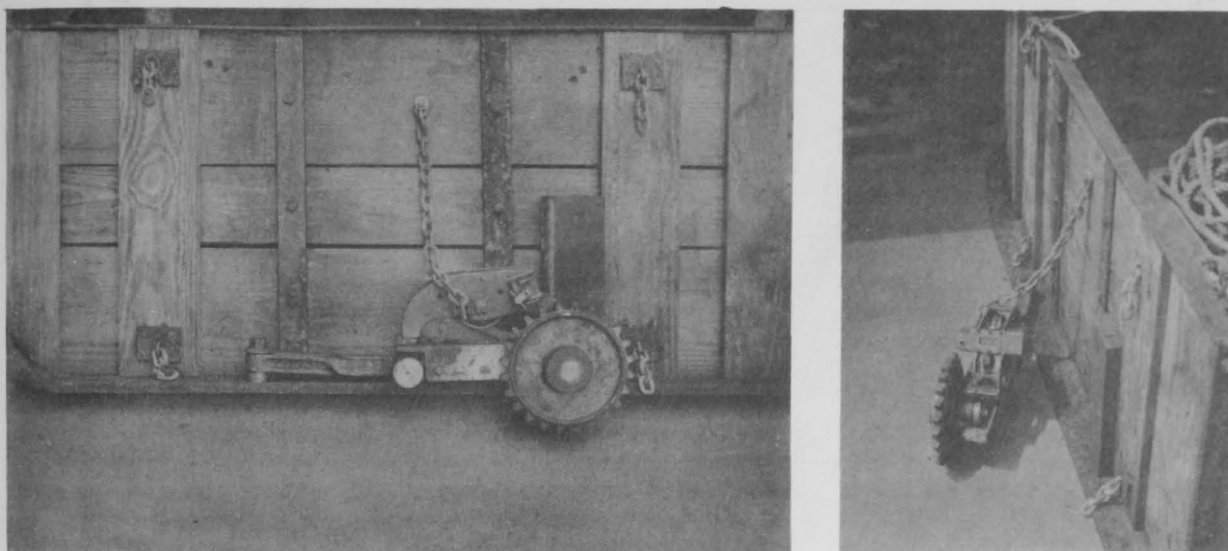


Fig. 4 - Two views of a prototype bottom-distance meter used to determine the actual distance a trawl works the bottom during a drag.

this instrument, it has been possible to obtain an approximate figure of the catch per unit of trawl-working distance. By plotting the readings obtained from a series of drags covering different time intervals, it has also been possible to obtain data on the length of time it takes for the gear to reach the bottom and to start fishing.

Double warps have been used, but a large majority of the drags were made using a single warp and bridle. Galvanized, 6 x 7 performed, improved plow steel, hemp center, marine lubricated wire has proved to be satisfactory construction for trawl warp. Bridles are made of $\frac{3}{8}$ -inch-diameter wire, with the main warp of $\frac{1}{2}$ -inch diameter wire.

100-foot flat and 80-foot balloon trawls (also described in FL 394) have been used in "production" trials. Generally speaking, the balloon trawl gave the best performance, particularly off the Mississippi Delta, where a mud rope was needed to keep the flat trawl from bogging.

The 80-foot balloon trawl was used with 8-, 9-, and 10-foot trawl doors, heavily weighted, as were the 5- and 6-foot doors described previously. Widening the runner to 6 inches or 8 inches, shortening the top door chains by one link each, and adding 100 to 150 pounds of iron bar to each door above the runner practically eliminated the bogging problem.

Hauling back of the trawl takes from 25 to 40 minutes, depending on the depth fished. An additional 20 to 25 minutes are needed to dump the catch and re-set the gear. With this amount of fishing time lost per set, it has been found profitable to make long drags, bottom conditions permitting. Drags of 5 or more hours duration are possible since accumulation of bottom trash is moderate.

To effectively fish the deep-water shrimp grounds, the use of loran is imperative. The known fishing areas are bounded on both ends by bad trawling bottom, much of which is not detectable by depth-recording equipment. Also, occasionally small zones of temporarily high concentrations of shrimp will be found, and without the definitive positioning available with loran, it would be extremely difficult to fish them with maximum efficiency.

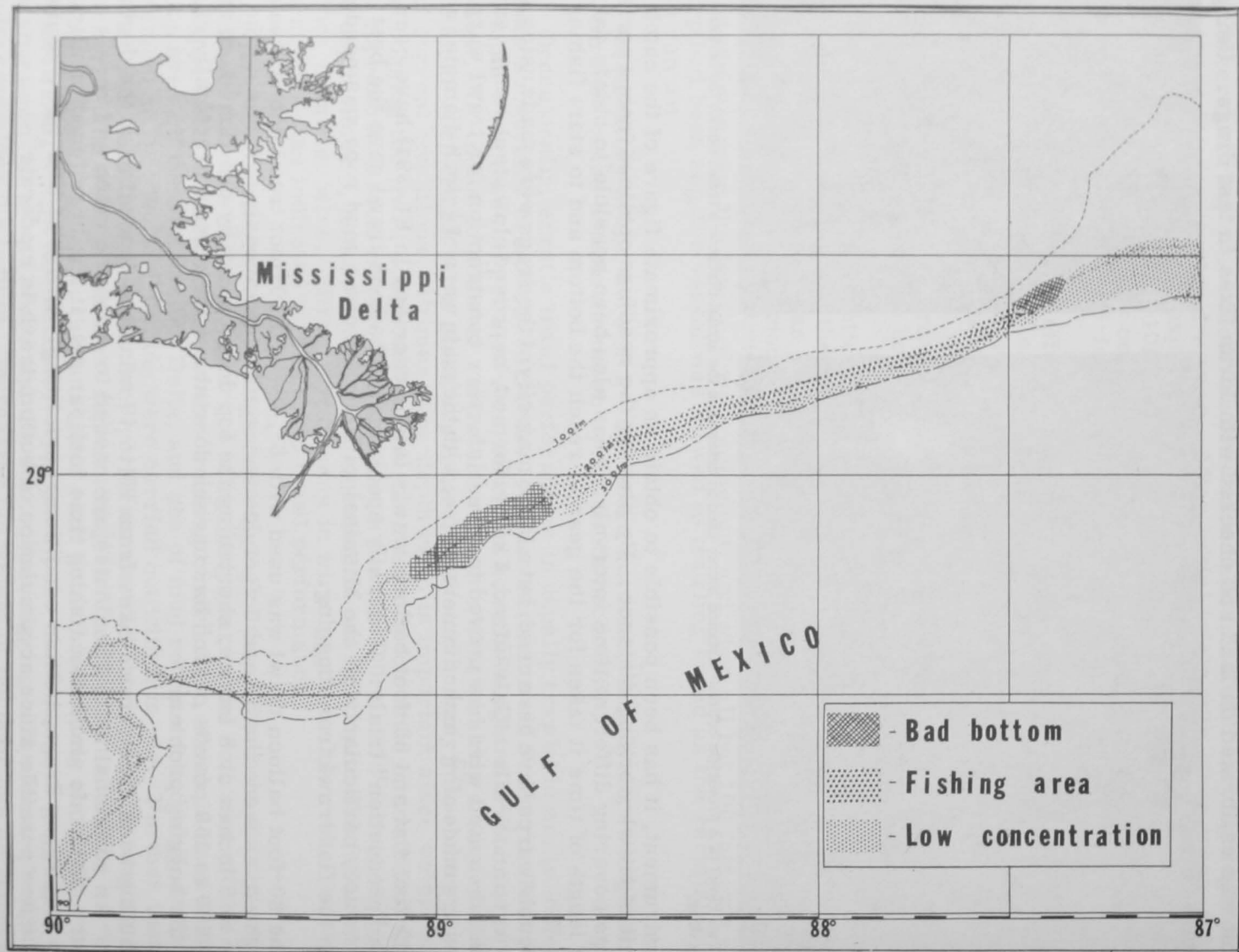


Fig. 5 - Mississippi Delta royal-red shrimp grounds showing areas of fishing concentrations and bad trawling bottom.

DESCRIPTION OF FISHING GROUNDS AND CATCH DATA FROM COMMERCIAL-SCALE TRAWLING

Royal-red shrimp catches of commercial significance have been restricted, for the most part, to two well-defined areas; off Dry Tortugas, and east of the Mississippi Delta. Although the species is widely distributed, highest catches from all other areas in the Gulf were under 50 pounds of heads-on shrimp an hour. Between March 1955 and June 1956 six cruises were devoted to obtaining commercial-catch estimates in the two areas of promise. The following description of these areas includes a summary of the catch rates obtained.

MISSISSIPPI DELTA AREA: These grounds cover an area of approximately 300 square miles, extending from 87° 30' west longitude to 88° 40' west longitude between the 190- and 275-fathom curve. The bottom is cohesive blue mud with very small quantities of sand or shell fragments. The continental slope is moderately pitched, and with the exception of a few "gullies," echograph tracings show no trawling obstructions in the area. Earliest trawling attempts resulted in repeated bogging of trawl doors in the soft mud, which appears to be the principal trawling hazard of the area.

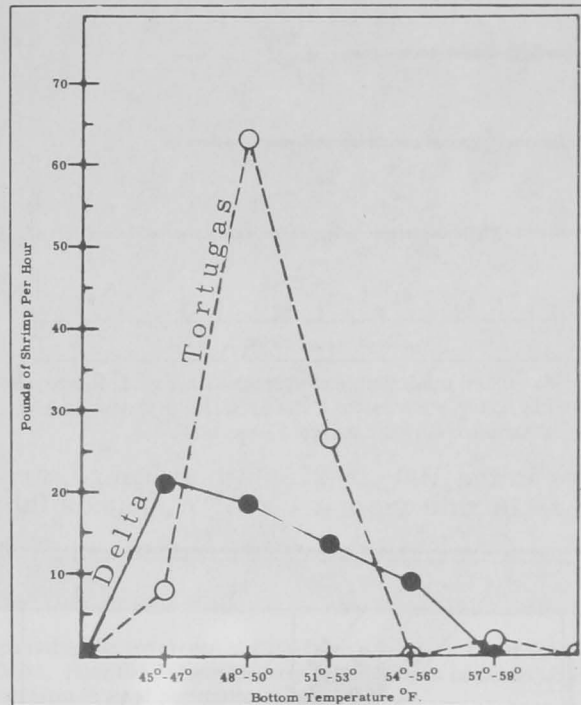


Fig. 6 - Average hourly catches in the Delta and Tortugas areas, at various bottom temperature. Includes data from all successful catches with bottom temperature records, covering all seasons, 1950-1956.

Bottom temperatures at trawling stations have been obtained with a standard reversing thermometer. Close correlation of royal-red shrimp concentrations and bottom temperatures in the Delta area has been noted. With few exceptions, royal-red shrimp appear to be confined within a temperature range of 45°-54° F., which is characteristic of the 190- to 220-fathom range both in the Delta and Tortugas grounds. Largest concentrations have been found in a range of 47° to 52° F., and highest catches have been centered in 47°-50° F. water for both areas. There is strong empirical evidence indicating that the fluctuations in depth-temperature relationships that occur along the continental slope of the northeastern Gulf of Mexico are of primary importance in determining the depth location of fishable concentrations. The shallowest royal-red shrimp record was in a depth of 150 fathoms, at a bottom temperature of 52° F. The usual temperature range at that depth varies from 54° to 58° F. On other occasions temperatures of up to 55° F. have been observed at 200 fathoms. At these times royal-red shrimp apparently move out of the area, and it has been necessary to extend fishing operations down to depths of 240 to 270 fathoms, where temperatures then range between 48°-52° F., to locate maximum concentrations.

There appears to be no seasonal correlation to these occasional depth-temperature changes, and changes in depth of shrimp concentrations. This type of offshore (deeper water) movement of shrimp has been noted in the fall of 1951, in the summer of 1953, in the spring of 1955, and in the summer of 1956. Spring and fall catches in 1950 and catches from early spring through late fall in 1952 showed no variation in optimum depth range and little temperature change.

It is probable that the imperfectly known current changes in this area, which may be brought about by a combination of wind and tidal oscillation factors, induce

irregularly-timed shifting of water masses along the continental shelf and slope, which in turn determines the depths of maximum royal-red shrimp concentrations. It would be profitable for vessels fishing this area to carry a reversing thermometer and a small winch to determine water temperature prior to the start of fishing operations. The use of this equipment could save a considerable amount of time in locating the optimum depth for trawling at the start of a trip, and could provide a periodic check throughout the trip. Trying to locate optimum depths within the vertical range of about 80 fathoms (190 to 270 fathoms) often takes a day or more of test fishing.

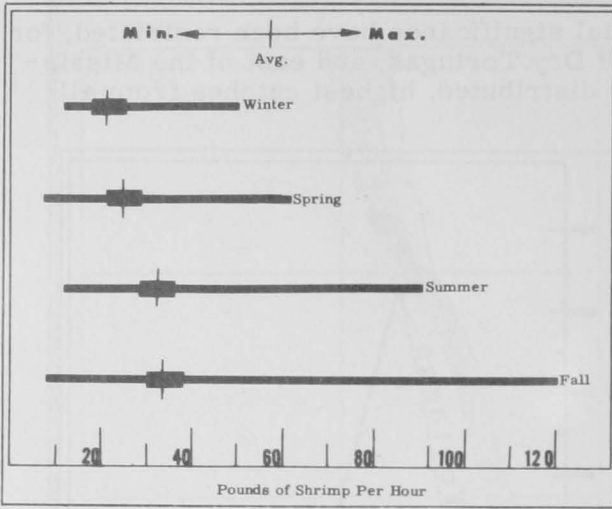


Fig. 7 - Maximum, minimum, and average catch rates for royal-red shrimp in the Mississippi Delta grounds, in depths of 190 to 270 fathoms. Includes data from June 1956.

Seasonal catch rates, based on 80-foot trawl averages, for all successful drags in the 190- to 275-fathom range, are relatively low, but show a gradual increase in rate from a low of 21 pounds (heads-on) an hour in the winter to a high of

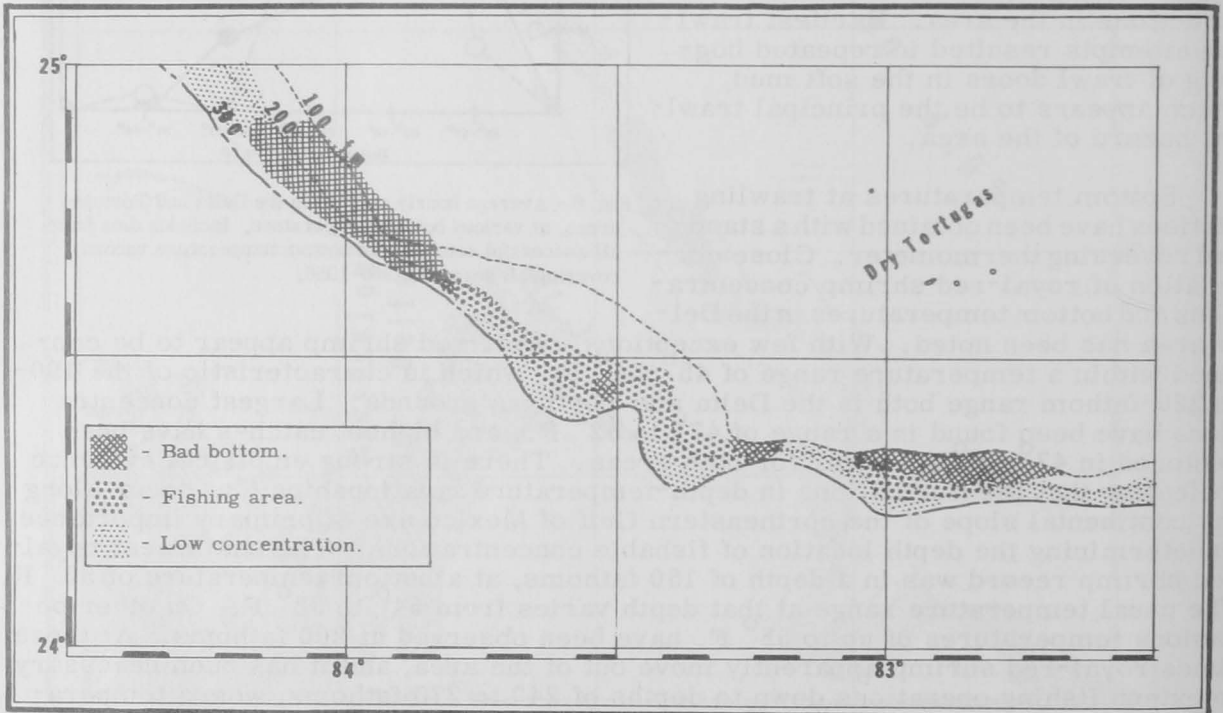


Fig. 8 - Dry Tortugas royal-red shrimp grounds showing areas of fishing concentrations and bad trawling bottom.

36 pounds (heads-on) an hour during the fall. However, these averages include many drags of a purely exploratory nature made outside of the limits of highest known concentrations. The increasing catch rate from winter to fall is shown by the maximum catch rates that have been obtained. In the Delta area, highest winter catches have run approximately 50 pounds heads-on shrimp per hour of dragging. In the spring, the rates increase to 60 pounds of heads-on shrimp an hour. In the summer and fall, maximum catch rates have reached 86 and 120 pounds of heads-on shrimp an hour, respectively.

In limited production trials by the Oregon, high rates have not been reached on a continuing basis. Not infrequent gear failures (i.e, water-hauls, bogging, etc.), particularly during the earlier production trials, resulted in materially reducing daily catch totals. For the winter months these averaged approximately 300 pounds (heads on) a day. For the spring, summer, and fall, catches averaged 600, 700, and 900 pounds a day, respectively. With no apparent change in catch rate between day and night dragging, it is possible to complete approximately four 5-hour tows a day, with an average dragging time of 20 hours a day. Individually good catches by the Oregon indicate a potential round-the-clock catch of 1,000 pounds of heads-on shrimp a day in the winter, to a high of 2,400 pounds a day during the fall.

TORTUGAS AREA: These grounds (see fig. 8) cover an area of approximately 120 square miles, extending from $83^{\circ}17'$ west longitude to $83^{\circ}45'$ west longitude, between the 190- and 250-fathom curves. The distance between these curves varies from approximately 2 to 6 miles, with an average width of 4 miles. With the exception of a narrow ridge of loose limestone rock along the 212-fathom curve at $83^{\circ}33.5'$ west longitude, and $24^{\circ}2.3'$ north latitude (loran reading: 2H6 - 1370; 2H7 - 2955), this entire area provides excellent trawling bottom. The bottom is characterized by a light gray to gray-green calcareous mud. The mud has a fine, gritty texture, and packs hard when allowed to settle in a bucket of water.

At both ends of this area are patches of the hydrocoral, Stylaster, which appear to be impossible to detect on depth recorders because of its low height. Trawls dragged over these patches are invariably torn to shreds. Another smaller trawling area east of the main grounds is centered between $82^{\circ}40'$ and $83^{\circ}08'$ west longitude between 190 and 250 fathoms.

Depth contours for the principal fishing grounds form a slight indentation into the continental shelf, which seems to afford some protection from the main current flow of the Gulf Stream. In fact, during trawling operations by the Oregon, a westerly current set of approximately 0.5 knots was observed. Here bottom temperatures have shown little variation in the royal-red shrimp range. Temperatures from April 1954 varied between 49.1° and 52.7° F. in the 190- to 250-fathom range, with an average temperature of 50.2° F. Temperatures from the same area in June 1956 varied from 48.7° to 50.5° and averaged 50.0° F.

Deep-water trawling by the Oregon has been carried out in the Tortugas area in April 1954 (cruise 22), July 1955 (cruise 32), and June 1956 (cruise 39). During the two earlier trips, primary emphasis was placed on delimiting the areas of good catch rates. Although promising catches were made using 40-foot trawls, little success was achieved using larger commercial-scale gear in early trials. On Cruise 22, catches ran from 10 to 120 pounds an hour, and averaged 52 pounds an



Fig. 9 - Separating the royal-red shrimp from a large catch off the Mississippi Delta. Note the porportionately small amount of scrap which is characteristic in good shrimping areas.

hour of heads-on shrimp. Highest catch rates were obtained between 190 and 200 fathoms. On cruise 32, extensive gear damage restricted the amount of work accomplished. Catch rates ran from 8 to 24 pounds an hour using 40-foot trawls, and averaged 13 pounds a hour. Highest catches were made in 200-220 fathoms. Commercial-type dragging on cruise 39 yielded catch rates of from 50 to 196 pounds of heads-on shrimp an hour using 80-foot balloon trawls. Good fishing ranged between 210 and 220 fathoms with highest catches along 212 fathoms. A total of 3,145 pounds of 26-30 count heads-off royal-red shrimp were landed during three days of round-the-clock fishing.



Fig. 10 - One of the potentially valuable byproducts of royal-red shrimp fishing is tasty deep sea red crab (*Geryon quinquedens*) which is occasionally caught in large numbers in 200 to 400 fathoms.

DESCRIPTION OF THE CATCHES

Royal-red shrimp have shown no apparent seasonal variation in average size. In areas of maximum fishing concentrations, the heads-off count consistently averaged 26-30, in both the Tortugas and Delta areas. A larger average size is noted in greater depths, but the concentrations are much smaller. No uniform size dominates the catch, which contains individuals ranging from 12- to 50-count heads-off shrimp.

There is some color variation in royal-red shrimp. Nighttime catches are typically bright red, while catches landed during daylight hours are a light pink.

Other species of deep-water shrimp are often found mixed with royal-red shrimp. While dragging in depths of 150 to 225 fathoms, varying quantities of a smaller pink-colored shrimp, *Peneopsis megalops*, have been caught. Average sizes of this species vary from 40 to 60 count heads on. The largest individuals reach approximately 35-count. Highest concentrations of this species in most areas are generally located 10 to 30 fathoms shallower than highest concentrations of *H. robustus*. Incidental catches of *P. megalops* have varied from 10 to over 200 pounds a drag while fishing for royal-red shrimp with large commercial gear. This species has a good flavor and could provide a valuable supplement to royal-red shrimp catches.

Royal-red shrimp catches in the Dry Tortugas area, in addition to *P. megalops*, included from 1 to 45 pounds of large (21-25 count) striped shrimp, *Plesionika longipes*. This species belongs to the family *Pandalidae*, as do the commercial shrimp of northern Europe and of the coasts of Oregon, Washington, and Alaska.

The few drags made beyond the 300-fathom curve have produced small numbers of several other species of large penaeid shrimp. Most common of these is the scarlet red *Plesiopenaeus edwardsianus*, which averages about 16-20 count. This species has extremely long swimming legs, and is probably not a bottom dweller.

Another common species throughout the Gulf in 225 fathoms is the hard-shell-ed *Glyphocrangon longleyi*. Occasionally, catches will contain from 50 to 100

pounds of this species. Although it reaches a fairly large size (31-40 count heads-on) and the meat has a good flavor, considerable work is required to crack the shell and remove the meat. The yield is proportionately small.

Delta Grounds (85 Tows)		Tortugas Grounds (83 Tows)	
	No. of Fish-- % of Total		No. of Fish-- % of Total
A. Fish (92 percent by weight):		A. Fish (63 percent by weight):	
Macrourids	27	Merluccius magnoculus	22
Merluccius magnoculus	26	Chaunax pictus	20
Physis cirratus	26	Chlorophthalmus chalybicus	16
Bembrops goboides . . .	9	Peristedion miniatum . .	8
Peristedion miniatum . .	3	Peristedion gracile . . .	7
Scorpaena sp.	2	Macrourids	5
Other species	7	Other species	22
B. Invertebrates (8 percent by weight):		B. Invertebrates (27 percent by weight):	
	No. of Invertebrates-- % of Total		No. of Invertebrates-- % of Total
Peneopsis megalops . . .	82	Plesionika longipes . . .	48
Actinauge longicornis . .	5	Munidia sp.	20
Sympagurus pictus	2	Peneopsis megalops . . .	15
Polycheles sp.	1	Tugurium longleyi	4
Other species	10	Other species	13

The identification of some species is still in progress, but to date 87 shrimp or prawn species have been found in the Gulf exploratory catches. All of these could be considered edible, but only about 40 are of sufficient size to be of present commercial value, if found in suitable concentrations.

Accumulation of scrap species has not created much of a problem on long drags. Catches of Gulf whiting (*Merluccius magnoculus*) frequently run from 100 to over 500 pounds a drag, but this species accounts for 25 to 75 percent of the scrap catch, and it is easily handled. The Gulf whiting averages $\frac{3}{4}$ of a pound and is very similar to the commercially-important Atlantic whiting (*M. bilinearis*). It may eventually prove to be a profitable by-product. A listing of scrap species by approximate numerical strength is presented in table 1.

**ROYAL-RED SHRIMP
ICING TESTS**

Yield, quality, and handling studies on *H. robustus* are now being made by the Service's Technological Section and will be reported on separately.



Fig. 11 - Heading a catch of large royal-red shrimp that have been previously separated from the scrap species.

Yield, quality, and handling studies on *H. robustus* are now being made by the Service's Technological Section and will be reported on separately.

CONCLUSIONS

Two areas in the Gulf of Mexico contain sufficient quantities of deep-water royal-red shrimp to permit profitable exploitation throughout most of the year. The magnitude of this potential resource, in terms of continuing yield, is unknown. Although these two areas embrace a total area of several hundred square miles, high concentrations are not found throughout either area at any one time. Therefore, the number of vessels that could sustain profitable production is probably small in relation to the number of large shrimp vessels available for deep-water shrimping, after carrying out winch and rigging modifications.

From preliminary exploratory work along the South Atlantic Coast, it appears promising that additional and more extensive grounds will be available for royal-red shrimp exploitation. This work will be reported on in the near future.

Royal-red shrimp are a very palatable seafood, with a distinctive flavor that cannot be confused with the present commercial species. Preliminary consumer acceptance tests have been tried in selected seafood restaurants, and highly favorable comments have been received on taste, appearance, and texture.

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