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SUMMARY REPORT OF EXPLORATORY LONG-LINE FISHING FOR TUNA IN GULF OF MEXICO AND CARIBBEAN SEA, 1954-1957

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CONTENTS

BACKGROUND

Exploratory fishing to find out more about the fishery resources in the Gulf of Mexico and adjacent waters has been conducted since 1950 by the U. S. Fish and Wildlife Service. Observations of surface tuna from the Service's exploratory fishing vessel Oregon during 1950 and 1951 offshore operations indicated a potential commercial resource.

Fig. 1 - The M/V Oregon, a 100-foot West-coast combination-type fishing vessel engaged in exploratory fishing in the Gulf of Mexico and Caribbean Sea.

Exploratory tuna fishing began in 1952. Pacific Coast purse-seining and live-bait techniques were used until May 1954. Since that time, because results with those methods were inconclusive (Bullis and Captiva 1955), the Japanese method of tuna long-lining has been used. Results of long-line fishing from May 1954 through June 1955 are reviewed by Bullis and Captiva (1955). This report includes results of subsequent long-line cruises by the Oregon and an analysis of the environmental, geographical, and operational factors which have been experienced.

The common names of fishes are used throughout the text, and the scientific names and authority for each species are listed separately.

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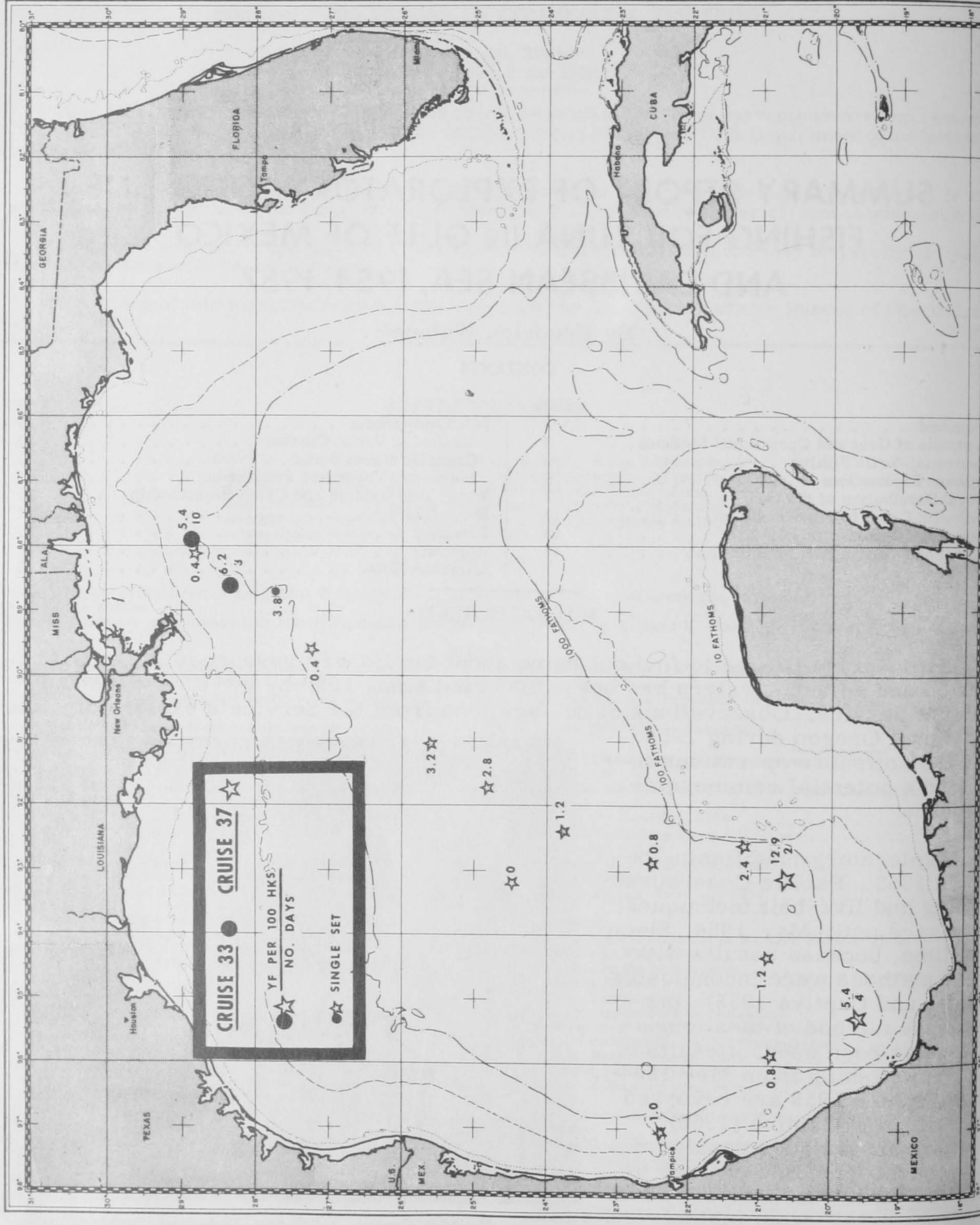

Fig. 2 - Locations and catch rates of the long-line sets on cruises 33 and 37.

DESCRIPTION OF GEAR AND OPERATIONAL METHODS

A description of the long-line gear used by the U. S. Fish and Wildlife Service in the Gulf of Mexico is described in detail by Bullis and Captiva (1955) and is summarized as follows: One standard unit of gear, called a basket, is composed of 138 fathoms of mainline and ten 4-fathom branch lines attached to the mainline at 12-fathom intervals. The first and last branch lines are 15 fathoms from the ends of the mainline. The most important modification to the gear used in the Gulf in recent years was the change of mainline fiber from cotton and manila to nylon. Experiments aboard the Oregon demonstrated that nylon was superior from both operational and efficiency viewpoints.

The gear is fished by joining baskets end to end and suspending them below the surface with a buoy and a buoy line (usually 10 or 20 fathoms long) at each junction of the baskets. The entire operation is termed a set.

Setting the gear is usually started before dawn and completed from one to two hours later. Hauling ordinarily commences from nine o'clock to noon and is completed from 3 to 7 hours later, depending on the amount of gear fished. Specific details of the time involved in the setting and hauling operations of four cruises are given in appendix tables 20 through 23.

COMMERCIAL-SCALE FISHING

Results of the initial long-line fishing by the Oregon indicated the existence of a possible commercial long-line fishery for yellowfin tuna in the Gulf. In August 1955, a program incorporating commercial-scale fishing into the long-line exploratory program was initiated. Three cruises (Nos. 33, 37, and 41)1/ in the Gulf have been carried out on this basis. The primary objective of this phase of the tuna program was to demonstrate whether a profitable long-line operation for yellowfin tuna could be conducted by United States fishermen in the Gulf of Mexico.

On the basis of the previous work in the Gulf and Central Pacific (Iversen and Murphy 1955), it was decided that daily fishing of 100 baskets (1,000 hooks) constituted a commercial-scale effort.

Table 1 - Yellowfin Catch Rates for Commercial-Scale Long-Line Cruises

Cruise Number	Days at Sea	Fishing Days	Number of Hooks Fished	Tons Caught	Tons Per Day at Sea	Tons Per Fishing Day	Average Catch Rate (No. of Fish/100 Hooks)	Catch Rate Range (No. of Fish/100 Hooks)
33	1/15	14	12870	29.5	1.96	2.1	5.0	1.7-11.2
37	2/23	16	10030	26	1.1	1.6	4.4	0-12.9
41	25	18	13400	35	1.4	1.9	4.5	0.2- 9.6

1/Cruise 33 - Days at sea do not include 1 day taken in middle of trip to return to Pascagoula for unloading.
2/Cruise 37 - Days at sea do not include days taken for port call at Brownsville, Tex.

Data on yellowfin tuna catches for the three cruises in the Gulf devoted to commercial-scale long-lining are summarized in table 1. Locations and yellowfin tuna catch rates of the long-line sets on cruises 33 and 37 are presented in figure 2 and for cruise 41 in figure 3.

Of the three cruises, only cruise 33 was in an area and during a season when yellowfin were known to exist in possible commercial concentrations. Cruises 37 and 41 were carried out during seasons and in areas not previously explored; consequently, a good part of the time was spent locating fish. For example, cruise 37 took a total of 26 tons in 16 fishing days, $12\frac{3}{4}$ tons of which were taken the last two fishing days of the trip. Although cruises 37 and 41 include results of a considerable number of poor exploratory sets, the total catches for the periods fished are of a magnitude considered commercially profitable for a Gulf of Mexico operation.

1/Cruise 33 was in the north Gulf during August 1955; Cruise 37 was in the central and south Gulf during March and April 1956; and Cruise 41 was in the north and south Gulf during November and December 1956.

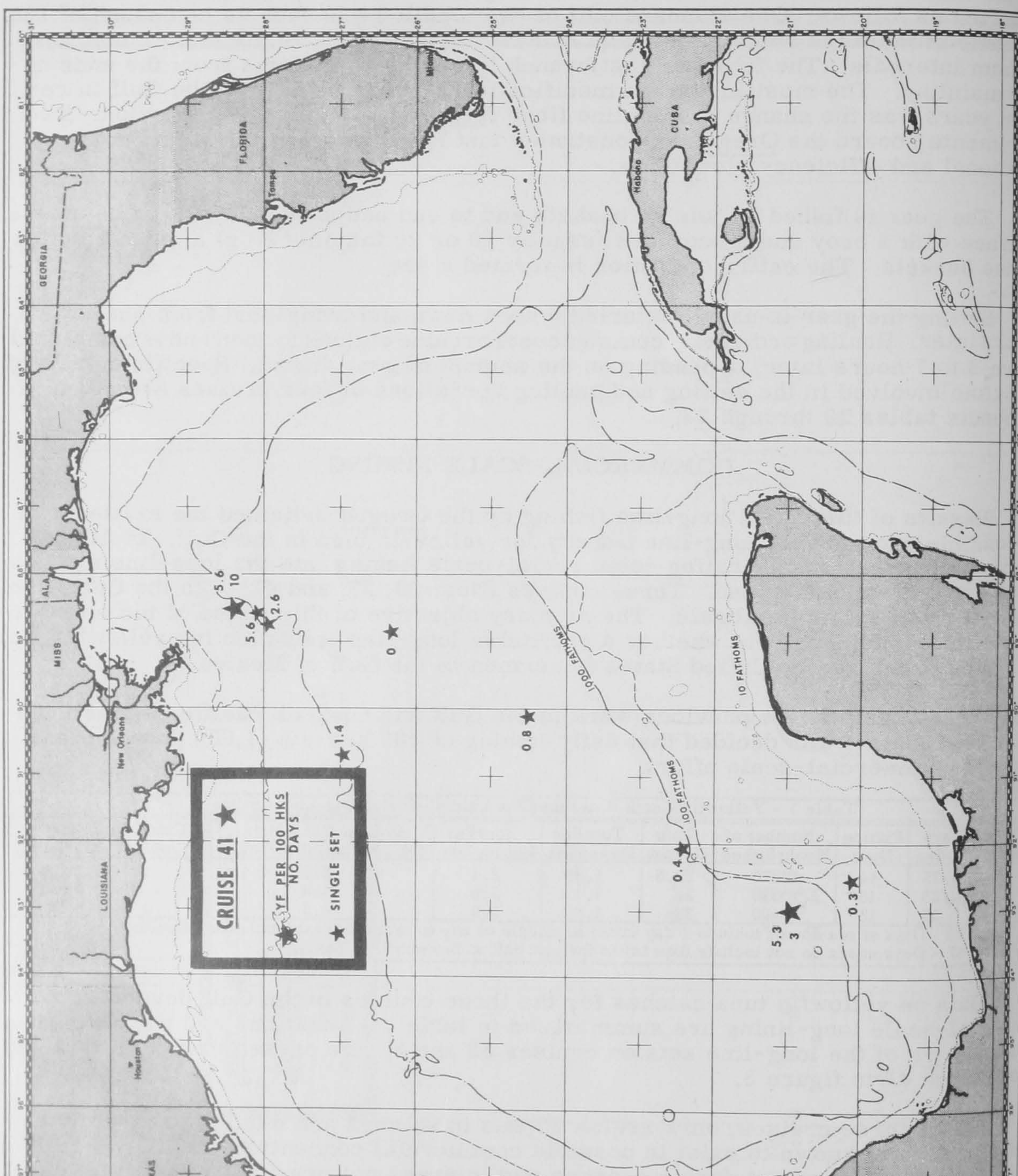

Fig. 3 - Locations and catch rates of the long-line sets on cruise 41.

The tons per day away from port (1.1, 1.9, 1.4) taken on these cruises compare favorably with that averaged by 50- to 100-ton capacity West Coast live-bait tuna vessels (Shimada and Schaefer 1956). It is indicated that vessels of that size are desirable for Gulf operations.

Early attempts by commercial vessels to exploit the yellowfin stocks in the Gulf were handicapped by the absence of a local market for their catches. From September 1954 to December 1956, six vessels were engaged sporadically in long-line fishing with limited amounts of gear. They were, however, forced to discontinue fishing because the cost of shipping the catches to either the West Coast or Puerto Rico for canning made the operation unprofitable. In February 1957, a local canner began accepting some fish for experimental packing and has subsequently contracted to take the fish of four vessels. Another local canner has contracted to purchase the fish of still another vessel. Of the five vessels presently operating, three are converted World War II subchasers, one a converted minesweeper, and the fifth a Pacific Coast sardine purse seiner.

Daily records of fishing effort and catches are available from only the commercial M/V Alfhild. Since May 1957, when this vessel began long-line operations, it landed 88 tons of yellowfin from 65 sets of which only 15 sets were of 90 baskets or more. Although the catch for the period (May-November) is poor, the catch per fishing day (1.4 tons) is fair and the potential is good considering the vessel fished only about half the amount of gear it is capable of operating. The total catches of the other vessels has been slightly less than the Alfhild's, but their daily effort has also been considerably below their capabilities.

It is believed that as areas and seasons of high productivity are more precisely delineated, over-all catches can be materially increased.

CARIBBEAN EXPLORATIONS

A series of four cruises planned to determine the extent of subsurface tunas in the northern, western, and eastern Caribbean and to gain information on the possible continuity of yellowfin tuna stocks between the Gulf and these areas available to long lines commenced with cruise 30 during April and May 1955. During this cruise the northern Caribbean region from Hispaniola to Yucatan Channel was explored. The location of each long-line set of the Oregon in the Caribbean is shown in figure 4.

Seven 42-basket sets were made east and north of Jamaica. All of these sets took yellowfin at catch rates from 1 to 2.6 fish per 100 hooks and from one to six 50- to 60-pound albacore per set were also taken. Eight bluefin tuna weighing from 400 to 800 pounds each were taken on two of these sets at the head of Windward Passage, and approximately an equal number were lost due to gear failure. Between the western end of Jamaica and Yucatan Channel four sets caught no yellowfin or albacore, although on each of two of these sets a single large bluefin was taken.

The second of this series of cruises--cruise 35--in January 1956, extended from southeast of Puerto Rico through the north-central Caribbean to Yucatan Channel. Four sets averaging 920 hooks each, from St. Croix to a point south of central Hispaniola, caught yellowfin averaging 126 pounds at the rate of 0.6 fish per 100 hooks and albacore averaging 51 pounds at the rate of 0.4 fish per 100 hooks. Four sets from approximately 90 miles south of Jamaica to Yucatan Channel caught yellowfin at the rate of 0.3 fish per 100 hooks but no albacore.

During the third cruise--cruise 46--in August and September 1957, six 500-hook sets were made in the western Caribbean beyond the 1,000-fathom curve off the coasts of Nicaragua, Costa Rica, and Panama. Four of the sets caught yellowfin at rates of 2.0, 2.9, 4.6, and 6.9 fish per 100 hooks. Two sets further offshore took no tuna.

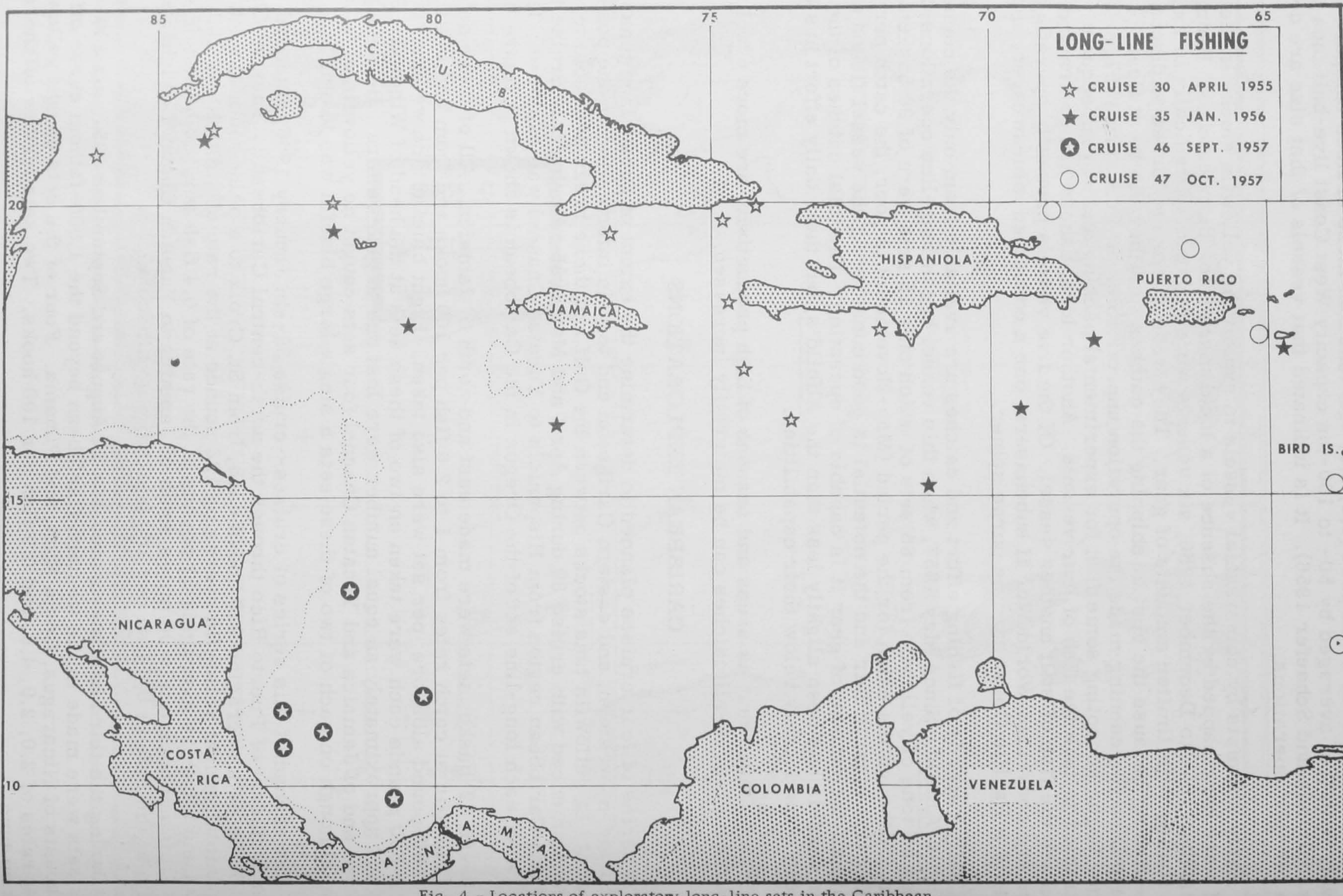

Fig. 4 - Locations of exploratory long-line sets in the Caribbean.

On cruise 47, the last of this series, in October 1957, a 500-hook set 40 miles southwest of Bird Island took 111 yellowfin for an average of 22.2 fish per 100 hooks and one 35-pound albacore. All yellowfin taken on this set ranged in size from 60 to 80 pounds each with the exception of one which weighed 125 pounds. During this cruise single sets were also made north of Hispaniola off Navidad Bank, north of Puerto Rico, between Puerto Rico and St. Croix, and 270 miles south of Bird Island. Catches on these 4 sets were uniformly poor, ranging from no yellowfin on the southernmost set to only 9 large yellowfin on the set north of Puerto Rico.

VERTICAL DISTRIBUTION OF THE GEAR

As pointed out by Murphy and Shomura (1953) it is of considerable commercial and biological importance to know at what depths the subsurface tunas are most abundant. Since the fishing level of the hooks is variable and affected by numerous factors, not all of which can be controlled, the problem of determining the absolute depth at which individual fish are taken is not any easy one.

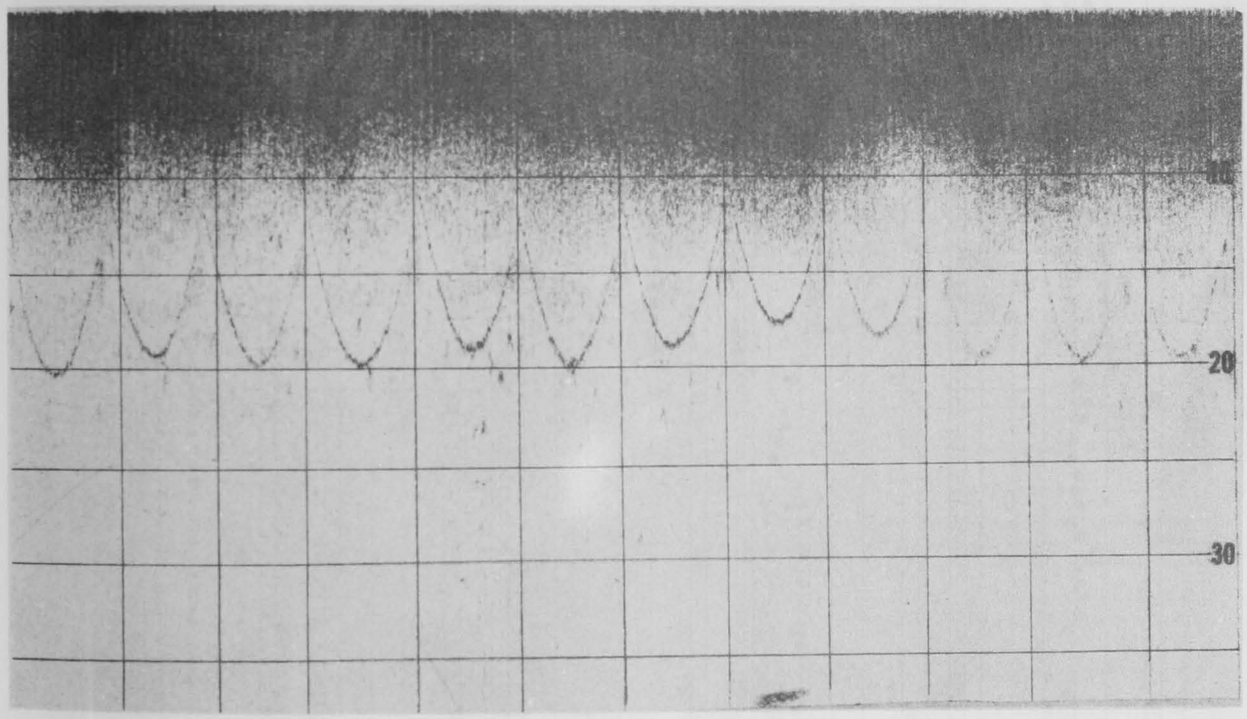

Fig. 5 - Depth-sounder tracing of a section of a long-line set. Depth scale is in fathoms.

The most reliable means for measuring the depth of the gear has been the depth-sounder. A depth-sounder tracing of a section of an Oregon long-line station is shown in figure 5. Figures 6 and 7 are diagrammatic representations of certain stations where tracings were obtained showing the depth to which the center of the mainline had sagged. The value of the depth-sounder in determining the depth of a basket on which a yellowfin is taken is somewhat limited. In many cases, the basket cannot be recorded because it has moved laterally out of the range of the signal. Frequently, the end baskets are too deep to be recorded, particularly on rough days, and in some instances the basket is recorded only after the fish has pulled it out of its original position.

Factors which determine the depth of the gear are: construction of the basket, amount of slack allowed while setting, normal sagging of the baskets on either end of the set, and effects of current and wind. Construction of the gear affects the fishing depth in that the longer the mainline the deeper it can be made to sag. The longer the buoy lines from which the mainline is suspended, the deeper the basket will

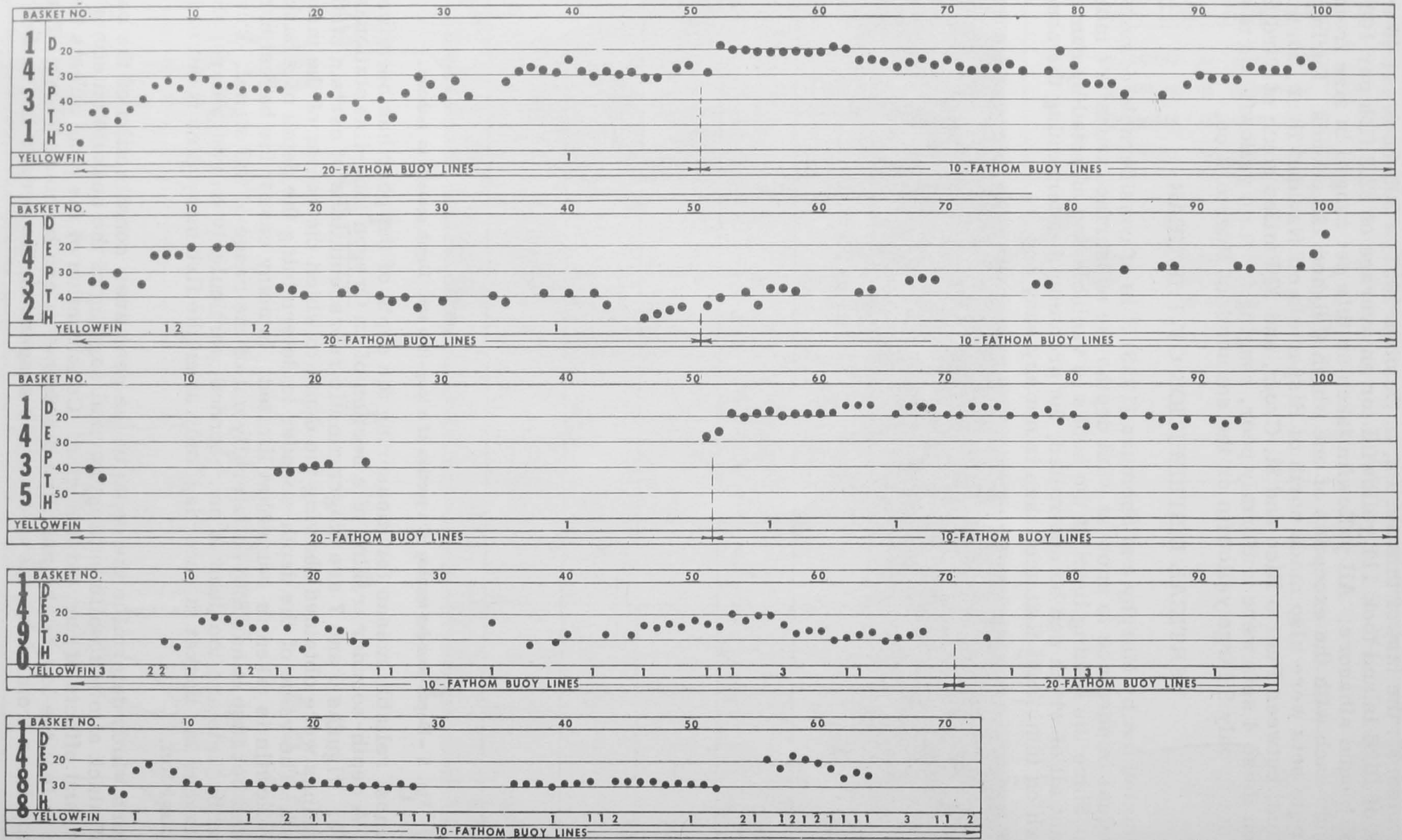

Fig. 6 - Diagrammatic presentation of depth-sounder records of individual baskets of long-line gear for M/V Oregon stations 1431, 1432, 1435, 1490, and 1488. The bottom edge of the symbol indicates the depth of the center of the basket of gear. Only the baskets of gear recorded by the depth-sounder are shown.

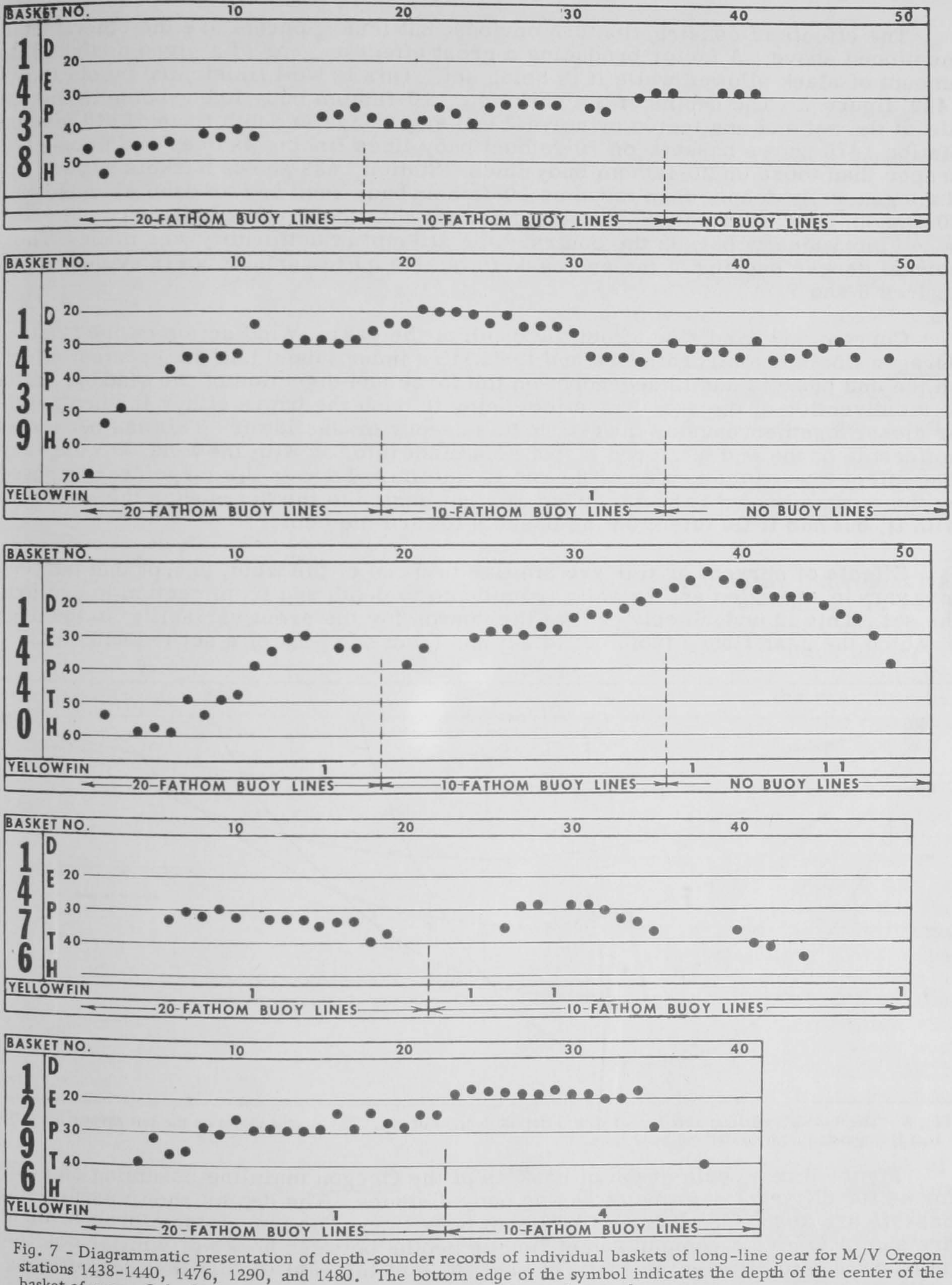

Fig. 7 - Diagrammatic presentation of depth-sounder records of individual baskets of long-line gear for M/V Oregon stations 1438-1440, 1476, 1290, and 1480. The bottom edge of the symbol indicates the depth of the center of the basket of gear. Only the baskets of gear recorded by the depth-sounder are shown.

fish and the hooks can be made to fish shallower or deeper with respect to the mainline by regulating the length of the branch lines.

The effects of construction are obvious, but less apparent are the other factors mentioned above. A factor producing a great effect on gear of a given design is the amount of slack allowed while it is being set. This is well illustrated by station 1440, figure 7. The depths of the baskets on 10-fathom buoy lines, being in the middle of the set and unaffected by normal end sag, range in depth from 18-40 fathoms. Station 1476 shows baskets on 10-fathom buoy lines fishing as deep and in cases deeper than those on 20-fathom buoy lines. Station 1439 shows baskets without buoy lines generally deeper than those on 10-fathom buoy lines and as deep as those on 20-fathom buoy lines. It should be pointed out that these variations were not produced intentionally but, on the contrary, an attempt at uniformity was made. The normal deeper sagging of the end baskets is also quite variable as is evident from figures 6 and 7.

Current and wind also affect the depth of the gear. Wind action on the floats (Oregon floats are aircraft-tire and truck-tire inner tubes) has the greatest effect on the end baskets and is dependent on the force and direction of the wind in relation to the direction of the set. The effect being to push the buoys either farther apart or closer together, causing the gear to fish deeper or shallower. This has been most noticeable on the end retrieved last of sets made into, or with the wind, on windy days. The effect toward the center of the set is minimized due to the large drag imposed by the many adjacent baskets. Wind at right angles to the set pushes the end buoys with it, but has little effect on the baskets toward the center.

Effects of current or tide are similar to those of the wind, except that currents may vary in direction and velocity from depth to depth and from section to section of the set. This is undoubtedly part of the reason for the great variability in the depth at which the gear fishes from set to set and from one part of a set to another.

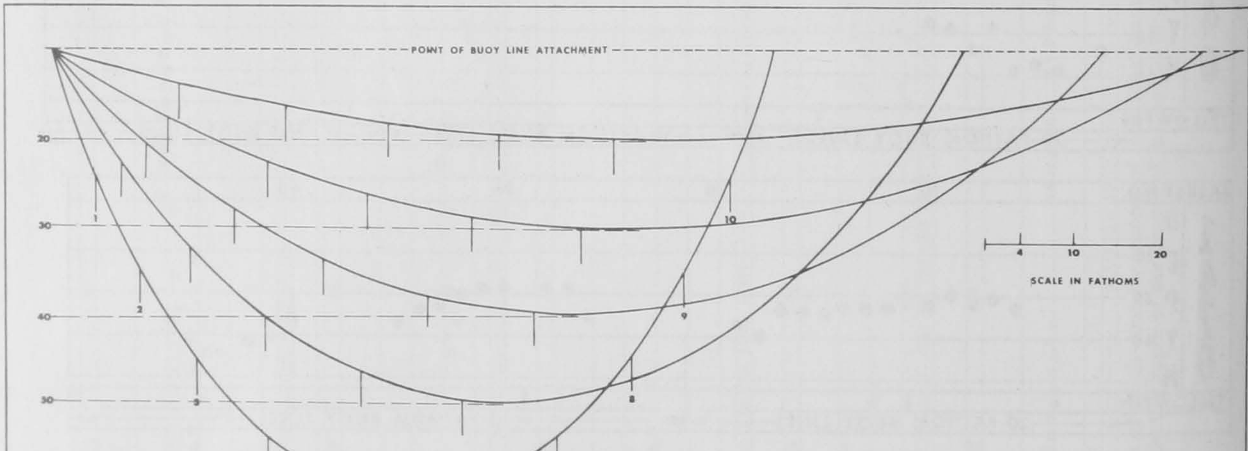

Fig. 8 - The 138-fathom long-line basket with different degrees of sag. The depths shown on the left assume the mainline is suspended from 10-fathom buoy lines.

Figure 8 is a scale graph of baskets of the Oregon mainline assuming catenary forms for different degrees of sag or buoy distance. The depths shown assume the baskets are suspended from a 10-fathom buoy line. The four-fathom branch lines are shown to give a comparison of fishing depths between hooks of similar position on baskets with different degrees of sag. It is of interest to note that deep-fishing hooks (5 and 6) of a basket at 20 fathoms are fishing shallower than the shallow-fishing hooks (1, 2, 9, 10) of a basket at 40 fathoms.

Another complicating factor in determination of optimum fishing depth for yellowfin is the possibility that baskets fishing at greater depths take yellowfin during the setting and hauling period, i.e., while they are either settling to or being retrieved from their normal fishing depth through the range normally fished by the shallower gear.

Considering the many variables acting sometimes simultaneously and sometimes independently which determine the depth at which the gear fishes, and the actual behavior as shown by the depth-sounder tracings, it was apparent that determination of optimum fishing depths for yellowfin within the range of the Oregon long-line gear (18-50 fathoms) was extremely difficult, if not impossible.

Table 2 - Near-Surface Depths Produce the Greatest Yellowfin Catches, M/V Oregon Cruise 40

Station Number	Catch Rate--No. of Fish Per 100 Hooks--with Varied Buoy-Line Lengths							
	Surface	10 Fathoms	20 Fathoms	30 Fathoms	70 Fathoms	100 Fathoms	150 Fathoms	200 Fathoms
1582	-	4.4	-	4.1	-	1.3	-	-
1584	-	-	4.5	8.7	4.4	3.0	0.0	0.0
1586	2.2	-	1.1	0.0	0.0	2.7	-	-
1588	-	3.6	2.5	0.0	-	0.0	-	-
1590	-	5.4	6.5	4.0	2.2	0.0	-	0.0
1594	-	3.6	1.0	-	-	-	-	-
Average Rate	2.2	4.2	3.1	3.4	2.2	1.4	0.0	0.0

On cruise 40 in the northern Gulf, an attempt to determine yellowfin availability at greater depths was made. Table 2 shows the catch rates for the different length buoy lines. This limited trial suggests that the 18-50 fathom range normally fished is the most practicable from a production and operational viewpoint.

YELLOWFIN CATCH BY HOOK POSITION: The position of the individual hook on the basket, figure 9, has considerable influence on the relative number of yellowfin caught. Data from the Gulf operations suggests that the differences are due, at least in part, to "mainline interference." Since the end hooks fish much closer to the mainline than those in the middle, figure 9, aversion to the mainline by the tuna might be part of the reason for the lower catches of the end hooks.

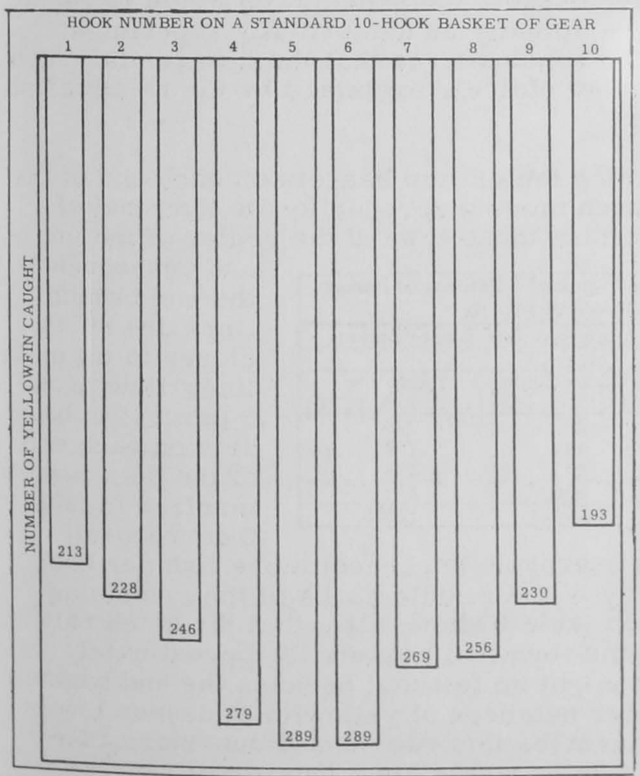

Fig. 9 - Number of yellowfin taken on standard gear by hook number. All cruises except 40.

The yellowfin catch by the position of the hook on the basket is tabulated by individual cruises in table 18 of the appendix and summarized in figure 9. The higher catches by the center hooks is consistent with the findings in the Pacific by the U. S. Fish and Wildlife Service (Murphy and Shomura, 1953, 1954, 1955), and the Japanese (Yoshihara 1954). It is obvious that the long-line basket as a unit does not function with uniform efficiency. Figure 9 reveals that the end hooks (1, 2, 3, 8, 9, and 10) caught 1,366 yellowfin or 228 per hook, whereas the middle hooks (4, 5, 6, and 7) caught 1,126 yellowfin or 281 per hook. The average catch per hook of the middle hooks is 23.2 percent greater than that of the end hooks. Accordingly, if all hooks had fished at the rate of the center hooks the over-all catch would have been 2,810 yellowfin, a 12.8-percent increase. It is apparent then that increasing the relative efficiency of the basket would result in a considerable economic gain.

It has been concluded (Shomura and Murphy 1955) that because the middle and end hooks of a basket fish at different relative levels, the differential distribution of the catch is a reflection of greater numbers of yellowfin at the deeper levels. Yoshihara (1954) suggests the same reason. Although the catch distribution by hook position in Gulf operations has been similar to that in the Pacific there are a number of indications in the data that the disproportionate catch is not fully explained by the relative fishing-depth theory. The explanation offered by Shomura and Murphy (1955) assumes that similar hook positions of all baskets are fishing at approximately the same level. As pointed out earlier, the assumption that any given hook position on different baskets reflects a similar fishing level is questionable. Another consideration is the comparative slight difference in fishing depth of adjacent hooks of Oregon long-line gear. As indicated by figure 9, the difference of depth of the two end hooks (1 and 2 or 9 and 10) is approximately six fathoms. Because of this, little difference would be expected between the catch of these hooks. Figure 9 reveals that the catch of hooks 2 and 9 was 12.8 percent, larger than that of hooks 1 and 10. A difference of this magnitude between hooks with a vertical difference of only six fathoms would appear to be related to something other than only the depth differential. Another relationship which contradicts the depth theory is the comparative catch between the end hooks (1 and 10). Again, assuming that the two hooks fish the same level at all times, the catch should be approximately equal. However, figure 9 shows hook number 1 took 10.4 percent more yellowfin than hook number 10.

The discrepancy between the catch of hooks on either end of the basket is tentatively attributed to the action of current on the branch line. If a set is made parallel to the current then the branch lines on the end of the basket toward the source of the current would be streamed toward the mainline and those on the other end away from it.

A final consideration refers again to the extreme variability of the fishing level of the baskets. Since end hooks of some baskets at times fish as deep and deeper than intermediate and center hooks of other baskets the expectation would be for a more uniform distribution if yellowfin were actually as numercially superior at deeper levels as the pattern indicates. The conclusion is that the differential catch distribution by hook position in the Gulf is not entirely explained by the relative fishing-depth theory.

If mainline interference is a contributing factor, the baskets on each end of the set should display a distribution pattern even more disproportionate than that of figure 9 since they sag considerably more than those toward the center of the set and consequently the end branch lines are much closer to the mainline Data of the 5 percent of baskets on each end of the sets summarized in table 3 corroborate this. The middle hooks for these baskets averaged 39 percent more fish per hook than the end hooks, whereas the superiority of the middle hooks of the remaining baskets was only 17.9 percent. The data in table 3 show, also, that the catch rate of both the intermediate and end hooks of the terminal baskets is approximately twice that of the intermediate baskets. It might be felt that because the end baskets fish deeper the superiority is due to greater numbers of yellowfin at deeper levels. It does not seem reasonable, however, to ascribe this two-to-one superiority entirely to greater numbers of yellowfin at deeper levels for a number of reasons. The baskets on each end of the set fish deeper due to end sag but they also fish a

Table 3 - Summary of Yellowfin Catch by Hook Position of Terminal 5 Percent of Baskets (Total 10 Percent) and Intermediate (90 Percent) of Baskets

Cruise Number	Terminal 5% of Baskets		Intermediate 90% of Baskets	
	Yellowfin Catch on			
	Middle Hooks (4, 5, 6, 7)	End Hooks (1, 2, 3, 8, 9, 10)	Middle Hooks (4, 5, 6, 7)	End Hooks (1, 2, 3, 8, 9, 10)
33	51	40	252	299
37	20	29	141	179
41	46	57	213	293
Total Yellowfin Catch	117	126	606	771
Catch Per 100 Hooks	29.2	21	151.5	128.5

larger volume of water per basket than the intermediate ones and therefore a larger catch per unit would be expected. For purposes of illustration consider the area exploited by a long-line set as shown in two dimensions in figure 10. The distances X, Y, and Z are dependent on the distances to which a yellowfin can detect the bait. Theoretically all fish entering areas A and B are available to basket number 1 and equal areas are available to all other baskets. In addition to areas A and B, the end baskets have available to them the fish in areas C and D. This relationship is an extremely complex one, greatly simplified here, but does illustrate how baskets on the ends of sets would be expected to have higher catch rates than the intermediate ones. Another consideration connected with the much higher catch rates of the end (and deeper) baskets are the results of the experimental gear fished on cruise 40, table 2. Fishing to levels considerably below that of the standard Oregon gear did not increase the catch rate, but actually diminished it.

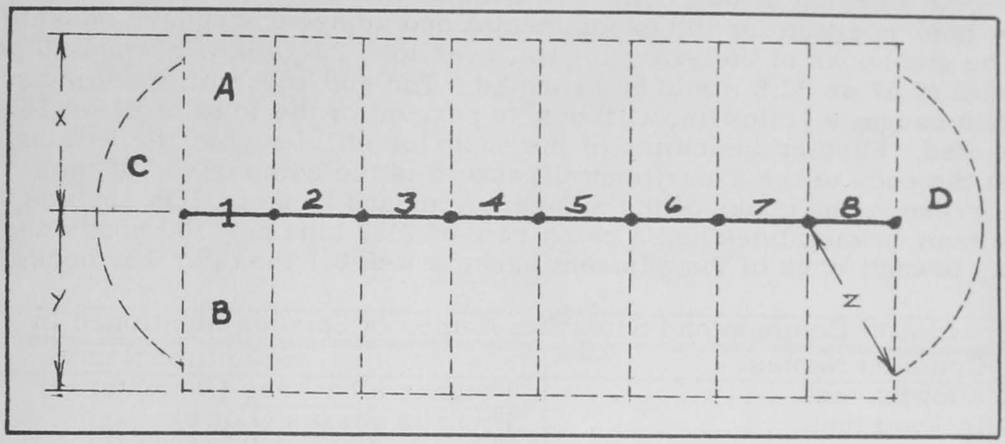

Fig. 10 - The theoretical areas fished by the baskets of a hypothetical 8-basket long-line set as viewed from above.

GEAR MODIFICATIONS: If mainline interference was a factor contributing to the lower catches of the end hooks, certain modifications to the gear might overcome this and consequently create a more efficient unit. On the basis of this, a limited experiment with modified baskets was conducted during cruises 45 and 47. The experimental baskets differed from the standard in that the two branch lines on each end of the mainline were lengthened to six fathoms--the six intermediate branch lines remained the standard four fathoms in length.

During cruise 45 three long-line sets were made. Seven experimental baskets were fished on two of these sets and five on the other. Standard baskets were alternated with experimental ones. Occasionally, however, two standard or experimental baskets were set consecutively. Consequently, to obtain as accurate a comparison as possible, the catches on all standard baskets which fished adjacent to an experimental one were used in the evaluation. As is shown in table 4, the average catch rate of the experimental gear was 103 percent greater than the standard. On

Table 4 - A Comparison of Catch Rates of Standard and Experimental Baskets during Cruises 45 and 47

Station	Long Branch-Line Baskets			Standard Branch-Line Baskets		
	No. Baskets Fished	No. Yellowfin Caught	Catch Rate	No. Baskets Fished	No. Yellowfin Caught	Catch Rate
Cruise 45:						
1845	7	15	21.4	7	7	10.0
1846	7	12	17.1	8	11	13.7
1847	5	18	36.0	10	13	13.0
Average Catch Rate (No. of fish/100 hooks)			24.8			12.2
Cruise 47:						
1978	6	12	20.0	9	10	11.1

cruise 47 only one set took enough yellowfin to permit evaluation of the comparative effectiveness of the experimental gear. As shown in table 4 the experimental gear had an average catch rate 80 percent greater than the adjacent standard baskets.

Of interest at this point is a comparison of the relative distribution of the catch by hook position for the experimental and adjacent standard baskets for these sets. The end hooks of the experimental gear took 22 yellowfin when 40 percent of the total of 57 or 22.8 would be expected. The end hooks of the adjacent standard baskets caught 9 yellowfin, whereas 40 percent of the total of 41 or 16.4 would be expected. Further indication of the superior efficiency of the 6-fathom branch lines on the ends of the experimental baskets is the comparison of these hooks with the corresponding hooks of the adjacent standard baskets. On cruises 45 and 47 the 6-fathom branch lines had a catch rate of 21.0 tuna per 100 hooks and the corresponding branch lines of the adjacent baskets was 8.1 tuna per 100 hooks.

List of Common and Scientific Names of Species Mentioned in This Article

Common Names	Scientific Names
Yellowfin tuna	Thunnus albacares (Bonnaterre)
Big-eyed tuna	Thunnus obesus (Lowe)
Bluefin tuna	Thunnus thynnus (Linnaeus)
Albacore	Thunnus alalunga (Gmelin)
Blackfin tuna	Thunnus atlanticus (Lesson)
Skipjack	Katsuwonus pelamis (Linnaeus)
White-tipped shark	Pterolamiops longimanus (Poey)
Silk shark	Eulamia floridanus (Bigelow, Schroeder & Springer)
Mako shark	Isurus oxyrhincus (Rafinesque)
White marlin	Makaira albida (Poey)
Blue marlin	Makaira ampla (Poey)
Sailfish	Istiophorus americanus (Cuvier & Valenciennes)
Swordfish	Xiphias gladius (Linnaeus)
Spearfish	Tetrapterus sp.
Lancetfish	Alepisaurus ferox (Lowe)
Cigarfish	Decapterus punctatus (Agassiz)
Squid	Loligo peali (Lesueur)
Herring	Etrumeus sp.
Razorbelly	Harengula pensacolae (Goode & Bean)
Menhaden	Brevortia patronus (Goode)
Croaker	Micropogon undulatus (Linnaeus)
Mackerel	Scomber grex (Mitchill)

If the increased catch of the experimental baskets was the result of a superiority of longer branch lines rather than a minimizing of mainline interference, then the 6-fathom branch lines should have a markedly higher catch rate than the remaining branch lines of the same basket. On cruises 45 and 47 the catch rate of the long branch lines was 22.2 tuna and the standard branch lines 21.5 tuna. This is consistent with the findings of Shomura and Murphy (1955) who have compared the efficiency of long and short branch lines and found no significant differences.

Quite obviously the large superiority of the experimental gear cannot be attributed to merely lengthening the four terminal branch lines when the intermediate branch lines of the same baskets were unchanged but yet caught approximately twice as many fish as the corresponding hooks of the adjacent gear. One reason which may contribute to this phenomenon is set forth by Shomura (1955)--the superiority of sardines over squid as long-line bait in moderate and rough seas, i.e., visibility. Shomura found that in calm seas there was no significant difference in the catches of the two baits, but in rough seas the sardines produced significantly larger catches. This was attributed to the silvery sardine being more visible to the tuna than the nearly translucent squid, particularly when rough seas caused the bait to move.

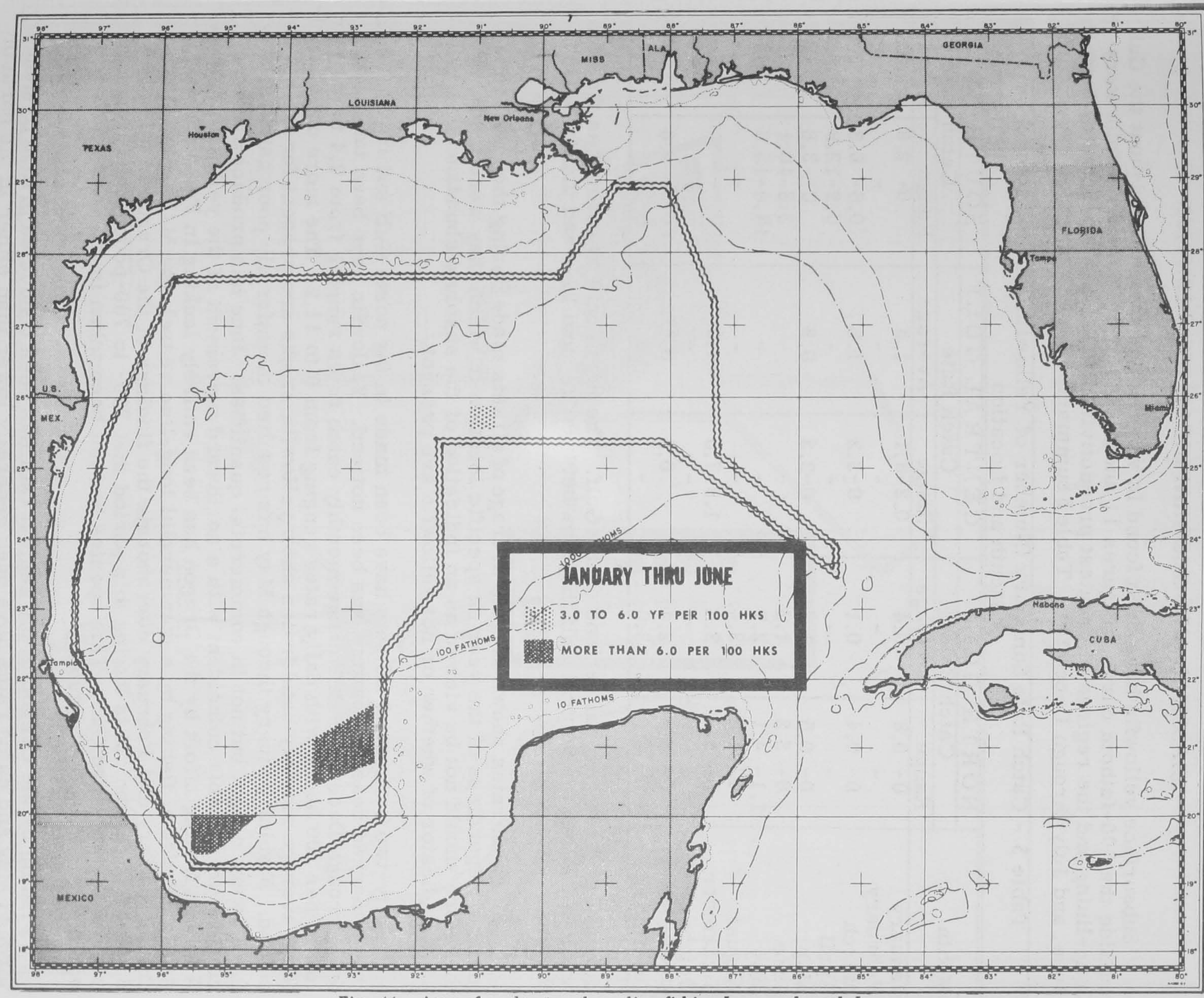

Fig. 11 - Area of exploratory long-line fishing January through June.

A similar effect may have been influencing the catches of the experimental gear during cruises 45 and 47. It is possible that higher catches on the long branch lines produced greater activity on the adjacent baits, making them more attractive to more fish and thereby increasing the catch of the entire basket.

SEASONAL AND GEOGRAPHICAL DISTRIBUTION

Subsurface yellowfin have been found in varying abundance throughout the Gulf outside the 500-fathom curve. Figures 11 and 12 depict the areas of exploratory long-lining and the regions of greatest productivity for the periods January through June, and July through December. Table 5 summarizes the catch rates experienced

Table 5 - Catch Rate Summary (Number of Yellowfin Per 100 Hooks) by Month and Location

Month	NORTH GULF		CENTRAL GULF		SOUTH GULF	
	Catch Rate		Catch Rate		Catch Rate	
	Range	Average	Range	Average	Range	Average
January	0- 0.8	0.4	0.2-3.1	1.6	0- 2.6	0.8
February	-	-	-	-	-	-
March	0- 0.4	0.1	0-3.2	1.8	0.8- 6.8	3.8
April	-	-	-	-	0.8-12.9	5.2
May	0- 0.5	0.2	0-2.3	0.8	0- 3.8	1.0
June	0- 3.2	1.2	-	-	3.8-10.1	6.9
July	1.1- 4.1	2.7	-	-	13.6-15.6	14.7
August	0-11.2	3.4	-	-	-	-
September	0- 8.2	2.4	1.3-7.5	4.0	-	-
October	-	-	-	-	-	-
November	0- 6.6	2.4	0.5	0.5	0.3- 9.6	2.9
December	0- 8.6	3.0	-	-	-	-

monthly in three general regions of the Gulf. The north Gulf is defined as the area north of 27° N., the central Gulf the area between 23° and 27°, and the south Gulf the area south of 23° N.

The catch rates shown are the average of all sets made during the respective months, regardless of the year or specific location in which they were made, and therefore should not be viewed as an indication of the absolute abundance but rather as an indicator of whether or not yellowfin are present.

Sixty-two percent of all sets have been made in the north Gulf and it is here that a marked seasonal pattern has been noticed. Yellowfin have been taken from July through December at average monthly catch rates ranging from 2.4 to 3.4 yellowfin per 100 hooks with daily rates ranging from 0 to 11.2. The more or less uniform average monthly catch rates show yellowfin stocks are present for the entire period. Fishing January through May has resulted in uniformly poor catches. Yellowfin were caught but not in commercial quantities. June has produced better catches presumably coincident with a northward movement of the yellowfin stocks. Although fishing effort by the <u>Oregon</u> has been entirely lacking in February and April, results of fishing by a commercial long-line vessel, the M/V <u>Mike Flechas</u>, during January and February corroborate the findings of the <u>Oregon</u> in this area during this season. It is during this period that 300- to 700-pound bluefin tuna appear in the northern Gulf. This species has not been taken in the west, central, or south Gulf during any season.[2]

Fishing by the <u>Oregon</u> in the central Gulf has been conducted primarily January through May and catch rates have been generally lower than either in the north or south Gulf. Fishing by the commercial long-liner <u>Mike Flechas</u> during February

2/Bluefin were later caught in the western Gulf by the commercial long-liner M/V <u>Milmar</u> in the early summer of 1958.

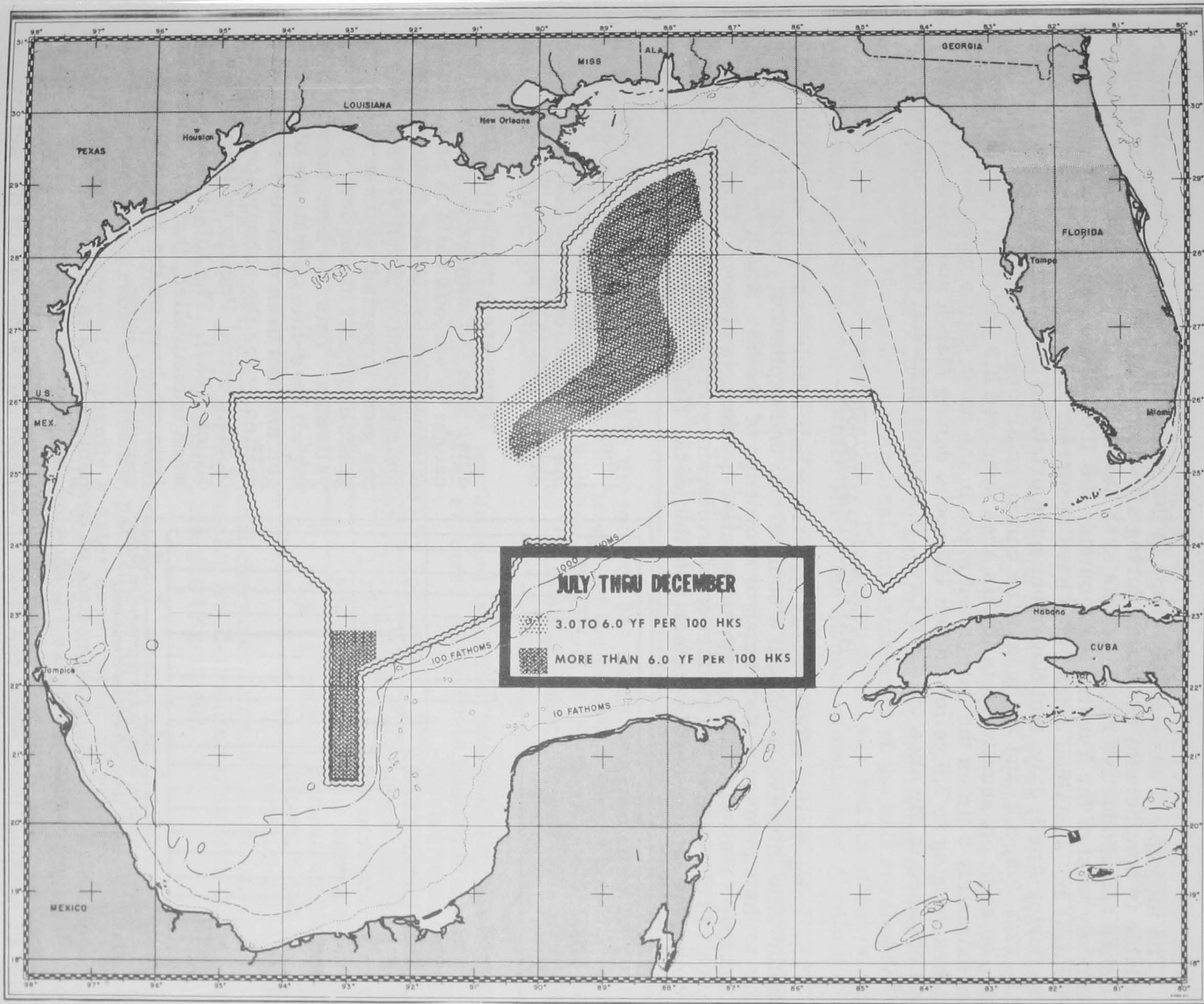

Fig. 12 - Area of exploratory long-line fishing July through December.

experienced substantially the same rates as the Oregon. However, the commercial long-liner Santo Antonino fishing in this area south of the Mississippi Delta during September experienced catch rates ranging from 1.3 to 7.5 tuna. Data from this area are not sufficiently comprehensive to reveal any seasonal presence of yellowfin.

The incomplete seasonal coverage in the south Gulf indicates that yellowfin are available in commercial quantities during all seasons of the year. The most intensely fished and productive region of this area has been in the Gulf of Campeche immediately west of the Yucatan Shelf outside the 100 fathom curve. Here, the highest individual and sustained catch rates have occurred. The eight sets by the Oregon here during April, July, and November have produced catch rates of 15.4, 14.9, 13.6, 12.9, 12.7, 9.6, 3.8, and 2.4 tuna. The commercial long-liner, Alfhild, during July 1957, on eight consecutive sets in this area averaged 8.3 yellowfin per 100 hooks--approximately 5 times the rate it had made in the north Gulf a week earlier. Good catches ranging to 7.6 yellowfin per 100 hooks during March and April also have been obtained in the area off Vera Cruz. Complete seasonal data for this region is lacking.

BAIT COMPARISONS

The comparative effectiveness of various bait species used in any fishery is of considerable interest, from both a commercial and exploratory point of view. The value to the commercial fisherman of knowledge of species, which for one reason or another result in either larger or smaller catches, is obvious. Cognizance of any bait preference in the evaluation of exploratory results is necessary in order to obtain the most accurate picture possible of the fishery.

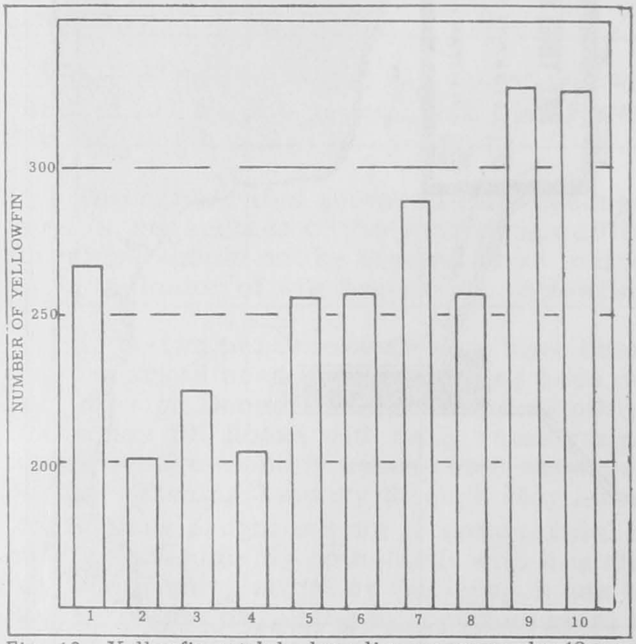

Fig. 13 - Yellowfin catch by long-line gear grouped as 10 percent units of 100-basket sets--all cruises combined.

Since yellowfin was the only tuna taken in commercial quantities with long-line gear in the Gulf of Mexico, the examination of the bait data is concerned with this species only.

There are a number of factors other than the number of yellowfin caught by various baits to be taken into consideration in the evaluation of their respective effectiveness. One of the most important of these is the schooling habit of the deep-swimming yellowfin. This has been noticed during all long-line operations of the Oregon and has been demonstrated mathematically for the subsurface yellowfin of the Central Pacific by Murphy and Elliot (1954). The misleading effect, when uncontrolled, that this characteristic can have on the data will be demonstrated later.

Consideration of the soaking time of respective baits is important in evaluating their effectiveness also. Figure 13, showing the catch by 10 percent units of the set verifies this. The breakdown of the catch in this manner represents a measure of catch by soaking time since the first 10 percent unit is the end of the set hauled first and consequently soaked the shortest time. The factor of schooling is important here also since it is obvious that regardless of how long a section of the gear is soaked, the catch rate will be low if comparatively few schools happen to come in contact with it. This has been evident on numerous sets, but since the chances are greater for schools to locate gear soaked for longer rather than shorter periods, the soaking time is a factor of importance.

Table 6 - Bait Loss by 10-Percent Units of Long-Line Sets - Cruise 37

	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
No. of Baits Lost	222	221	233	203	234	230	246	238	263	331
Percentage Baits Lost	9.2	9.1	9.6	8.4	9.7	9.5	10.1	9.8	10.9	13.7

Another important factor in the evaluation of bait species is that of bait loss during the soaking period. Table 6 shows the bait losses of cruise 37 by 10-percent units of the sets. The progressive loss of baits with increased soaking time is consistent with the findings of Shomura (1955).

The principal factors contributing to bait loss during the fishing period are the action of the sea on the gear, the physical characteristics of the bait species and bait stealing by tuna and other species. The action of the sea and its effect on bait loss is demonstrated in table 7 which shows the number of baits lost by relative hook position. The end hooks (1, 2, 9, 10), which are subject to the greatest agitation from surface swells acting on the floats (Shomura 1955), lost 1,063 baits when only 40 percent of the total or 944 would be expected to be lost had the action of the swells been uniform throughout the basket, whereas hooks 5 and 6 (the center hooks) lost only 406 baits when 20 percent of the total or 472 would be expected to be lost. Shomura (1955) has demonstrated that this bait-loss problem can be minimized by double-hooking.

Table 7 - Bait Loss by Hook Position

Baits	Hook Number									
	1	2	3	4	5	6	7	8	9	10
No. Lost	317	256	254	213	201	205	198	227	245	245
Percentage Lost	13.4	10.8	10.7	9.0	8.5	8.7	8.4	9.6	10.4	10.4

Bait stealing by tuna, sharks, marlin, and lancetfish has been established by the baits found in their stomachs after capture. An extreme case of this was revealed when seven baits were found in a single lancetfish. The relative ability of various bait species to remain on the hook is shown in table 8. The variations are considerable and appear to be due to the physical characteristics of the fish, i.e., the tougher, smaller-eyed, wider-headed species (mullet) suffered smaller losses than the tender, large-eyed, narrow-headed species (cigarfish).

Table 8 - Percentage Bait Loss by Species

Baits		Mullet	Menhaden	Mackerel	Herring	Cigarfish
No.	Used	551	510	3,220	1,790	2,140
	Lost	51	94	793	482	604
Percentage Lost		9.3	18.4	24.6	26.9	28.2

The factor of bait loss, as demonstrated for herring and sardines by Shomura (1955), is of considerable significance, particularly in rougher seas, where one species may experience significantly greater catch rates, not because there is a preference on the part of the yellowfin, but because one species has a much greater tendency to remain on the hook and consequently is available where others may not be. Double-hooking will minimize this discrepancy.

The factors previously mentioned which may give rise to erroneous conclusions, i.e., the schooling behavior of subsurface yellowfin and the soaking time may be controlled by alternating by basket or hook the species being tested.

MENHADEN VERSUS CROAKER: Two bait species readily available in the Gulf of Mexico, menhaden and croaker, were utilized primarily on cruise 41. Comparison of the over-all catch rates with the two species, eliminating stations where no yellowfin were taken, shows the apparent superiority of menhaden, as menhaden caught 5.1 yellowfin per 100 hooks and croaker 2.6 yellowfin per 100 hooks. Comparison of the catch rates using only those stations where both baits were used again shows a preference, but to a lesser degree, for menhaden. Menhaden caught 4.1 and croaker 2.6 fish per 100 hooks. If, however, only the data where the baits were alternated are considered (to minimize the effects of schooling behavior and soaking time), the resultant rates are menhaden 3.8 and croaker 3.1.

During cruise 41, for the first time, commercial long-line vessels were operating with the Oregon. Table 9 summarizes the data for those Oregon stations where the M/V Milmar was fishing in the same area. The comparison of the rates of the two vessels for stations 1612, 1613, and 1615 indicates a striking preference for menhaden and is apparently confirmed by stations 1617 and 1618 where the Milmar catch rate increased considerably coincident with the change of bait from croaker to menhaden. However, it should be noted that the Oregon catch rate for these two stations using the same bait (menhaden) dropped considerably and on station 1621 picked up again, whereas the Milmar catch rate, still using menhaden, dropped, indicating something other than a bait preference influencing the catches. The construction of the gear fished by both vessels was identical, sea conditions were the same, and the soaking time of the gear approximately equal which suggests that catch-rate differences were in part the result of chance variation in the number or size of schools encountered by the gear of the respective vessels.

Table 9 - Comparative Catch Rates by Bait Species of M/V Oregon and M/V Milmar

Station	M/V Oregon		M/V Milmar	
	Bait Used	Catch Rate	Bait Used	Catch Rate
1613	Menhaden	6.0	Croaker	2.3
1615	Menhaden	8.6	Croaker	2.5
1617	Menhaden	5.2	Menhaden	6.0
1619	Menhaden	3.8	Menhaden	5.5
1621	Menhaden	7.7	Menhaden	3.0

CIGARFISH VERSUS SQUID: The first two long-line cruises (23 and 24) of the Oregon employed principally cigarfish and squid as bait. The bait results for these cruises are summarized in table 10. The combined data of the two cruises indicates an apparent strong preference on the part of the yellowfin for cigarfish as squid caught 0.6 yellowfin per 100 hooks and cigarfish 1.9 yellowfin per 100 hooks.

Using only the data where the baits were alternated reveals a rate of 1.1 yellowfin per 100 hooks for squid and 4.2 for cigarfish. Although the data do not lend themselves to mathematical analysis, in view of the magnitude

Table 10 - Comparative Catch Rates of Squid and Cigarfish, Cruises 23 and 24

Station	Squid		Cigarfish	
	No. of Hooks Fished	Yellowfin Catch Rate	No. of Hooks Fished	Yellowfin Catch Rate
Cruise 23:				
1043	156	0.6	80	5.0
1053	170	0	60	4.5
1065	157	0	79	2.5
1067	182	0	54	1.9
1071	193	2.1	43	2.3
1073	210	0.5	26	0
Cruise 24:				
1111	135	2.2	137	1.5
1114	110	1.8	216	4.1
1120	113	0.9	168	0.6
1122	108	2.8	167	0
1123	99	0	312	0.3
1125	108	0	167	1.8
1126	108	0.9	176	0.6
1128	99	0	166	2.4
1129	99	0	171	2.3
1130	99	0	171	2.3
1133	151	0	151	0.7
1135	63	0	198	0.5
1138	54	0	248	3.6
Average Rate for Both Cruises (No. of Fish/100 Hooks)		0.6		1.9

of the difference and the comparatively large sample, it is concluded that cigarfish are superior to squid as long-line bait.

MACKEREL, CIGARFISH, AND HERRING: Comparisons of the relative effectiveness of these species on cruises 33 and 37 (table 11) is difficult due to the lack of a systematic distribution of baits throughout the sets.

Examination of the rates for those sets where these baits were used simultaneously reveals variations of considerable magnitude. However, observation of the distribution of baits for each station reveals in all cases a bias to the advantage of the bait with the highest catch rate. A good example of this is station 1488A, cruise 37, table 11. In this case, herring has a rate (5.9) approximately twice that of mackerel (2.9) and cigarfish (3.1), but the distribution of the baits was such that the last baskets of the set with herring as bait accounted for 16 yellowfin, thus 20 percent of the gear accounted for 42 percent of the yellowfin taken. If the last 15 baskets are not considered and using only the data where the baits are more or less competitive, the catch rates for the three species are cigarfish 3.1, mackerel 2.9, and herring 2.9. In view of the consistency of this phenomenon on these cruises and pending experiments of a design lending to valid statistical analysis, the tentative conclusion is that these species are equally effective.

Table 11 - Comparative Catch Rates (Number of Yellowfin Per 100 Hooks) of Three Bait Species

Station	Mackerel		Cigarfish		Herring	
	No. of Hooks	Yellowfin Catch Rate	No. of Hooks	Yellowfin Catch Rate	No. of Hooks	Yellowfin Catch Rate
Cruise 33:						
1373.	400	2.8	320	1.6	220	3.6
1375.	250	1.6	470	2.8	280	1.8
1377.	310	4.2	580	3.6	-	-
1379.	440	5.2	570	6.0	-	-
1381.	10	0	260	7.3	-	-
Cruise 37:						
1486.	-	-	90	1.1	370	0.8
1488A.	70	2.9	130	3.1	320	5.9
1488B.	90	1.1	80	0	170	4.1
1490.	20	5.0	580	2.5	90	3.3
1491.	110	12.7	130	13.1	90	30.0
1493.	350	15.1	190	11.6	80	12.5
Average Catch Rate Per 100 Hooks		5.06		4.8		7.7

WATER TEMPERATURE AND CATCH RELATIONSHIP

Surface water temperatures exhibit a definite seasonal pattern with average monthly temperatures in the north Gulf generally a few degrees lower than those of the south Gulf. In both areas the temperature reaches a peak in July or August, with a gradual decrease until January or February and a gradual increase until summer.

Table 12 depicts the monthly surface temperature range for the north and south Gulf, with corresponding catch rates. In the northern Gulf the period from January through May shows a rise of temperature range from 69°-75° F. to 78°-80° F. and a uniformly low catch rate. During June, July, and August the temperature continues to rise as does the average catch rate. From August through December the temperature drops steadily but the average catch rate remains more or less constant. In the south Gulf the data are very limited; however, it is also apparent that surface temperature and catch rate are not directly related in this area.

Table 12 - Surface Water Temperatures and Catch-Rate Relationship for the North and South Gulf

Month	North Gulf		South Gulf	
	Yellowfin Catch Rate	Temperature Range (°F.)	Yellowfin Catch Rate	Temperature Range (°F.)
January	0.4	69-75	0.8	73-76
February	-	-	-	-
March	0.1	70-74	3.8	73-77
April	-	80	5.2	76-78
May	0.2	78-80	1.0	78-80
June	1.2	78-82	6.9	-
July	2.7	83-85	14.7	87
August	3.4	79-85	-	-
September	2.4	82-83	-	-
October	-	83	-	-
November	2.4	75-83	2.9	80-84
December	3.0	75-76	-	-

Bathythermograph recordings of water temperatures to a depth of 450 feet have been obtained on most long-line stations. Table 13 is a tabulation of these data for the north Gulf for the months of August and December. The temperature range from a depth of 100 to 300 feet is given, since the information from depth-sounder trac-

Table 13 - Water Temperatures and Catch-Rate Relationship in the North Gulf, August and December

Station	Yellowfin Catch Rate	Surface Temperature (°F.)	Temperature (°F.) From 100 to 300 Ft.	Thermocline Depth (Ft.)
August--Cruise 33:				
1356	7.1	84	83-65	100
1360	8.9	85	83-66	130
1362	6.7	85	83-66	100
1364	6.7	85	80-67	90
1366	5.6	85	83-68	100
1368	4.4	85	82-65	100
1369	1.7	85	84-73	130
1371	1.9	79	82-67	100
1373	2.4	84	83-64	100
1375	2.2	85	84-65	100
1377	3.8	85	85-66	110
1379	5.7	80	77-60	130
1381	11.2	84	-	-
Average	5.2			
December--Cruise 41:				
1609	5.6	75	75-68	240
1610	8.4	75	75-69	250
1612	7.3	75	75-69	260
1615	7.5	75	75-69	250
1617	4.7	76	75-70	260
1619	3.8	76	75-71	250
1621	7.7	76	75-70	250
1622	5.3	75	75-69	210
1624	1/	75	75-69	210
1626	2.6	75	75-70	210
Average	5.9			

1/Not used in computing average catch rate since 3 vessels fishing this area on this day caught only one yellowfin.

tracings indicates this is the depth range within which the Oregon's standard gear fishes. The depth of the thermocline, the lower limit of the warmer surface layer, is also shown.

The maximum temperature range (19 degrees F.) observed within the fishing zone during the summer is much greater than the maximum winter range of 7 degrees F. Coincident with this relationship is the much deeper thermocline and a slightly higher average catch rate during the winter.

Table 14 - Water Temperature and Catch-Rate Relationship in the South Gulf, March-April and November

Station	Yellowfin Catch Rate	Surface Temperature (° F.)	Temperature (° F.) From 100 to 300 Ft.	Thermocline Depth (Ft.)
March-April--Cruise 37:				
1473 . . .	2.8	76	76-70	130
1474 . . .	1.0	74	74-68	200
1475 . . .	0	73	73-71	-
1476 . . .	0.8	74	74-75	-
1478 . . .	2.4	77	76-66	150
1480 . . .	1.2	76	75-73	330
1481 . . .	6.9	76	75-63	150
1482 . . .	7.6	76	75-62	150
1484 . . .	0.8	76	76-66	100
1486 . . .	1.0	77	76-73	300
1488 . . .	4.7	78	76-62	-
1490 . . .	3.4	77	77-61	100
1491 . . .	12.9	77	77-65	150
Average	4.2			
November--Cruise 41:				
1596 . . .	1.4	80	80-68	180
1597 . . .	0	83.5	83-74	210
1598 . . .	0.8	82	82-73	240
1599 . . .	0.4	84	84-78	225
1601 . . .	0.3	82	82-77	180
1603 . . .	9.8	82	82-71	180
1606 . . .	3.8	82	82-70	100
Average	2.3			

Table 14 summarizes the temperature data for the south Gulf during the months of November and March-April. Comparison of the two periods shows a temperature range of approximate equal width (12° F.) with the November range 6° F.-8° F. warmer. Again, coincident with the lower temperatures in the fishing zone, the average catch rate is somewhat higher. When the temperature within the 100- to 300-foot range has not fallen below 72° F., the catch rates have been low.

The available data neither establishes nor excludes the possibility that yellowfin in the Gulf inhabit an optimum temperature range and pending more precise information as to the absolute depth at which the fish are caught, this relationship cannot be further evaluated.

SHARK DAMAGE

The fraction of the total yellowfin catch damaged by sharks has varied from 4.2 percent on cruise 45 to 23.2 percent on cruise 24, and averaged 13.6 percent. Although approximately 50 percent of the damaged fish are acceptable for canning, shark damage constitutes a considerable economic loss to a commercial operation as seen in figure 14.

The relative severity of shark damage appears to be the result of a combination of factors. Iversen and Yoshida (1956) reported the degree of shark damage in Central Pacific long-line operations directly related to the magnitude of the shark catch. A similar relationship has been found in the Gulf of Mexico. This is particularly true when large shark catch rates are associated with high yellowfin catch rates. Environmental influence appears to be considerable also. Table 15 summarizes this information for the north and south Gulf. In the north Gulf a 10° F. drop of average surface water temperature from August to December is accompanied by a sharp drop in shark population as evidenced by the much lower shark catch rate. As would be expected, the percentage of damaged yellowfin dropped also. Shomura and Murphy (1955) pointed out that since the sharks taken on long-line gear are commonly seen at the surface, they are primarily a surface species. The indication then is that the 10° F. drop of surface water temperature in the northern Gulf creates an environment unfavorable to sharks. In the south Gulf a drop of surface temperature from 82° F. in December to 77° F. in March-April resulted in no significant changes in either shark catch or percentage of damaged yellowfin.

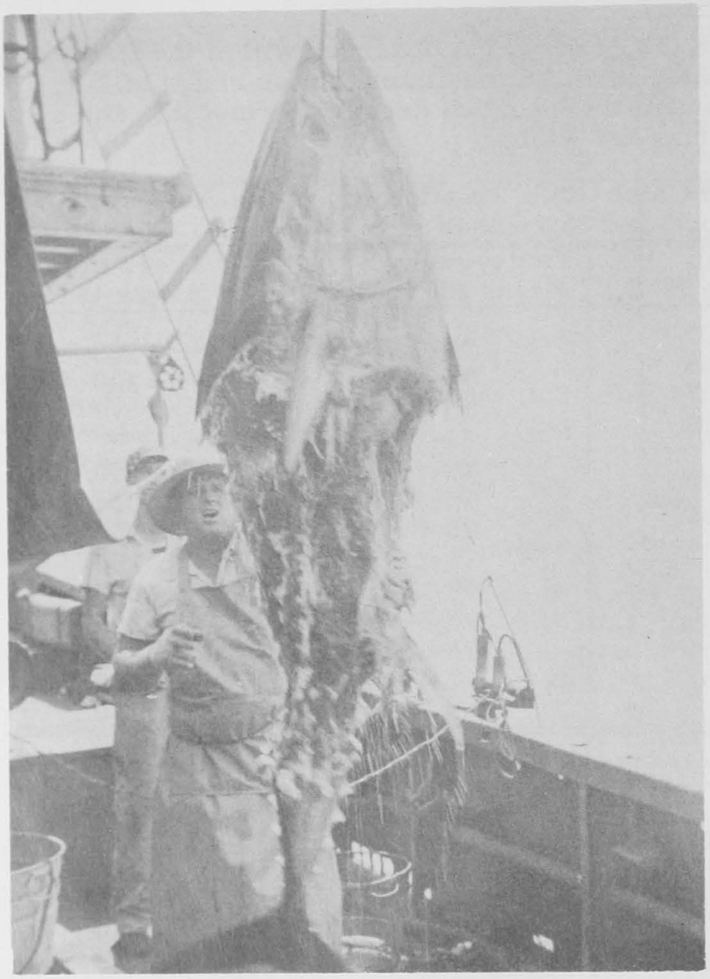
Fig. 14 - A shark-damaged bluefin tuna being brought aboard the vessel.

An important factor affecting the severity of shark damage is the time taken to haul the individual baskets. Shark damage occurs principally while the gear is being hauled and greater shark damage occurs with slow-hauling speeds. These data for four cruises are summarized in table 16. It is evident that the fraction of the catch damaged by sharks can be reduced by rapid and alert handling of the gear while hauling.

Table 15 - Shark Damage to Tuna Related to Shark Catch and Surface Water Temperatures

	North Gulf				South Gulf		
	Percentage of Yellowfin Damage	Shark Catch Rate	Average Surface Temp. °F.		Percentage of Yellowfin Damage	Shark Catch Rate	Average Surface Temp. °F.
Summer	21.2	1.5	85°	Winter	11.8	0.6	82°
Winter	8.6	0.6	75°	Spring	12.9	0.7	77°

The relationship between soaking time of the gear and the percentage of shark-damaged yellowfin is also shown in table 16. The larger damage rate with longer soaking time indicates that damage occurs to some extent while the gear is soaking and not only during the hauling period.

Table 16 - The Relationship Between Hauling Time, Soaking Time, and Shark Damage

Cruise No.	Average Soaking Time (Minutes)1/	Percentage of Shark-Damaged Yellowfin	Hauling Time Per Basket (Minutes)
24.	10.2	23.2	4.5
33.	8.2	19.2	4.04
37.	7.8	12.8	3.2
41.	7.4	8.6	3.4

1/Computed by dividing the total soaking time of the set by the number of baskets fished.

SUMMARY

1. Commercial-scale fishing on three trips produced quantities of yellowfin tuna of commercial magnitude.

2. Because of numerous factors affecting the vertical distribution of the long-line gear, determination of optimum depths of the subsurface yellowfin is difficult.

3. Yellowfin tuna catches were greater on the center hooks than on the end hooks of individual baskets. This disproportionate distribution was apparently rectified by employing longer branch lines on the ends of the baskets.

4. Yellowfin are present in commercial quantities in the north Gulf from July through December and apparently during all seasons in the south Gulf.

5. With the exception of squid, bait species were equally effective.

6. No relationship was noted between surface water temperatures and occurrence of yellowfin.

7. Shark damage to the catch is determined by the number of sharks in the fishing area and the speed with which the gear is hauled.

APPENDIX

Detailed long-line stations list of the M/V Oregon and other detailed tables are not included here, but are available upon request as an appendix to the reprint of this article. Request Separate No. 545. The reprint, which contains the appendix, includes these tables:

Table 17 - M/V Oregon Long-Line Stations List.

Table 18 - Yellowfin Catch by Hook Position (Standard Gear).

Table 19 - Yellowfin Catch by 10-Percent Units of Set.

Table 20 - Time of Setting and Hauling Long-Line Gear, Cruise 33.

Table 21 - Time of Setting and Hauling Long-Line Gear, Cruise 37.

Table 22 - Time of Setting and Hauling Long-Line Gear, Cruise 41.

Table 23 - Time of Setting and Hauling Long-Line Gear, Cruise 45.

Table 24 - Shark Damage, Cruise 33.

Table 25 - Shark Damage, Cruise 37.

Table 26 - Shark Damage, Cruise 41.

Table 27 - Shark Damage, Cruise 45.

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FISHING WITH UNDERWATER LIGHTS

An Italian Food and Agriculture Organization fisheries expert reports that he has successfully demonstrated to Tunisian fishermen that they can catch more fish with less wattage by setting their fishing lights beneath the water rather than above. He found fishermen using powerful petrol engines to generate power for a great number of surface lamps in their night fishing for sardines and anchovies. In Mahdia, one had 24 light bulbs of 500 watts each. Another had 16 and a third had 12. But most of the light from these lamps was wasted as it was reflected by the surface of the sea. The whole area was illuminated like a city square, but fishing results were poor. A different technique, using a 32-volt generating set and a 500-watt lamp placed under the water, was so successful in attracting fish that the local fishermen wanted to change their system so that they could use their lights underwater. Besides saving 50 percent in fuel costs, the underwater lights make for more effective fishing in rough seas and in strong moonlight. The submarine lamp is even more effective when used with an echo-sounder, which reduces waste of time because the fisherman can use it to make sure that worthwhile shoals of fish are present before he anchors his boat and switches his lights on (Current Affairs Bulletin of the Indo-Pacific Fisheries Council, November 1957).