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INVESTIGATION OF THE POTENTIAL ALBACORE RESOURCE OF THE CENTRAL NORTH PACIFIC

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ABSTRACT

A study of the albacore tuna resources in the central and eastern North Pacific by exploratory fishing of a research and a chartered vessel of the U. S. Bureau of Commercial Fisheries Laboratory, Honolulu, culminated in a commercial-scale test. The test was made with gill nets in the central North Pacific during July and August 1958. The catches obtained from the chartered vessel Paragon showed that summer gill-netting for albacore in the central North Pacific was not commercially feasible. However, environmental conditions encountered in 1958 were not similar to those in 1955 and 1956 when the exploratory catches, which prompted the test, were made. Colder surface water was present during 1958, and as a result, there was a southward shift of surface temperatures and a corresponding shift in albacore distribution. An instance of unusual albacore behavior was also observed which might have been related to the environment and have affected the efficiency of the gill net fished from the Paragon. It is suggested that one vessel on a single cruise does not provide an adequate test of the potential albacore fishery in the area.

INTRODUCTION

In 1954 the U. S. Bureau of Commercial Fisheries Biological Laboratory at Honolulu, Hawaii, received an allotment of funds from the Saltonstall-Kennedy Act (68 Stat. 376) to study the albacore tuna, Thunnus germo (Lacepede),[1] in the central and eastern North Pacific. One of the major objectives of this study was to determine whether commercially profitable concentrations of albacore tuna were present in the mid-ocean area between the Japanese fishery in the western North Pacific and the United States fishery along the west coast of North America. A series of exploratory fishing and oceanographic cruises was made in the area between 170° E. longitude and the United States west coast. This phase of the study culminated in a commercial-scale test of albacore fishing in the mid-ocean area during July and August of 1958.

The series of cruises leading up to the commercial test provided information on the seasonal distribution and relative abundance of albacore (Graham MS.)[2]. The results may be summarized as follows. In the fall, there was an almost continuous distribution of albacore

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1/Also known as Germo alalunga (Bonnaterre), Thunnus alalunga (Gmelin), and Germo germo (Lacepede).
2/Graham, Joseph J. MS. "The macroecology of the albacore tuna, Thunnus germo (Lacepede), in the central North Pacific."

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across the North Pacific between the Japanese and the American west coast fisheries. This same area was to a large extent devoid of fish in the winter. During the spring, albacore were present between the two fisheries, but their distribution was discontinuous, and they were difficult to find in abundance. A concentration of albacore was located in the summer around the mid-forty latitudes between 175° W. and 160° W. longitude south of the Aleutian Island chain. East of 160° W., fish were scarce until the vicinity of the west coast of North America was reached.

The discovery of the summer concentration of fish in the central North Pacific came about primarily through the use of surface gill nets. Surface trolling lines, the major gear used in the American west coast fishery, were only of secondary importance (Tester 1956, Anonymous 1956, Graham 1957, and Graham and Mann 1959). It appeared that this area contained albacore which could be exploited commercially, because (1) the concentration of fish was located in the same area during two consecutive summers, 1955 and 1956; (2) in 1956, within the area of concentration, good catches were persistent locally for a period of 2 to 3 days; and (3) the fish captured were mostly of a size acceptable for canning (10 to 28 pounds).

THE PLAN

These findings warranted a practical test with gill nets by commercial fishermen. It was decided to engage a chartered vessel, with a guaranteed return to the fishermen. This arrangement allowed us to take advantage of the knowledge we had gained and insured an adequate test of the area. It also provided freedom of operation in order to take advantage of the skills and knowledge of the fishermen and simulated as nearly as possible a commercial fishing operation. The bid specifications were prepared with these features in mind.

The general area delimited for fishing encompassed all positions where promising catches had been made during the 1955-56 summer cruises (41° N. to 48° N. latitude, and 175° W. to 155° W. longitude). Locations of the individual gill-net sets were left to the discretion of the master of the vessel. Each prospective bidder was provided with background material summarizing previous catch data for the area.

The successful bidder was required to equip his vessel so that a minimum of 40 shackles of gill-netting could be set. The construction of the shackles was to be based in part on a study by Graham and Mann (1959) on the results of previous gill-net fishing conducted by the Honolulu Laboratory. The mesh was to measure between $7\frac{1}{2}$ and $8\frac{1}{2}$ inches (stretched measure) which would allow the escape of small fish. The minimum length of each shackle was to be 50 fathoms and its depth 5 fathoms. To obtain full payment of the contract price, the vessel was to set 1,200 shackles between July 20 and September 10, 1958, or as an alternative, catch at least 60 tons of albacore. All sets were to be made during evening twilight and allowed to soak at least 6 hours before being retrieved. In addition to fishing gill nets, a minimum of 6 surface lines were to be trolled during all daylight runs within the fishing area and at least 3 lines on runs to and from the fishing area.

The Bureau's research vessel Hugh M. Smith was to make oceanographic and biological observations in the fishing area, on conditions usually associated with the presence or absence of albacore. These observations were to be compared with those of previous summer cruises (1955 and 1956) and to assist the contract vessel by delineating the distribution of albacore. Albacore were to be sampled in the surface layer by using: (1) 10 shackles of gill net with mesh sizes of $4\frac{1}{2}$ to $7\frac{1}{2}$ inches; (2) 5 trolling lines; and (3) 20 baskets of a specially designed long line with 12 droppers per basket and with each hook suspended from a buoy. Droppers were placed 15 fathoms apart along the continuous mainline and were grouped in series of 3 each with 4 lengths, 2, 4, 8, and 12 fathoms. The gill net was set at twilight and allowed to fish overnight. Lines were trolled on daylight runs between stations and when patrolling long-line sets, which were made primarily in the morning hours. A more complete description of the fishing methods employed aboard the Hugh M. Smith and the contract vessel is presented elsewhere (McGary and Graham 1960).

THE COMMERCIAL TEST

Northwestern Fisheries Inc. of Seattle, Wash., submitted the low bid of $45,990 for their vessel the M/V Paragon, a 90-foot (over-all) halibut schooner with a beam of 19 feet and a 9-foot draft (empty). Her cruising and maximum speeds were 10½ and 11 knots, respectively. The ability of the vessel to fish gill nets under the summer weather conditions of the central North Pacific had been proven during previous salmon research cruises fielded by the Bureau's Seattle Exploratory Fishing Station (Powell and Peterson 1957).

Fig. 1 - Crew of the Paragon. One crew member is not shown here.

The M/V Paragon departed from Ballard, Wash., on July 16 with a master, a crew of four fishermen (fig. 1), and one of our Laboratory's biologists aboard.

The first gill-net set from the Paragon was made on July 26 at 41° 40' N., 157° 11' W. (fig. 2), and resulted in a promising catch of 145 albacore (2,800 pounds). Two subsequent sets in the same vicinity yielded successively smaller catches of 133 fish (2,000 pounds) and 119 fish (1,900 pounds). Compared to the first 3 sets, the second group of 3 catches in this vicinity was drastically reduced and declined steadily to a low of 13 fish (200 pounds). The Paragon then explored northward and westward to 163° 37' W., without any significant improvement in catch. Meanwhile, gill nets were set from the Hugh M. Smith for the first time on July 29; five sets were made along 160° W. (fig. 3) in about the same latitudes as the sets made by the M/V Paragon. Only 4 and 5 albacore each were caught in two of the sets; none in the other three sets.

As a result of these poor catches, the efforts of the two vessels were coordinated in an attempt to locate albacore in abundance. It was decided to explore and compare catches made in western and eastern portions of the area. Therefore, after the completion of work along 160° W., the Hugh M. Smith's cruise plan was altered, and instead of working along 165° W. the vessel turned westward to 175° W. The M/V Paragon returned eastward. The numbers of fish caught per set from both vessels varied considerably (figs. 2 and 3). The one relatively good catch of 49 albacore in the 10 shackles of gill net fished from the Hugh M. Smith was offset by the fact that about one-half of these fish weighed less than 10 pounds each. As pointed out above, fish less than 10 pounds were purposely excluded from the Paragon's catch by the large gill-net meshes (7½ to 8½ inches).

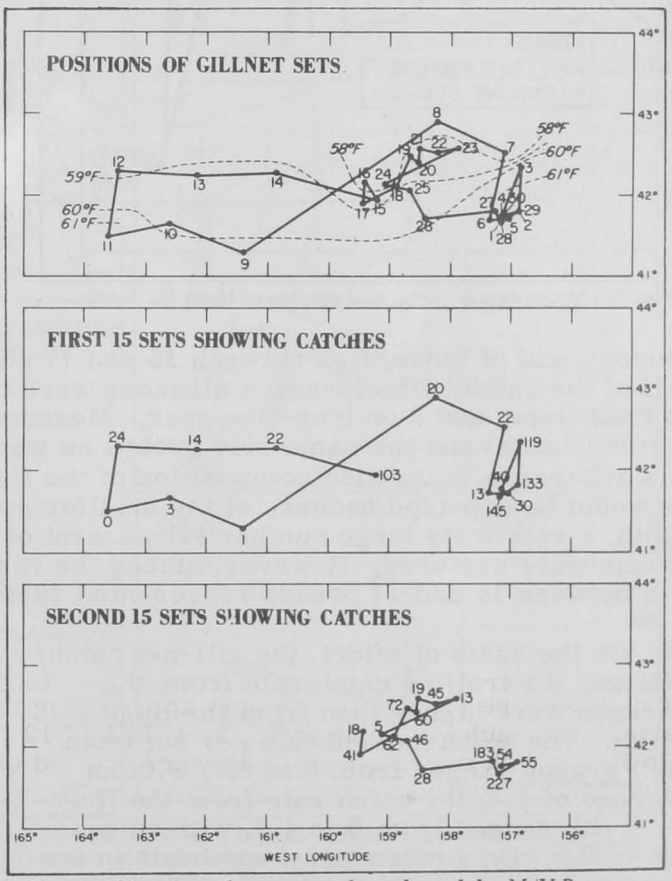

Fig. 2 - Vessel tracks, sets, and catches of the M/V Paragon.

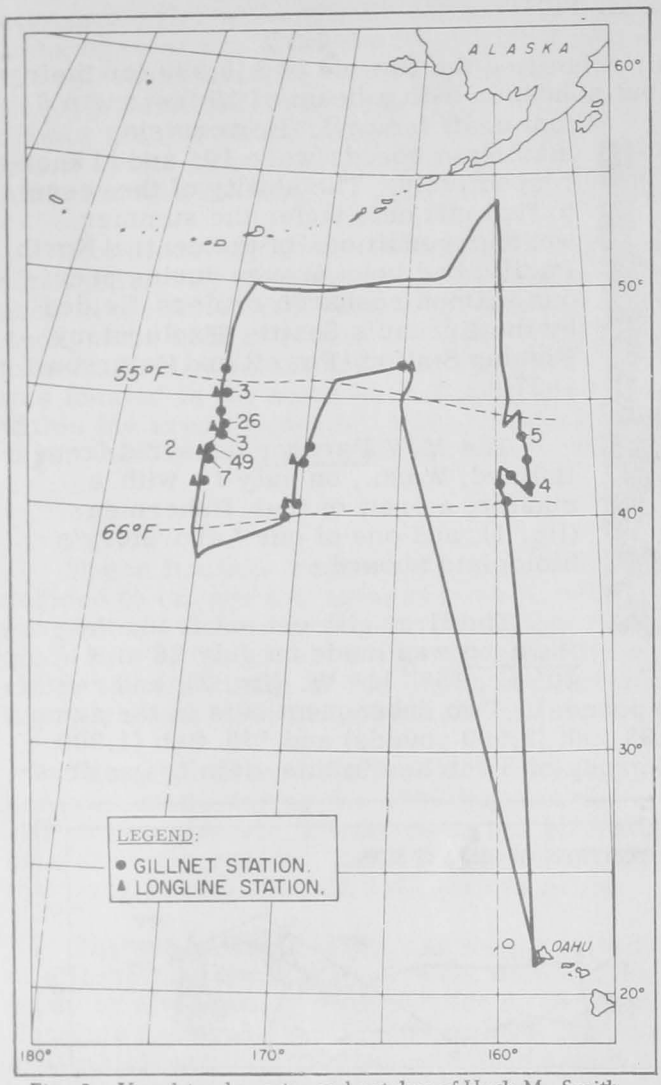

Fig. 3 - Vessel tracks, sets, and catches of Hugh M. Smith.

The master of the Paragon considered these results and elected to remain in the vicinity of 158° W. (fig. 2), where he judged that the fishing, while not good, showed some promise. Unfortunately, this promise was not fulfilled, and the Paragon then returned to the vicinity of her first set. There, 2 good catches of about 2,800 pounds (183 fish) and 3,400 pounds (227 fish) were made in 4 sets. The catches made from the Paragon and those from the Hugh M. Smith, which in the meantime had explored as far west as 170° W. and found no commercial quantities of albacore, did not indicate to the master of the former vessel that it would be profitable to continue fishing beyond the contract period, so he departed the fishing area for Seattle on August 30. The Hugh M. Smith was scheduled to remain in the area to continue fishing and to make oceanographic observations along 165° W. longitude. However, the serious illness of a fisherman forced the captain to discontinue the cruise on September 2, and the vessel returned to Honolulu (fig. 3).

A summary of the catch statistics shows that 1,617 albacore were caught from the Paragon by gill nets and 234 fish by trolling; of the latter number, 212 were caught in the area of gill-netting. The weight of the catch unloaded from the Paragon at Seattle was 27,053 pounds. This weight was made up of individual fish ranging in size from $6\frac{1}{2}$ to 46 pounds. Three size groups were present: $6\frac{1}{2}$-10 pounds, 10-21 pounds, and 21-46 pounds. (A total of 781 albacore were measured by the biologist aboard the Paragon.) Approximately 92 percent of the fish were desirable commercially (i.e., each greater than 10 pounds), and of those, fish between 15 and 17 pounds accounted for 49 percent or almost one-half of the catch. Ninety-seven albacore were caught by the Hugh M. Smith with gill nets, 13 on troll lines, and 2 on long-line gear. Measurements of 107 showed a similar size range ($6\frac{1}{2}$-35 pounds) and the same size groups as were found in the catch made from the Paragon. One difference in the size composition of the fish obtained from the two vessels was evident. As would be expected because of the smaller meshes ($4\frac{1}{2}$ - $6\frac{1}{2}$ inches) used from the Hugh M. Smith, a relatively large number (41 percent of the total catch) of albacore smaller than 10 pounds were captured. However, among the remaining fish of commercially desirable sizes, fish between 15 and 17 pounds represented 29 percent of the total catch.

On the basis of effort, the gill-net catch rate and the trolling catch rate from the Paragon were higher than from the Hugh M. Smith. The catch per shackle per set from the Paragon ranged from 0 to 5.7, with an average of 1.3; the catch rate from the Hugh M. Smith ranged from 0 to 4.9, with an average of 0.5. On a catch-per-hour basis in the fishing area, the troll catch rates from the Paragon varied from 0.0 to 7.4 per hour for individual days, with an average of 1.1. The

Table 1 - Summary of Expenses and Proceeds from the M/V Paragon Albacore Venture

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Expenses:	
Salaries	5,548.30
Fuel	1,742.00
Food	1,344.29
Gear1/.	4,553.95
Total	13,188.54
Proceeds from the sale of albacore	4,800.00

1/Only one-third of the total cost of the gill net ($13,406) and trolling gear ($85.28) has been entered. It is assumed that with a reasonable amount of repair both could be used for at least two additional trips.

rates from the Hugh M. Smith were much lower; 0.0 to 0.5 per hour, with an average of only 0.06.

The $13\frac{1}{2}$ tons of albacore captured from the Paragon were far below the 60 tons anticipated from the results of previous summer surveys (1955 and 1956). The weight of the catch after a storage period of 3 months was approximately 24,000 pounds; it was sold for 20 cents a pound for a total of $4,800. The degree to which this particular test of the potential albacore fishery of the area was a financial failure is evident from the cost and proceeds statistics of table 1.

AN ENVIRONMENTAL DIFFERENCE

The failure of the albacore catch by the Paragon to live up to expectations appears to be related to a difference between the oceanic environments which existed during the summers of the previous surveys (1955 and 1956), on the one hand, and that which prevailed during the summer of the test (1958), on the other. The oceanic circulation in the fishing area is largely zonal (east-west), and only slight seasonal and annual shifts occur in the location of the boundaries of the major water types (McGary et al. 1958). However, a major change in the physical characteristics of the area does occur in the form of large seasonal fluctuations in surface

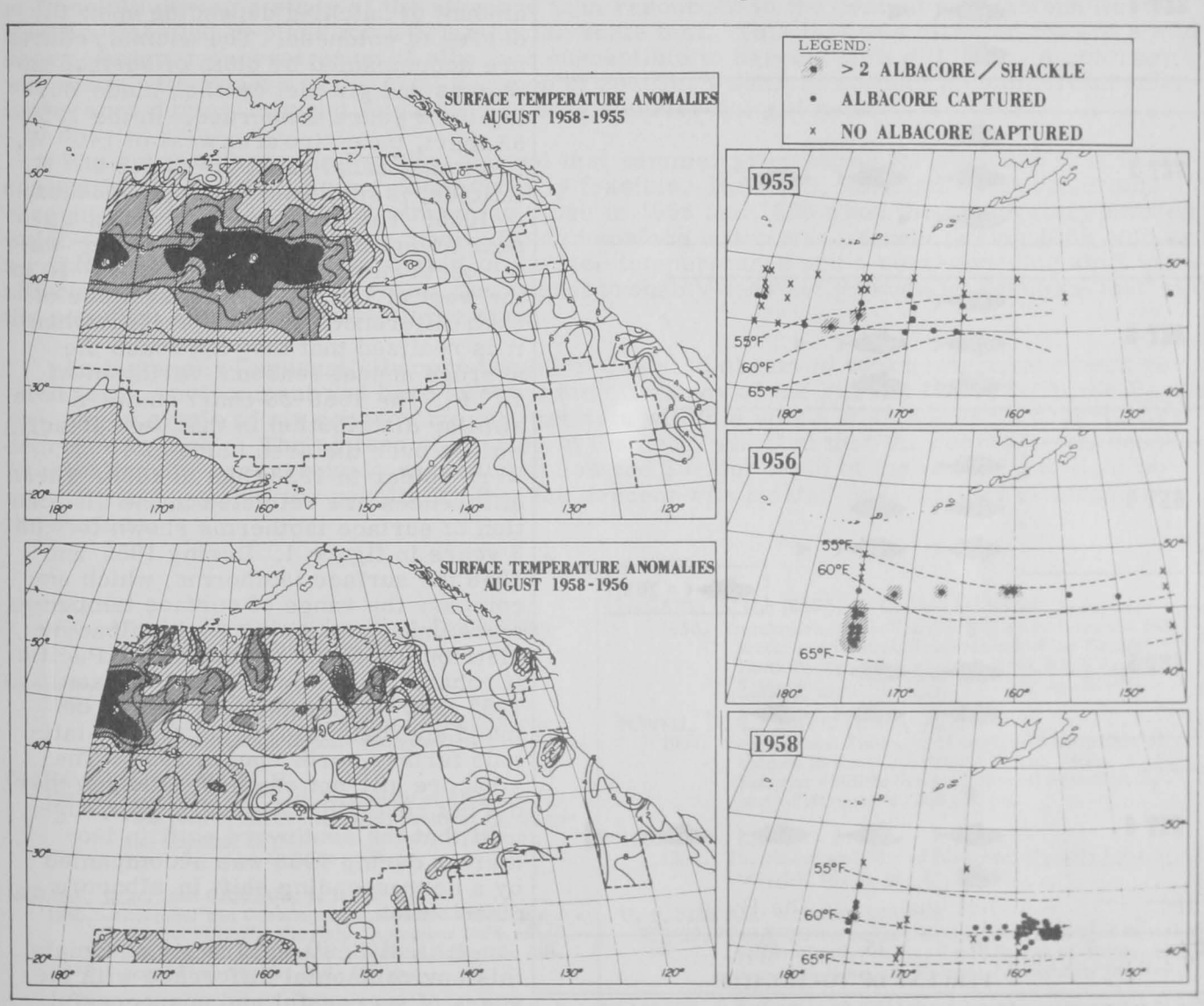

Fig. 4 - Surface temperature anomalies (U. S. Bureau of Commercial Fisheries 1957-59), surface isotherms and positions of gill-net catches of albacore during the summers of 1955, 1956 and 1958. The 1955 gill net catches were obtained from Powell and Peterson (1957), and isotherms and the 1956 and 1958 catches from the Honolulu Laboratory. Hatching indicates areas colder in 1958 than in 1955 and 1956.

temperature. Also, local annual differences in surface temperature can be considerable for a given year, and such a change occurred during the summer of 1958.

Sea-surface temperatures observed from the Hugh M. Smith and M/V Paragon in the summer of 1958 were as much as 8° to 10° F. colder in some parts of the fishing area than those obtained during the summer cruises of 1955 and 1956. These colder temperatures represented either (1) differences in seasonal warming (which were not as great in 1958) or (2) the influx of a water mass having inherently different temperature characteristics. However, the thickness of the surface layer above the thermocline (50-150 feet) was approximately the same in 1958 as during the previous years, discounting the second possibility.

Charts in figure 4 show the August 11-20 anomalies or departures of local surface temperatures in 1955 and 1956 from those of 1958. Lines are drawn through points of equal departure at intervals of 2° F. Where the lines enclose an area colder in 1958 than in 1955 and 1956, it is hatched, the amount of hatching depending upon the degree of coldness. The anomaly charts are accompanied by plots of surface isotherms and gill-net catches made during the 3 years concerned. In the 1958-55 chart, the entire area west of 140° W. longitude, from about 35° N. to 50° N. latitude, is shown as colder in 1958 than in 1955. The greatest differences appear as areas of 10°-12° F. colder water occurring in the vicinity of 44° N. to the west of 155° W. The magnitude of such differences is more evident when it is realized that they approach the average annual seasonal variation of 15° F. The 1958-56 chart shows a similar distribution in that the surface waters over the area north of 40° N. were colder in 1958 than in 1956. These differences are reflected in the distribution of surface isotherms shown for the 3 years in figure 4. During 1955 and 1956 the surface isotherms, which encompass the range of surface temperature usually coincident with albacore distribution in the central North Pacific (Graham 1957, Powell and Peterson 1957, and Graham MS.2/), are to be found approximately 3 degrees of latitude farther north than in 1958. The albacore gill-net catches, although they did not cover the area very well, suggest that the southward shift in isotherms during 1958 was accompanied by a corresponding shift in albacore distribution.

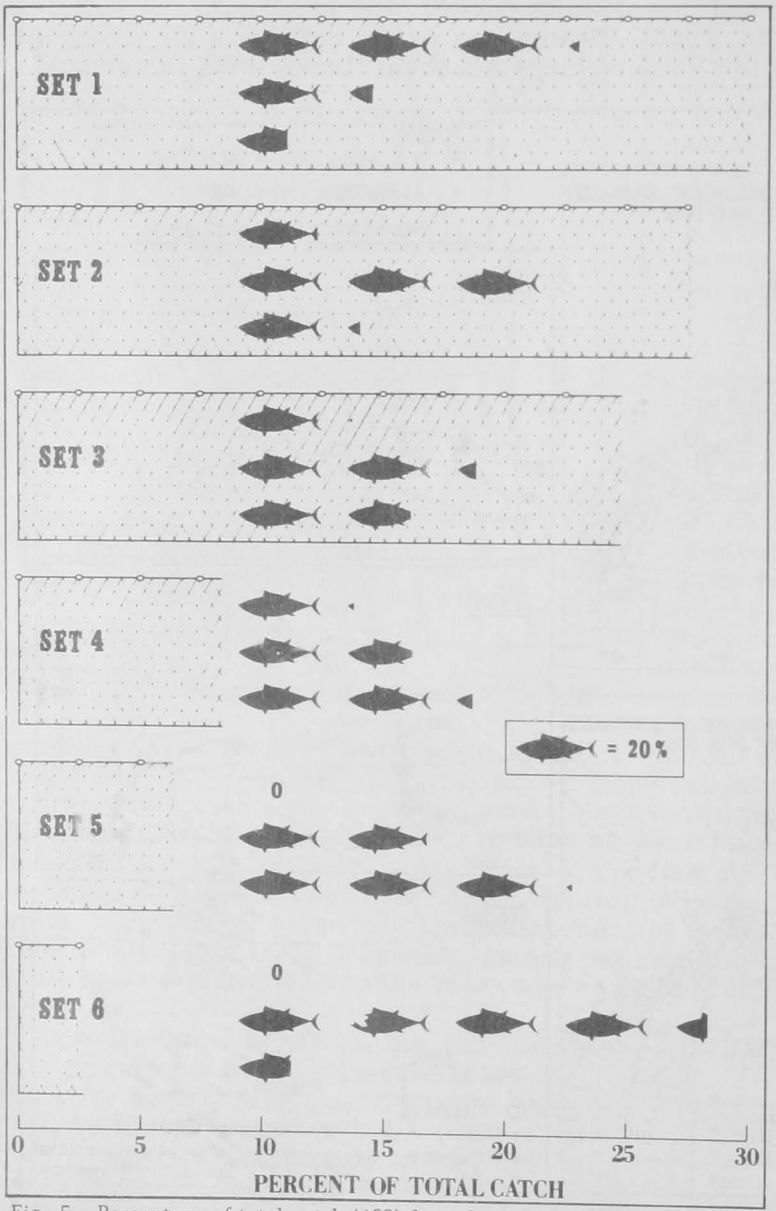

Fig. 5 - Percentage of total catch (480) from the first six gill-net sets and the percentage (per set) of the fish observed in the top, middle, and bottom of the net. The length of the net simulates the percentage of the total catch and the number of fish represents the percentage captured in that position of the net. A total of 393 observations was made concerning the position of fish in the net.

2/See footnote 2 on p. 1.

It is difficult to directly associate this environmental difference with the years of successful and unsuccessful gill-netting. However, one instance of unusual behavior exhibited by the albacore deserves mention because of its possible relation to the environment

and its bearing on the efficiency of the Paragon's gill nets. Analysis of the depth positions of albacore caught in the Paragon's net at her first six stations (fig. 5), when the catch dropped from 1½ tons to almost nothing, showed a progressive increase in the catch percentiles of the bottom and middle two-thirds of the net[3/]. Possibly the albacore progressively went below the 30-foot depth of the net in search of forage which was generally low according to surface night-light counts of saury and squid from the Paragon (McGary and Graham 1960). Whether or not this represented a general decrease of albacore forage in the fishing area during 1958 as compared to 1955 and 1956 cannot be ascertained.

In conclusion, the annual variability in the oceanic environment and in the distribution of albacore is so great that the operation of a single vessel on a single cruise is not an adequate test of the commercial fishing potentiality of the area investigated.

SUMMARY

Exploratory fishing by the U. S. Bureau of Commercial Fisheries Biological Laboratory at Honolulu during a study of the albacore tuna resources in the central and eastern North Pacific, resulted in plans for a commercial-scale test. This test was directed toward a mid-ocean, summer concentration of albacore susceptible to harvest with gill nets. A contract was made with owners of the M/V Paragon of Seattle, Wash., to conduct a commercial trial in the area during July and August 1958 using commercial gill nets.

The catches from the Paragon showed that summer gill-netting for albacore tuna in the central North Pacific was not commercially feasible. However, environmental conditions encountered in 1958 were not similar to those in 1955 and 1956 when the exploratory catches, which prompted the test, were made. Colder surface water was present during 1958, and as a result there was a southward shift of surface temperatures and a corresponding shift in the albacore distribution. In addition, one vessel probably does not provide an adequate test of the potential albacore fishery in the area.

An instance of unusual albacore behavior was also observed which might have been related to the environment and have affected the efficiency of the gill net fished from the Paragon. An analysis of six consecutive gill-net sets within a single area showed a progressive decrease in catch. The pattern of the fish in the nets indicated that the decrease was caused by the albacore progressively decending below the 30-foot depth of the net. Night-light observations suggested the possibility that the descent was related to a scarcity of forage at the surface.

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3/This trend was determined by inspection. Also, the data were examined using the Chi-square. A hypothesis was set up that the fish were distributed in the net in a 1:1:1 ratio in the top, middle, and bottom. The sums of the Chi-squares of the first five stations showed a statistically significant deviation from this expected ratio ($X^2 = 102.05$, degrees of freedom 9). The interaction between sets was also statistically significant ($X^2 = 90.04$, degrees of freedom 7), and it is thought that this heterogeneity lends credence to the suggested trend.