ANALYSIS OF CATCHES OF NINE JAPANESE TUNA LONGLINE EXPEDITIONS TO THE WESTERN PACIFIC OCEAN

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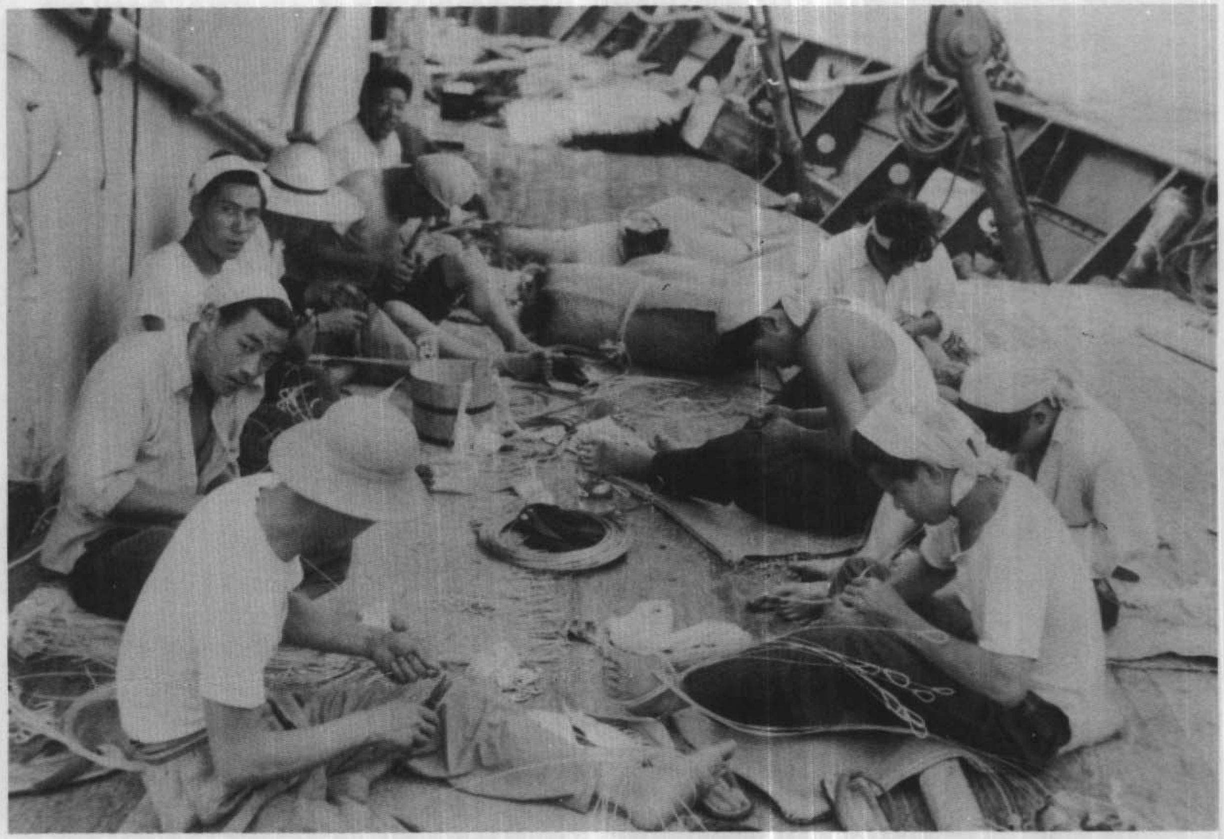

ANALYSIS OF CATCHES OF NINE JAPANESE TUNA LONGLINE EXPEDITIONS TO THE WESTERN PACIFIC

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The tuna resources of the western tropical Pacific are of great interest to the Japanese people, who before the war had begun to exploit them; to the people of the Philippines, Indonesia, and New Guinea, who would like to exploit them; and to the people of Micronesia, who may find in them one of the few things that they can sell. These tuna stocks are also of interest to Americans because some of the islands of the area are presently under U. S. trusteeship and it is continguous to portions of the central Pacific now being explored by the U. S. Fish and Wildlife Service.

Most of the knowledge of these western Pacific resources has been reported in scattered Japanese fishery literature on the prewar activities of Japanese fishermen. Following the war, tuna mothership fishing operations in the equatorial western Pacific (fig. 1) were authorized by the Allied Governments in control in Japan. There were nine of these expeditions between June 1950 and October 1951. Each took the form of a mothership that stored the catch and supplied logistic support to a fleet of relatively small catcher vessels that fished with longlines. Observers from the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service accompanied six of these expeditions and the general observations on the methods, catch, and area fished during these voyages have been published (Shimada 1951a and b, Ego and Otsu 1952, and Van Campen 1952).

In addition to the records obtained by the American observers with the expeditions, the operators were required to maintain a daily log on each of the longline catcher vessels. These logs contain observations on the weather and sea, the number of hooks set each day, the kind of bait used, and the numbers and weights of each of the principal species in the daily catches. Most of the observations were recorded with reasonable accuracy excepting the weights of the fishes, which perforce were estimates on the part of the captains.

The purpose of this paper is to summarize the records with regard to the abundance of the principal species comprising the catch (yellowfin, bigeye, and black marlin), and to examine the relation of abundance to factors in the environment. Since this type of consideration involves interpreting catch rates (usually expressed as catch per 100 hooks) as indexes of abundance, we also examine the possibility that the catch rates might be affected by factors other than abundance, such as the type of bait used and vessel efficiency.

SPECIES OF FISH IN THE CATCHES

The vernacular names of the various species of fish in the catches are used in the text. These are listed below with their usually accepted scientific names.

Yellowfin tuna - Neothunnus macropterus (Temminck and Schlegel)
Bigeye tuna - Parathunnus sibi (Temminck and Schlegel)
Skipjack - Katsuwonus pelamis (Linné)
Albacore - Germo alalunga (Bonnaterre)
Black marlin - Makaira mazara (Jordan and Snyder)
Pacific white marlin - Makaira marlina (Jordan and Hill)
Striped marlin - Makaira mitsukurii (Jordan and Snyder)
Pacific sailfish - Istiophorus orientalis (Schlegel)
Broadbill swordfish - Xiphias gladius (Linné)
Sharks - These are not listed specifically because of inadequate identification in the records.

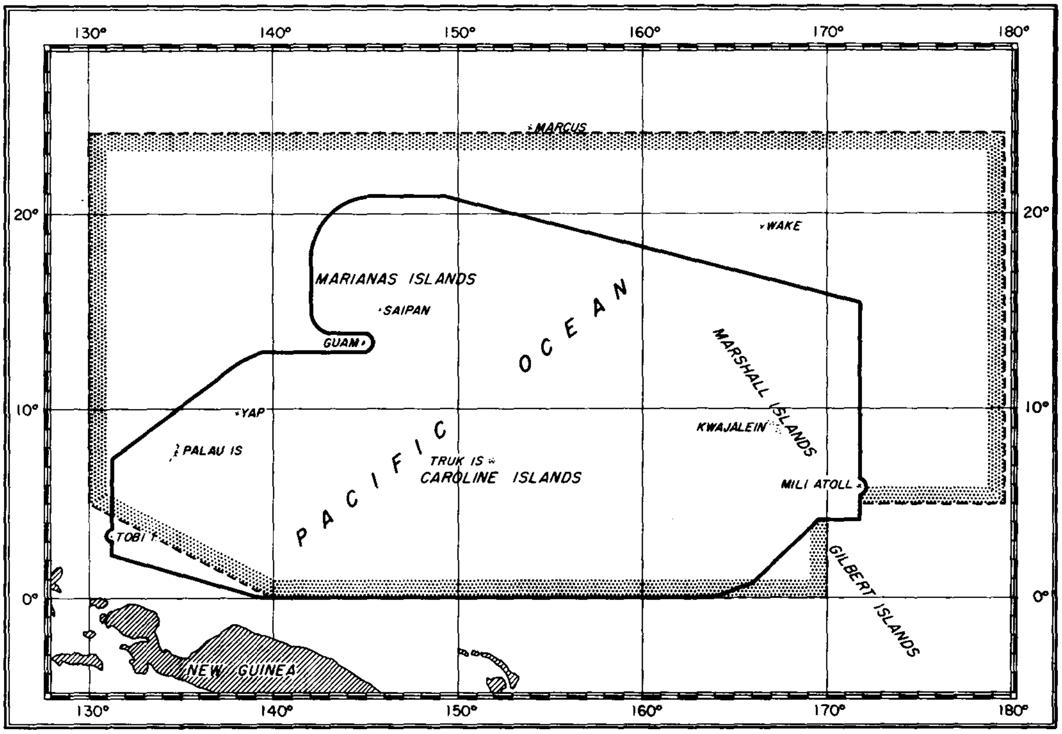


Figure 1.--Western equatorial Pacific. The dotted-stippled border shows the authorized area for tuna mothership expeditions. The solid black line around the Marianas, Marshall, and Caroline islands shows the U. S. Trust Territory of the Pacific islands. After Shimada (1951a).

EFFECT OF TYPE OF BAIT ON THE CATCH

The capture of a fish on a longline requires that the fish voluntarily strike at a relatively motionless baited hook. Consequently, the possibility is considered that the rate of capture was in part dependent on the type of bait used by the catcher vessels of the mothership expeditions. Three different baits--sardines, Sardinia melanostica (Temminck and Schlegel); sauries, Cololabis saira (Brevoort); and squid--were used on the expeditions, but because squid were used only incidentally, the comparisons are confined to sauries and sardines.

Quantitative data on the relative effectiveness of sardines and sauries are available from the daily log sheets of each catcher vessel, which list the number of pieces of each type of bait used each day. (Typically, a daily set of gear consisted of around 2,000 hooks and was baited with sardines or sauries or a mixture of the two.) Prior to analysis of these records, each day's fishing was coded on a linear scale of 0 to 10, with 10 representing all sauries, and 0 representing all sardines. The coded catches were then grouped by the relative amount of sauries used as bait as shown in table 1. This summary of all the data indicates that the two baits were about equally effective, although the higher catch rate of yellowfin on 100-percent saury sets is puzzling. However, interpretation of the results requires the assumption that the fishing in all of the 11 categories was similarly distributed in time and space. This probably was not the case, but as a further check we have summarized the catch rates during a single month in each of two limited areas (table 2). We find considerable variations, but for these sets of data the 100-percent saury baitings are not anomalous, and the conclusion that neither bait is superior is confirmed.

Table 1.--Catch per 100 hooks of yellowfin and bigeye tuna arranged by the relative amount of sauries and sardines used as bait (all expeditions combined)

	Percent saury used as bait										
	0	10	20	30	40	50	60	70	80	90	100
Yellowfin	1.97	1.53	2.04	1.18	2.10	1.94	2.03	1.72	1.88	1.88	2.51
Bigeye	0.41	0.76	0.34	0.48	0.57	0.47	0.57	0.68	0.89	0.67	0.61
Thousands of hooks	286	8	169	162	720	4,196	1,232	1,162	828	401	2,071

Table 2.--Summary of the yellowfin tuna catch rates (catch per 100 hooks) by amount of saury used as bait for two limited areas

	Percent saury used as bait										
	0	10	20	30	40	50	60	70	80	90	100
	6°-7°N. latitude, 177°-179°E. longitude, October 1951										
Yellowfin catch rate	0.33	3.24	3.14	0.60	0.70	0.52	0.90	0.48	0.77	-	0.57
Boat/days of fishing	6	1	3	10	12	58	3	14	2	-	5
	1°-2°N. latitude, 160°-165°E. longitude, May 1951										
Yellowfin catch rate	3.42	-	-	-	-	2.47	2.16	0.98	2.24	2.09	2.59
Boat/days of fishing	6	-	-	-	-	12	4	5	5	3	56

Also confirming the conclusion that there is no difference in the catch associated with type of bait are the results of experiments aboard the Sagami Maru, a research vessel from Kanagawa Prefecture, conducted during the seventh mothership expedition (Anonymous 1952). Sardines and sauries were alternated on each hook (5 hooks per basket). Slightly more yellowfin (73 versus 65) and black marlin (75 versus 63) were taken on sardines than on sauries, bigeye and other tunas were taken equally, and more sharks (77 versus 62) were taken on sauries. Thus it appears that the catches made during the nine mothership expeditions can be used as indexes of abundance without regard to the type of bait used on the longline.

RELATIVE CATCHING EFFICIENCY OF THE VESSELS

The mothership expeditions comprised numerous catcher vessels, many of which participated in several expeditions. Analysis of their catches for evidence of geographical and temporal variations in relative abundance would be considerably simplified if it could be shown either that there are no differences in relative efficiency or that such differences as exist are unimportant in magnitude. In longline fishing the total catch made by any vessel is related to the number of hooks fished and the abundance of the fish. This affords ample opportunity for the total catch to be related to such factors as vessel size and the skill of the fishermen, because these affect the amount of gear fished each day. On the other hand, the catch per unit of effort--catch per 100 hooks--should be relatively stable, because once a given number of hooks is placed in the water the number of fish taken on these hooks is largely a function of the availability of fish. There were, however, minor variations in the design of the gear used by the various vessels (Shimada 1951a) and these could conceivably affect the catch per 100 hooks.

In order to test for difference in vessel efficiency, as it affects the catch per unit of effort, a two-way tabulation by vessels and by months was made of the catch rates for each expedition except those of the Nansei Fisheries Company (3, 4, 6, and 9), which were much smaller in size and scope. The catches of yellowfin, comprising about half the total catch, were then studied by analysis of variance (Snedecor 1948). This classification actually affords some statistical control of the catch rate of vessels by area as well as time, because all of the expeditions tended to fish in a group that moved from west to east (and in some of the later expeditions from south to north near the end of their operating period).

The results of the analyses of variance (table 3) show that while there were differences in the catch rates associated with time (and area implied), there were no significant differences associated with vessels except on the fifth expedition. This single exception is puzzling but perhaps can be attributed to failure to completely control area and time in the analysis, a factor that may also account for the several near-significant F values associated with vessels of the first, second, and seventh expeditions. With this in mind, it appears that in general the catch rates of the various vessels do not have to be adjusted for relative efficiency in order to use them interchangeably as indexes of abundance. Further comfort may be taken from the fact that nearly all of the geographical areas and time periods discussed in the balance of this report are represented by the catches of several vessels, tending to average out any differences in efficiency that might exist.

DISTRIBUTION OF THE PRINCIPAL SPECIES AS INDICATED BY THE CATCHES

The longline catches made by the mothership expeditions afford a means of estimating the spatial and temporal distribution of the species of fish comprising the catch. These catches were made during several months of 1950 and 1951 over a wide area (135°E. to 179°E. long., and 1°N. to 10°N. lat.). The present study is confined to the yellowfin tuna, bigeye tuna, and black marlin, in part because together they comprised about 70 percent of the catch, and in part because the yellowfin tuna is a species of considerable economic importance on the American market. Other species that are taken in some numbers by longlining in this region are albacore, skipjack, white marlin, striped marlin, sailfish, broadbill, and sharks. While the catch rates of these species have not been subjected to analysis, they are listed in the tables of catch rates in the appendix.

Table 3.--Analyses of variance of the catch of yellowfin tuna of the mothership expeditions (data in table 12, appendix)

Expedition	Source of variation	Degrees of freedom	Sum of squares	Mean square	F	F, P = 0.05
1	Vessels	19	6.2217	0.3275	1.78	1.85
	Months 1/	2	1.1801	0.5901	3.20	3.25
	Discrepancy	38	7.0087	0.1844	--	--
	Total	59	14.4105	--	--	--
2	Vessels	11	6.5186	0.5926	2.05	2.26
	Months 2/	2	1.4735	0.7368	2.54	3.44
	Discrepancy	22	6.3735	0.2897	--	--
	Total	35	14.3656	--	--	--
5	Vessels	12	7.5790	0.6316	5.35	2.18
	Months 3/	2	3.3242	1.6621	14.07	3.40
	Discrepancy	24	2.8346	0.1181	--	--
	Total	38	13.7378	--	--	--
7	Vessels	21	11.6621	0.5553	1.57	1.82
	Months 4/	2	45.7537	22.8768	64.48	3.22
	Discrepancy	42	14.9010	0.3548	--	--
	Total	65	72.3168	--	--	--
8	Vessels	20	4.0191	0.2010	0.36	1.99
	Months 5/	2	37.5728	18.7864	34.08	3.23
	Discrepancy	40	22.0508	0.5513	--	--
	Total	62	63.6427	--	--	--

1/ June to August, 1950
2/ July to September, 1950
3/ April to June, 1951
4/ June to August, 1951
5/ August to October, 1951

It should be emphasized that catches made by longline fishing do not represent cross sections of the population. Rather these catches, particularly in the instance of the tunas, represent the larger, older individuals in the population, and of course only that portion of the latter that occupy subsurface levels. This topic is treated in some detail in the section immediately following the discussion of numerical abundance.

The analysis of the expeditions' catch records was facilitated by utilizing IBM punch cards, requiring the adoption of a coding system. Preliminary inspection indicated that the variation in catch rate was more closely related to latitude than to longitude, and for this reason all catches were assigned to blocks of 1° of latitude and 5° of longitude. Temporally, the catches were coded by month and by year. This grouping has the disadvantage of obscuring individual catches, but it would have been impracticable to handle the approximately 6,000 individual daily catch records without it.

Variation in the catch with longitude and time

We shall first consider the variation in the longline catch rates of yellowfin, bigeye, and black marlin as they are related to longitude and time, deferring consideration of variation with latitude. Working statistical control of latitude was achieved in the following manner. Trial latitudinal plots of individual longitudes indicated that the catch rates were relatively constant between 1° and 5° N. latitude, in that there was relatively little variation within these bounds as compared to the variation between this zone and the area to the north. Confining the consideration of longitudinal and temporal variation in catch rates to the relatively restricted latitudes bounded by 1° and 5° provided partial control of latitude. Additional statistical control was effected by taking advantage of the fact that at nearly all longitudes there was some fishing at each latitude between the limits of 1° and 5° N. This was done by computing the average catch rate for each of the four degrees of latitude and computing the unweighted mean catch rate of the four samples. The end result was a catch rate representative of an area of the ocean surface that is 5° of longitude in length and 4° of latitude in height for 1 month of 1 year.

The catch rates derived by this method are shown in table 4 arranged by species, year, month, and longitude. Each of the three species--yellowfin, bigeye, and black marlin--will be considered separately because, as will be shown later, there is little or no relationship between the presence of bigeye and the presence of yellowfin, and there is no reason to expect the presence or absence of marlin to be in anyway related to the presence of the tunas.

The catch rates of the yellowfin (table 4) show that during some months, e.g., July of 1950, they were more abundant at the eastern end of the area than at the western end. During other months, e.g., September 1951, the gradient appears to have been reversed. Of the three months for which good records were obtained in both 1950 and 1951 (June, August, and September), two show a reversal of the gradients between the two years. For these reasons it seems likely that the longitudinal gradients, even if real, are not caused by regularly recurring phenomena.

Averaging all the unweighted monthly catches for each longitude appears to eliminate these apparently transient differences associated with longitude. If this is done, the average catches for the four zones of longitude east of 150°E., for which sampling is reasonably well stratified, have a range of only 2.20-2.50 yellowfin per 100 hooks. If the area under consideration is extended west to 140°E. (the samples to the west are not as well stratified as those to the east of 150°E.), the range of variation is increased to only 1.84-2.50, or a 36-percent difference between the highest and the lowest values. This is a remarkably constant abundance for any species of animal to maintain over a 2,000-mile range (140°-170°E.), and probably means that the environment is highly uniform over that range.

Table 4.--Catch per 100 hooks of yellowfin tuna, bigeye tuna, and black marlin between 1° and 5°N. latitude. The figures in parentheses are the number of boat days of fishing on which each catch rate is based

Species	Year	Month	Longitude						
			135°-140°E.	140°-145°E.	145°-150°E.	150°-155°E.	155°-160°E.	160°-165°E.	165°-170°E.
Yellowfin tuna	1950	June	--	2.31 (107)	2.64 (71)	--	--	--	--
		July	--	2.08 (19)	1.78 (139)	2.16 (238)	2.66 (88)	2.78 (51)	--
		Aug.	--	0.90 (2)	1.66 (3)	1.61 (7)	2.30 (412)	2.45 (104)	2.40 (177)
		Sept.	--	--	--	--	--	1.85 (53)	2.56 (176)
		Dec.	4.18 (83)	4.02 (4)	--	--	--	--	--
	1951	Feb.	--	--	--	2.46 (1)	3.00 (166)	3.41 (39)	--
		Mar.	2.54 (8)	1.82 (28)	1.45 (2)	--	--	--	--
		Apr.	4.17 (1)	1.82 (12)	1.66 (105)	1.90 (159)	2.70 (72)	--	--
		May	--	--	--	2.56 (40)	1.82 (181)	1.84 (214)	4.31 (2)
		June	--	--	--	2.97 (124)	2.87 (183)	3.76 (85)	--
		July	--	--	--	--	--	2.47 (152)	2.24 (252)
		Aug.	--	--	--	2.63 (24)	2.31 (254)	1.90 (42)	--
		Sept.	--	--	--	2.27 (6)	2.24 (118)	2.03 (202)	1.52 (130)
		Oct.	--	--	--	--	--	--	1.72 (44)
Bigeye tuna	1950	June	--	0.28 (107)	0.29 (70)	--	--	--	--
		July	--	0.23 (19)	0.32 (139)	0.36 (238)	0.40 (88)	0.45 (51)	--
		Aug.	--	0.25 (2)	0.38 (3)	0.19 (7)	0.30 (412)	0.37 (104)	0.65 (177)
		Sept.	--	--	--	--	--	0.18 (53)	0.19 (176)
		Dec.	0.44 (83)	0.58 (4)	--	--	--	--	--
	1951	Feb.	--	--	--	0.35 (1)	0.37 (166)	0.34 (39)	--
		Mar.	0.44 (8)	0.40 (28)	0.42 (2)	--	--	--	--
		Apr.	0.83 (1)	0.45 (12)	0.55 (105)	0.49 (159)	0.39 (72)	0.39 (1)	--
		May	--	--	--	0.76 (40)	0.62 (181)	0.56 (214)	1.06 (2)
		June	--	--	--	0.91 (124)	0.81 (183)	0.65 (85)	--
		July	--	--	--	--	--	0.82 (151)	1.03 (252)
		Aug.	--	--	--	0.64 (24)	0.52 (254)	0.74 (42)	--
		Sept.	--	--	--	0.27 (6)	0.53 (118)	0.79 (202)	0.66 (130)
		Oct.	--	--	--	--	--	--	0.46 (2)
Black marlin	1950	June	--	0.50 (107)	0.53 (70)	--	--	--	--
		July	--	0.56 (19)	0.53 (139)	0.53 (238)	0.55(88)	0.64 (51)	--
		Aug.	--	0.60 (2)	0.48 (3)	0.33 (4)	0.47 (412)	0.86 (104)	0.83 (177)
		Sept.	--	--	--	--	--	0.54 (53)	0.56 (176)
		Dec.	--	0.40 (83)	0.17 (4)	--	--	--	--
	1951	Feb.	--	--	--	0.15 (1)	0.66 (166)	0.47 (39)	--
		Mar.	0.19 (8)	0.25 (28)	0.21 (2)	--	--	--	--
		Apr.	0.97 (1)	0.19 (12)	0.27 (105)	0.40 (159)	0.50 (72)	0.33 (1)	--
		May	--	--	--	0.34 (40)	0.36 (181)	0.39 (214)	0.83 (2)
		June	--	--	--	0.27 (124)	0.36 (183)	0.41 (85)	--
		July	--	--	--	--	--	0.30 (152)	0.45 (252)
		Aug.	--	--	--	0.47 (24)	0.32 (254)	0.30 (42)	--
		Sept.	--	--	--	0.52 (6)	0.34 (118)	0.31 (202)	0.35 (130)
		Oct.	--	--	--	--	--	--	0.73 (44)

The seasonal distribution of the longline yellowfin catches shows more prominent variation than the longitudinal distribution. For instance, June showed a catch peak irrespective of longitude (table 4). A second peak during the December-February period is also evident. This is shown graphically in figures 2 to 4. Figure 2 is a plot of the monthly catches at 160°-165°E. longitude, figure 3 is a plot of the catches at 155°-160°E. longitude, and figure 4 shows the mean catch by month irrespective of longitude. (The two longitudes illustrated in figs. 2 and 3 were chosen because they were the best represented in time.) It is of interest to note that the shapes of the curves for the two longitudes are nearly identical, and that these in turn resemble the curves for all longitudes combined. Furthermore, in each of the three figures there is considerable similarity in the shapes of the curves for the two years 1950 and 1951. This relative stability of the pattern of seasonal variation in this portion of the western Pacific indicates that the pattern is real, and furthermore, because it is apparently repeated during two years, the pattern is probably the result of regularly recurring changes in the tuna population. Precisely what factors induce these changes in the population level is unknown.

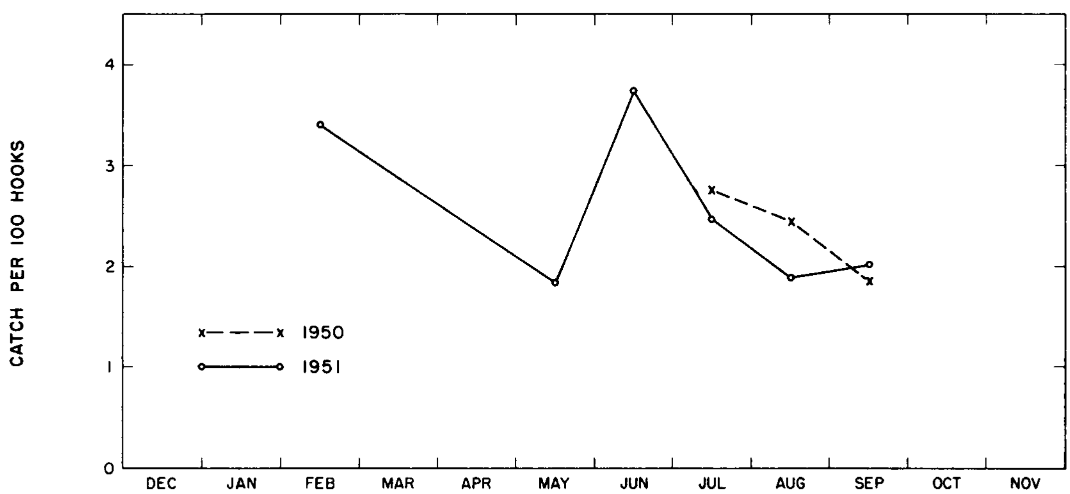


Figure 2.--Yellowfin tuna catch per 100 hooks by months for 1°-5°N. latitude, 160°-165°E. longitude. Points obtained from table 4.

The longitudinal distribution of bigeye tuna in the area under consideration resembles that of the yellowfin in that the differences in abundance associated with longitude appear to be slight and inconsistent (table 4). This is a further indication that the environment over the area under consideration is relatively uniform insofar as its east-west component is concerned.

The seasonal distribution of bigeye (fig. 5) bears a general similarity to that of the yellowfin in that there appear to be two peaks of abundance, one in June-July-August, and one in December. The latter peak is not well developed as it was in the instance of the yellowfin, but the July peak is very prominent, particularly in 1951. The 1950 peak that corresponds to the July 1951 peak is well developed but occurred 1 month later, in August, and in magnitude is only half as large as the 1950 maximum. As in the instance of the yellowfin, the general regularity of the seasonal distribution of bigeye in the western Pacific just north of the Equator suggests the operation of cyclic phenomena.

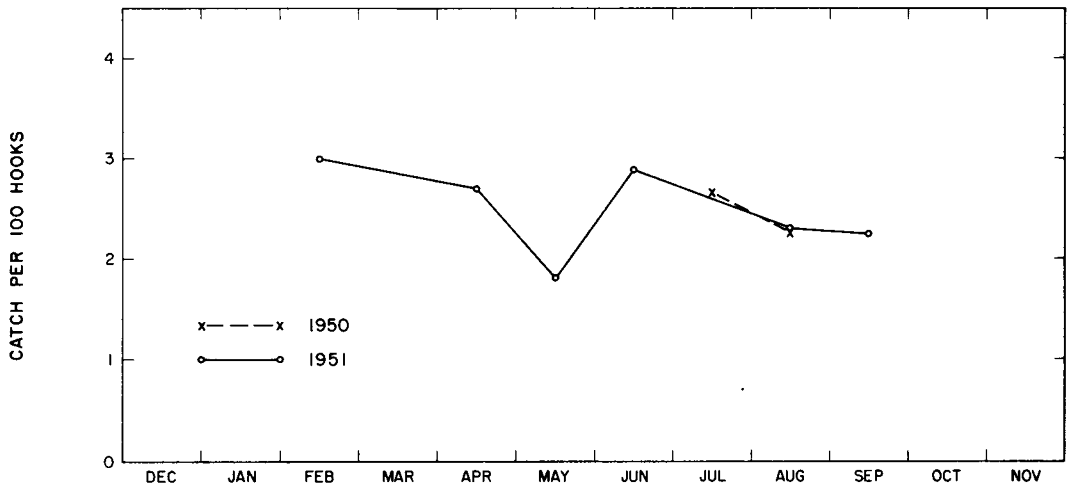


Figure 3.--Yellowfin tuna catch per 100 hooks by months for 1°-5°N. latitude, 155°-160°E. longitude. Points obtained from table 4.

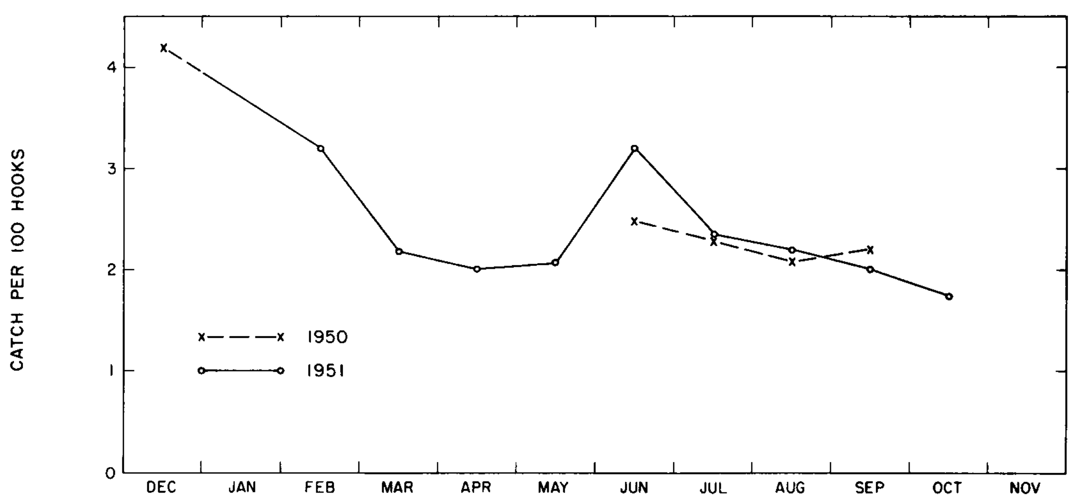


Figure 4.--Yellowfin tuna catches per 100 hooks by months for 1°-5°N. latitude, 135°-170°E. longitude. Points obtained from table 4 by averaging the unweighted mean catch rates, excluding those based on less than 3 days.

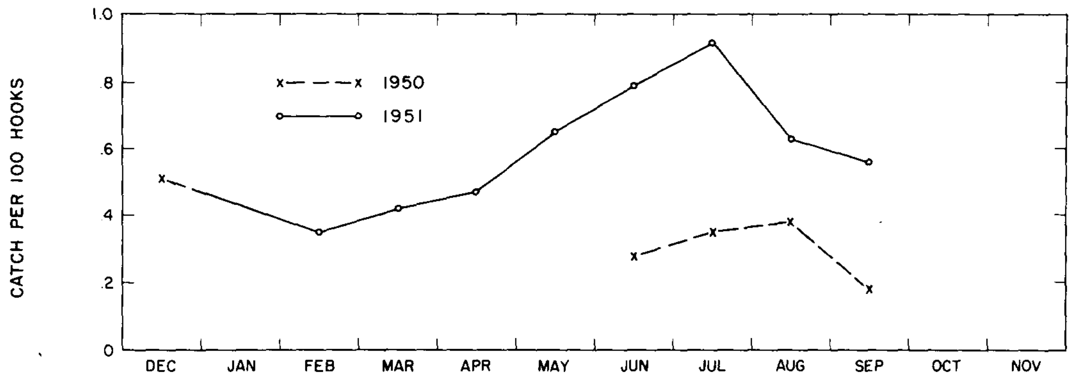


Figure 5.--Bigeye tuna catches per 100 hooks by months, 1°-5°N. latitude, 135°-170°E. longitude. Points obtained from table 4 by averaging the unweighted mean catch rates, excluding those based on less than 3 days.

Black marlin catches in the mothership area fail to show a recognizable pattern of variation in abundance with respect to longitude (table 4). With respect to time there do not appear to be the well marked peaks and valleys of abundance (fig. 6) evidenced by the two species of tuna. However, the catch rate in 1951 fell to about one-half that of 1950 (fig. 6).

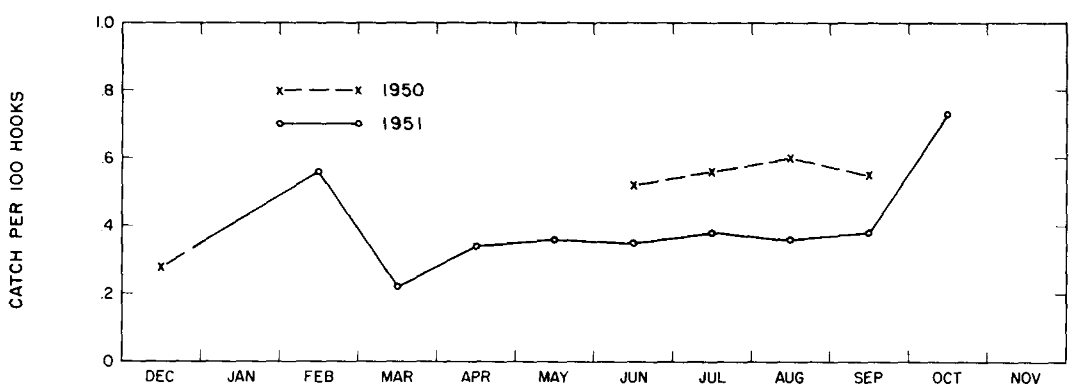


Figure 6.--Black marlin catches per 100 hooks by months, 1°-5°N. latitude, 135°-170°E. longitude. Points obtained from table 4 by averaging the unweighted mean catch rates, excluding those based on less than 3 days.

Examination of the relative abundance of yellowfin, bigeye, and black marlin with respect to time and longitude in a narrow band north of the Equator in the western Pacific has shown that with respect to longitude there is little difference in abundance between the limits of 135°-169°E. longitude. Therefore, insofar as the relative abundance of a species of animal can be regarded as an indicator of the constancy of the environment, this 2,000-mile zone of water just north of the Equator must be relatively uniform in character. Analysis of the catches of these same species with respect to time showed that the populations of two of them were markedly different at different periods of the year, but the black marlin did not vary greatly in abundance from month to month. It does not seem likely that the absolute number of yellowfin and bigeye in the western Pacific fluctuates rapidly from month to month, indicating that the fluctuations are a response to changes in the local environment stimulating ingress or egress of tuna. These changes could occur within the area of study, or could occur outside the area.

Latitudinal variation in catch rates

In the central Pacific the abundance of tuna has been found to vary significantly with latitude in the vicinity of the Equator (Murphy and Shomura 1953). For this reason the catches were tabulated by each degree of latitude instead of the 5° groups used in the case of longitude. Before examining the variation in catches with respect to latitude it should be necessary to take into account variation associated with longitude and time. However, in this instance it did not appear necessary to eliminate variations in catch rate associated with longitude because these variations are considerably smaller than those associated with latitude and time and, empirically, latitudinal plots of catches by both longitude and time resulted in the same latitudinal distribution as those plotted against time alone.

A series of panels representing the variation in longline catch rates of yellowfin, bigeye, and black marlin associated with latitude is given in figure 7. These panels represent each month in which there was a substantial amount of fishing in the area between 1°-10°N. latitude. The catches from longitudes east of 170°E. are separated from the remaining longitudes because there was no fishing between 1° and 5°N. latitude, and consequently no evidence that the catch patterns can be regarded as similar to those of the sections farther west during the same months.

The most striking feature common to all of the panels in figure 7 is the relatively greater abundance of yellowfin tuna at latitudes near the Equator. During some months the center of abundance appeared to be a few degrees north of the Equator, but during seven months abundance appeared to be increasing at the most southerly penetration of the fishing fleets (1°N. lat.). This carries the implication that abundance was even greater to the south, but unfortunately fishing data are not available.

The latitudinal distribution of bigeye tuna appears to be independent of yellowfin (fig. 7). Instead of being most abundant at or near the Equator, the bigeye appear most abundant north of 5°-6°, although in no instance does the magnitude of the peak bigeye catch approach that of the peak yellowfin catch.

Further indication that the latitudinal distributions of yellowfin and bigeye are independent of each other is obtained from a plot of the bigeye catches for each degree of latitude against the yellowfin catches for the same areas (fig. 8). This scatter diagram reveals an utter lack of systematic relationship between the catches. The lack of any relationship is a reflection of the latitudinal variation shown in figure 7, in which yellowfin are shown to vary rather markedly with latitude and bigeye only slightly. A scatter diagram of bigeye catch rates against yellowfin catch rates for individual fishing stations (fig. 9) also resembles figure 8 in that there is no evidence of relationship. From these considerations we may infer that the distribution of the two species is not dependent on the same set of ecological factors, and that within a particular area the two species do not school together. The same situation seems to prevail in the central Pacific (Murphy and Shomura 1953).

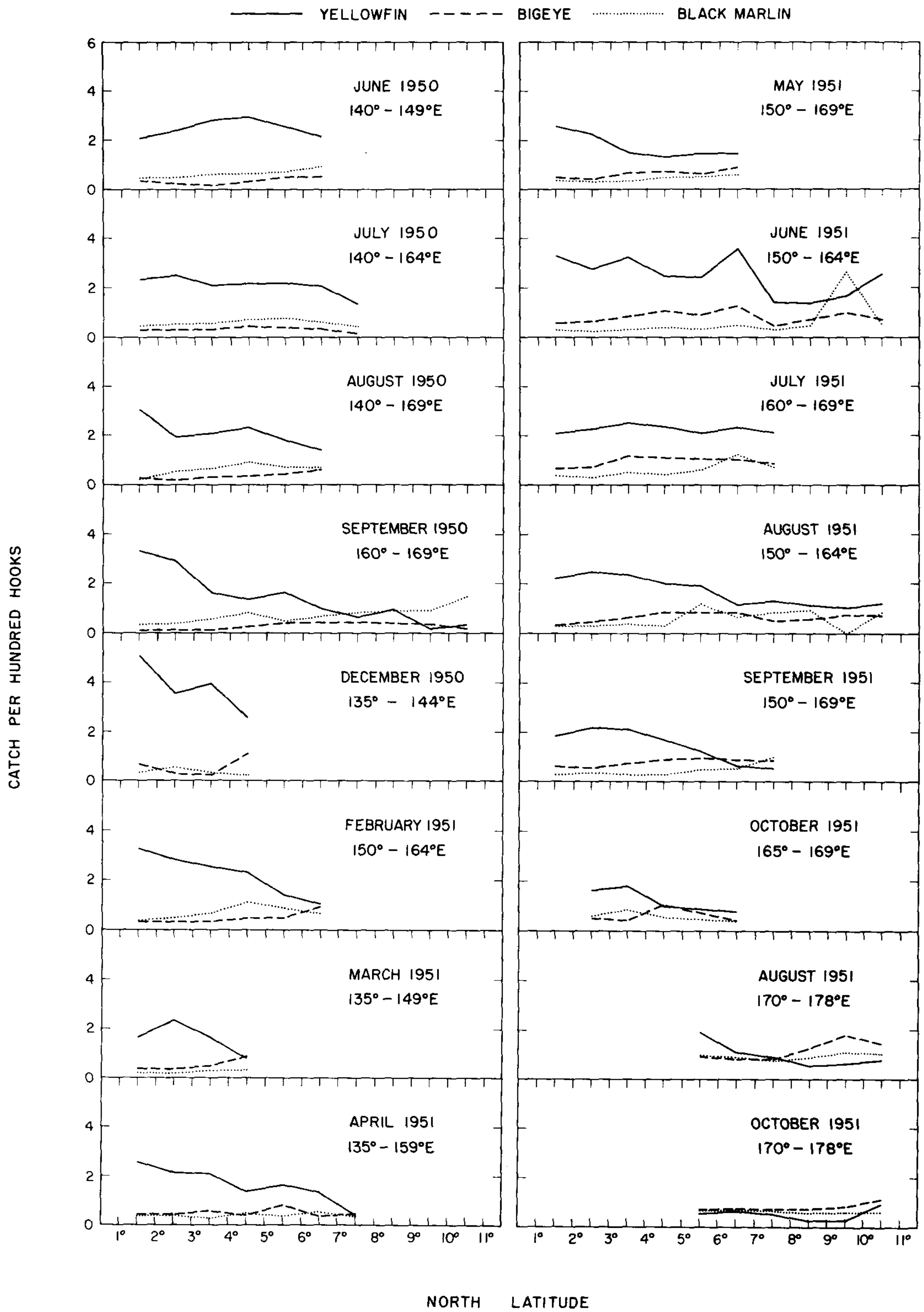


Figure 7.--Latitudinal variation in the catch rates of yellowfin tuna, bigeye tuna, and black marlin by months and years.

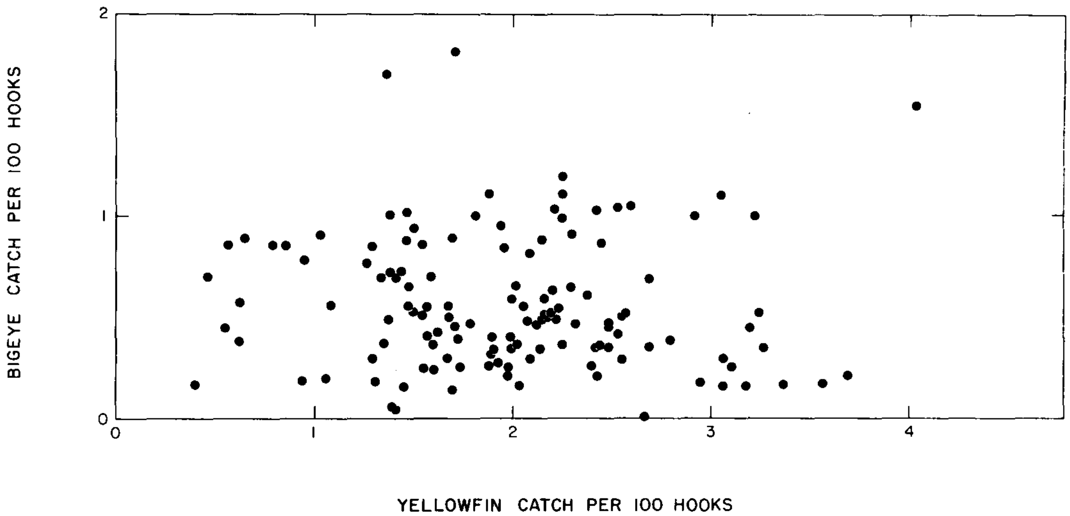


Figure 8.--Catch rate of yellowfin tuna plotted against catch rate of bigeye tuna for each 1° of latitude by 5° of longitude block for all available data.

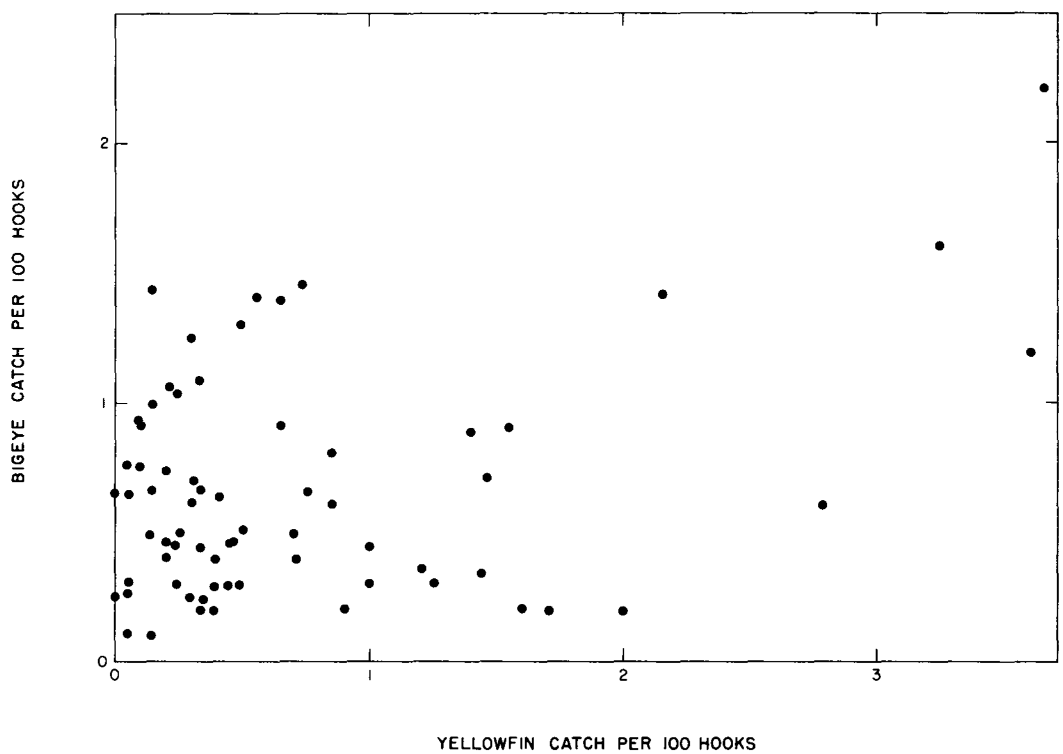


Figure 9.--Yellowfin catch rate plotted against bigeye catch rate for stations fished at 6°-7°N., 178°-179°E. in October 1951.

The latitudinal distribution of black marlin (fig. 7) resembles the bigeye distribution in that there is in general little variation in catch rate with latitude. There is, however, a slight tendency for the catch rates to rise to the north, and in this respect also the black marlin distribution resembles that of the bigeye.

In summary, the catch rate of the yellowfin tuna taken by longlining during the mothership expeditions appears to be largely independent of the catch of bigeye and black marlin, which tend to be more abundant to the north. Yellowfin exhibit a striking tendency to be more abundant in the immediate vicinity of the Equator, with the center of abundance varying in location from 3°-4°N. latitude to a location apparently on or south of the Equator. These variations in the location of yellowfin abundance appear to be related to time, but there is no systematic pattern common to both years (1950 and 1951).

SIZE FREQUENCIES OF TUNAS

The size frequencies of the tunas taken on the motherships provide a means of detecting intrinsic changes in the fish population from area to area and from time to time, and they describe the segment of the population sampled by the fishing method employed. Technologically they are of interest because they tell the fisherman how many fish he must catch to achieve a particular tonnage, and they afford the canner a means of estimating the special problems involved in processing fish from that area.

Aboard the motherships an attempt was made to measure[1/] random samples of the catches of tunas as they were unloaded from the catcher vessels. The attempt at randomness was not entirely successful as small yellowfin and bigeye tuna were handled separately from the larger fish in the same load, resulting in a tendency to measure a greater proportion of the fish less than 90 cm. in length. This is not regarded as a serious objection as only 4 percent of the total yellowfin measured and 9 percent of the total bigeye measured were less than 90 cm. in length.

Turning to the yellowfin length frequencies (fig. 10 and table 5), it is evident that there is considerable variation from sample to sample in the mean length (113-129 cm.) and modal class (or classes), but this variation does not appear to be systematically related to time or space. In addition, length frequencies of fish captured by longline in the same general area in 1940 (table 6, Ikebe 1941) indicate there has been little material change in the size composition of the population during the intervening 10 years in that the mean falls within the range noted above.

The restricted size range of yellowfin in the longline catches (fig. 10) is of further interest for it indicates that this method of fishing is sampling only the larger mature fish (90 percent weigh between 40 and 126 pounds) that must surely be in a minority considering the population as a whole. The smaller, and theoretically more abundant, yellowfin tuna almost entirely lacking in longline catches are taken at the surface by trolling and pole-and-line fishing. In the Hawaiian Islands these surface-caught fish range from 50 to 90 cm. (Moore 1952). In the equatorial region south of the Hawaiian Islands they range from 50 to 150 cm. with a mode around 85 cm. Trolling in the northern Marshall Islands at 10°N. latitude, 170°E. longitude, just north of the area from which the mothership samples were taken, yielded the catches of medium-sized yellowfin shown in table 7. These data show quite clearly that gear fishing the deeper waters (longlines) takes a very different portion of the population than do surface fishing techniques. The different sizes of the fish may be the result of a real ecological separation of the large and small fish or may be simply the result of gear selection. At any rate it is evident that the several

1/ Total length (Marr and Schaefer 1949). Actually this is a fork length measured from the tip of the upper jaw to the center of the tail.

methods presently available do not furnish samples of the population or populations that are random with respect to the sizes of individuals.

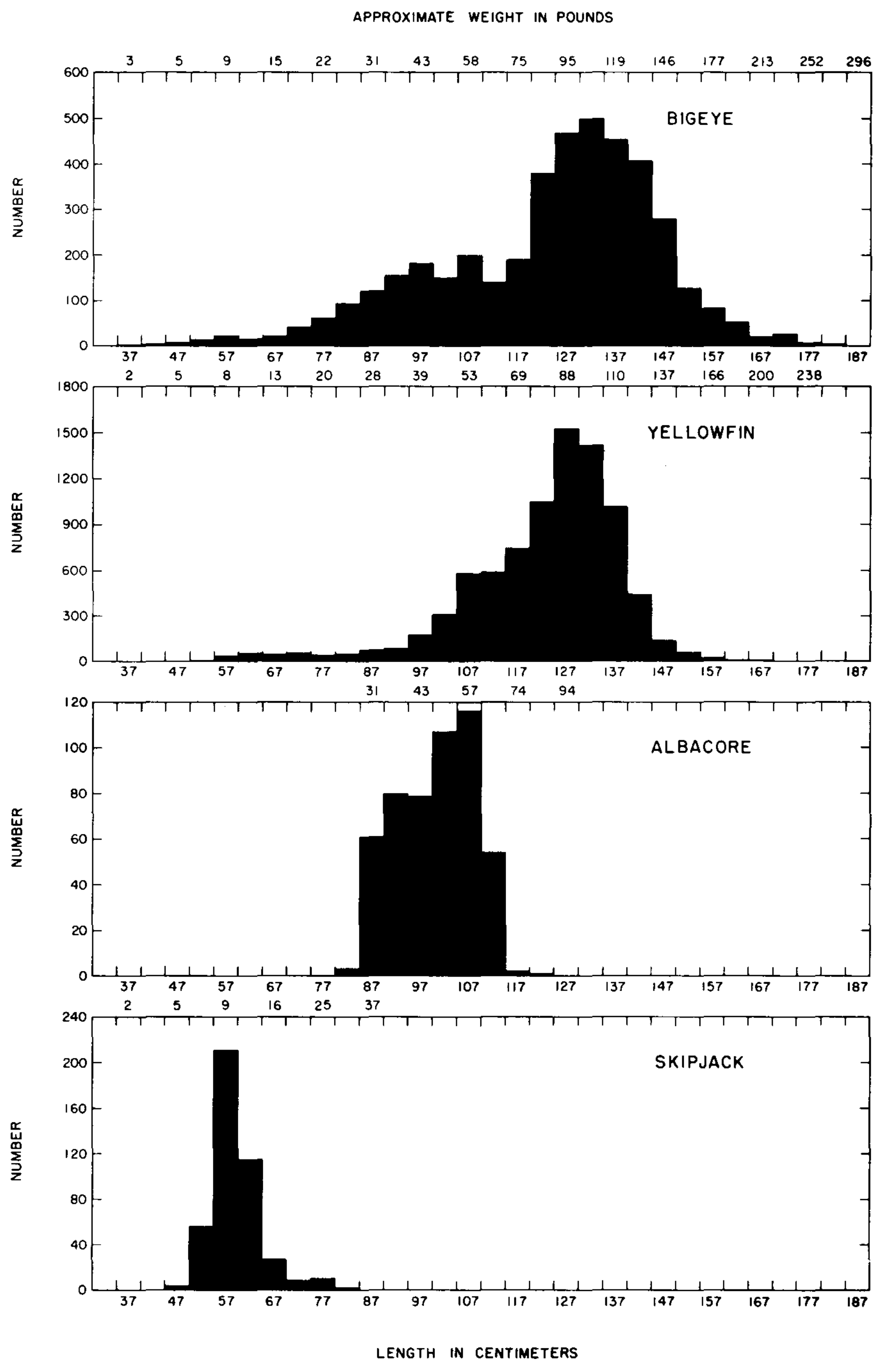


Figure 10.--Length frequencies of the four species of tuna commonly taken during the mothership operations. For convenience a pound scale is provided above each polygon.

Table 5.--Length frequencies of samples of yellowfin tuna from the nine mothership expeditions (East longitude)

Length (cm)	June 1950 140°-150°	July 1950 140°-150°	Aug. 1950 150°-160°	Dec. 1950 134°-141°	Feb. 1951 156°-161°	Mar. 1951 138°-150°	Apr. 1951 147°-155°	May 1951 150°-161°
52	1	-	-	-	-	-	-	-
57	1	-	1	-	-	-	3	-
62	6	2	2	2	-	-	1	-
67	5	2	5	1	-	-	-	2
72	5	2	10	10	-	1	3	1
77	14	3	5	6	-	-	-	1
82	3	0	15	4	-	5	-	3
87	10	5	23	7	-	9	2	1
92	10	1	12	4	1	12	3	6
97	50	3	8	4	1	27	18	4
102	152	8	9	5	2	25	24	19
107	320	22	24	9	16	31	23	15
112	180	16	26	26	16	16	23	16
117	168	10	38	42	30	19	25	28
122	306	21	89	23	66	31	37	37
127	395	42	238	20	99	63	68	80
132	280	54	215	16	150	63	92	105
137	124	65	121	11	86	21	42	64
142	26	31	31	4	19	9	16	29
147	14	5	23	1	2	-	1	2
152	2	2	8	-	1	-	1	1
157	-	1	-	-	0	-	-	1
162	-	-	-	-	2	-	-	-
167	-	-	-	-	2	-	-	-
Mean	119	126	125	113	129	118	122	126
Estimated mean wt. (lb.)	72	86	84	62	92	70	78	86

Table 5.--Length frequencies of samples of yellowfin tuna from the nine mothership expeditions (East longitude) (cont'd)

Length (cm)	May 1951 158°-164°	June 1951 153°-161°	June 1951 154°-162°	July 1951 162°-170°	Aug. 1951 168°-175°	Sept. 1951 155°-161°	Sept. 1951 159°-171°	Oct. 1951 164°-179°	Total
52	-	-	1	-	3	-	-	-	5
57	-	1	9	3	4	10	1	-	33
62	1	-	1	7	6	13	7	2	50
67	-	2	1	4	5	2	11	6	46
72	1	1	2	4	4	1	2	3	50
77	-	4	0	3	0	2	1	2	41
82	2	3	1	5	3	1	1	1	47
87	2	0	0	4	1	0	3	3	70
92	3	13	1	9	6	0	1	3	85
97	5	17	8	11	6	0	3	3	168
102	5	20	13	12	3	1	8	4	310
107	12	12	17	29	12	12	16	11	581
112	12	13	16	37	22	60	84	23	586
117	20	18	24	47	21	82	132	44	748
122	46	42	19	62	31	70	115	56	1050
127	51	51	44	80	39	91	104	61	1526
132	61	50	36	51	38	77	78	51	1417
137	47	34	43	60	70	86	80	66	1020
142	25	18	26	53	55	37	36	27	442
147	5	3	14	23	15	10	13	5	136
152	1	-	4	22	6	6	2	1	57
157	-	-	3	8	5	1	-	1	20
162	-	-	-	2	2	1	-	-	7
167	-	-	-	2	-	-	-	-	4
Mean	126	121	123	124	125	123	122	124	
Estimated mean wt. (lb.)	86	76	80	82	84	80	78	82	

Table 6.--Length frequencies of yellowfin tuna from the Equatorial Countercurrent area, 2°30' - 5°28'N., 135°14' - 165°40'E.; November 1940 (reported by Ikebe 1941)

Length (cm)	Frequency
92	--
97	2
102	9
107	30
112	15
117	19
122	43
127	46
132	15
137	6
142	1
Mean	120
Estimated mean weight (lbs.)	74

Table 7.--Length frequencies of troll-caught yellowfin tuna from the northern Marshall Islands (after Marr 1951)

Length (cm)	Frequency
52	23
57	27
62	22
67	27
72	12
77	11
82	5
87	5
92	9
97	4
102	5
107	2
112	3
117	2
122	1
Mean	70
Estimated mean weight (lbs.)	15

Length frequencies of bigeye tuna taken during the nine mothership expeditions are given in table 8 and figure 10. As in the instance of yellowfin tuna, only the larger fish (50-145 pounds) are well represented, and the individual samples differ in their means (111-132 cm.) and modal group or groups, though without any evident systematic order in respect to either time or space. The longline-caught bigeye in this region are some 20 pounds heavier than the yellowfin. A difference in the same direction and of greater magnitude was noted in the central Pacific (Murphy and Shomura 1953).

The bulk of the albacore catch were 86-112 cm. in total length (30-65 pounds) (table 9, fig. 10), which contrasts sharply with, for instance, catches of 65-90 cm. (10-35 pounds) off San Pedro, California (Brock 1943). These small albacore taken off the Pacific coast of the U. S. are found at the surface, whereas albacore have not been reported at the surface in equatorial waters. Perhaps the large, adult fish tend to occupy cooler, deeper strata of water in the tropics, waters comparable in temperature to those at the surface in more northern latitudes.

The skipjack taken during the mothership expeditions are represented in the two length frequencies in table 10 and one in figure 10. The length distribution of the skipjack appears to represent what might be expected if the sampling were done from a complete population, one in which each size category was proportionally represented, and with gear selection precluding the capture of the smallest individuals[2/]. There is considerable increase in size of the second skipjack length frequency (table 10). The displacement of approximately 4 cm. in about 3-1/2 months elapsed time may represent growth.

The skipjack length distribution (fig. 10) provides a strong argument against attributing the shape of the yellowfin, bigeye, and albacore length frequencies to gear selection but rather indicates habitat selection by size; this is based on the fact that the upper end of the skipjack distribution almost coincides with the lower end of the distributions of these species. It might be argued that small yellowfin, bigeye, and albacore are not taken because they feed on a group of organisms different from those the larger individuals feed on. However, Reintjes and King (1953) have shown that the foods taken are not related to the size of the yellowfin within the limits of the fish sizes taken by trolling, livebait fishing, and longlining. These observations permit the tentative conclusion that there is considerable habitat selection, possibly both vertical and horizontal, between small and large tuna, with the possible exception of the skipjack. The large, mature yellowfin, bigeye and albacore tend to occupy sub-surface waters in the tropics and small, immature fish tend to occupy the surface waters, resulting in longline catches of yellowfin, bigeye, and albacore being composed in the main of large fish. There may also be a considerable horizontal displacement between small and large yellowfin and bigeye tuna, and there certainly is in the instance of albacore, small individuals almost never being taken in the tropics in the central and western Pacific and never having been recorded at the surface there.

RELATION OF YELLOWFIN CATCH RATES TO THE ENVIRONMENT

The catch rates of yellowfin tuna experienced by the mothership expeditions have been shown to vary significantly with time and with latitude. Presumably these changing rates reflect changing local abundance, and it seems reasonable to assume that these are a reflection of changes in the environment, particularly in view of the lack of evidence for change in the absolute magnitude of the population. Of necessity we confine the bulk of our discussion to the persistently greater abundance of yellowfin tuna in the immediate vicinity of the Equator, restricting our discussion of time variation to speculation on the causes of an apparent decline in abundance between the pre- and post-World War II periods.

2/ Longline gear utilizes relatively large hooks and baits designed to catch large tuna and marlin. It would not be expected to be an efficient sampling tool for fish less than about 55 cm. in length (about 8 pounds).

Table 8.--Length frequencies of samples of bigeye tuna measured during the mothership expeditions (East longitude)

Length (cm)	June 1950 140°-150°	Feb. 1951 156°-161°	Apr. 1951 138°-150°	May 1951 150°-161°	May 1951 158°-164°	June 1951 153°-161°	June 1951 154°-162°	July 1951 162°-170°	Aug. 1951 168°-175°	Sept. 1951 155°-161°	Oct. 1951 159°-171°	Oct. 1951 164°-179°	Total
37	-	-	-	-	-	-	-	-	2	-	-	-	2
42	-	-	1	-	-	-	-	-	3	-	-	-	4
47	-	-	-	-	-	-	-	3	3	-	-	-	6
52	-	-	-	-	1	-	-	4	7	1	-	-	13
57	2	-	1	-	2	-	3	4	2	8	-	-	22
62	-	-	1	-	1	-	-	2	2	7	2	-	15
67	2	1	4	2	2	2	1	2	-	3	3	-	22
72	1	4	11	4	5	2	2	1	1	6	4	1	42
77	1	5	16	4	7	3	4	6	-	11	4	1	62
82	4	7	2	4	4	7	5	8	4	26	24	-	95
87	1	2	3	5	8	7	5	10	5	32	38	6	122
92	1	7	10	3	7	9	4	6	3	42	52	12	156
97	1	13	8	10	5	10	6	13	4	42	51	19	182
102	3	5	20	8	15	12	11	13	3	17	28	15	150
107	17	1	1	12	13	17	6	25	7	35	49	17	200
112	18	5	2	4	14	14	7	10	11	11	27	16	139
117	15	12	22	18	27	15	10	14	7	13	24	14	191
122	28	9	17	30	55	34	32	39	19	50	51	16	380
127	31	11	37	28	72	29	25	58	31	52	58	36	468
132	42	12	33	38	62	33	29	47	47	41	65	51	500
137	31	11	27	21	74	21	30	60	24	44	64	48	455
142	15	11	17	33	58	39	21	51	44	23	50	45	407
147	9	15	16	20	40	20	14	48	32	6	23	37	280
152	4	7	5	5	15	9	7	19	10	3	18	26	128
157	2	8	9	5	6	6	3	8	12	1	14	9	83
162	1	3	2	-	1	-	3	8	14	1	6	13	52
167	-	1	-	-	2	-	1	1	3	-	3	8	18
172	-	-	-	-	-	-	1	2	9	-	3	9	24
177	-	-	-	-	-	-	-	2	-	-	-	4	6
182	1	-	-	-	-	-	-	-	-	-	-	4	4
Mean	125	122	119	125	127	124	124	126	129	111	118	132	
Estimated mean wt. (lbs.)	91	85	79	91	95	89	89	93	100	64	77	107	

Table 9.--Length frequencies of albacore measured during the mothership expeditions (East longitude)

Length (cm.)	July 1950 162°-170°	Aug. 1950 168°-175°	Sept. 1951 155°-161°	Sept. 1951 159°-174°	Oct. 1951 164°-179°	Total
84	-	-	2	1	-	3
85	-	1	2	1	-	4
86	-	2	3	2	-	7
87	1	3	6	4	-	14
88	-	1	10	8	-	19
89	-	1	9	7	-	17
90	-	1	4	8	1	14
91	2	1	3	6	1	13
92	2	2	6	4	2	16
93	1	-	6	7	1	15
94	6	1	7	7	1	22
95	4	3	1	5	-	13
96	4	-	1	4	2	11
97	4	4	1	5	-	14
98	7	1	6	8	1	23
99	4	2	1	8	3	18
100	9	1	6	11	4	31
101	3	2	4	8	1	18
102	3	3	2	13	2	23
103	5	-	7	6	-	18
104	3	-	9	5	-	17
105	4	1	4	4	2	15
106	7	-	9	6	1	23
107	7	3	5	9	-	24
108	1	2	8	11	-	22
109	3	3	9	14	3	32
110	2	4	11	7	-	24
111	3	-	3	4	1	11
112	2	2	5	3	-	12
113	1	-	1	2	-	4
114	-	-	-	2	1	3
115	-	-	-	-	-	-
116	1	-	-	1	-	2
117	-	-	-	-	-	-
118	-	-	-	-	-	-
119	-	-	-	-	-	-
120	-	-	-	-	-	-
121	-	-	-	-	-	-
122	-	-	-	-	-	-
123	-	-	-	-	-	-
124	-	-	1	-	-	1
Mean	101	99	100	100	100	
Estimated mean wt. (lbs.)	48	46	47	47	47	

Table 10.--Length frequencies of longline-caught skipjack measured during the mothership expeditions (East longitude)

Length (cm.)	April 14-June 10, 1951	June 11-Oct. 21, 1951
	138°-164°	155°-179°
47	1	1
48	0	-
49	0	2
50	0	-
51	4	1
52	4	3
53	14	2
54	25	3
55	34	11
56	22	13
57	37	22
58	22	16
59	11	23
60	6	26
61	10	17
62	4	20
63	5	14
64	5	8
65	2	8
66	1	4
67	1	3
68	-	6
69	-	2
70	-	4
71	-	3
72	-	1
73	-	-
74	-	-
75	-	3
76	-	2
77	-	1
78	-	1
79	-	3
80	-	-
81	-	1
82	-	1
Mean	57	61
Estimated mean weight (lbs.)	9	12

It is an attractive notion that the variations in catch rates associated with latitude are a reflection of variations in the circulation of the ocean in the vicinity of the Equator in the western Pacific. The attractiveness is enhanced by the knowledge that the major currents flow either east or west in that area (fig. 11), resulting in rapid changes in the environment on its north-south axis and little change along its east-west axis. This simple observation of the environment correlates rather well with the observation that within the mothership area there was little consistent change in abundance with longitude, and considerable change in abundance with latitude, with yellowfin most abundant near the Equator.

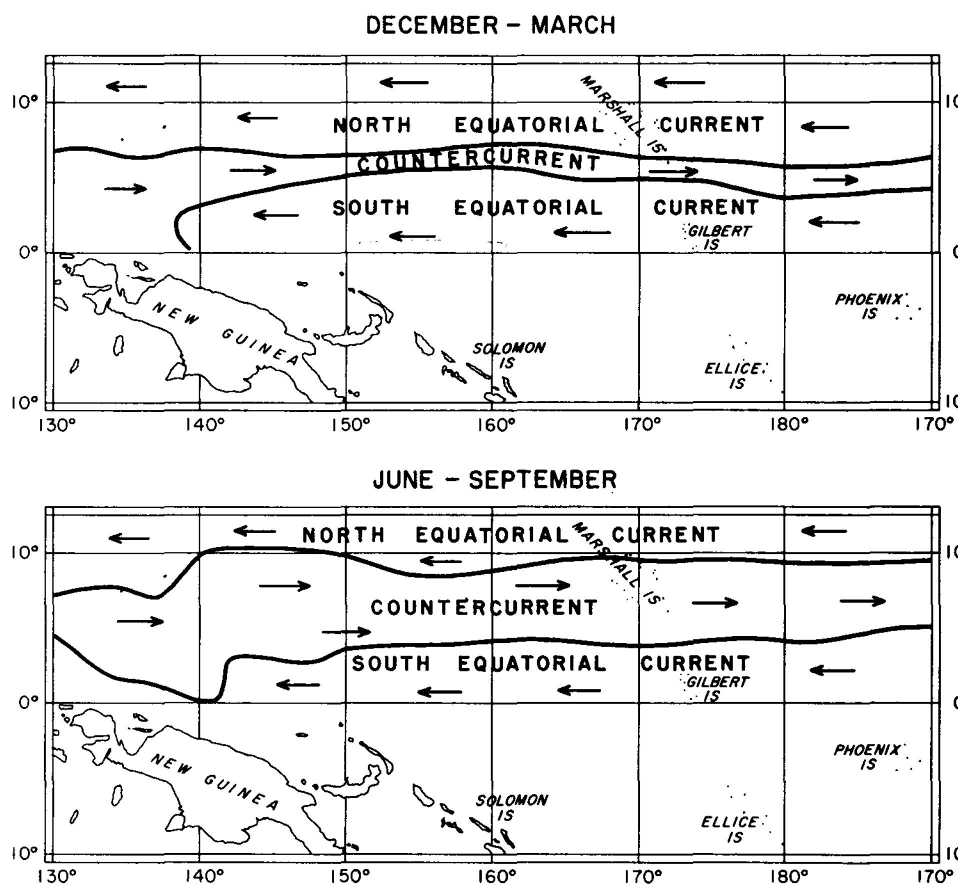


Figure 11.--Location of the major currents in the mothership area of operation (after Schott 1935).

Farther east, in the central Pacific, a zone in the vicinity of the Equator, extending to a few degrees north, is enriched by wind-induced upwelling (Cromwell 1954). The most important winds in this area are those from the southeast quadrant, which create upwelling and displace the upwelled water to the northward. This upwelling results in an increased supply of zooplankton (King and Demond 1953), and this basic food appears to be related to the relatively dense population of yellowfin found near the Equator (Murphy and Shomura 1953a). The location of tuna in the western Pacific is very similar and it seems possible that similar ecological factors, influencing the distribution of tuna in the central Pacific, are operating farther to the west.

However, in the western Pacific the relative absence of vigorous winds, particularly those from the southeast quadrant (table 11), would seem to preclude the same intensity of both the upwelling and the northern displacement of the richer water described by Cromwell (1954); at best a system activated by these winds would be weak or sporadic. The general weakness of the winds in the western Pacific is indicated in table 11 by the size of the index numbers, which are measures of the relative constancy and force of winds from the southeast quadrant. Pilot chart indices derived for the central Pacific (140°W. long.) were in general 2 to 10 times those from the western Pacific during the 2 years of mothership records, indicating that the forces activating the circulation are of a lesser order of magnitude in the western Pacific.

An examination of the seawater temperature sections in figures 12-15 reveals a lack of evidence of upwelling in any of the sections; that is, the cooler deeper isotherms do not reach the surface near the Equator as is typical of the temperature sections from the central equatorial Pacific (Cromwell 1951, 1954; Yoshida et al. 1953). While it is true that the 3 sections shown in figure 12 are pre-war and those in figure 14 adapted from Robinson were from 1946 data, the feature of the lack of doming of the isotherms at the Equator is common to all the sections including those taken by the Japanese research vessel Tenyo Maru in August and September 1951 in the region of the mothership operations (fig. 13). These two sections are the most pertinent as they were taken concurrently with the mothership fishing at a time when yellowfin showed a definite peak of abundance just north of the Equator (fig. 7).

Accompanying the general lack of evidence for upwelling in the western Pacific, as contrasted with the central Pacific, are differences in the catch rates of yellowfin tuna even though the pattern of latitudinal distribution is similar. In the central Pacific, with good evidence of strong upwelling, catches averaging around 6 per 100 hooks have been experienced to the north of the Equator (Murphy and Shomura 1953a, b, and unpublished data). In the apparent absence of upwelling in the western Pacific, catches were in the order of 2 to 3 fish per 100 hooks. However, the fact that the relative latitudinal distribution of yellowfin in the western Pacific, where evidences of upwelling appear to be absent at least part of the time, is similar to that in the central Pacific, where upwelling is definitely evident most of the time, suggests a possible conflict with the upwelling-plankton-forage-tuna cycle proposed for the central Pacific (Murphy and Shomura 1953). This conflict may not be real, however, because there may be upwelling in the western Pacific during some months and during some years as indicated by Mao and Yoshida (1953), and the distribution pattern of the yellowfin found there may reflect an integration of average conditions rather than the momentary ecological situation measured by hydrographical or biological means. It may also be that the peculiar ecological conditions in the immediate vicinity of the Equator favor yellowfin at the expense of other fishes occupying the same position in the food-chain, with or without upwelling. Even slight and occasional upwelling superimposed on this background might have permitted the expansion of the yellowfin population.

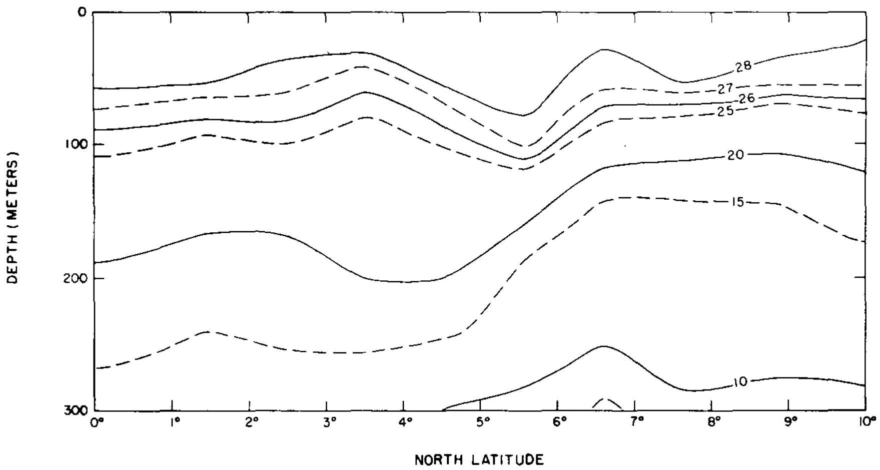
Superimposed on the rather regular occurrence of a peak in yellowfin abundance near the Equator are the variations in abundance with time. Analysis of the mothership catch records, while only for two years, suggests that there may be regularly occurring cycles of abundance within a year.

Table 11.--A comparison of the indices of the amount and strength of southeast winds during the Japanese mothership expeditions[1/] with those derived from average winds from 1951 U. S. Pilot Charts. The block used is the 0°-5°N. latitude. The longitude refers to the western boundary of a block 5° wide. Only those blocks with 10 or more observations are included

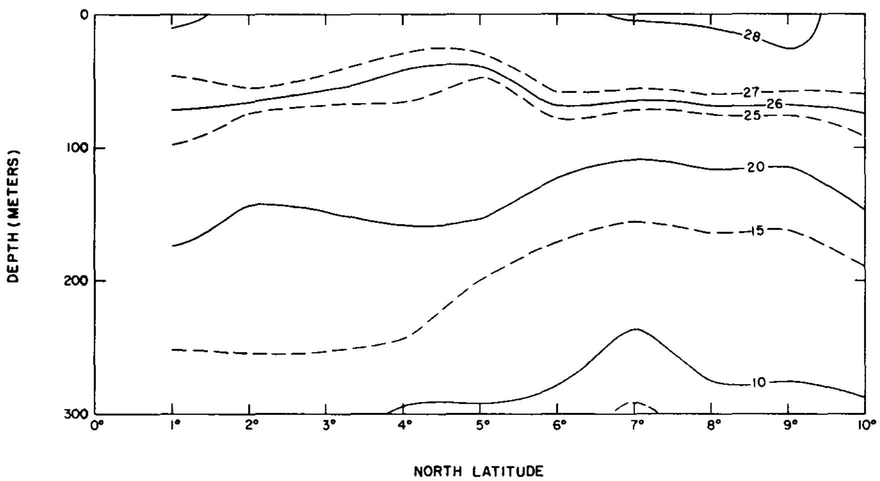
Date	Data from Japanese Mothership Expeditions							Data from U. S. Pilot Charts	
	East longitude						Mean monthly indices	Average monthly winds, mothership area[2/]	Average monthly winds for 140° W. L.
	140°	145°	150°	155°	160°	165°			
June 1950	131	98	--	--	--	--	115	93	207
July 1950	88	80	119	114	136	--	107	108	316
Aug. 1950	--	--	--	114	111	151	125	83	228
Sept. 1950	--	--	--	--	178	174	176	169	252
April 1951	47	34	40	22	--	--	36	60	144
May 1951	--	--	26	36	21	--	28	68	144
June 1951	--	--	40	46	11	--	32	131	207
July 1951	--	--	--	--	66	46	56	176	316
Aug. 1951	--	--	28	38	24	--	30	72	228
Sept. 1951	--	--	--	6	38	48	30	147	252
Oct. 1951	--	--	--	--	--	21	21	96	288

1/ These data were taken from catcher vessel logs. Winds from the SE quadrant were summarized by multiplying the percent of the time the wind blew from that quadrant by the average Beaufort Force. One-half of the border winds, E and S, were credited to the SE quadrant. This yields a rough relative index, though it is not linear, and furthermore, winds of various strengths do not move water in direct proportion to their velocity. Nevertheless the index provides a comparison between areas and time periods. Meteorological and hydrographic observations taken during the mothership expeditions are summarized by year, month, and 5° square blocks in appendix table 13.

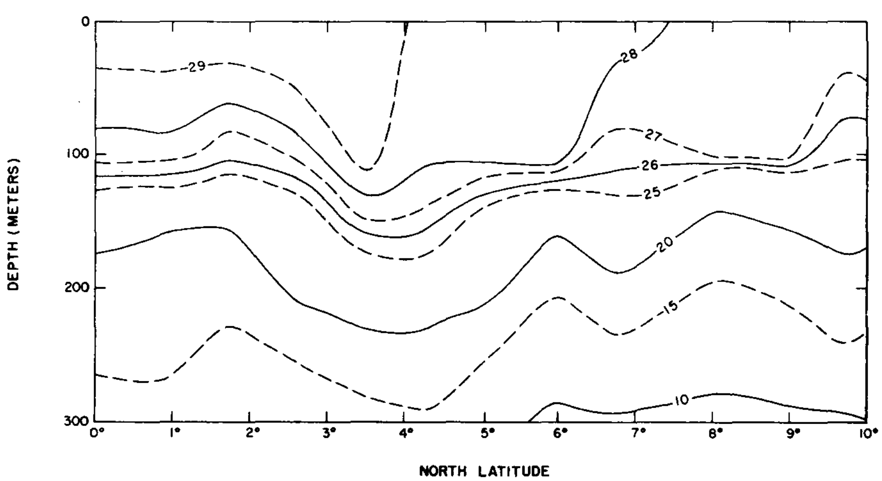
2/ Data taken from 1951 U. S. Pilot Charts for the same blocks as those from the mothership logs.



TEMPERATURE SECTION AT 138° EAST LONGITUDE JANUARY 1936

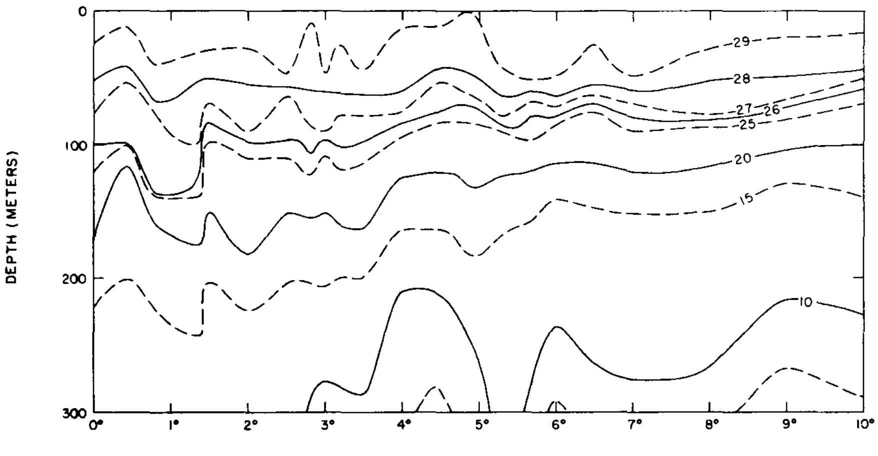


TEMPERATURE SECTION AT 136° EAST LONGITUDE FEBRUARY 1935

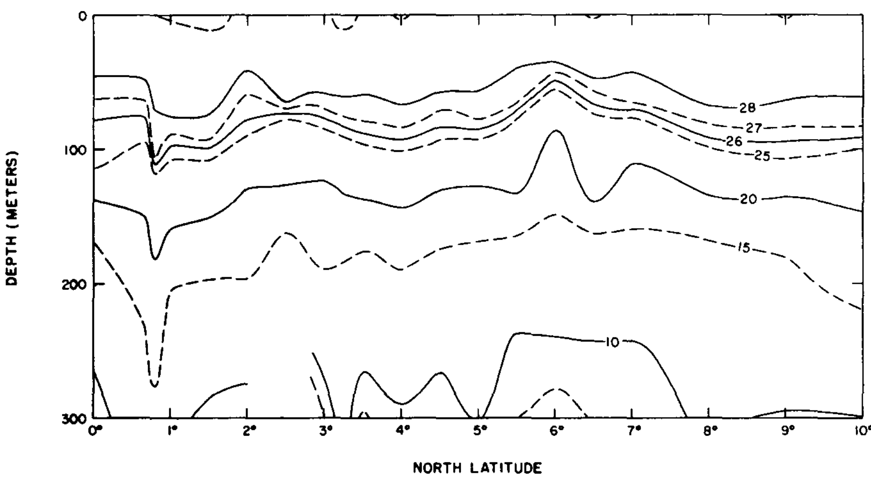


TEMPERATURE SECTION AT 147° (SOUTH END) – 150° (NORTH END) EAST LONGITUDE FEBRUARY 1936

Figure 12. --Three temperature sections based on Japanese hydrographic stations. Data furnished by U. S. Navy Hydrographic Office cruise reference numbers 90015 and 90019. Isotherms are in centigrade.



TEMPERATURE SECTION AT 160° EAST LONGITUDE SEPTEMBER 1951



TEMPERATURE SECTION AT 150° EAST LONGITUDE AUGUST 1951

Figure 13.--Two temperature cross sections based on hydrographic stations taken by the Japanese research vessel Tenyo Maru. Bottle depths were estimated from wire angles and so the location of the deeper isotherms must be accepted with caution. Isotherms are in centigrade.

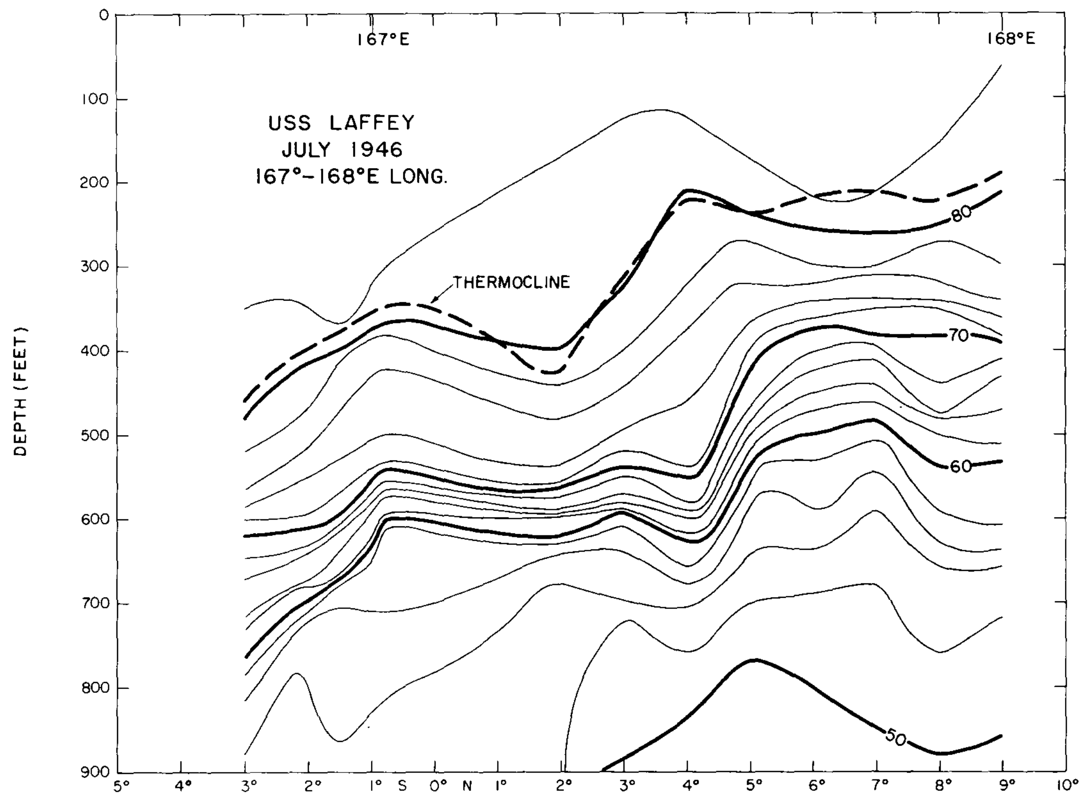


Figure 14.--Vertical temperature section at 167°-168°E. longitude. Adapted from Robinson (1952). Isotherms are in Fahrenheit.

There is also some indication from the pre- and post-war fishing in the mothership area of long term cyclic or epochal fluctuations in abundance. Nakamura (1943) reported commercial catches (tunas and spearfishes) of 6.05 per 100 hooks between 0° and 5°N. latitude and 1.70 north of 10°N. during pre-war years. If these data are comparable with the post-war mothership data, the indications are that the location of greatest abundance was the same then as now, but that the pre-war level of abundance was higher. In addition to the general figures on the commercial catch, a considerable amount of exploratory fishing was carried out by the Japanese in the area. Watanabe (1940) reported 3.4 yellowfin tuna per 100 hooks at 1° 20'N., 172° 30'E. on May 16, 1940. Uehara (1941) reported catches of 10 to 14 tunas and spearfishes per 100 hooks for four stations from 0° 11' to 1° 11' north of the Equator between 131° and 134°E. longitude during May 1941. Ikebe (1942) reported slightly higher catches in this same general longitude but south of the Equator during July 1941. Ikebe (1941) reported on five stations between the Equator and 5°N. lying between 146° and 169°E. longitude with catches of yellowfin tuna of 6, 5, 23, 19, and 15 per 100 hooks.

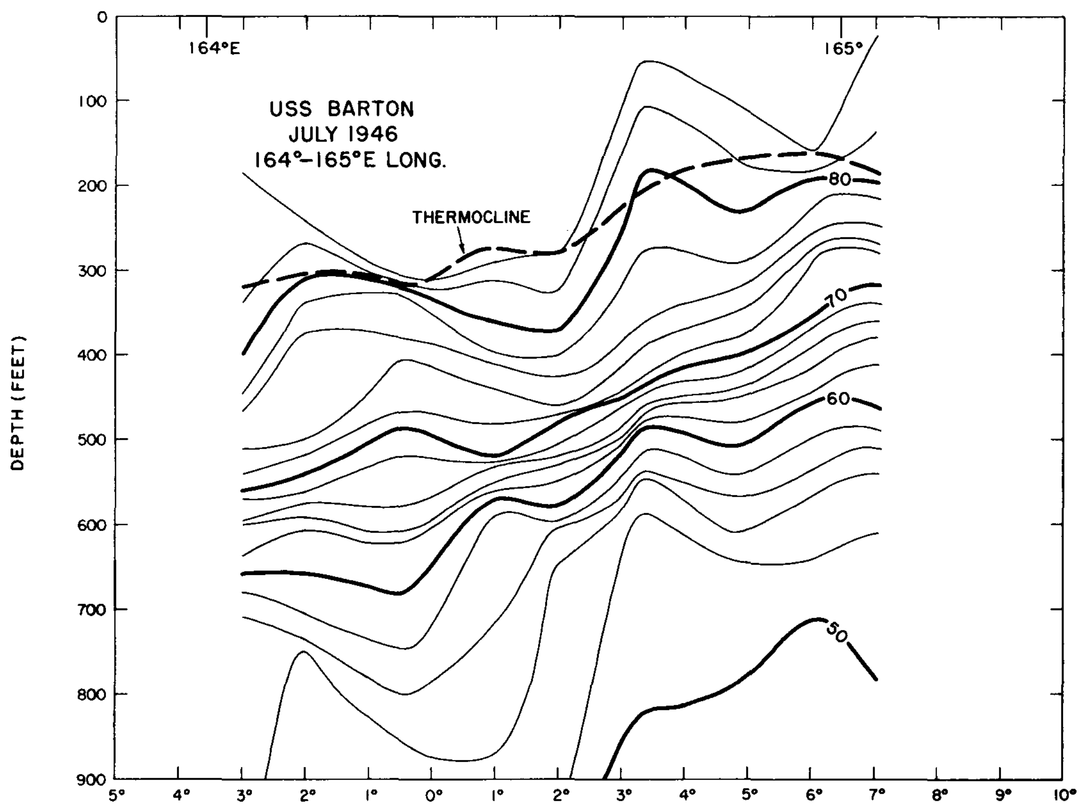


Figure 15.--Vertical temperature section at 164^{o}-165^{o}E. longitude. Adapted from Robinson (1952). Isotherms are in Fahrenheit.

Even if the difference between pre-war survey catch rates and post-war commercial fishing catch rates is not a reflection of a change in abundance, there remains a considerable difference between the catches of commercial operations in 1940-41 and 1950-51 (roughly 6 fish per 100 hooks versus 3 fish per 100 hooks). The cause of this apparent decline in abundance is presently obscure. It should, however, be pointed out that the decline occurred during a period (World War II) characterized by little or no fishing for tuna in the western Pacific, indicating that either there were natural changes in the population level or there were changes in the environment in the mothership area that reduced its suitability for yellowfin tuna.

SUMMARY

1. Nine Japanese mothership expeditions fished for tuna in the western equatorial Pacific Ocean between June 1950 and October 1951. Fishing was carried on from 135° to 180°W. longitude and from 1° to 10°N. latitude.

2. Each catcher vessel maintained a daily log of its fishing activity.

3. The two baits used, sardines and sauries, were about equal in terms of catch.

4. With minor exceptions the vessels participating in the expeditions were about equal in efficiency, indicating the catch rates could be used as indexes of abundance without adjustment.

5. In the region just north of the Equator (1°- 5°N.) the abundance of yellowfin tuna, bigeye tuna, and black marlin does not change appreciably between 135° and 170°E. longitude.

6. In the region just north of the Equator there were some evidences of a mid-northern summer and a mid-northern winter peak in abundance of yellowfin and bigeye tuna. Black marlin did not show any such peaks.

7. In general, within the range of latitudes sampled, yellowfin tuna were most abundant between the Equator and 4°N. latitude. Abundance of bigeye tuna appeared to increase north of 4°N. latitude, as did that of black marlin also.

8. The sizes of tunas caught indicate that the longline is sampling only a fraction of the population--the older, larger fish. Consideration of the size of longline skipjack leads to the conclusion that there is an ecological separation by size of yellowfin, bigeye, and albacore, with these species represented in the deeper waters mainly by large adults.

9. Wind velocities, particularly those from the southeast quadrant, were of a low order of magnitude when compared with those from the central Pacific.

10. The pattern of latitudinal distribution of yellowfin tuna in the western Pacific, where evidences of equatorial upwelling are lacking from the data at hand, is similar to the pattern in the central Pacific, where evidences of equatorial upwelling are prèsent on all hydrographic seçtions examined. However, the absolute level of the population of yellowfin was higher in the central Pacific in 1951 than in the western Pacific in 1950-51.

11. Judging from pre-war published reports and post-war mothership data, tunas, in particular the yellowfin, were considerably more abundant just prior to World War II than during 1950-51 in the equatorial region of the western Pacific.

APPENDIX

Table 12.-- Catch per 100 hooks of yellowfin tuna by vessels and by months[1/]

Month	Year	Expe-dition	Vessel																					
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
June	1950	1	2.06	2.71	2.85	2.77	3.03	1.59	3.15	2.16	2.44	3.04	2.88	2.09	2.02	2.08	1.71	3.11	3.16	2.72	2.63	2.91	-	-
July			1.96	2.00	2.26	2.48	2.63	1.71	2.05	2.17	1.70	1.97	2.59	2.11	2.14	3.66	1.70	2.77	1.57	1.95	2.80	2.07	-	-
Aug.			2.32	2.24	3.53	2.38	2.68	2.28	2.11	1.82	2.25	2.86	2.36	1.50	2.68	3.05	2.04	1.93	2.06	2.21	2.53	2.15	-	-
July	1950	2	1.83	2.33	2.69	2.57	2.84	2.48	3.47	2.07	2.48	1.97	3.87	1.97	-	-	-	-	-	-	-	-	-	-
Aug.			2.06	1.69	1.80	2.37	1.76	3.33	3.07	2.01	2.48	2.30	3.72	1.40	-	-	-	-	-	-	-	-	-	-
Sept.			3.08	2.74	2.94	2.30	3.86	2.45	2.75	2.09	2.21	3.56	3.17	2.77	-	-	-	-	-	-	-	-	-	-
April	1951	5	2.72	1.99	3.17	1.21	2.00	1.65	2.05	2.59	1.54	1.98	1.41	2.23	2.18	-	-	-	-	-	-	-	-	-
May			2.66	1.92	2.19	1.51	2.47	1.70	2.17	2.05	1.34	2.67	1.52	2.15	2.21	-	-	-	-	-	-	-	-	-
June			3.31	2.34	2.82	2.50	3.07	2.34	2.46	2.53	1.49	4.11	2.28	2.52	2.92	-	-	-	-	-	-	-	-	-
June	1951	7	3.29	3.21	1.36	1.87	3.78	4.75	3.40	1.82	4.26	1.93	3.50	3.40	3.68	3.53	2.30	2.66	4.01	2.68	3.45	2.57	3.16	2.49
July			2.26	2.27	3.00	1.71	2.54	2.27	2.24	1.43	4.31	1.46	3.08	2.60	2.31	2.28	2.21	2.53	2.43	2.49	2.78	2.09	2.13	2.62
Aug.			1.59	1.26	1.73	0.79	2.05	0.73	0.96	0.54	0.97	1.02	0.94	0.50	1.35	0.57	0.96	1.28	0.65	1.06	0.62	1.38	0.75	1.47
Aug.	1951	8	1.71	1.66	1.96	2.32	2.42	2.91	1.91	2.50	2.29	2.73	2.56	2.42	2.65	2.28	3.27	1.79	2.16	1.83	2.25	2.69	2.00	-
Sept.			1.56	1.13	1.35	2.16	1.77	1.38	1.75	2.11	2.31	2.08	2.26	2.49	2.59	1.66	1.68	2.37	2.20	1.29	1.74	1.53	1.36	-
Oct.			0.73	0.60	0.47	0.89	0.86	0.11	0.55	0.47	0.25	1.31	0.18	0.45	0.28	1.61	0.13	0.15	0.31	0.11	0.18	0.37	0.18	-

1/ Vessels which did not fish all of the three months are omitted from table.

Table 13.--Wind and surface temperature data from noon reports of catcher vessels, 1950-51. The data are grouped in 5-degree blocks identified by the SW coordinates. The upper figure is the percent of observations, the lower the average force (all longitudes are east and all latitudes north)

Date	Block	Mean temp.	No. obs.	Direction																
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
June 1950	0^{o}-145^{o}	29.1	68	-	1.5	2.9	7.4	20.6	13.2	22.1	10.3	5.9	1.5	1.5	-	-	-	-	-	13.2
				-	1.0	2.0	2.2	1.9	1.4	1.8	1.9	1.8	2.0	2.0	-	-	-	-	-	0.0
	5^{o}-145^{o}	29.0	9	-	-	11.1	11.1	22.2	22.2	22.2	11.1	-	-	-	-	-	-	-	-	-
				-	-	1.0	1.0	2.0	2.0	2.0	2.0	-	-	-	-	-	-	-	-	-
	5^{o}-140^{o}	29.2	11	-	-	-	9.1	27.3	18.2	45.4	-	-	-	-	-	-	-	-	-	-
				-	-	-	1.0	1.0	2.0	2.0	-	-	-	-	-	-	-	-	-	-
	0^{o}-140^{o}	29.0	104	-	-	4.8	1.9	18.3	11.5	34.6	3.8	8.6	4.8	4.8	-	1.9	-	1.0	-	3.8
				-	-	1.2	2.0	1.4	1.7	1.5	2.0	1.4	2.0	1.6	-	2.0	-	1.0	-	0.0
July 1950	0^{o}-145^{o}	29.4	137	1.5	2.9	5.8	5.8	19.7	3.7	27.7	5.8	5.8	-	2.2	-	1.5	-	1.5	-	16.0
				1.0	1.0	1.4	1.4	1.3	2.4	1.9	1.4	1.0	-	1.0	-	1.5	-	1.0	-	0.0
	5^{o}-145^{o}	29.3	25	-	4.0	8.0	4.0	28.0	8.0	28.0	4.0	-	4.0	-	-	-	-	-	-	12.0
				-	1.0	1.5	2.0	1.7	2.0	1.6	1.0	-	1.0	-	-	-	-	-	-	0.0
	0^{o}-140^{o}	29.3	18	-	-	11.1	-	22.2	22.2	33.3	-	5.6	-	5.6	-	-	-	-	-	-
				-	-	1.5	-	1.2	2.0	1.2	-	1.0	-	1.0	-	-	-	-	-	-
	0^{o}-150^{o}	29.2	239	1.3	0.8	6.7	5.9	13.0	16.7	28.9	7.1	4.6	0.4	1.3	-	0.4	0.4	1.3	0.4	10.9
				1.3	1.5	1.6	1.6	1.8	1.7	1.6	1.5	1.5	1.0	1.3	-	1.0	1.0	1.3	1.0	0.0
	5^{o}-150^{o}	29.2	60	-	3.3	5.0	8.3	21.7	6.7	38.3	3.3	1.7	-	3.3	-	-	-	5.0	-	3.3
				-	1.0	1.3	2.0	1.5	2.2	1.5	2.5	2.0	-	1.5	-	-	-	1.3	-	0.0
	0^{o}-155^{o}	29.3	106	2.8	2.8	4.7	5.7	17.0	20.8	24.5	4.7	2.8	-	0.9	-	-	-	2.8	2.8	7.5
				1.3	1.7	1.4	1.3	1.7	1.9	1.8	1.2	1.7	-	1.0	-	-	-	2.0	1.3	0.0
	5^{o}-155^{o}	29.2	11	18.2	-	-	-	27.3	-	36.4	9.1	9.1	-	-	-	-	-	-	-	-
				1.0	-	-	-	1.0	-	1.0	2.0	1.0	-	-	-	-	-	-	-	-
	0^{o}-160^{o}	28.9	59	-	-	13.6	8.5	27.1	18.6	23.7	1.7	-	-	-	-	1.7	-	-	1.7	3.4
				-	-	1.6	1.8	1.6	2.5	1.7	2.0	-	-	-	-	1.0	-	-	1.0	0.0
	5^{o}-160^{o}	29.0	14	7.1	-	14.3	-	14.3	21.4	-	14.3	-	-	-	-	-	7.1	-	-	21.4
				1.0	-	1.5	-	1.5	2.0	-	2.5	-	-	-	-	-	1.0	-	-	0.0
Aug. 1950	0^{o}-150^{o}	29.4	7	14.3	-	14.3	14.3	-	28.6	28.6	-	-	-	-	-	-	-	-	-	-
				2.0	-	2.0	3.0	-	1.5	2.5	-	-	-	-	-	-	-	-	-	-
	0^{o}-155^{o}	29.0	510	0.8	1.8	8.6	7.6	22.0	20.6	22.7	2.2	4.1	0.6	1.8	0.8	0.6	0.2	0.8	-	4.9
				1.0	2.0	1.9	1.9	1.9	2.3	1.9	1.7	2.0	2.0	1.6	1.8	2.0	1.0	1.5	-	0.0
	5^{o}-55^{o}	29.1	50	8.0	2.0	14.0	10.0	16.0	6.0	10.0	4.0	10.0	2.0	4.0	2.0	2.0	-	4.0	-	6.0
				1.2	2.0	1.7	2.0	1.9	2.3	1.6	3.0	1.8	2.0	2.5	3.0	1.0	-	1.5	-	0.0
	0^{o}-60^{o}	29.0	104	2.9	1.9	12.5	10.6	17.3	16.3	21.2	9.6	4.8	1.0	-	-	-	-	-	-	1.9
				1.0	2.5	2.5	2.1	1.7	1.7	2.1	1.6	3.0	4.0	-	-	-	-	-	-	0.0

Table 13.--Wind and surface temperature data from noon reports of catcher vessels, 1950-51. The data are grouped in 5-degree blocks identified by the SW coordinates. The upper figure is the percent of observations, the lower the average force (all longitudes are east and all latitudes north) (cont'd)

Date	Block	Mean temp.	No. obs.	Direction																
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
Aug.	5°-60°	28.9	6	-	16.7	-	16.7	16.7	-	33.3	16.7	-	-	-	-	-	-	-	-	-
1950				-	2.0	-	1.0	1.0	-	1.5	1.0	-	-	-	-	-	-	-	-	-
(Con.)	0°-65°	28.8	175	0.6	2.3	6.3	13.7	30.3	16.0	23.4	6.3	-	-	-	-	0.6	-	-	-	0.6
				2.0	2.5	2.1	2.3	2.5	2.5	2.2	1.7	-	-	-	-	2.0	-	-	-	0.0
	5°-65°	28.7	30	-	-	6.7	16.7	53.3	10.0	10.0	-	3.3	-	-	-	-	-	-	-	-
				-	-	2.5	2.2	2.1	2.0	1.7	-	2.0	-	-	-	-	-	-	-	-
Sept.	5°-50°	29.0	22	-	-	-	-	22.7	9.1	40.9	13.6	4.5	-	4.5	-	-	-	4.5	-	-
1950				-	-	-	-	1.8	2.5	1.4	1.3	1.0	-	2.0	-	-	-	2.0	-	-
	5°-55°	29.0	35	-	-	5.7	-	8.6	20.0	40.0	8.6	8.6	-	-	-	-	-	2.9	-	5.7
				-	-	1.5	-	1.3	1.3	1.9	2.0	1.0	-	-	-	-	-	1.0	-	0.0
	0°-60°	28.2	53	-	-	7.5	1.9	15.1	28.3	22.6	11.3	7.5	1.9	-	-	-	-	1.9	-	1.9
				-	-	2.8	1.0	1.6	2.7	2.2	2.7	2.2	2.0	-	-	-	-	2.0	-	0.0
	5°-60°	28.8	15	-	-	13.3	20.0	20.0	6.7	36.7	6.7	6.7	-	-	-	-	-	-	-	-
				-	-	1.0	2.0	2.7	3.0	1.5	3.0	4.0	-	-	-	-	-	-	-	-
	0°-65°	28.0	172	-	-	5.2	7.0	27.9	30.2	27.9	1.2	0.6	-	-	-	-	-	-	-	-
				-	-	2.9	2.0	2.2	2.2	2.6	2.0	1.0	-	-	-	-	-	-	-	-
Dec.	0°-40°	28.8	4	50.0	-	25.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-
1950				1.0	-	2.0	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-
	0°-35°	29.1	82	18.3	8.5	11.0	-	-	-	2.4	-	2.4	1.2	3.7	4.9	9.8	7.3	20.7	7.3	2.4
				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jan.	25°-40°	-	5	-	-	40.0	-	40.0	20.0	-	-	-	-	-	-	-	-	-	-	-
1951				-	-	4.5	-	4.5	2.0	-	-	-	-	-	-	-	-	-	-	-
Feb.	0°-55°	29.1	165	0.6	0.6	11.5	27.9	42.4	9.7	4.2	1.2	0.6	0.6	0.6	-	-	-	-	-	-
1951				2.0	3.0	2.2	2.0	1.9	1.6	1.4	2.5	1.0	2.0	1.0	-	-	-	-	-	-
	5°-55°	29.1	15	-	20.0	46.7	26.7	6.7	-	-	-	-	-	-	-	-	-	-	-	-
				-	3.3	3.0	3.5	2.0	-	-	-	-	-	-	-	-	-	-	-	-
	0°-60°	29.0	40	2.5	5.0	10.0	22.5	25.0	27.5	7.5	-	-	-	-	-	-	-	-	-	-
				2.0	1.5	2.0	1.9	1.5	1.7	1.7	-	-	-	-	-	-	-	-	-	-
Mar.	0°-40°	29.4	28	25.0	14.3	7.1	7.1	-	-	-	-	3.6	3.6	3.6	-	-	10.7	14.3	10.7	-
1951				1.6	1.5	1.0	1.0	-	-	-	-	1.0	1.0	3.0	-	-	2.0	1.8	1.7	-
	0°-35°	29.7	9	44.4	55.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				1.5	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 13.--Wind and surface temperature data from noon reports of catcher vessels, 1950-51. The data are grouped in 5-degree blocks identified by the SW coordinates. The upper figure is the percent of observations, the lower the average force (all longitudes are east and all latitudes north) (cont'd)

Date	Block	Mean temp.	No. obs.	Direction																
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
April 1951	0°-45°	29.1	105	5.7	14.3	21.9	8.6	21.0	1.9	5.7	2.9	7.6	3.8	2.9	-	1.0	-	1.0	-	1.9
				2.2	2.1	2.3	2.2	1.9	3.0	2.0	2.0	3.1	3.5	3.0	-	3.0	-	2.0	-	0.0
	5°-45°	28.6	15	-	13.3	46.7	20.0	6.6	-	-	6.7	-	-	-	-	-	6.7	-	-	-
				-	2.0	3.3	3.3	1.0	-	-	2.0	-	-	-	-	-	2.0	-	-	-
	0°-40°	29.5	13	-	15.4	15.4	23.1	30.8	7.7	-	-	-	-	-	-	-	-	7.7	-	-
				-	3.0	1.5	2.7	1.8	2.0	-	-	-	-	-	-	-	-	1.0	-	-
	0°-50°	29.0	155	11.6	4.5	11.6	6.5	5.8	3.2	11.0	2.6	1.3	1.9	12.3	5.2	10.3	3.2	7.1	1.9	-
				1.3	1.7	1.3	1.7	2.2	2.2	1.9	1.8	2.0	2.3	2.1	2.5	2.1	3.2	2.2	1.3	-
	0°-55°	29.0	71	2.8	2.8	22.5	4.2	12.7	-	7.0	1.4	7.0	4.2	9.9	5.6	8.5	1.4	8.5	1.4	-
				1.5	1.0	1.4	2.3	1.4	-	1.6	1.0	1.2	3.3	2.7	3.2	2.2	4.0	2.0	4.0	-
May 1951	0°-50°	29.0	40	12.5	-	5.0	5.0	5.0	2.5	10.0	-	-	2.5	2.5	-	2.5	2.5	32.5	12.5	5.0
				3.4	-	1.0	1.5	1.5	1.0	1.5	-	-	2.0	1.0	-	4.0	3.0	3.1	3.8	0.0
	0°-55°	28.6	176	2.3	3.4	23.3	10.2	13.6	2.3	5.1	1.1	4.5	2.3	9.7	2.8	6.2	3.4	5.1	2.8	1.7
				2.8	1.8	1.7	1.9	1.6	1.8	1.0	3.0	2.0	2.8	2.6	3.8	2.6	3.3	3.6	4.2	0.0
	5°-55°	28.5	36	2.8	-	25.0	33.3	33.3	5.6	-	-	-	-	-	-	-	-	-	-	-
				1.0	-	2.1	1.7	1.9	3.0	-	-	-	-	-	-	-	-	-	-	-
	0°-60°	28.8	209	4.8	1.9	23.0	11.5	9.1	1.0	3.8	2.9	4.8	6.2	15.3	9.6	2.9	-	1.4	1.0	1.0
				1.3	1.5	2.1	2.5	1.9	1.5	1.4	2.2	1.4	1.5	2.1	2.1	1.3	-	1.0	1.5	0.0
	5°-60°	28.4	27	-	7.4	33.3	48.1	3.7	-	3.7	-	-	-	-	-	-	-	-	3.7	-
				-	2.5	3.3	2.7	3.0	-	3.0	-	-	-	-	-	-	-	-	1.0	-
June 1951	0°-50°	29.3	102	2.9	2.9	24.5	15.7	21.6	4.9	3.9	1.0	-	-	8.8	1.0	1.0	1.0	7.8	2.0	1.0
				2.0	1.7	1.7	2.0	2.1	1.4	2.5	1.0	-	-	1.9	2.0	1.0	1.0	1.6	1.0	-
	0°-55°	29.0	183	3.8	3.8	17.5	13.1	16.4	2.7	9.3	2.7	6.0	3.8	6.0	1.6	2.7	1.6	6.6	1.6	0.6
				1.4	2.1	1.8	1.7	1.9	1.8	1.7	2.0	2.5	2.9	1.9	2.0	1.8	2.7	1.5	1.3	0.0
	5°-55°	28.5	39	2.6	5.1	23.1	15.4	12.8	2.6	15.4	-	-	5.1	2.6	-	2.6	2.6	10.3	-	-
				1.0	2.0	1.4	2.2	1.2	3.0	1.7	-	-	2.0	2.0	-	2.0	2.0	1.2	-	-
	0°-60°	28.7	82	6.1	7.3	26.8	3.7	4.9	-	4.9	1.2	8.5	7.3	7.3	1.2	6.1	1.2	9.8	2.4	1.2
				1.4	1.3	1.5	1.0	1.8	-	1.2	1.0	1.6	1.7	1.2	1.0	1.6	2.0	1.4	1.5	0.0
	5°-60°	28.8	8	-	12.5	25.0	12.5	12.5	12.5	-	-	-	-	12.5	-	12.5	-	-	-	-
				-	2.0	2.5	2.0	2.0	2.0	-	-	-	-	2.0	-	1.0	-	-	-	-
July 1951	0°-60°	28.9	147	0.7	2.7	21.8	13.6	16.3	14.3	12.9	4.8	4.8	0.7	1.4	-	1.4	2.0	2.0	-	0.7
				1.0	1.8	1.4	1.6	1.8	1.4	1.8	1.9	1.0	1.0	1.5	-	1.5	1.0	2.0	-	0.0
	5°-60°	28.8	25	-	12.0	28.0	16.0	20.0	4.0	8.0	4.0	-	-	-	4.0	-	-	4.0	-	-
				-	3.3	2.0	2.0	2.0	2.0	1.5	1.0	-	-	-	2.0	-	-	2.0	-	-

Table 13.--Wind and surface temperature data from noon reports of catcher vessels, 1950-51. The data are grouped in 5-degree blocks identified by the SW coordinates. The upper figure is the percent of observations, the lower the average force (all longitudes are east and all latitudes north) (cont'd)

Date	Block	Mean temp.	No. obs.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
July 1951 (con.)	0°-65°	28.9	235	4.3	3.4	24.7	17.4	18.3	4.3	6.8	2.1	4.3	2.6	3.4	0.4	0.9	0.9	1.7	0.4	4.3
				1.2	2.2	2.2	2.4	1.9	1.6	1.7	2.6	1.1	1.7	1.2	3.0	2.0	2.0	1.8	1.0	0.0
	5°-65°	28.7	90	5.6	6.7	37.8	17.8	12.2	3.3	6.7	2.2	2.2	2.2	-	-	1.1	-	1.1	-	1.1
				2.0	2.2	1.9	2.1	1.5	2.3	1.7	1.5	1.5	1.5	-	-	2.0	-	1.0	-	0.0
	5°-70°	28.6	83	2.4	4.8	41.0	10.8	14.5	3.6	16.9	1.2	1.2	-	-	-	-	2.4	-	-	1.2
				1.0	1.2	1.8	1.9	1.6	3.0	1.5	2.0	2.0	-	-	-	-	2.5	-	-	0.0
Aug. 1951	0°-50°	28.9	25	4.2	-	25.0	-	16.7	4.2	8.3	-	8.3	-	-	4.2	4.2	-	12.5	-	12.5
				1.0	-	1.2	-	1.0	3.0	1.0	-	2.0	-	-	3.0	3.0	-	1.3	-	0.0
	0°-55°	29.0	245	7.3	1.6	4.9	0.8	4.5	4.5	9.8	3.7	8.2	5.3	8.2	3.7	13.5	3.3	10.6	3.7	6.5
				1.7	1.8	1.1	1.5	1.5	1.2	1.7	2.4	2.2	2.5	2.0	2.1	1.9	1.5	1.7	1.9	0.0
	5°-55°	29.2	14	-	-	14.3	-	7.1	-	7.1	-	14.3	-	14.3	-	7.1	7.1	14.3	-	14.3
				-	-	1.0	-	1.0	-	1.0	-	1.5	-	2.0	-	1.0	2.0	2.0	-	0.0
	0°-60°	29.1	42	9.5	-	-	-	9.5	4.8	2.4	4.8	4.8	-	11.9	4.8	28.6	4.8	4.8	4.8	4.8
				1.0	-	-	-	1.0	1.0	2.0	2.0	1.0	-	1.6	2.5	2.4	1.0	2.0	1.0	0.0
	5°-60°	29.2	12	-	8.3	16.7	8.3	25.0	-	16.7	-	-	-	-	8.3	-	-	-	16.7	-
				-	2.0	2.0	2.0	2.0	-	1.0	-	-	-	-	1.0	-	-	-	2.0	-
	5°-65°	28.8	69	2.9	4.3	42.0	7.2	11.6	2.9	4.3	4.3	4.3	1.4	2.9	-	-	1.4	2.9	2.9	4.3
				1.0	2.0	1.7	1.2	1.8	2.5	1.0	1.3	2.7	2.0	2.0	-	-	1.0	2.0	1.5	0.0
	5°-70°	28.8	199	1.5	3.0	40.2	16.1	16.1	2.5	4.5	1.0	2.0	1.5	1.5	0.5	0.5	-	2.0	1.0	6.0
				2.0	1.2	1.8	1.8	1.3	2.4	1.3	1.0	2.0	1.7	1.7	2.0	1.0	-	1.2	1.0	0.0
	5°-70°	28.8	88	2.3	6.8	36.4	17.0	15.9	2.3	2.3	-	-	-	3.4	1.1	2.3	1.1	2.3	1.1	5.7
				3.5	3.0	2.2	2.2	2.4	2.0	2.5	-	-	-	1.7	2.0	1.0	2.0	1.5	1.0	0.0
	10°-70°	28.4	10	10.0	-	50.0	20.0	-	10.0	-	-	10.0	-	-	-	-	-	-	-	-
				1.0	-	2.0	1.5	-	1.0	-	-	2.0	-	-	-	-	-	-	-	-
	10°-75°	28.5	12	-	-	41.7	16.7	33.3	-	-	-	-	-	-	8.3	-	-	-	-	-
				-	-	2.0	2.5	2.8	-	-	-	-	-	-	1.0	-	-	-	-	-
Sept. 1951	0°-50°	29.5	6	16.7	-	-	-	-	16.7	-	-	16.7	16.7	-	-	16.7	-	-	-	16.7
				2.0	-	-	-	-	1.0	-	-	2.0	1.0	-	-	2.0	-	-	-	0.0
	0°-55°	30.0	118	12.7	0.8	0.8	1.7	0.8	-	2.5	3.4	10.2	3.4	14.4	2.5	9.3	1.7	10.2	4.2	21.2
				1.1	2.0	1.0	1.0	1.0	-	1.3	1.0	1.2	1.5	1.1	1.0	1.2	1.0	1.2	1.0	0.0
	5°-55°	29.6	9	11.1	-	-	-	-	-	-	-	-	-	44.4	-	-	-	11.1	11.1	22.2
				1.0	-	-	-	-	-	-	-	-	-	1.2	-	-	-	1.0	1.0	0.0
	20°-55°	29.3	4	25.0	-	-	-	-	-	-	-	-	-	-	25.0	50.0	-	-	-	-
				1.0	-	-	-	-	-	-	-	-	-	-	2.0	2.0	-	-	-	-
	0°-60°	30.0	202	7.4	2.5	9.9	3.0	17.3	2.0	7.9	0.5	2.5	1.0	6.9	1.5	6.9	3.0	4.5	3.5	19.8
				1.1	1.8	1.4	1.0	1.8	1.5	1.6	2.0	1.2	1.0	1.3	1.7	1.3	1.2	1.0	1.1	-

Table 13.--Wind and surface temperature data from noon reports of catcher vessels, 1950-51. The data are grouped in 5-degree blocks identified by the SW coordinates. The upper figure is the percent of observations, the lower the average force (all longitudes are east and all latitudes north)

Date	Block	Mean temp.	No. obs.	Direction																
				N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Calm
Sept.	5°-60°	30.4	6	16.7	16.7	-	33.3	-	-	-	-	16.7	-	-	-	-	-	-	-	16.7
1951				2.0	3.0	-	1.0	-	-	-	-	1.0	-	-	-	-	-	-	-	0.0
(Con.)	0°-65°	29.7	129	5.4	3.1	14.0	14.0	20.9	7.0	8.5	2.3	2.3	0.8	-	0.8	2.3	2.3	5.4	1.6	9.3
				1.6	1.5	1.9	2.2	1.5	1.2	1.6	1.3	1.0	3.0	-	1.0	1.3	1.3	1.0	1.0	0.0
	5°-65°	29.7	53	1.9	9.4	20.8	7.5	26.4	3.8	5.7	3.8	3.8	1.9	1.9	-	3.8	-	-	-	9.4
				1.0	2.2	2.4	1.8	1.7	2.5	1.7	2.0	2.0	1.0	1.0	-	2.0	-	-	-	0.0
	5°-70°	29.5	42	2.4	-	31.0	19.0	28.6	7.1	7.1	-	2.4	-	-	-	-	-	2.4	-	-
				2.0	-	3.2	3.0	2.8	1.7	1.3	-	2.0	-	-	-	-	-	2.0	-	-
Oct.	20°-50°	28.0	4	-	-	25.0	50.0	25.0	-	-	-	-	-	-	-	-	-	-	-	-
1951				-	-	3.0	3.0	4.0	-	-	-	-	-	-	-	-	-	-	-	-
	0°-65°	29.5	45	11.1	13.3	6.7	4.4	15.6	2.2	11.1	-	4.4	6.7	13.3	-	-	-	6.7	-	4.4
				1.0	1.7	1.0	1.0	1.0	1.0	1.0	-	1.0	1.0	1.3	-	-	-	2.0	-	0.0
	25°-65°	28.3	4	-	-	25.0	25.0	50.0	-	-	-	-	-	-	-	-	-	-	-	-
				-	-	4.0	3.0	2.0	-	-	-	-	-	-	-	-	-	-	-	-
	5°-70°	29.3	32	6.2	-	25.0	3.1	25.0	6.2	6.2	3.1	9.4	9.4	-	3.1	-	-	-	3.1	-
				1.5	-	1.4	3.0	2.2	3.0	2.5	2.0	2.0	2.3	-	1.0	-	-	-	1.0	-
	5°-75°	29.3	360	7.2	2.8	20.0	8.9	24.4	2.8	13.3	2.8	3.9	1.4	3.3	-	1.1	-	1.9	0.8	5.3
				1.7	1.7	1.7	2.1	1.7	1.6	1.9	2.2	1.9	1.4	1.8	-	1.0	-	1.1	1.7	0.0
	10°-75°	28.8	22	4.5	18.2	22.7	4.5	18.2	-	4.5	4.5	4.5	4.5	-	-	4.5	-	4.5	4.5	-
				2.0	2.2	2.2	3.0	2.5	-	2.0	3.0	1.0	4.0	-	-	1.0	-	2.0	1.0	-
	20°-75°	26.8	4	-	-	-	25.0	75.0	-	-	-	-	-	-	-	-	-	-	-	-
				-	-	-	2.0	2.0	-	-	-	-	-	-	-	-	-	-	-	-
	25°-75°	24.9	4	-	-	50.0	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-
				-	-	2.5	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov.	25°-60°	28.0	7	-	-	42.9	-	42.9	14.3	-	-	-	-	-	-	-	-	-	-	-
1951				-	-	2.7	-	2.3	2.0	-	-	-	-	-	-	-	-	-	-	-
	25°-65°	27.6	8	-	-	25.0	25.0	25.0	-	25.0	-	-	-	-	-	-	-	-	-	-
				-	-	3.0	2.0	2.5	-	4.5	-	-	-	-	-	-	-	-	-	-
	35°-65°	18.6	6	-	-	-	-	16.7	-	-	-	-	-	-	-	16.7	50.0	16.7	-	-
				-	-	-	-	3.0	-	-	-	-	-	-	-	3.0	4.0	4.0	-	-
	25°-75°	28.1	21	-	4.8	52.4	19.0	9.5	4.8	4.8	-	-	-	-	-	-	-	4.8	-	-
				-	3.0	2.1	3.2	3.5	1.0	2.0	-	-	-	-	-	-	-	1.0	-	-

Table 14.--Catches of the mothership expeditions for 1950. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks								
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
June	01°-40°	10	203	1.6	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.6
	01°-45°	13	271	2.5	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.8
	02°-40°	57	1,047	2.4	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.6
	02°-45°	18	307	2.4	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.7
	03°-40°	33	572	2.9	0.2	0.0	0.0	0.6	0.0	0.0	0.0	0.8
	03°-45°	10	202	2.6	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.9
	04°-40°	7	130	2.3	0.5	0.0	0.0	0.8	0.0	0.0	0.0	0.9
	04°-45°	30	579	3.1	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.6
	05°-40°	9	155	2.2	0.6	0.0	0.0	0.9	0.0	0.0	0.0	1.0
	05°-45°	9	181	3.2	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.7
	05°-50°	1	22	0.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1
	06°-40°	3	52	2.2	0.5	0.0	0.0	0.9	0.0	0.1	0.1	0.7
July	01°-40°	12	240	2.2	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.8
	01°-45°	24	468	1.4	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.7
	01°-50°	65	1,298	2.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.4
	01°-55°	29	581	3.7	0.2	0.0	0.1	0.3	0.0	0.0	0.0	0.7
	01°-60°	10	207	2.7	0.4	0.0	0.0	0.5	0.0	0.0	0.0	0.9
	02°-40°	4	80	2.1	0.1	0.0	0.2	0.5	0.0	0.0	0.0	2.0
	02°-45°	28	542	1.6	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.7
	02°-50°	82	1,532	2.8	0.4	0.0	0.0	0.5	0.0	0.0	0.0	0.4
	03°-40°	3	43	2.0	0.6	0.0	0.0	0.6	0.0	0.1	0.0	2.3
	03°-45°	41	783	2.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.5
	03°-50°	37	706	1.9	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.5
	03°-55°	41	772	2.1	0.5	0.1	0.0	0.6	0.0	0.0	0.0	0.5
	03°-60°	9	180	2.8	0.4	0.0	0.0	0.5	0.0	0.0	0.0	0.3
	04°-45°	46	889	2.1	0.6	0.0	0.0	0.6	0.0	0.0	0.0	0.5
	04°-50°	54	990	1.9	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.6
	04°-55°	18	343	2.2	0.5	0.0	0.0	0.8	0.0	0.0	0.0	0.3
	04°-60°	32	614	2.8	0.6	0.0	0.0	0.9	0.1	0.0	0.0	0.4
	05°-40°	3	52	2.8	0.6	0.0	0.0	0.9	0.0	0.1	0.0	1.1
	05°-45°	21	413	2.2	0.5	0.0	0.0	0.7	0.0	0.0	0.0	0.7
	05°-50°	41	710	1.9	0.3	0.0	0.0	0.7	0.0	0.0	0.0	0.7
	05°-55°	9	161	2.6	0.5	0.1	0.1	1.0	0.0	0.0	0.0	0.7
	05°-60°	14	273	2.6	0.8	0.0	0.0	1.0	0.0	0.0	0.0	0.3
	06°-45°	3	60	1.7	0.1	0.0	0.0	0.9	0.0	0.0	0.0	0.4
	06°-50°	17	318	2.1	0.3	0.1	0.1	0.5	0.0	0.0	0.0	0.6
	06°-55°	3	55	2.3	0.5	0.0	0.0	1.0	0.0	0.0	0.0	0.3
	07°-45°	1	21	1.3	0.3	0.0	0.0	0.4	0.0	0.0	0.0	1.5
	07°-50°	2	37	1.4	0.1	0.1	0.0	0.5	0.0	0.0	0.0	0.8
Aug.	01°-40°	1	18	1.1	0.2	0.0	0.0	0.8	0.0	0.0	0.0	0.4
	01°-50°	3	53	1.4	0.3	0.0	0.0	0.4	0.1	0.0	0.0	0.6
	01°-55°	244	4,634	3.1	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.7
	01°-65°	16	325	3.6	0.2	0.1	0.0	0.3	0.0	0.0	0.0	0.6
	02°-40°	1	18	1.3	0.3	0.0	0.0	0.4	0.0	0.2	0.0	0.2

Table 14.--Catches of the mothership expeditions for 1950. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks								
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Aug. (con.)	02°-45°	1	18	2.8	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.8
	02°-50°	1	18	0.9	0.1	0.0	0.0	0.3	0.1	0.0	0.0	0.3
	02°-55°	67	1,222	2.0	0.2	0.0	0.1	0.5	0.0	0.0	0.0	0.5
	02°-60°	1	20	0.1	0.4	0.0	0.0	0.4	0.0	0.2	0.0	2.8
	02°-65°	9	177	1.7	0.2	0.0	0.0	0.8	0.0	0.0	0.0	0.3
	03°-45°	1	18	1.9	0.8	0.1	0.0	0.3	0.1	0.0	0.1	2.5
	03°-50°	1	18	3.5	0.1	0.1	0.0	0.3	0.0	0.0	0.0	0.1
	03°-55°	11	2,023	2.0	0.4	0.1	0.0	0.5	0.0	0.0	0.0	0.4
	03°-60°	30	619	2.5	0.3	0.0	0.0	0.8	0.0	0.0	0.0	0.3
	03°-65°	53	1,032	1.9	0.3	0.0	0.0	1.1	0.0	0.0	0.0	0.3
	04°-45°	1	18	0.3	0.1	0.1	0.0	0.5	0.0	0.0	0.0	0.7
	04°-50°	2	42	0.7	0.2	0.2	0.0	0.3	0.0	0.0	0.0	0.4
	04°-55°	90	1,760	2.1	0.3	0.1	0.0	0.6	0.0	0.0	0.0	0.4
	04°-60°	74	1,426	2.5	0.4	0.1	0.0	0.9	0.0	0.0	0.0	0.2
	04°-65°	99	1,845	2.4	0.4	0.1	0.0	1.2	0.0	0.0	0.0	0.2
	05°-50°	3	60	0.6	0.6	0.2	0.0	0.3	0.0	0.0	0.0	0.3
	05°-55°	40	776	1.9	0.4	0.1	0.0	0.7	0.0	0.0	0.0	0.5
	05°-60°	5	112	2.1	0.4	0.1	0.0	1.1	0.0	0.0	0.0	0.2
	05°-65°	24	452	1.7	0.5	0.1	0.0	0.8	0.0	0.0	0.0	0.3
	06°-55°	10	190	1.5	0.5	0.1	0.0	0.7	0.0	0.0	0.0	0.6
	06°-60°	1	21	0.9	0.5	0.1	0.0	0.7	0.0	0.0	0.0	0.1
	06°-65°	6	110	1.4	1.0	0.0	0.0	0.8	0.0	0.0	0.0	0.6
Sept.	01°-55°	1	22	1.4	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.4
	01°-60°	25	436	3.2	0.2	0.0	0.2	0.3	0.0	0.0	0.0	0.6
	01°-65°	69	1,326	3.4	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.7
	02°-60°	8	138	1.3	0.2	0.0	0.0	0.6	0.0	0.1	0.0	1.1
	02°-65°	79	1,486	3.1	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.6
	03°-50°	1	18	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	03°-60°	6	112	0.9	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.6
	03°-65°	15	260	2.1	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.3
	04°-55°	2	39	1.0	0.3	0.2	0.1	0.3	0.0	0.1	0.1	1.1
	04°-60°	14	242	1.1	0.2	0.0	0.0	0.8	0.0	0.1	0.0	0.3
	04°-65°	13	241	1.7	0.3	0.0	0.0	0.9	0.1	0.1	0.0	0.9
	05°-50°	1	18	5.8	0.6	0.0	1.2	0.8	0.1	0.2	0.2	1.8
	05°-55°	4	77	0.7	0.5	0.0	0.6	0.0	0.0	0.1	0.0	0.7
	05°-60°	12	217	1.6	0.4	0.0	0.0	0.7	0.0	0.0	0.0	0.3
	05°-65°	2	36	1.7	0.4	0.0	0.0	0.5	0.0	0.3	0.0	0.5
	06°-50°	8	146	1.5	0.4	0.0	0.1	1.0	0.0	0.1	0.0	1.0
	06°-55°	14	261	0.7	0.4	0.0	0.0	0.5	0.0	0.0	0.0	0.6
	06°-60°	1	21	0.6	0.4	0.0	0.0	1.0	0.0	0.0	0.0	0.3
	07°-50°	6	106	0.5	0.4	0.1	0.0	0.7	0.0	0.0	0.0	0.6
	07°-55°	11	204	0.8	0.5	0.1	0.0	0.8	0.0	0.0	0.0	0.1
	07°-60°	2	38	0.5	0.4	0.0	0.1	1.2	0.0	0.0	0.0	0.5
	08°-50°	7	126	1.0	0.4	0.0	0.0	1.0	0.0	0.0	0.0	0.5
	08°-55°	5	107	0.9	0.4	0.0	0.0	0.9	0.0	0.0	0.0	0.4

Table 14.--Catches of the mothership expeditions for 1950. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks								
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Sept. (con)	09°-55°	1	20	0.2	0.3	0.1	0.0	0.9	0.0	0.0	0.0	0.5
	10°-60°	2	42	0.3	0.2	0.0	0.0	1.5	0.0	0.0	0.0	0.3
Oct.	06°-60°	1	12	0.2	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0
	06°-75°	1	22	0.3	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.6
	10°-60°	1	21	0.1	0.3	0.0	0.0	0.9	0.0	0.0	0.0	0.5
Dec.	01°-35°	8	146	5.1	0.7	0.3	0.2	0.4	0.0	0.0	0.0	0.2
	02°-35°	60	1,082	3.6	0.4	0.1	0.1	0.5	0.0	0.0	0.0	0.2
	02°-40°	1	18	4.5	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	03°-30°	1	12	3.1	0.2	2.2	0.0	0.1	0.0	0.1	0.1	0.7
	03°-35°	15	248	3.9	0.2	0.0	0.1	0.3	0.0	0.0	0.0	0.3
	03°-40°	2	34	5.0	0.4	0.0	0.1	0.3	0.0	0.0	0.0	0.3
	04°-40°	1	19	2.6	1.1	0.0	0.0	0.2	0.0	0.1	0.1	0.9

1/ In hundreds

Table 15.--Catches of the mothership expeditions for 1951. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks								
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Feb.	01°-55°	46	870	3.3	0.4	0.1	0.0	0.4	0.0	0.1	0.0	0.0
	01°-60°	8	149	3.2	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
	02°-50°	1	20	2,5	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0
	02°-55°	63	1,026	2.7	0.4	0.0	0.0	0.4	0.0	0.1	0.0	0.1
	02°-60°	16	285	3.3	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.1
	03°-55°	16	221	2.0	0.3	0.0	0.0	0.7	0.0	0.0	0.0	0.2
	03°-60°	10	187	3.3	0.4	0.0	0.0	0.6	0.0	0.0	0.0	0.2
	04°-55°	41	664	2.1	0.5	0.1	0.2	1.1	0.0	0.1	0.0	0.2
	04°-60°	5	93	3.8	0.4	0.1	0.0	0.7	0.0	0.1	0.0	0.2
	05°-55°	13	207	1.4	0.5	0.1	0.0	0.9	0.0	0.0	0.0	0.1
	06°-55°	2	36	1.0	0.9	0.0	0.0	0.7	0.0	0.0	0.0	0.2
Mar.	01°-35°	3	53	2.4	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.5
	01°-40°	7	132	1.6	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.5
	01°-45°	1	18	0.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2
	02°-35°	5	92	2.7	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.4

Table 15.--Catches of the mothership expeditions for 1951. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks fished[1/]	Catch per 100 hooks: Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Mar. (con.)	02°-40°	16	312	2.3	0.4	0.1	0.0	0.2	0.0	0.0	0.0	0.2
	03°-40°	5	96	1.6	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	03°-45°	1	20	2.2	0.8	0.0	0.0	0.2	0.0	0.0	0.0	0.4
	04°-40°	1	15	0.8	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.5
Apr.	01°-35°	1	14	4.2	0.8	0.0	0.0	1.0	0.0	0.1	0.0	0.4
	01°-45°	2	36	1.5	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	01°-50°	76	1,375	2.5	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.2
	01°-55°	46	892	2.8	0.4	0.0	0.1	0.4	0.0	0.0	0.0	0.2
	01°-60°	1	18	3.0	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.1
	02°-40°	1	20	0.9	0.5	0.0	0.0	0.2	0.0	0.1	0.0	0.1
	02°-45°	15	276	1.7	0.4	0.0	0.1	0.2	0.0	0.0	0.0	0.2
	02°-50°	51	887	2.2	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.2
	02°-55°	26	320	2.6	0.4	0.0	0.2	0.6	0.0	0.1	0.0	0.3
	03°-40°	8	150	2.0	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.2
	03°-45°	66	1,126	2.2	0.6	0.0	0.0	0.3	0.0	0.0	0.0	0.2
	03°-50°	9	136	1.5	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	03°-55°	1	20	2.4	0.4	0.0	0.0	0.6	0.0	0.0	0.0	0.0
	04°-40°	4	68	1.6	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.4
	04°-45°	22	391	1.3	0.7	0.0	0.0	0.5	0.0	0.0	0.0	0.3
	04°-50°	22	322	1.4	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.3
	04°-55°	1	19	1.7	0.1	0.0	0.3	0.7	0.1	0.0	0.0	0.3
	05°-45°	11	221	1.7	0.9	0.0	0.1	0.4	0.0	0.0	0.0	0.4
	05°-50°	2	28	1.9	1.1	0.0	0.0	0.6	0.0	0.2	0.0	0.5
	05°-55°	3	50	1.7	0.6	0.0	0.0	0.4	0.0	0.1	0.0	0.4
	06°-45°	3	60	1.4	0.4	0.0	0.1	0.5	0.0	0.0	0.0	0.5
	07°-45°	1	21	0.5	0.7	0.0	0.0	0.4	0.0	0.1	0.0	0.2
	07°-50°	1	18	0.4	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.1
May	01°-50°	28	468	2.5	0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.3
	01°-55°	86	1,486	2.7	0.6	0.2	0.3	0.4	0.0	0.0	0.3	0.0
	01°-60°	91	1,582	2.5	0.4	0.0	0.1	0.3	0.0	0.0	0.0	0.3
	02°-50°	12	212	2.6	0.9	0.0	0.1	0.3	0.0	0.0	0.0	0.3
	02°-55°	42	531	1.7	0.5	0.0	0.0	0.3	0.0	0.1	0.0	0.3
	02°-60°	61	971	2.4	0.4	0.0	0.3	0.4	0.0	0.0	0.0	0.2
	03°-55°	19	343	1.4	0.7	0.0	0.1	0.3	0.0	0.0	0.0	0.3
	03°-60°	12	199	1.1	0.6	0.0	0.2	0.3	0.0	0.0	0.0	0.3
	03°-65°	2	35	4.3	1.1	0.0	0.1	0.8	0.0	0.1	0.1	0.3
	04°-55°	34	558	1.5	0.6	0.0	0.0	0.5	0.0	0.1	0.0	0.3
	04°-60°	50	981	1.3	0.8	0.0	0.1	0.5	0.0	0.0	0.0	0.4
	05°-55°	33	550	1.7	0.6	0.0	0.0	0.4	0.0	0.1	0.0	0.3
	05°-60°	27	524	1.3	0.8	0.0	0.1	0.7	0.0	0.1	0.0	0.5
	06°-55°	3	51	1.5	0.9	0.0	0.0	0.6	0.0	0.0	0.0	0.6
	11°-60°	1	22	3.2	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.1

Table 15.--Catches of the mothership expeditions for 1951. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks								
				Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
June	01°-50°	30	514	3.8	0.9	0.0	0.1	0.3	0.0	0.0	0.0	0.4
	01°-55°	59	1,056	3.2	0.5	0.1	0.1	0.4	0.1	0.0	0.0	0.4
	01°-60°	18	357	2.6	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	02°-50°	46	756	2.8	0.7	0.0	0.0	0.2	0.0	0.0	0.0	0.3
	02°-55°	53	951	2.7	0.7	0.1	0.1	0.3	0.0	0.0	0.0	0.5
	02°-60°	39	766	2.8	0.6	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	03°-50°	23	391	2.8	0.8	0.0	0.0	0.2	0.0	0.0	0.0	0.3
	03°-55°	59	908	3.2	1.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
	03°-60°	23	386	3.7	0.6	0.0	0.1	0.5	0.0	0.0	0.0	0.4
	04°-50°	5	83	2.4	1.3	0.0	0.0	0.4	0.0	0.0	0.0	0.3
	04°-55°	12	227	2.4	1.0	0.0	0.1	0.4	0.0	0.1	0.0	0.3
	04°-60°	3	34	2.0	0.9	0.0	0.1	0.5	0.0	0.0	0.0	0.2
	04°-60°	2	35	3.9	0.9	0.0	0.0	0.6	0.0	0.0	0.0	0.2
	05°-55°	24	399	2.5	1.0	0.0	0.1	0.3	0.1	0.1	0.0	0.4
	05°-60°	6	106	2.1	0.5	0.0	0.0	0.6	0.0	0.0	0.0	0.5
	06°-50°	1	27	3.3	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.1
	06°-55°	12	246	4.0	1.5	0.0	0.1	0.5	0.0	0.1	0.0	0.4
	06°-60°	2	37	1.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.9
	07°-50°	1	24	1.6	0.1	0.0	0.1	0.3	0.0	0.1	0.0	0.2
	07°-60°	1	18	1.2	0.9	0.1	0.0	0.3	0.0	0.0	0.0	0.3
	08°-55°	1	18	1.4	0.7	0.0	0.0	0.5	0.0	0.2	0.0	0.0
	09°-55°	1	18	1.7	1.0	0.0	0.0	2.7	0.8	0.0	0.0	0.0
	10°-50°	2	42	2.6	0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.5
	10°-55°	2	35	2.6	0.8	0.0	0.0	0.7	0.0	0.0	0.0	0.1
	15°-50°	2	24	5.0	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	17°-50°	1	24	4.6	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	20°-50°	1	24	4.0	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.4
July	01°-60°	25	482	2.0	0.6	0.0	0.1	0.3	0.0	0.1	0.0	0.7
	01°-65°	19	404	2.1	0.9	0.3	0.2	0.4	0.0	0.1	0.0	0.9
	02°-60°	34	566	2.2	0.5	0.0	0.3	0.2	0.0	0.1	0.0	0.8
	02°-65°	32	628	2.3	0.9	0.0	0.1	0.4	0.0	0.1	0.0	0.5
	03°-60°	49	751	3.1	1.1	0.0	0.1	0.4	0.0	0.1	0.0	0.6
	03°-65°	95	1,663	2.3	1.2	0.1	0.1	0.5	0.0	0.1	0.0	0.5
	04°-60°	44	874	2.6	1.1	0.0	0.2	0.3	0.0	0.0	0.0	0.4
	04°-65°	106	2,029	2.3	1.1	0.1	0.1	0.5	0.0	0.0	0.0	0.5
	05°-60°	26	524	1.8	1.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6
	05°-65°	52	912	2.2	1.0	0.1	0.1	0.6	0.0	0.0	0.0	0.6
	05°-70°	37	706	2.4	0.8	0.0	0.0	0.8	0.0	0.0	0.0	0.6
	06°-65°	26	482	2.1	0.8	0.1	0.0	0.8	0.1	0.0	0.0	1.0
	06°-70°	34	665	2.2	0.7	0.0	0.0	0.7	0.0	0.0	0.0	0.6
	07°-65°	13	250	2.3	1.0	0.1	0.0	1.2	0.0	0.0	0.0	1.1
	07°-70°	13	261	2.2	0.8	0.0	0.1	0.7	0.0	0.0	0.0	0.1
Aug.	01°-50°	4	82	1.7	0.3	0.1	0.0	0.3	0.0	0.0	0.0	0.8
	01°-55°	29	559	2.4	0.4	0.3	0.0	0.4	0.0	0.0	0.0	0.6

Table 15.--Catches of the mothership expeditions for 1951. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks[1/] fished	Catch per 100 hooks: Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Aug. (con.)	01°-60°	6	128	1.7	0.4	0.4	0.1	0.2	0.0	0.0	0.0	0.3
	02°-50°	7	130	2.7	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	02°-55°	62	1,157	2.5	0.5	0.1	0.0	0.3	0.0	0.0	0.0	0.4
	02°-60°	1	22	1.3	0.5	0.1	0.1	0.2	0.0	0.1	0.0	0.3
	03°-50°	9	173	3.0	0.8	0.0	0.1	0.8	0.0	0.0	0.0	0.4
	03°-55°	99	1,811	2.4	0.6	0.1	0.1	0.3	0.0	0.0	0.0	0.3
	03°-60°	14	262	2.1	1.0	0.1	0.1	0.4	0.0	0.0	0.0	0.3
	04°-50°	4	78	3.1	0.9	0.1	0.0	0.4	0.0	0.0	0.0	0.4
	04°-55°	64	1,209	2.0	0.8	0.1	0.1	0.3	0.0	0.0	0.0	0.3
	04°-60°	21	408	2.0	0.9	0.2	0.1	0.3	0.0	0.0	0.0	0.3
	05°-50°	1	22	0.8	0.6	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	05°-55°	6	111	2.9	1.0	0.9	0.8	3.1	0.0	0.0	0.0	0.4
	05°-60°	9	162	1.8	0.9	0.1	0.0	0.5	0.0	0.0	0.0	0.4
	05°-65°	9	173	1.6	0.8	0.0	0.1	0.7	0.0	0.0	0.0	0.5
	05°-70°	55	1,049	2.0	0.9	0.1	0.2	1.0	0.0	0.1	0.0	0.9
	05°-75°	2	34	1.2	1.1	0.0	0.0	1.1	0.0	0.0	0.0	0.6
	06°-50°	1	21	1.0	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.7
	06°-55°	7	135	1.5	1.0	0.1	0.0	0.4	0.0	0.0	0.0	0.6
	06°-60°	3	58	1.3	0.9	0.2	0.0	0.5	0.1	0.0	0.0	0.6
	06°-65°	29	514	1.1	0.8	0.1	0.0	0.8	0.0	0.0	0.0	0.2
	06°-70°	75	1,426	1.1	0.9	0.0	0.0	0.9	0.0	0.0	0.0	0.7
	06°-75°	6	116	1.1	0.7	0.1	0.0	1.1	0.0	0.1	0.0	0.9
	07°-55°	1	19	0.6	0.6	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	07°-65°	22	414	1.3	0.5	0.1	0.1	0.9	0.0	0.0	0.0	0.8
	07°-70°	45	842	1.3	1.0	0.1	0.1	1.0	0.0	0.0	0.0	0.9
	07°-75°	30	568	0.4	0.7	0.1	0.0	0.6	0.0	0.0	0.0	0.6
	08°-65°	9	178	1.1	0.6	0.0	0.0	0.9	0.0	0.0	0.0	0.7
	08°-70°	21	372	0.7	1.3	0.0	0.0	0.9	0.0	0.0	0.0	0.7
	08°-75°	50	897	0.5	1.3	0.1	0.0	0.9	0.0	0.0	0.0	0.4
	09°-65°	1	18	1.0	0.7	0.1	0.0	0.0	0.7	0.0	0.0	0.5
	09°-70°	11	230	0.9	1.7	0.0	0.0	1.1	0.0	0.1	0.0	0.1
	09°-75°	9	163	0.4	2.0	0.1	0.0	1.0	0.0	0.0	0.0	0.6
	10°-65°	1	18	1.2	0.7	0.0	0.0	0.9	0.0	0.0	0.0	0.2
	10°-70°	5	102	1.4	1.3	0.1	0.2	1.0	0.0	0.0	0.0	0.0
	10°-75°	8	144	0.4	1.6	0.1	0.0	1.1	0.1	0.1	0.2	1.1
	11°-65°	1	18	0.3	0.9	0.2	0.0	0.9	0.0	0.0	0.0	0.6
	11°-70°	4	74	0.4	1.2	0.0	0.0	0.6	0.0	0.0	0.0	0.0
	11°-75°	4	70	0.9	1.6	0.1	0.0	1.2	0.0	0.0	0.0	0.9
	12°-65°	2	35	0.1	0.2	0.0	0.0	0.9	0.0	0.0	0.0	0.8
	12°-70°	1	20	0.2	0.8	0.0	0.0	1.0	0.0	0.0	0.0	0.0
	25°-70°	2	37	0.1	0.2	0.1	0.0	0.6	0.0	0.0	0.0	0.7
Sept.	01°-55°	37	811	2.0	0.7	0.4	0.0	0.3	0.0	0.0	0.0	0.5
	01°-60°	19	341	1.7	0.7	0.7	0.2	0.3	0.0	0.0	0.0	0.4
	01°-65°	15	322	1.5	0.5	0.6	0.0	0.4	0.0	0.0	0.0	0.6

Table 15.--Catches of the mothership expeditions for 1951. Catches are lumped by blocks of 1° of latitude and 5° of longitude with each block identified by its SW coordinates. All locations are N. latitude and E. longitude less 100 degrees (cont'd)

Month	Lat. Long.	Boat days fished	Hooks fished[1/]	Catch per 100 hooks: Yellow-fin	Big-eye	Alba-core	Skip-jack	Black marlin	Striped marlin	Sail-fish	Broad-bill	Sharks
Sept. (con.)	02°-50°	2	37	2.4	0.2	0.0	0.0	0.6	0.0	0.0	0.0	0.5
	02°-55°	57	1,056	2.6	0.5	0.4	0.0	0.4	0.0	0.0	0.0	0.4
	02°-60°	66	1,215	2.3	0.6	0.6	0.1	0.4	0.0	0.0	0.0	0.3
	02°-65°	35	715	1.6	0.6	0.6	0.0	0.4	0.0	0.0	0.0	0.6
	03°-50°	4	73	2.2	0.3	0.0	0.0	0.4	0.0	0.1	0.0	0.4
	03°-55°	20	315	2.1	0.5	0.0	0.0	0.5	0.0	0.0	0.0	0.3
	03°-60°	80	1,461	2.4	0.9	0.3	0.0	0.3	0.0	0.0	0.0	0.3
	03°-65°	34	681	1.4	0.7	0.1	0.1	0.3	0.0	0.0	0.0	0.5
	04°-55°	4	70	1.8	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	04°-60°	37	651	1.9	1.0	0.1	0.1	0.3	0.0	0.0	0.0	0.4
	04°-65°	46	776	1.6	0.9	0.1	0.1	0.3	0.0	0.0	0.0	0.4
	05°-50°	1	18	1.2	0.4	0.1	0.0	0.3	0.0	0.1	0.0	0.5
	05°-55°	7	123	2.2	1.0	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	05°-60°	6	116	1.4	1.7	0.2	0.1	0.2	0.0	0.0	0.0	0.5
	05°-65°	27	434	1.0	0.8	0.0	0.1	0.6	0.0	0.0	0.0	0.5
	05°-70°	12	224	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.7
	05°-75°	1	18	0.2	1.2	0.1	0.0	1.2	0.0	0.0	0.1	1.7
	06°-55°	2	40	0.9	0.9	0.0	0.0	0.5	0.0	0.0	0.0	0.4
	06°-65°	22	394	0.7	0.9	0.0	0.1	0.6	0.0	0.0	0.0	0.8
	06°-70°	23	368	0.8	0.7	0.0	0.1	0.7	0.0	0.0	0.0	0.8
	07°-65°	4	58	0.6	0.9	0.0	0.1	1.0	0.0	0.0	0.0	1.5
	13°-60°	1	21	2.2	0.2	0.6	0.2	0.6	0.0	0.2	0.0	0.1
	14°-65°	1	18	0.5	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.2
	24°-55°	4	72	0.3	1.1	0.1	0.1	0.9	0.0	0.0	0.0	0.0
	24°-60°	2	42	0.4	0.5	0.1	0.2	0.6	0.0	0.0	0.0	0.5
	25°-55°	1	18	0.1	0.3	0.9	0.0	1.0	0.0	0.0	0.0	0.1
	25°-70°	4	76	0.2	0.2	0.1	0.0	1.0	0.0	0.0	0.0	0.6
Oct.	02°-65°	15	182	1.6	0.5	0.1	0.0	0.6	0.0	0.0	0.0	0.1
	03°-65°	29	294	1.8	0.4	0.1	0.0	0.9	0.0	0.0	0.0	0.1
	04°-65°	1	16	1.0	1.1	0.0	0.0	0.6	0.0	0.0	0.0	0.0
	05°-70°	5	88	0.3	0.5	0.0	0.1	0.6	0.0	0.0	0.0	0.7
	05°-75°	49	927	0.6	0.7	0.0	0.1	0.6	0.0	0.0	0.0	0.6
	06°-65°	2	42	0.8	0.5	0.2	0.0	0.4	0.0	0.0	0.0	0.0
	06°-70°	16	279	0.7	0.7	0.1	0.1	0.6	0.0	0.0	0.0	0.8
	06°-70°	1	18	0.5	0.8	0.0	0.2	1.2	0.0	0.0	0.0	1.0
	06°-75°	156	2,923	0.6	0.7	0.0	0.1	0.7	0.0	0.0	0.0	0.6
	07°-70°	4	78	0.3	0.8	0.0	0.0	0.5	0.0	0.0	0.0	1.0
	07°-75°	81	1,408	0.5	0.7	0.0	0.1	0.7	0.0	0.0	0.0	0.8
	08°-70°	2	42	0.2	0.7	0.0	0.0	0.5	0.0	0.0	0.0	0.7
	08°-75°	43	753	0.3	0.7	0.0	0.0	0.6	0.0	0.0	0.0	0.9
	09°-70°	5	85	0.2	0.4	0.0	0.0	0.8	0.0	0.0	0.0	0.2
	09°-75°	32	591	0.3	0.9	0.0	0.1	0.5	0.0	0.0	0.0	1.2
	10°-75°	22	399	1.0	1.1	0.0	0.0	0.6	0.0	0.0	0.0	0.9

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