SIZE COMPOSITION AND SEXUAL MATURITY OF BILLFISH CAUGHT BY THE JAPANESE LONGLINE FISHERY IN THE PACIFIC OCEAN EAST OF 130°W*

by

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INTRODUCTION

The Japanese longline fishery for deep swimming tunas and billfishes began along the western margin of the eastern Pacific at about 130°W during 1956 and since then has expanded rapidly eastward throughout the temperate and tropical waters. During the early years, tuna was the primary object of the fishery; some billfishes were taken but only incidentally (Suda and Schaefer 1965a). During 1963, the fishery expanded towards the north and northeast where high concentrations of striped marlin were encountered, especially around the Revillagigedo Islands (Kume and Schaefer 1966). Since 1964, this expansion has continued northward to exploit striped marlin and swordfish and eastward to the mainland for sailfish (Kume and Joseph 1969). This increased fishing effort on billfish was due to decreased catch rates of tunas in the equatorial region and to an increased demand and concomitant higher price for billfish. The increased demand for billfish, excluding swordfish, was an outgrowth of the development of the fish sausage and fish ham industry in Japan. Marlin and sailfish are important ingredients of these products.

In addition to the Japanese longline fishery for billfish in the eastern Pacific, artisanal fisheries for these species exist in most of the Latin American countries bordering the Pacific Ocean; these fishermen capture marlin and sailfish primarily. Though catch statistics are not available, the quantity landed is thought to be small. In the northern hemisphere, swordfish are harvested commercially by U. S. fishermen and in the south by fishermen of Peru and Chile; neither fishery harvests on a very large scale.

Sport fisheries exist for nearly all species of billfish but marlin and sailfish are the primary species sought. Principal sportfishing centers are located in Mexico, Panama, Ecuador, Peru and Chile. Estimates of total catch by these fisheries are not available but it is believed to be increasing.

The geographical distribution of billfish in the eastern Pacific based on

* This research was supported by the U. S. Bureau of Commercial Fisheries and Bureau of Sport Fisheries and Wildlife Contract 14-17-0007-768 and by the Inter-American Tropical Tuna Commission.

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catches of the Japanese longline fishery has been described by Suda and Schaefer (1965a), Kume and Schaefer (1966) and most recently by Kume and Joseph (1969). Howard and Ueyanagi (1965), in a study of the billfish (excluding swordfish) of the Pacific Ocean, discussed their distribution in the eastern Pacific. Shiohama (1969) presented statistics on longline catches of billfishes from the eastern Pacific during 1963 and 1964 and commented briefly on certain related biological features. Chernyi (1967) discussed the distribution of sailfish in southern Mexico, and attempted to relate this to oceanographic features. Parin (1967) commented very briefly on the distribution, fisheries and biology of swordfish, striped marlin and blue marlin in the eastern Pacific. Though many authors have commented on the occurrence of billfish in near coastal waters, information is very fragmental.

In this study we present information on size composition and sexual maturity collected from billfish captured by longline east of 130°W during the period 1963–1967. On the basis of these studies, some inferences are drawn concerning the population structure of the billfish inhabiting the eastern Pacific.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Dr. H. Yabe, Director of the Far Seas Fisheries Research Laboratory (FSFRL) for making it possible for the senior author to join the staff of the Inter-American Tropical Tuna Commission as a visiting scientist and for allowing us to use for this study data collected by personnel of his laboratory. We are also grateful to Dr. J. L. Kask, Director of Investigations of the Tuna Commission, for supporting this program. Thanks are also extended to Mr. Susumu Kato for his many helpful suggestions on the swordfish fishery in the eastern Pacific.

NOMENCLATURE

The nomenclature for billfish adopted by Kume and Joseph (1969), including common names in Japanese, Spanish and English with their abbreviations, are used throughout this report. When the term billfish is used in this report, it is meant to include the following species:

Spanish	*Japanese*	*English*	*Abbreviation*	*Scientific*
Pez espada	Mekajiki	Swordfish	SW	*Xiphias gladius*
Pez aguja corta	Furaikajiki	Shortbill spearfish	SS	*Tetrapturus angustirostris*
Marlin rayado	Makajiki	Striped marlin	SM	*Tetrapturus audax*
Marlin azul	Kurokajiki	Blue marlin	BUM	*Makaira mazara*
Marlin negro	Shirokajiki	Black marlin	BKM	*Makaira indica*
Pez vela	Bashokajiki	Sailfish	SF	*Istiophorus platypterus*

COLLECTION AND PROCESSING OF DATA

Billfish caught by commercial longliners operating in distant waters are generally gilled and gutted, dressed, or filleted at sea depending on their size. It is nearly impossible to determine the time and location of capture of those fish landed in Japan because longline vessels are at sea for extended periods and fish over wide areas before a full load of fish is obtained. Thus the fish only rarely serve as representative samples of the size-composition of catches of billfish made by commercial longline fishing gear.

To obtain suitable samples, the Far Seas Fisheries Research Laboratory (formerly the Nankai Regional Fisheries Research Laboratory), the Fisheries Agency of Japan, the Prefectural experimental fishing groups and Prefectural training groups joined in a cooperative research program in which arrangements were made to place men aboard these training and experimental vessels who could collect, among other things, the desired information on fish size and gonad weight. All data collected in this way pertain to the eastern Pacific south of 20°N during the period January 1963 to July 1967. These data are used in our analysis together with data from three cruises of the R/V *Shoyo-Maru*, the research vessel of the Fisheries Agency of Japan, (Japan Fishery Agency 1963, 1964, 1965).

For the analysis which follows, we have used 5-cm intervals of the eye-fork length (the shortest distance between the posterior margin of the eye-cavity and the distal tip of the central rays of the tail) to express the size of billfishes. Additional details of the methodology of collecting and processing data on size composition and gonads are given by Suda and Schaefer (1965b) and Kume and Joseph (1966).

Most of the data presented in this study pertain to striped marlin, blue marlin and swordfish (Appendix Table 1). The data concerning sailfish and shortbill spearfish are few and those on black marlin too fragmentary to analyze. The data are summarized by the major fishing areas (Figure 1) employed by Kume and Joseph (1969), and by quarters of the year. To remove chance fluctuations, data or size-frequencies were smoothed by a moving average of three giving double weight to the middle value.

Gonad indices (GI) were computed as

$$GI = (w/L^3) \cdot 10^4$$

where

w = weight of both ovaries in grams, and

L = eye-fork length in cm.

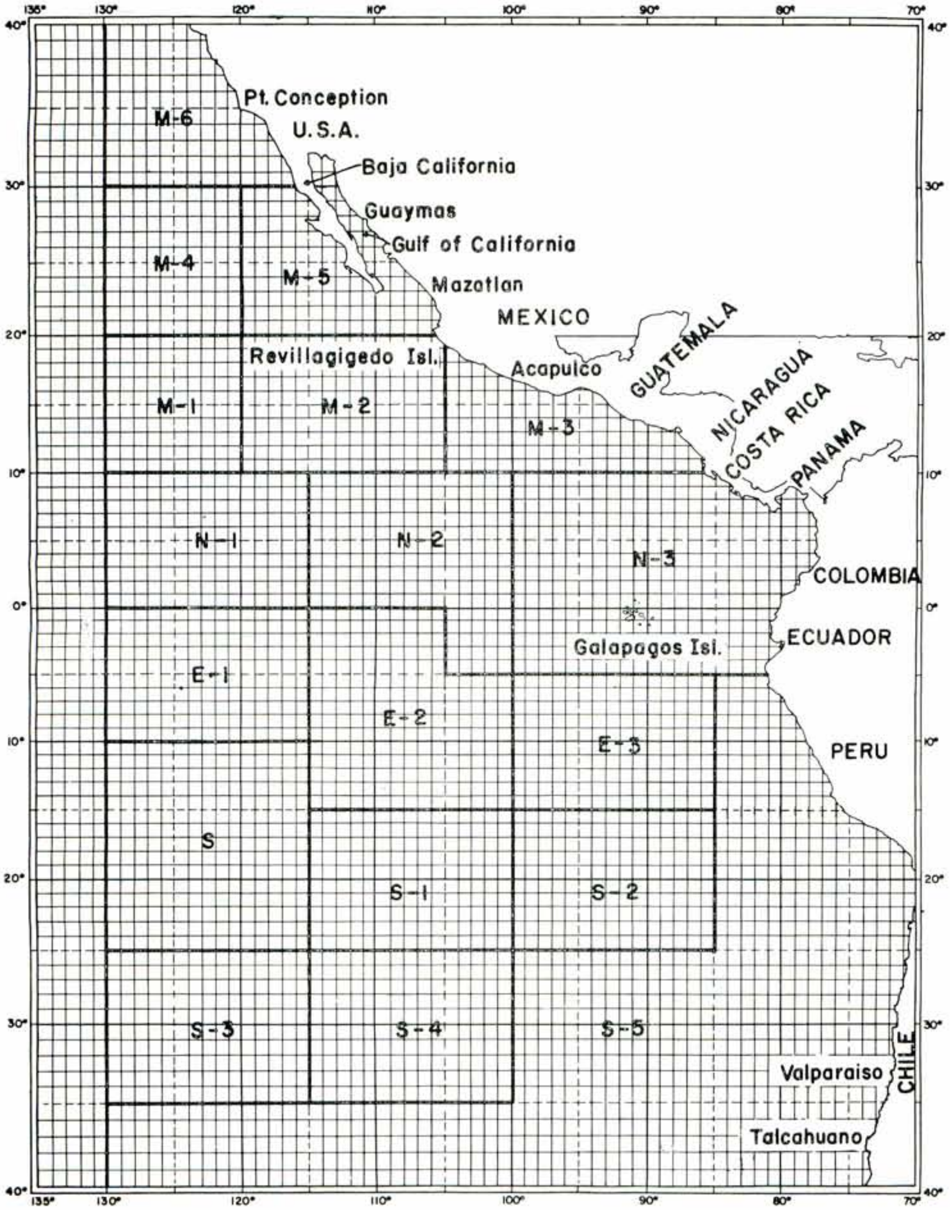


Fig. 1. Major fishing areas referred to in this study (after Kume and Joseph 1969).

RESULTS

Striped marlin

Distribution

As reflected by longline catches, striped marlin is the most abundant (in terms of weight) of the billfish species in the eastern Pacific. To examine their relative seasonal distribution, we prepared Figures 2a through 2d, showing the average catch per 1000 hooks by quarters of the year within 1°-areas. The figures include all available data from Suda and Schaefer (1965a), Kume and Schaefer (1966) and Kume and Joseph (1969), pooled by quarters.

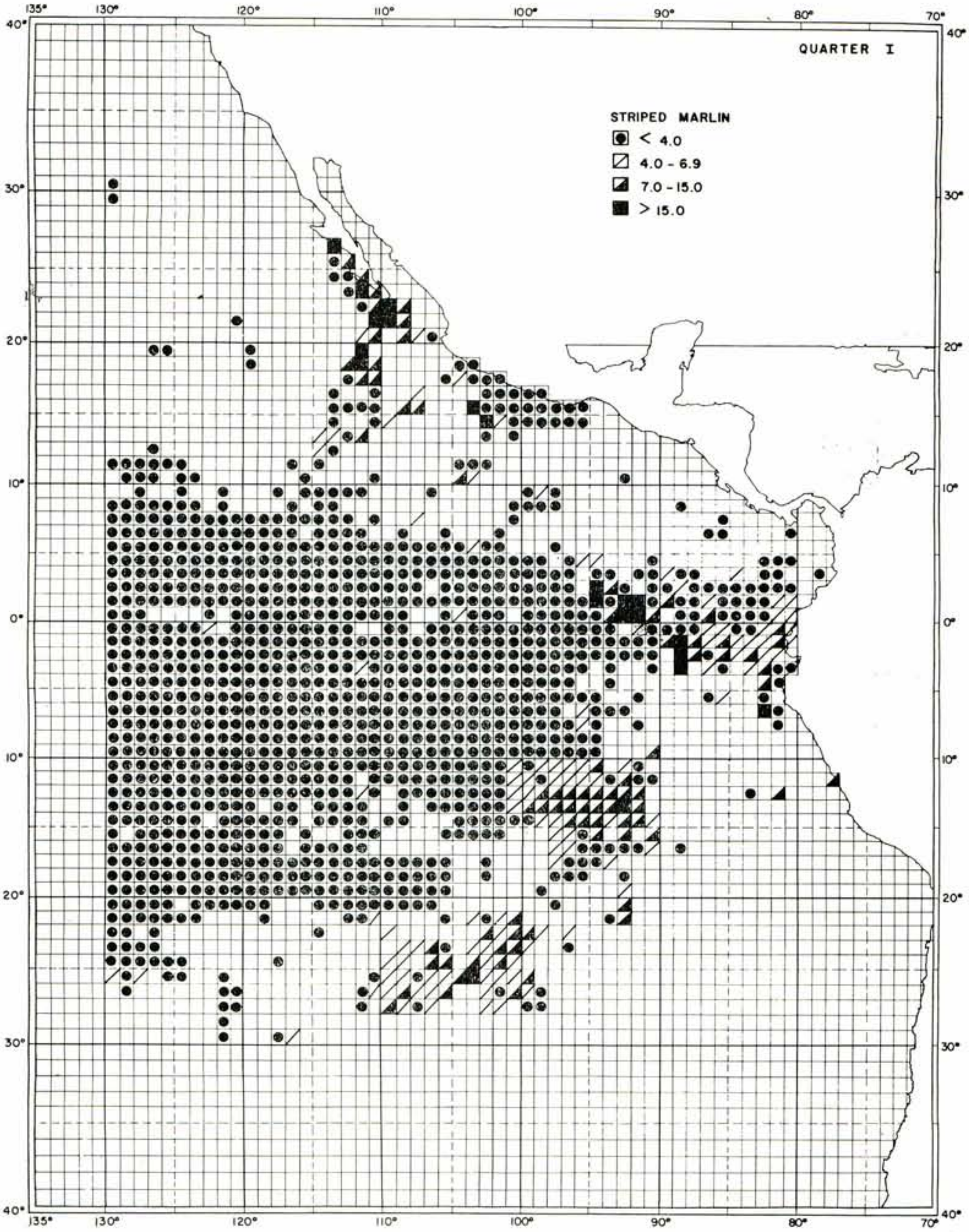


Fig. 2a. Average number of striped marlin caught per 1000 hooks by Japanese longline vessels in the eastern Pacific during the first quarter, 1957-1966, shown by 1-degree areas.

Striped marlin are encountered throughout the year between 30°N and 30°S but generally appear to become more abundant towards the coast. Concentrations also occur throughout the year in the area of the Revillagigedo Islands,

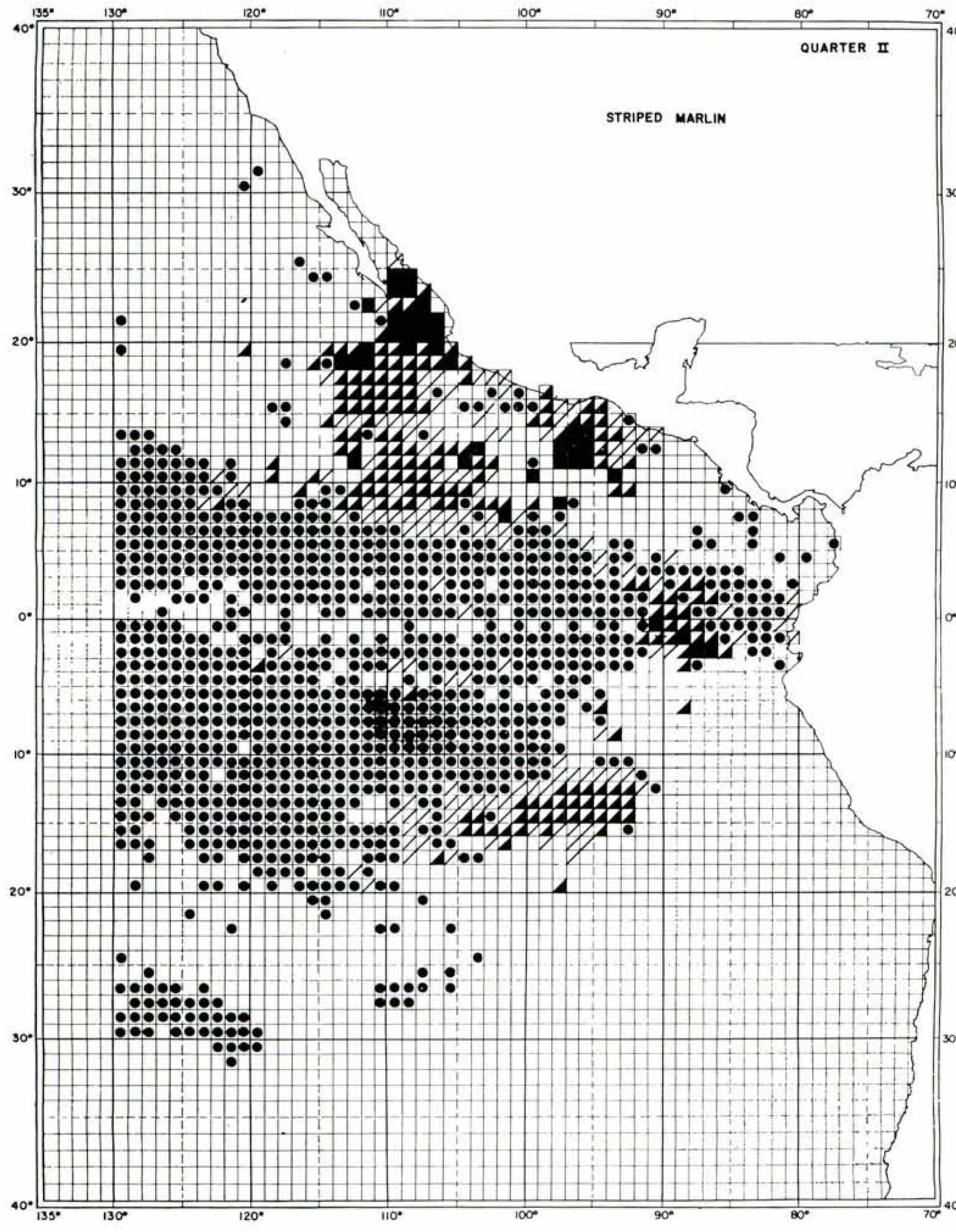


Fig. 2b. ditto, second quarter

Baja California, Ecuador, the Galapagos Islands and in the high-seas region bounded by 90–110°W and 10–30°S.

Distributional patterns change remarkably from season to season. In the Baja California-Revillagigedo area, highest concentration during the first quar-

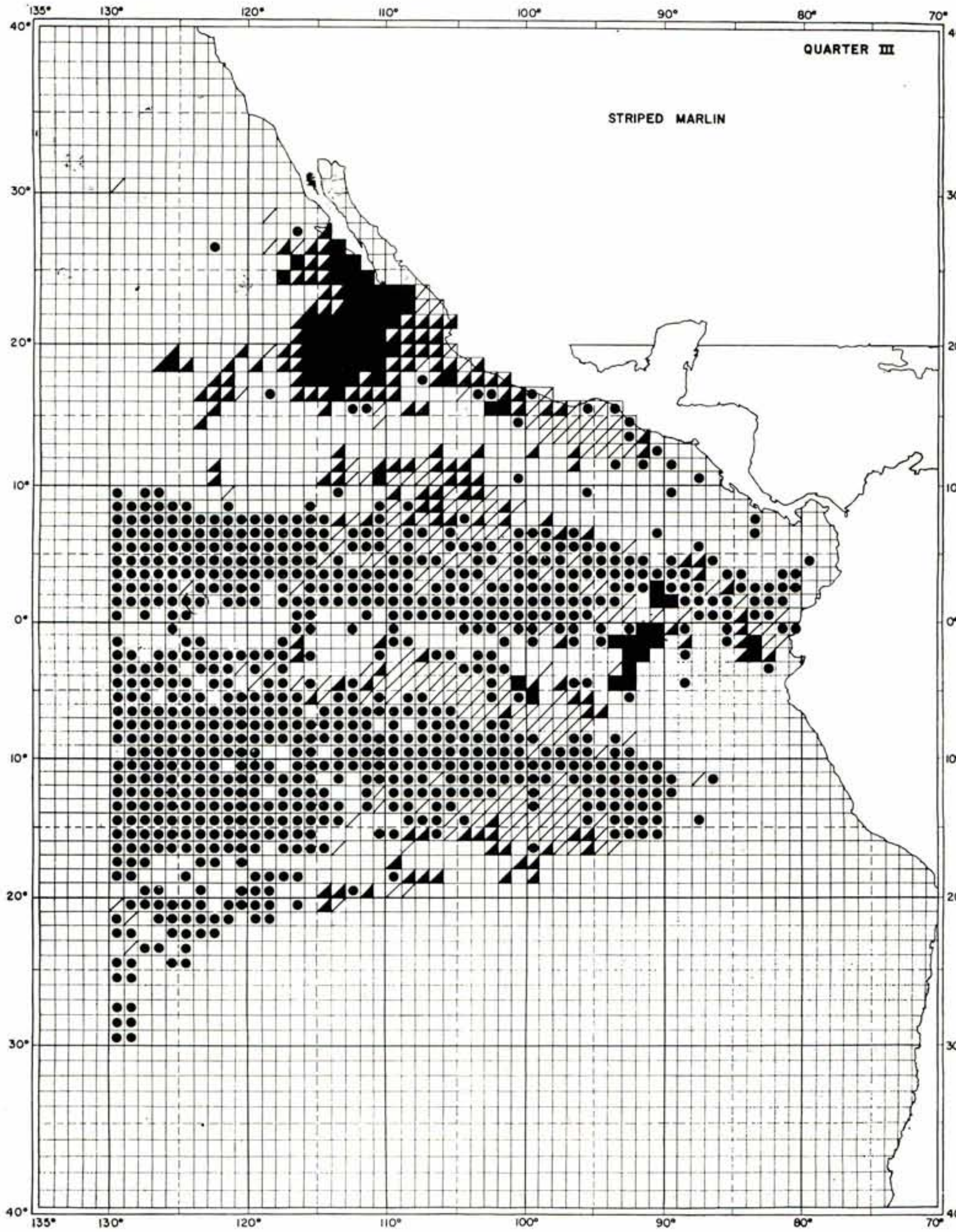


Fig. 2c. ditto, third quarter

ter appears to occur in a relatively narrow region about the tip of Baja California and extending southwest to encompass the Revillagigedo Islands. During the second quarter, this area of high concentration extends southerly along the coast of Mexico to about 10°N and seaward to 115°W. By the third quarter,

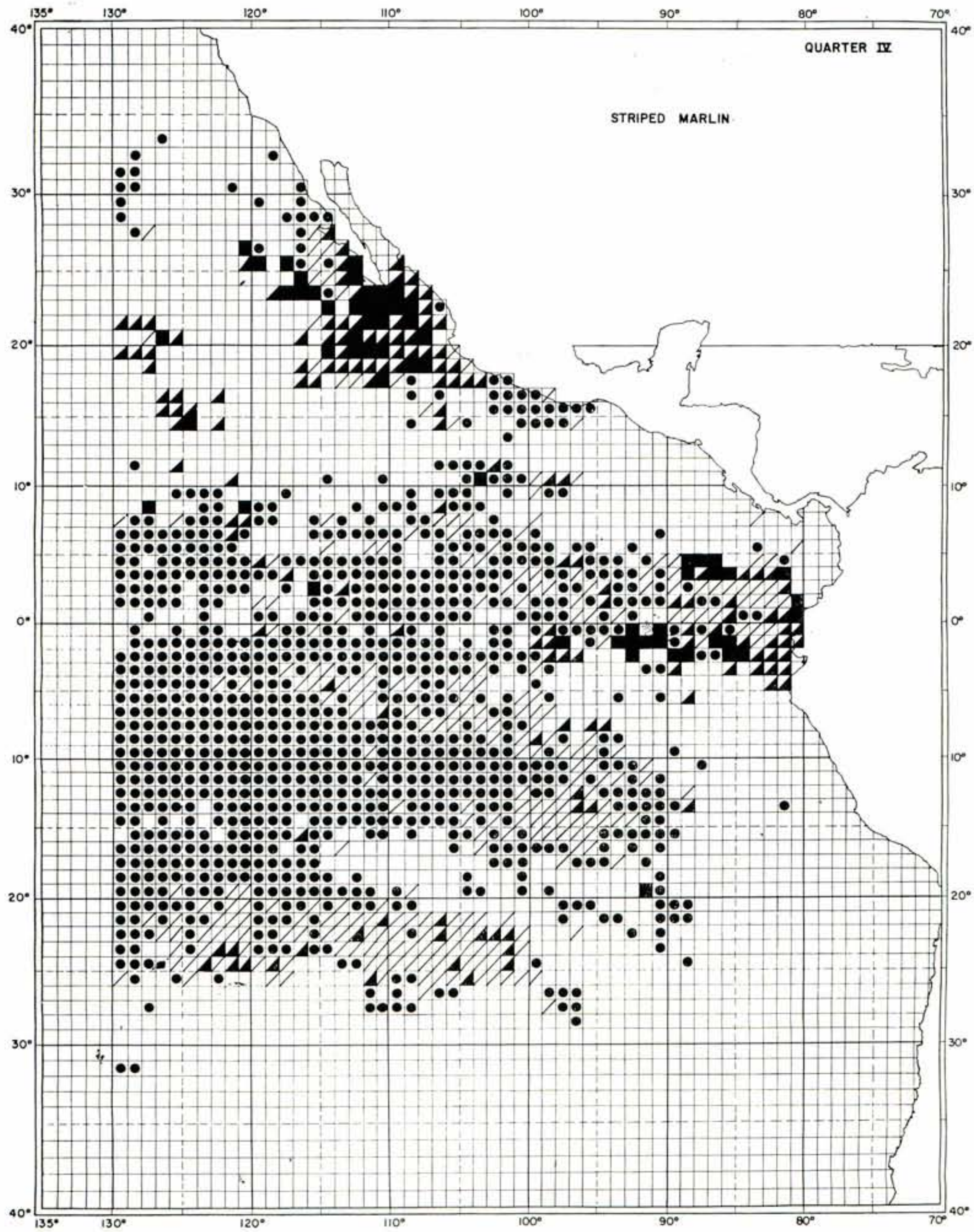


Fig. 2d. ditto, fourth quarter

the area has expanded northward along the coast to about 28°N and seaward to approximately 125°W. Though the area of high hook rates in the fourth quarter appears to be smaller than during the third quarter, it extends farther seaward, to about 130°W. During the second and third quarters of the year, an area of high hook rates also occurs centered at about 8-13°N. It is interesting to note that this corresponds to the period when the equatorial countercurrent develops strongly in this area (Wyrtki 1965).

During the second quarter, striped marlin appear to be concentrated about the Galapagos Islands but shift shoreward during the third. By the fourth quarter, the approach of the southern summer, high concentrations extend all along the coast of Ecuador; these concentrations begin to recede seaward during the first quarter.

In the high-seas area between about 10°N and 10°S, marlin are not abundant except for the area between 8-13°N mentioned above. They also occur in moderate abundance during the third and fourth quarters in a band extending diagonally from about 5°S-120°W to 8°S-95°W. It is in this general region that the eastern extension of the south equatorial countercurrent is located (Wyrtki 1963).

During the second and third quarters, the southern winter, high concentrations are found in the area bounded by 13°S-19°S and 90°-115°W but extend southerly to about 28°S during the first and fourth quarters which correspond to the southern summer.

Generally, striped marlin are confined to the more coastal waters during the first quarter of the year. As the year progresses, they appear to move westerly and towards the equator from coastal areas of high concentration in the northeast and southeast; by the fourth quarter they are found at their maximum seaward extent. This strongly suggests a seaward migration but could be equally attributable to increasing catchability of the fish themselves. It is not possible to determine which of these factors is operating.

Aside from information on the distribution of striped marlin obtained through records of the longline fishery, some data are available from artisanal and sport fisheries. Though striped marlin are taken in subsistence fisheries throughout much of Latin America, only Ecuador appears to take them in any quantity (Univ. of Miami 1955). Sportsmen capture them intermittently from Southern California to northern Chile but reliable information on the amount landed is not available. Fitch (n. d.) states that their northern coastal limit is Point Conception, California, and the University of Miami (1955) reports that their southern limit occurs off northern Chile.

Review of the literature on sportfishing for striped marlin reveals the following seasonal patterns in distribution:

1) In South American coastal waters striped marlin occur throughout the first semester of the year, but are most abundant from February through May (Univ. of Miami 1955);

2) Howard and Ueyanagi (1965) state that the fishing season for striped marlin along the Mexican coast, north of 17°N, is from December through June;

3) In the Gulf of California, striped marlin are most abundant in May and June off Guaymas (Farrington 1953);

4) Striped marlin appear off Southern California during the summer and fall months (Fitch 1963).

Thus the seasonal distribution of striped marlin as reflected by sport catches corresponds well with that inferred from commercial longline catches.

Size composition

The size composition of 6526 striped marlin taken by longline vessels in the eastern Pacific from January 1963 to July 1967 is shown in Figure 3 in terms of percentage. All but about 15% of the samples were taken south of 10°N. The fish range from 80 to 275 cm in eye-fork length; however, the majority of the samples fall between 140 and 190 cm. The frequency is unimodal and the mode occurs in the 170 cm class.

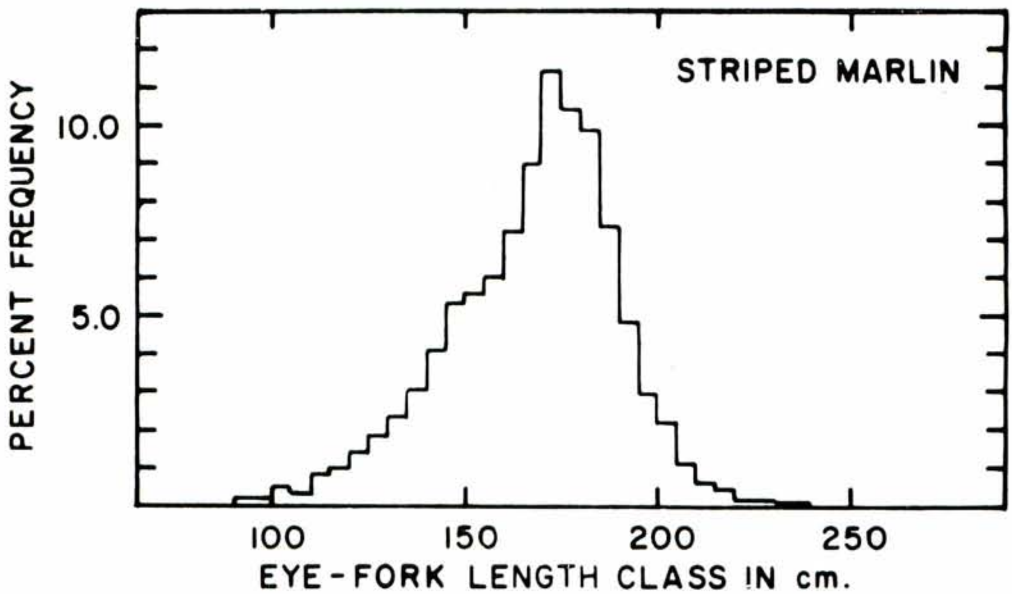
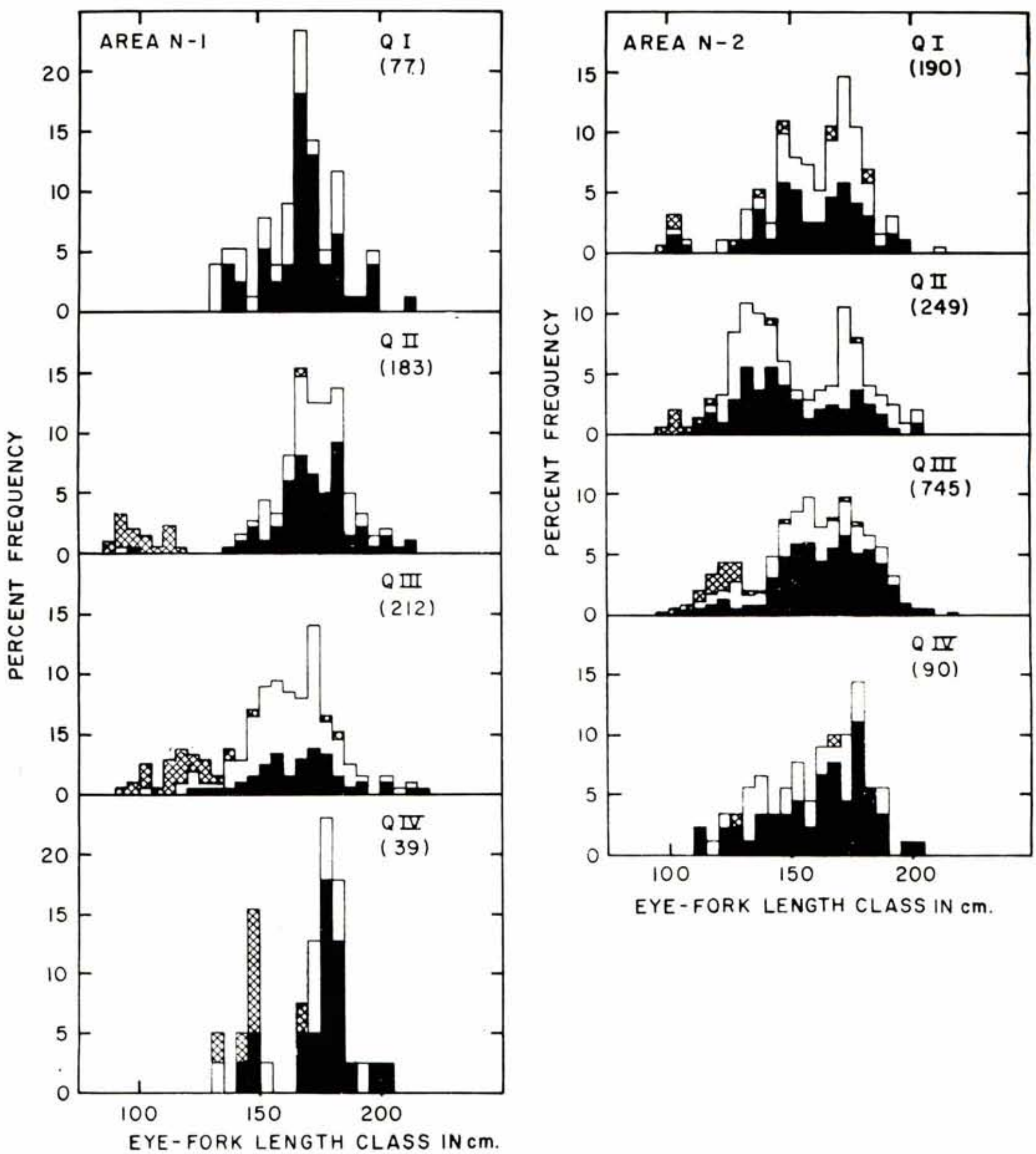


Fig. 3. Smoothed length-frequency distribution, in percent, of 6526 striped marlin captured by Japanese longline vessels in the eastern Pacific, 1963-1967.

To examine this size composition in greater detail, percentage-frequency distributions are shown by major fishing areas and averaged within quarters by three categories, i. e. males, females and sex unkown (Figure 4). Because of natural breaks that occur in the distribution and size composition of striped marlin in Area N-3, we divided it into two sub-areas; N-3e for the sub-area east of 90°W and N-3w for that portion of N-3 lying west of 90°W.

In areas N-1, N-2, N-3w, M-2 and M-3, a large share of the fish measured appears to be below 150 cm in eye-fork length. Though some recruitment of these smaller fish takes place throughout the year, with the exception of area N-3w it appears to be the highest during the second and third quarters. A medium-sized group of fish between 150 and 190 cm appears in nearly every quarter and

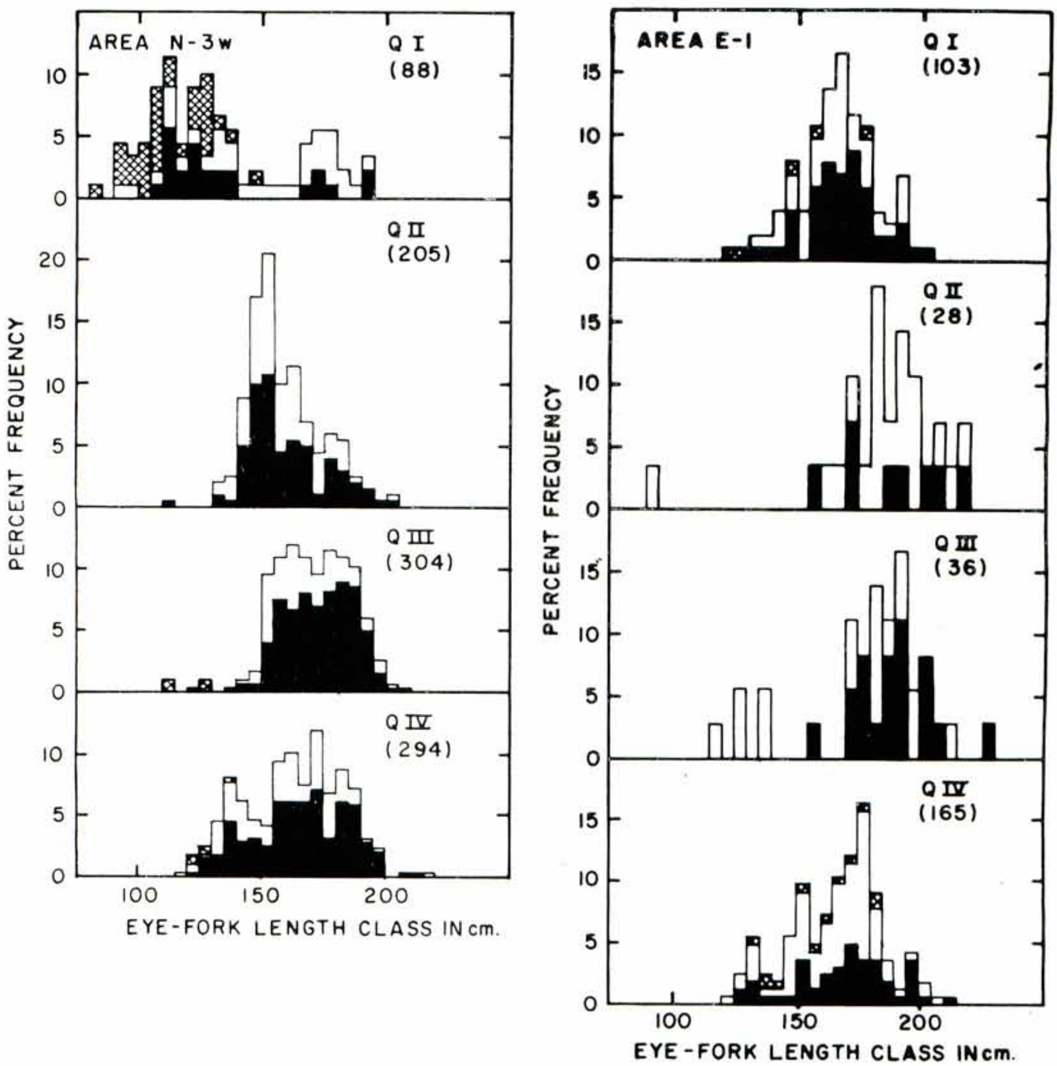
Fig. 4 (1)



area stratum and it is by far the dominant size group in E-1, E-2, E-3 and N-3e. In area S, a large proportion of the catch is made up of fish greater than 190 cm. With the exception of area N-3w, there does not appear to be a great deal of seasonal fluctuation in size composition of fish greater than 150 cm in eye-fork length.

There appears to be a general tendency for average size to increase in a southerly direction, if one compares the size-composition data during the second quarter only. This gradient of increasing size in a southerly direction is also striking in the fish captured from December through February by the R/V *Shoyo-Maru* (Figure 5); in the north, the size range is 80 to 180 cm while in the south

Fig. 4 (2)



it is 160 to 220 cm.

According to Howard and Ueyanagi (1965, Figs. 10 and 11), two modal groups (80 and 130 pounds) of striped marlin are taken in the sport fishery off southern California in some years; these weights correspond to approximately 150 and 180 cm in eye-fork length, respectively. Since these sizes compare well with those of areas M-2 and M-3, the fish caught off southern California probably represent a northerly extention of the distribution in this general area (Figures 2c and 2d).

There seems to be a general trend for the proportion of females of striped marlin to increase as size increases (Figure 4). This trend is even more evi-

Fig. 4 (3)

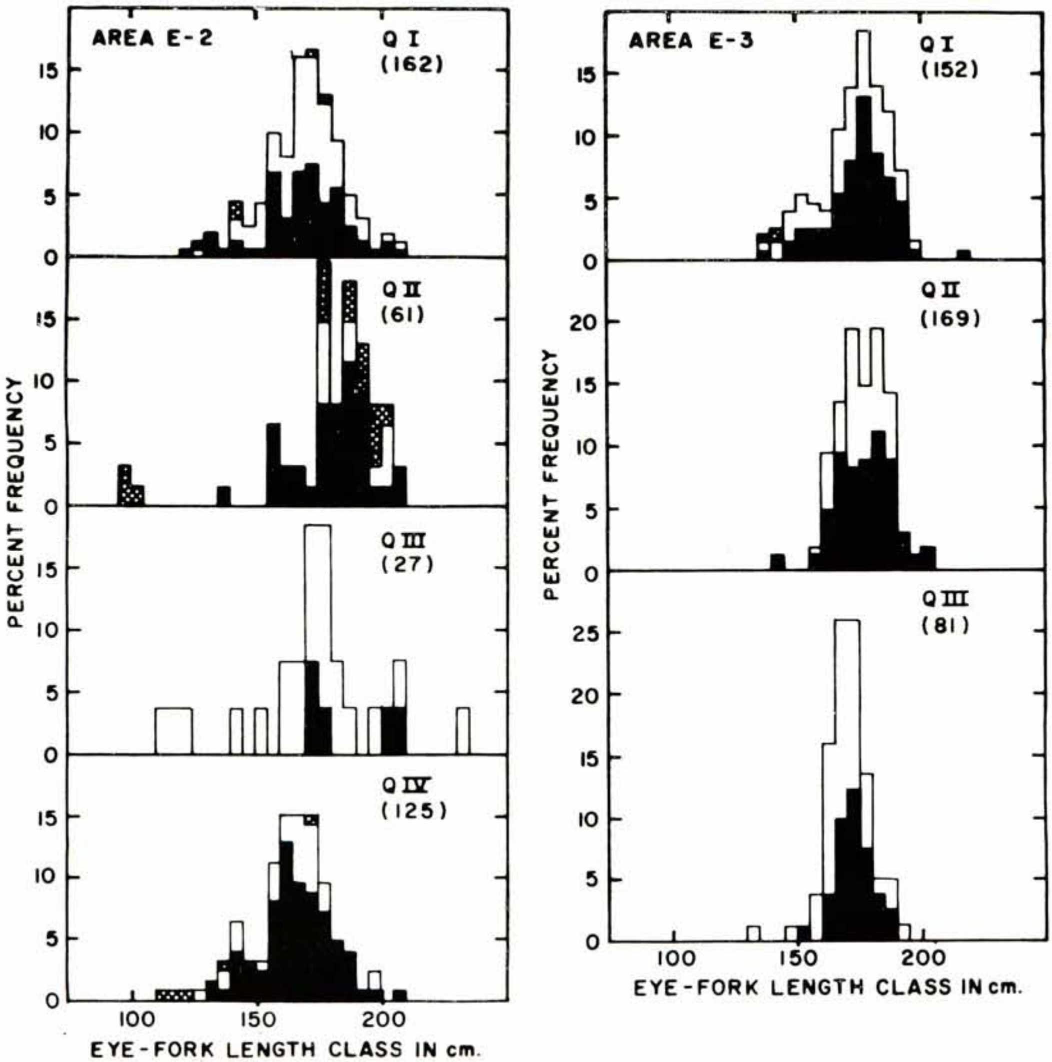


Fig. 4 (4)

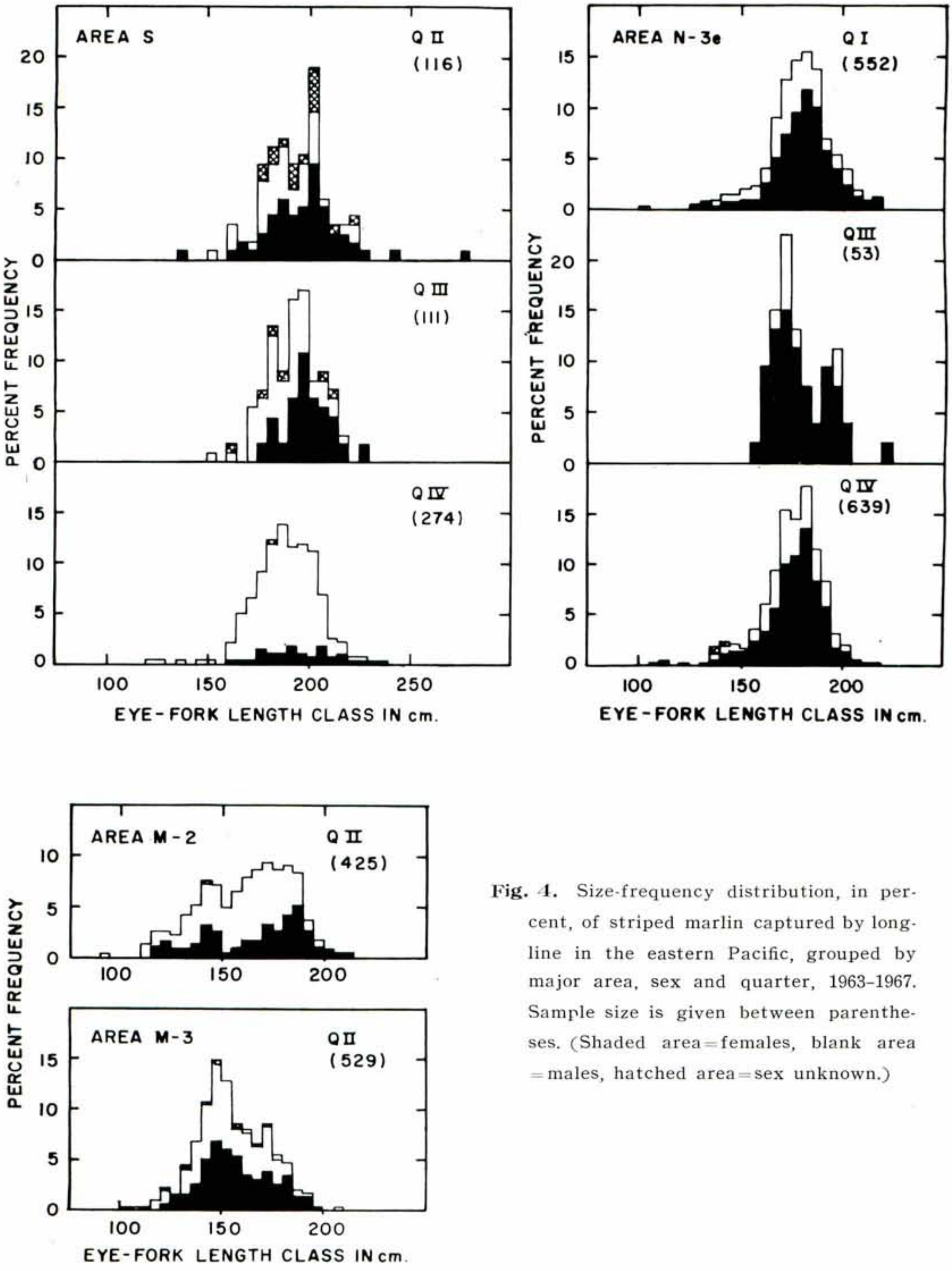


Fig. 4. Size-frequency distribution, in percent, of striped marlin captured by longline in the eastern Pacific, grouped by major area, sex and quarter, 1963–1967. Sample size is given between parentheses. (Shaded area = females, blank area = males, hatched area = sex unknown.)

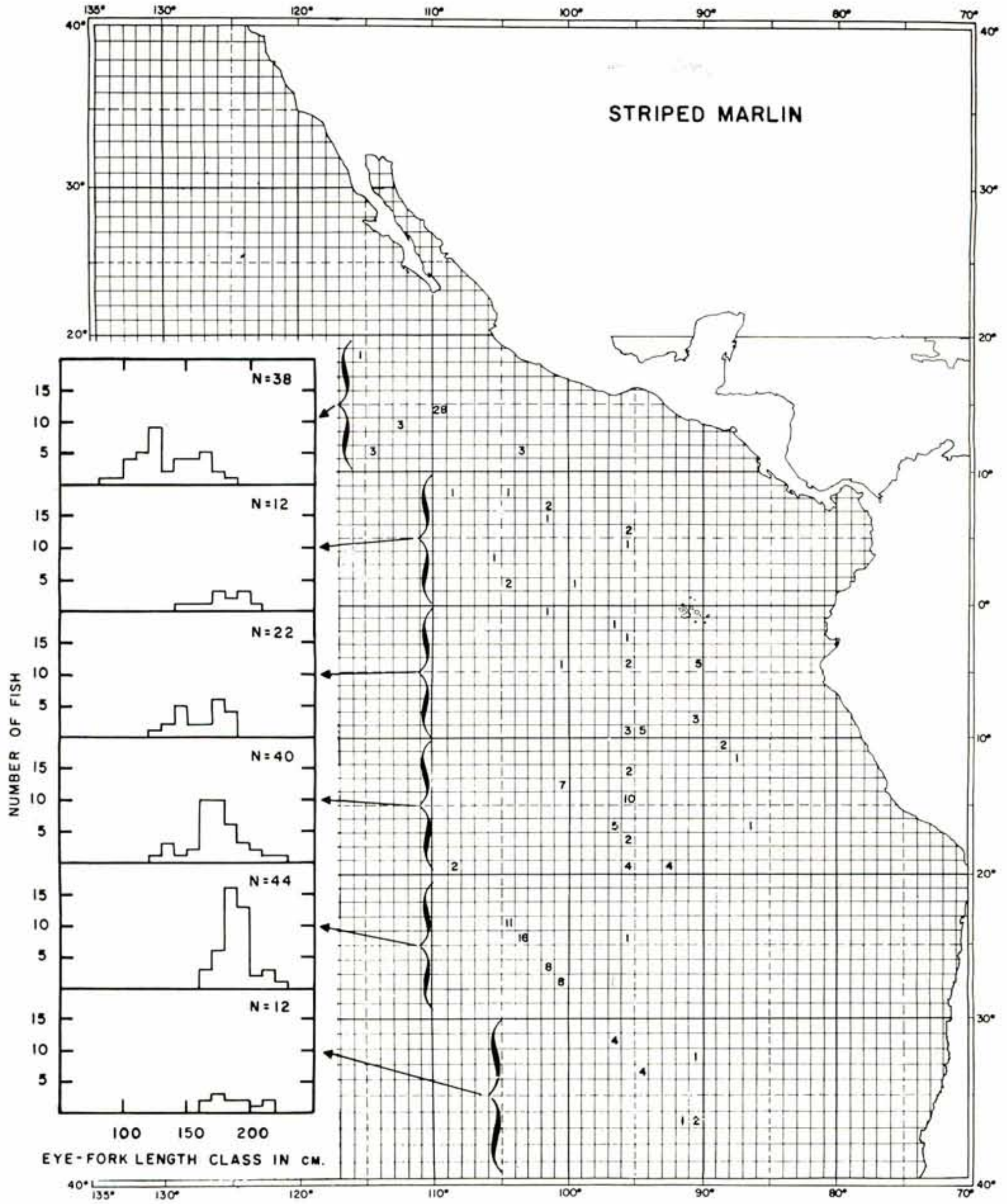


Fig. 5. Mean length frequency of striped marlin captured by the R/V *Shoyo-Maru*, December-February, 1962-1965. Numbers within 1-degree squares denote quantity and location of fish sampled.

dent in Table 1 which shows quarterly sex ratios, in terms of the percentage of females, by major areas and by size intervals of <150 cm, 150-189 cm, and >189 cm. Two hundred and eighty eight fish (4.4% of the total) were eliminated from our analysis because their sex could not be determined.

Exceptions to this predominance of females with increasing size are noted

Table 1. The numbers of male and female striped marlin captured by Japanese longliners in the eastern Pacific, grouped by size-class, area, and quarter.

		Quarter I			Quarter II			Quarter III			Quarter IV		
Area	Size class (cm)	Male	Female	Percentage of females	Male	Female	Percentage of females	Male	Female	Percentage of females	Male	Female	Percentage of females
M-2	<150				95	38	28.6	1	0	0.0			
	150~189				185	79	29.9	10	6	37.5			
	>189				8	19	70.4	0	0	—			
	Totals				288	136	32.1	11	6	35.3			
M-3	<150				119	93	43.9						
	150~189				139	152	52.2						
	>189				2	8	80.0						
	Totals				260	253	49.3						
N-1-2 and -3w combined	<150	47	51	52.0	97	104	51.7	117	109	48.2	47	59	55.7
	150~189	97	101	51.0	180	190	51.4	316	535	62.9	94	184	66.2
	>189	6	12	66.7	16	19	54.3	18	61	77.2	4	20	83.3
	Totals	150	164	52.2	293	313	51.7	451	705	61.0	145	263	64.5
N-3e	<150	15	12	44.4				0	0	—	16	19	54.3
	150~189	144	267	65.0				6	33	84.6	156	350	69.2
	>189	29	84	74.3				2	12	85.7	30	60	66.7
	Totals	188	363	65.9				8	45	84.9	202	429	68.0
E-1-2 and -3 combined	<150	22	18	45.0	1	3	75.0	11	0	0.0	24	20	45.5
	150~189	155	175	53.0	84	117	58.2	67	46	40.7	98	112	53.3
	>189	14	20	58.8	13	23	63.9	8	12	60.0	7	12	63.2
	Totals	191	213	52.7	98	143	59.3	86	58	40.3	129	144	52.7
S	<150	2	0	0.0	0	1	100.0	0	0	—	4	0	0.0
	150~189	2	2	50.0	23	19	45.2	29	9	23.7	122	13	9.6
	>189	5	1	16.7	18	39	68.4	26	41	61.2	111	23	17.2
	Totals	9	3	25.0	41	59	59.0	55	50	47.6	237	36	13.2

in areas M-2 during the second quarter and S during the fourth quarter; males are predominant in nearly all size classes in these areas. These two time and area strata correspond to the areas and periods of highest spawning activity as reflected by gonad indices. This apparent predominance of males on the spawning grounds has been observed for billfish in other areas as well.

Though distinct modes occur within the strata of time and area presented in Figure 4, it is not possible to detect any orderly modal progressions which might reflect growth rates. Neither is it possible to detect seasonal progression of the modes when data from different areas are pooled within quarters (Figure 6). Figure 6, however, does seem to indicate that there are differences in modal sizes between the sexes. During the first semester of the year, the modal sizes for females are distinctly larger than those for males. However, during the second semester the modes are superimposed. As was demonstrated above, the proportion of females to males generally increases with size. Similarly modes occur at smaller sizes during the second and third quarters and, as discussed earlier, may reflect recruitment. The fact that smaller secondary modes are not more prominent may be attributable to the difficulty of distinguishing the sex of these smaller individuals.

Sexual maturity of females

To examine the sexual maturity of striped marlin in the eastern Pacific, we plotted the ovary weight against the eye-fork length for 2046 individuals (Figure 7). Clearly most of the individuals have ovary weights of less than 1 kg but some are as high as 9 kg. To obtain some idea of the relative maturity of striped marlin from the magnitude of the gonad indices, we refer to the work of Ueyanagi (1957) who examined ovarian eggs from 22 fish captured in the western Pacific during May and June which ranged in size from 157 to 204 cm in eye-fork length. Eleven of these specimens were mature or maturing, and their gonad indices ranged from 1.9 to 10.3 with a mean of 6.0. On the basis of his study and for the purposes of this analysis, we shall assume that females with gonad indices ≥ 3.0 are in a spawning condition and are members of a spawning group. Isopleths of gonad indices at 3.0 and 5.0 are shown in Figure 7. Clearly most of the individuals have gonad indices less than 3.0 which suggests that not many of these fish were in a spawning condition. The number shown in Figure 7 at each X, Y-intercept above a gonad index of 3, represents the month the sample was collected. Those numbers that are underlined pertain to samples that were taken from southern latitudes and the others from northern latitudes. The smallest female occurring in the spawning group was in the 148 cm class; however, individuals do not regularly occur in the spawning group until about 160 cm. In the north, the highest frequency of fish in the spawning group occur in May and June, whereas November and December are the peak months in the southern latitudes. These months correspond to the summer months in both cases.

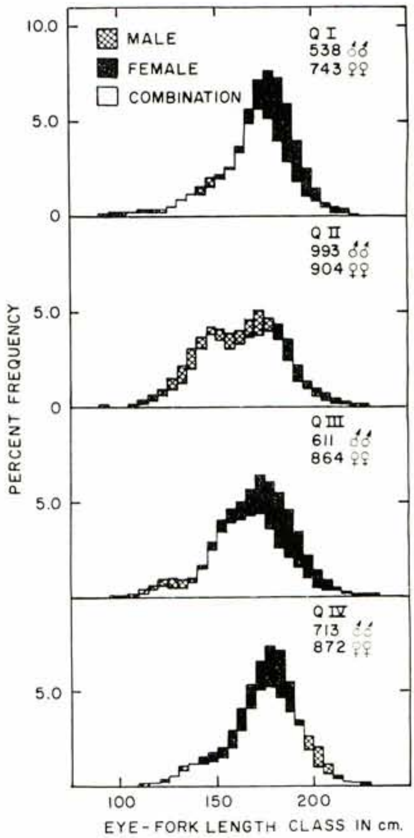


Fig. 6. Percent-frequency curves of male and female striped marlin from the eastern Pacific longline fishery for all areas combined, averaged by quarters. A hatched area indicates a predominance of males, a shaded area indicates a predominance of females and a blank area indicates where the two sexes overlap.

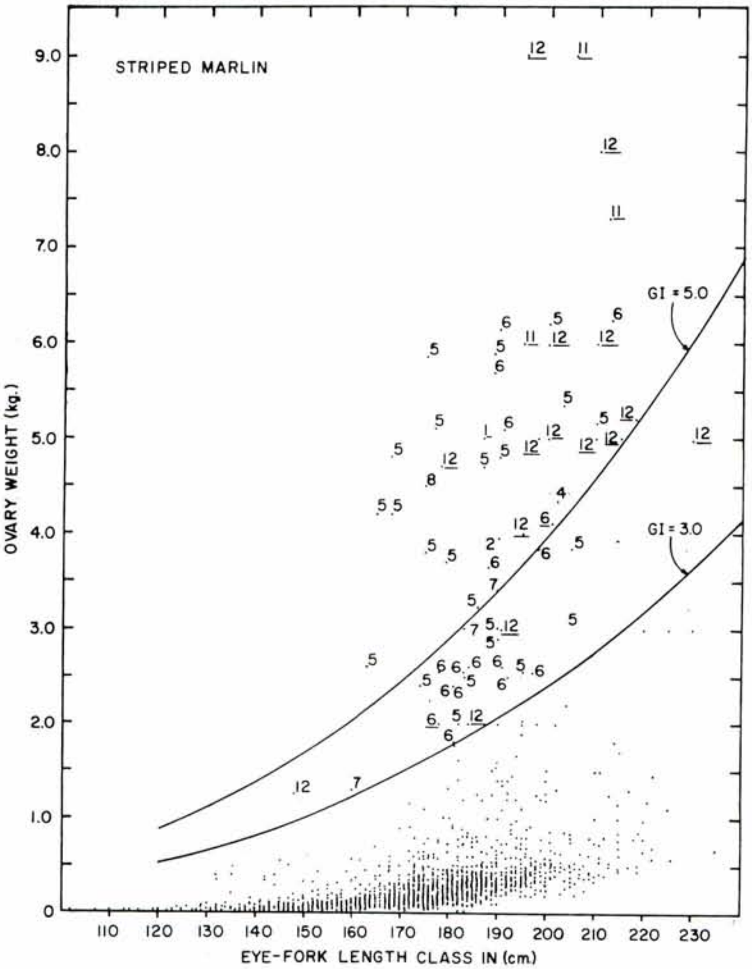


Fig. 7. Scatter diagram showing the relation between length and ovary weight of 2046 striped marlin from the eastern Pacific longline fishery. Numbers show the occurrence of the month and underlines denote individuals from southern latitudes. Isopleths are for gonad indices of 3.0 and 5.0.

To examine the seasonal and geographical distribution of these spawning groups in more detail, we plotted the highest gonad index encountered during a quarter within a given 1° area (Figures 8a–8d). The indices were divided into three categories: >5.0, 3.0–5.0 and <3.0. In the northern latitudes, the spawning group of striped marlin shows up quite well in the second and, to a lesser degree, in the third quarter, in the general area bounded by 5–20°N and 105–112°W. Unfortunately, not many samples were taken in this area during the first and fourth quarters. In the southern latitudes, where sampling coverage was more complete, spawning groups are found in the first, second and fourth quarters; however, the occurrence of fish within the spawning groups is much higher during the fourth quarter. The area occupied by this southern spawning group is generally bounded by 20-25°S and 125-130°W. On the basis of these analyses, it appears that striped marlin spawn in two isolated areas at opposite times of the year. It also is clearly demonstrated that fish in a near-spawning condition have not been captured by longline gear in the equa-

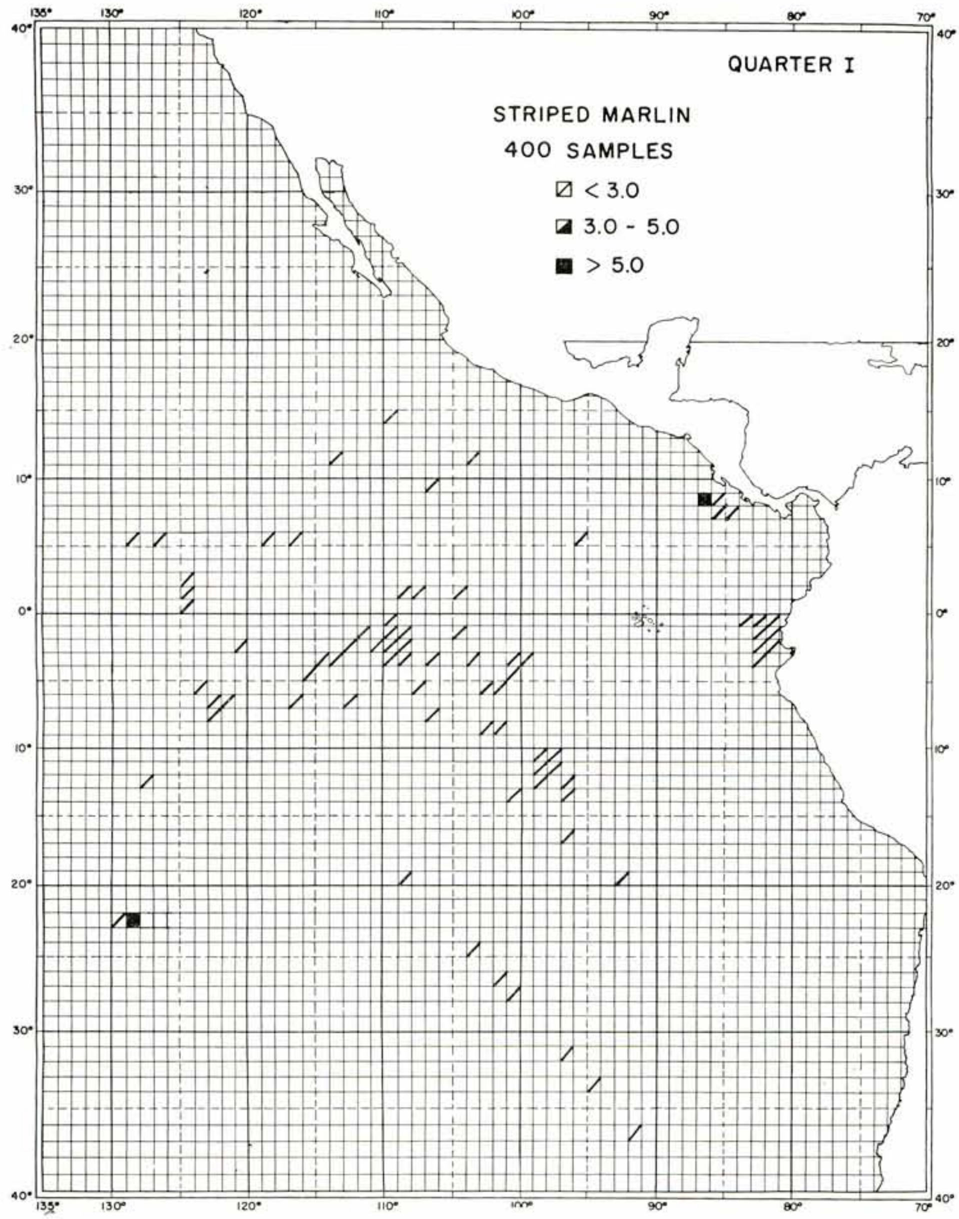


Fig. 8a. Highest gonad index of striped marlin from the eastern Pacific observed during the first quarter, shown by 1-degree areas and by three size categories.

torial regions of the eastern Pacific.

The size composition of the two spawning groups appears to be different (Figure 4). Fish in the north are smaller, the majority falling between 140 and 180 cm, while most of those in the south fall between 160 and 220 cm.

Population structure

Striped marlin are found widely distributed throughout the eastern Pacific

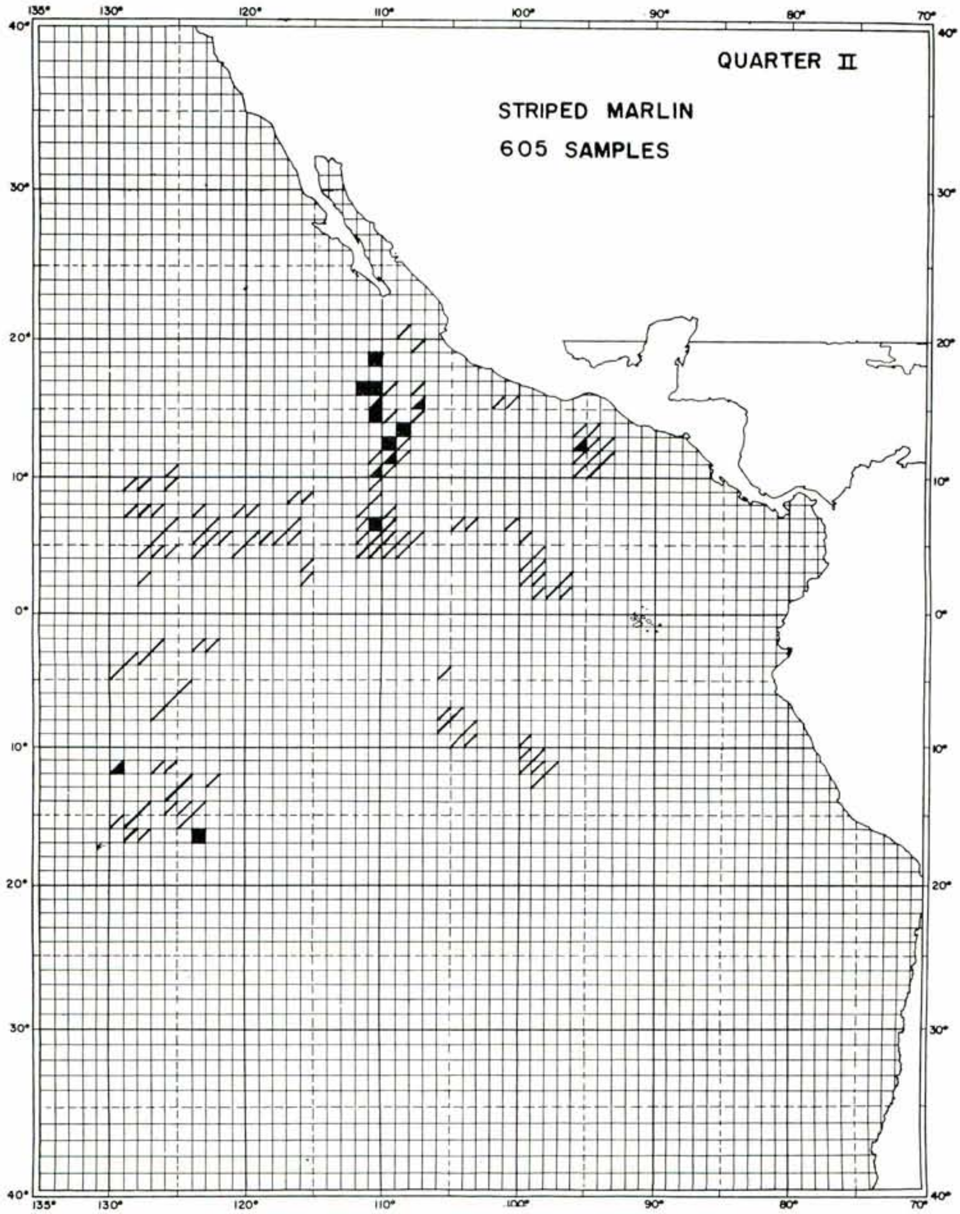


Fig. 8b. ditto, second quarter

Ocean. Although they extend seaward north of about 15°N and south of about 20°S, highest concentrations appear to be more coastal. Areas of high concentration seem to change seasonally and do not necessarily adjoin each other. Size-composition data suggest a tendency for the average size of striped marlin to increase in a southerly direction. This could be explained by a tendency of fish to inhabit more southerly waters as they grow, differential catchability, or

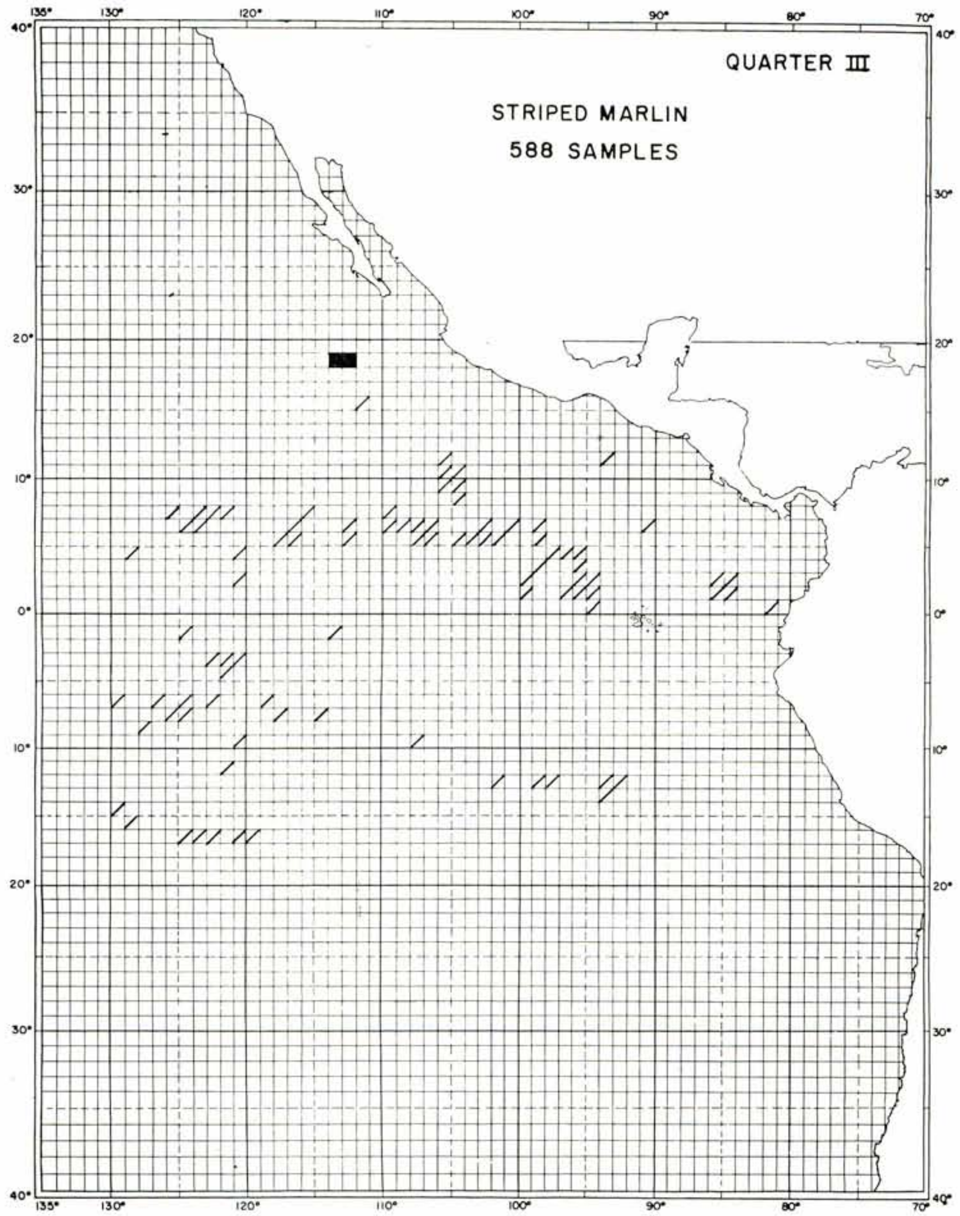


Fig. 8c. ditto, third quarter

a number of semi-independent stocks of fish distributed in a north-south plane. Although few marlin have been tagged and recovered, one tagged off Baja California moved south to near the equator, and a second fish tagged in the same area moved westerly to near the Hawaiian Islands(Anonymous 1968). Such recoveries suggest an intermingling of fish over large areas.

The two areas, where fish in a near-spawning condition were found, are suf-

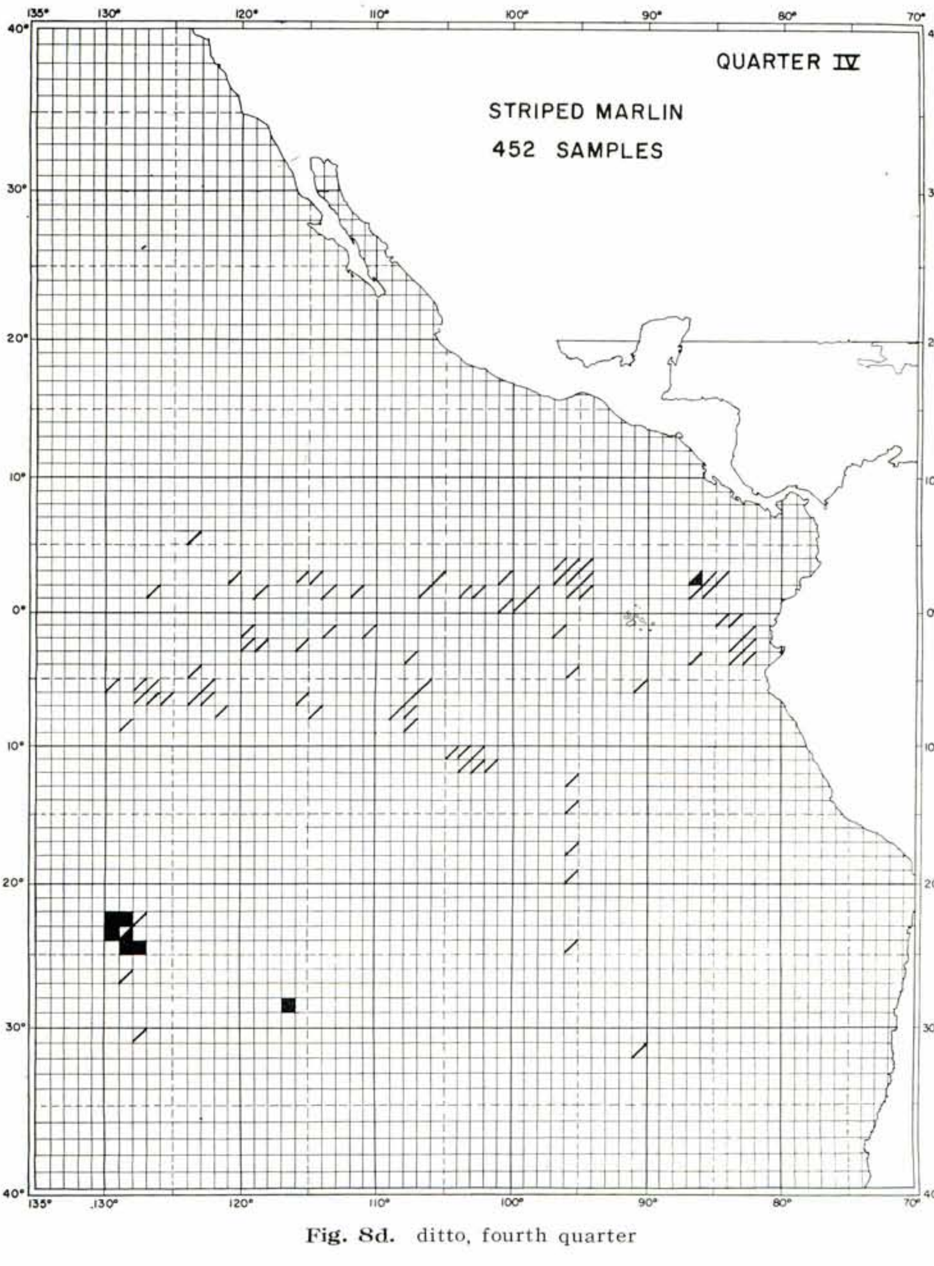


Fig. 8d. ditto, fourth quarter

ficiently far apart to afford an opportunity for genetic isolation. However, judging from the difference in size of the spawning groups inhabiting the two areas, it seems simpler to suppose that the smaller spawning group spawns first in the north, then reappears as larger fish in a spawning condition at some later date in the south.

Though adequate information is lacking, it does not seem probable that striped marlin in the eastern Pacific Ocean are comprised of more than a single stock. It is realized that this analysis is based only on results of the longline fishery and only that segment of it which operates within the eastern Pacific. A more detailed analysis should include catches from the sport and subsistence fisheries and the area of study should be extended farther to the west.

Blue marlin

Distribution

Catches of blue marlin by the Japanese longline fishery operating in the eastern Pacific show this species to occur in heaviest concentrations in the southern hemisphere at about 20°S and west of 110°W, especially during the southern summer. In the equatorial regions of the eastern Pacific, blue marlin are moderately abundant, but in the newly exploited areas north of 13°N, their relative abundance is quite low (Kume and Joseph 1969).

Information obtained through sources other than the longline fishery on the distribution of blue marlin in coastal waters of the Americas has been scanty. Aside from the Japanese longline fishery, this species does not appear to be taken commercially in the eastern Pacific. It is rare in the sport fishery too relative to striped marlin.

Rivas (1956a), examining sport-caught fish, remarks that blue marlin occur at least as far north as southern Baja California. He also recorded specimens from off Acapulco, Mexico and Piños Bay, Panama. Specimens have also been reported in the sport catch off Ecuador (Univ. of Miami 1955) and off Peru (Morrow 1957). Kume and Joseph (1969) record longline catches of blue marlin along the Peruvian coast to as far south as 12°S.

Size composition

All 3595 measurements of the eye-fork length of blue marlin collected from the eastern Pacific during January 1963 to July 1967 were pooled to form a single percentage-frequency curve (Figure 9). Nearly all of the samples used in the figure were collected south of 15°N and the geographic distribution of the samples corresponds reasonably well with that of this species in the eastern Pacific. The fish examined range between 100 and 340 cm in eye-fork length but most specimens fall between 150 and 250 cm. Though the frequency curve is bimodal, a dominant mode occurs at about 200 cm.

Size-frequency distributions by sex within major areas, averaged by quarters,

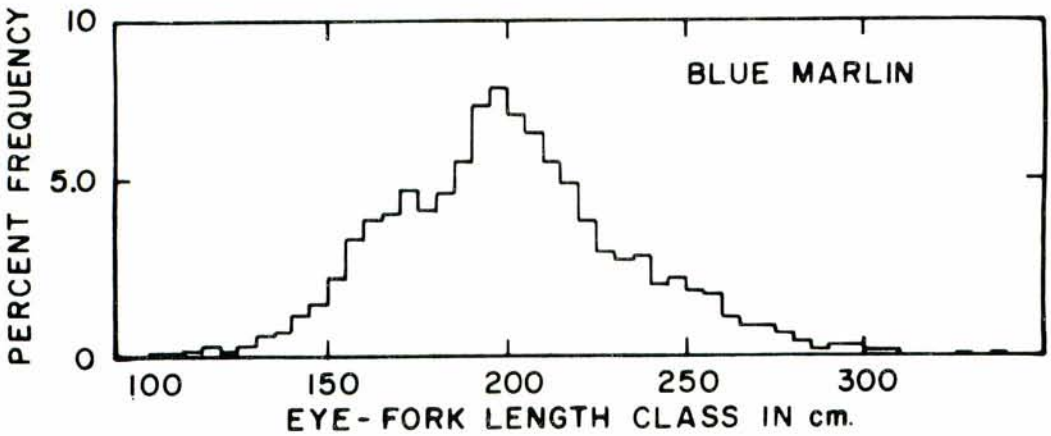


Fig. 9. Smoothed length-frequency distribution, in percent, of 3595 blue marlin captured by Japanese longline in the eastern Pacific, 1963-1967.

are shown in Figure 10. The shading represents females, white represents males and cross-hatching denotes those samples for which sex was unknown. Areas which showed little variation among one another and which appear to fall into natural groups have been combined into larger units. In the equatorial region, areas N-1, N-2, and E-1 to E-3, the largest proportion of fish are between 190 and 230 cm. Seasonally the proportion of fish in this size category are highest during the first and fourth quarters. These equatorial areas are also characterized by a number of fish below 150 cm in eye-fork length. In area N-3, nearly all fish are larger than 150 cm and most are over 180 cm. Seasonality is also apparent in this area where larger fish occur on the average during the second and third quarters. This seasonality in size composition suggests the possibility of smaller fish moving into the more near-shore areas (N-3) during the first and fourth quarters.

In the southern area of the fishery (S), where highest concentrations of blue marlin occur, there appear to be three modal groups in the catch: 170, 190 and 250 cm. These are evident only during the first and fourth quarters; during the other two quarters samples are too few to draw any conclusions.

In the north, areas M-1 to M-3, where samples are few, the largest proportion of fish ranges from 170 to 210 cm.

Sex ratios were computed in terms of the percent of females within areas and averaged by quarters within size-categories (Table 2). Individual fish for which sex could not be determined (only about 2.5% of the total) were not included in the averages of Table 2.

It is obvious from Table 2 and Figure 10 that in area N-3 females are the dominant sex, in numbers, over the entire range of sizes encountered. In the more equatorial regions, areas N-1, N-2, E-1, E-2 and E-3, females occur in

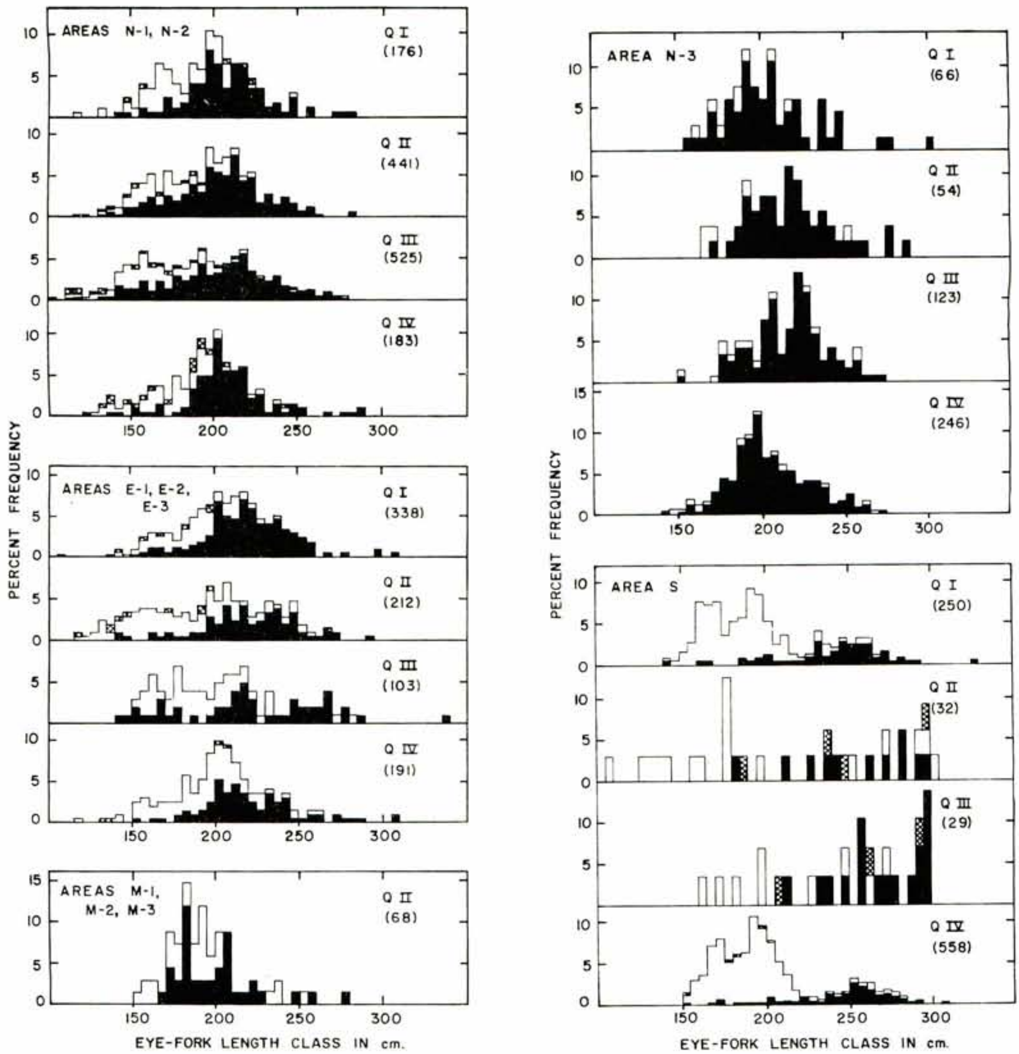


Fig. 10. Size-frequency distribution, in percent, of blue marlin captured by longline in the eastern Pacific and shown by major area, sex and quarterly average, 1963-1967. Sample numbers are given in parentheses. (Shaded area = females, blank area = males, hatched area = sex unknown.)

about equal proportion, or slightly less, to males in size categories less than 199 cm, but females predominate in larger sizes. In the southern area (S), males are by far the dominant sex among fish up to about 220 cm but beyond that size females become relatively more abundant. Such extreme differences in sex ratios between areas N-3 and S strongly suggest the possibility that blue marlin segregate into distinct areal groups according to sex, at least in the case of fish smaller than 220 cm. It is also noteworthy that those blue marlin captured by Japanese longline gear in the eastern Pacific which are larger than

Table 2. The numbers of male and female blue marlin captured by Japanese longliners in the eastern Pacific, grouped by size-class, area and quarter.

		Quarter I			Quarter II			Quarter III			Quarter IV		
Area	Size class (cm)	Male	Female	Percentage of females	Male	Female	Percentage of females	Male	Female	Percentage of females	Male	Female	Percentage of females
N-1~2	100-149	5	2	28.6	16	9	36.0	43	23	34.8	9	2	18.2
	150-199	45	41	47.7	89	118	57.0	108	125	53.6	42	34	44.7
	200-249	14	59	80.8	24	163	87.2	15	163	91.6	7	65	90.3
	250≦	0	5	100.0	1	10	90.9	2	21	91.3	0	7	100.0
N-3	100-149	—	—	—	—	—	—	—	—	—	2	1	33.3
	150-199	6	26	81.3	4	11	73.3	8	20	71.4	10	110	91.7
	200-249	2	29	93.5	0	32	100.0	3	80	96.4	4	105	96.3
	250≦	0	3	100.0	1	6	85.7	2	8	80.0	2	12	85.7
E-1~3	100-149	3	2	40.0	19	3	13.6	1	2	66.7	3	0	0
	150-199	73	40	35.4	58	17	22.7	31	12	27.9	56	18	24.3
	200-249	26	165	86.4	31	62	66.7	16	22	57.9	36	60	62.5
	250≦	0	23	100.0	3	9	75.0	5	14	73.7	2	12	85.7
S	100-149	2	1	33.3	5	0	0	—	—	—	—	—	—
	150-199	140	7	4.8	7	1	12.5	5	0	0	324	10	3.0
	200-249	36	29	44.6	0	4	100.0	2	4	66.7	99	40	28.8
	250≦	6	29	82.9	5	6	54.5	2	13	86.7	19	62	77.5
M	100-149				—	—	—	—	—	—			
	150-199				24	20	45.5	1	1	50.0			
	200-249				6	15	71.4	—	—	—			
	250≦				1	2	66.7	—	—	—			

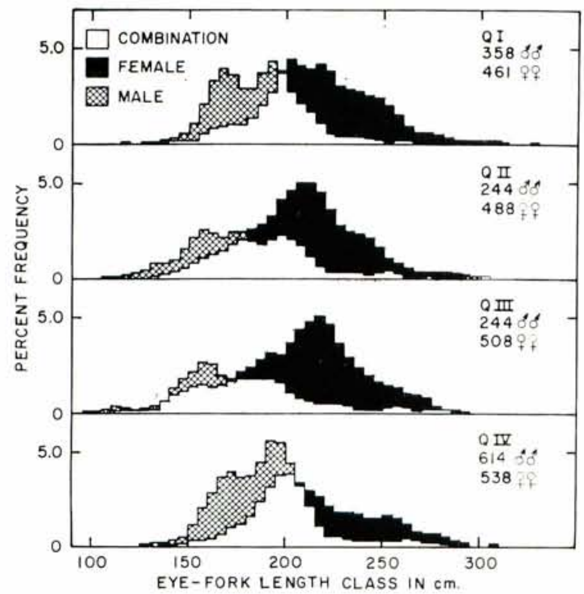


Fig. 11. Percentage length-frequency curves of blue marlin from the eastern Pacific longline fishery for all areas combined, averaged by quarters and shown by sexes. Hatched area indicates a predominance of males, shaded area indicates a predominance of females and blank area indicates where the two overlap.

220 cm are predominantly females.

It has not been possible to estimate growth of blue marlin from the progression of modal groups. Judging from the difference in size composition between sexes, it will be necessary to consider these differences when such estimates of growth become possible. To look at these differences in more detail, we plotted the percentage-frequency curves of the eye-fork length of blue marlin from the eastern Pacific for all areas, pooled by quarters and sex (Figure 11). Most obvious is the fact that all modal values for females, except for one at 155 cm in the third quarter, are larger than 190 cm whereas all modal sizes for males occur at less than

200 cm. Obviously some factor such as differential growth rate, differential availability and/or differential mortality is operating and must be accounted for in any future studies of growth.

Sexual maturity of females

The relationship between ovary weight and fish length for blue marlin from the eastern Pacific longline fishery is shown in Figure 12. Information on the relationship between spawning time and gonad index is not available for blue marlin. Therefore, on the basis of the studies discussed above, we have somewhat arbitrarily chosen a gonad index of 3 to distinguish those fish which are nearly ready to spawn. Isopleths representing gonad indices of 3.0 and 5.0 are shown in the figure; it is clear that inferences based on either of the lines differ little.

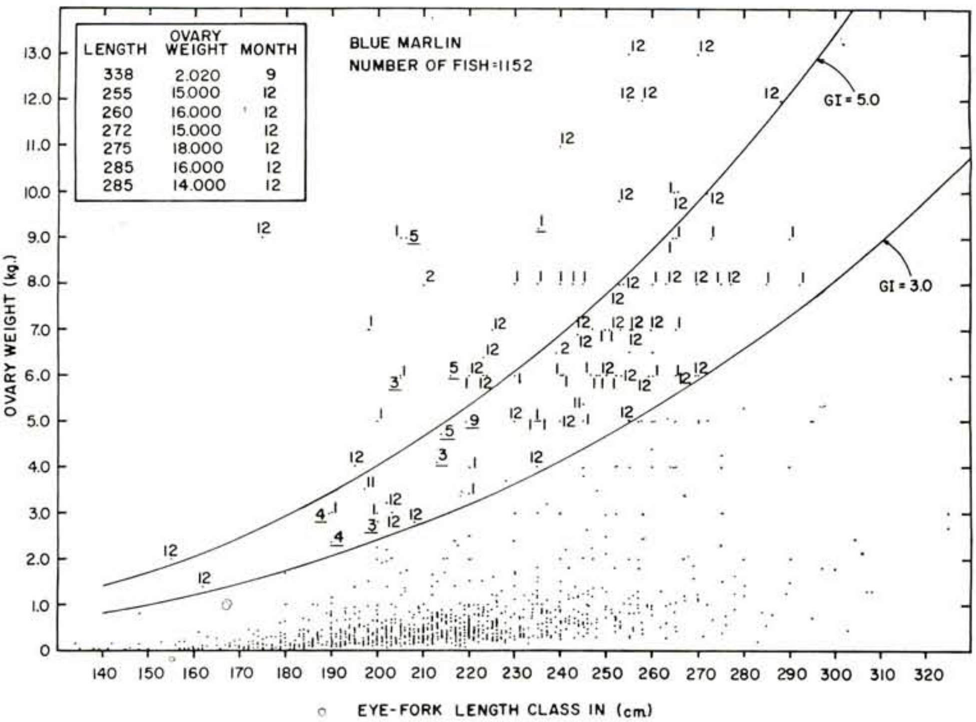


Fig. 12. Scatter diagram showing the relation between length and ovary weight of blue marlin from the eastern Pacific. Numbers show the month of sampling and underline denotes samples from northern latitudes. Isopleths are for gonad indices of 3.0 and 5.0. Observations falling outside of the limits of the figure, which are all from southern latitudes, are shown in the insert.

The most striking feature in Figure 12 is the preponderance of fish whose gonads weigh less than 1 kg, i. e. apparently not in a state of spawning. The smallest females encountered in a condition believed to be near spawning were about 155 cm, although most ripe fish were about 200 cm long or greater. The periods of peak spawning activity appear to occur during January and December.

To examine the distribution of mature blue marlin in time and space in more detail, we plotted the highest gonad index encountered during a quarter within a given 1° area (Figure 13). The indices were divided into three categories: >5.0, 3.0-5.0, <3.0. Mature blue marlin appear to be confined to oce-

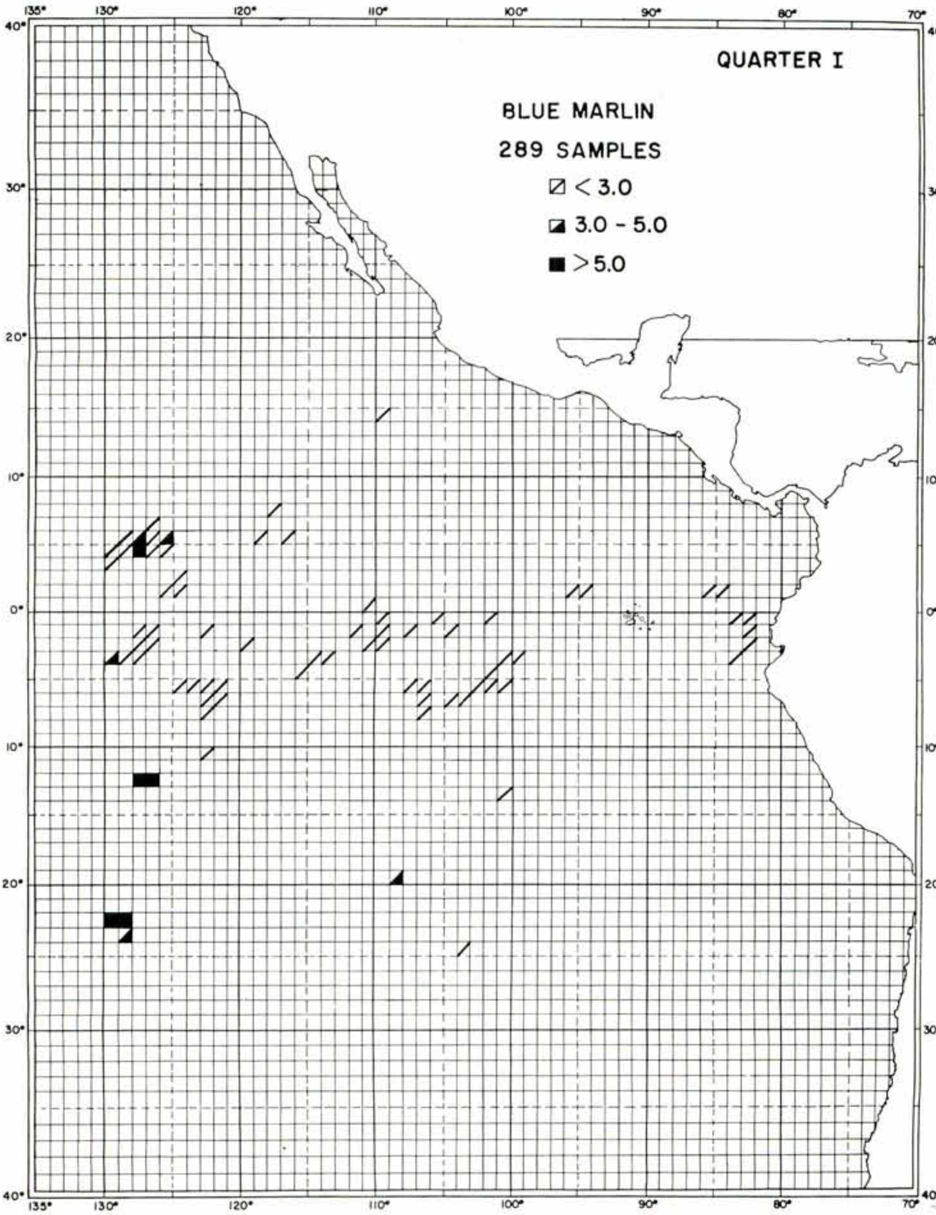


Fig. 13a. Highest gonad index of blue marlin from the eastern Pacific observed during the first quarter, shown by 1° areas and by three size categories.

anic waters. Most of the fish with gonad indices higher than 3.0 are encountered west of 120°W between 20 and 25°S during the first and fourth quarters of the year. Though there is evidence that mature fish occur in the more equatorial latitudes, the magnitude does not appear to be great. These data suggest that blue marlin spawn primarily in the southwestern portions of the eastern Pacific during the southern summer. It is during this period that longline

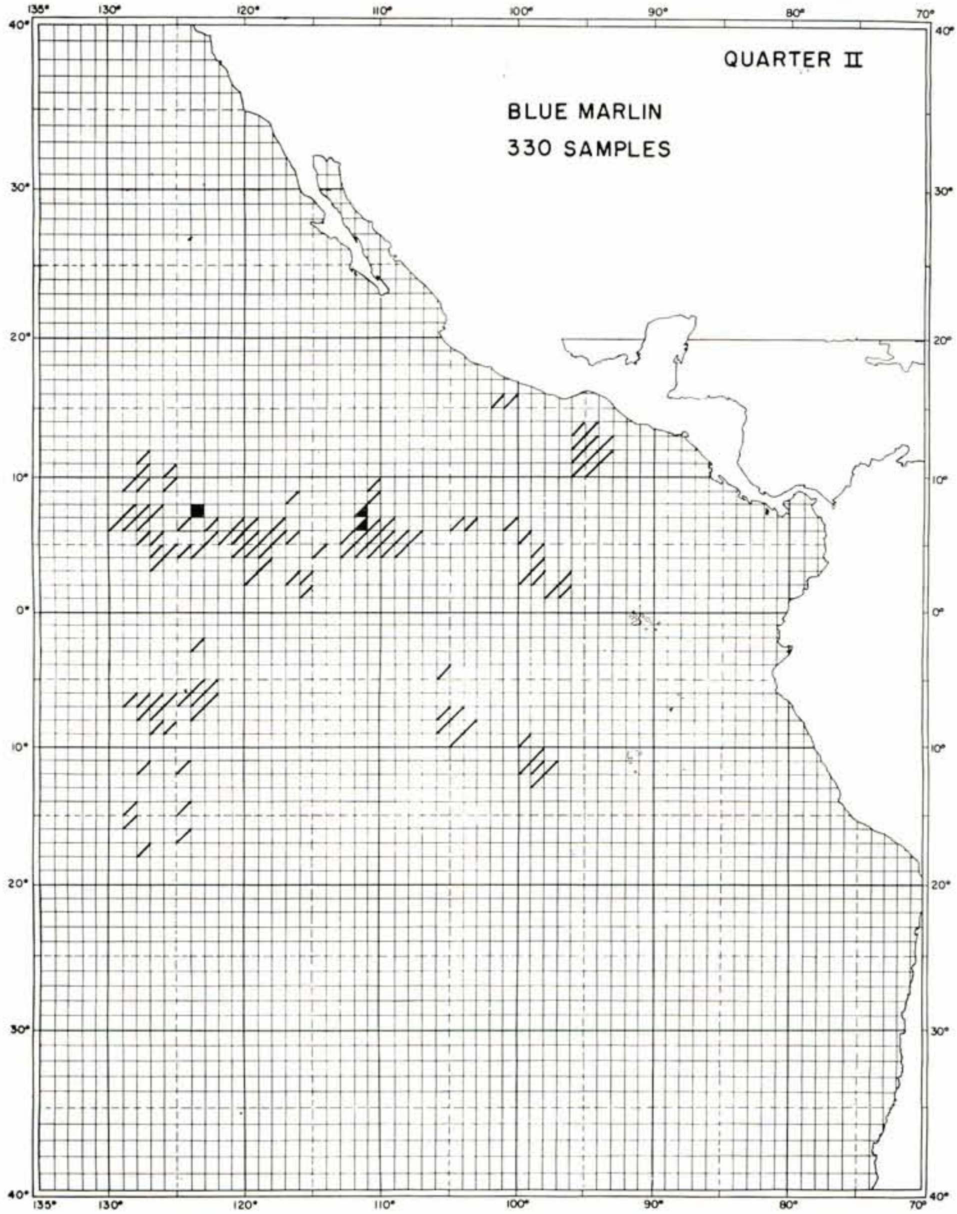


Fig. 13b. ditto, second quarter

fishermen make their best catches of blue marlin; perhaps this is related to the fact that fish congregate in this area for breeding purposes.

It is of interest to note that in the general spawning area, during the first and fourth quarters, the size composition of males and females is markedly different (Figure 10). Most of the fish sampled below 220 cm are males and most over 230 cm are females. A similar phenomenon has been observed among blue

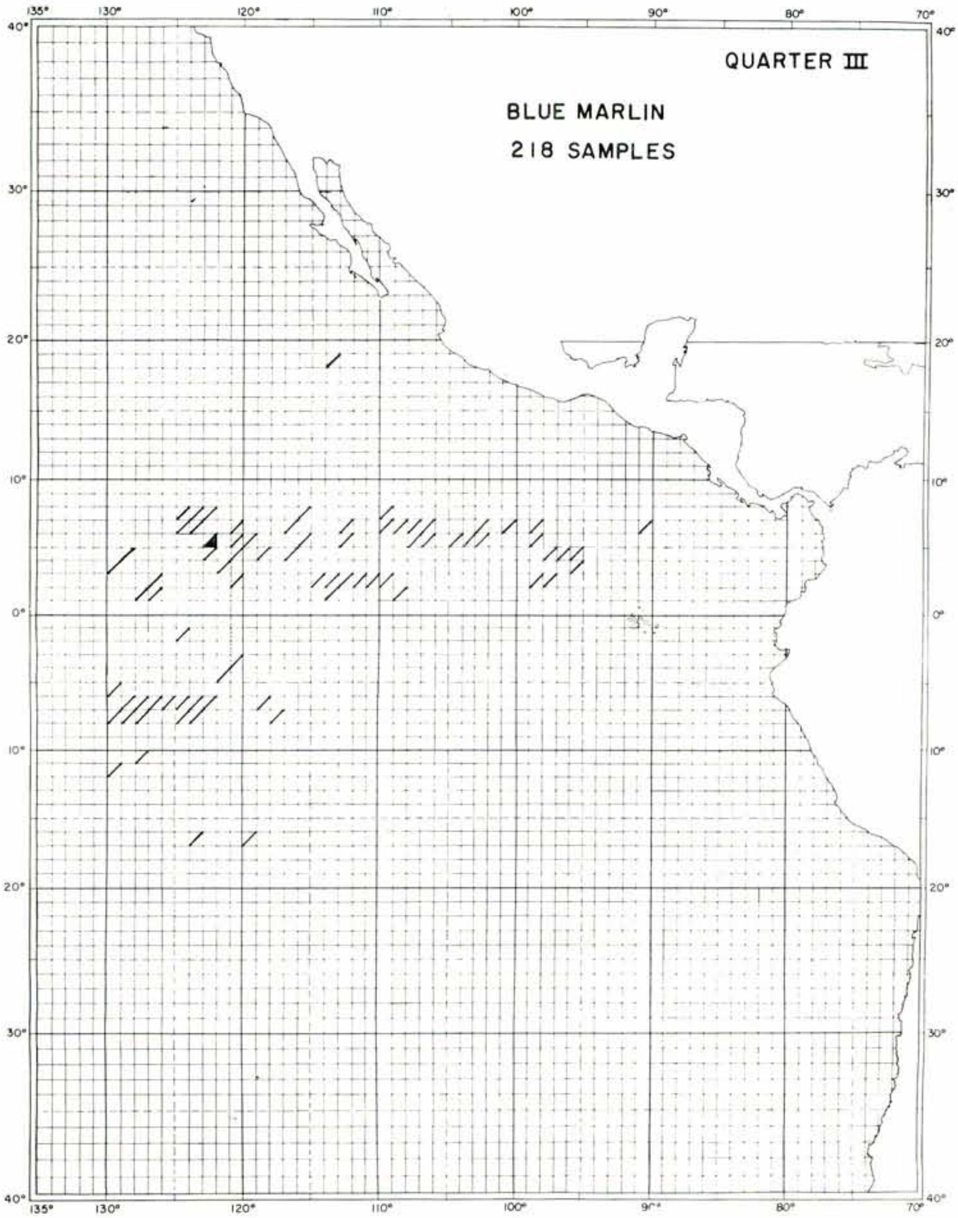


Fig. 13c. ditto, third quarter

marlin spawning in the northwestern Pacific (Nakamura 1944).

Population structure

Anraku and Yabuta (1959) considered blue marlin of the Pacific Ocean to be a single intermingling unit which undergoes rather widespread migrations, moving to the southeastern Pacific during the southern summer and returning to the northwestern Pacific during the northern summer. Since the blue marlin

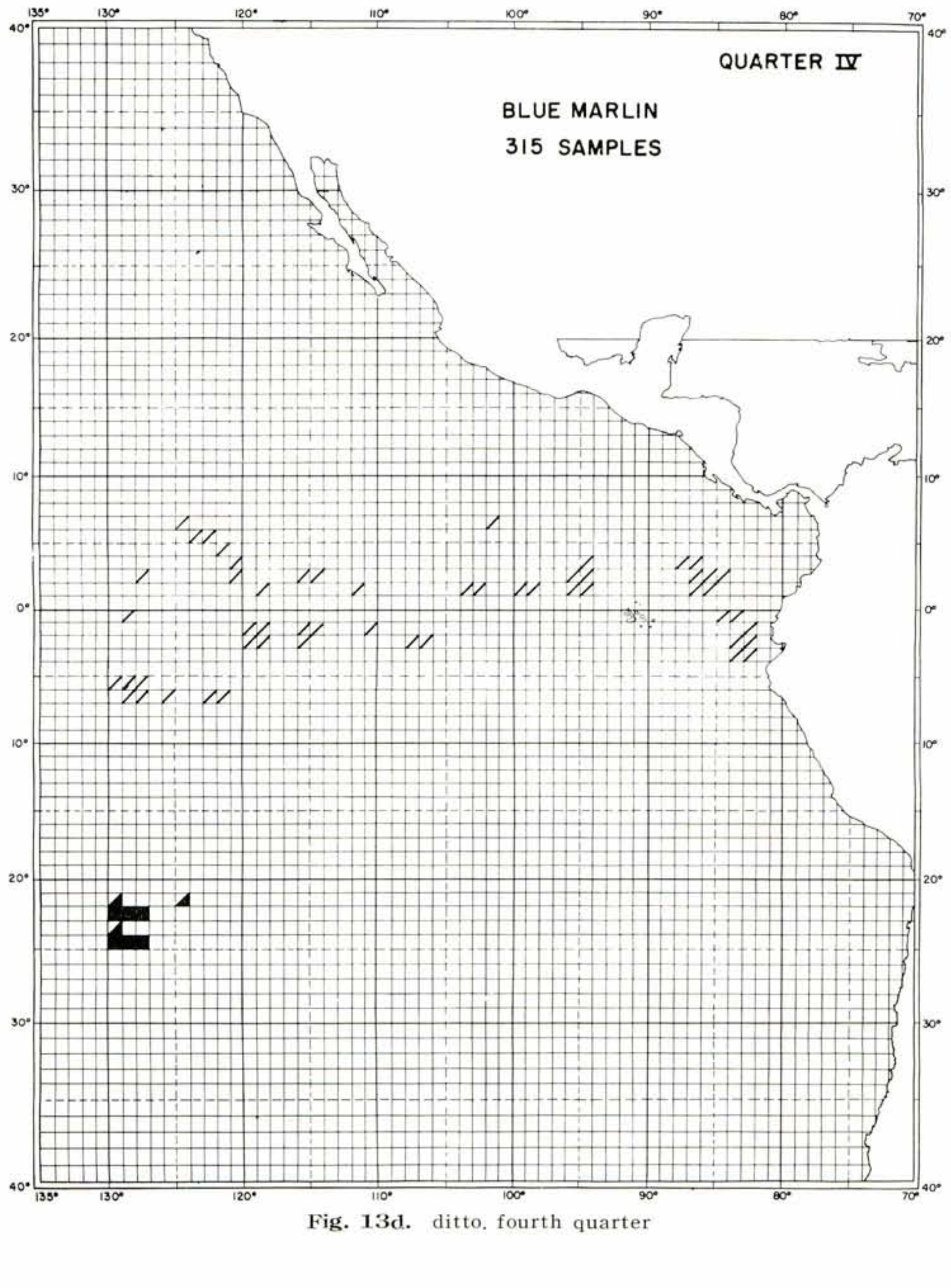


Fig. 13d. ditto. fourth quarter

data we examined do not pertain to the entire area over which this species is distributed, we cannot add to Howard and Ueyanagi's interpretations regarding the population structure of blue marlin.

Swordfish

Distribution

Longline data on the relative abundance of swordfish in the eastern Pacific suggest that this species is most abundant throughout the year in the inshore areas off Baja California in the north and off Peru-Ecuador in the south (Kume and Joseph 1969). Though some swordfish are encountered on the open ocean, they are generally less abundant there than near shore with the exception of an area at about 20°N between 125 and 130°W. Swordfish are found in low relative abundance near the equator from Ecuador westward; they are probably associated with the cool upwelled waters in that region.

In addition to longlining, swordfish are also taken by sport and harpoon fishermen in coastal waters. In the northern areas, the harpoon fishery takes more swordfish than the sport fishery (Staff of the Bureau of Marine Fisheries 1949) and this is most likely true for the southern areas as well. Commercial fisheries exist as far north as Monterey Bay, California in the north (Radovich 1961) and to Valparaiso, Chile in the south (Lobell 1947). This species has been recorded as far north as off Oregon (Fitch, n. d.) and as far south as Talcahuano, Chile (Lobell 1947).

Catch records tend to show a movement of fish from off the tip of Baja California during the spring towards the north during the summer and fall. Along the coastal regions of South America, it has been suggested that swordfish move northward from Chile to Peru during June to September (southern winter). Since all swordfish taken off Chile are immature females, it has been further postulated that they move seaward to spawn from November through February (Univ. of Miami 1955).

Size composition and growth

Measurements from 1449 swordfish collected south of 10°N were pooled to examine their size composition within the eastern Pacific Ocean. The percentage-frequency curve of these samples is multimodal and fish range from 50 to 280 cm in eye-fork length (Figure 14). In Figure 15 we show the size-composition data by sex and quarters of the year within four major areas of the fishery. In this case the frequency distributions are expressed in numbers of fish because of the paucity of the samples within the time-area strata. Immature fish less than 130 cm in length appear during all quarters in all major areas although they appear to be more abundant in the equatorial areas of the high seas (areas N-1, N-2, E-1, E-2 and E-3). In these latter areas the most abundant size category of fish falls between 130 and 180 cm. In area N-3, however, larger fish

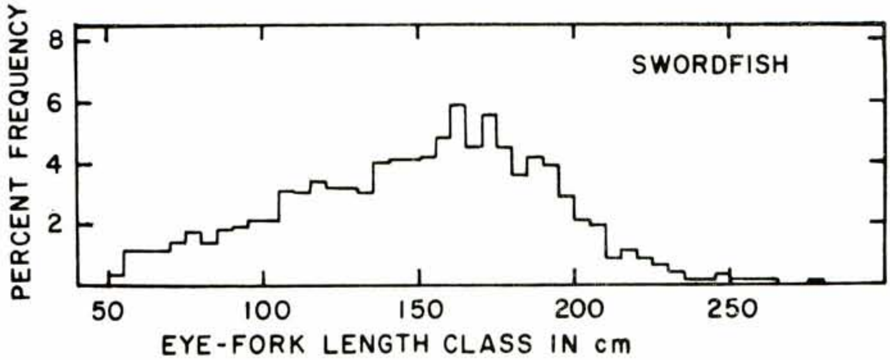


Fig. 14. Size-frequency curve, in percent, for 1449 swordfish caught by longline vessels in the eastern Pacific.

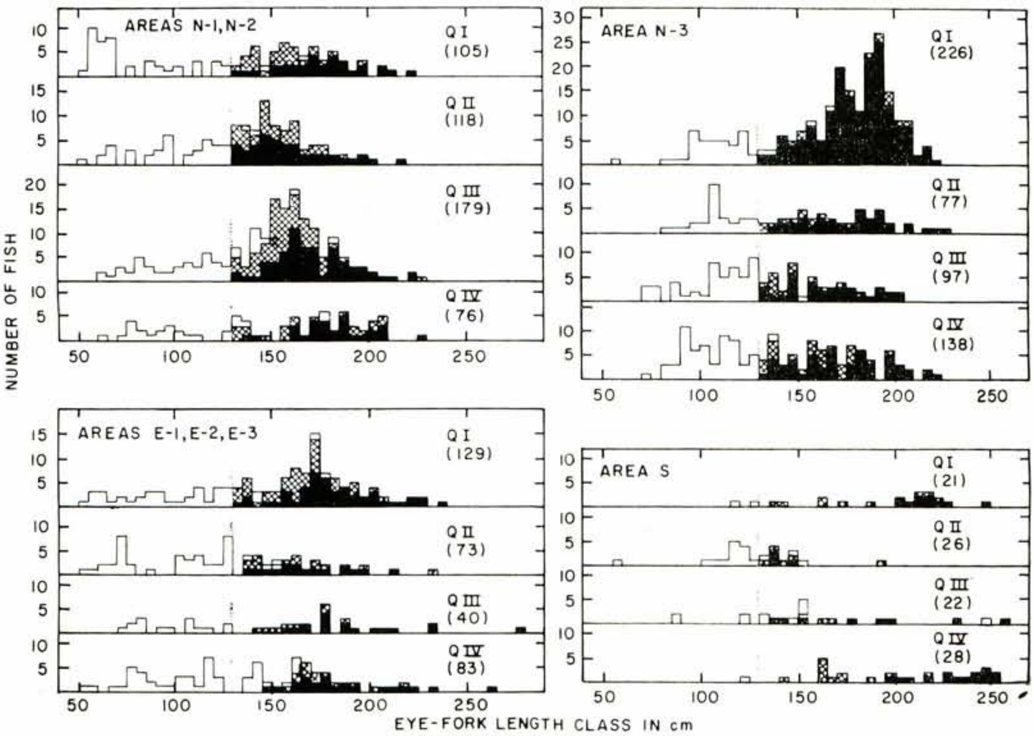


Fig. 15. Size-frequency distribution of longline-captured swordfish in the eastern Pacific by area, sex and quarterly average, 1963–1967. Number of fish samples is shown in parentheses. The shaded areas denote females, hatched areas above 130 cm denote males and blank areas above 130 cm represent individuals for which sex is unknown. Sex of all fish below 130 cm was not determined.

appear to be more common in the catches, especially during the first quarter when most fish fall between 175 and 210 cm. Most of the samples from this area during the first quarter are from near-shore waters off Ecuador. Samples from area S are few but they do reflect larger sizes on the average than all other areas.

In all areas except N-3, the proportion of females to males is roughly equal over the size range 130 to 170 cm. Above this size, the proportion of females becomes progressively higher. In area N-3, however, females are more abundant than males for all size categories above 130 cm, especially during the first quarter when almost all fish over 130 cm are females.

In Figure 16, we show the quarterly size composition for all areas combined. Below 130 cm, sexes are combined because it is not always possible to differentiate between them; however, above 130 cm, sexes are shown separately. The regular progression of modal values observable in the figure appears to represent growth. We could not fit the von Bertalanffy growth function to these data which is not surprising considering the small number of samples and their relatively high degree of variability. However, we did estimate the average change in length for both sexes and all sizes combined by computing for each series of modal progressions the change in modal length (Figure 16) during an interval of 3 months and then averaging these. It was found that swordfish between 62 and 165 cm grow on the average about 38 cm per year. Though modal values for each sex are few, they do demonstrate that females grow more rapidly than males. The only other published information on swordfish growth of which we are aware is that of Yabe, *et al.* (1959) which shows that swordfish in the western Pacific grow 25 cm per year on the average. Their data extend over the same size range of fish as our data from the eastern Pacific.

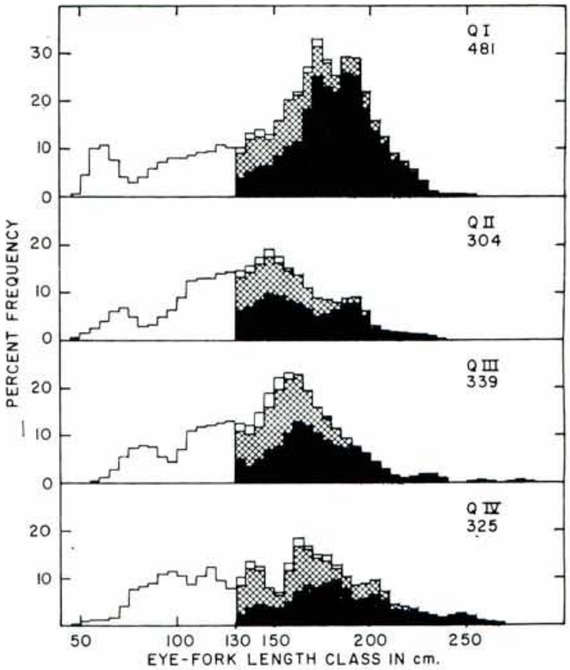


Fig. 16. Smoothed size frequency of swordfish from the eastern Pacific averaged by quarters and shown by sexes. Hatched area shows males, shaded area females and blank area individuals where sex could not be determined. Arrows designate modes.

Sexual maturity of females

The relationship of eye-fork length to ovary weight for 362 swordfish from the eastern Pacific is shown in Figure 17. Most of the observations appear as a cluster of points representing individuals with low ovary weights and gonad indices less than 3.0. Though information on the relationship between gonad index and state of maturation is lacking for swordfish, we assume for the pur-

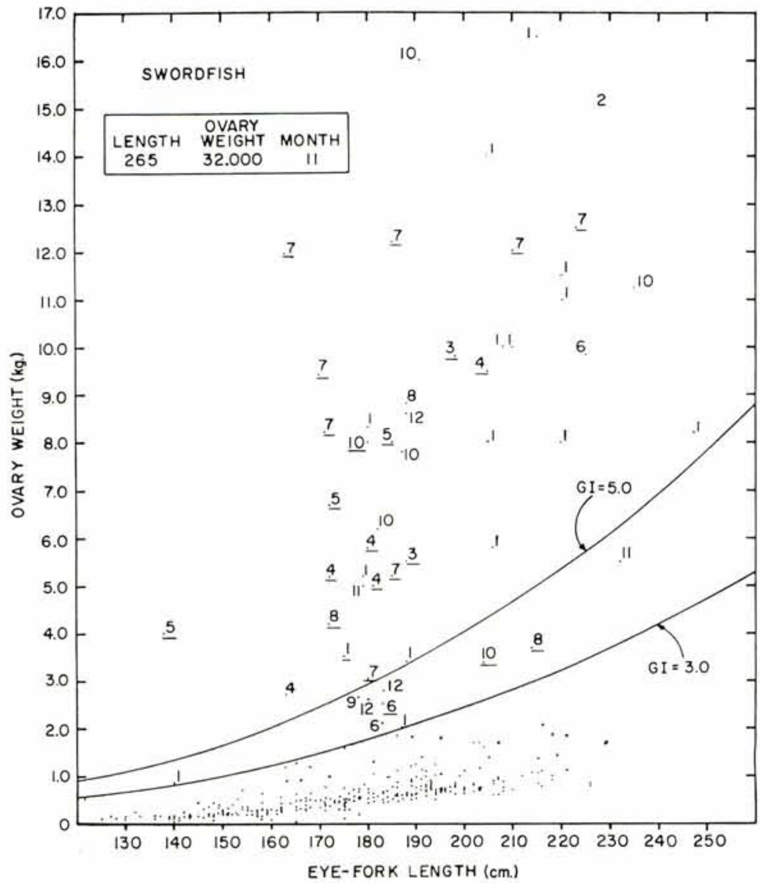


Fig. 17. Scatter diagram showing the relationship between eye-fork length and ovary weight of 362 swordfish from the eastern Pacific. Numbers show the month in which the sample was taken and underlines denote those from northern latitudes. Isopleths are for gonad indices of 3.0 and 5.0. A single specimen falling outside the limits of the figure is shown in the inset.

poses of this study that fish with gonad indices equal to or greater than 3 are about to spawn. Two *running ripe* specimens have been taken from the south-eastern Pacific, both in January. The first, captured at 2°S-120°W measured 208 cm in eye-fork length and had a gonad index of 11.1. The second, captured at 28°S-100°W, was 220 cm in length and had a gonad index of 10.8.

Isopleths for gonad indices of 3.0 and 5.0 are shown in Figure 17. For individuals with gonad indices greater than 3.0, the month of occurrence is designated by the appropriate numeral. All individuals from north of the equator are designated by underlining.

The smallest individual observable in a spawning condition is 139 cm, although swordfish in this condition are not regularly encountered until about

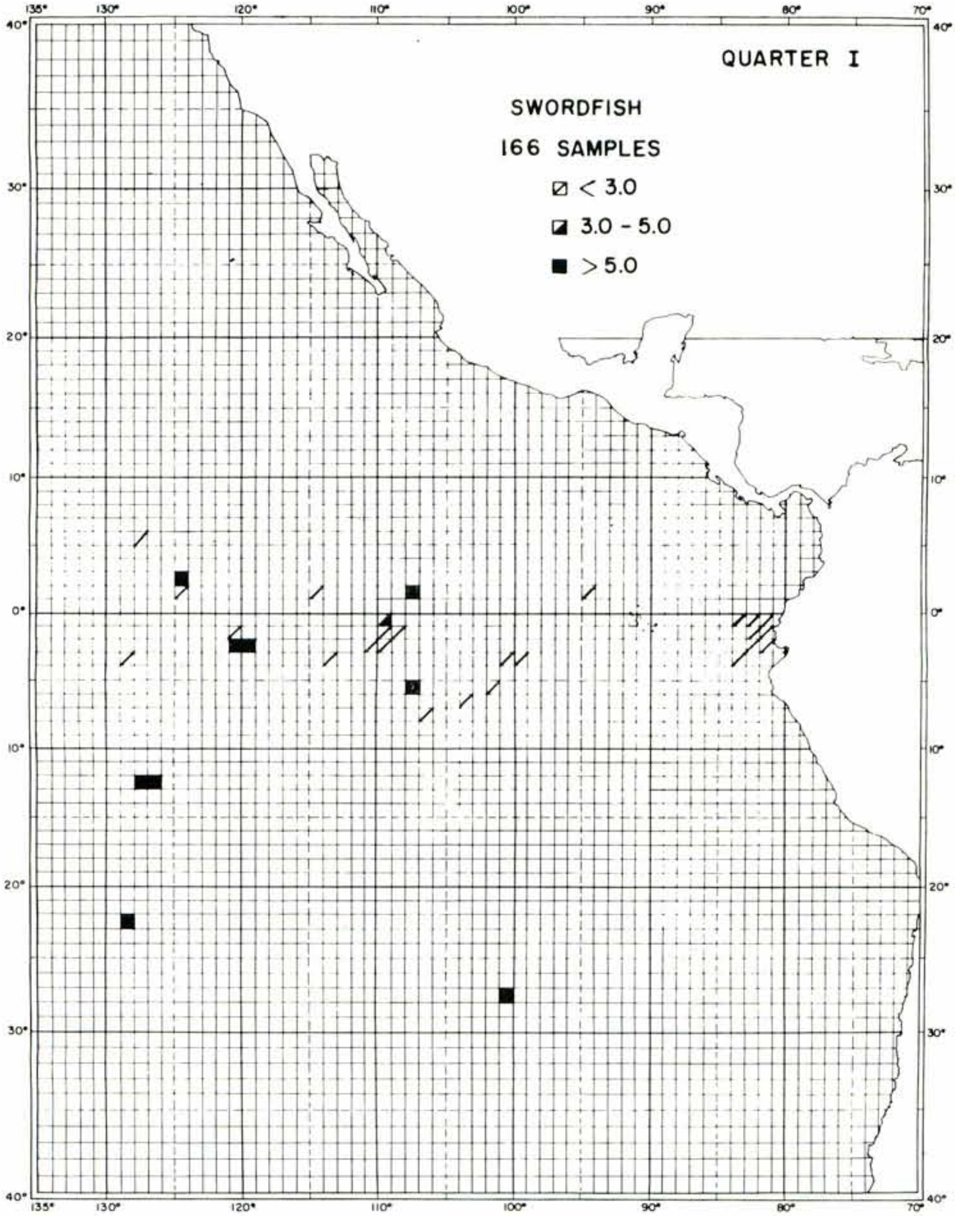


Fig. 18a. Highest gonad index of swordfish from the eastern Pacific observed during the first quarter, shown by 1-degree areas and three size categories.

170 cm. Sexually immature fish are represented in all size categories encountered in the fishery.

Fish about to spawn are found in every month of the year. Though the data are not adequate to make detailed quantitative comparisons among months, it generally appears that fish which are about to spawn are most abundant from March through July in the northern latitudes and around January in the

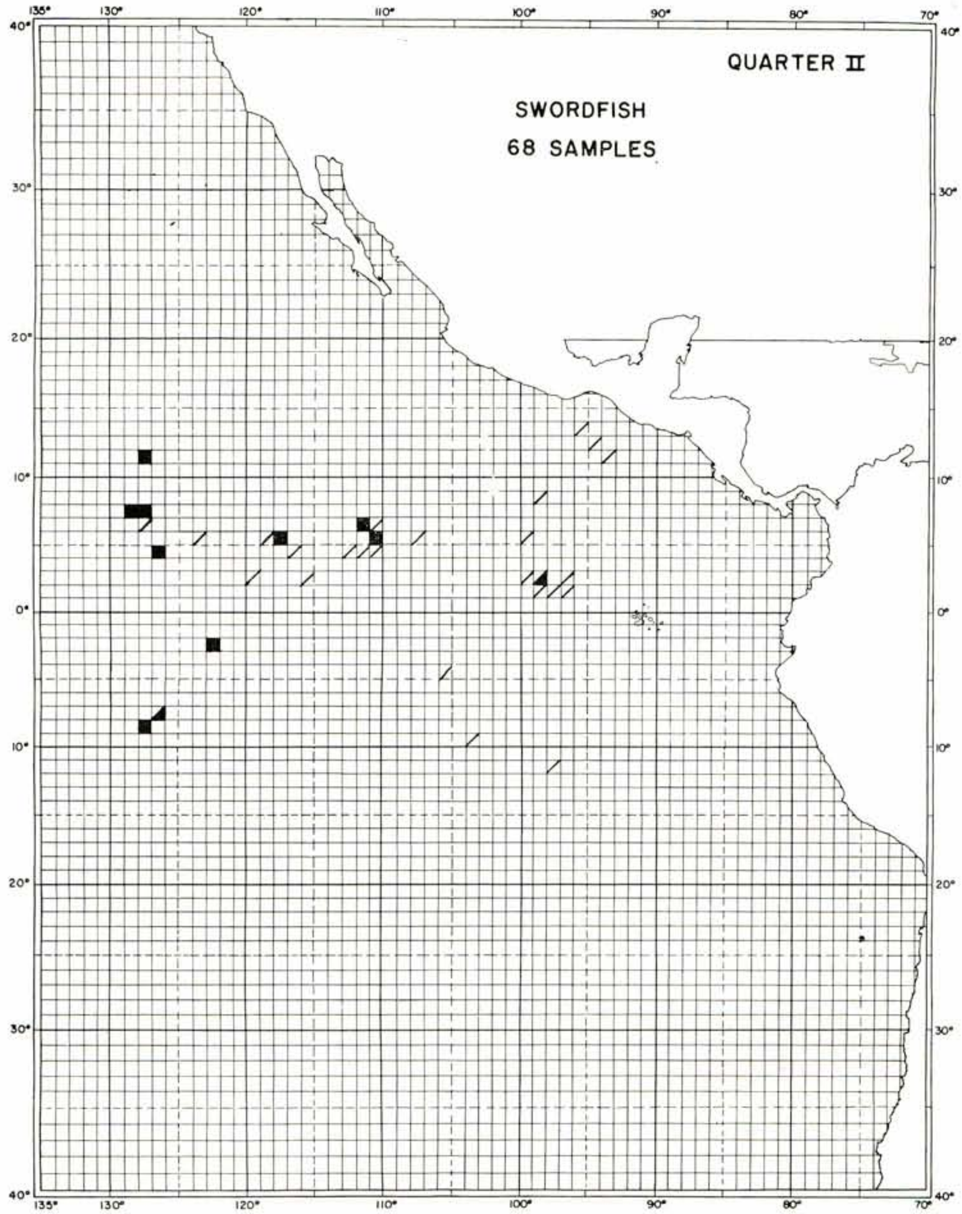


Fig. 18b. ditto, second quarter

southern latitudes.

To examine the distribution of these spawning fish in more detail, we plotted their occurrence by 1° areas and quarters of the year and by three categories of gonad index: <3.0, 3.0–5.0 and >5.0 (Figures 18a–d). It is obvious that some spawning occurs throughout every quarter of the year; it appears to be cofined to the area west of 100°W and, except for the southern summer,

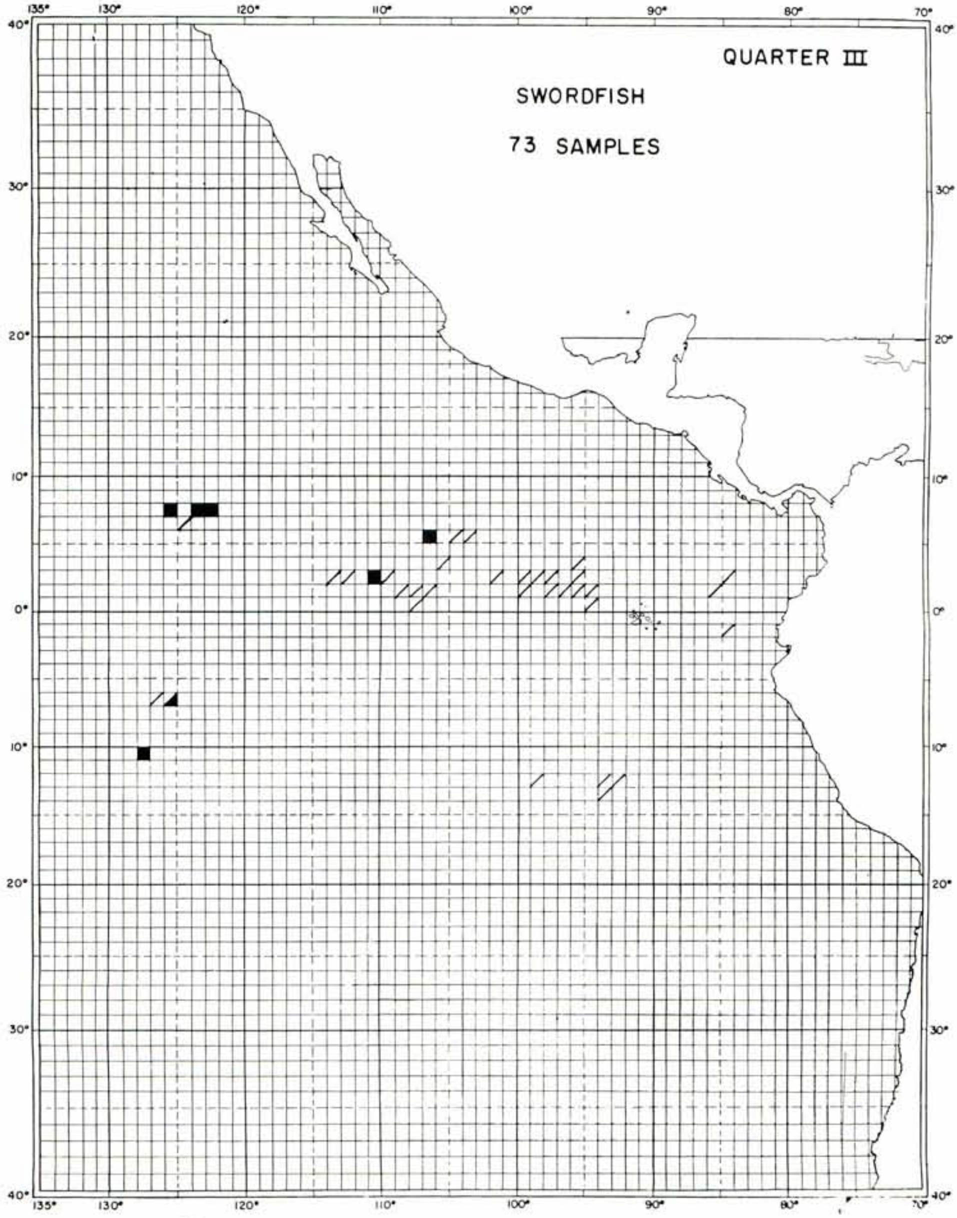


Fig. 18c. ditto, third quarter

is infrequent between 10° north and south of the equator. Since sampling coverage is extremely sparse north of 10°N and south of 10°S, we cannot comment on the spawning activities of swordfish in these areas.

Population structure

The foregoing discussion suggests that swordfish do not breed east of 100°W but to a degree do so throughout the year in the equatorial waters of the open

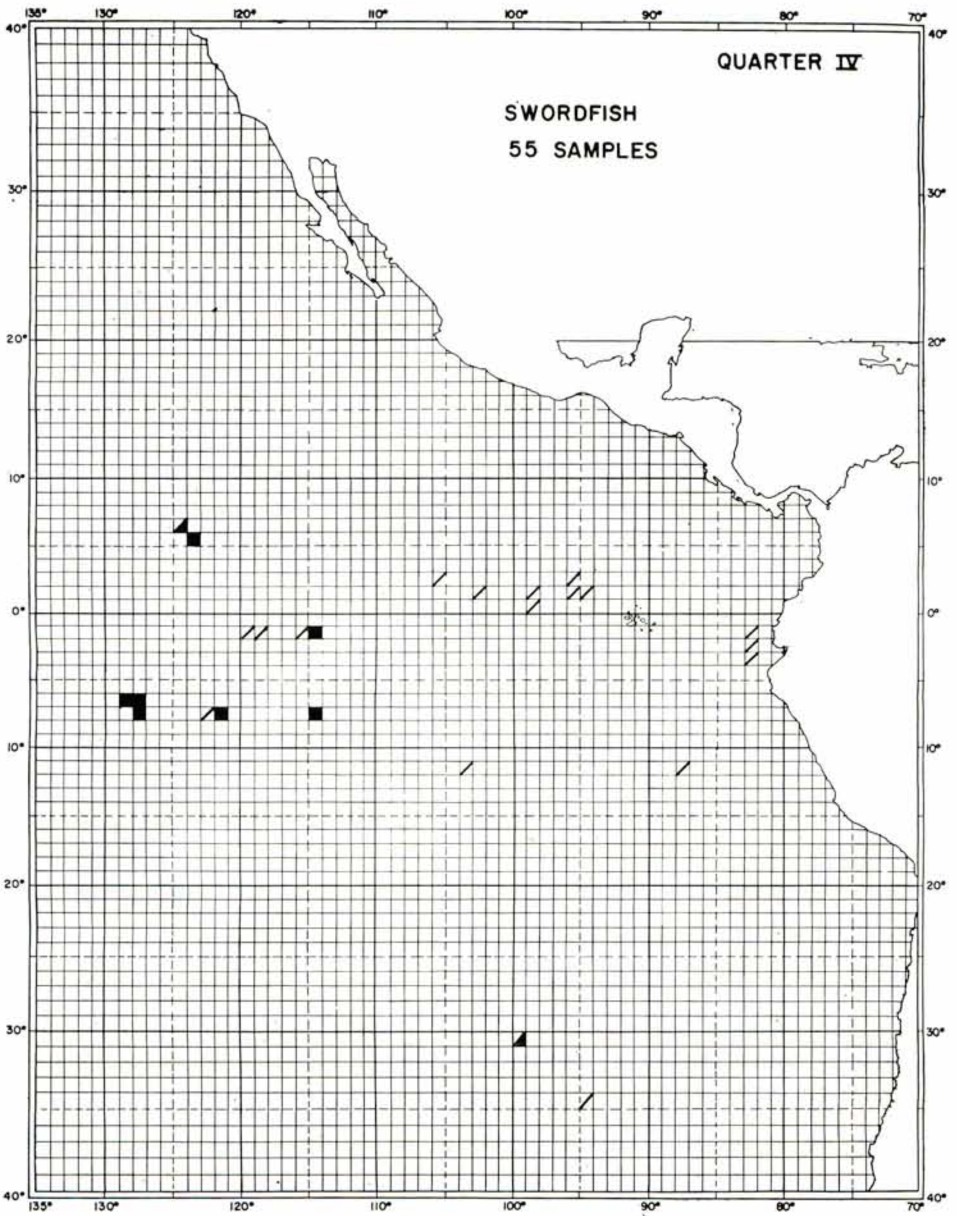


Fig. 18d. ditto, fourth quarter

ocean. Judging from the high proportion of small fish in the equatorial region of the high seas, this is probably a feeding or nursery area for immature fish. As these immature fish grow, they appear to move into the coastal waters of North and South America where the best commercial fishing occurs. Upon reaching sexual maturity, they move offshore again to spawn.

Though there are two distinct commercial fishing areas for swordfish, one off South America from Chile to Ecuador and the other in the northern hemisphere from Baja California to central California, it is not known whether the stocks inhabiting these two areas are distinct subpopulations or whether they are a single one which intermingles freely during the breeding seasons in the equatorial high seas. Before this problem can be solved, it will be necessary to analyze data collected specifically for this purpose.

Sailfish

Sailfish occur most abundantly in the coastal waters of the Americas between Ecuador and Baja California. The recent expansion of the Japanese longline fishery to the coastal waters of the eastern Pacific has disclosed that (1) the center of abundance of this species is probably off Acapulco, Mexico during the winter months; (2) they migrate north to lower Baja California with the northward displacement of warm waters during the summer and fall; (3) they are abundant seasonally to as far south as Guatemala; and (4) they are relatively abundant between the coast of Ecuador and the Galapagos Islands throughout the year (Kume and Joseph 1969). The distribution of sailfish in the coastal sport fisheries has been reviewed by Howard and Ueyanagi (1965). Their findings are in good agreement with our data for the longline fishery.

Size-composition data on sailfish from the longline fishery are virtually nonexistent. For this study only two size-frequency samples are available (Figure 19). These were obtained from research cruises. The sample of 77 fish from offshore was collected from 1962 through 1965, December-Februay by the R/V *Shoyo-Maru*. The sample of 193 fish from off Costa Rica was collected during February through March of 1967 by the R/V *Taisei-Maru* of the Mie Prefecture.

Two distinct modal groups are evident for each sex (145 to 165 and 175 to 190 for males, and 155 to 180 and 185 to 210 cm for females) in the offshore samples. In the inshore area, there is only one distinct modal group for each sex and this corresponds to the larger modal group from the offshore area. Mr. James L. Squires, Jr. of the Bureau of Sport Fisheries and Wildlife, Laboratory at Tiburon, California kindly provided us with 170 length-frequency measurements from sailfish caught by sportsmen during 1968 off Mazatlan, Mexico. These data overlap very closely with the smaller modes from the offshore *Shoyo-Maru* samples. Males were most abundant in the range from about 160 to 180 cm and females from 160 to 185 cm.

Gonad indices, which are not shown, were computed for 50 of the fish collected by the *Shoyo-Maru*. All of the fish were sexually immature with gonad indices of less than 1.0, indicating that sailfish probably do not spawn in this area during December through Ferbruary. This analysis cannot be extended to

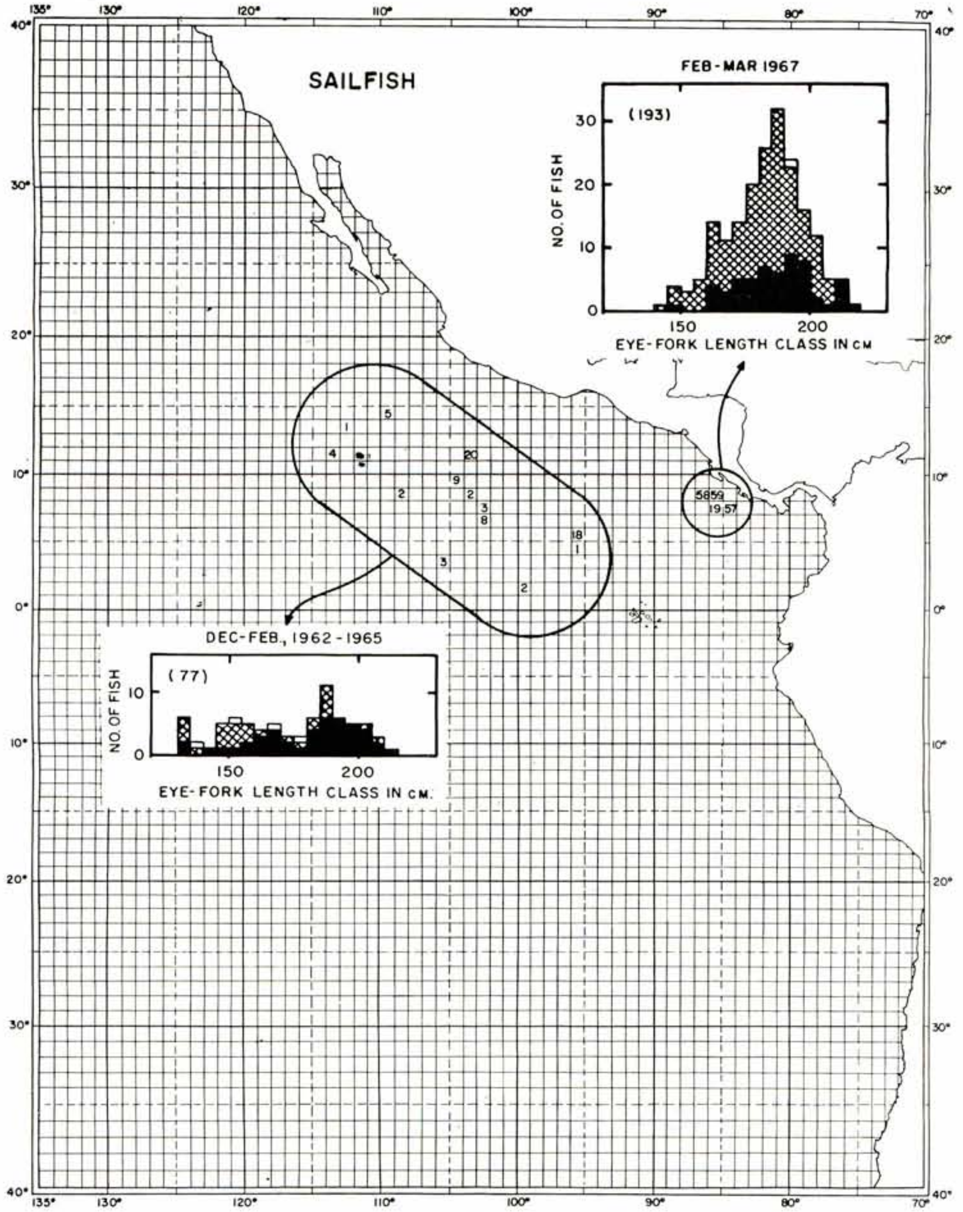


Fig. 19. Size composition of sailfish from the eastern Pacific. Number of fish sampled is shown in parentheses. Shaded areas denote females, hatched aseas denote males and blank areas represent fish for which sex could not be determined. Numbers within the 1-degree areas represent location and quantity of fish caught.

other seasons of the year in this area since samples were taken only during December through February. Though the data on gonad weights from samples off Costa Rica were not available to us, it is reported (Mie Pref. Fish. Exper. Sta. 1968) that some of these fish were in a spawning condition. Male fish are predominant in this area (Figure 19). Such a preponderance of males associated with spawning groups of fish has been noted earlier in this report for other species of billfish.

Shortbill spearfish

The distribution of this species in the eastern Pacific has been discussed in a general manner by Kume and Joseph (1969). They found that shortbill spearfish occur only in the high-seas area beyond about 600–700 miles from shore. Only three specimens were recorded in the inshore areas; two from off California and one from off Chile (Howard and Ueyanagi 1965).

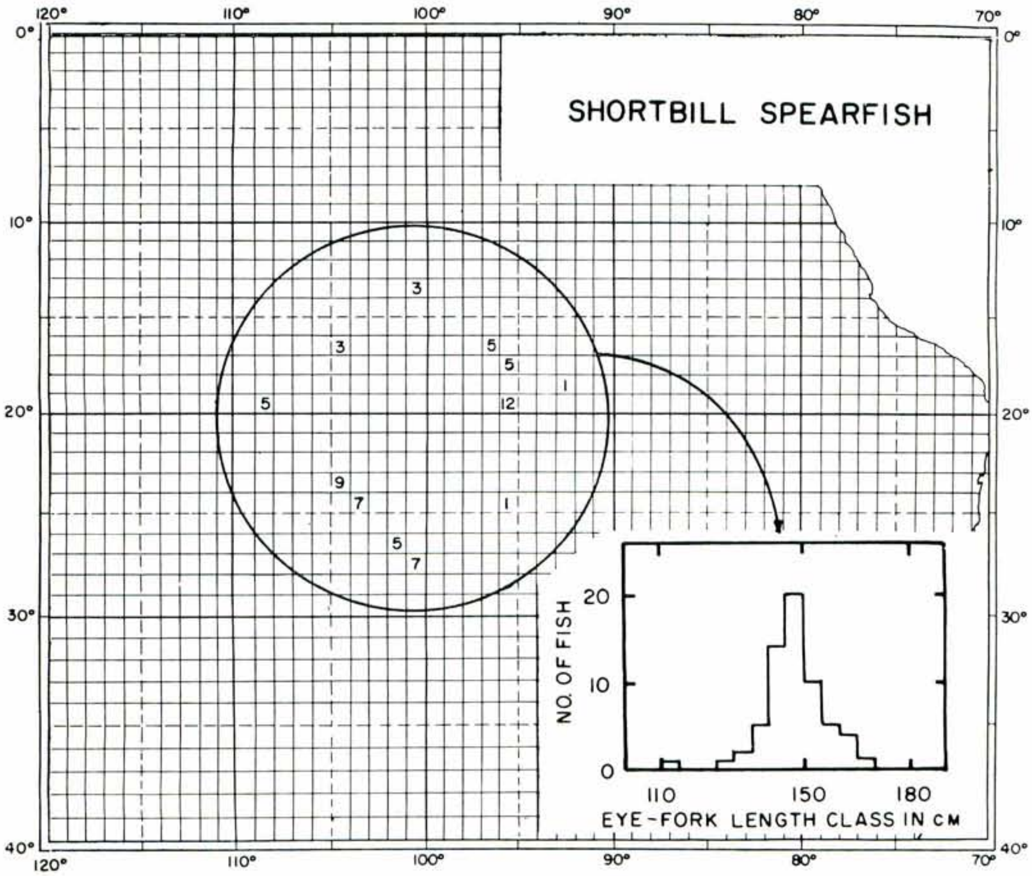


Fig. 20. Size composition of 63 shortbill spearfish captured in the eastern Pacific during 1963 and 1964 by the R/V *Shoyo-Maru*. Number and location of fish measured are shown by 1-degree areas.

Size-composition data for this species from the eastern Pacific are extremely scanty. The only available information is from 63 fish measured aboard the R/V *Shoyo-Maru* from December 1963 to January 1964 (Figure 20). These fish range from 110 to 170 cm but most fall between 140 and 155 cm.

We computed gonad indices for 12 of the 63 fish measured. All 12 were immatur except for one fish with a gonad index of 5. 1.

Length-weight relation

Knowledge of the length-weight relation of billfish is necessary to convert catch statistics from weight to numbers of fish and to compare size-composition samples gathered in different ways. The present report deals with length-weight data from the eastern Pacific Ocean collected aboard the R/V *Shoyo-Maru* during 1962 through 1965 (Japan Fishery Agency 1963, 1964, 1965).

For the purposes of this analysis, it is assumed that a linear relation exists between the logarithms of length and those of weight for each of the billfish species studied. It is also assumed that the distributions of the y variables are independent and normal with homogeneous variance. The equation used to describe the relationship is:

$$\log_{10} Y = \log_{10} a + b \log_{10} X$$

where

Y = weight in kilograms

X = eye-fork length in centimeters

a and b = constants.

Equations were fit to the data by the method of least squares. The estimates of the constants for each specimen are listed in Table 3 together with the number of samples and the size range, in eye-fork length, of the fish sampled. Two

Table 3. Weight-length relationship for billfish from the eastern Pacific longline fishery. Constants given for $\log_{10}$ gilled and gutted weight and $\log_{10}$ whole weight in kg and eye-fork length in cm.

Species	Class	Number of fish	Size range of sample in cm.	$\log_{10} a$	b
Striped marlin	gilled & gutted	111	132. 0～222. 0	-4. 9896	2. 9749
	whole	51	108. 0～211. 0	-5. 2552	3. 0888
Blue marlin	gilled & gutted	24	97. 6～234. 2	-6. 2101	3. 5644
	whole	11	167. 0～270. 0	-4. 4455	2. 8223
Swordfish	gilled & gutted	10	74. 6～231. 2	-4. 8020	3. 0304
	whole	5	131. 0～229. 0	-4. 6754	2. 9605
Sailfish	gilled & gutted	44	132. 2～212. 5	-4. 8325	2. 8202
	whole	28	134. 0～205. 0	-3. 9357	2. 4156
Shortbill spearfish	gilled & gutted	89	102. 4～167. 0	-7. 2239	3. 9195
	whole	19	128. 0～156. 0	-6. 8146	3. 7242

sets of constants are given for each species. The first set represents the relationship between gilled and gutted weight and length and the second set the relationship between whole (round) weight and length. Most of the samples are from gilled and gutted fish and these are so few that the estimates of the constants must be considered as only tentative; this applies even more so to the constants estimated for the whole weights.

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要　　約

東部太平洋においてカジキ類が漁獲の主対象として本格的に開拓されるようになったのは 1964 年以降のことであり主として 10°N 以北の海域におけるマカジキ，メカジキ，バショウカジキがその主体となっている。ここでは，130°W 以東の東部太平洋に分布するカジキ類について 1963 年から 1967 年の間に日本のまぐろはえなわ漁業を通して得られた体長および卵巣重量資料の解析を行い，生物学的な特長を明らかにするとともに，加えて各魚種について体長体重関係（第 3 表）も求めた。また，東部太平洋では，はえなわ漁業以外にもカジキ類がアメリカ大陸沿岸国によって漁獲されているが，それに関する情報もあわせて，魚群構造について若干の

考察を加えた。各魚種別に得られた結果を示すと以下の如くである。

マカジキ：　10°N 以北のマカジキ漁場が開拓されて以来，東部太平洋で漁獲されるカジキ類のなかで最大の漁獲量を示す。海域別の体長組成は北から南へと魚体の大型化を明瞭に示すが季節変化はそれ程顕著ではない。性成熟度の高い魚群は 10—20°N および 20—25°S の海域に分離してみられ，ともに出現する季節は各半球の夏期に相当する。同時にこれらの魚群では雄の卓越が著しい。赤道海域には性成熟度の高い個体の出現はみられない。東部太平洋に分布するマカジキは決定的な推論を下すことはできないが，単一の stock またはそれに属する一部から成り立っているものと考えられる。

クロカジキ：　東部太平洋で多少まとまって漁獲される海域は 15°S 以南，110—130°W の海域で季節的には南半球の夏期である。体長組成の海域および季節変化はむしろ不明瞭である。性成熟度の高い個体の出現は上記の南半球の海域で季節も夏期となっている。産卵期には 220 cm 以下の体長範囲で雄の著しい卓越が認められるが，赤道海域東部では雌の卓越がみられ産卵行動と関連した性による生息域の「すみわけ」が示唆される。

メカジキ：　東部太平洋でメカジキの多獲される海域はカリフォルニア半島の西岸およびエクアドル沖である。体長測定資料は少ないが，比較的資料数の多い東部赤道海域では第I四半期（1－3月）に大型魚の増加と同時に雌の著しい卓越がみられる。また 100°W 以西の赤道域では小型魚の出現割合の高い傾向が認められる。全海域の資料をこみにすると 130 cm 以下では，モードの位置が季節的に大きな体長へ移行し年 35 cm 前後の成長が示唆される。性成熟度の高い個体の出現は沖合の低緯度海域に周年認められる。上記メカジキの多獲される2つの海域の魚群は性的活性は低いものと推定され，産卵は沖合の低緯度海域で行われると考えられるが両魚群間の資源構造上の関係は明らかではない。

バショウカジキ：　マカジキと同様に東部太平洋で多量に漁獲される。本種の濃密分布域は赤道以北からカリフォルニア半島にかけての沿岸域である。体長資料は2例得られただけで，全体的な展望には不充分であるが，沖合海域では小型魚の割合が大きいことを示している。しかし，Mazatlan 沖で sport fishing によって漁獲される魚体は沿岸域でも小型魚となっている。Costa Rica 沖の魚群は性的活性度が高く，しかも雄の卓越がみられ，他のカジキ類と同様に，性的活性の高い魚群の場合には雄が卓越するという関係を反映しているものと思われる。

フウライカジキ：　沿岸域での漁獲は極めて稀で沖合海域で多少混獲されるに過ぎない。1例だけの体長組成は魚群の主体が 150 cm 群であることを示唆している。

Appendix table 1. Number of billfishes measured aboard experimental and training longline vessels operating within the eastern Pacific, by quarters within major areas.

Year	Quarter	N-1	N-2	N-3	E-1	E-2	E-3	S	M-1	M-2	M-3
		MAJOR AREAS									
Striped marlin											
1963	1	32			41						
	2	32	35		15			83			
	3	84	476	122	32	21		108			
	4	21	33	223	61	4		254			
1964	1		21	359	21	69		12	13		
	2	17			13	40		33			
	3	128	20	60		6	81	3			
	4	13	38	54	104	121		20			
1965	1	8	9	77	9						
	2									361	
	3		35							17	
	4	5	19	609							
1966	1	11	160	151		3					
	2	99	209	205							
	3		56	175	4						
	4			47							
1967	1	26		53	32	90	152				
	2	35	5			21	169			64	529
	3		158								
Total		511	1274	2135	332	375	402	513	13	442	529
											6526
Blue marlin											
1963	1	73	34		111	77		8			
	2	133	13		86			21			
	3	183	157	36	58	7	4	19		2	
	4	139		40	100	10		494			
1964	1	22	1	6	86			242			
	2	25			36	20		11	9		
	3	145	12	75		1		3			
	4	21		9	64	17		64			
1965	1	11		22							
	2	59			3					25	
	3										
	4	11	12	178							
1966	1	31		30	19	8					
	2	109	60	54							
	3		11	10	33			7			
	4			19							
1967	1		4	8		26	11				
	2	16	26		34	18	15			2	32
	3		17								
Total		978	347	487	630	184	30	869	9	29	32
											3595
Swordfish											
1963	1	44		2	27	2		4			
	2	31			9			17			
	3	48	50	13	11		22	18			
	4	44	16	20	7			22			

Appendix table 1, (Continued)

		MAJOR AREAS									
Year and quarter		N-1	N-2	N-3	E-1	E-2	E-3	S	M-1	M-2	M-3
1964	1	23	19	183	55	33		17			
	2	10			8	18		9	5		
	3	31	19	46				1			
	4	6			47	29		6			
1965	1	12	3	4							
	2	16			14						
	3										
	4	4	6	92							
1966	1	3		37		3					
	2	23	20	77	19						
	3		10	38	7			3			
	4			26							
1967	1		1			5	4				
	2	4	14				5				5
	3		22								
Total		299	180	538	204	90	31	97	5	0	5
											1449